The Stormy Lake Adaptive Management Plan

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CHAPTER 1

What Is the Stormy Lake Adaptive Management Plan?

The *Stormy Lake Adaptive Management Plan* is a comprehensive lake management plan prepared for the Stormy Lake Association (SLA). It results from a large-scale project funded by a Wisconsin Department of Natural Resources (WDNR) Aquatic Invasive Species Control Grant (Subchapter II – Education, Prevention, and Planning Projects). The project was sponsored by Friends of the Gile Flowage (FOG) and conducted by White Water Associates with assistance by volunteer lake stewards. This project was undertaken because the aquatic invasive species (AIS) known as spiny water flea (*Bythotrephes longimanus)* was discovered in Stormy Lake. Since Stormy Lake was a primary subject of this project, SLA is the recipient of this adaptive management plan.

Project participants have embraced the concept of "adaptive management" in their approach to Stormy 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 Stormy Lake and the SLA. 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 Stormy Lake plan that future monitoring will focus on tangible indicators.

It is appropriate that SLA 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 SLA is a healthy, sustainable Stormy 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 *Stormy 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 Stormy Lake and its environs by providing summaries of information in nine subsections. Chapter 6 (*What Goals Guide the Plan?*) presents the desired future condition and goals established by the Stormy Lake 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 Stormy Lake and its surroundings. Six Appendices complete this document. Appendix A contains literature cited. Appendix B contains the *Stormy Aquatic Plant Management Plan*. Appendix C presents the *Stormy Lake Review of Water Quality*. Appendix D includes the *Stormy Lake WDNR Fisheries Summary*. Appendix E consists of the *Review of Water Regulations and Planning Relevant to Stormy Lake*. Finally, Appendix F is the *Stormy Lake Spiny Water Flea Plan*.

CHAPTER 2

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

The title of Chapter 3 poses the question: “Why Have the *Stormy 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 Stormy 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 Stormy Lake and its surroundings. People who care are also those who live beyond the watershed boundaries. Some of these people visit Stormy 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 keen with respect to this plan since Stormy Lake is a source lake for spiny water fleas. 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 Stormy Lake and other regional waters. It lays the groundwork for how to “get along” with a spiny water flea infested lake. 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 SLA and the FOG have interacted with the plan writers throughout the process and reviewed draft components of the plan. Both groups have 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 Stormy 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 Stormy Lake Adaptive Management Plan?

Why have the *Stormy 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 Stormy 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 Stormy 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 long-term economic health of the municipality is tied to the health of Stormy Lake and other lakes and streams in the area. At even larger scales yet, this applies to Vilas County, to the State of Wisconsin, and so on.

The Stormy Lake Association 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 SLA and this plan endeavor to harness that energy and apply it to restoration and protection actions focused on Stormy 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 Stormy Lake landscape in some way. Because we feel a civic responsibility to care for the lake. Because we realize Stormy 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 Stormy Lake ecosystem for them to enjoy and use.

The adaptive management plan will be successful if it allows and organizes meaningful stewardship work for Stormy 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 *Stormy 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 Stormy Lake and its surroundings are quite pristine, part of the Stormy 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, etc.
- 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 structure 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 Stormy Lake biology in science curriculum of area schools. Every person that visits Stormy 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 Stormy Lake years ago with basic water quality measures and are ongoing today. More recently, research on aquatic plants and spiny water fleas have contributed to our understanding of the Stormy 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 SLA, recreationists that use Stormy Lake, Vilas County Land and Water Conservation Department, and the Wisconsin Department of Natural Resources are among these stakeholders.

The Vilas County Land and Water 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 in during subsequent phases of Stormy Lake stewardship.

The integrating feature of this lake management plan is Stormy 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 Stormy Lake Management Plan Made?

The Stormy Lake project is part of a larger program that includes another water body in northern Wisconsin (the Gile Flowage) and a very large lake in the Upper Peninsula of Michigan (Lake Gogebic). A grant from the Wisconsin Department of Natural Resources (WDNR) funded the Wisconsin lakes component of the program. Other sources funded the Lake Gogebic component. Stormy Lake, the Gile Flowage, and Lake Gogebic all have populations of the spiny water flea. This small aquatic crustacean was the impetus for the larger project. The project included a three prong approach to spiny water fleas in Stormy Lake and the Stormy Lake Watershed. This approach is encompassed by three project categories and associated goals:

1. ***Education and Response*** – Deliver an education and response program that serves to increase lake users' knowledge of the biology and transport of AIS (with particular focus on spiny water fleas) and reduces the opportunity for spiny water flea (and other AIS) to invade new bodies of water.
2. ***Research*** – Design and conduct a graduate level research program that endeavors to answer practical, management-oriented questions on the presence, requirements, distribution, and management of Northwoods populations of spiny water fleas, (this component is being conducted by a University of Wisconsin, Center for Limnology, graduate student with separate funding from the WDNR).
3. ***Planning*** – Develop an adaptive lake management plan for Stormy Lake that integrates existing information about the lake and addresses AIS, including spiny water fleas.

This adaptive management plan is the product of the planning goal, although some of the spiny water flea research findings inform the planning effort. There are several objectives and associated tasks that support the planning goal. 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 SLA 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.

Watershed - Stormy Lake watershed analysis included delineating the Stormy Lake watershed area, mapping land cover/use and soils of the watershed; and digital elevation models. This information is discussed further in the *Stormy 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 *Vilas County Land & Water Resources Management Plan*, and various township zoning ordinances).

Aquatic Plants - A formal aquatic plant survey was conducted on Stormy Lake in 2012 by the WDNR using a point-intercept protocol. These data were obtained from the WDNR in electronic form for our analysis and summary in this plan. The data allowed for 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 allowed for 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 *Stormy 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 Stormy Lake. This involved interpreting and summarizing the Stormy 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. Because of the relative size of the APMP, it 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 Stormy 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 Stormy Lake, (2) analyze and summarize existing Stormy Lake water quality data, (3) assess the existing regimen of water quality sampling for Stormy Lake and determine appropriateness to lake conditions, and (4) revise (if need) the water quality sampling regimen for Stormy Lake as dictated by current information needs. Water quality data has been collected for Stormy Lake since 1989. These data are a useful starting point for adaptive lake management.

Fisheries - Another project objective was to gather and summarize information about Stormy Lake fisheries. This objective was fulfilled by reviewing WDNR fisheries reports. White Water biologists then summarized this information for inclusion in this adaptive management plan. Information about Stormy Lake's fishery can be viewed in Appendix D.

Wildlife – A study of wildlife was beyond the scope of the current study, however, some information about loons, eagles and other species and communities of concern is described in Chapter 5, Part 5 of this plan.

Spiny Water Flea - Another objective was to gather and integrate information on spiny water fleas as it pertains to Stormy Lake. In order to do this we collected and summarized existing information on the Stormy Lake spiny water flea population. Additionally, the spiny water flea information gathered by the graduate student researcher was useful in our preparation of the spiny water flea plan component of this adaptive plan. Finally, we reviewed scientific and resource management literature for information and techniques relevant to the *Stormy Lake Spiny Water Flea Plan*.

Spiny Water Flea Plan - This adaptive management plan includes the *Stormy Lake Spiny Water Flea Plan*. We prepared this plan with information obtained during the project (both original data and scientific literature). The purposes of the spiny water flea plan are to: (1) present ideas for reducing impacts of spiny water fleas in Stormy Lake; (2) monitor the Stormy Lake spiny water flea population; (3) track how spiny water fleas influence the Stormy Lake ecosystem, and (4) describe the method by which spiny water fleas can be contained in the Stormy Lake system. Preventing the spread of spiny water fleas will require a cooperative effort between many stakeholders. Like the APMP, the *Stormy Lake Spiny Water Flea Plan* is a fairly large document and is included as Appendix F in this adaptive management plan.

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, *Vilas County Land & Water Resources Management Plan*) and review these in the *Stormy Lake Adaptive Management Plan* where appropriate. We also reviewed federal, state, and local regulations and ordinances that serve to protect water quality.

Stormy Lake Attributes and Risks – Another objective was to prepare a catalog of Stormy 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 FOG and other Stormy 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 Stormy Lake attributes.

Educational Outreach - A planning objective was to support the educational program efforts where related to Stormy Lake spiny water flea and other management elements. Toward this end, White Water staff will be available for phone consultation with members of the SLA and other stakeholders. We endeavored to increase support, capacity, and involvement of the SLA and other stakeholders in long-term stewardship of Stormy Lake through communication of project progress and findings. Finally, White Water staff attended public meetings that reported and discussed the Stormy Lake planning process and other project-related issues.

Adaptive Management Plan – A final project objective called for the creation of this initial adaptive management plan for Stormy 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 integrates the APMP and the *Stormy Lake Spiny Water Flea Plan* with other information about Stormy Lake and its watershed. This objective was guided by two basic tasks. The first task was to develop management recommendations for Stormy 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.

CHAPTER 5

What is the State of Stormy Lake and its Watershed?

An understanding of the features and conditions of Stormy 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 Stormy 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

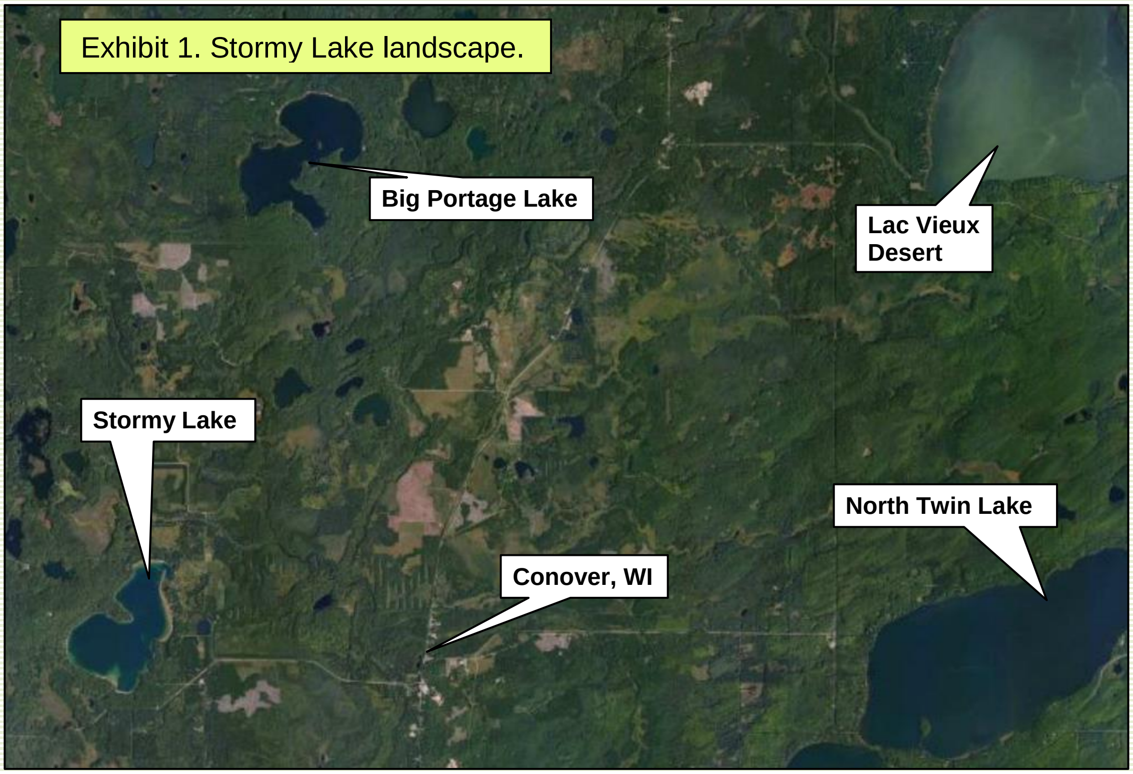
If you are new to Stormy Lake and its surroundings, this chapter will make you familiar with features and conditions that exist here and provide some insight as to why things are the way they are. If you are a life-long resident of Stormy Lake area, you may be familiar with parts of the discussion in 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 nine parts, each part reflecting the following topics: the lake and surroundings; aquatic plants; water quality; fisheries; wildlife; non-native species; regional plans, special attributes, and threats. Various appendices are referenced from the text.

Part 1. Stormy Lake and the Surrounding Area

Stormy Lake is located in Vilas County, Wisconsin about 3 miles west of the town of Conover, and 9 miles south of the Wisconsin-Michigan 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. Stormy Lake has value and function in this larger landscape as well as its own watershed.

Stormy Lake has 5.1 miles of shoreline and 523 acres surface area. There is no State of Wisconsin ownership on the lake. One improved boat ramp allows public access. The lake is fairly developed with permanent homes and cottages, although areas of more natural riparian area also exist. Exhibit 1 shows the Stormy Lake area and identifies major landmarks.



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 Stormy Lake. Over the years, no particular aquatic plant nuisance issues have demanded control action. A point-intercept aquatic plant survey was conducted by WDNR biologists on Stormy Lake in 2012. Twenty species were observed. Stormy Lake's aquatic plant community was highly diverse and had high floristic quality. These findings support the contention that the Stormy Lake plant community is healthy and diverse. The 2012 aquatic plant survey is more thoroughly discussed in the *Stormy Lake Aquatic Plant Management Plan*, followed by tables and figures.

Part 3. Stormy Lake Water Quality

Stormy Lake is listed as an "outstanding resource water (ORW)" (State of Wisconsin Legislature). An ORW is a body of water that provides outstanding recreational opportunities, supports valuable fisheries and wildlife habitat, has good water quality, and is not significantly impacted by human activities. It does not typically have any point sources discharging pollutants directly into the water, though it may receive runoff from nonpoint sources. In addition, new discharges may be permitted only if their effluent quality is equal to or better than the background water quality of that waterway at all times—no increases of pollutant levels are allowed (WDNR, 2013). Stormy Lake has a max depth of 63 feet and has a complex bathymetry (Exhibit 2).

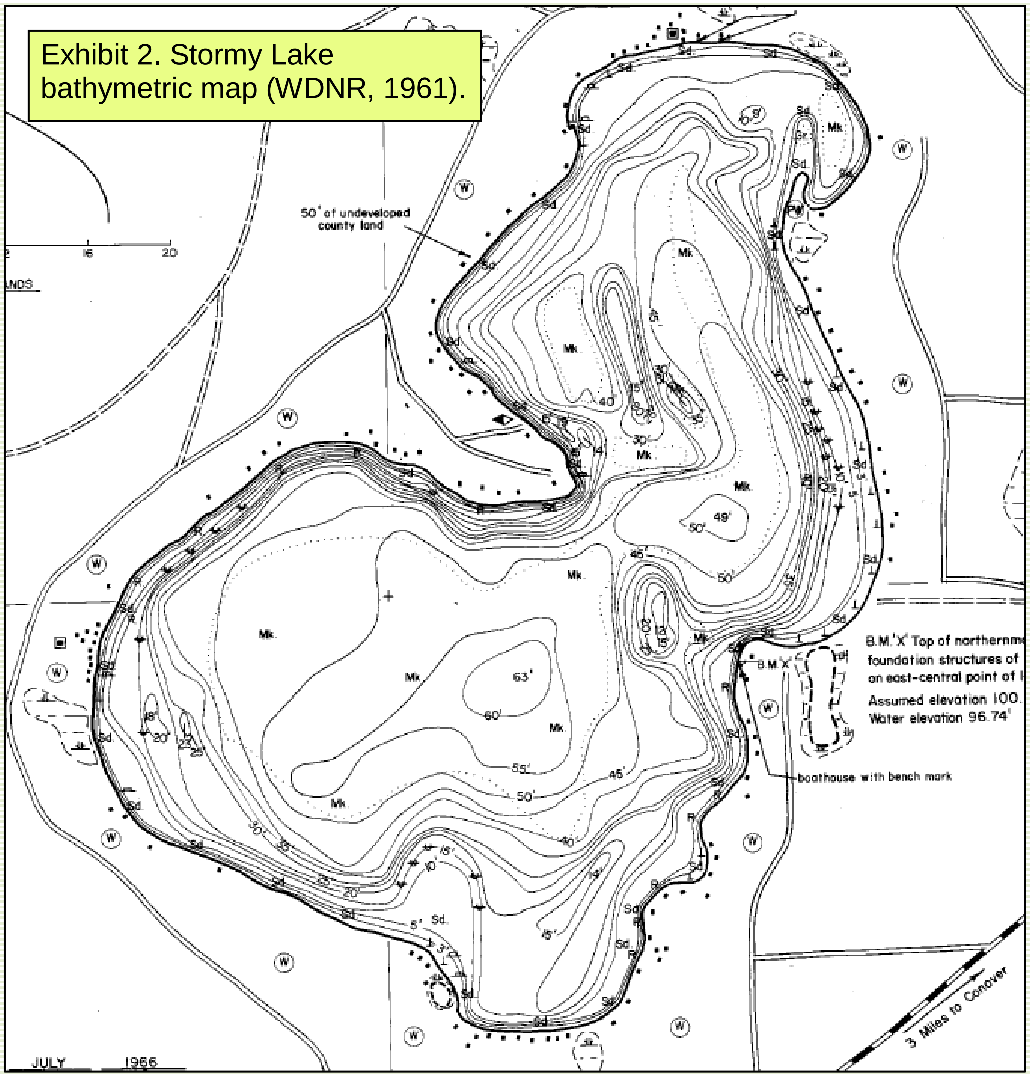


Exhibit 2. Stormy Lake bathymetric map (WDNR, 1961).

Existing water quality data has been collected by the Citizen Lake Monitoring Network (CLMN) on Stormy Lake in 1989 and from 1993 to present. White Water Associates also collected water quality data in 2012. Stormy Lake water quality data can be obtained from the WDNR SWIMS database. Water quality information is briefly summarized in this section, but more fully interpreted in Appendix C.

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).

Temperature and dissolved oxygen showed stratification in Stormy Lake in the ice-free season. Water clarity is very good and user perception of Stormy Lake aesthetic quality is generally regarded as high. Water color is very 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 amount of algae) is very low. Nitrogen, hardness, sodium, and potassium levels are considered low. Alkalinity (a measure of a lakes buffering capacity against acid rain) was moderately low. The pH of Stormy Lake is relatively neutral.

Part 4. Stormy Lake Fisheries

Stormy Lake has had extensive efforts of fish stocking since the 1970s. Over 200,000 rainbow trout, almost 800,000 brown trout, nearly 25,000 brook trout and about 15,000 Coho salmon have been stocked in

Stormy Lake since 1976 (WDNR, 2015b). Presently, brown trout are the only fish still stocked in Stormy Lake. Fish species present include: smallmouth bass, largemouth bass, brown trout, yellow perch, crappies, bluegills, sunfish and northern pike. For information about the Stormy Lake fishery, view Appendix D, *Stormy Lake Fisheries Summary.*

Part 5. Stormy Lake Wildlife

A study of wildlife was beyond the scope of the current study, but would be valuable to study and interpret in future iterations of the plan. Eagle and loon studies have been conducted by the Wisconsin Department of Natural Resources and by volunteers as part of programs such as LoonWatch. Rare species and communities have also been identified by the WDNR.

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, 2015). 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., 2015). 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, 2015). No information was available for loon nests and territories near Stormy Lake.

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, 2014a). Bald eagles live near water and eat small animals, carrion, and 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). In 2014, there were 1,279 known bald eagle nest territories occupied by breeding adults (NHI, 2014). This was a decrease of 65 pairs from 2013 (NHI, 2014). Stormy Lake, located in Vilas County, has 2 known nests with one pair of breeding eagles (Ron Eckstein, email). 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."

Other rare species and communities live and are near Stormy 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 Stormy Lake.

Exhibit 4. Rare Species and Communities located near Stormy Lake.

Common Name	*Scientific Name*	*State Status*[1]	*Group Name*
Spruce grouse	*Falcipennis canadensis*	THR	Bird
Trumpeter swan	*Cygnus buccinators*	SC/M	Bird
Open bog			Community
Spring pond			Community
Algal-like pondweed	*Potamogeton confervoides*	THR	Plant
Northeastern bladderwort	*Utricularia resupinata*	SC	Plant
Robbins' Spikerush	*Eleocharis robbinsii*	SC	Plant

Part 6. Stormy Lake Aquatic Invasive Species

In the past several years, three AIS have been recorded in Stormy Lake: rusty crayfish (*Orconectes rusticus*) discovered in 2001, Chinese mystery snails (*Cipangopaludina chinensis*) discovered in 2012, and spiny water fleas (*Bythotrephes longimanus*) discovered in 2007.

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 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, 2015a). It is also illegal to release crayfish into a water body without a permit (WDNR, 2015a).

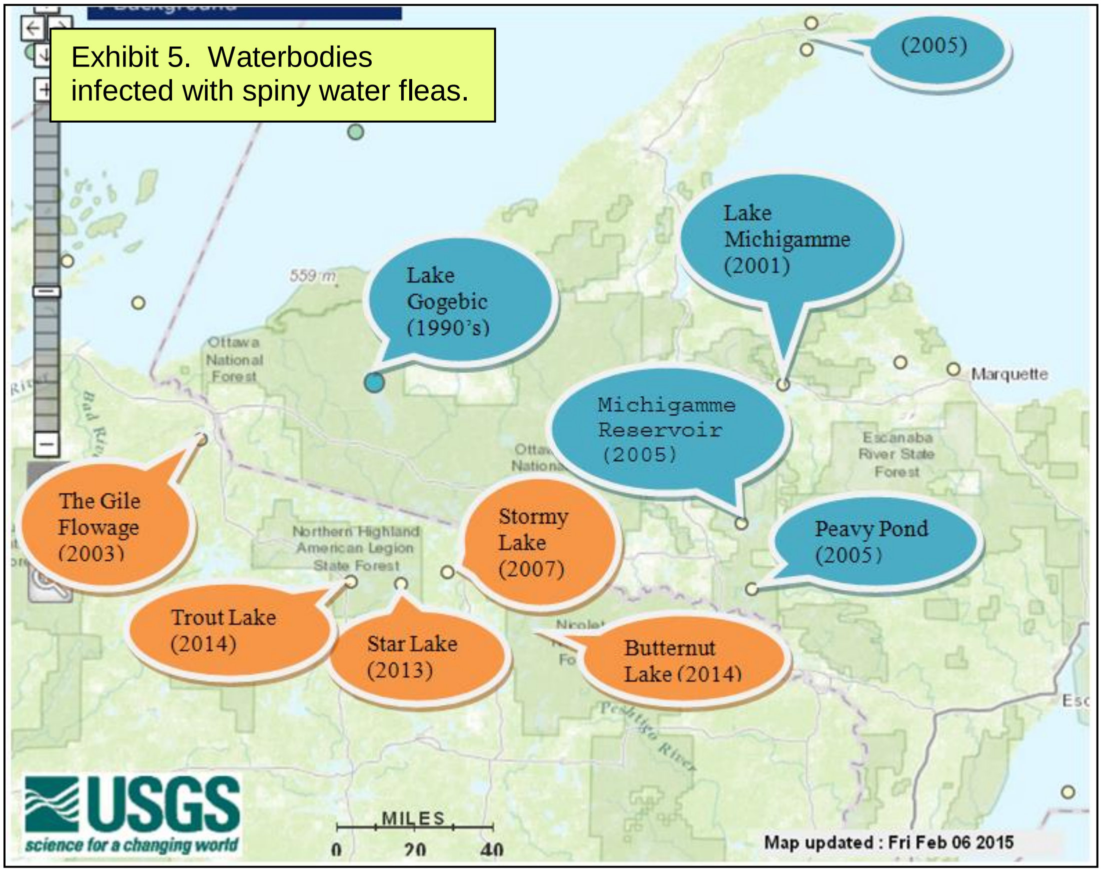
[1] **END**=Endangered; **THR**=Threatened; **SC**=Special Concern; **SC/P**=fully protected; **SC/N**=no laws regulating use, possession or harvesting; **SC/H**=take regulated by establishment of open/closed seasons; **SC/FL**=federally protected as endangered or threatened, but not so designated by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

Chinese mystery snail is originally from Southeast Asia and Eastern Russia and was likely released to the Great Lakes from an aquarium between 1931 and 1942 (Kipp et al., 2015). The snail does not seem to have a significant impact on native species, but its ecological and human threat comes from its potential to transmit parasites and diseases (Kipp et al., 2015). It is illegal to introduce the Chinese mystery snail into Wisconsin waters.

Spiny water fleas are native to northern Europe and Asia and were likely introduced from ship ballast water (Liebig et al., 2015). Spiny water fleas can reproduce asexually as well as sexually, allowing for larger populations (Liebig et al., 2015). Possible impacts of spiny water fleas include: changes in zooplankton community structure and competition with small fish for food sources (Liebig et al., 2015).

When this project began in 2012, there were only two lakes in northern Wisconsin with recorded spiny water flea populations (Stormy Lake and Gile Flowage). Recently, additional spiny water flea locations have been documented (Star Lake, Vilas County, 2013, Trout Lake, Vilas County, 2014, and Butternut Lake, Forest County, 2014) (Exhibit 5). For more information about spiny water fleas in Stormy Lake, see Appendix F (*Stormy Lake Spiny Water Flea Plan*).

Exhibit 5. Waterbodies infected with spiny water fleas.



Part 7. Water Resource Regulations and Planning Relevant to Stormy 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 E contains our documentation of these reviews and provides substantive information on (1) federal, state, and county regulations and ordinances that influence water quality, and (2) a review of the *Vilas County Land & Water Resource Management Plan* (Vilas County Land Conservation Department, 2009). 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 Vilas County ordinances.

Part 8. Stormy Lake Area Special Attributes

One of the objectives of the Stormy Lake Aquatic Invasive Species Control Grant was to prepare a description of Stormy 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. What 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."

Part 9. Environmental Threats to Stormy Lake

As outlined in the previous part, the Stormy Lake watershed ecosystem has numerous attributes of high ecological and aesthetic significance. These attributes combine to help make Stormy Lake a unique and special place. Stormy Lake and its surroundings, however, are subject to environmental threats from a variety of sources. We outline some of these threats in this part of the Stormy Lake plan.

Recreational pressure – Stormy Lake is a well-known and much-loved fishing and water recreation lake for people from near and far. 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 spiny water fleas from Stormy Lake.

Development pressure – Stormy Lake has some areas of residential development as well as areas with predominantly natural vegetation and broad and diverse riparian areas. In some areas of the lake, old-style lawns, cropped short and in close proximity to the shore indicate a need for some 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 Stormy Lake is affected by all inputs of water (groundwater, precipitation, and overland runoff). All of these sources have potential to carry pollutants of various kinds to Stormy Lake. Stormy Lake has outstanding water quality and a long record of water quality monitoring. Non-point source pollution (see next paragraph) remains an important threat to Stormy Lake water quality.

Non-point source pollution – Surface runoff from the land, roadways, parking lots and other surfaces flows into Stormy Lake. This runoff carries with it sediment, nutrients (for example, from fertilizers) and contaminants (for example, herbicides) that can have detrimental effects on the Stormy 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 spiny water fleas in Stormy Lake is worthy of such concern. The threat remains for other AIS introductions as well. Appropriate and consistent sanitation of all recreational equipment prior to introducing it to the lake, is a critical behavior to establish in all recreationists to avoid introductions of AIS (plants and animals). When it comes to non-native aquatic plant invaders, a critical second line of defense is a healthy community of native plants. A diverse native plant community presently exists in Stormy Lake. 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 Stormy 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 Stormy 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 Stormy 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.

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CHAPTER 6

What Goals Guide the Stormy 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 *Stormy Lake Adaptive Management Plan* is to perpetuate the quality of Stormy 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 *Stormy 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 identified specific areas in the Stormy 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 Stormy 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 Stormy 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 *Stormy 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 two specific plans (*Aquatic Plant Management Plan* and *Stormy Lake Spiny Water Flea Plan*), each with its own set of objectives and actions.

CHAPTER 7

What Objectives and Actions Move Us Toward Our Goals?

The Stormy Lake watershed is healthy, diverse, and productive. Our challenge through this adaptive management plan is to perpetuate that condition into the future. The challenge will be met by a capable set of program partners that are prepared to devote themselves to Stormy Lake stewardship. These partners include the members of the Stormy Lake Association, the Vilas County Land and Water Conservation Department, the ecological scientists of White Water Associates, Inc., the WDNR, and others.

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 Stormy 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 Stormy Lake 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, grant monies, and other factors.

Recommended Actions for the Stormy Lake Adaptive Management Plan

Action #1 (Education): Work with WDNR to understand and manage the Stormy Lake fishery.

Objective: To support scientific and effective restoration of a quality Stormy 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 #2 (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 Stormy Lake and outline how such introductions can be minimized.

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

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

Status: Action included in *Adaptive Management Plan*. This can begin in 2015.

Action #3 (Education): Provide educational material at the boat landing that emphasizes the threat of carrying spiny water fleas from Stormy 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 Stormy Lake. SLA should document that updated educational material is maintained.

Status: Action included in *Adaptive Management Plan*. This can begin in 2015.

Action #4 (Research): Conduct periodic assessments of Stormy Lake for aquatic invasive animals.

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 to begin in 2016.

Recommended Actions for the Stormy Lake Adaptive Management Plan

Action #5 (Research): Conduct periodic assessments of Stormy Lake for aquatic invasive plants.

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 #6 (Education): Establish an award or recognition of riparian owners that preserve or rehabilitate “natural shoreline” habitat on their property. This could be recognized in SLA 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 Stormy Lake.

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

Status: Action included in *Adaptive Management Plan*. Ongoing practice to begin in 2016.

Action #7 (Education): Create periodic updates of the adaptive management plan.

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

Outcome: Up-to-date management plan is available for ongoing implementation and stewardship of Stormy Lake.

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

Recommended Actions for the Stormy Lake Adaptive Management Plan
Action #8 (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 Stormy Lake, and reduce opportunities for introduction of aquatic invasive plant species. ***Outcome:*** A healthy, diverse Stormy 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 2015.
Action #9 (Education): Conduct a formal lake users' survey. ***Objective:*** To gather information about Stormy Lake users' knowledge base, concerns, and goals for Stormy Lake. The formal survey would also serve as an educational vehicle to inform lake users about SLA, the *Adaptive Management Plan*, the *Aquatic Plant Management Plan*, and the *Spiny Water Flea Plan*. ***Outcome:*** A knowledgeable population of Stormy Lake users and a better informed SLA that can apply new information and tools to Stormy Lake management. ***Status:*** Action included in *Adaptive Management Plan*. Planned for a future phase.
Action #10 (Restoration): Work with WDNR to implement "Fish Sticks" habitat. ***Objective:*** To restore missing habitat elements. ***Outcome:*** Improved habitat for aquatic animals (including fish). ***Status:*** Action included in the *Adaptive Management Plan*. The association oversees activity.

Future phases of Stormy Lake stewardship will build on the foundation established in this *Adaptive Management Plan*. Additional aspects of the Stormy Lake watershed ecosystem will be explored. Future phases will likely include revisions to the lake management plan, the aquatic plant management plan, and the spiny water flea plan.

Stormy Lake and its watershed serve its 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.

Appendix A
Literature Cited

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Appendix B
Stormy Lake Aquatic Plant Management Plan

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An Integrated Education, Planning, and Research Approach to Spiny Water Flea Populations in Northern Lakes:

Aquatic Plant Management Plan – Stormy Lake

Prepared for:
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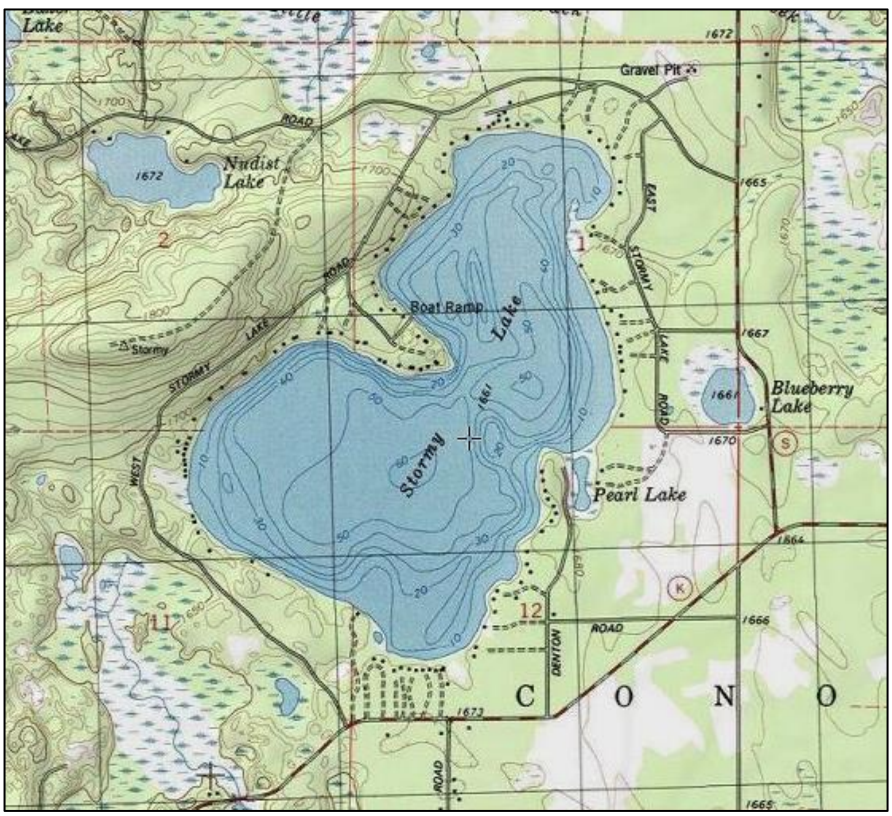

Date: April 2016

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WHITE WATER ASSOCIATES, INC.

An Integrated Education, Planning, and Research Approach to Spiny Water Flea Populations in Northern Lakes:

Aquatic Plant Management Plan – Stormy Lake

This plan is a product of a WDNR Aquatic Invasive Species Control Grant AEPP-363-12 (Subchapter II – Education, Prevention, and Planning Projects) awarded to:

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CHAPTER 1 Introduction

This *Stormy Lake Aquatic Plant Management* (APM) Plan results from the broader efforts undertaken on under the project entitled ***An Integrated Education, Planning, and Research Approach to Spiny Water Flea Populations in Northern Lakes***. In this project, an integrated adaptive approach is used to understand three ecosystems (Stormy Lake, Gile Flowage and Lake Gogebic) that share a common feature: the presence of spiny water fleas (*Bythotrephes longimanus*). Each of these lakes has an active lake association that is involved with the overall project. A broadly-based adaptive lake management plan will be written for each lake. This Stormy Lake APM Plan is part of ***The Stormy Lake Adaptive Management Plan*** (Premo et al., 2015). The Wisconsin component of the project (including Stormy Lake and Gile Flowage) was funded by a Wisconsin Department of Natural Resources (WDNR) Aquatic Invasive Species Control Grant Proposal (Subchapter II – Education, Prevention, and Planning Projects). The project sponsor is the Friends of the Gile Flowage (FOG).

A principal partner in the spiny water flea project is the Stormy Lake Association (SLA). The SLA has committed to lake stewardship by way of an integrated adaptive management plan. This *APM Plan* is a component of the *Stormy Lake Adaptive Management Plan*. After review and approval of the management plan, the SLA will formally adopt the plan. The SLA 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 Stormy Lake. 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 Wisconsin Department of Natural Resources (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 the preparation of the 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.

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 modified as new information becomes available. The WDNR guidance document outlines three objectives that may influence preparation of an aquatic plant management plan. Currently, the motivation for this plan lies in the first two objectives:

- ***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.

Stormy Lake is a high quality resource with good water quality and a diverse and interesting community of aquatic plants. It also has a recreational history and current human use that has caused only moderate degradation to the ecosystem. Stormy Lake, however, does have 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 spiny water flea.

During the course of this project and through earlier efforts, the SLA and consultant White Water Associates, Inc. (White Water) have followed the first five steps in the seven-step plan outlined in the guidance document[1] for developing an aquatic plant management plan:

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;

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

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 Stormy Lake, and Appendix 3 contains the *Review of Stormy Lake Water Quality*.

CHAPTER 2

Study Area

Stormy Lake is in Vilas County, Wisconsin about 8.5 miles southwest of Land O'Lakes, Wisconsin which is on the Wisconsin-Michigan border. The water body identification code (WBIC) is 1020300. Other lakes and streams are in this landscape. Exhibit 1 is an aerial view of the Stormy Lake landscape showing a few of the other water features. This water landscape is a target for migrating and breeding waterfowl and other birds. Stormy Lake has value and function in this larger landscape as well as its own watershed.

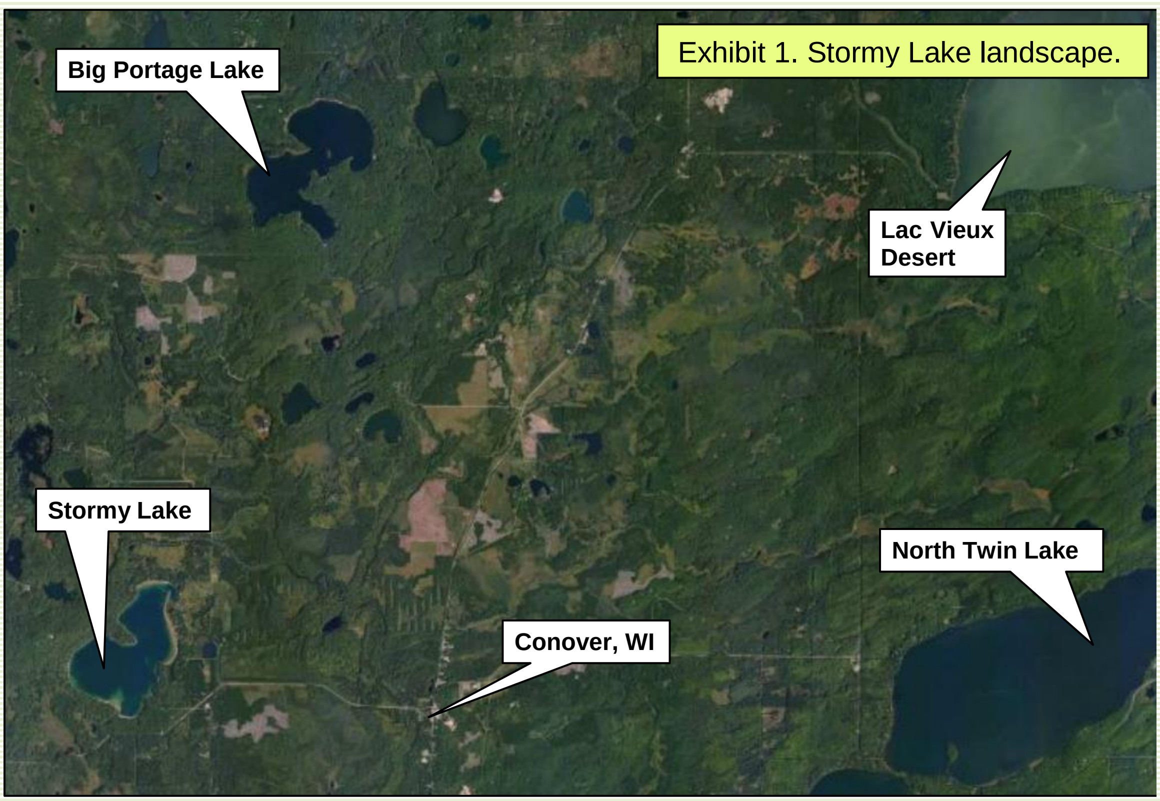

Exhibit 1. Stormy Lake landscape.

Stormy Lake has a 5.13 mile shoreline and 523 acres surface area. One improved boat ramp allow for public access. The lake is fairly developed with permanent homes and cottages, although areas of more natural riparian area also exist. Stormy Lake has been listed as an "outstanding resource water (ORW)" (State of Wisconsin Legislature). Stormy Lake is classified as oligotrophic, and has a complex bathymetry (Exhibit 2).

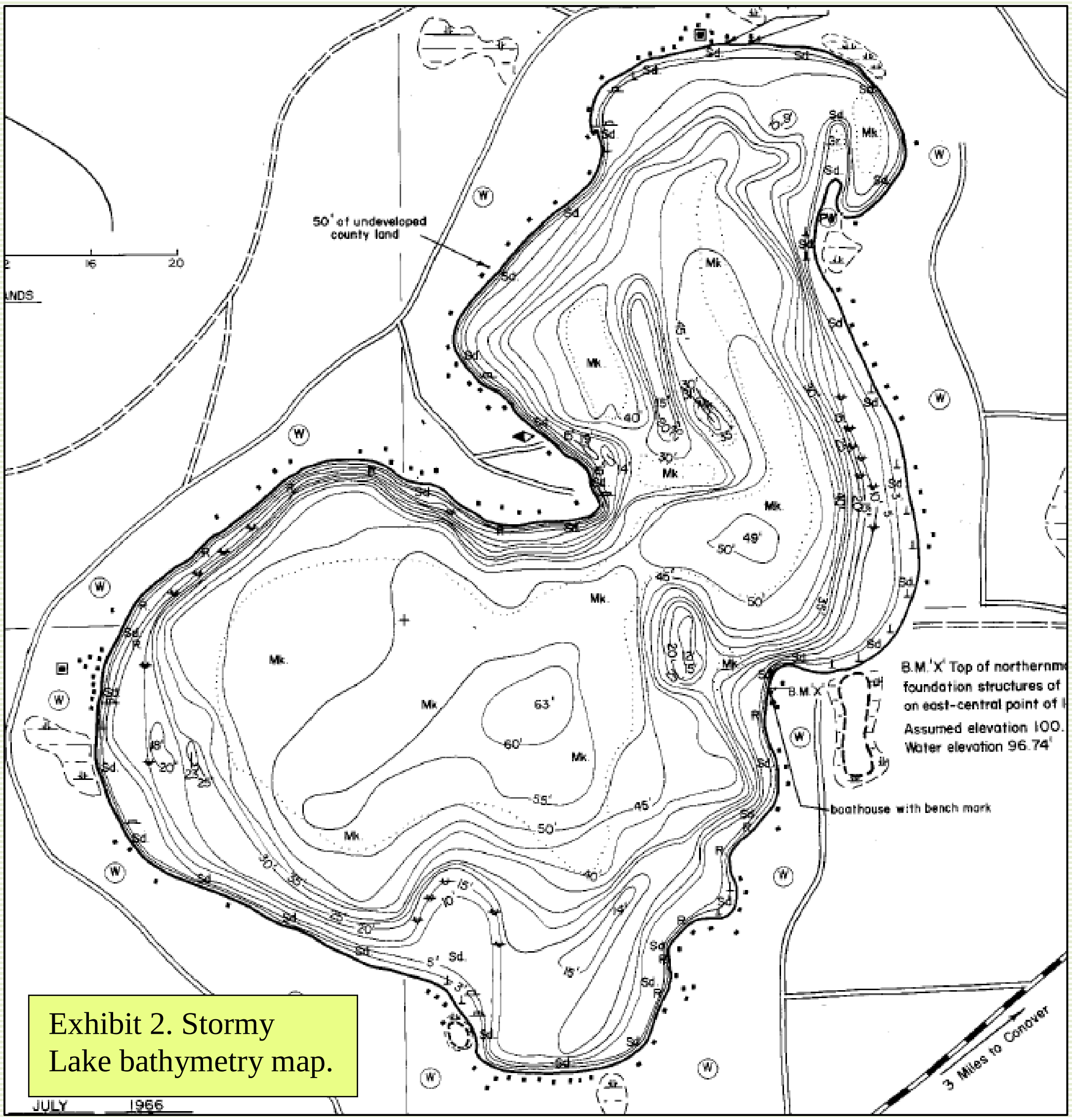

Exhibit 2. Stormy Lake bathymetry map.

Descriptive water body parameters for Stormy Lake are in Exhibit 3. It is a seepage lake of about 523 acres and maximum depth of 63 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	Stormy Lake
County	Vilas
Township/Range/Section	T41N-R9E-S1, 2, 11, 12
Water Body Identification Code	1020300
Lake Type	Seepage
Surface Area (acres)	523
Maximum Depth (feet)	63
Maximum Length (miles)	1.3
Maximum Width (miles)	1.0
Shoreline Length (miles)	5.13
Shoreline Development Index	1.6
Total Number of Piers (2009 aerial)	89
Number of Piers / Mile of Shoreline	17.3
Total Number of Homes (2009 aerial)	114
Number of Homes / Mile of Shoreline	22.2

We observed a total of 89 piers on the shoreline of Stormy Lake from a 2009 aerial photograph, or about 17.3 piers per mile of shoreline. The riparian area consists of both upland and wetland areas (Exhibit 4).

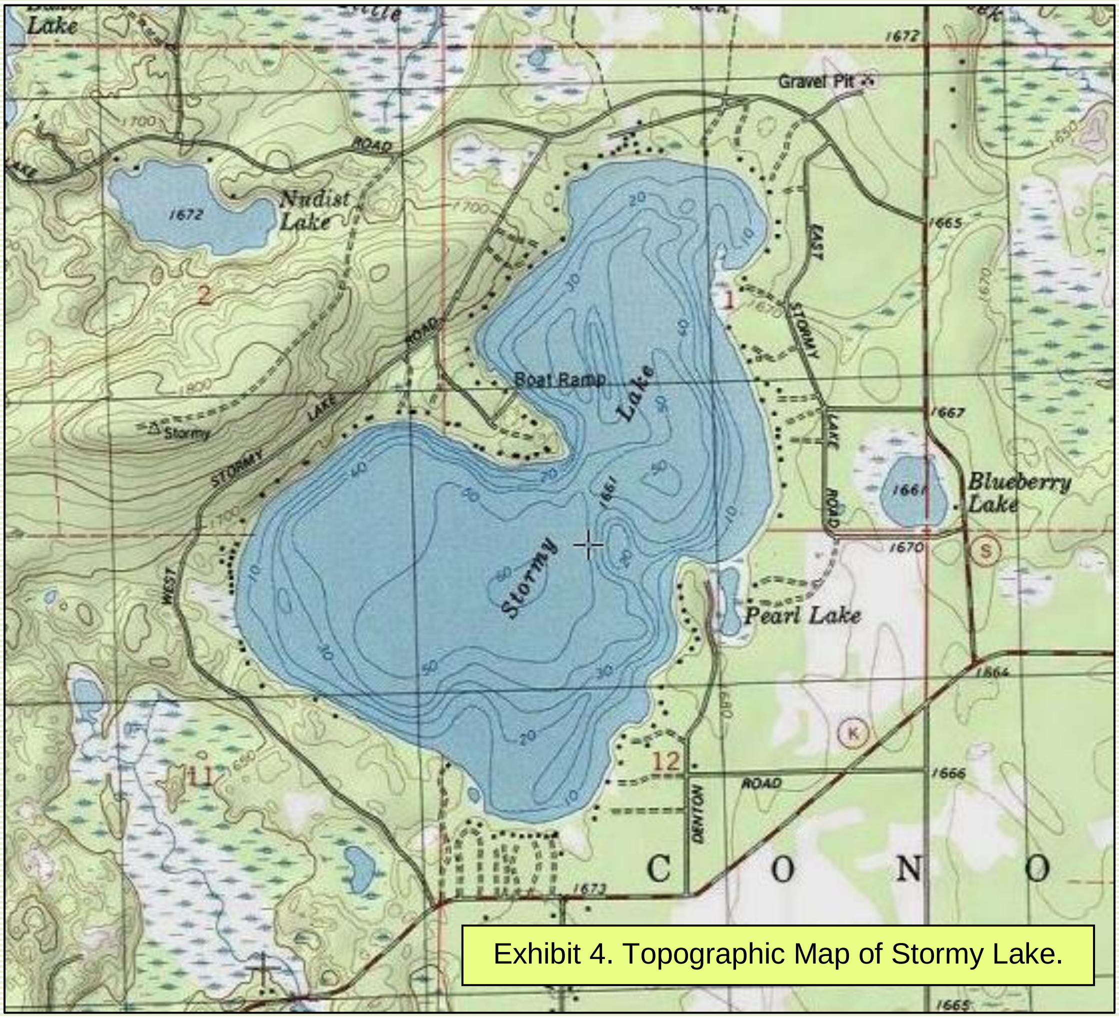

Exhibit 4. Topographic Map of Stormy Lake.

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:

> ***Stormy Lake has a native 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 *Stormy 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 Stormy Lake stewards.

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WHITE WATER ASSOCIATES, INC.

CHAPTER 4

Information and Analysis

Our efforts in this project have compiled information about historical and current conditions of the Stormy Lake ecosystem and its surrounding watershed. Of particular importance to this *Stormy Lake 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

Stormy 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. Stormy Lake is located in the Upper Mississippi watershed region (Exhibit 5). The Upper Mississippi region is also made up of many sub-regions. The Wisconsin sub-region (more specifically the Wisconsin River sub-region) (HUC#070700) is where Stormy Lake is found. The Wisconsin River sub-region includes the Upper Wisconsin watershed, where Stormy Lake is located (Exhibit 6). The Upper Wisconsin watershed (HUC#07070001) (Exhibit 7) covers parts of Vilas (including Stormy Lake), Forest, Langlade, Lincoln, Oneida, Price, and Taylor counties in Wisconsin, and parts of Gogebic, and Iron County in Michigan. Exhibit 8 displays the Buckatabon Creek, the sub-watershed where Stormy Lake is located (HUC#070700010306). Exhibit 9 displays the watershed boundary specific to Stormy Lake, which eventually flows into all the watersheds listed above.

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

Exhibit 6. Wisconsin River sub-regional watershed. The Upper Wisconsin sub-basin is also visible (USEPA, 2009).

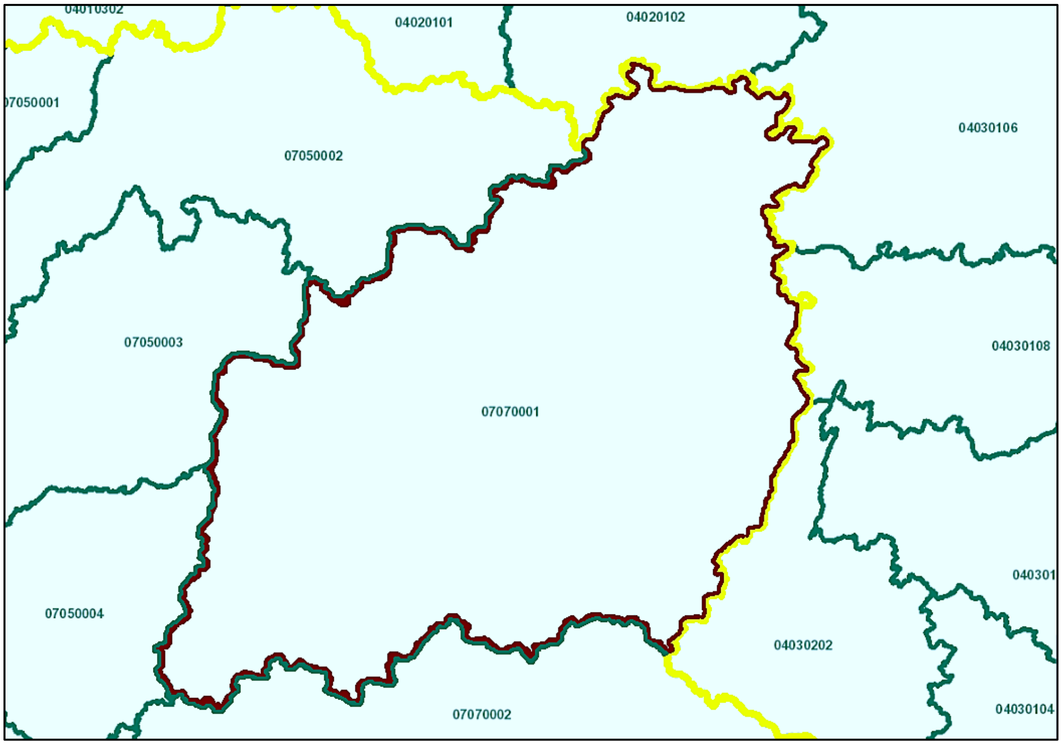

Exhibit 7. Upper Wisconsin watershed (red) lies on the border of the Upper Mississippi Region (numbers starting with 07) and the Great Lakes Region (number starting with 04) (WDNR, 2013).

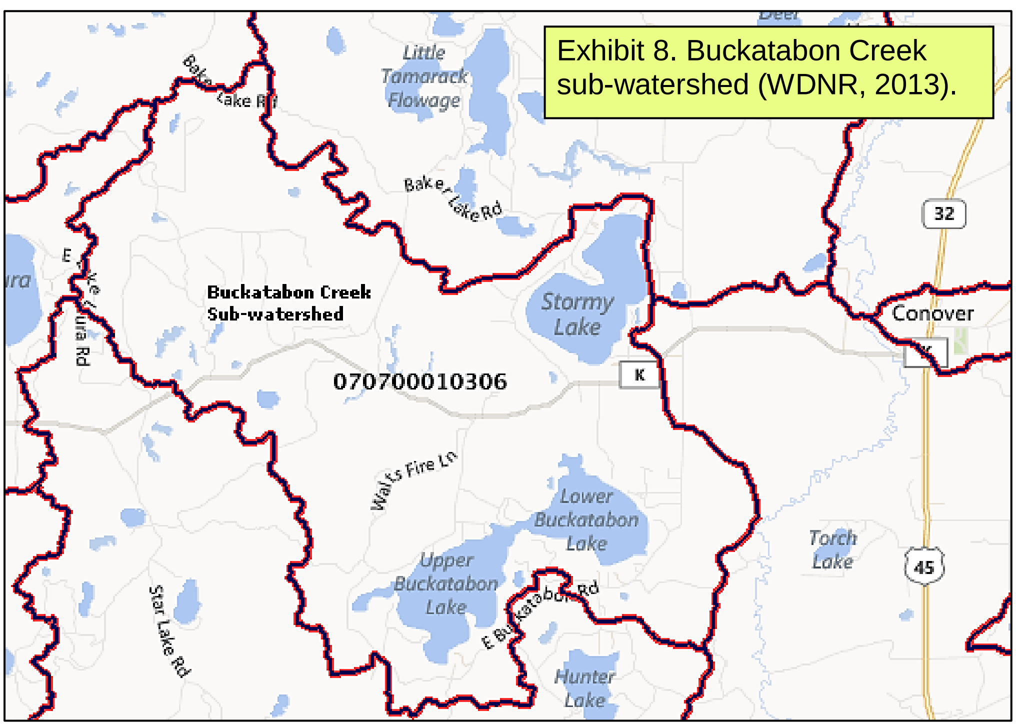

Exhibit 8. Buckatabon Creek sub-watershed (WDNR, 2013).

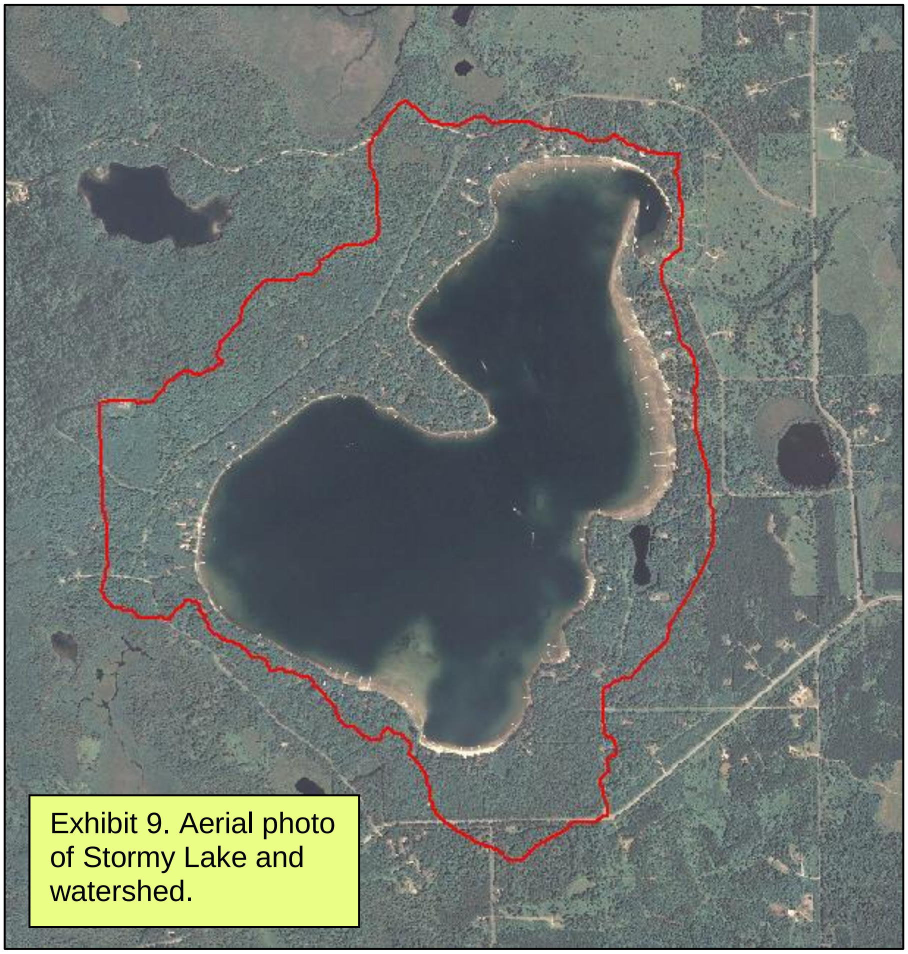

Exhibit 9. Aerial photo of Stormy Lake and watershed.

The elevation of the Stormy Lake watershed ranges from around 1,629 to 1,825 feet above sea level. A digital elevation model, shown in Exhibit 10, displays the relative elevations for the Stormy Lake watershed. Orange and red areas show the highest elevations, and greens and blues are the lowest elevations.

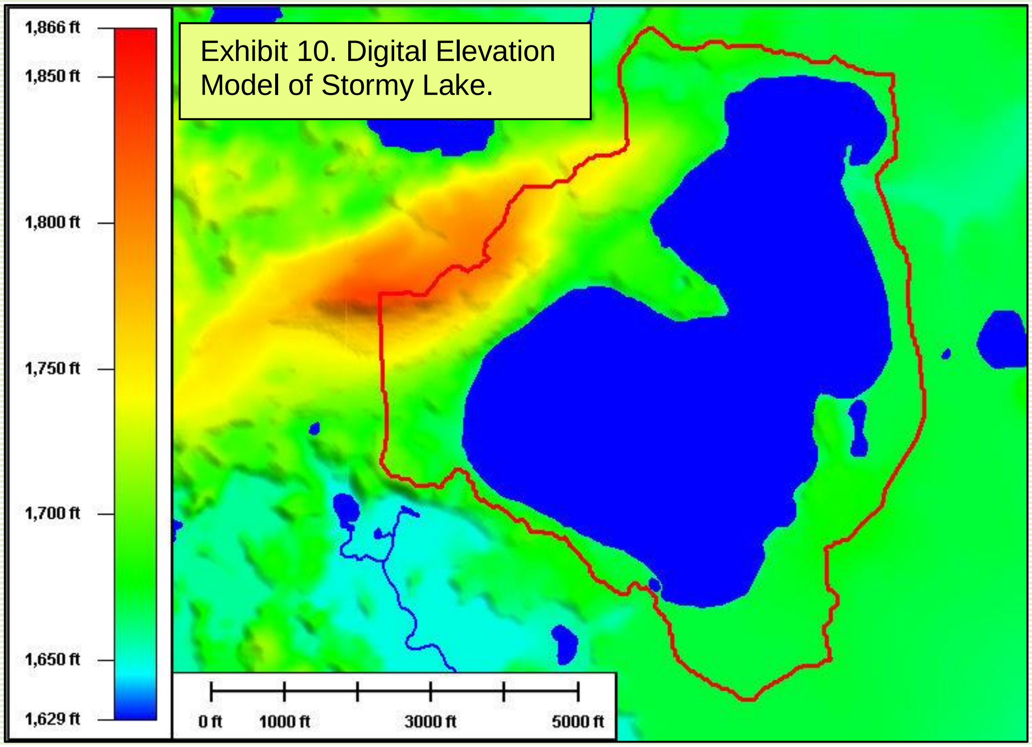

Exhibit 10. Digital Elevation Model of Stormy Lake.

The watershed (seepage 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 Stormy Lake watershed is about 972 acres. Forest and surface water comprise the largest components. Soil groups A, B, and D are present in the Stormy Lake watershed (Exhibit 11). Soil group D represents about 59% of the watershed, soil group A makes up around 41%, and soil group B makes up a very small 0.1%. Soil group A has the highest infiltration capacity, and the lowest runoff potential. Conversely, soil group D has the lowest infiltration capacity, and the highest runoff potential. The watershed to lake area ratio is 2:1. Water quality often decreases with an increasing ratio of watershed area to lake area because there are more sources and amounts of runoff. 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 Stormy Lake Watershed.

Cover Type	Acres	Percent
Agriculture	0.0	0.0
Commercial	0.0	0.0
Forest	274.0	28.2
Grass/Pasture	0.0	0.0
High-density Residential	0.0	0.0
Low-density Residential	74.9	7.7
Water	623.2	64.1
Industrial	0.0	0.0
Total	972.2	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	402.1	41.4	**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	1.3	0.1	**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	0.0	0.0	**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	568.8	58.5	**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

As far as we can determine, no systematic or large-scale plant management activity has ever taken place in Stormy Lake. Over the years, no particular aquatic plant nuisance issues have required control action. In 2012, WDNR conducted an aquatic plant survey on Stormy Lake. White Water Associates scientists have analyzed the 2012 data set for this APM Plan. Findings from the 2012 aquatic plant survey are discussed in the next section (Part 3).

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 or conversion to an agricultural field. 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.

The WDNR conducted a point-intercept aquatic plant survey on Stormy Lake in summer, 2012. This formal survey assessed 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, field staff navigated to the points and used a rake mounted on a pole or rope to sample plants. These were identified, recorded, and put into a dedicated spreadsheet for storage and data analysis. This systematic survey provides baseline data about the lake. Future monitoring will be able to identify and track changes in the plant community. 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 remainder of this section (Part 3) we report the findings of the point-intercept aquatic plant survey. The supporting tables and figures for the aquatic plant survey are provided in Appendix B.

Species richness refers to the total number of species. In the Stormy Lake survey, twenty aquatic plant species were recorded. Of these, 13 were collected at sampling sites and the others were observed from the boat. Table 1 displays summary statistics for the survey. Table 2 provides a list of the species encountered, including common and scientific name along with summarizing statistics.[2] The number of species encountered at any given sample point ranged from 0 to 4. Sixty-nine sample points were found to have aquatic vegetation present. The average number of species encountered at these vegetated sites was 1.38. 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 density). The plant densities (considering all species) are displayed for each sampling site on Figure 2.

The maximum depth of plant colonization was 40 feet (Table 1 and Figure 3). It is not surprising to find nitella at 40 feet deep in clear, oligotrophic lakes. Rooted vegetation was found at 69 of the 266 sample sites with depth ≤ the maximum depth of plant colonization (25.9% 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

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[2] *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)."*

substrate often harbors more plants than hard substrate). Sand substrate was frequently encountered on Stormy Lake. This is not a good medium for aquatic plant growth and may explain why many areas with appropriate depth lacked aquatic vegetation. 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. 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 variable pondweed (*Potamogeton gramineus*) 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 8-20.

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 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 Stormy Lake is 0.87 (Table 1) which indicates a highly 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 species a *coefficient of conservatism* representing the probability that a species 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 Stormy Lake FQI (27.2) compares to other lakes and regions. The statewide medians for number of species and FQI are 13 and 22.2, respectively. Stormy Lake values are comparable 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. Stormy 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. Stormy Lake data is consistent with that find. Finally, the Stormy Lake FQI (22.7) is near the median value for the Northern Lakes and Forests lakes group (24.3). This analysis means that the Stormy Lake plant community has a typical number of plant species that are sensitive to disturbance. The plant community appears to be in a healthy condition.

We observed no aquatic plants in Stormy Lake that would be considered a nuisance-level population density/distribution. Our survey found no aquatic invasive plant species. We found no state or federally listed species.

Part 4. Fish Community

Wisconsin Department of Natural Resources fisheries data for Stormy Lake is reviewed in Appendix X of the *Stormy Lake Adaptive Management Plan*. The WDNR Lake Pages website (http://dnr.wi.gov/lakes/lakepages/) indicates that the bottom of Stormy Lake is comprised of 90% sand, 5% gravel, 5% rock, and 0% muck.

Part 5. Water Quality and Trophic Status

Stormy Lake is a 523 acre seepage lake with a maximum depth of 63 feet. Stormy Lake has been listed as an “outstanding resource water (ORW)” (State of Wisconsin Legislature). Existing water quality data has been collected by the Citizen Lake Monitoring Network (CLMN) on Stormy Lake in 1989, and from 1993 to present. White Water Associates also collected water quality data in 2012. Stormy Lake water quality data can be obtained from the WDNR SWIMS database. Stormy Lake water quality information is briefly summarized in this section, but more fully interpreted in Appendix 3.

Temperature and dissolved oxygen showed stratification in Stormy Lake in the ice-free season. Water clarity is very good and user perception of Stormy Lake aesthetic quality is generally regarded as high. Water color is very low. The trophic state is oligotrophic. Water quality would be classified as very good with respect to phosphorus concentrations. Chlorophyll *a* (a measure of the amount of algae), nitrogen, hardness, sodium, potassium, and alkalinity (a measure of a lakes buffering capacity against acid rain) are considered low. The pH of Stormy Lake is near neutral.

Part 6. Water Use

Stormy Lake has one public access site and is used by riparian owners and their guests for a variety of recreational activities. There is no State of Wisconsin ownership on the lake.

Part 7. Riparian Area

Part 1 (Watershed) describes the larger riparian area context of Stormy Lake. The near shore riparian area can be appreciated by viewing Exhibit 4. The lake is developed, but has a fairly intact forested riparian zone that extends for hundreds of feet back from the lake. The forest is a mixture of coniferous and deciduous trees and shrubs. Our review of 2009 aerial photography reveals 114 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 can contribute important habitat elements to the lake, although inspection of aerial photography indicates that there is a paucity of this large woody material around the shallow water margin of 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. These data can be viewed in the *Stormy Lake Adaptive Management Plan.* Also of special importance would be monitoring for aquatic invasive animal species not presently found in Stormy Lake (zebra mussels, rainbow smelt, or common carp) and to monitor existing populations of invasive animal species (spiny water flea, rusty crayfish and Chinese mystery snail).

Stormy Lake is currently designated as an *area of special natural resource interest* (ASNRI) (WDNR, 2012). A water body designated as an ASNRI can be any of the following: WDNR trout streams; Outstanding or Exceptional Resource Waters (ORW/ERW); waters or portions of waters inhabited by endangered, threatened, special concern species or unique ecological communities; wild rice waters; waters in ecologically significant coastal wetlands along Lake Michigan and Superior; or federal or state waters designated as wild or scenic rivers (WDNR, 2012). Stormy Lake is considered an ASNRI because it is an outstanding resource water.

Part 9. Stakeholders

At this juncture in the ongoing aquatic plant management planning process, members of the SLA have represented the Stormy 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.

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 Stormy Lake is a healthy ecosystem with regard to its aquatic plant community, we could simply recommend an alternative of "no action." In other words, Stormy 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 the SLA feel great responsibility to minimize the threats. In addition, the relatively new addition of spiny water fleas to the lake ecosystem may have repercussions to aquatic plants and 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).

At this time, we recommend no direct manipulation of plant populations in Stormy Lake. No aquatic invasive plant species are known to be present and no native plants exhibit nuisance population size or distribution.

Recommended Actions for the Stormy Lake APM Plan

Action #1: Formally adopt the *Stormy 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: The SLA oversees activity and maintains the plan.

Status: Planned for 2016.

Action #2: Monitor water quality.

Objective: Continue with collection and analysis of water quality parameters to detect trends. Expand monitoring to include parameters for which little information exists (see Appendix C for individual parameters).

Monitoring: The SLA and/or its consultant oversees activity and enters data into the SWIMS database.

Status: Ongoing.

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

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

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

Status: Ongoing.

Recommended Actions for the Stormy Lake APM Plan

Action #5: 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: The SLA coordinates this activity.

Status: Planned for 2016.

Action #6: Conduct quantitative plant surveys 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, and plant distribution and to check for the occurrence of non-native, invasive plant species and the presence of rare plants.

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

Status: Anticipated in 2018.

Action #7: 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: The SLA oversees and maintains data with assistance from a consultant as needed; copies to WDNR.

Status: Ongoing.

Action #8: 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: The SLA oversees activity and reports possible introductions of AIS.

Status: Anticipated to begin in 2017.

Recommended Actions for the Stormy Lake APM Plan
Action #9: 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 #10: Create an education plan for the property owners and other stakeholders that will address issues of healthy aquatic and riparian plant communities. ***Objective:*** To educate stakeholders about issues and topics that affect the lake's aquatic and riparian plant communities, including topics such as: (1) the importance of the aquatic plant community; (2) no or minimal 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 the aquatic plant community and lake health; (4) nutrient sources to the lake 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:*** The SLA oversees activity and assesses effectiveness. ***Status:*** Anticipated to begin in 2017.
Action #11: Monitor the lake watershed for purple loosestrife. ***Objective:*** Identify purple loosestrife populations before they reach large size. ***Monitoring:*** The SLA oversees activity. ***Status:*** Anticipated in 2016.

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 Stormy Lake. There is an increasing likelihood of accidental introduction of AIS through conveyance of life stages by boats, trailers, and other vectors. It is important for the SLA 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 evokes a sense of tragedy 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 12 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

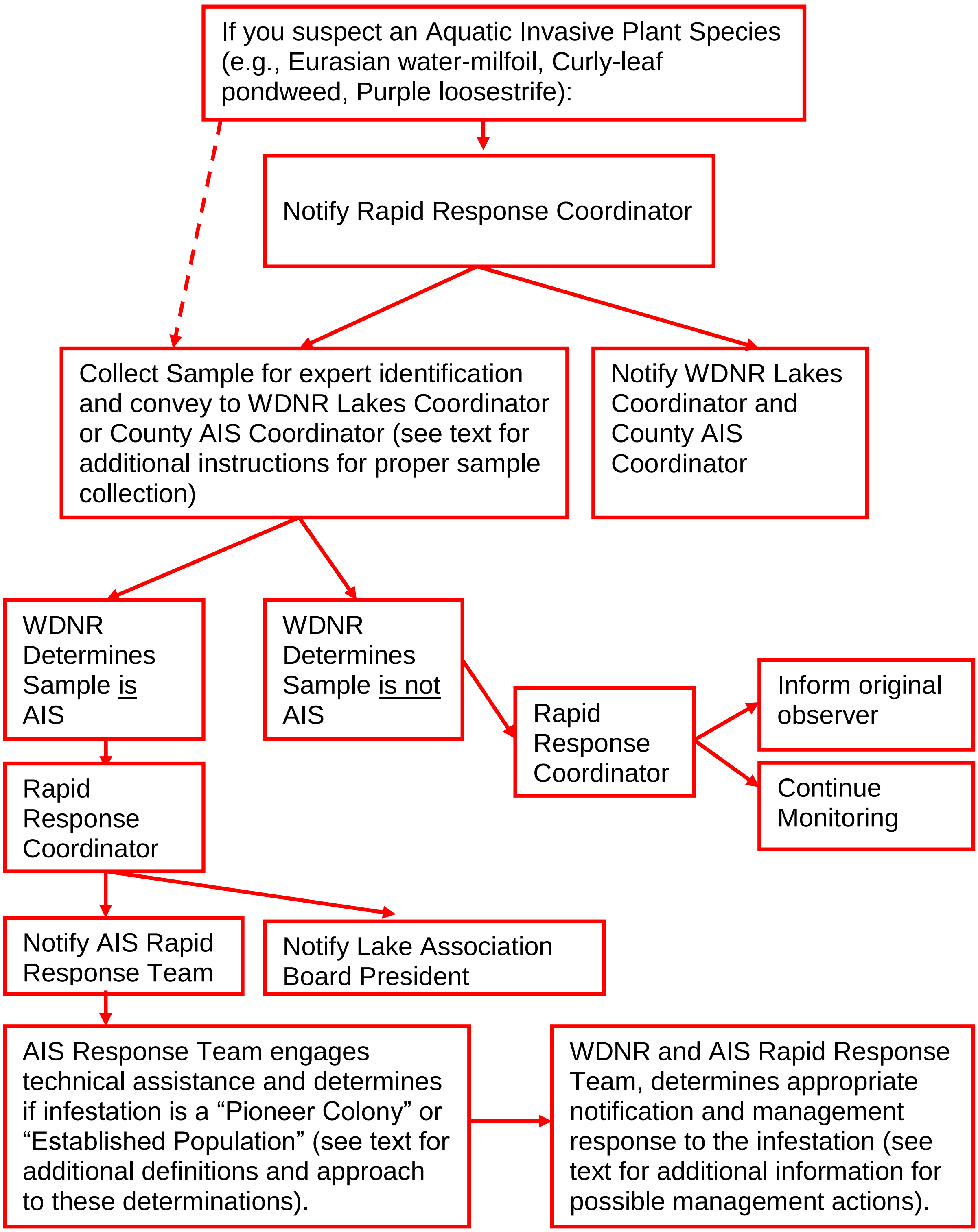
GPS is available). The sample should be placed on ice in a cooler or in a refrigerator. Deliver the sample to the WDNR Water Resource Management Specialist (Kevin Gauthier) or the County AIS Coordinator, Cathy Higley, as soon as possible (at least within three days). The WDNR or their botanical expert(s) 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" (Beall, 2005). If greater than five acres (or >5% of the lake surface area) then it is designated an "Established Population" (Beall, 2005). 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 Water Resource Specialist, 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 12. Aquatic Invasive Plant Species Rapid Response



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Appendix 1

Literature Cited

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WHITE WATER ASSOCIATES, INC.

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Appendix 2

Aquatic Plant Survey Tables and Figures

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Appendix 2

Aquatic Plant Survey Tables and Figures

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

Summary Statistic	Value	Notes
Total number of sites on grid	463	Total number of sites on the original grid (not necessarily visited)
Total number of sites visited	286	Total number of sites where the boat stopped, even if much too deep to have plants.
Total number of sites with vegetation	69	Total number of sites where at least one plant was found
Total number of sites shallower than maximum depth of plants	266	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	25.9	Number of times a species was seen divided by the total number of sites shallower than maximum depth of plants.
Simpson Diversity Index	0.87	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.)	40.0	The depth of the deepest site sampled at which vegetation was present.
Number of sites sampled with rake on rope	171	
Number of sites sampled with rake on pole	115	
Average number of all species per site (shallower than max depth)	0.36	
Average number of all species per site (vegetated sites only)	1.38	
Average number of native species per site (shallower than max depth)	0.36	Total number of species collected. Does not include visual sightings.
Average number of native species per site (vegetated sites only)	1.38	Total number of species collected including visual sightings.
Species Richness	13	
Species Richness (including visuals)	20	
Floristic Quality Index (FQI)	27.2	

Table 2. Plant species recorded and distribution statistics for the 2012 Stormy 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
Variable pondweed	*Potamogeton gramineus*	7.14	27.54	20.00	19	27	1.21
Nitella	*Nitella* sp.	6.39	24.64	17.89	17	17	1.41
Dwarf water-milfoil	*Myriophyllum tenellum*	4.89	18.84	13.68	13	15	1.15
Muskgrasses	*Chara* sp.	4.51	17.39	12.63	12	12	1.33
Brown-fruited rush	*Juncus pelocarpus* f. *submersus*	3.76	14.49	10.53	10	13	1.00
Slender naiad	*Najas flexilis*	3.76	14.49	10.53	10	12	1.00
Needle spikerush	*Eleocharis acicularis*	2.26	8.70	6.32	6	8	1.00
Wild celery	*Vallisneria americana*	1.13	4.35	3.16	3	4	1.00
Water lobelia	*Lobelia dortmanna*	0.38	1.45	1.05	1	3	1.00
Ribbon-leaf pondweed	*Potamogeton epihydrus*	0.38	1.45	1.05	1	1	1.00
Small pondweed	*Potamogeton pusillus*	0.38	1.45	1.05	1	1	1.00
Fern pondweed	*Potamogeton robbinsii*	0.38	1.45	1.05	1	1	2.00
Creeping spearwort	*Ranunculus flammula*	0.38	1.45	1.05	1	2	1.00
Creeping spikerush	*Eleocharis palustris*				Visual	6	
Soft rush	*Juncus effusus*				Visual	2	
Waterwort	*Elatine minima*				Visual	1	
Pipewort	*Eriocaulon aquaticum*				Visual	1	
Golden hedge-hyssop	*Gratiola aurea*				Visual	1	
Softstem bulrush	*Schoenoplectus acutus*				Visual	1	
Narrow-leaved bur-reed	*Sparganium angustifolium*				Visual	1	

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.

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

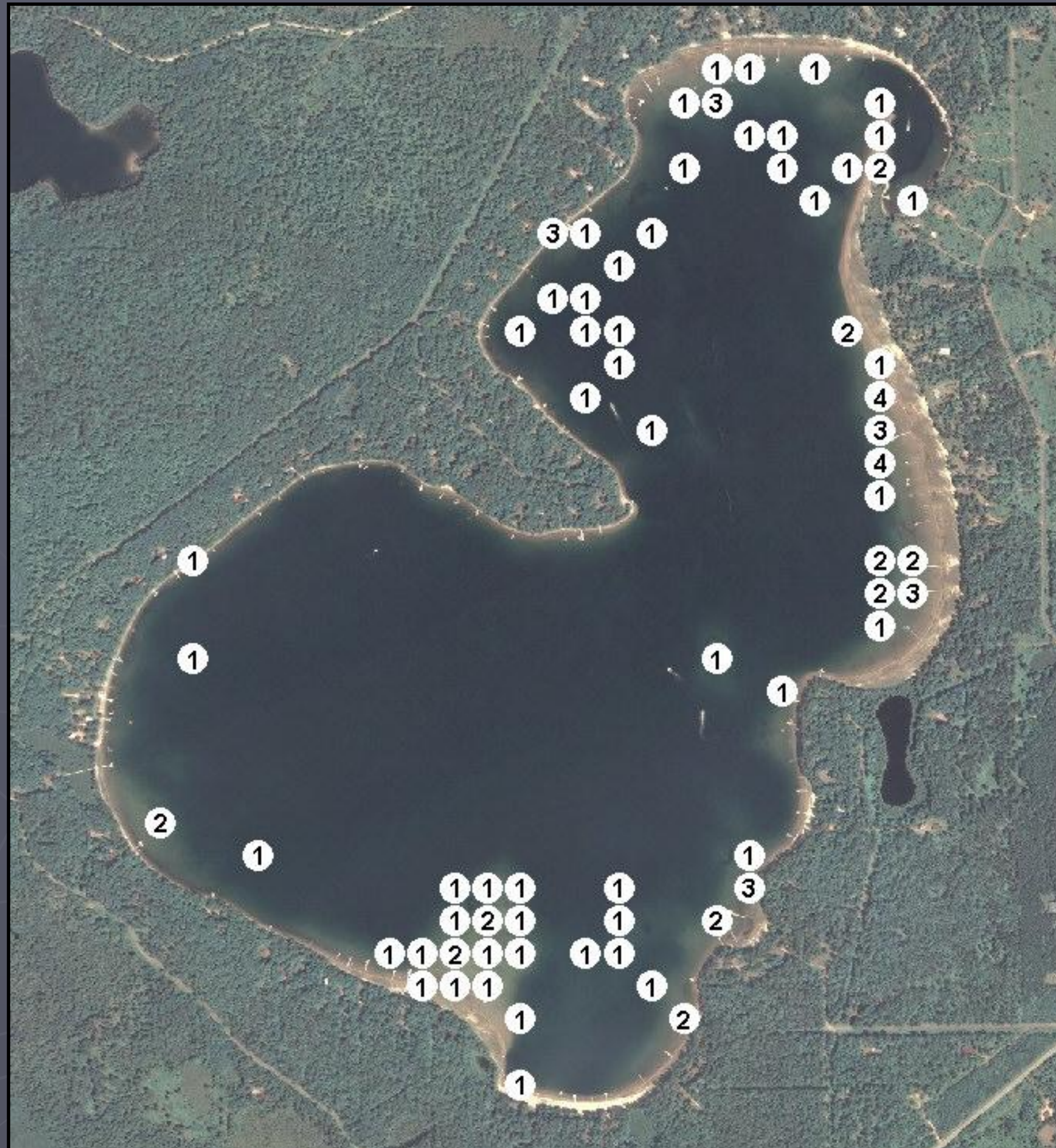
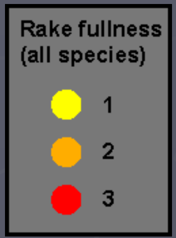
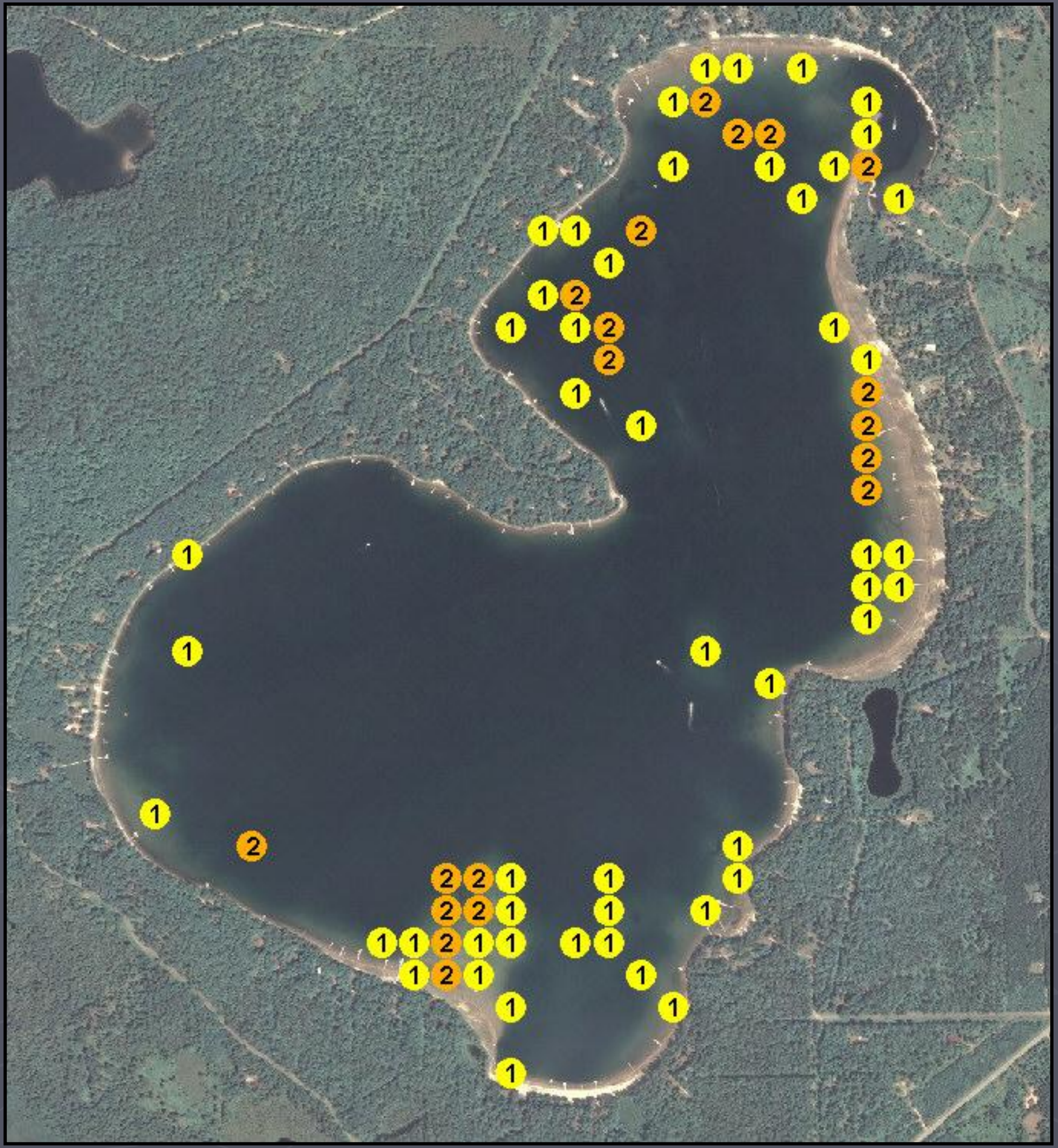


Figure 2. Rake fullness ratings for Stormy Lake sample sites (2012).





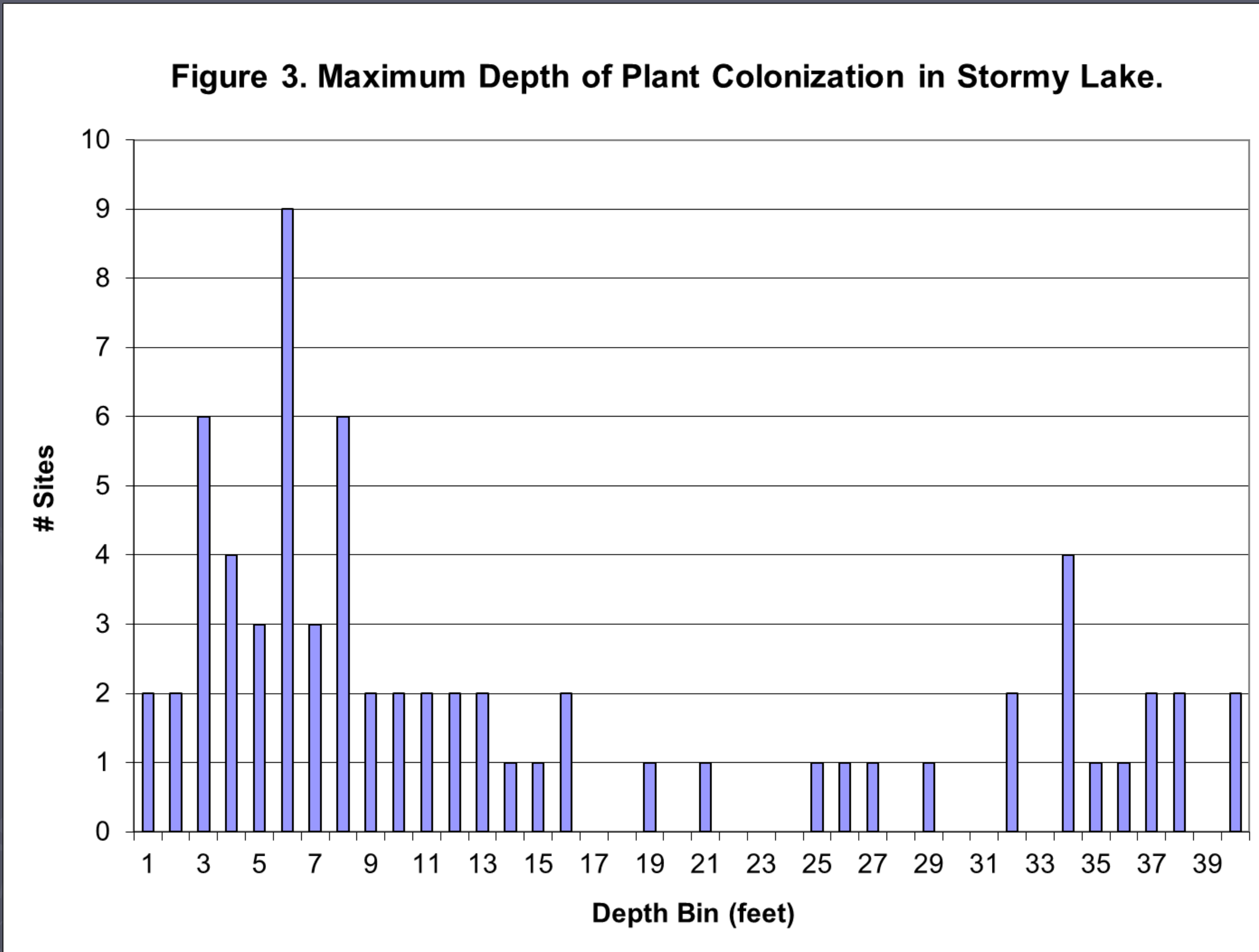


Figure 3. Maximum Depth of Plant Colonization in Stormy Lake.
Sites
Depth Bin (feet)
0
1
2
3
4
5
6
7
8
9
10
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
37
39

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

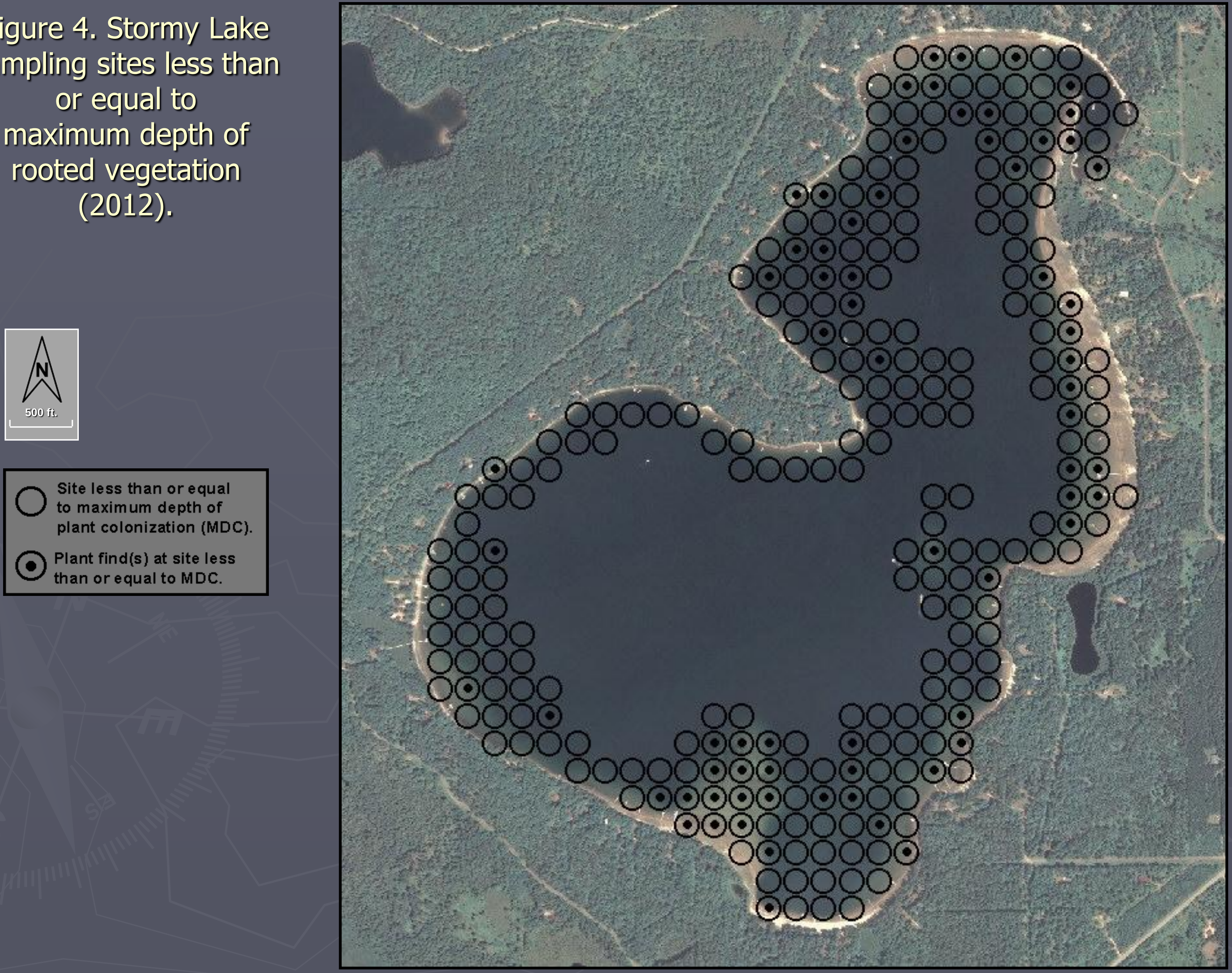


Figure 5. Stormy Lake substrate encountered at point-intercept plant sampling sites (2012).

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

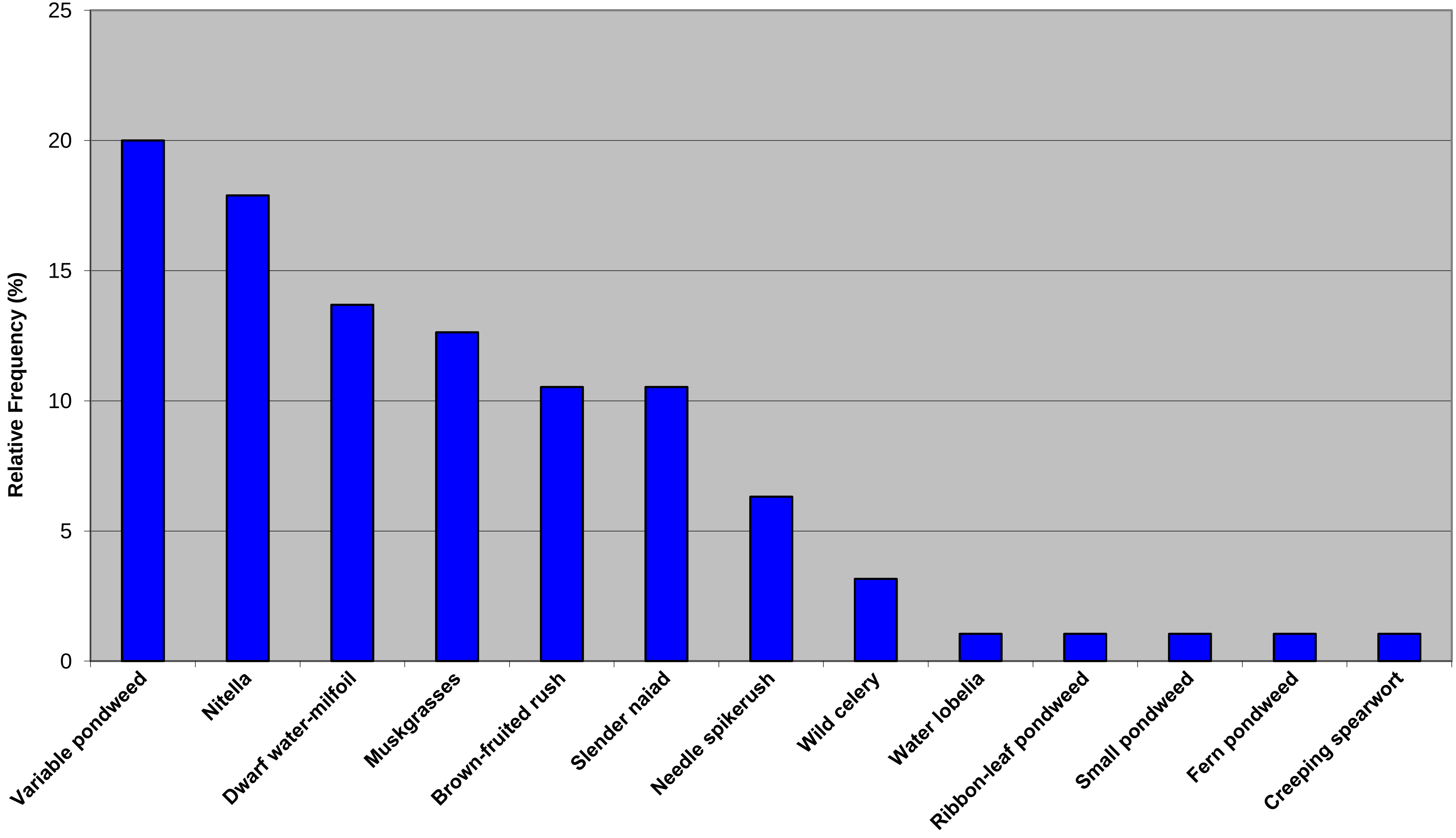


Figure 7. Stormy Lake point-intercept plant sampling sites with emergent and floating aquatic plants (2012).

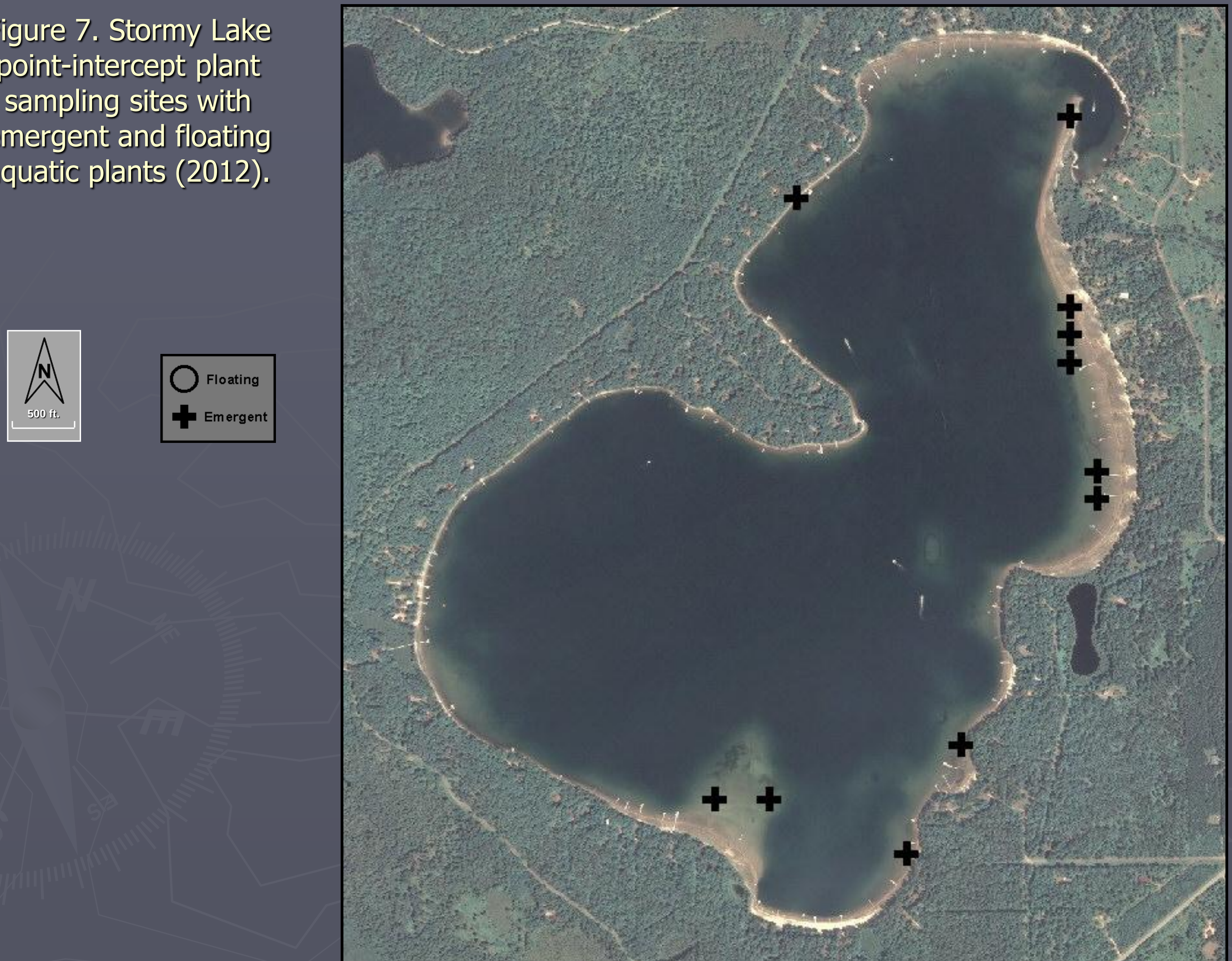


Figure 8. Distribution of plant species, Stormy Lake (2012).

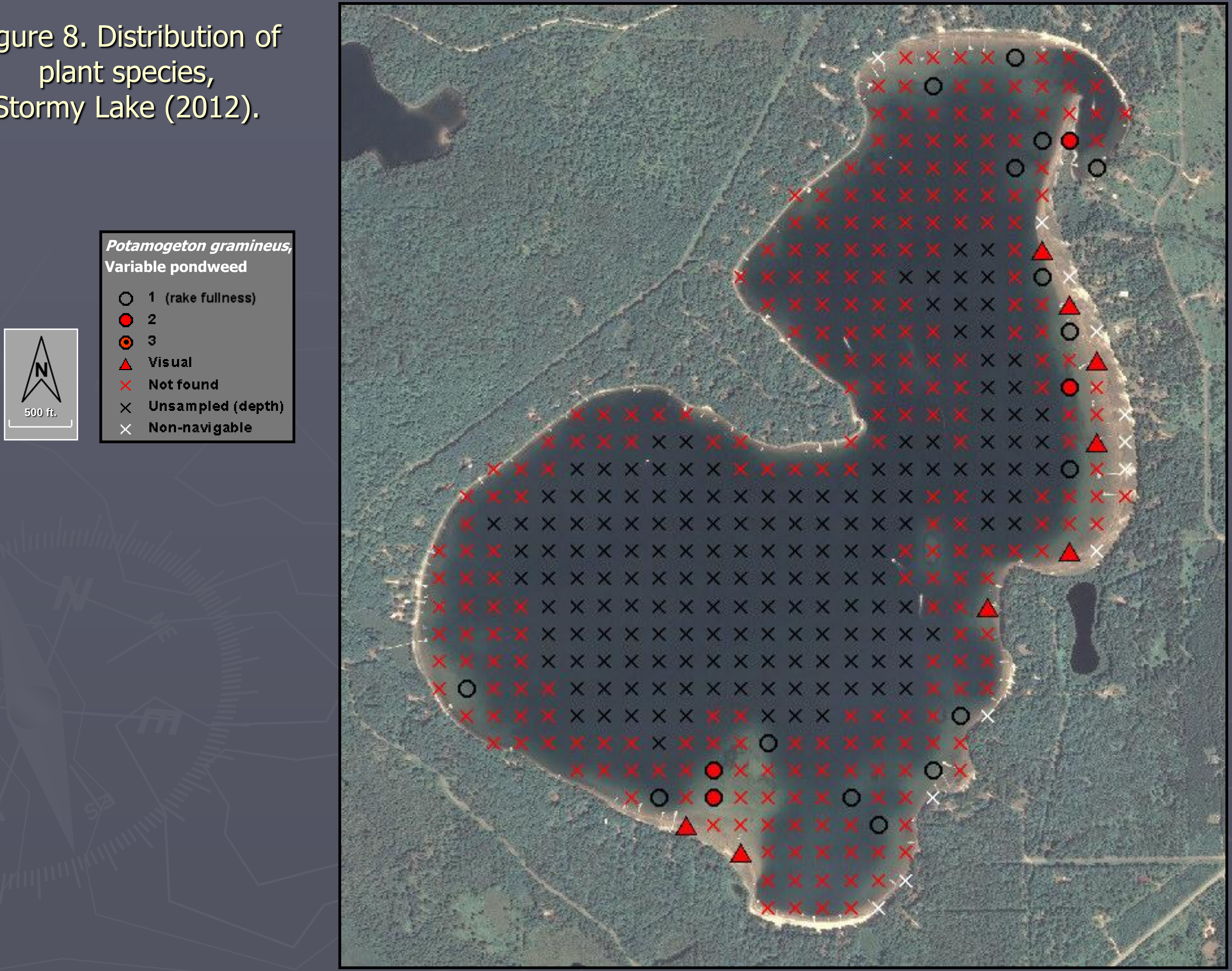


Figure 9. Distribution of plant species, Stormy Lake (2012).

Nitella sp.,
Nitella

- 1 (rake fullness)
- 2
- 3
- Visual
- Not found
- Unsampled (depth)
- Non-navigable

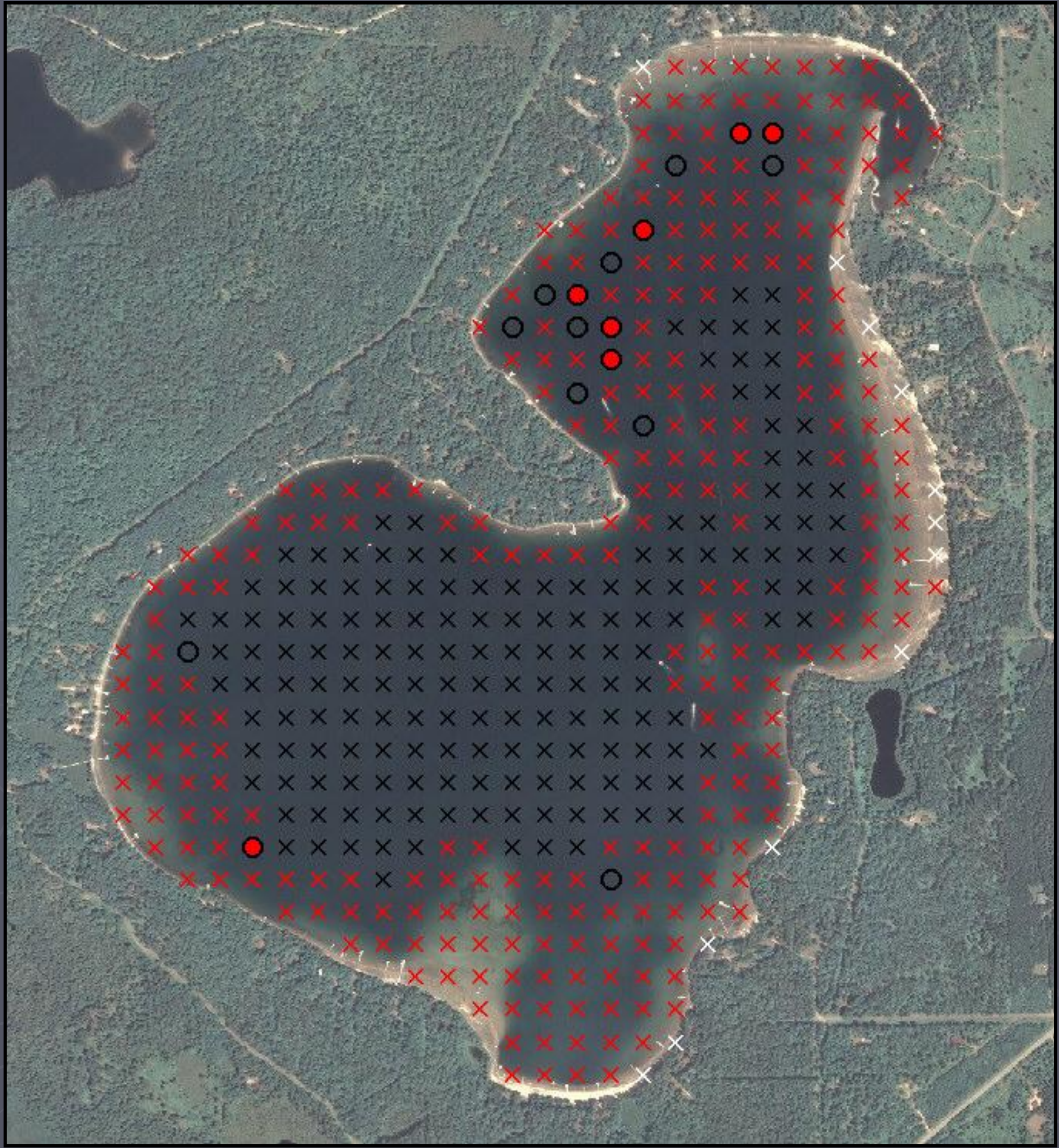


Figure 10. Distribution of plant species, Stormy Lake (2012).

***Myriophyllum tenellum*, Dwarf water-milfoil**

- ○ 1 (rake fullness)
- ● 2
- ◉ 3
- ▲ Visual
- × Not found
- × Unsampled (depth)
- × Non-navigable

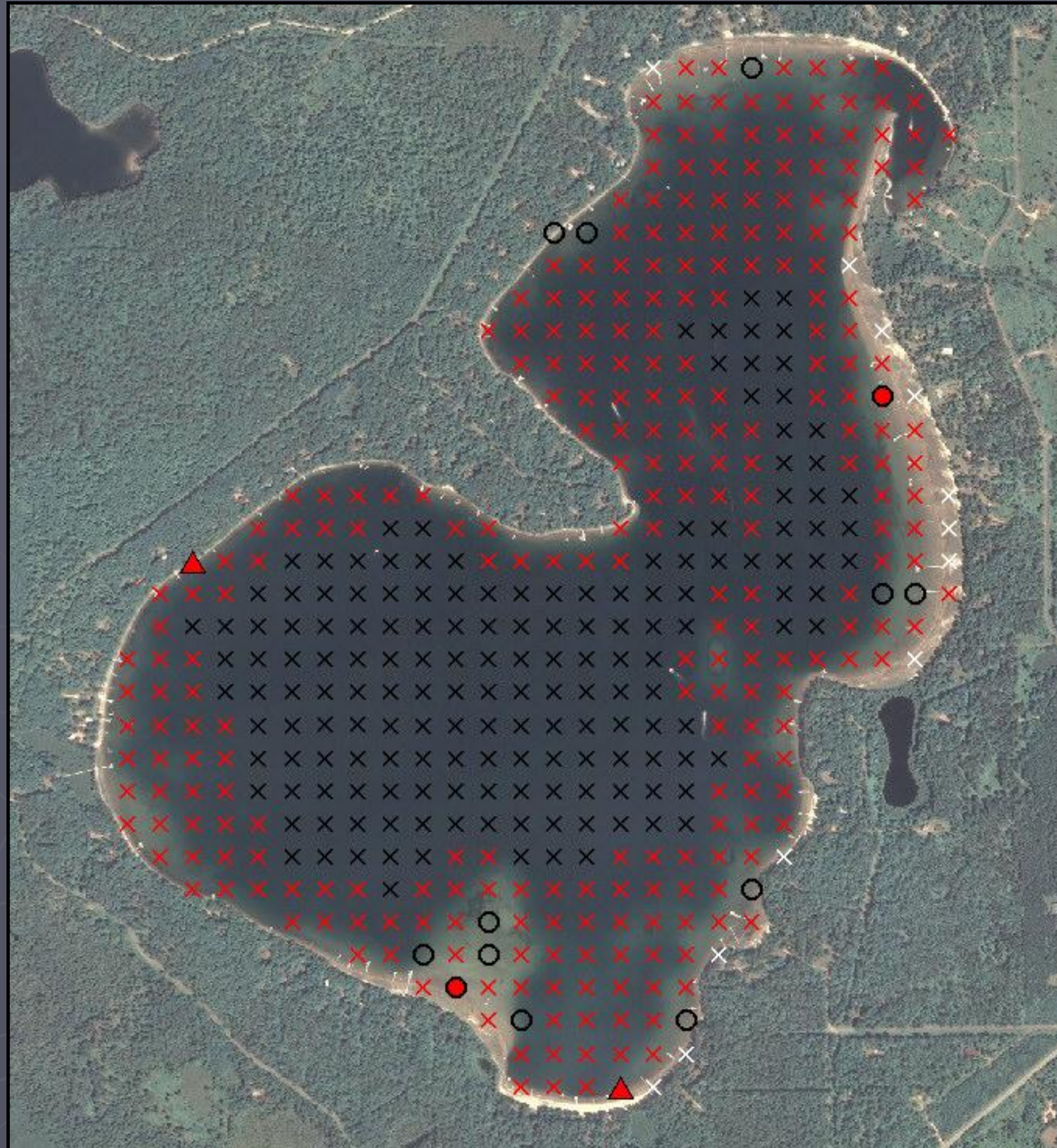


Figure 11. Distribution of plant species, Stormy Lake (2012).

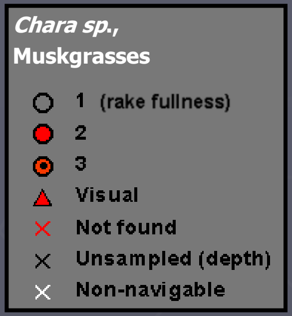


Figure 12. Distribution of plant species, Stormy Lake (2012).

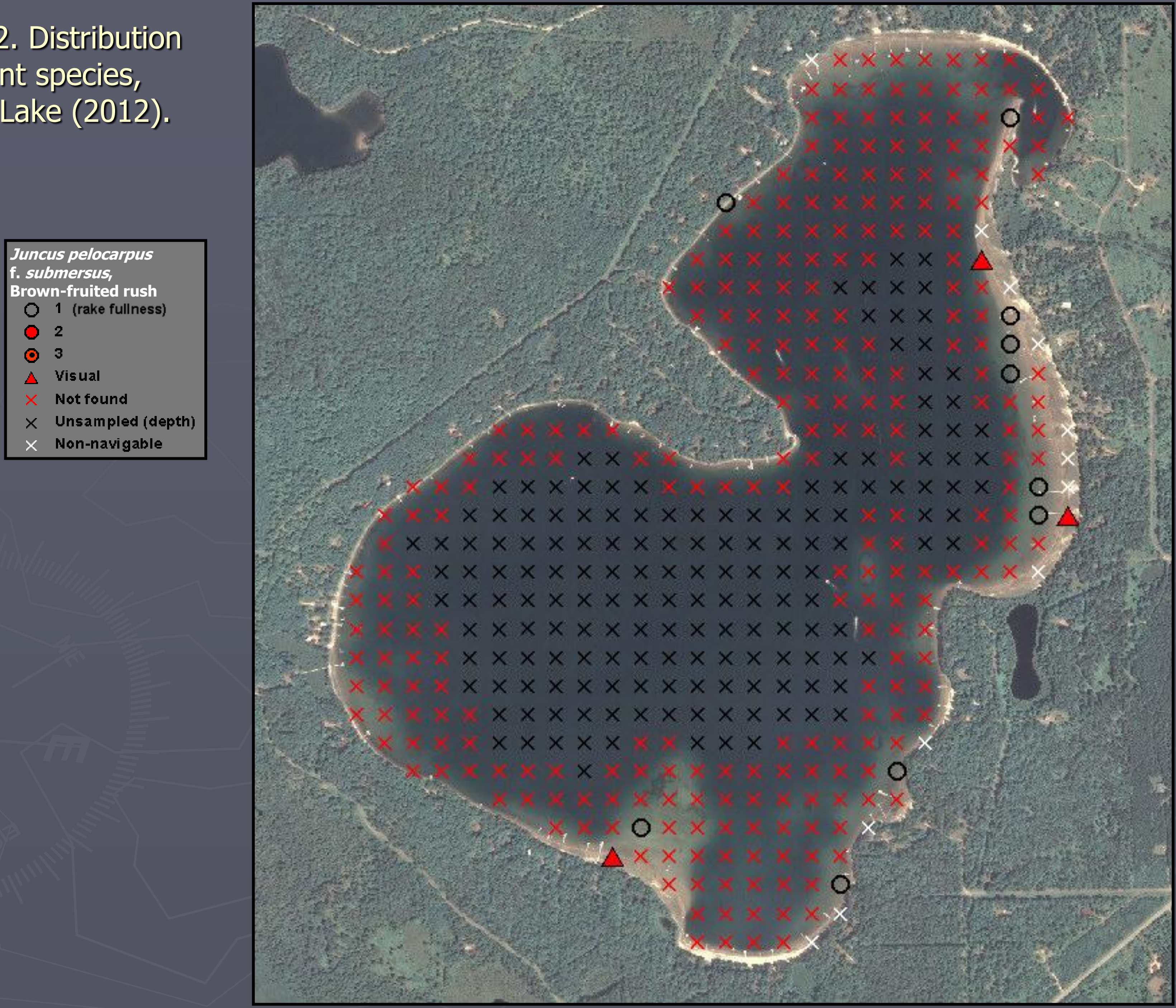


Figure 13. Distribution of plant species, Stormy Lake (2012).

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

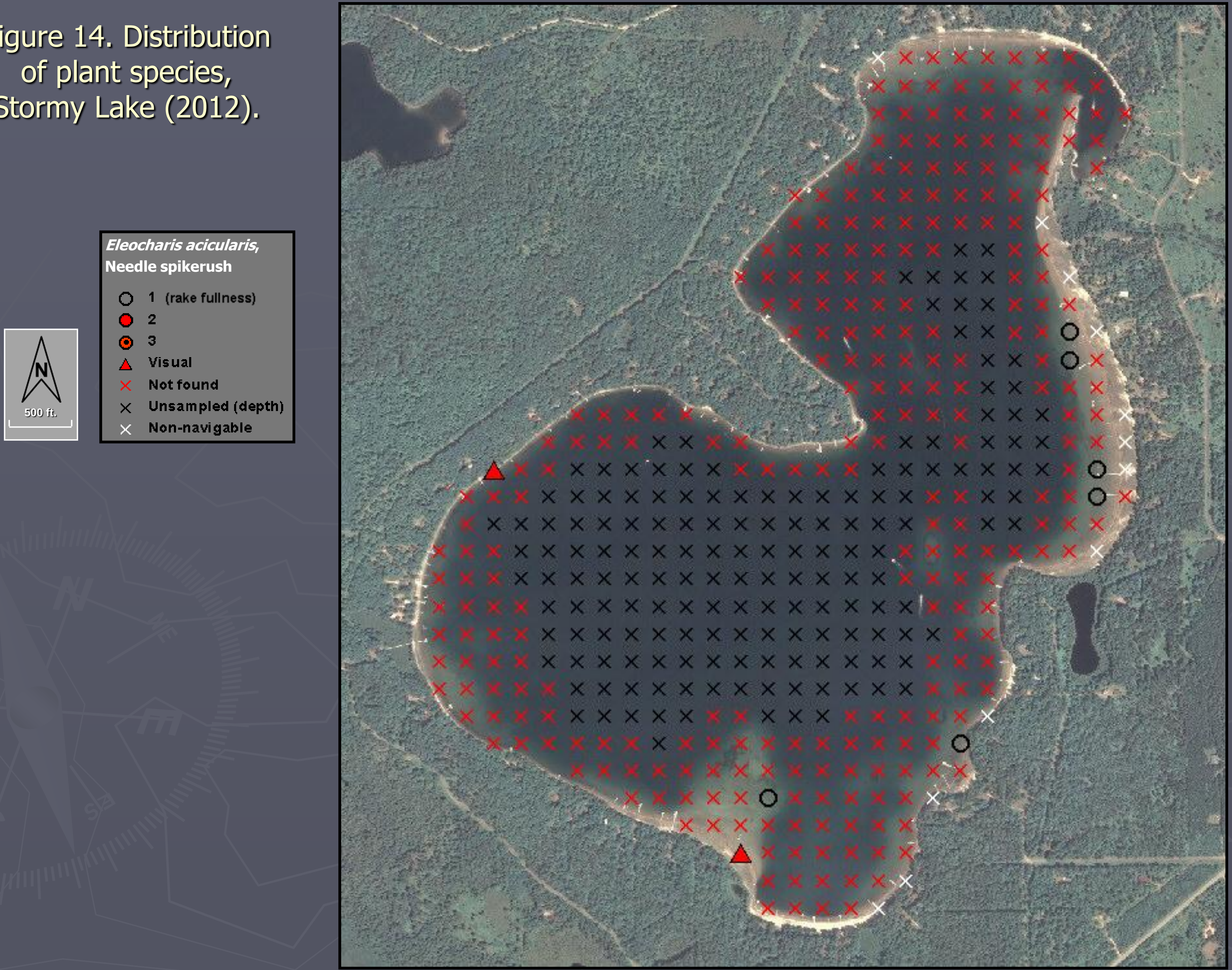


Figure 15. Distribution of plant species, Stormy Lake (2012).

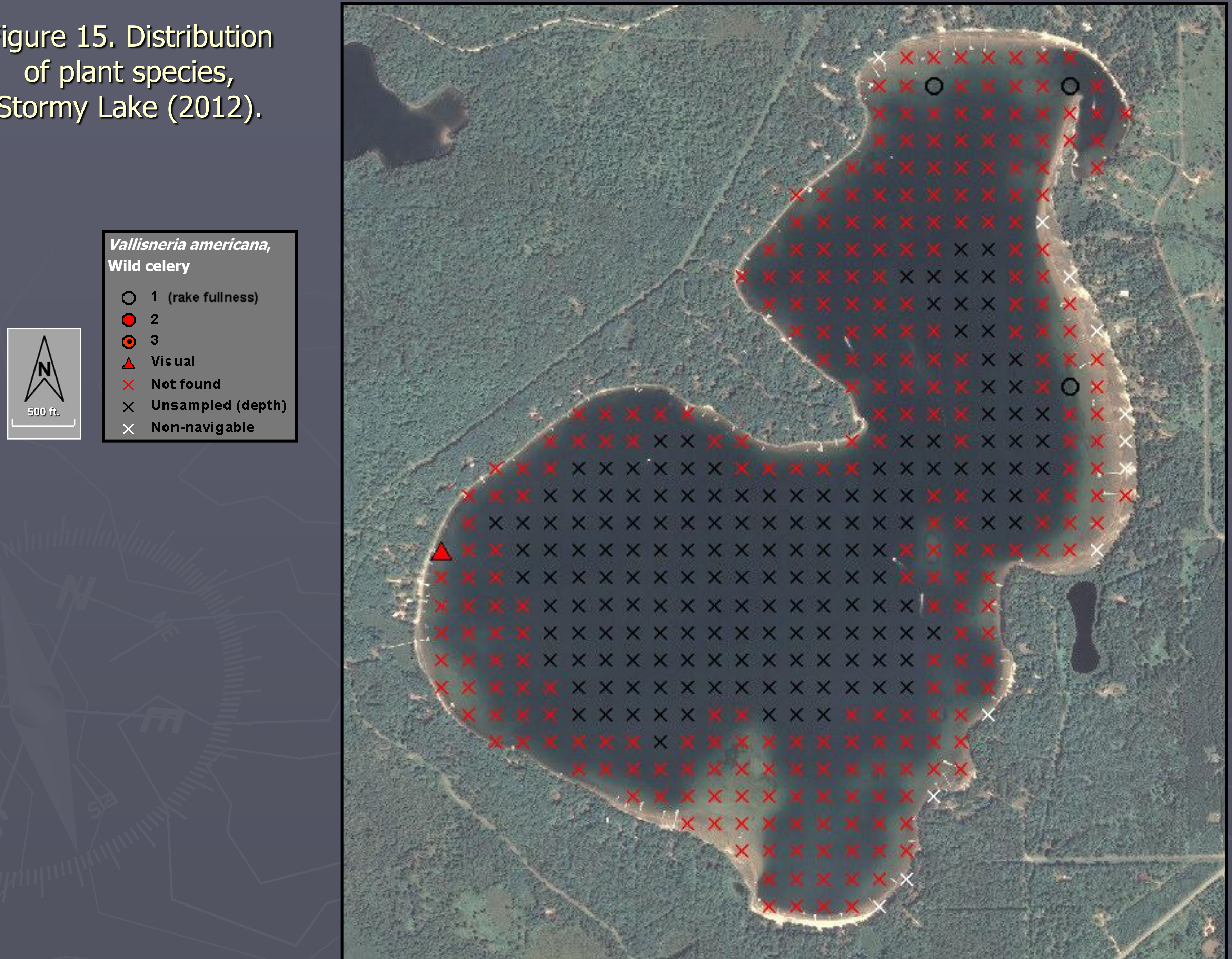


Figure 16. Distribution of plant species, Stormy Lake (2012).

Lobelia dortmanna, Water lobelia

- ○ 1 (rake fullness)
- ● 2
- ◉ 3
- ▲ Visual
- × Not found
- × Unsampled (depth)
- × Non-navigable

Figure 17. Distribution of plant species, Stormy Lake (2012).

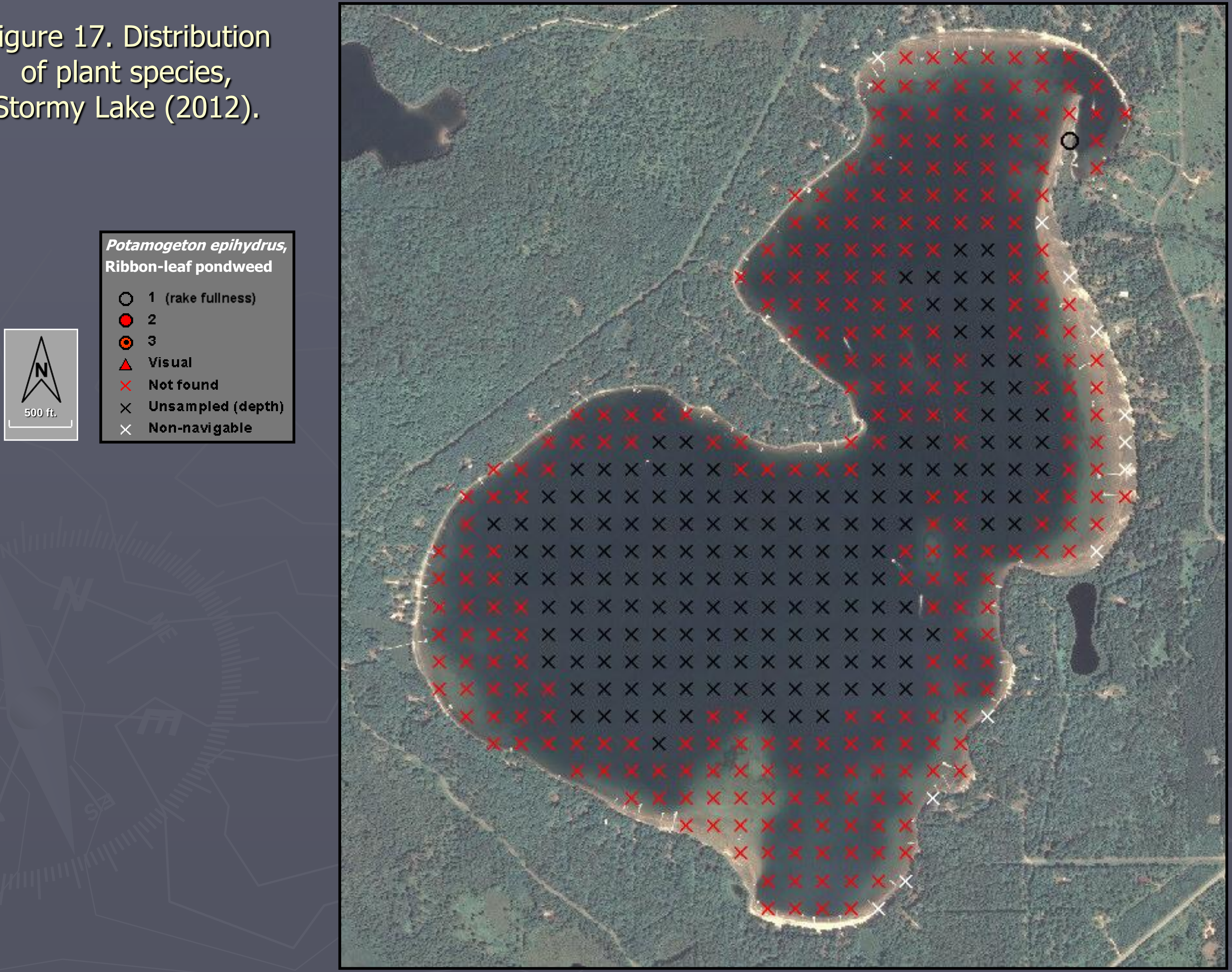


Figure 18. Distribution of plant species, Stormy Lake (2012).

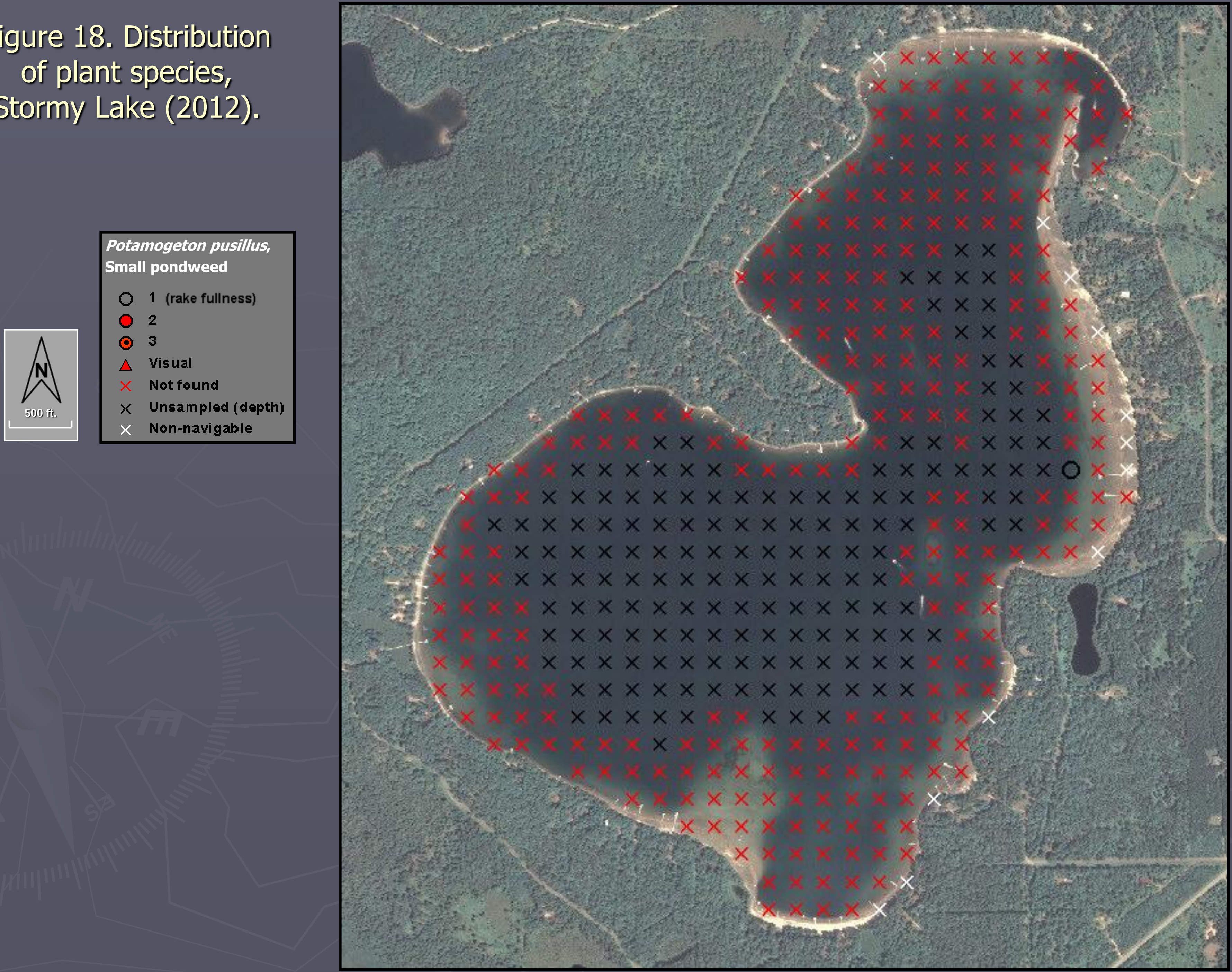


Figure 19. Distribution of plant species, Stormy Lake (2012).

Potamogeton robbinsii,
Fern pondweed

- 1 (rake fullness)
- 2
- 3
- Visual
- Not found
- Unsampled (depth)
- Non-navigable

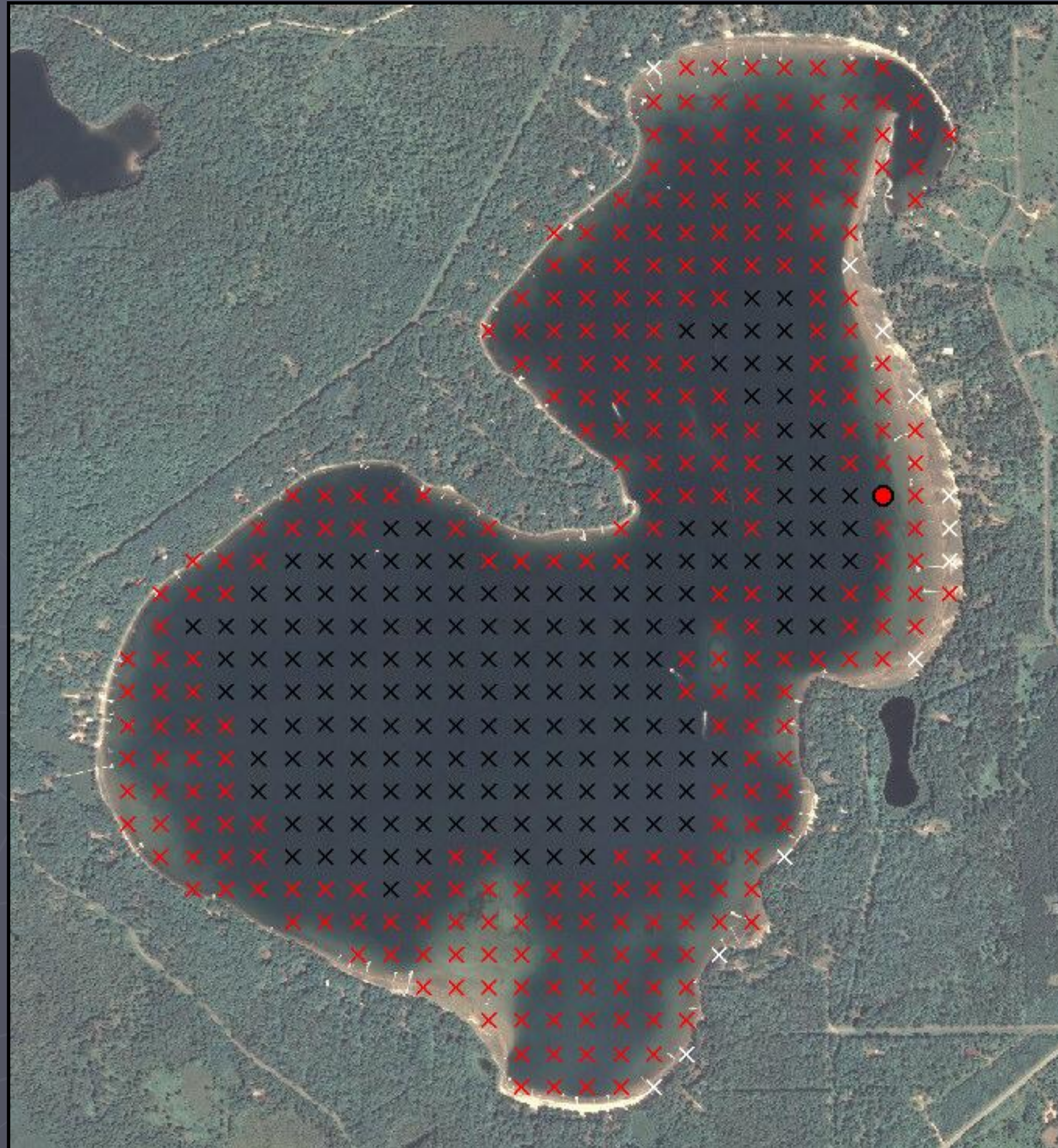
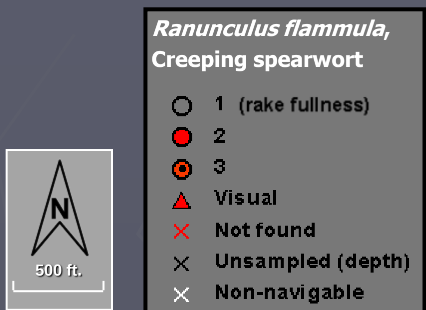
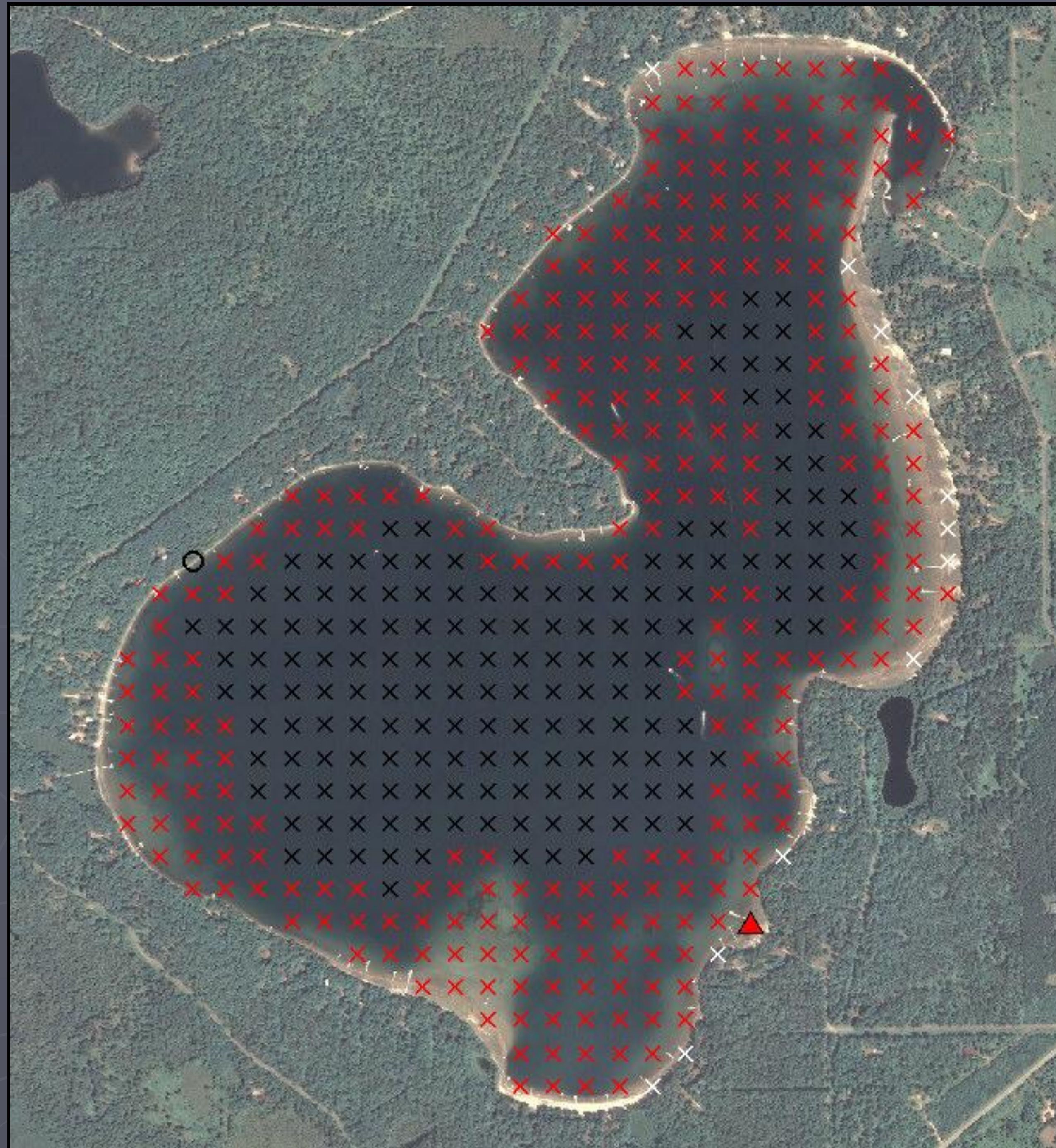


Figure 20. Distribution of plant species, Stormy Lake (2012).





Appendix 3

Review of Stormy Lake Water Quality

Note: This document is available as Appendix C of the

Stormy Lake Adaptive Management Plan

(starts on following page)

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Appendix C
Stormy Lake Review of Water Quality

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WHITE WATER ASSOCIATES, INC.

Appendix C
Review of Lake Water Quality

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Review of Stormy Lake Water Quality

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

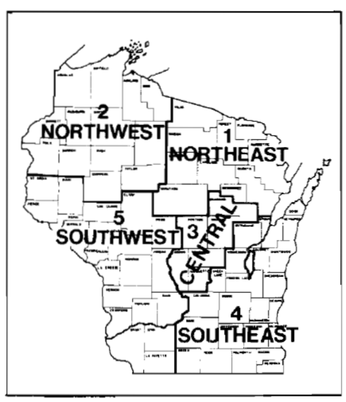
Introduction

Stormy Lake is located in Vilas County, Wisconsin. It is a 523 acre drainage lake with a maximum depth of 63 feet. The Waterbody Identification Code (WBIC) is 1020300. The purpose of this study is to develop baseline data. Our goal is to analyze existing water quality data, and continue monitoring Stormy Lake for environmental and human changes. Water quality data was retrieved from the Wisconsin Department of Natural Resources (WDNR) SWIMS database from 1989, and from 1993 to present. Secchi depth, water appearance and water level were taken by Citizen Lake Monitoring Network (CLMN) volunteers from 1993 to present. White Water Associates collected water quality in July, 2012.

Comparison of Stormy Lake with other datasets

Lillie and Mason's *Limnological Characteristics of Wisconsin Lakes* (1983) is a great source to compare lakes within our region to a subset of lakes that have been sampled in Wisconsin. Wisconsin is divided into five regions of sampling lakes. Vilas 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 the temperature of a lake at different depths 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. The following figures indicate the changes in water temperature in June (Figure 2), July (Figure 3), and August (Figure 4). Surface temperatures in July and August, 2012 were highest. Stormy Lake shows stratification in June, July and August.

Figure 2. Stormy Lake temperature profile, June.

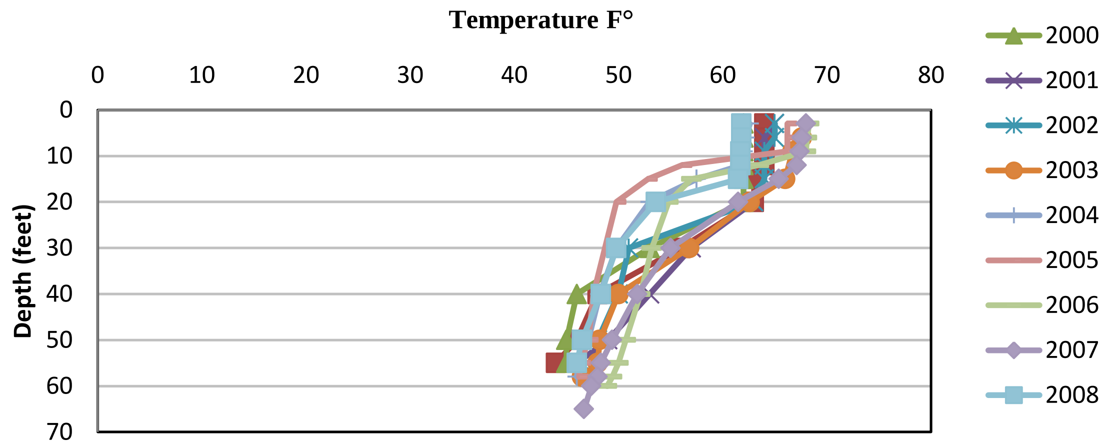


Figure 3. Stormy Lake temperature profile, July.

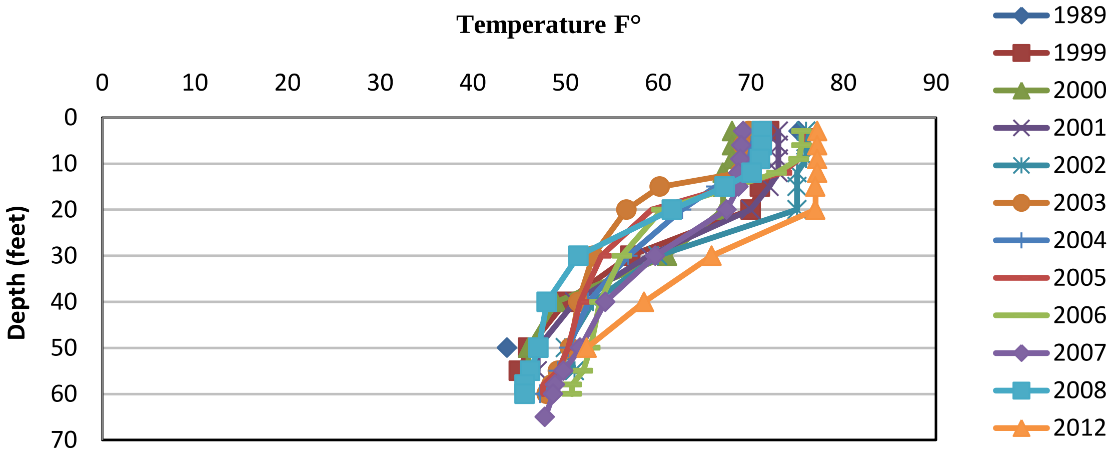
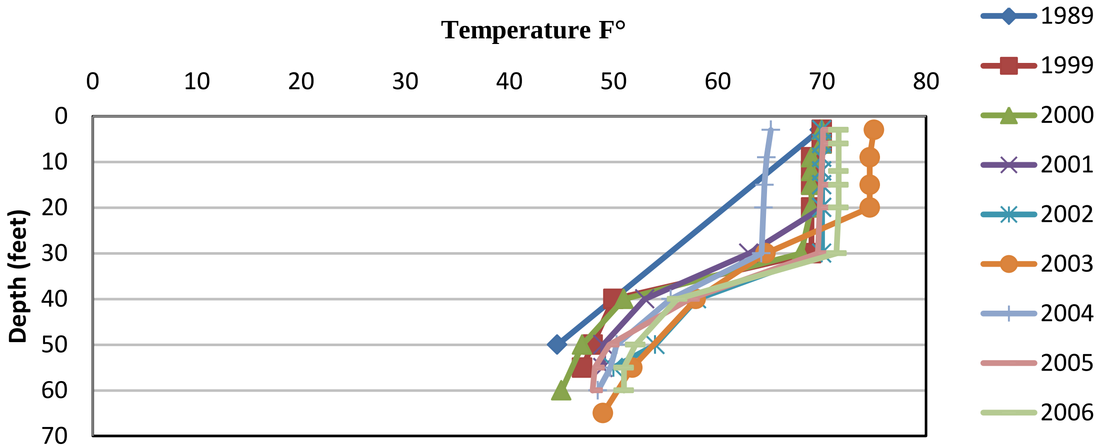


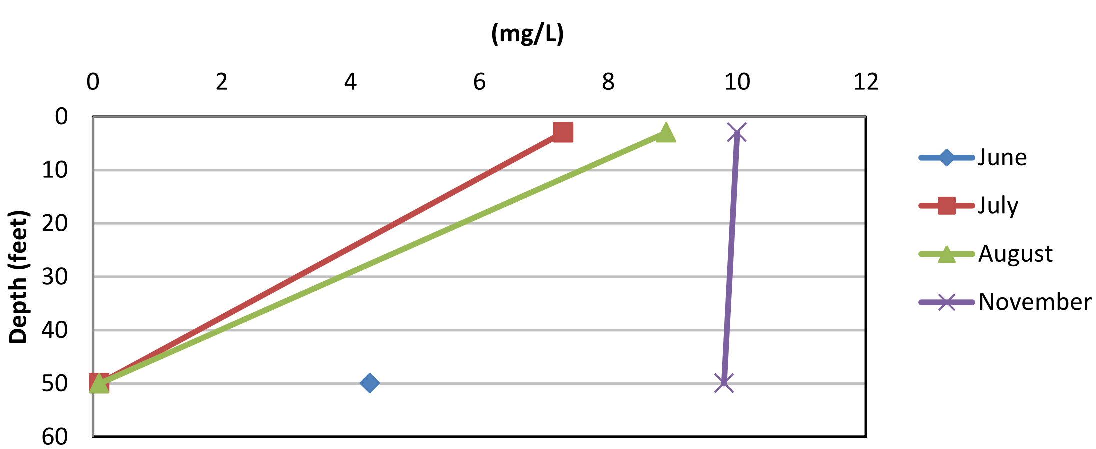
Figure 4. Stormy Lake temperature profile, August.

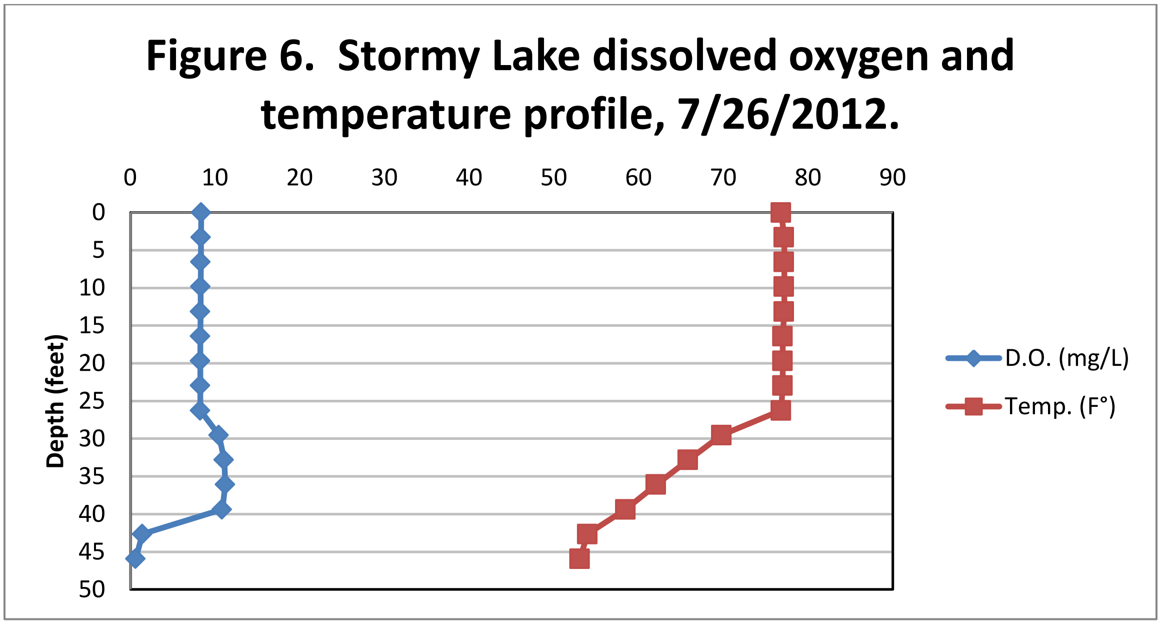


Dissolved Oxygen

The dissolved oxygen (D.O.) content of lake water is vital in determining presence 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, 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 critical to overall health. Figure 5 shows the dissolved oxygen of Stormy Lake in 1989, showing adequate amounts of dissolved oxygen throughout the year. In July, 2012 White Water Associates conducted a dissolved oxygen and temperature profile (Figure 6) showing that dissolved oxygen levels were sufficient for fish down to approximately 42 feet.

Figure 5. Stormy Lake dissolved oxygen, 1989.





Water Clarity

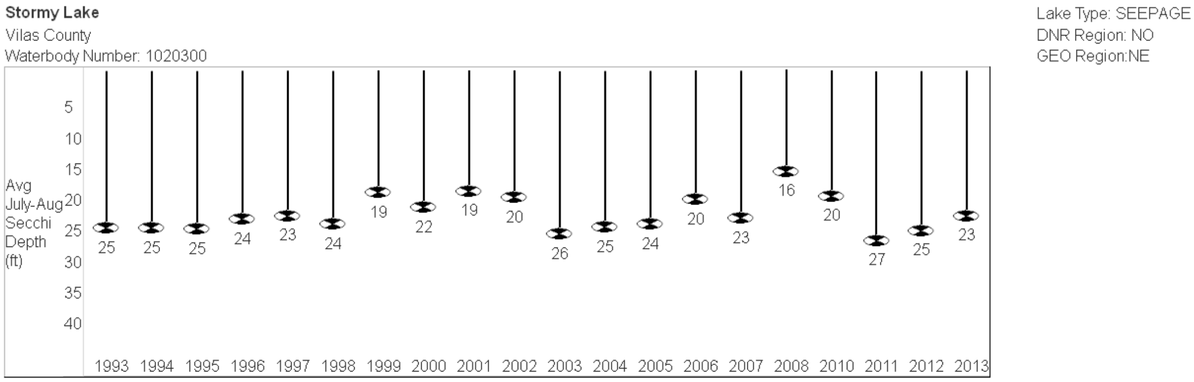
Water clarity has two main components: turbidity (suspended materials such as algae and silt) and true color (materials dissolved in the water) (Shaw et al., 2004). Water clarity gives an indication of the overall water quality in a lake. Water clarity is typically measured using a Secchi disk (black and white disk) that is lowered into the water column on a tether. In simple terms, the depth at which the disk is no longer visible is recorded as the Secchi depth.

Figure 7 shows the July and August mean Secchi depths from 1993 to 2013. The shallowest mean Secchi depth was 15.7 feet in 2008, and the deepest reading was at 27 feet in 2011 (Figure 8). The spiny water flea was discovered in 2007, so that may be one explanation of the shift in water clarity. According to Table 1, Stormy Lake's 2013 Secchi depth is "very good" with respect to water clarity.

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 7. Stormy Lake Secchi depth averages (July and August only).



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

(WDNR, 2013b)

Figure 8. Stormy Lake's July and August Secchi Data: Mean, Min, Max, and Secchi Count (1993-2013).

Year	Secchi Mean	Secchi Min	Secchi Max	Secchi Count
1993	24.9	21	26.25	8
1994	24.9	22.5	27	5
1995	25.2	24.5	26.5	3
1996	23.6	20.25	27.5	5
1997	22.9	20.25	25	5
1998	24.4	22	26.5	4
1999	19.1	16.75	22.25	4
2000	21.6	17.25	26.25	6
2001	18.9	17.75	20.25	5
2002	19.9	18.75	22	5
2003	25.9	21.25	29.75	4
2004	24.7	21.75	30	3
2005	24.4	21.75	26.25	3
2006	20.4	17.5	25.75	4
2007	23.3	19.25	27.25	2
2008	15.7	10.91	19.08	3
2010	19.8	18	22.75	3
2011	27	27	27	2
2012	25.4	22.5	27.5	4
2013	23	23	23	1

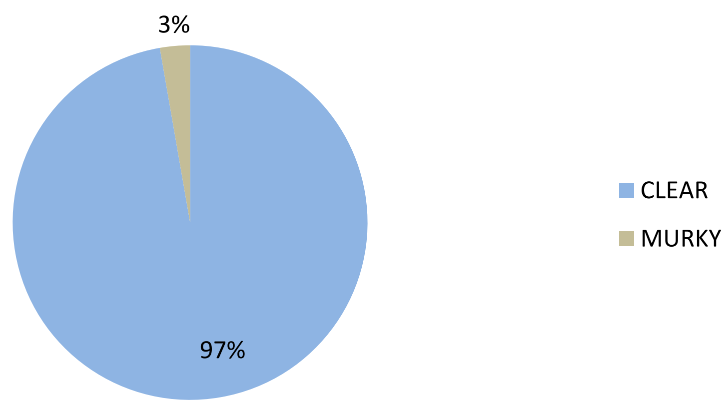
Report Generated: 11/19/2013

(WDNR, 2013b)

Turbidity

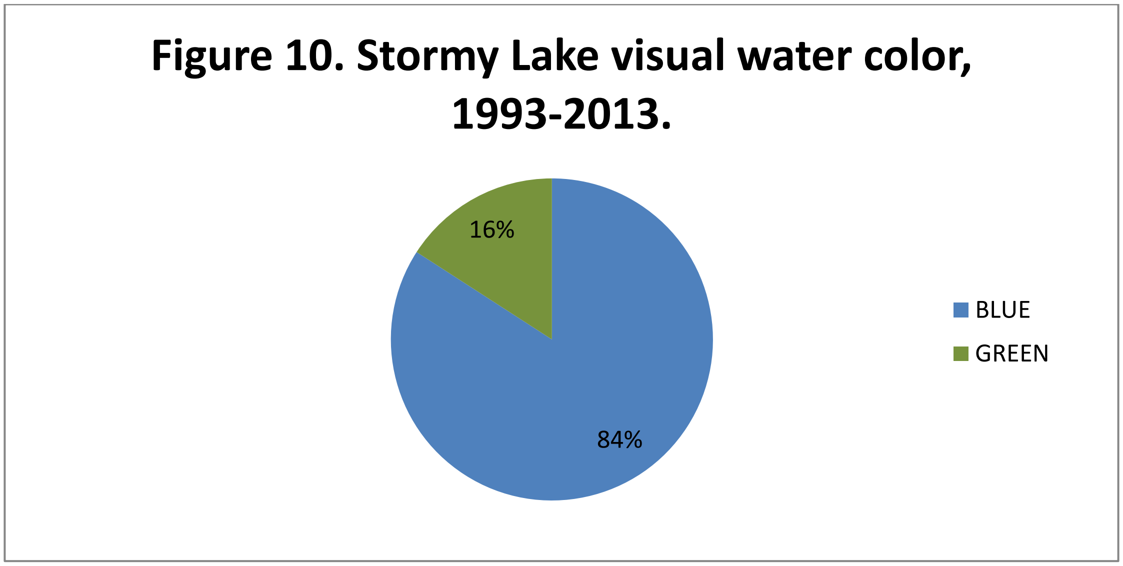
Turbidity is another measure of water clarity, but is caused by suspended particulate matter rather than dissolved organic compounds (Shaw et al., 2004). Particles suspended in the water dissipate light and reduce the depth at which the light can penetrate. This affects the depth at which plants can grow. Turbidity also affects the aesthetic quality of water. Water that runs off the watershed into a lake can increase turbidity by introducing suspended 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. Because turbidity data is unknown for Stormy Lake, future water quality sampling could include measurement of this parameter. While collecting samples, the CLMN volunteers also rate the water clarity and describe the water as “clear” or “murky.” From 1993 to 2013, 97% of volunteers rated the water as “clear” (Figure 9).

Figure 9. Stormy Lake water column appearance, 1993-2013.



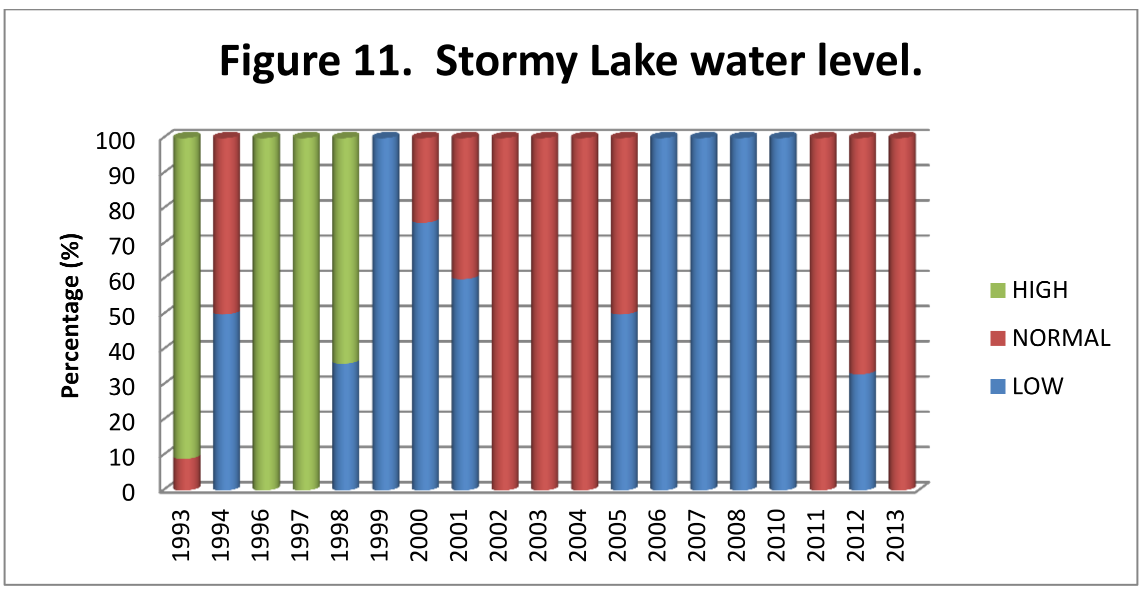
Water Color

Color of lake water is related to the type and amount of dissolved organic chemicals. 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. Stormy Lake water color was 5 Pt-Co in November, 1989. The mean for northeast Wisconsin is 46 Pt-Co units. CLMN volunteers also recorded their perception of water color as “brown,” “blue,” or “green” and the majority of volunteers said Stormy Lake appeared “blue” (Figure 10).



Water Level

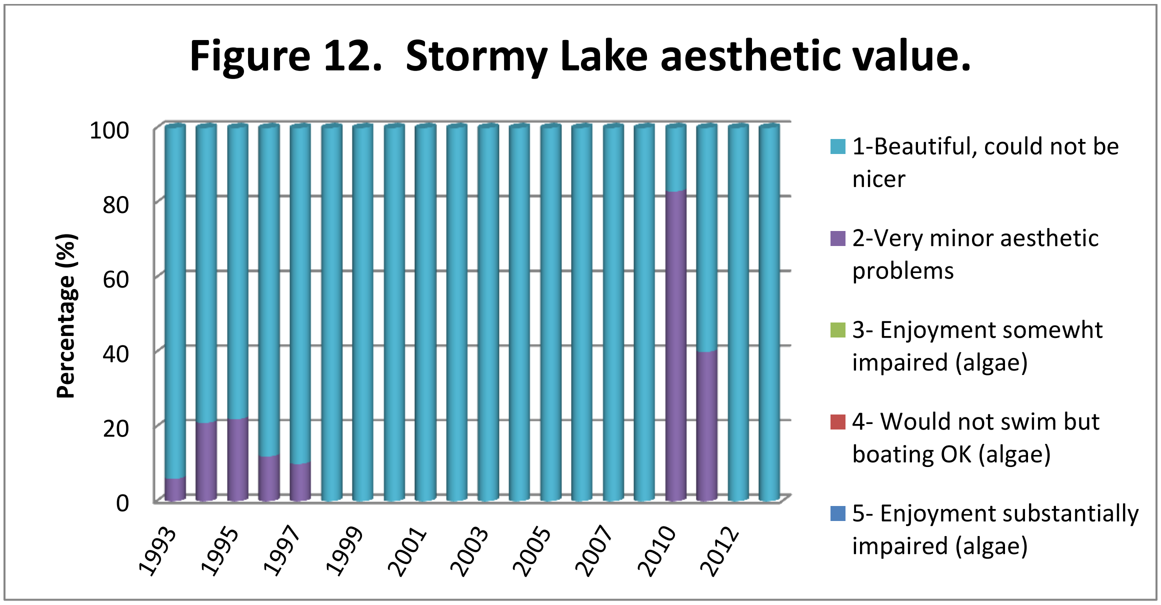
When CLMN volunteers collect Secchi depth readings, they also record the lake level as "high," "normal," or "low." Figure 11 shows that in 1996 and 1997, Stormy Lake was viewed as having "high" water levels. In 2002-2004, 2011, and 2013, 100% of volunteers viewed the lake levels as "normal" and in 1999, 2006-2008, and 2010, 100% of volunteers felt the water level of Stormy Lake was "low."



User Perceptions

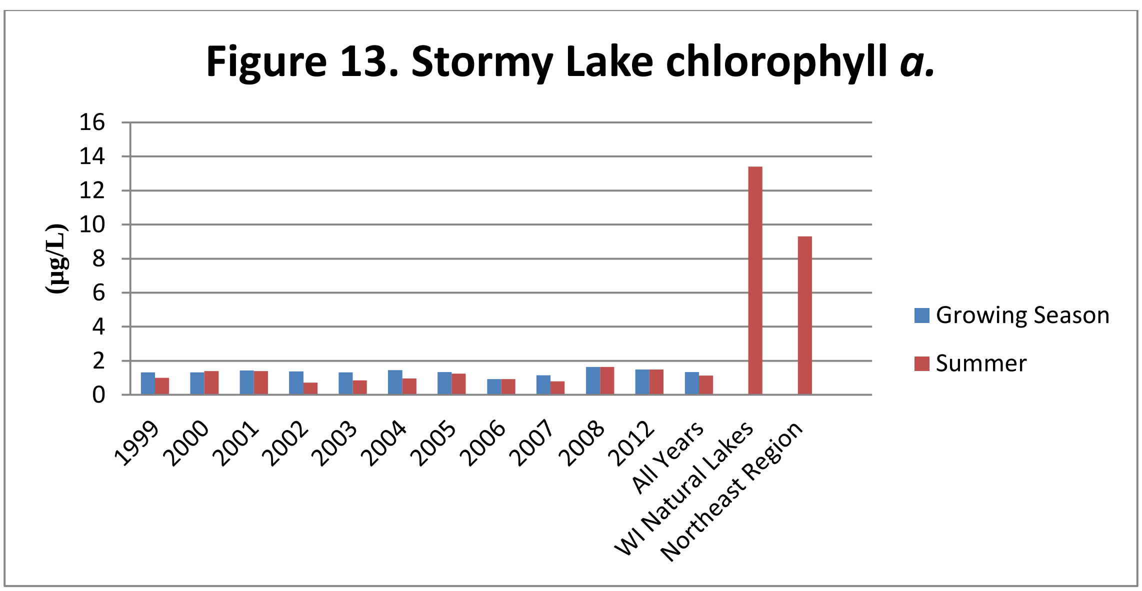
When Secchi depth readings are collected, the CLMN record their perceptions of the water, based on the physical appearance and the recreational suitability. These perceptions can be compared to water quality parameters to see how the lake user would experience the lake at that time. When interpreting 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

12. From 1998 to 2008, and in 2012 and 2013, 100% of CLMN volunteers recorded Stormy Lake to be "beautiful, could not be nicer." In 2010, the majority of the CLMN volunteers (83%) recorded that Stormy Lake had "very minor aesthetic problems."



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 > 10 µg/L are perceived as a mild algae bloom, while concentrations greater than 20 µg/L are perceived as a nuisance. Chlorophyll *a* has been monitored in Stormy Lake extensively (Figure 13) and average growing season (April-Oct) and summer (June-Sept) chlorophyll *a* values are significantly lower than Wisconsin natural lakes and other lakes in the northeast region.

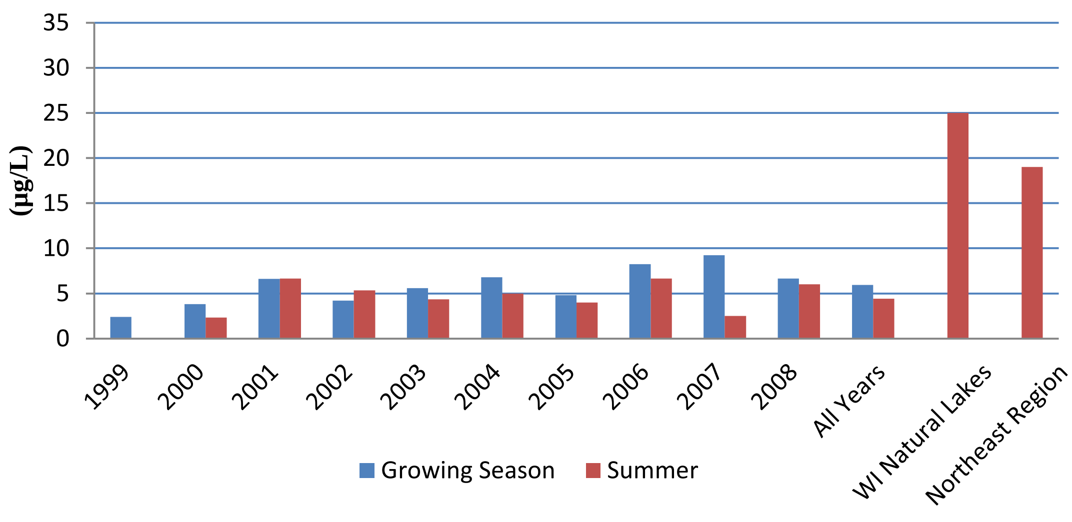


Phosphorus

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, excessive aquatic plant 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). Phosphorus concentration data from 1989 to 2012 indicates that total phosphorus levels were much lower than Wisconsin natural lakes and northeast regional lakes (Figure 14). Figure 15 displays the total phosphorus values at 50 feet deep. According to Figure 16, Stormy water quality is considered "very good" with respect to average total phosphorus concentrations.

Figure 14. Stormy Lake total phosphorus.



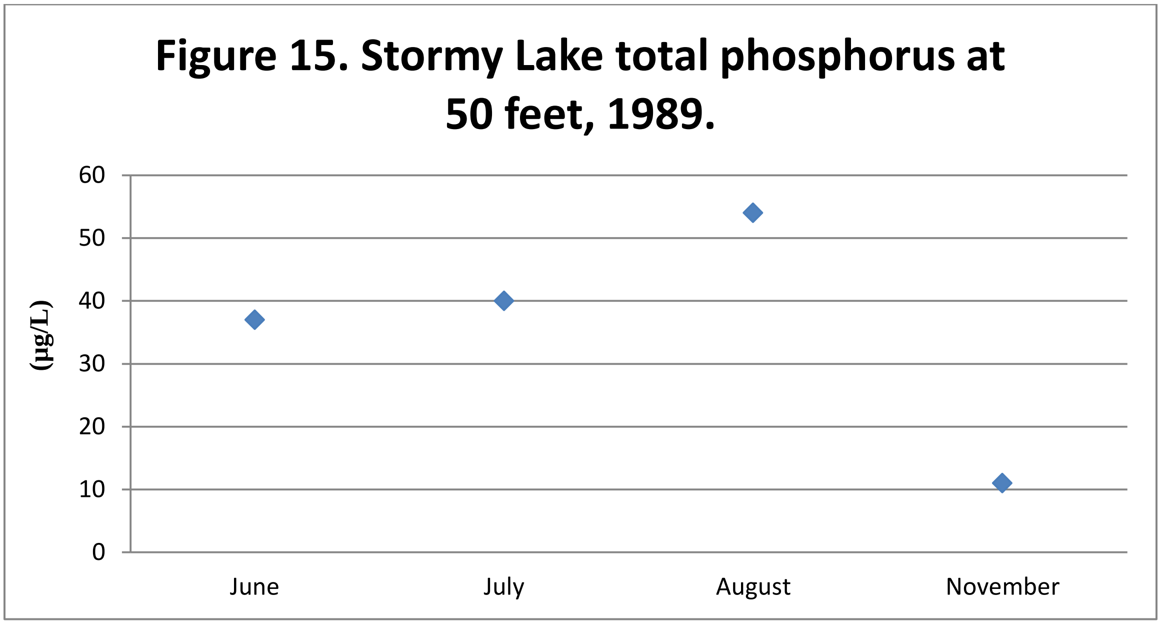
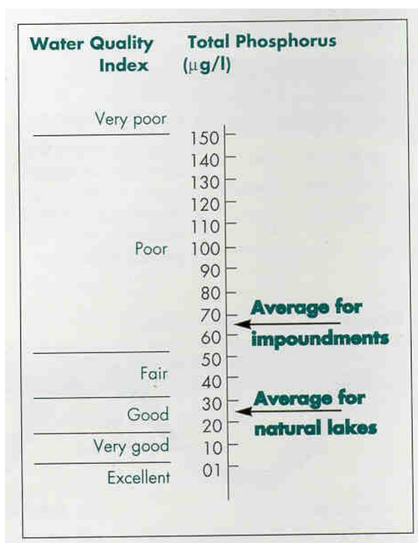


Figure 16. Total phosphorus concentrations for Wisconsin's natural lakes and impoundments (Shaw et al., 2004).



Trophic State

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

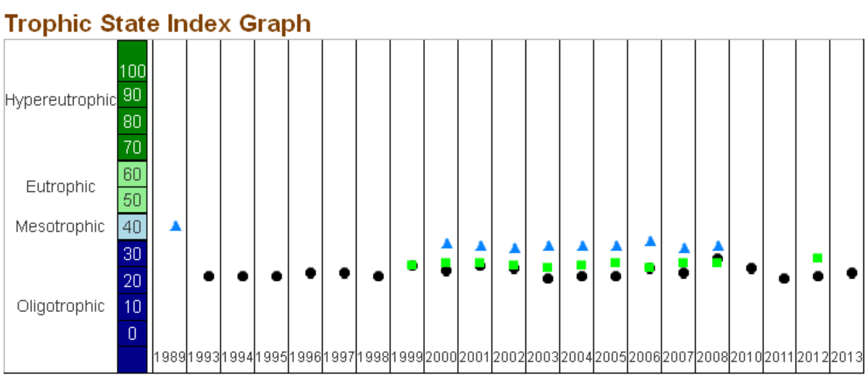
Researchers use various methods to calculate the trophic state of lakes. Common characteristics used to make the determination are: total phosphorus (important for algae growth), chlorophyll *a* concentration (a measure of the amount of algae present), and Secchi disk readings (an indicator of water clarity) (Shaw et al., 2004) (Table 2).

Table 2. 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

Trophic State Index (TSI) was calculated by the WDNR using only Secchi measurements collected from the CLMN. The July and August average TSI in the North Basin was consistent from 1989 to 2013 (Figure 17), classifying Stormy Lake as "oligotrophic" (Table 3).

Figure 17. Stormy Lake, North Basin Trophic State Index (1989-2013).



Monitoring Station: Stormy Lake - Deep Hole, Vilas 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, 2013b)

Table 3. 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, 2013b)

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. Stormy Lake was analyzed for total Kjeldahl nitrogen (0.3 mg/L in November, 1989 and 0.42 mg/L in July, 2012), nitrate-nitrite (not detected), and ammonium, <0.02 mg/L in 1989. Nitrogen is a major component of all organic (plant and animal) 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 (as N) 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 stimulate or enhance the development, maintenance and proliferation of primary producers (phytoplankton, benthic algae, marcrophytes), contributing to the widespread phenomenon of the cultural (human-made) eutrophication of aquatic ecosystems (Camargo et al., 2007). The nutrient enrichment can cause important ecological effects on aquatic communities, since the overproduction of organic matter, and its subsequent decomposition, usually lead to low dissolved oxygen concentrations in bottom waters, and sediments of eutrophic and hypereutrophic aquatic ecosystems with low turnover rates (Camargo et al., 2007). Total nitrogen values are low in comparison 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). Chloride does not affect plant and algae growth and is not toxic to aquatic organisms at most of the levels found in Wisconsin (Shaw et al., 2004). Chloride was tested 1989 with a value of 0.5 mg/L. The northeast region has a mean chloride value of 2 mg/L.

Sulfate

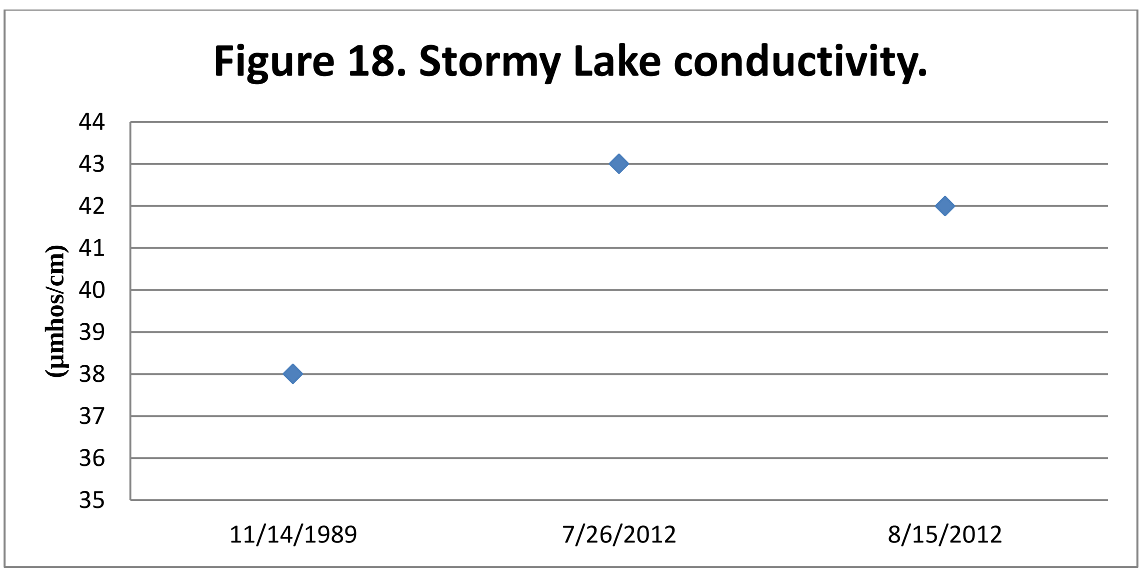
Sulfate in lake water is primarily related to the types of minerals found in the watershed, and to acid rain (Shaw et al., 2004). Sulfate concentrations are noted to be less than 10 mg/L in the northeast region (Lillie and Mason, 1983). Stormy Lake had a low sulfate reading of 3 mg/L in 1989.

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, fertilizations, 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 of these elements 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 tested in November, 1989 and was <1 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 has been measured three times in Stormy Lake (Figure 18).



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 averages a pH of 5.6. Some minerals become 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 tainted 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. 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 survival. Stormy Lake is relatively neutral with pH values of 7.3 (1989) and 7.58 (2012). 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 important. 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 rain has long been a problem with lakes that have low alkalinity levels and high potential sources of acid deposition. The alkalinity was sampled twice, 12 mg/L (November, 1989) and 19.1 mg/L (July, 2012). The mean for the northeast region is 37 mg/L. Based on the most recent alkalinity level, Stormy Lake has a low sensitivity to acid rain (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 ($CaCO_3$). Stormy Lake was sampled in 1989, and had a hardness value of 15 mg/L. The surface water of Stormy Lake is generally categorized as having “soft 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. Stormy Lake had low calcium levels (3.9 mg/L, 1989) and (4.5 mg/L, 2012), which is an indication that zebra mussels could not flourish if introduced. Magnesium levels were 1 mg/L (1989), which is low in comparison to the northeast region (5 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, fertilizations, 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 of these elements 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 <1 mg/L in 1989 and potassium has not been analyzed.

Dissolved Organic Carbon

Dissolved Organic Carbon (DOC) is a food supplement, supporting growth of microorganisms, and 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 from dead organic matter such as plants. 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. Baseflow concentrations of DOC in undisturbed watersheds generally range from 1 to 20 mg/L carbon. Stormy 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. Stormy Lake had a silica value of 0.4 mg/L in 1989.

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. Stormy Lake had an aluminum value of 25 µg/L in 1989.

Iron

Iron can form sediment particles that bind with and store phosphorus when dissolved oxygen is present. 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. Stormy Lake iron levels have not been tested, and could be included in future water quality sampling.

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 data is unknown for Stormy Lake, so future sampling could include this parameter.

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 the sediment. 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 was not collected for Stormy 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 bottom-feeding fish. 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 in turn 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." Because total suspended solids data is unknown for Stormy Lake, future water quality sampling could include measurement of this parameter.

Aquatic Invasive Species

In the past several years, three aquatic invasive species (AIS) have been recorded in Stormy Lake: rusty crayfish (*Orconectes rusticus*) discovered in 2001, spiny water fleas (*Bythotrephes longimanus*) discovered in 2007, and Chinese mystery snails (*Cipangopaludina chinensis*) discovered in 2012.

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 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).

Spiny water fleas are native to northern Europe and Asia and were likely introduced from ship ballast water (Liebig et al., 2013). Spiny water fleas can reproduce asexually as well as sexually, allowing for larger populations (Liebig et al., 2013). Impacts of spiny water fleas include: changes in zooplankton community structure, competition with small fish for food sources, ruin fishing equipment, and are not easily digested by larger fish (Liebig et al., 2013). For more information about spiny water fleas in Stormy Lake, see Appendix E.

Chinese mystery snails are originally from Southeast Asia and Eastern Russia and were likely released to the Great Lakes from an aquarium between 1931 and 1942 (Kipp et al., 2013). The snail does not seem to have a significant impact on native species, but its ecological and human threat comes from its potential to transmit parasites and diseases (Kipp et al., 2013). It is illegal to introduce the Chinese mystery snail into Wisconsin waters.

The University of Wisconsin-Madison's Aquatic Invasive Species Smart Prevention program classifies Stormy Lake as "not suitable" for zebra mussels, based on calcium and conductivity levels found in the lake (UW-Madison).

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. In 2010, CBCW inspected 2 boats in one hour and contacted four people on Stormy Lake (WDNR, 2013a).

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WHITE WATER ASSOCIATES, INC.

Appendix D
Stormy Lake WDNR Fisheries Summary

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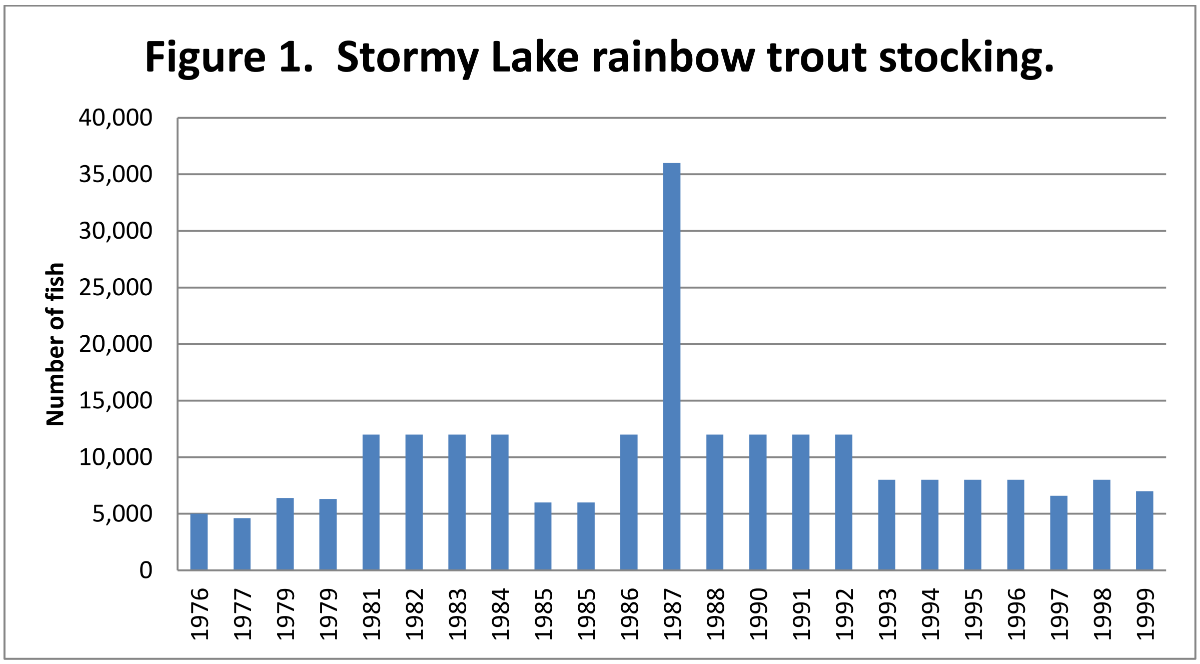
WHITE WATER ASSOCIATES, INC.

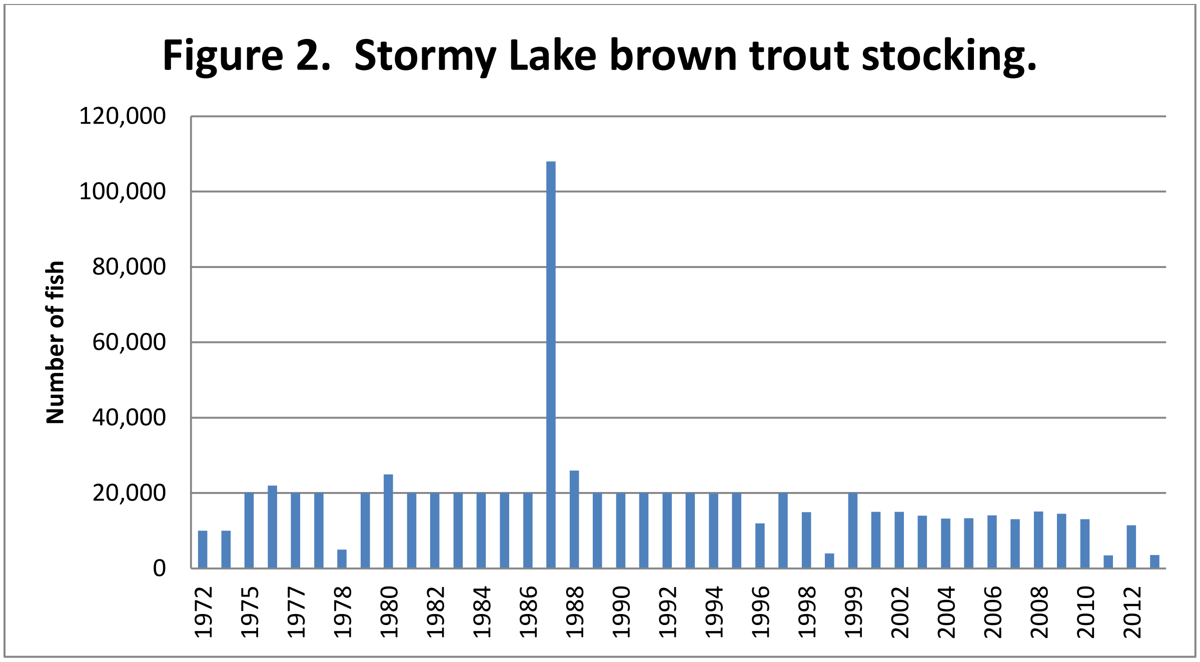
Stormy Lake Fisheries Summary

Stormy Lake, located in Vilas County, is a 523 acre oligotrophic seepage lake with a maximum depth of 63 feet and a mean depth of 33 feet. The bottom is comprised of 90% sand, 5% gravel, 5 % rock, and 0% muck (WDNR, 2014). Fish present in Stormy Lake are smallmouth bass, largemouth bass, brown trout, yellow perch, crappies, bluegills, sunfish, and northern pike.

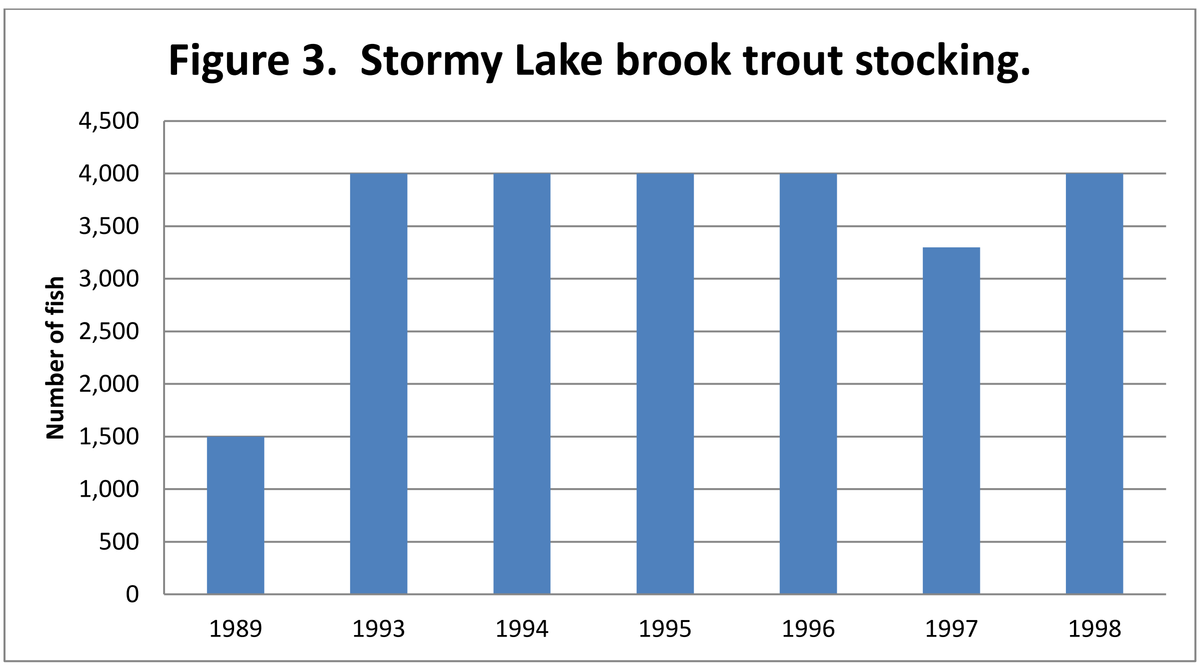
There has been an extensive trout stocking program in Stormy Lake via the Wisconsin Department of Natural Resources (WDNR). There have been 231,939 rainbow trout stocked in the lake from 1976 to 1999 (Figure 1); 775,889 brown trout from 1972 to 2013 (Figure 2); 24,797 brook trout from 1989 to 1998 (Figure 3), and 15,000 Coho salmon from 1972 to 1974 (Figure 4). Presently, brown trout are the only fish still stocked in Stormy Lake (WDNR, 2014).



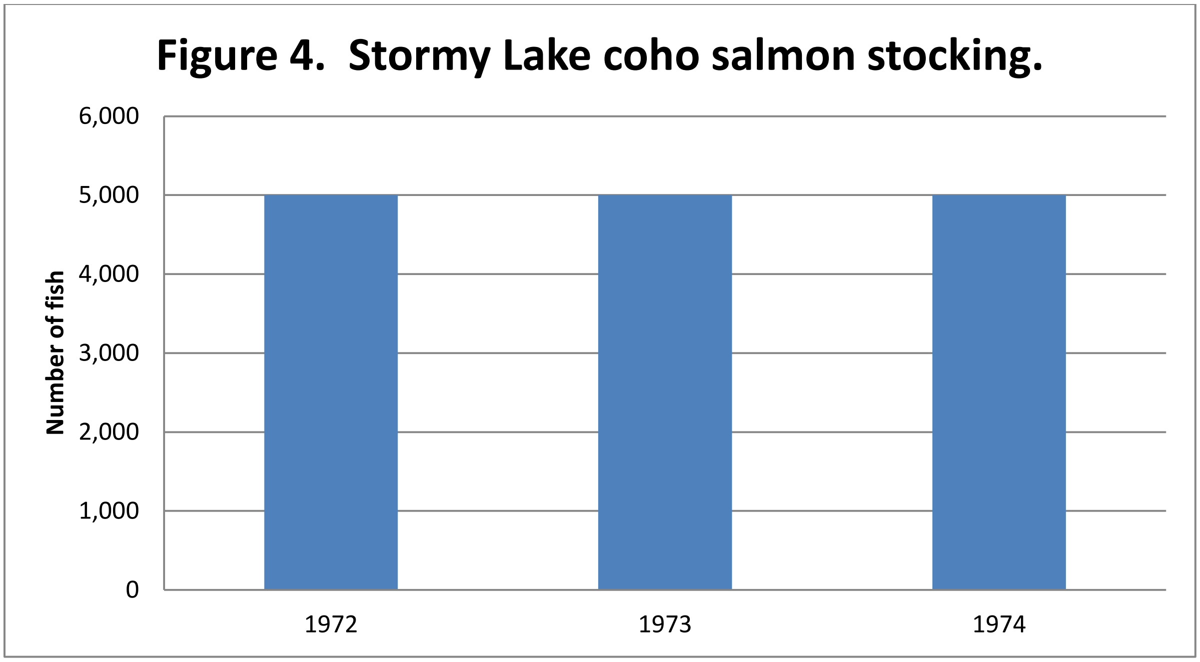
We see from Figure 1 that in 1987, over 35,000 rainbow trout were stocked in Stormy Lake. Since then, stocking numbers for rainbow trout have slowly decreased to about 7,000/year.



Similar to trends for rainbow trout, the stocking number of brown trout after 1987 (Figure 2) has decreased. In 2013, only 3,500 brown trout were stocked in Stormy Lake.



Five of the seven years Stormy Lake was stocked with 4,000 brook trout (Figure 3). After 1998, Stormy Lake did not have brook trout stocked.



Coho salmon were stocked in Stormy Lake from 1972 to 1974 (Figure 4).

In an article from the *Milwaukee Journal Sentinel*, Bob Riepenhoff and Gary Wroblewski's fishing experience on Stormy Lake was described along with information from Steve Gilbert, the fisheries biologist for Vilas County. According to Gilbert, "Stormy Lake is the biggest stocked trout lake in Vilas County" (Riepenhoff, 2007). "There is no natural reproduction of trout there" and Gilbert continues, "We stock 13,000 to 15,000 brown trout, about 7 ½ inches long, each spring" (Riepenhoff, 2007). A WDNR survey conducted in 2003, some trout were found up to 18 inches long (Riepenhoff, 2007). Stormy Lake has a sandy bottom with a few scattered weeds. Gilbert believes that the lake "gets a fair amount of angler pressure" (Riepenhoff, 2007). According to the article, "Riepenhoff and Wroblewski studied the [bathymetric] map and found some structure that looked promising - a steep, deep-water break line with a nearby sand bar" (Riepenhoff, 2007). "There's a good chance that structure will concentrate trout in that area," Wroblewski predicted. They headed for that spot, anchored and, within 10 minutes or so, started to catch trout. As stated by Riepenhoff (2007), "For the next three or four hours, the action was steady. We caught trout on minnows suspended beneath bobbers and also on those presented on the live-bait rigs, just a crank or two up from the bottom. It was a nice change of pace from shallow-water bass and panfish fishing. By the time we ran out of bait, we had caught eight "keeper" size brown trout and released at least that many that were a little short of the mark." "It proved to be a great trout lake," Wroblewski said.

Gary Wroblewski displays a brown trout from Stormy Lake, where the "keeper" length is 12 inches (Riepenhoff, 2007).

Literature Cited

Riepenhoff, Bob. June 10, 2007. *Stormy Lake brims with trout.* Milwaukee Journal Sentinel. Retrieved 2014. <http://www.jsonline.com/sports/outdoors/29366914.html#ixzz2rL9BO3TN>

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Appendix E
Review of Water Regulations and Planning Relevant to Stormy Lake

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Review of Water Resource Regulations and Planning Relevant to Stormy Lake

In this appendix, we provide reviews of documents created to preserve and protect Wisconsin waters, including Stormy 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 Vilas County Planning and Zoning Department, the Vilas County Land and Water Conservation Department, and the Vilas 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 Stormy Lake. Second is a review of the *Headwaters Basin Integrated Management Plan*. This plan describes issues of concern within the Headwaters Basin (where Stormy 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 Vilas County Land and Water Conservation Department, providing recommendations to enhance an already well-documented and comprehensive *Vilas County Land & Water Resource Management Plan.*

Regulations and Ordinances that Protect the Water Quality of Stormy Lake

Federal

The Army Corps of Engineers oversees projects that alter waterways-including discharges to wetlands, and 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, 2012).

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, 2013).

County

Regulations and ordinances set by Vilas County can be found in the *Vilas County Shoreland and Zoning Ordinance* (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 Stormy Lake.

Article II discusses general shoreland protection provisions. 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 (Vilas County, 2003). In general, all structures are required to be 75 feet from the ordinary high-water mark (OHWM) of a navigable waterbody (Vilas Co., 2003).

To prevent erosion, boathouses cannot be constructed if the slope of the land is greater than 20% (Vilas Co., 2003). Similarly, no land disturbances (filling, grading, excavating, creating of impervious areas, etc.) are allowed within 35 feet of the OHWM (Vilas Co., 2003). However, an erosion control plan is required (along with a Shoreland Alteration Permit) for conducting any alterations such as: land disturbance, construction of boat landing or roadway, and/or construction on slopes (Vilas Co., 2003).

Article VIII (Removal of Trees and Shore Cover) states, "Except as set forth in this section, natural shrubbery, trees, and undergrowth shall be preserved as far as practicable on all shoreland properties, and if removed, it shall be replaced with vegetation that is equally effective in meeting the objectives of this Ordinance." It is also prohibited to remove trees, shrubs or undergrowth within 75 feet of the lake. By keeping this vegetation, soils are less likely to erode and pollutants and contaminants are less likely to enter the water.

Land owners receive mitigation points for the width of their buffer zones. A Primary Active Buffer Zone is 35 feet from the OHWM and earns the property owner three points (Vilas Co., 2003).

Vilas County lakes have been categorized as part of the Vilas County Lakes Classification System. As quoted by the Shoreland Zoning Ordinance, "Each lake in Vilas County greater than 50 acres in surface area was individually evaluated and classified (low, medium, high) based upon its sensitivity to development and the level of existing development along privately-owned shorelines" (Vilas Co., 2003). Further, "Minimum lot size and setback requirements for specified uses were then developed based on the lake's sensitivity level" (Vilas Co., 2003). Stormy Lake is classified as having "high" sensitivity and a "low" level of existing development (Vilas Co., 2003, Table 1).

Literature Cited

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Review of *Headwaters Basin Integrated Management Plan* Relevant to Stormy 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 Stormy 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). Stormy Lake is considered an Outstanding Resource Water. There are seven ORWs within 10 miles of Stormy Lake: Black Oak Lake, Lac Vieux Desert, North Twin Lake, Partridge Lake, Plum Lake, South Twin Lake and Star Lake (2013 discovery of spiny water flea). In contrast, eight waterbodies within 10 miles of Stormy Lake are listed as Impaired Waters (303 (d)): Ballard Lake, Irving Lake, Myrtle Lake, Pioneer Lake, Shannon Lake, Snipe Lake, Upper Buckatabon Lake, and White Birch Lake. All waterbodies except Myrtle Lake are considered impaired because of mercury contamination in fish tissues, whereas Myrtle Lake is considered impaired due to its average total phosphorus exceeding thresholds for recreational uses (20 µg/L). Nearby Big Portage Lake, Goose/Forest Lake and Eagle Lake were previously listed as impaired because of mercury levels, but have since been delisted (WDNR, 2013b). Because of Stormy Lake's outstanding 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 Stormy Lake.

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Wisconsin Department of Natural Resources, Headwaters Basin Partnership Team and Stakeholders--DRAFT. 2002. *Headwaters State of the Basin Report*. Retrieved 2014. <http://dnr.wi.gov/water/basin/upwis/>

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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(906)822-7889

March 1, 2013

Vilas County Lands and Water Conservation Department
330 Court Street
Eagle River, WI 54521

To whom it may concern:

As ecological consultants, White Water Associates works with lake associations to conduct studies, review data, and create lake management plans. We have helped organizations like *High Fish-Trap Rush Lakes Association, Stormy Lake Association, Stormy Lake District,* and *Black Oak Lake Riparian Owners* 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 Vilas 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

I first recommend reorganizing the Table of Contents. For example, under Land Resources/Land Use, the sub-categories (Agriculture, Forestry, etc.) are not listed in the Table of Contents; however, that is not the case with Surface Water Resources. In the Table of Contents, after Surface Water Resources, most of the sub-categories are listed, but not all. Sections missing are: River Drainage System, Wetlands, Lakes and Streams, and Lake Classification. Instead, it may be beneficial to create two major categories: Land Resources and Water Resource and list each sub-category thereafter. This would then be reflected in the Table of Contents.

In the Water Resources section, I recommend discussing the major water types first: Basins and Watersheds, Groundwater, and Surface Waters (including River Drainage System, Lakes and Streams, and Wetlands). After these sections (and their corresponding sub-sections), I would then address Impaired Waters-303(d) Waters, and Outstanding/Exceptional Resource Waters since these subjects reflect a combination of lakes, rivers and wetlands.

[1] The Vilas County Land & Water Resource Management Plan used for this review was found at http://www.ncwrpc.org/vilas/lwrmp.html.

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

Within the River Drainage System 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 there are any streams classified as “trout streams,” the Lakes and Streams section would be a good place to list the names of these streams, list how many miles of streams there are, and how a stream becomes classified.

The Lakes and Streams section could also benefit from providing statistics about what lake classifications are most common in Vilas County. Listing the number of lakes that are seepage, drainage and spring would be a nice addition to this section.

The Impaired Waters section is already very thorough; however, a sentence or two describing the priority level of clean-up on these waters would be educational.

It would be informative for readers to provide information about soil associations in Vilas County. It may also be beneficial to create a table and/or a map listing each soil association and showing where in the county they are located.

Lastly, in the Wetlands section, I recommend stating the acres of wetlands in the county, and refer to the Clean Water Act (Section 404) in regard to wetland protection.

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 Vilas County well. If you have questions or comments regarding my recommendations, please contact me at the phone number given above.

Sincerely,

Caitlin Clarke
Biologist

Appendix F

Stormy Lake Spiny Water Flea Plan

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Stormy Lake Spiny Water Flea Plan

(Vilas County, Wisconsin)

Part of:

An Integrated Education, Planning, and Research Approach to Spiny Water Flea Populations in Northern Lakes

Prepared for:

Stormy Lake Association
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Date: April 2016

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An Integrated Education, Planning, and Research Approach to Spiny Water Flea Populations in Northern Lakes:

Stormy Lake Spiny Water Flea Plan

This plan is a product of a WDNR Aquatic Invasive Species Control Grant AEPP-363-12 (Subchapter II – Education, Prevention, and Planning Projects) awarded to:

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WHITE WATER ASSOCIATES, INC.

TABLE OF CONTENTS

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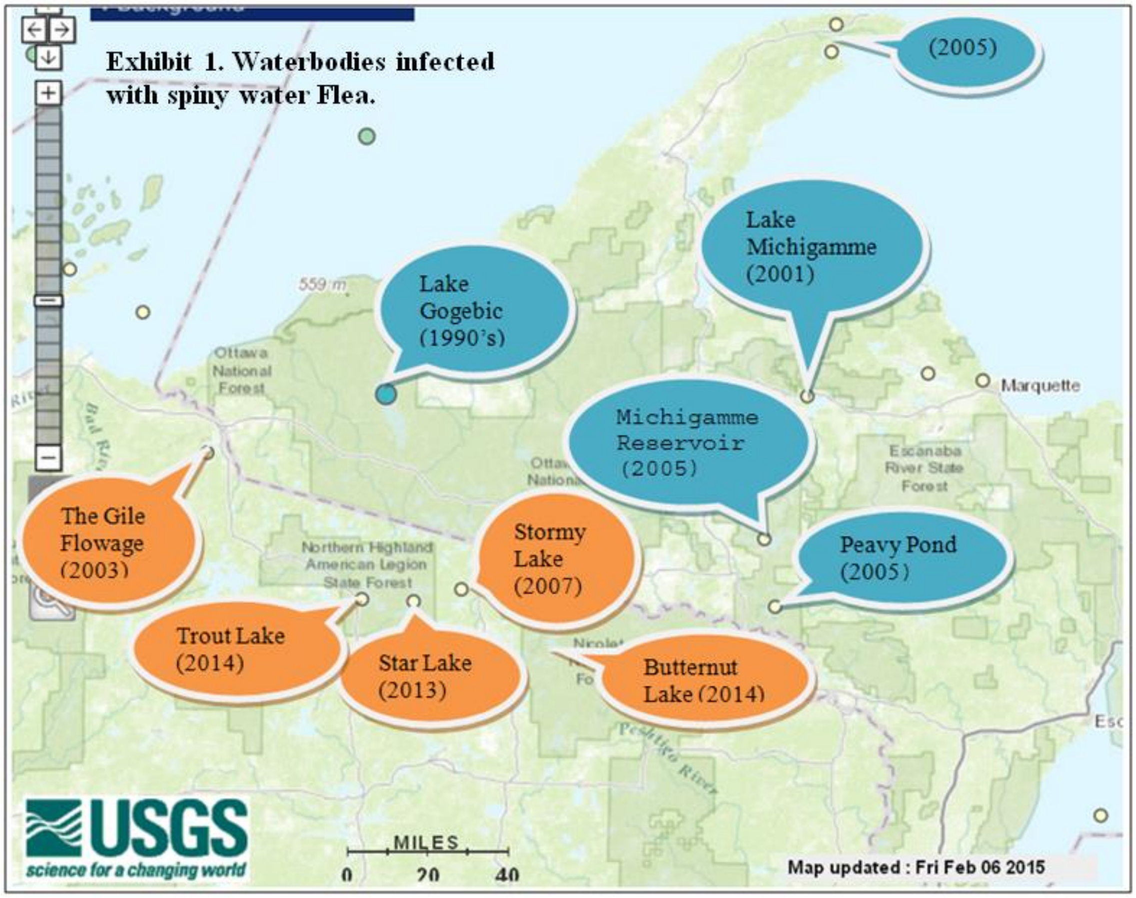
WHITE WATER
ASSOCIATES, INC.

OVERVIEW AND PURPOSE

The spiny water flea (SWF), a predatory aquatic invasive species (AIS), was documented in Stormy Lake (Vilas County, Wisconsin) in 2007. Spiny water fleas were first observed in the Great Lakes system in the early-1980s and since then have spread rapidly throughout the Great Lakes and increasingly into inland lakes, and reservoirs in Wisconsin and Michigan's Upper Peninsula (Exhibit 1). Some of these spiny water flea waterbodies are very large and very popular among recreationists. It is of paramount importance to take precautions when traveling from lake to lake in this region in order to avoid new introductions of spiny water fleas and other AIS. As a prolific predator of native water fleas and other zooplankton, the spiny water flea has potential to cause significant impacts to the aquatic ecosystem.

For those of us who appreciate the lakes and streams of the north woods, the discovery of an aquatic invasive species (AIS) is viewed as a tragedy and evokes a strong desire to fix the problem. Since there are no methods available for eradication or control of the spiny water flea, understanding the potential impacts is essential to managing Stormy Lake. Our focus in this plan is to minimize the risks that Stormy Lake faces from its population of spiny water fleas and to minimize the opportunities for Stormy Lake spiny water fleas to invade unoccupied lakes.



In response to the spiny water flea infestation of Stormy Lake (Wisconsin), Gile Flowage (Wisconsin), and Lake Gogebic (Michigan), a large-scale project was undertaken which included: (1) a comprehensive education and response program; (2) adaptive management plans for the Stormy Lake, the Gile Flowage, and Lake Gogebic; (3) graduate level research on the subject spiny water flea populations, related ecosystem impacts, early detection. The research is also intended to predict susceptibility of lakes to spiny water flea invasion and to predict spiny water flea abundance. The *Stormy Lake Adaptive Management Plan* is an overarching document that contains several major components including the *Stormy Lake Aquatic Plant Management Plan* and the *Stormy Lake Spiny Water Flea Plan* (this document).

Another product of the large-scale project was a regional strategic response plan: ***A Strategic Plan to Address Spiny Water Fleas in Northern Lakes Region*** (Premo and Stine 2015). That document establishes a systematic protocol for responding to spiny water fleas in the lakes of northern Wisconsin and Michigan's Upper Peninsula. This *Stormy Lake Spiny Water*

Flea Plan (this document) focuses primarily on Stormy Lake itself. Nevertheless, its benefits will extend to the entire region.

The audience for this plan includes those who are concerned with the quality of Stormy Lake. This includes landowners, recreationists, natural resource professionals, educators, law enforcement, the Stormy Lake Association (SLA), watershed organizations, businesses and organizations involved with tourism and outdoor recreation (such as bait dealers and shops, resorts, and tourism councils), invasive species organizations, and many others.

The purpose of *Stormy Lake Spiny Water Flea Plan* is to: (1) summarize the context and status of spiny water fleas in Stormy Lake, (2) outline the potential impacts to the Stormy Lake system, (3) describe mitigation approaches to spiny water fleas and present ideas for minimizing their impacts in Stormy Lake; (4) describe the method by which spiny water fleas can be contained in the Stormy Lake system, and (5) outline ways to monitor the Stormy Lake ecosystem and spiny water flea population, and (6) outline practical actions to take.

It is important that this *Stormy Lake Spiny Water Flea Plan* leads to actions that serve to minimize the spread of invasive spiny water fleas to new water bodies and also to prevent the introduction of any new aquatic invasive species into Stormy Lake. What is the knowledge base of the lake home/resort owners living on Stormy Lake about the spiny water flea and its dispersal? Who is watching out for Stormy Lake and protecting the lake from further introductions of AIS? Are you? We cannot do it alone. With help of others this plan can be implemented.

This plan offers actions steps to be undertaken by responsible stewards at Stormy Lake and water bodies in the surrounding region. These actions steps are summarized below but can be found in full detail at the end of this document.

- Education – Work with law enforcement, members of the SLA, other agencies, resorts, and bait dealers etc. on the dispersal of the spiny water flea.

- Volunteers - Enlist more volunteers to monitor boat landings to educate patrons that use Stormy Lake on spiny water flea dispersal and continue to create funding for the boat sprayer attendant already in place. Continue to enroll members in the Stormy Lake Association to help with this endeavor and others.

- Monitoring – Continue to conduct baseline monitoring for water quality and zooplankton densities on Stormy Lake. Conduct a baseline fishery survey to see if the fishery ecology has changed over time due to spiny water flea invasion. Continue to research the spiny water flea and other AIS for a better understanding of them.

This plan has benefitted by the work and contributions of many individuals familiar with Stormy Lake. Members of the Stormy Lake Association have been supportive throughout the project. Their concerns and observations have been a great asset. University of Wisconsin-Madison graduate student Jake Walsh has researched the Stormy Lake spiny water flea population as part of his doctoral program. His work had a practical approach that will prove to be useful in future work on spiny water fleas in Stormy Lake and elsewhere. This document benefits greatly from his contributions.

INTRODUCTION

This plan is one product of a broad project funded by the Wisconsin Department of Natural Resources (WDNR) Aquatic Invasive Species Control Grant that addressed spiny water flea populations in Stormy Lake (Vilas County, Wisconsin), the Gile Flowage (Iron County, Wisconsin), and Lake Gogebic (Ontonagon and Gogebic Counties, Michigan). The broadly-scoped project included research, planning, education, and response components. Since our area of interest includes two states and several counties and other jurisdictions, plan implementation requires earnest cooperation between these entities. The project for which this plan is a product, has an associated research component that will further our understanding of spiny water fleas in northern inland lakes. At the time this project was initiated, we realized the importance of quickly increasing our knowledge of spiny water flea ecology. The research component took as its premise the fact that spiny water fleas are being introduced to inland water bodies by humans (usually unknowingly).

Graduate student Jake Walsh (University of Wisconsin Madison, Center for Limnology) with separate funding from the WDNR, has investigated the impact and management of the spiny water flea in the invaded lakes of Wisconsin including four Yahara Chain Lakes near the city of Madison (Lakes Mendota, Monona, Waubesa and Kegonsa), two Northern Wisconsin lakes (the Gile Flowage and Stormy Lake) and Lake Gogebic in the Upper Peninsula of Michigan. Carol Warden (AIS Specialist) from the UW Trout Lake Research Station conducted the zooplankton monitoring on Stormy Lake, the Gile Flowage, and Lake Gogebic and also helped with other segments of Walsh's research. Working closely with the WDNR (Iron and Vilas Counties, Wisconsin), lake associations (Lake Gogebic Improvement Association, Friends of the Gile Flowage, and the Stormy Lake Association), and a private consulting firm in Northern Michigan (White Water Associates), the research hopes to contribute to a better understanding of the impact of the spiny water flea and improve our strategies for limiting its spread in the region.

Since there are no methods for eradication or control, understanding spiny water flea impacts is essential to managing invaded systems. Walsh's research regularly monitored zooplankton communities and water clarity of the six invaded Wisconsin Lakes and Lake Gogebic (Michigan), to lend insight into how invaded food webs are changing after the spiny water flea invasion.

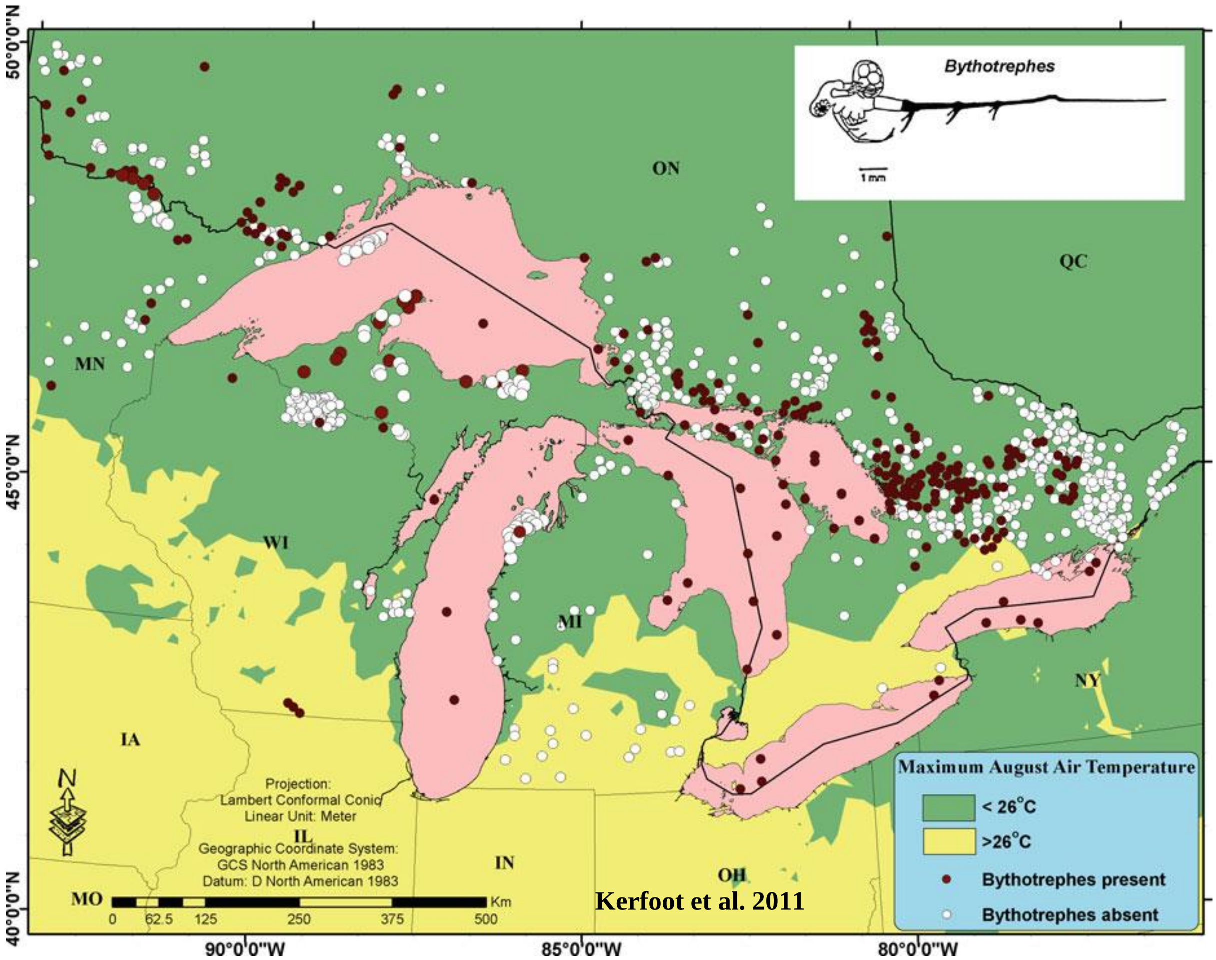
Walsh's research investigated early detection methods. The spiny water flea is a particularly difficult invader to detect early in newly invaded lakes due to high spatial and seasonal variability in its abundance. To improve detection methods Walsh evaluated the detection probability of currently employed and known zooplankton net haul methods at times of low spiny water flea densities in lakes. He is also investigated a detection method that is effective regardless of seasonal or spatial variability by searching for tail spines and resting eggs in sediment samples (Exhibit 2).

Exhibit 2. Jake Walsh taking a sediment core from Wisconsin's Gile Flowage. Photo: Carol Warden.

Finally, some of Walsh's research effort was directed at identifying spiny water flea transport vectors. By simulating recreational activities on various types of watercraft, Walsh conducted thorough inspections to identify where spiny water flea are most likely to escape current decontamination efforts. Integrating this information with current research on the most effective decontamination solutions (conducted by Dr. Branstrator at the University of Minnesota-Duluth) will hopefully reveal the most effective tools and techniques for minimizing the spread of spiny water fleas in Wisconsin and Michigan.

We feel a sense of urgency with this effort. When we began in 2012, there were only two lakes in northern Wisconsin with documented spiny water flea populations. Recently, additional spiny water flea locations have been documented in Wisconsin, including Star Lake in Vilas County (2013), Butternut Lake in Forest County (2014), Trout Lake in Vilas County (2014), and most recently, Ike Walton Lake in Vilas County (2015). Exhibit 1 displays a map of the northern Wisconsin Lakes with the spiny water flea present with a few noted in the Upper Peninsula. Exhibit 3 displays a map from research conducted by Kerfoot et al. (2011) that illustrates presence/absence of spiny water fleas in lakes of the Great Lakes region. In this study, presence or absence was determined by evaluating the sediment for spines and resting eggs. With each additional spiny water flea population the risk to other water bodies increases. We must collectively act now to minimize this dispersal. The ecological and economic impacts are largely unknown and potentially enormous. Humans are the cause. Humans are the answer. What can you do? This plan will answer that question. Our children and grandchildren depend on our responses. This *Stormy Lake Spiny Water Flea Plan* comprises eleven sections (including this one). This is an adaptive plan that we assume will be modified as time passes.

Exhibit 3. Presence/absence of spiny water fleas of the Great Lakes region.



SPINY WATER FLEA

The spiny water flea is predatory zooplankter in the genus *Bythotrephes* (byth-o-TREH-feez). A spiny water flea has an exceptionally long, sharp, barbed tail spine and a balloon-like egg (brood) pouch (Exhibit 4). The overall length (head to tip of tail) is about half inch long and this makes spiny water fleas much larger than most other zooplankton native to northern lakes region. *Bythotrephes* is native to Europe and possibly was introduced to North America by ballast water from ocean going ships. It first appeared in Lake Huron in 1984. Since then populations have exploded in the Great Lakes and many inland lakes.

Exhibit 4. Spiny water fleas have a long tail spine and brood pouch (Photo by Jake Walsh).

The rapid spread and great abundance of spiny water fleas is in part due to their reproductive cycles. Spiny water fleas are active in waters from late spring until late autumn (Berg 1991). As water temperature increases, individuals hatch from resting eggs that have overwintered on the lake bottom (Berg 1991). An individual spiny water flea may live for several days to a few weeks. Spiny water flea populations consist mainly of females (Berg 1991). The females produce eggs that remain unfertilized and are carried in the mother's brood pouch until they develop into female offspring (Berg 1991). This cycle of asexual reproduction (requiring no fertilization) continues as long as the water temperature is neither too hot nor too cold and food is abundant (Berg 1991). When the environment deteriorates, or when water temperature and sunlight decline in the late summer and early autumn, the number of males and sexually reproductive females present in the population increase (Jarnagin 2000). With males present sexual reproduction can occur and the resulting fertilized eggs (Berg 1991). The diapausing eggs are dense and rapidly sink to the bottom, where they overwinter to form a seed bank that founds the next season's population (Jarnagin 2000). The adult spiny water flea dies following reproduction (Berg 1991). Spiny water flea resting eggs can withstand many environmental stresses. In the *Great Lakes Echo*, Hopps (2013) quotes University of Minnesota researcher Donn Branstrator, "You can put them in chlorination for a few days, and they can survive that. You can put them to salt water or warm temperatures, and they survive that. They're really durable. They're believed to be the life state that helps facilitate dispersal from one location to the next."

Spiny water fleas are predators that feed on smaller planktonic animals (for example, native water fleas). Spiny water fleas compete with native planktivores and fishes for this food source and the food web can be altered because of this competition. The most noticeable effects are on populations of native water fleas in the genera *Daphnia* and *Leptodora*. In the article *A Plague of Fleas,* Goodrich (2014) quotes Michigan Technological University Professor Charles Kerfoot, "*Bythotrephes* is having as much impact on the plankton communities as quagga mussels have had in Lake Huron and Lake Michigan. We expect it will have cascading effects up to the fish, but right now, we can see a major collapse of the plankton community." Tail spines protect *Bythotrephes* against young of the year, but not larger fish (Kerfoot et al. 2011). Once ingested by fish, spiny water flea spines may cause damage to the digestive tract of fish (Kerfoot et al. 2011). In the *Great Lakes Echo*, Hopps (2013) quotes Branstrator, "The bigger fish that do consume the spiny water fleas have a big difficulty in passing that spine, so that spine gets hung up in the stomach like a ball and needles. In some of the fish, the spines were penetrating the stomach wall, and the stomachs looked like a pincushion with a bunch of spines sticking out of it." Resting eggs can survive passage through the digestive tract of fish predators, a trait that enhances their dispersal abilities (Kerfoot et al. 2011). This implies that minnows taken from *Bythotrephes*-infested waters and used for bait in another lake can deficate viable eggs into the new lake (Kerfoot et al. 2011). Dispersal by recreational fishing is linked to use of bait fish, diapausing eggs defecated into live wells and bait buckets, and *Bythotrephes* snagged on fishing line, anchor ropes, and minnow seines (Kerfoot et al. 2011). Since the spiny water flea discovery zooplankton sampling has been conducted on Stormy Lake.

STATUS OF THE STORMY LAKE INVASION

Spiny water fleas were discovered in Stormy Lake in August, 2007. At that time, Stormy Lake was one of a few lakes in the northern region to have a confirmed population of *Bythotrephes*. In the Lakeland Times, Bortz (2007) quotes a researcher from the University of Wisconsin Trout Lake Station Jim Rusak, "The populations of tiny invasive crustaceans were discovered by fellow researchers toward the end of August, 2007. A graduate student of mine and her undergraduate assistant were working on another project looking at zooplankton in lakes that had been invaded by rusty crayfish, and in the course of that sampling, they came across *Bythotrephes*." University of Wisconsin limnologist, Jake Vander Zanden, said that the spiny water flea may have been brought to Stormy Lake by someone who had been on the Gile Flowage or possibly a lake in Michigan's Upper Peninsula and did not properly wash their boat before launching at Stormy Lake (Bortz 2007). In a follow-up visit, the researchers went back to confirm spiny water flea presence in Stormy Lake because they only found one individual when they were looking at the original samples. Rusak said "It turned out that there were more of them than I would have expected (Bortz 2007)." To test the water, the researchers sampled at different depths and found densities that were very high. Rusak said, "For instance, in one two-minute tow we found over 50 individuals (Bortz 2007)." Carol Warden, Aquatic Invasive Species Specialist, UW Trout Lake Center for Limnology, assisted in Jake Walsh's spiny water flea research project by monitoring *Bythotrephes* abundance in the northern lakes (including Stormy Lake). Walsh conducted monitoring on southern Wisconsin lakes that had the spiny water fleas. Walsh and Warden conducted this monitoring work using a zooplankton net (Exhibit 5). During a given monitoring bout, three vertical tows were taken at the deepest spot on Lake Gogebic to cover essentially the entire water column. Two meters were subtracted from the whole depth to compensate for the length of the net; this ensures not to get sediment in the sample. Native zooplankton species were sampled during each monitoring bout using a single tow with a finger-meshed net. Stormy Lake was sampled every other week during the sampling seasons of 2012 to 2014.

Exhibit 5. Carol Warden sampling for spiny water fleas (Photos: Jim Kreitlow WDNR).

Bythotrephes' abundance is shown in Exhibit 6 for Stormy Lake and the Gile Flowage. Stormy Lake SWF densities are shown in Exhibit 7. Walsh (2015) explains *Bythotrephes* is more consistently abundant throughout the Gile Flowage than in Stormy Lake. *Bythotrephes* seems to appear earlier in the Gile Flowage and sustain higher densities throughout the summer while Stormy Lake densities are less consistent later in the fall. Densities in both lakes remain low until May or June and return to lower densities in late-November or December (Walsh 2015).

Exhibit 6. Gile Flowage and Stormy Lake Spiny Water Flea Densities 2013 (Walsh 2015).

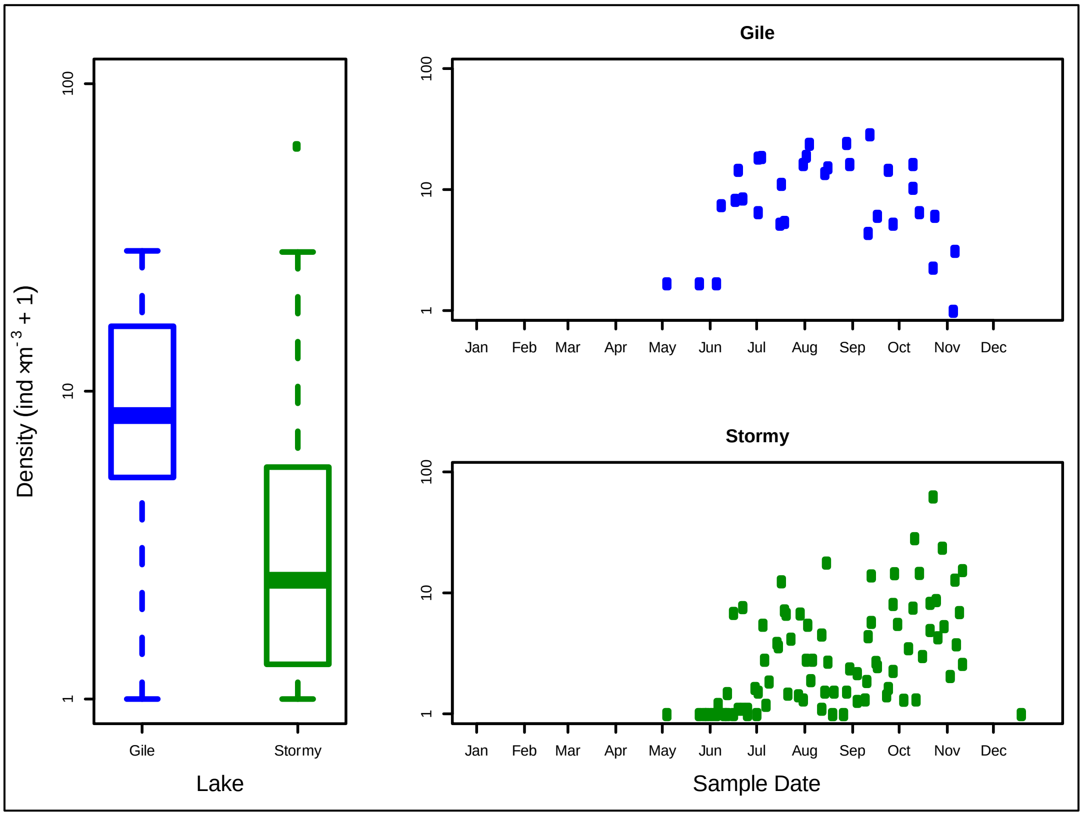
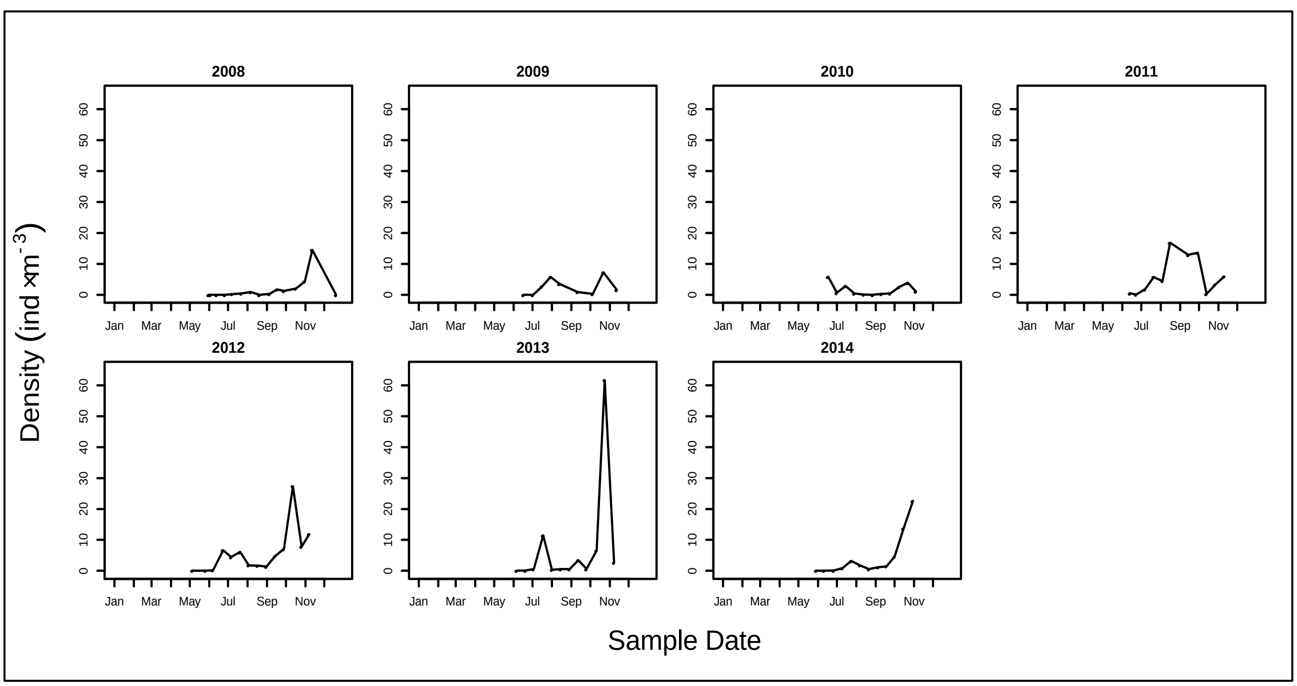
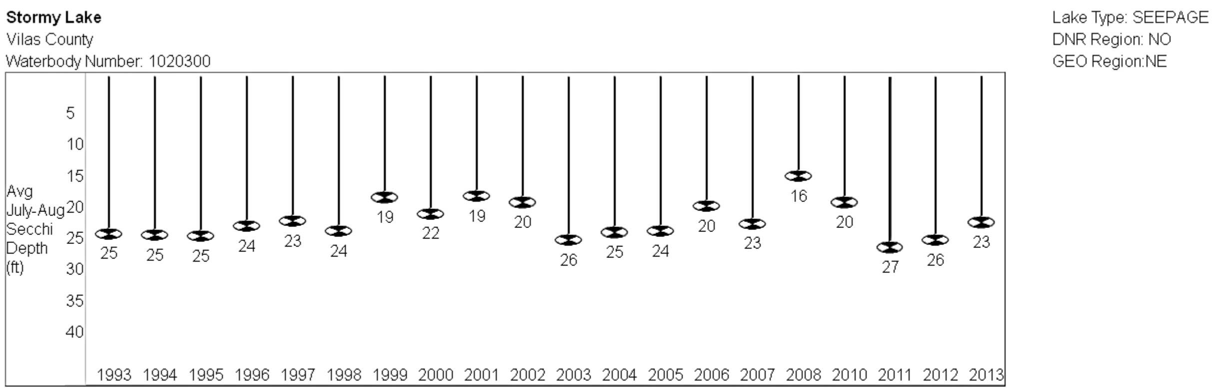


Exhibit 7. Stormy Lake Spiny Water Flea Densities (Walsh 2015).



The 2007 discovery of spiny water fleas in Stormy Lake was followed by a year of lower typical water clarity (2008), although this clarity increased back to typical levels the following year (2009) (Exhibit 8 and 9).

Exhibit 8. Stormy Lake Secchi Disk Reading (feet) (1993-2013) (WDNR 2015).



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

Exhibit 9. Stormy Lake Secchi Disk (1993-2013) (WDNR 2015).

Year	Secchi Mean	Secchi Min	Secchi Max	Secchi Count
1993	24.88	21	26.25	8
1994	24.9	22.5	27	5
1995	25.17	24.5	26.5	3
1996	23.6	20.25	27.5	5
1997	22.85	20.25	25	5
1998	24.44	22	26.5	4
1999	19.06	16.75	22.25	4
2000	21.58	17.25	26.25	6
2001	18.85	17.75	20.25	5
2002	19.85	18.75	22	5
2003	25.88	21.25	29.75	4
2004	24.67	21.75	30	3
2005	24.42	21.75	26.25	3
2006	20.44	17.5	25.75	4
2007	23.25	19.25	27.25	2
2008	15.65	10.91	19.08	3
2010	19.75	18	22.75	3
2011	27	27	27	2
2012	25.8	22.5	27.5	5
2013	23	23	23	1

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POTENTIAL IMPACTS

Spiny water fleas can have important impacts on the freshwater ecosystem, altering it in both obvious and subtle ways. Spiny water fleas can:

- Alter and redirect food web pathways,
- Deplete the food supply for native zooplankton,
- Reduce food supplies for small baitfish and young game fish (e.g., bass, walleye, and yellow perch),
- Easily spread between waterbodies on angling equipment, mud on anchors and rope, bait buckets, in live wells, and bilge water,
- Reproduce rapidly and form large populations,
- Create conditions favorable to noxious algal blooms, and
- Impact recreational angling and commercial fishing (spines catch on fishing line and other equipment, clog fishing nets, and foul trawl lines).

In an article called *Invasive Spiny Water Flea Found in Trout Lake* (2014) on the UW-Madison Center for Limnology website, Jake Walsh mentions that the spiny water fleas negatively impact water quality. Walsh has spent several years researching the impacts of spiny water fleas in Lake Mendota in Madison, Wisconsin. In Lake Mendota, spiny water fleas eat the native water fleas in the genus *Daphnia* that would otherwise be eating the planktonic algae. The result is more algae in the water column and reduced water clarity. "After the spiny water flea invasion was detected in 2009," he says, "summer and fall *Daphnia pulicaria* populations were reduced by 93% and the average Secchi depth, a measure of water clarity, declined by a meter."

MITIGATION

At present, there is no known method for eliminating spiny water fleas once established in a lake. Currently, no chemical treatments are effective or feasible for controlling spiny water fleas in water bodies. Some fish are able to prey on spiny water fleas despite the defensive tail spines. Roesler (2004-08) explains that fish larger than 4 inches in length can feed on spiny water fleas. For some water bodies (for example the Gile Flowage), the WDNR considered enhancement of the planktivorous fish populations, especially bluegills and crappies to possibly control spiny water fleas through predation. Of course, this action might cause unanticipated changes in the ecosystem.

CONTAINMENT

When we began the spiny water flea project in 2012 there were only two water bodies in the northern Wisconsin that contained spiny water fleas. Since that time, three additional spiny water flea locations have been discovered. Exhibit 1 and Exhibit 3 illustrate the spiny water flea localities known to date in the northern region of Wisconsin and a few locations in the Upper Peninsula. With each additional spiny water flea infestation, the risk to other water bodies increases. Since within lake control of spiny water fleas is not currently possible, we must focus our attention on minimizing their dispersal to new lakes. Not only do Stormy Lake stakeholders have to care for a spiny water flea-stressed Stormy Lake, they have an additional responsibility of protecting other lakes from getting infected by spiny water fleas coming from Stormy Lake. Making sure that Stormy Lake users are educated about AIS transport, and more importantly, clean their boats and gear upon entering AND leaving Stormy Lake is crucial to containing spiny water fleas in Stormy Lake. Our best option for protecting other waterbodies is to contain the existing populations of spiny water fleas and other AIS. The broader, strategic response plan ***A Strategic Plan to Address Spiny Water Fleas in the Northern Lakes Region*** (Premo and Stine 2014) discusses a strategic response to spiny water fleas in the northern region, but has information and references of interest in the context of the *Stormy Lake Spiny Water Flea Plan*. In this section, we discuss aspects of spiny water flea containment for Stormy Lake stakeholders.

Spiny water fleas originally traveled to North America in the ballast water of transoceanic ships. When the ballast was emptied in the Great Lakes, spiny water fleas were released into an environment ripe for their colonization. Adults and/or resting eggs may have hitched a ride on a sediment-incrusted anchor, a damp rope or live wells that may have been used. From the original introduction, these spiny water fleas, primarily moved from one body of water to another along pathways that are either natural (for example, water connections between lakes) or human-influenced (such as roads along which recreationists and their boats and trailers might travel).

Some type of vector(s) facilitates the transport of viable spiny water fleas along human-influenced pathways. Likely vectors are sometimes obvious and sometimes unexpected. Boats, canoes, kayaks, engines, and boat trailers are among the more obvious. Less obvious vectors include live bait containers and bait, anchors and ropes, fishing equipment (down riggers, line, and nets), SCUBA gear, mud on waders, research equipment (such as plankton nets and aquatic plant rakes), fish management equipment (such as nets, trucks, and hoses for planting fish), float planes, recreational fun equipment (lifejackets, tubes, and ski rope), and even pets that might swim in a spiny water flea infected lake. Water taken from a "dry hydrant" for fire-fighting purposes might carry an aquatic invasive species to a new location.

It is strategic to focus attention on the pathways that emanate from known spiny water flea source waters. These waters allow opportunities for transfer of spiny water fleas to uninfected sites. Spiny water flea adults are sensitive to exposure to air and sunlight but the resting eggs are more durable and can survive through winter on lake bottoms and can be transported long distances on boats and equipment if they stay moist. Shorter transportation distances increase the likelihood of a viable introduction to a new water body. With regard to understanding and minimizing the dispersal of spiny water fleas, several questions are germane:

- How do recreationists and other people use Stormy Lake?
- After leaving Stormy Lake, where do people go next?
- What is the basic understanding of recreationists and other water users regarding AIS?
- How do recreationists and other surface water users behave with respect to minimizing AIS transport?

A Vulnerability Assessment of Wisconsin's Inland Lakes to the Invasive Aquatic Predator Bythotrephes (Braun et al. 2009) indicates that lakes within a 50 mile radius of a source lake may be more vulnerable to the spiny water flea than others due to their proximity to infected waters. Star Lake (Vilas County, Wisconsin) was listed as one of the lakes vulnerable to infection by spiny water flea. In 2014, spiny water fleas were documented in Star Lake.

HOW CAN WE STOP MOVEMENT OF INVASIVE SPINY WATER FLEAS BETWEEN WATER BODIES?

In order to stop the movement of spiny water fleas to new locations it is crucial that we intercept and sanitize the vectors that humans move from one water body to another. There are several tools to assist in this endeavor and they can be organized in the following three categories: (1) laws, regulations, and agreements, (2) education and information, and (3) techniques and equipment for cleaning and decontamination. Each of these categories is described in this section.

Laws, Regulations, and Agreements

Although we must rely in large part on the good intentions and conservation-minded behavior of recreationists with respect to preventing movement of AIS, laws and regulations are essential tools. Traffic signs remind us of laws that, for the most part, we voluntarily respect. For example, most of us obey a “STOP” sign whether a police officer is in view or not. We not only feel an obligation to be law-abiding, but we also tend to avoid the risk of a fine or ticket. In recent years, laws and regulations have been drafted to control the spread of AIS. These are useful in that they provide additional incentive to recreationists and others to practice “safe recreation” – that is, taking care not to infect water bodies with AIS. The threat of a significant fine for plant fragments on boats or un-drained live wells helps alert people to the importance of the issue and reminds them that resource agencies and law enforcement treat these topics very seriously.

The prevention and control of aquatic invasive species requires laws, regulations, policies, and programs at various levels of government. Because of the many ways AIS can travel and the importance of transportation to their movement, a consistent regulatory approach and program implementation is needed at both the state and federal levels.

At the federal level, the National Invasive Species Act (overseen by the US Coast Guard) is responsible for regulating ballast water. The Office of Law Enforcement of the US Fish and Wildlife Service is responsible for enforcing the injurious wildlife provisions of the Lacey Act. This law authorizes the Secretary of the Interior to list as “injurious” any wildlife deemed to be harmful “to human beings, to the interests of agriculture, horticulture, forestry, or to wildlife or the wildlife resources of the United States.” It prohibits import and interstate transport of any live specimen of a listed species without a permit from the U.S. Fish and Wildlife Service. The maximum penalty for violating the injurious wildlife provisions of the Lacey Act is six months in prison and a $5,000 fine. This includes crustaceans. The National Invasive Species Information Center (USDA) has a site that has links to Wisconsin’s and Michigan’s existing laws and regulations that address prevention and control of AIS (http://www.invasivespeciesinfo.gov/laws/wi.shtml#.UPcYS_L55iQ).

In 2001, Wisconsin adopted Act 109: s. 30.715 which states that, “Placement of boats, trailers, and equipment in navigable waters. No person may place or use a boat or boating equipment or place a boat trailer in a navigable water if the person has reason to believe that the boat, boat trailer, or boating equipment has any aquatic plants or zebra mussels attached; a law enforcement officer may order the person to remove plants or zebra mussels, or to remove or not place the boat in the water." Fines can be substantial under this law. In Wisconsin, the spiny water flea is classified as "prohibited invasive species," meaning it is unlawful to transport, possess, transfer, or introduce it within the state. The stakeholders that use Stormy Lake need to understand what precautions to take.

Along with laws, it is important to have law enforcement agencies engaged with educating and enforcing AIS prevention and laws. WDNR wardens, Wisconsin Water Guards, and other law enforcement officials perform education and law enforcement duties to protect Wisconsin lakes, rivers, and waterways. Continuing education of these important players is crucial in preventing the spread of AIS. Wisconsin has initiated a Water Guards Program through which "Deputy Conservation Wardens" perform education and law enforcement duties to protect Wisconsin's water bodies. Their main efforts are aimed at ensuring compliance with Wisconsin's laws relating to preventing the spread of aquatic invasive species and aquatic diseases. CBCW in Wisconsin has added a violation report form to fill out so they can contact a regional water guard or warden with information such as make/model of the boat and registration number and vehicle license numbers. Many recreationists feel as though enforcement of the Wisconsin laws with regard to AIS transport could be more rigorous in order to elevate the profile of this kind of recreational violator.

Over the course of our work on this spiny water flea project, we have noted as more that decontamination practices are varied and have changed as more research was conducted. Some organizations followed one decontamination protocol while others did something different. We feel it is important for there to be greater communication and cooperation between resource agencies, university researchers, consulting scientists, and other groups when it comes to developing and sharing standard operating procedures for decontamination of equipment and monitoring.

Education and Information

Education and outreach have been important to limiting the movement of AIS to other water bodies. Surveys and data indicate that education can be extremely effective in preventing the spread of invasives, but the battle will not be won with a statewide educational approach alone. Individuals have to think about how they can make a difference and help to educate others in efforts to help prevent the spread of spiny water fleas. During the course of our work on this project, it has been surprising to us how few anglers know about spiny water fleas even though they may fish and boat in spiny water flea waters. On a hopeful note, the recent discovery of spiny water fleas in Trout Lake, Vilas County, Wisconsin (2014) was made by a concerned citizen that was aware of the spiny water flea. Carol Warden, (AIS Specialist UW Trout Lake) states "It's so important to have citizens who are aware and volunteers out there looking for things like this." "They can be our eyes and ears for when the DNR and the Center for Limnology can't be out on the water." Warden also says that the new discovery highlights the importance of continuing many education and outreach programs, like Clean Boats, Clean Waters.

The Clean Boats, Clean Waters (CBCW) program has been active for many years in Wisconsin. The CBCW program has made great strides in improving its data collection and in understanding what educational materials and outreach techniques are working. Boaters are getting the message about draining water from their boats and looking for aquatic plants and animals before leaving the landing. Improvement needs to occur in using live bait and releasing unwanted live bait into water (viable resting eggs may be in the gut of baitfish and transferred to another lake when the baitfish eliminates). An effective technique to prevent transfer of spiny water fleas is to allow boats and equipment to dry for at least five days if other forms of decontamination are not used. Most boaters are not going out of their way to wash their boat if there is not a sprayer handy at the landing and many are not flushing the motor's cooling system with tap water after each use. The CBCW handbook is available on-line (see below). As part of this project, we have developed a brochure directed at the northern lakes region by drawing from brochures that specifically address the spiny water flea. This brochure is included as the final pages of this document. For the Wisconsin handbook, see the following link:

- CBCW Wisconsin Handbook:
  http://www.uwsp.edu/cnrap/UWEXLakes/Pages/programs/cbcw/forms.aspx

The CBCW program staff gathers information at boat landings from recreationists regarding their behaviors with respect to decontamination and travel to and from lakes. Information regarding the lake where a boat was last used and where it is likely to go next is important in understanding the pathways for AIS. It would be very beneficial for Stormy Lake to enlist volunteers to monitor the Stormy Lake boat landing for educational purposes on AIS entering the lake and also from AIS leaving the lake. Workshops on volunteer monitoring are effective educational opportunities and are hosted by the various organizations. Wisconsin County AIS coordinators often host these workshops.

Signage has been the most frequently used means of helping boaters learn about aquatic invasive species and ways to minimize the possibility of transport. Another effective educational product is the dissemination of brochures on procedures of cleaning your boat. Dane County, Wisconsin has realized that people do more to remove AIS from their boats and equipment if they have appropriate tools available. Dane County has, therefore, incorporated a selection of actual tools attached to AIS signage and available for public use (Exhibit 10). The most current sign the WDNR is shown in Exhibit 11. The sign posted at many of the northern lakes in the Ottawa National Forest is very descriptive with nine colored images and a picture of a boat and trailer (Exhibit 12).

Exhibit 10. Aquatic invasives removal station sign in Dane County, Wisconsin (photo by Pete Jopke, Wakeman 2012).

Exhibit 12. Ottawa National Forest AIS Sign.

Exhibit 11. Current WDNR Boat Landing Sign (WDNR 2013).

Techniques and Equipment for Cleaning and Decontamination

Laws, regulations, and education are all important precursors for getting recreationists to adopt "safe" practices with regard to transporting AIS. In addition, several techniques and types of equipment have been found useful in that regard. For example, an effective way to stop the spread of spiny water fleas is to wash boats and equipment using a high-pressure washer with water heated to at least 122°F. It is most effective if the contact is five minutes in duration.

If a portable boat sprayer is not available, a car wash is a suitable alternative to clean your boat. In the absence of a boat sprayer or car wash, the boat and trailer can be sanitized by allowing your boat and equipment to dry for at least 5 days (depending on the time of year) before entering another water body. It is important for recreationists to understand that some of the simplest and the least expensive measures that take only minutes will make the biggest difference in the fight to stop invasives. The following steps are effective, efficient, and economical to reduce the spread of AIS:

- **INSPECT** and **REMOVE** aquatic plants and animals, including gelatinous or cotton batting-like material from lines, especially where they meet a swivel, lure or downrigger ball connection (a helpful check list see SWF brochure at conclusion of this appendix);
- **DRAIN** water from the boats, motors and all equipment before leaving access;
- **NEVER MOVE** live fish or bait water away from a waterbody;
- **DISPOSE** of unwanted live bait, worms, and fish parts in trash;
- **BUY** minnows from a State bait dealer. [1]
- **RINSE** boat, trailer and equipment (anchor/rope) with hot and/or high-pressure water, AND/OR
- **DRY** for five days or more before use. Open up areas that may have a lid to dry out. Use a towel to dry out your live well or areas that may hold standing water. If you are using a canoe/kayak dry the inside and outside using a towel.

  In a 2015 email correspondence with Angie Stine (White Water Associates), researcher Jake Walsh summarized the latest decontamination research conducted by Donn Branstrator (Walsh 2015). In the following bullets, we capture Walsh's summary.

[1] *The WDNR website describes bait laws: http://dnr.wi.gov/topic/Invasives/boat.html.*

- Donn Branstrator (U. of MN – Duluth) has done quite a bit of work looking at survivorship of resting eggs under different physical and chemical stressors.
- The most reliable method for decontaminating boats and equipment of resting eggs is desiccation. Eggs will die after only a few days of dry conditions, however ensuring dry conditions in areas of equipment and boats that hold water for longer time periods could take longer than just a few days. For example, exposure to desiccation at 17°C (62.6 °F) for more than 6 hours will dramatically reduce hatching success, however ensuring that all possible egg-carrying areas on boats and equipment will clearly take more than 6 hours.
    - Relatively (to other cladoceran zooplankton) low tolerance to desiccation (tolerance for < 4 hrs.) could be a factor in why *Bythotrephes* has spread more slowly than zooplankton with more desiccation tolerant resting stages. This means that if we can control how long we dry out boats, trailers, and equipment, we could have a solid chance at dramatically reducing the speed at which *Bythotrephes* in spreading. This is particularly true for lake-rich regions like the Northern Highlands Lake District.
- A combination of intense heat and drying is likely the best option for sediment sampling equipment (see Branstrator 2013, Limnology and Oceanography).
    - Exposure to 50°C (122 °F) for 5 min should render all eggs unviable.
    - If greater than 50°C (122 °F) can be reached, the time of exposure should be shorter (however, it may be worth investigating heat's effect on expensive research equipment).
    - So for equipment like zooplankton nets or Ekman grabs, heating should be followed up by dry conditions for 6 hrs.; however the heat should be effective at killing resting eggs.
    - It would be difficult to heat boats and trailers to 50°C (122 °F), highlighting the need to dry boats and trailers for the appropriate length of time.
- It is very important to follow decontamination protocol for any equipment used to sample for *Bythotrephes*. This is particularly true for the sediment where hardy resting eggs are waiting to hatch. Eggs in the sediment may be among the primary

pathways of spreading *Bythotrephes* due to their wide range of tolerance to physical and chemical stresses.

- Bleach, salt, vinegar (or other acids), and freezing are not reliable methods of killing resting eggs. In fact, trying to dry out equipment in sub-freezing conditions could increase the probability of egg survival.

If you must enter another body of water within 5 days, wash your boat, trailer, anchor, rope, downriggers, waders, etc. with hot water (sustained exposure to 122 °F for 5 min, or shorter durations at higher temperature-eliminate hatching of resting eggs (Branstrator et al. 2013) first. Then dry. Flush your motor's cooling system, live wells, bilge and other boat parts that get wet. Consider having alternative anchor ropes, nets, equipment, etc. A suggestion for Stormy Lake landowners is to designate a boat to use on Stormy Lake and have another boat to use on other waterbodies. Another suggestion is to purchase a portable boat sprayer for the boat landing to be used by stakeholders using the lake.

In August and September of 2006, a study was conducted to determine the effectiveness of using a boat sprayer to remove spiny water flea and Eurasian water milfoil (Rothlisberger et al. 2010). Northern Wisconsin and Upper Peninsula (Michigan) lakes were part of this study (including Lake Gogebic). They gathered data on the types and quantities of aquatic organisms inadvertently transported by recreational boaters. All arriving and departing boats were washed using a portable high-pressure wash and reclaim system and visually inspected. The wash water was captured on a waterproof mat and then pumped into a filtration and reclamation system, using a food-grade polyethylene filter that trapped materials removed from the washed boats. They used separate filters for departing and arriving boats but boats, but more than one boat was washed per filter. An in-person survey was also conducted along with mailing out surveys asking questions about boating travel and AIS removal. They performed two experiments to test the effects of cleaning method and duration on the removal of aquatic macrophytes (Eurasian water-milfoil) (first experiment) and small-bodied animals (spiny water flea) and plant seeds (second experiment) from the exterior of boats and trailers. They looked at three levels of cleaning methods: (1) low-pressure wash, (2) high-pressure wash, and (3) timed visual inspection (90 or 180 seconds) and removal of placed items on the boats and trailers. Of the 85 boats inspected and washed, 38 (45%) carried one or more plant fragments, but 30 of these had little material attached. Boats and trailers leaving the lakes were three times more likely to be carrying vegetation than those arriving: 7 of 36 boats (19%) arriving at a lake had vegetation attached, whereas, 31 out of 49 boats (63%) leaving had vegetation attached (Rothlisberger et al. 2010).

They collected 13 species of macrophytes but none were invasive. They also collected 51 taxa of small-bodied organisms which no AIS were found.

High-pressure washing, and visual inspection combined with hand removal, removed a significantly greater percentage of macrophyte vegetation than low-pressure washing. High-pressure washing removed a significantly higher percentage of small-bodied organisms (i.e., wetland plant seeds and *Bythotrephes longimanus*) than did low-pressure washing or visual inspection plus hand removal. The duration of cleaning effort (90 vs. 180s) did not significantly affect the percent removal of either. Drury and Rothlisberger (2008) demonstrated that for a wide range of hypothetical cleaning efficiencies placing a given number of inspection and cleaning stations at invaded lakes slows landscape-level spread of AIS more effectively than placing the same number of stations at uninvaded lakes.

The boat cleaning study (Rothlisberger et al. 2010) concluded that despite many years of campaigns to educate boaters, overland transport of aquatic organisms by boaters still occurs frequently. Data on self-reported cleaning rates and observations of organisms attached to boats and trailers during the study suggest that existing and previous education campaigns have not resulted in consistently high cleaning rates by boaters in the Great Lakes region (Rothlisberger et al. 2010).The spread of small-bodies organisms such as the spiny water flea is a concern without the use of high-pressure washing that can remove over 90% of small-bodied organisms, making it the most effective option for preventing the transport of small organisms.

MONITORING

Since the spiny water flea is established in Stormy Lake, it is beneficial to monitor zooplankton and spiny water flea abundance to understand how the lake is changing. A plankton sampler is a monitoring technique used to estimate population densities. A commercially made net can be purchased for this type of monitoring. Systematically sampling for spiny water flea requires a bit more training and specialized equipment. A 0.5-1 meter diameter, 250 micron mesh plankton net is the plankton tow net of choice. Typically, three samples are collected from a given lake on each of three dates between June and September (a total of nine samples per lake). The water temperature should be 54 degrees F or above. The plankton net is lowered vertically into the water and slowly brought to the surface where the sample is flushed into a bottle. The sample is preserved until it is examined for abundance of spiny water flea at a later date. A single tow with a finger-meshed net can be used to assess the native zooplankton population.

Monitoring the fish populations in Stormy Lake will also be indicative of change that might be associated with presence of the spiny water flea. Are there changes in the fish community composition? Are there any changes in size structure of the fish species present? What fish are eating spiny fleas?

Members of the Stormy Lake Association have been involved in Citizen Lake Monitoring. It is important to continue to monitor for aquatic invasive species along with continued education as more and more AIS are discovered in nearby waterbodies. The Citizen Monitoring goal is to collect high quality data, to educate and empower volunteers, and to share this data and knowledge. The volunteers measure water clarity, using the Secchi Disk method, as an indicator of water quality. Volunteers may collect water chemistry, record temperatures, and dissolved oxygen data, map plants, and look for aquatic invasives such as the zebra mussel and Eurasian water milfoil. Data is entered into a database for analyzing trends and distributions. Baseline data is important for any lake. If other AIS do end up in the lake, it is nice to have water quality data from before and after the invasion. Finally, it is critical to continue to monitor the boat landing on Stormy Lake and to educate lake users on the containment of the AIS present in Stormy Lake and the prevention of new AIS introductions.

WHAT DO WE DO NEXT?

It is important that this *Stormy Lake Spiny Water Flea Plan* leads to actions that serve to minimize the spread of invasive spiny water fleas to new water bodies. With that in mind, we offer the following list of actions to be undertaken by responsible stewards at Stormy Lake and the surrounding region.

Action 1: Work with law enforcement to ensure rigorous enforcement and education occurs.

Action 2: Enlist more volunteers to monitor the boat landings and educate land owners on proper decontamination to help prevent the spread of spiny water fleas. Organize a Clean Boats/Clean Waters and an AIS educational class in your area.

Action 3: Evaluate existing signage at the Stormy Lake boat landings and, where needed, install updated/new signs explaining decontamination in regards to spiny water flea adults/resting eggs.

Action 4: Hand out the brochure specific to the northern lakes region which describes the decontamination procedure specifically for spiny water fleas.

Action 5: Organize a media campaign with public service announcements in order to expand public awareness.

Action 6: Continue to monitor baseline monitoring on Stormy Lake for water quality and possibly zooplankton densities over time.

Action 7: Have the DNR conduct a more current baseline fish study on Stormy Lake to determine if the spiny water flea has changed the ecology of the fishery.

Action 8: Continue research on spiny water fleas.

Action 9: Identify strategic audiences within the landscape surrounding Stormy Lake for education on the spread of spiny water fleas and how to protect our native ecosystems (for example, bait shops, resorts, sporting goods stores, boater safety education classes offered in the school, offices that sell fishing licenses, fishing organizations, and lake associations).

Action 10: Organize an Aquatics Day to enlist more members into the SLA and have fun games and prizes. This would be a great opportunity to describe AIS and educate on the spiny water flea. Enlist the help of other organizations to facilitate this endeavor.

CONCLUSIONS

Stormy Lake is an ecosystem under stress from spiny water fleas. It is important for Stormy Lake stakeholders to help the health of the lake by minimizing other potential stressors. These include additional AIS, maintaining and creating good buffer zones along the lake shore to prevent additional nutrients from entering the lake, and maintaining good habitat in Stormy Lake. The concepts and suggestions put forth in this plan should be applied to Stormy Lake. The Stormy Lake Association can continue to work with others to build interest, involve volunteers, and funding to make this happen. Spread the word to people about how spiny water fleas can impact Stormy Lake and your recreational use of the lake. Educate yourself and others on how to stop the spread of spiny water flea into other waters. Your efforts will also help to stop any additional AIS to enter Stormy Lake.

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Spiny Water Flea

Spiny Water Flea (image is to scale relative to the native water flea shown below)

The spiny water flea (*Bythotrepes longimanus*) is an aquatic invasive species that is colonizing inland lakes of northern Wisconsin and Michigan's Upper Peninsula. This species of zooplankton is native to Northern Europe and Asia. First discovered in Lake Huron in 1984, they were probably transported there by ship ballast water. Spiny water fleas have since flourished throughout the Great Lakes and have invaded a large number of inland lakes in the northeastern U.S. and eastern Canada.

The spiny water flea belongs to a group of tiny crustaceans collectively called cladocerans ("water fleas"). Most native water fleas are crucial components of the aquatic food web where they feed on single celled algae (phytoplankton). The native water fleas act to prevent dense algal blooms and are themselves eaten by native fishes in vast numbers (they are the "krill" of the freshwater ecosystem. In contrast to most native water fleas, the spiny water flea is a predator that eats tiny zooplanters including native water fleas. They have the potential to alter the entire zooplankton community by their foraging. They directly compete with small fish for the native water flea food source. Many fish (young fish and minnows) cannot eat spiny water fleas because of the spine

Magnification is helpful in identifying the spiny water flea. Individuals are about ¼ to ½ inch (5-13 mm) in length. They have a long barbed tail with one to four pairs of barbs running down it. Since they are small and rather transparent, they tend to go unnoticed. However, they can be present in large numbers and sometimes accumulate on fishing lines and downrigger cables (see photo in upper right corner). When this happens anglers are likely to take note and may be the first to identify a spiny water flea population in a lake. Monitoring for spiny water fleas sometimes involves dragging a fishing line through the water. Sometimes a plankton tow net is used (see photo at right).

Spiny water fleas on a fishing line

Spiny water fleas produce through parthenogenesis, commonly known as asexual reproduction. This means that males are not required and populations can explode in number. Through sexual reproduction, spiny water fleas produce overwintering eggs.

Boats and equipment can transport spiny water fleas and their eggs to new water bodies. The resting eggs survive long after the adults are dead. They overwinter and can survive extreme environmental conditions. Over-wintering eggs can even withstand being passed through the digestive system of a fish. Care must be taken not to transport water, mud, vegetation, or fish between water bodies so that the spiny water flea is not accidentally transported to a new lake.

A plankton net

The History of the Spiny Water Flea Invasion in Northern Wisconsin and the Western Upper Peninsula

Gile Flowage, Iron County Wisconsin

First found in 2003. Random mass die-off in 2004.

Stormy Lake, Vilas County, Wisconsin

First found in 2006. Native zooplankton populations have decreased. In 2008 – lake had the lowest Secchi reading (water clarity) in a 15 year history.

Lake Gogebic, Gogebic/Ontonagon Counties Michigan

First found late 90's. Established population. 2010 – Portable boat wash available with paid inspectors.

Lake Superior and a few other lakes are infested with the spiny water flea in Wisconsin and Michigan. It is best to assume any water body that you visit could potentially have an aquatic invasive species.

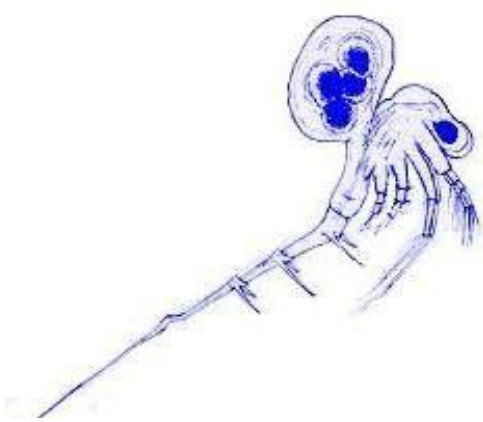
For each outing you should ***INSPECT, DRAIN, DRY!***

Spiny Water Flea – Infestations and Prevention

Spiny water fleas have spread from Lake Superior to inland lakes in the region. Spiny water fleas are present in northern Wisconsin: Gile Flowage (Iron County), Stormy, Star and Trout Lakes (Vilas County), Butternut Lake (Forest County), and a few southern Wisconsin lakes. Spiny water fleas are also present in Lake Gogebic (Gogebic and Ontonagon Counties, Michigan), several lakes in Keweenaw County, Michigan, and Lake Michigamme (Marquette County, Michigan).

Scientific literature shows that the spiny water flea is limited to regions where water temperature ranges between 4 and 30 ° C and salinity values between 0.04 and 8.0%, but it prefers temperatures between 10 and 24 ° C and salinity between 0.04 and 0.4% (Grigorovich et al. 1998). Spiny water flea frequent deeper waters during the day and come closer to the surface at night to feed.

Once spiny water fleas have established in a lake, there is no known way to eradicate them.



Prevention Steps

INSPECT and ***REMOVE*** aquatic plants and animals, including gelatinous or cotton batting-like material from lines, especially where they may meet swivel, lure or downrigger ball connection from boat, trailer and equipment.

DRAIN water from the boats, motors, live wells, and bilge.

NEVER MOVE live fish away from a waterbody. Fish may have resting eggs in them. DISPOSE of unwanted live bait, worms, and fish parts in trash.

RINSE boat, trailer and equipment with hot (at least 122 °F) and/or high-pressure water, ***AND/OR DRY*** for 5 days or more before use.

This brochure was made as part of a Wisconsin Department of Natural Resources Aquatic Invasive Species Control Grant awarded to the Friends of the Gile Flowage. Project partners include the Stormy Lake Association, Lake Gogebic Improvement Association, and White Water Associates, Inc.

WHITE WATER ASSOCIATES, INC.

WISCONSIN DEPT. OF NATURAL RESOURCES

FRIENDS OF THE GILE FLOWAGE