Horseshoe Lake Five Year Aquatic Plant Management Plan

Horseshoe Lake Aquatic Plant Management Planning

Washburn County, WI

DNR WBIC No. 2470000
SEH No. HORLP 121914

December 16, 2013

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RE: Horseshoe Lake Aquatic Plant Management Planning
Horseshoe Lake Five Year Aquatic Plant Management Plan
Washburn County, WI
WDNR WBIC No. 2470000
SEH No. HORLP 121914

Mr. Edward Wink, Secretary-Treasurer
Horseshoe Lake Property Association, Inc.
127 14th Ave. NW
New Brighton, MN 55112

Dear Edward:

The following document is the final deliverable related to the SEH/HLPA Agreement for Services (HORLP 121914) to prepare an Aquatic Plant Management Plan (APMP) for Horseshoe Lake in the Town of Minong, Washburn County. This APMP is the culmination of aquatic plant survey work, an evaluation of potential Eurasian watermilfoil (EWM) control techniques, HLPA input, review and comment, and WDNR input.

With this document, the HLPA should be able to embark upon appropriate EWM management actions and be eligible for grant funding to help in this endeavor.

Final presentation of this APMP to the membership of the HLPA and other interested parties can be arranged for some time in 2014.

Sincerely,

Lake Scientist

DLB
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Horseshoe Lake Five Year Aquatic Plant Management Plan

Horseshoe Lake Aquatic Plant Management Planning
Washburn County, WI

Prepared for:
Horseshoe Lake Property Association, Inc.
Spooner, WI

Prepared by:
Short Elliott Hendrickson Inc.
1701 West Knapp Street, Suite B, Rice Lake, WI 54868-1350
www.sehinc.com
| 715.236.4000 | 800.903.6970 | 888.908.8166 fax

With Input From:

Edward Wink, Laurie Johnson, Al and Sheri Angen, Bob and Peggy Holman, Dino and Gayle Pierotti, Heidi and Mark Reeves, Steve and Brenda Peterson, and Steve and Carole Burval.

Special Thanks to Pamela Toshner, WDNR, the Minong Township Lakes Committee, and the Washburn County Lakes and Rivers Association.

Distribution List

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4	Edward Wink, Secretary-Treasurer Horseshoe Lake Property Association, Inc. 127 14th Ave. NW New Brighton, MN 55112

Executive Summary

Horseshoe (WBIC 2470000) is a 194-acre, oligotrophic seepage lake located in north-central Washburn County, Wisconsin. The lake's average depth is 7ft, and the bottom substrate is predominantly sand and sandy/muck. Water clarity is good to very good with Secchi values averaging 10ft.

Eurasian water milfoil (*Myriophyllum spicatum*) (EWM), an exotic invasive plant species that is a growing problem in the lakes and rivers of northwestern Wisconsin, was first found in Horseshoe Lake in May 2011. EWM has been present in nearby Nancy Lake since 1991, the Minong Flowage since 2002, and Gilmore Lake since 2009, so, although disturbing, it is not entirely surprising that it was found in Horseshoe Lake.

The vision of the Horseshoe Lake Property Association (HLPA) was to develop a sustainable management plan that provides the direction necessary to address the variety of concerns and needs of the lake community while protecting the lake ecosystem. The primary goal of this plan was to establish long-term and realistic objectives for managing non-native and nuisance native plant growth while protecting valuable native species and their important habitat functions for the lake. To accomplish this, the aquatic plant (macrophyte) community was investigated, possible management alternatives were evaluated to determine preferred management options, and an implementation plan was developed which includes a mechanism to monitor and modify this management plan as needed.

Aquatic plant management in Horseshoe Lake will follow six broad goals, each with a number of objectives and actions, over the course of the next five years. Appendix D is an outline of the aquatic plant management goals and activities, and Appendix E is a five-year timeline for completion of the activities included in this APM Plan. Any major change in activities or management philosophy will be presented to the HLPA and the WDNR for approval. The six goals for this plan are as follows:

1. Native Plant Protection, Preservation, and Enhancement
2. EWM Management and Monitoring
3. AIS Education, Prevention, and Planning
4. Wildlife Appreciation and Awareness
5. Lake Community Understanding and Awareness
6. Aquatic Plant Management Plan Maintenance

This APM Plan will be implemented by the Horseshoe Lake Property Association, their consultants, and through partnerships formed with the WDNR, Washburn County, and other local clubs and organizations. Annual reports and end of project assessments will be completed throughout the duration of this 5-year plan.

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Horseshoe Lake Five Year Aquatic Plant Management Plan

Horseshoe Lake Aquatic Plant Management Planning

Prepared for Horseshoe Lake Property Association, Inc. (HLPA)

1.0 Introduction

Horseshoe (WBIC 2470000) is a 194-acre, oligotrophic seepage lake located in north-central Washburn County, Wisconsin (Figure 1). The lake's average depth is 7ft, and the bottom substrate is predominantly sand and sandy/muck. Water clarity is good to very good with Secchi values averaging 10ft. Eurasian water milfoil (*Myriophyllum spicatum*) (EWM), an exotic invasive plant species that is a growing problem in the lakes and rivers of northwestern Wisconsin, was first found in the eastern lobe of Horseshoe Lake in May 2011. EWM has been present in nearby Nancy Lake since 1991, the Minong Flowage since 2002, and Gilmore Lake since 2009, so, although disturbing, it is not entirely surprising that it was found in Horseshoe Lake.

Figure 1 – Lakes with Eurasian watermilfoil (EWM in the Town of Minong, Washburn County

2.0 Development of an Aquatic Plant Management Plan

After the discovery of EWM and two seasons of rapid response management, the HLPA contracted with SEH in the fall of 2012 to prepare a formal Aquatic Plant Management (APM) Plan for Horseshoe Lake to be completed in 2013. An APM Plan is required by the Wisconsin Department of Natural Resources (WDNR) if the HLPA intends to manage EWM by means other than physical removal. This APM Plan will guide EWM and other aquatic plant management efforts for at least the next 3-5 years.

The goal of aquatic plant management planning is to develop a sustainable management plan that provides the direction necessary to address the variety of concerns and needs of the lake community while protecting the lake ecosystem. The primary goal of the aquatic plant management plan for Horseshoe Lake is to establish long-term and realistic objectives for managing non-native aquatic plant growth while protecting valuable native species and their important habitat functions for the lake. To accomplish this, the aquatic plant (macrophyte) communities were investigated, possible management alternatives were evaluated to determine preferred management options, and an implementation plan was developed which includes a mechanism to monitor and modify this management plan as needed.

2.1 Aquatic Plant Management Strategy: WDNR, VITF, and GLIFWC

The WDNR aquatic plant management guidelines and the Northern Region Aquatic Plant Management Strategy (Appendix A) formed the framework for the development of this APM plan. All existing and new APM Plans and the associated management permits (chemical or harvesting) are reviewed by the WDNR. APM plans developed for northern Wisconsin lakes are evaluated according to the Northern Region APM Strategy goals that went into effect in 2007. Additional review may be completed by the Voigt Intertribal Task Force (VITF) in cooperation with the Great Lakes Indian Fish and Wildlife Commission (GLIFWC).

The VITF is composed of nine Tribal members plus the chairperson. The VITF recommends policy regarding inland harvest seasons, resource management issues, and budgetary matters to the Board of Commissioners. The VITF addresses matters that affect the treaty rights of the member tribes in the 1837 and 1842 Treaty ceded territories. The VITF recommends harvest seasons and regulations for each inland season. Those recommendations are then taken to the respective tribal councils for ratification prior to becoming an ordinance.

Formed in 1984, GLIFWC is an agency of eleven Ojibwe nations in Minnesota, Wisconsin, and Michigan, who retain off-reservation treaty rights to hunt, fish, and gather in treaty-ceded lands. It exercises powers delegated by its member tribes. GLIFWC assists its member bands in implementing off-reservation treaty seasons and in the protection of treaty rights and natural resources. GLIFWC provides natural resource management expertise, conservation enforcement, legal and policy analysis, and public information services. All member tribes retained hunting, fishing and gathering rights in treaties with the U.S. government, including the 1836, 1837, 1842, and 1854 Treaties.

This Aquatic Plant Management Plan supports sustainable practices to protect, maintain and improve the native aquatic plant community, the fishery, and the recreational and aesthetic values of the lake. This plan also lays out a plan to prevent the introduction of new aquatic invasive species (AIS) like curly-leaf pondweed (CLP) not currently known to be in the lake, and lays out a monitoring program to aid in early detection of any new AIS. This five-year plan is intended to be a living document which will be evaluated on an annual basis and can be revised to ensure goals and community expectations are being met.

3.0 Public Participation and Input

The Horseshoe Lake Property Association has been around since 1977, and became incorporated in 2011. In 2000, a lake association webpage was developed at www.horseshoelake.org The webpage is used to post lake association meeting minutes, promote lake events, share lake news and happenings, and provides a place for members to post comments and upload photos and other items related to the lake. Links are available to other pertinent lake sites including the Town of Minong, Washburn County, and the WDNR. They produce several newsletters annually which are sent to their constituency. In addition, they have at least one annual meeting where aquatic invasive species and more recently EWM has been a topic of great interest and discussion. Through these media outlets, the HLPA provides information, and solicits public input.

In 2012, the HLPA participated with other Minong area Lake Associations to sponsor an event where Matt Berg Proprietor of Endangered Resource Sciences, LLC presented his findings on the aquatic vegetation in the lake and the management implications of EWM being present in the system.

3.1 Community Involvement

The HLPA has been and will continue to be a supporter and participant in the Town of Minong bi-annual Lake Fair. The public boat landing on Horseshoe Lake has been posted with current WDNR recommended AIS signage and EWM established population warning signs. The HLPA also participates in lake education conferences sponsored by Wisconsin Association of Lakes and the UW-Extension Lakes Program.

3.2 Public Input Regarding the Aquatic Plant Management Plan

Throughout the process of this planning project, input from members of the HLPA and general lake use community has been sought. Beginning with a first draft of this plan in March of 2013, specific input from HLPA has been generated. A second draft of the plan was placed on the HLPA webpage in Sept 2013, generated additional public input. A record of public comment is included in Appendix G.

After the WDNR completed an initial review of this document, a discussion was held between the WDNR, HLPA, and the Consultant retained by the HLPA to prepare this document to solicit any additional comment or feedback the WDNR might have. A final version of the APM Plan was then completed and distributed to the HLPA. On December 29th, 2013 the HLPA board elected by the members, approved this Aquatic Plant Management Plan and the actions in it.

4.0 Eurasian Watermilfoil (EWM)

As previously mentioned, EWM was first discovered as a rooted plant and vouchers confirmed in 2011. Once discovered, the Horseshoe Lake Property Association (HLPA) marked the area with buoys, and authorized a June 2011 SCUBA removal of the known bed and a meandering littoral zone survey to look for evidence of further spread. Endangered Resource Sciences (ERS), LLC completed the June survey work. In the June survey, the initial bed of EWM was found to be bigger than anticipated making dive removal unfeasible and rooted plants were found at two additional locations in the east basin (Figure 2). As a result, the Wisconsin Department of Natural Resources (WDNR) authorized a lake-wide systematic point intercept macrophyte survey. This survey was conducted in August 2011 by ERS using points established by the WDNR (Figure 3), and led to a "rapid response" herbicide application on September 15th, 2011, and a post treatment swim-over on October 8th.

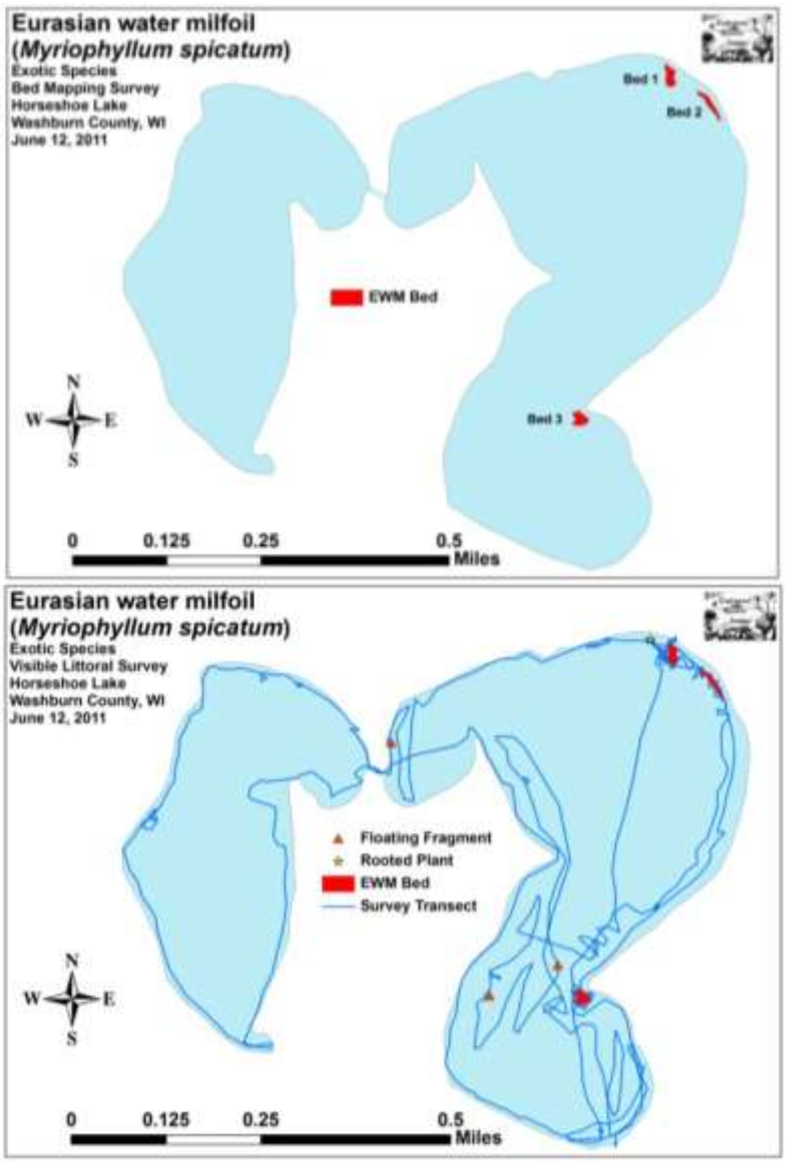


Figure 2 – June 2011 EWM Bed Mapping (top) and Visible Littoral Survey (bottom), ERS LLC

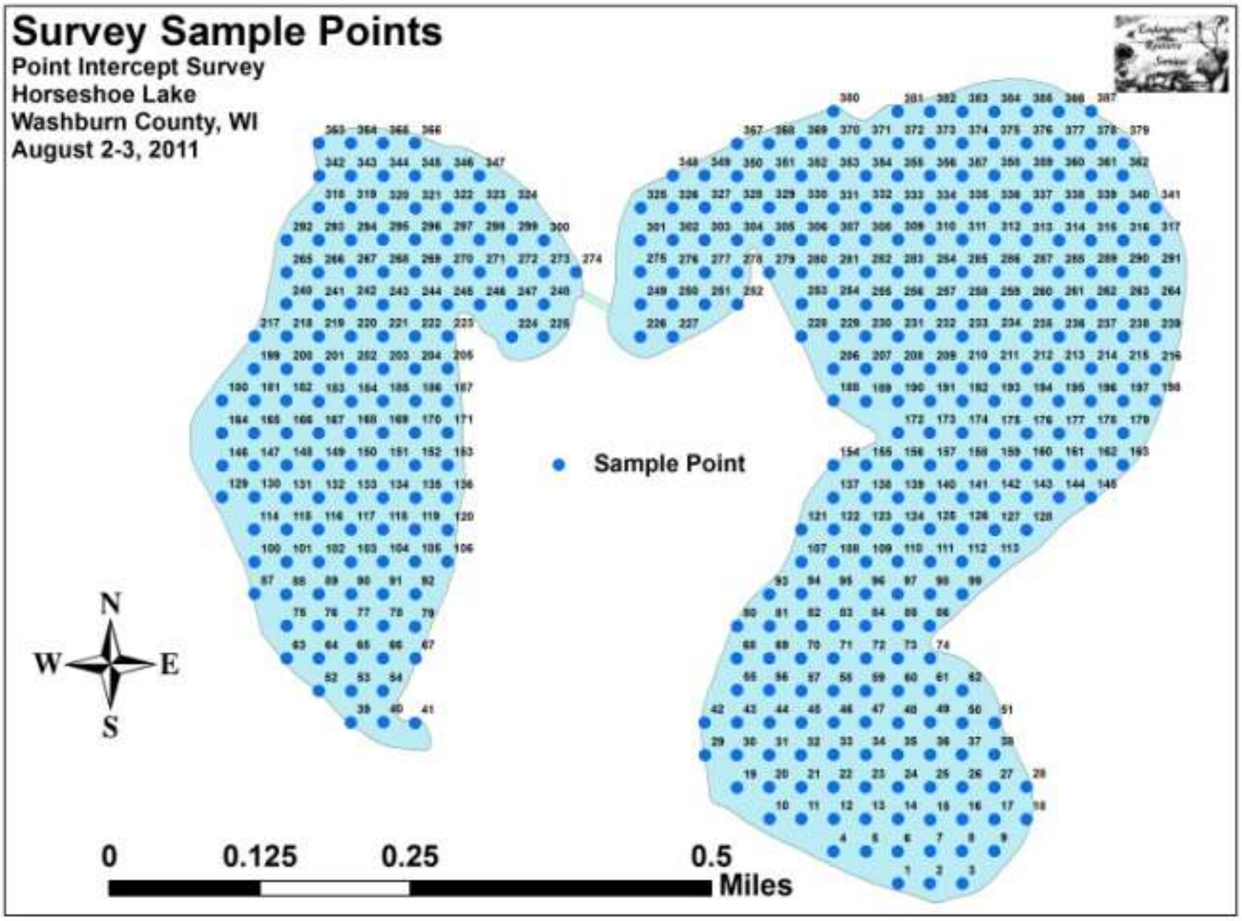


Figure 3 – WDNR Aquatic Plant Survey Points for Horseshoe Lake, Washburn County

4.1 June 2011 Diver Removal and Meandering Survey

On the June 12th, 2011, ERS, along with a host of volunteer helpers, gathered on the shoreline due north of the newly identified bed of EWM to begin what was supposed to be a diver removal of the entire known bed. When divers entered the water, they began to run into EWM plants only 15-20 meters from shore even though the buoyed bed of plants was still well over 40 meters away. The number of plants that were being found quickly ruled out the possibility of completing a successful diver removal, even over a period of several days with multiple divers. The bed originally targeted for diver removal (Bed 1 in Figure 2) was fully canopied in 10.5 ft of water and made up of 1000's of individual stems in a dense mass with a completely intertwined root-ball. The bed was actively fragmenting with perhaps 100's of additional individual plants/small clusters radiating away from it in all directions (1). Because of this, efforts to remove EWM while SCUBA diving was abandoned and more effort was focused on searching the rest of the lake from a boat to better quantify the extent of the infestation.

Approximately 9.4 miles of the lake's visible littoral zone was searched. Two additional beds were found and delineated bringing the total to three beds that covered just over half an acre (Table 1). Bed 2 was located southeast of Bed 1 in 4-7ft of water (Figure 2). Although there were two significant clusters within the bed where plants were canopied, monotypic, and extremely dense, most of the area had only scattered EWM and both the numbers and sizes of satellite clusters were generally smaller than in Bed 1. Located due south of a rock point and due north of the boat landing, Bed 3 appeared to be the most recently establish. Although EWM was nearly monotypic at the core, the bed became increasing fragmented on the periphery. Most plants were canopied or near canopy as the area was very shallow with the majority of plants in <4.5ft of water. Away from the three beds, an additional single rooted plant and three floating stem fragments sprouting roots were found and removed (Figure 2) (1).

Table 1
EWM Bed Mapping Survey Summary, Horseshoe Lake, Washburn County, June 12, 2011

Bed Number	June 2011 Area in Acres	June 2011 Perimeter in Meters	June 2011 Est. Mean Rakefull
1	0.19	129	<1-3
2	0.16	173	<1-3
3	0.18	118	<1-2
Total: 0.53 acres			

Source: ERS (1)

No evidence of EWM was found on the western side of the lake during the June 2011 survey. Random rake samples taken by the surveyor revealed that most of the substrate was firm sand or sandy muck with little organic matter and extremely limited plant growth. This area of the lake doesn't appear to offer ideal habitat for the growth of EWM (nutrient rich organic muck), but this does not rule out the possibility that EWM will be found in the West Basin in the future.

Despite the local expansion that was occurring around the three beds, the infestation in 2011 appeared contained to these areas. However, water clarity only allowed surveyors to confidently see down to about 6ft during the meandering survey. Rooted plants were found in as much as13ft of water while diving. Because of this, it was not possible to say that all the EWM was found (1). A chemical treatment was completed later in the season to try and control that which was found in the June 2011 survey (2).

4.2 2011 Chemical Management of EWM

Prior to completing a chemical treatment of the EWM beds identified in the June 2011 survey, a whole lake, point-intercept survey of 387 points established by the WDNR (Figure 3) was completed. This survey did not identify any new areas of EWM growth outside of the beds already documents. With this information, an herbicide application using Reward® with the active ingredient diquat dibromide (diquat) was completed on September 15, 2011. Northern Aquatic Services, LLC, an herbicide applicator company out of Dresser, WI was contracted to complete treatment of all the beds identified in the June 2011 survey. Diquat is a fast-acting non-selective contact herbicide which destroys the vegetative part of the plant but does not kill the roots. It is applied as a liquid. Typically diquat is used primarily for short term (one season) control of a variety of submersed aquatic plants. It is very fast-acting and is suitable for spot treatment.

A post treatment dive assessment survey was completed by ERS on October 8, 2011 to assess the effectiveness of the survey. Initial indications were good, as what appeared to be complete control of all visible plants was achieved. Unlike 2-4 D treated plants on other lakes that look burned (brown to black and withered), the Diquat treated plants just turned pale and fell over rather than disintegrating (1). The only hint of green was in a few stems that were raked up off the edge of the larger bed. However, according to the surveyor, the stems didn't seem viable as there was no evidence of any regrowth, and the roots looked black/dead as well. The surveyor also commented that many if not most of the native pondweeds in the treatment area (primarily Fern, Large-leaf, and White-stem pondweeds) seemed to survive the treatment.

Unfortunately, June 2012 surveying of the lake for EWM showed almost a total lack of control in the beds treated in September 2011. As indicated, diquat is a contact herbicide that is used for seasonal control and not known to substantially impact the root of a target plant affecting longer-term control. This seems to be the case in Horseshoe Lake, as plants that were completely pale and flopped over during the post treatment dive assessment in October 2011 were all back and growing. The giant tower in Bed 1 on the north side of the lake looked as though it was never touched, and it was canopied and actively fragmenting. All the beds as originally mapped in June 2011 were intact, and what were only scattered plants in the past had merged into solid beds (2).

4.3 2012 Chemical Management of EWM

On June 2, 2012 ERS and a lake representative toured the lake to determine possible EWM management areas. Long-term results that were hoped to be achieved by the September 2011 chemical treatment with a diquat-based herbicide were disappointing (2). All the beds that were originally mapped in June 2011 were intact, and what were only scattered plants in the past had merged into solid beds (2). As a result Beds 1 and 2 from June 2011 were combined into one larger bed, and Bed 3 from 2011 was expanded to include a larger area (Figure 4). Together these two areas of EWM now covered 3.73 acres instead of the 0.53 acres in 2011 (Table 2).

Table 2
EWM Bed Mapping Survey Summary, Horseshoe Lake, Washburn County, June 2, 2012

Bed Number	June 2012 Area in Acres	June 2011 Area in Acres	Change in Area	June 2012 Est. Mean Rakefull
1&2	3.18	0.35	+2.83	<1-3
3	0.55	0.16	+0.37	<1-2
	Total: 3.73 acres			

Source: ERS (2)

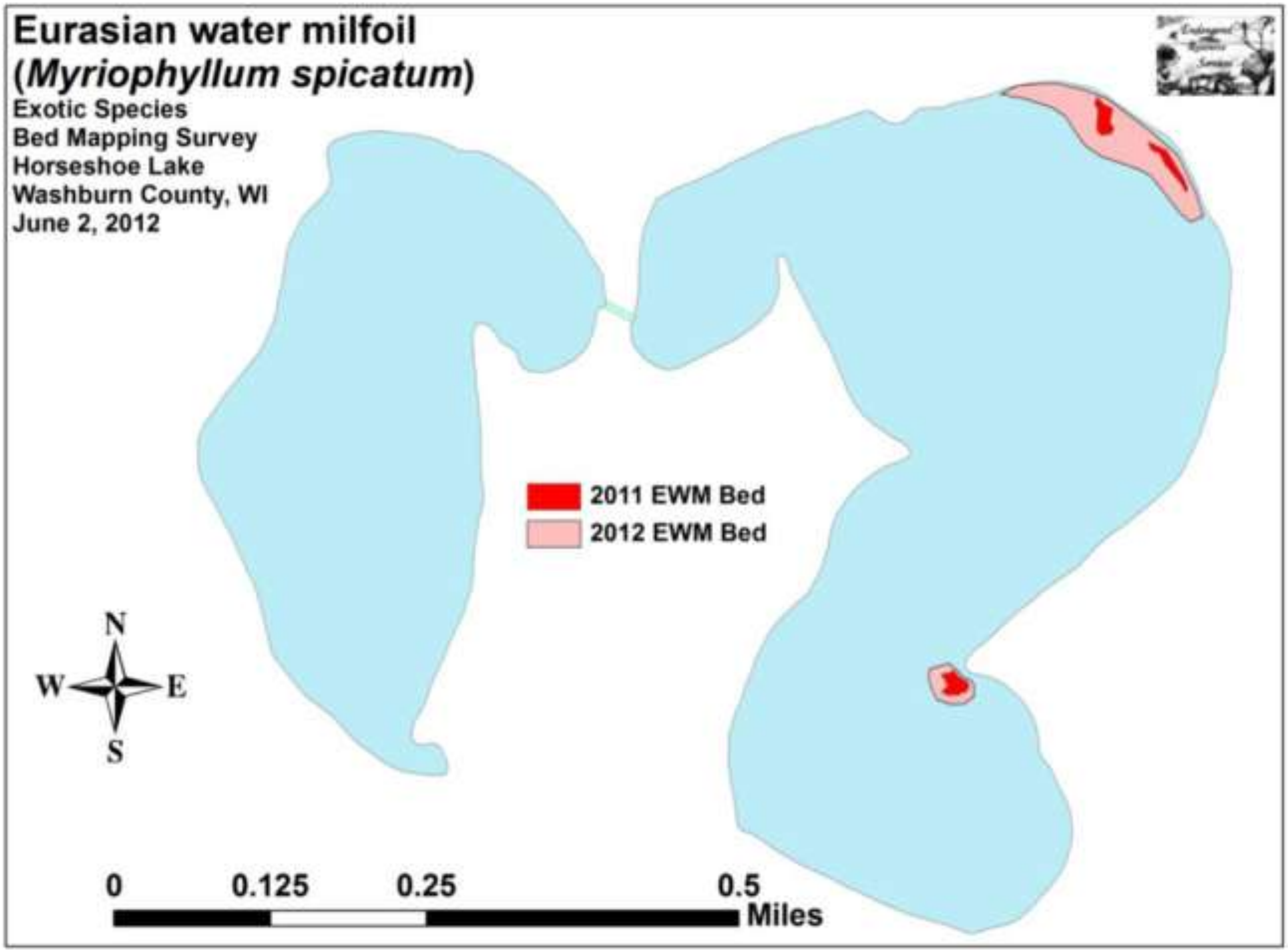


Figure 4 – June 2012 EWM Beds in Horseshoe Lake, Washburn County

On June 29, 2012, Northern Aquatic Services was again contracted by the HLPA to complete an herbicide application covering the entire area of the known EWM beds in the lake (3.67 acres). This time though, Navigate® with the active ingredient butoxyethyl ester, 2,4-Dichlorophenoxyacetic acid (2,4-D) at a concentration of 4.0 in what were beds 1 and 2, and at 2.5 ppm in what was bed 3 (7). 2,4-D is a relatively fast-acting, systemic, selective herbicide used for the control of Eurasian water milfoil and other broad-leaved, dicot species. 2,4-D has been shown to be selective to Eurasian water milfoil when used at the labeled rate, leaving native aquatic species relatively unaffected. Unlike diquat, a contact herbicide, a systemic herbicide is drawn into the plant affecting the entire plant, including the roots. It is expected to provide longer term control of the target plant.

On September 1, 2012, a follow up search of the lake's visible littoral zone and a dive assessment survey was completed by ERS. Water clarity was fair, with the bottom visible in up to 6ft of water. The perimeter of the entire lake was searched and no rooted EWM plants were found. There was also no evidence of floating fragments of EWM. SCUBA diving was used to assess the treatment of the three beds. No evidence of any EWM, plants or fragments with the exception of a single 4inch strand of rotten tissue was found. The bottom in the treatment areas was covered with large amounts of plant debris, but natives species (primarily Muskgrass (*Chara* sp.), White-stem pondweed (*Potamogeton praelongus*), Large-leaf pondweed (*Potamogeton amplifolius*), and Wild celery (*Vallisneria americana*)) were rapidly filling in the areas vacated by EWM (2).

4.4 2013 Management of EWM

Following herbicide treatments of the known EWM areas in 2011 and 2012, the HLPA authorized Endangered Resource Sciences (ERS, Matt Berg, Proprietor) to conduct two meandering shorelines surveys of the entire lake to look for surviving/new EWM plants/beds. They also requested snorkel/SCUBA checks of the previously treated beds. This section summarizes the results of these surveys conducted on June 19th and September 21st as well as two addition volunteer surveys conducted on July 19th and August 19th. The following is taken from the 2013 ERS Summary Report (Berg, 2013).

4.4.1 June 19th Meandering Littoral Zone and Dive Survey:

During the first visit of the year to Horseshoe Lake, there was no evidence of Eurasian water milfoil in any of the former beds or anywhere else. A boat survey and a shoreline survey were conducted, neither turning up any evidence of EWM fragments/plants. Snorkeling was also completed and other than a few completely black milfoil leaflets at the heart of the area, no evidence of EWM was found. Areas formally impacted by EWM beds had been re-colonized by native plants, especially fern-leaf pondweed, muskgrass, white-stem pondweed, and common waterweed.

4.4.2 July 19th Dive Survey:

On July 19th, ERS returned to the lake on an unscheduled visit to dive on the former beds as it was expected that the late spring had just resulted in a delay in EWM growth. Again there was no evidence of EWM found in either of the former treatment areas.

4.4.3 August 19th Meandering Littoral Zone and Snorkel Survey:

ERS returned again in August. During the August survey, improved water clarity allowed better searching conditions. The shoreline littoral zone in the east basin was again searched. A boat survey, walking survey, and snorkeling again found no evidence of EWM.

4.4.4 September 21st Meandering Littoral Zone and Snorkel Survey:

When ERS returned in late Sept, the water clarity was the best it had been all year. This allowed the survey to expand to a deeper water and a larger littoral zone which produced a search transect that stretched to 10.9km – up significantly from the 6.7km that was covered in June. Despite this increased search area, a walking survey of the shorelines north of the former beds, and another expanding square snorkel survey over the former beds, no evidence of EWM was found anywhere in the lake.

While it is possible that the EWM present in previous years has been eradicated, it is unlikely. Continued monitoring of the entire lake for EWM will become a regular activity on the lake.

5.0 Lake Information

Identifying appropriate aquatic plant management activities for Horseshoe Lake requires a basic understanding of its physical characteristics, including its morphology (size, structure, and depth), critical habitat, and the fishery, as well as factors influencing water quality, such as land use in the watershed. All of these factors have the potential to influence aquatic plant growth. Aquatic plant management will impact certain aspects of a lake including water quality, fish and wildlife habitat, and both target and non-target aquatic plants. Water quality and plant survey data were collected and summarized for the development of this plan. These data along with data collected in the past and future will provide the information necessary to evaluate the effects of aquatic plant management and other management activities on the lake and its ecosystem.

The lake inventory information that follows has been summarized from a number of resources. Some of the information has been updated with more recent data. For example, lake areas were obtained from high-resolution digital orthophotos (WROC imagery) and lake volumes were computed in ArcGIS using digitized bathymetric maps based on historic WDNR and recent plant survey data.

5.1 Physical Characteristics

Horseshoe Lake (WBIC 2470000) is a 194-acre, mesotrophic, seepage, lake located in north-central Washburn County, Wisconsin (Figure 5). It has a well developed shoreline. The lake’s maximum depth is 21-ft with an average depth of 7ft, and the bottom substrate is predominantly sand and sandy/muck. The lake is divided into two separate basins connected by a narrow channel that is periodically dredged to maintain clear and open passage between the two basins.

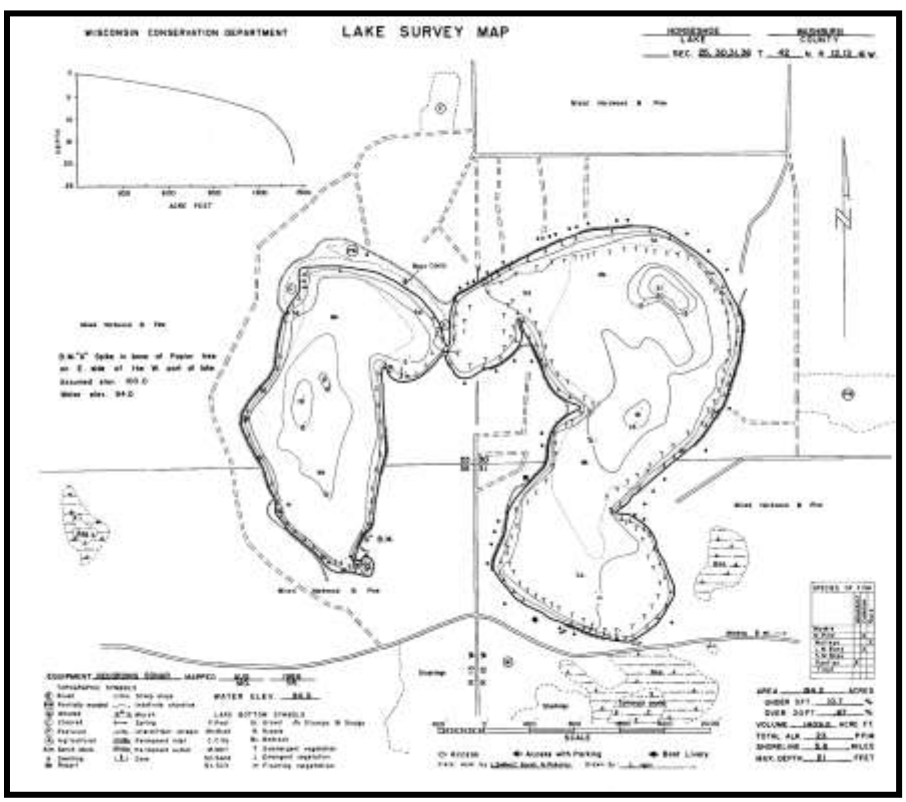


Figure 5 – Horseshoe Lake Map, WDNR (3)

During the 2011 summer point intercept survey, 387 points were surveyed for depth and bottom substrate (Figure 6). Most of the western side of the lake rapidly drops off from shore into at least 7ft of water before leveling out in the 10-12ft range with the exception of the >17.5ft hole on the west side mid-lake. Two 5-8 ft deep, approximately 10-acre flats occur on either side of the channel where the two basins meet. On the eastern side, there is greater underwater topography. An expansive 5-7 ft flat covers the southeast end near the boat landing, and the lake's two deepest holes reach 22ft in the northeast bay and more than 17.5 ft mid-lake.

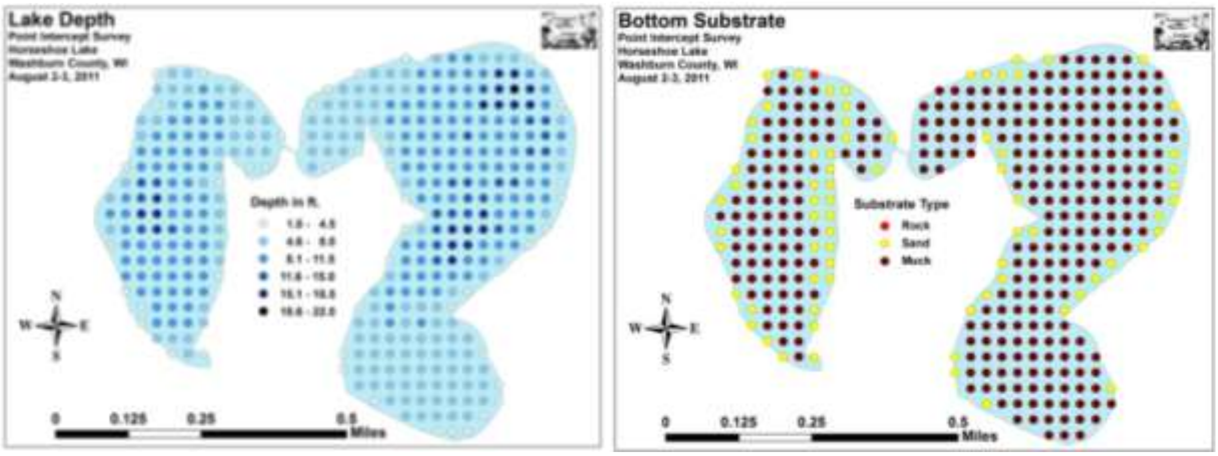


Figure 6 – Lake Depth and Substrate

5.2 Horseshoe Lake Watershed

A watershed is an area of land from which water drains to a common surface water feature, such as a stream, lake, or wetland. The watershed boundary of Horseshoe Lake is 947.2 acres (Figure 7). Land use and land cover in the watershed is primarily natural, comprised of forests (53.57%), wetlands (21.34%), open water (20.04%, including Horseshoe Lake), and grassland/shrub land (1.21%). The balance of the land use in the watershed is developed land (3.85%) (Table 3). Developed areas are primarily associated with areas of low to medium density residential development present around most of Horseshoe Lake, portions of a local golf course, and a small amount of agriculture.

The soils in the area consist of well-drained sandy deposits derived from glacial outwash plains. All of the soils in the Horseshoe Lake watershed are rated Very Limited for septic tank absorption fields. A Very Limited rating indicates that the soil has one or more features that are unfavorable for the specified use and poor performance and high maintenance can be expected (4) (5). The limitations generally cannot be overcome without major soil reclamation, special design (for example, tertiary systems), or expensive installation procedures.

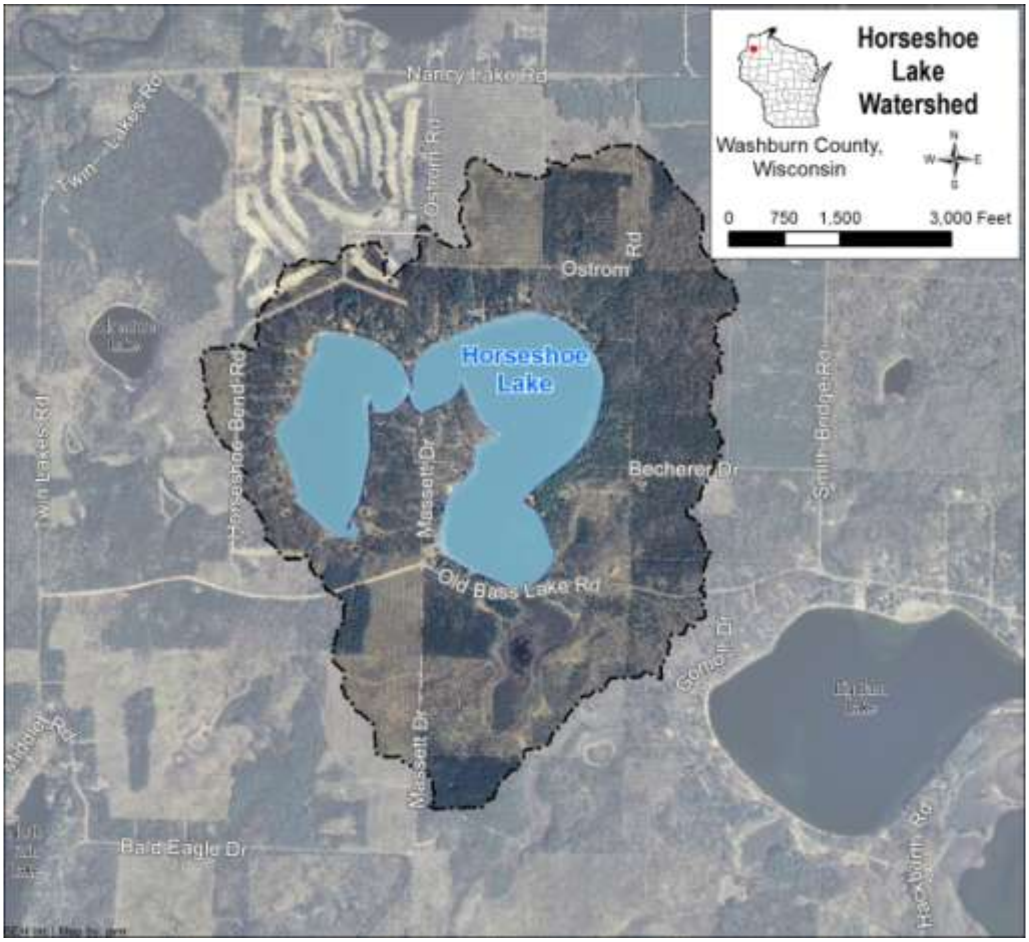


Figure 7 – Horseshoe Lake Watershed

Table 3
Land Use and Cover in the Horseshoe Lake Watershed

Land Use/Cover	Acres	Percent of Total
Medium density residential	10.3	1.09
Low density residential	14.3	1.51
Agriculture	11.8	1.25
Forest	507.7	53.57
Grassland/shrubland	11.5	1.21
Wetland	202.2	21.34
Open Water	189.9	20.04
Total Watershed	**947.2**	**100.0**

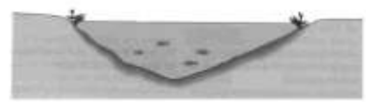
Source: 2006 National Land Cover Database (USGS)

6.0 Water Quality

The water quality of a lake influences the aquatic plant community, which in turn can influence the chemistry of a lake. Water clarity, total phosphorus and chlorophyll *a* are measures of water quality that can be used to determine the productivity or trophic status of a lake. The Carlson trophic state index (TSI) is a frequently used biomass-related index. The trophic state of a lake is defined as the total weight of living biological material (or biomass) in a lake at a specific location and time. Eutrophication is the movement of a lake's trophic state in the direction of more plant biomass. Eutrophic lakes tend to have abundant aquatic plant growth, high nutrient concentrations, and low water clarity due to algae blooms (Figure 8). Oligotrophic lakes, on the other end of the spectrum, are nutrient poor and have little plant and algae growth (Figure 8). Mesotrophic lakes have intermediate nutrient levels and only occasional algae blooms (Figure 8).

Oligotrophic waterbodies have the lowest level of biological productivity.

Criteria: total chlorophyll is less than 3 µg/L*
total phosphorus is less than 15 µg/L
total nitrogen is less than 400 µg/L
water clarity is greater than 13 feet



A typical oligotrophic waterbody will have clear water, few aquatic plants, few fish, not much wildlife, and a sandy bottom

Mesotrophic waterbodies have a moderate level of biological productivity.

Criteria: total chlorophyll is between 3 and 7 µg/L
total phosphorus is between 15 and 25 µg/L
total nitrogen is between 400 and 600 µg/L
water clarity is between 8 and 13 feet

A typical mesotrophic waterbody will have moderately clear water and a moderate amount of aquatic plants.

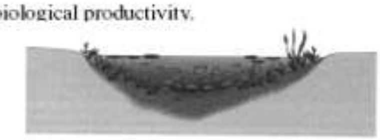
Eutrophic waterbodies have a high level of biological productivity.

Criteria: total chlorophyll is between 7 and 40 µg/L
total phosphorus is between 25 and 100 µg/L
total nitrogen is between 600 and 1500 µg/L
water clarity is between 3 and 8 feet

A typical eutrophic waterbody will either have lots of aquatic plants and clear water; or it will have few aquatic plants and less clear water. In either case, it has the potential to support lots of fish and wildlife.

Hypereutrophic waterbodies have the highest level of biological productivity.

Criteria: total chlorophyll is greater than 40 µg/L
total phosphorus is greater than 100 µg/L
total nitrogen is greater than 1500 µg/L
water clarity is less than 3 feet



A typical hypereutrophic waterbody will have very low water clarity, the potential for lots of fish and wildlife, and it may have an abundance of aquatic plants.

*** The unit of measurement "micrograms per liter" is abbreviated "µg/L."**

Figure 8 – Trophic status in lakes

Based on satellite images with a water clarity range of 6.6 to 13.1 ft. during the years of 2003-2005 (5), Horseshoe Lake is considered to be a mesotrophic lake. Water clarity in the western basin was higher during the years of 1999-2001 as compared to 2003-2005 (Figure 9).

Figure 9 – Trophic state of Horseshoe Lake in 1999-2001 compared to 2003-2005. Images source LakeSat.org, 2012. (The station identification number 10006919, as indicated by the red star, is linked to water clarity data in the SWIMs database.)

The same satellite images give Horseshoe Lake a Carlson's Trophic State Index in the 40-50 range on a 0-100 scale (Figure 10). The higher the index value the more nutrient rich the lake.

TSI	Description of Associated Conditions
< 30	Classical oligotrophy: clear water, many algal species, oxygen throughout the year in bottom water, cold water, oxygen-sensitive fish species in deep lakes. Excellent water quality.
30 - 40	Deeper lakes still oligotrophic, but bottom water of some shallower lakes will become oxygen-depleted during the summer.
40 - 50	Water moderately clear, but increasing chance of low dissolved oxygen in deep water during the summer.
50 - 60	Lakes becoming eutrophic: decreased clarity, fewer algal species, oxygen-depleted bottom waters during the summer, plant overgrowth evident, warm-water fisheries (pike, perch, bass, etc.) only.
60 - 70	Blue-green algae become dominant and algal scums are possible, extensive plant overgrowth problems possible.
70 - 80	Becoming very eutrophic. Heavy algal blooms possible throughout summer, dense plant beds, but extent limited by light penetration (blue-green algae block sunlight).
> 80	Algal scums, summer fishkills, few plants, rough fish dominant. Very poor water quality.

Figure 10 – The Trophic State Index and Description of Associated Conditions

There is no physical water quality data available for Horseshoe Lake. There have been no Citizen Lake Monitoring Network (CLMN) volunteers on the lake for the purpose of collecting water quality data. CLMN volunteers measure quantitative parameters such as temperature and Secchi depth measurements of water clarity, and in more advanced levels of the program, collect water samples for analysis of total phosphorus and chlorophyll *a*, and dissolved oxygen profiles. Qualitative observations such as lake level, color, and user perception of water quality are also documented in the program. All this data is entered and stored in the Surface Water Integrated Monitoring System (SWIMS) database maintained by the WDNR

6.1 Water Clarity

Water clarity is a measurement of how deep sunlight can penetrate into the waters of a lake. It can be measured in a number of ways, the most common being an 8" disk divided into four sections, two black and two white, lowered into the lake water from the surface by a rope marked in measurable increments (Figure 11). The water clarity reading is the point at which the Secchi disk when lowered into the water can no longer be seen from the surface of the lake. Water color (like dark water stained by tannins from nearby bogs and wetlands), particles suspended in the water column (like sediment or algae), and weather conditions (cloudy, windy, or sunlight) can impact how far a Secchi disk can be seen down in the water. Some lakes have Secchi disk readings of water clarity of just a few inches, while other lakes have conditions that allow the Secchi disk to be seen for dozens of feet before it disappears from view.

Figure 11 – Black and white Secchi disk for measuring water clarity

Secchi depths vary throughout the year, with shallower readings in summer when algae become dense and limit light penetration and generally deeper readings in spring and late fall. Because light penetration is usually associated with algae growth, a lake is considered eutrophic, or highly productive, when Secchi depths are less than 6.5 feet.

In Horseshoe Lake, water clarity has not been measured using a Secchi disk. However, using data generated from satellite images, average water clarity over the last decade was estimated to be about 10-ft (Figure 12).

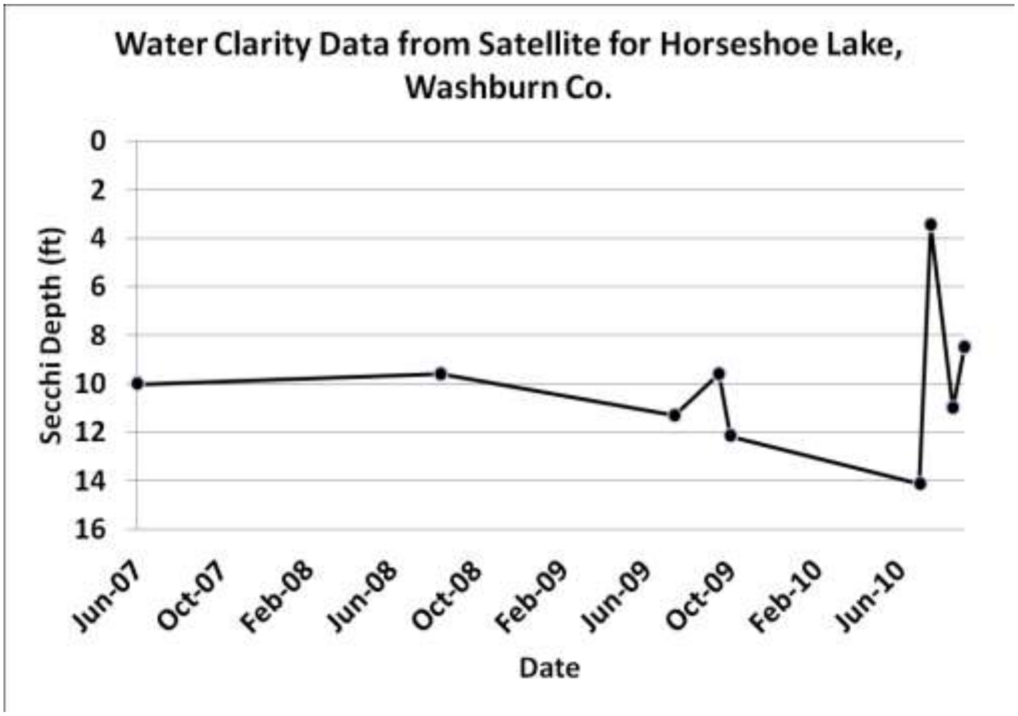


Figure 12 – Water clarity data measured by satellite and downloaded from the SWIMS database. Measurements not displayed for 9/5/2000 (14.93 ft) and 8/7/2001 (11.04 ft).

6.2 Dissolved Oxygen and Temperature

Dissolved oxygen and temperature data were absent for Horseshoe Lake in the SWIMS database.

6.3 Total Phosphorus and Chlorophyll a

Phosphorus is an important nutrient for plant growth and is commonly the nutrient limiting plant production in Wisconsin lakes. When phosphorus is limiting production, small additions of the nutrient to a lake can cause dramatic increases in plant and algae growth.

Chlorophyll *a* is the green pigment found in plants and algae. The concentration of chlorophyll *a* is used as a measure of the algal population in a lake. Concentrations >10 µg/L are considered indicative of eutrophic conditions and concentrations 20 µg/L or higher are associated with algal blooms. For trophic state classification, preference is given to the chlorophyll *a* trophic state index (TSI_{CHL}) because it is the most accurate at predicting algal biomass.

Phosphorus and chlorophyll a data were absent for Horseshoe Lake in the SWIMS database.

7.0 Aquatic Ecosystems

Aquatic plants are a natural part of most lake communities and provide many benefits to fish, wildlife, and people. Native macrophytes have many important functions and values to a lake ecosystem. They are the primary producers in the aquatic food chain, converting the basic chemical nutrients in the water and soil into plant matter, which becomes food for all other life.

Aquatic plants provide valuable fish and wildlife habitat. More food for fish is produced in areas of aquatic vegetation than in areas where there are no plants. Insect larvae, snails, and freshwater shrimp thrive in plant beds. Panfish eat aquatic plants in addition to aquatic insects and crustaceans. Plants also provide shelter for young fish. Northern pike spawn in marshy and flooded areas in early spring and bass, sunfish, and yellow perch usually nest in areas where vegetation is growing.

Many submerged plants produce seeds and tubers (roots) which are eaten by waterfowl. Bulrushes, sago pondweed, wild celery, and wild rice are especially important duck foods. Submerged plants also provide habitat to a number of insect species and other invertebrates that are, in turn, important foods for brooding hens and migrating waterfowl.

The lake aesthetic valued by so many is enhanced by the aquatic plant community. The visual appeal of a lakeshore often includes aquatic plants, which are a natural, critical part of a lake community. Plants such as water lilies, arrowhead, and pickerelweed have flowers or leaves that many people enjoy.

Aquatic plants improve water clarity and water quality. Certain plants, like bulrushes, can absorb and break down polluting chemicals. Nutrients used by aquatic plants for growth are not available to algae, thus reducing algae abundance and improving water clarity. Algae, which thrive on dissolved nutrients, can become a nuisance when too many submerged water plants are destroyed. Aquatic plants also maintain water clarity by preventing the re-suspension of bottom sediments. Aquatic plants, especially rushes and cattails, dampen the force of waves and help prevent shoreline erosion. Submerged aquatic plants also weaken wave action and help stabilize bottom sediment.

Native aquatic plant communities also offer protection from non-native aquatic invasive species. Current scientific literature accepts the concept that invasions of exotic plants are encouraged, and in some cases induced, by the disruption of natural plant communities. Most aquatic invasive plant species are opportunistic; much like lawn and agricultural weeds that germinate in newly disturbed soil, aquatic invasive plant species are more likely to invade areas in which the native plant community has been disturbed or removed. Removing the natural competition from native plants may also open up the door to new invasive species and less desirable plant communities.

As a natural component of lakes, aquatic plants support the economic value of all lake activities. Wisconsin's $13 billion tourism industry is anchored by 15,081 lakes and 12,600 rivers and streams which draw residents and tourists to hunt, fish, camp, and watch wildlife. According to the WDNR, the world class fishery lures more than 1.4 million licensed anglers each year, supports more than 30,000 jobs, generates a $2.75 billion annual economic impact, and $200 million in tax revenues for state and local governments.

7.1.1 Wetlands

In Wisconsin, a wetland is defined as an area where water is at, near, or above the land surface long enough to be capable of supporting aquatic or hydrophytic vegetation, and which has soils indicative of wet conditions (Wisconsin Statue 23.32(1)). Wetlands contain a unique combination of terrestrial and aquatic life and physical and chemical processes. Wetlands are protected under the Clean Water Act and state law and in some places by local regulations or ordinances. Landowners and developers are required to avoid wetlands with their projects whenever possible; if the wetlands can't be avoided, they must seek the appropriate permits to allow them to impact wetlands (for example, fill, drain or disturb soils).

According to the National Wetland Inventory, forested, scrub/shrub, emergent/wet meadow and aquatic bed (lake and freshwater pond) wetlands are present in the Horseshoe Lake watershed (Figure 13). Emergent wetlands are wetlands with saturated soil and are dominated by grasses such as redtop and reed canary grass, and by forbs such as giant goldenrod. Forested/shrub wetlands are wetlands dominated by mature conifers and lowland hardwood trees. Forested/shrub wetlands are the dominant form of wetlands in the watershed and are important for stormwater and floodwater retention and provide habitat for various wildlife. Aquatic bed wetlands are wetlands characterized by plants growing entirely on or within a water body that is no more than six feet deep.

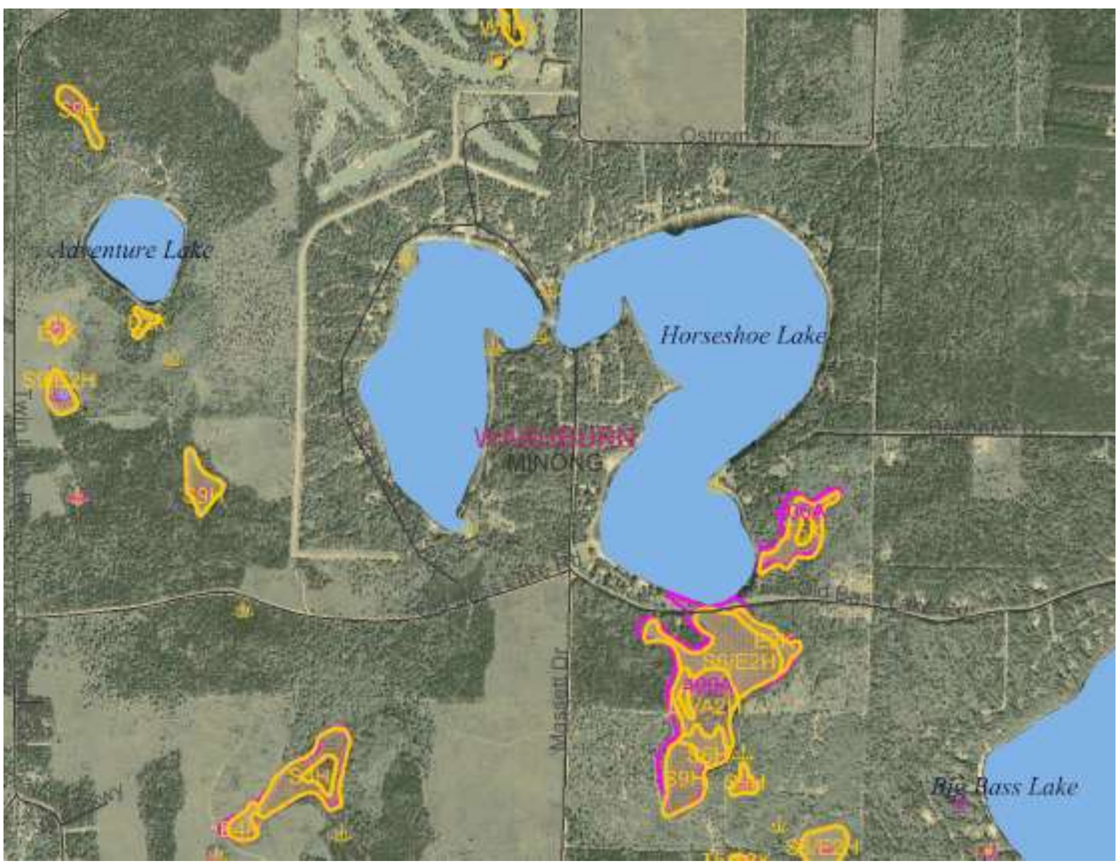


Figure 13 – Wetlands near Horseshoe Lake, Washburn County (Wisconsin Wetlands Inventory, March, 2013)

Wetlands serve many functions that benefit the ecosystem surrounding the Horseshoe Lake. Wetlands support a great variety of native plants and are more likely to support regionally scarce plants and plant communities. Wetlands provide fish and wildlife habitat for feeding, breeding, resting, nesting, escape cover, travel corridors, spawning grounds for fish, and nurseries for mammals and waterfowl. Contrary to popular belief, healthy wetlands reduce mosquito populations; natural enemies of mosquitoes (dragonflies, damselflies, backswimmers, and predacious diving beetles) need proper habitat (that is, healthy wetlands) to survive.

Wetlands provide flood protection within the landscape by retaining stormwater from rain and melting snow and capturing floodwater from rising streams. This flood protection minimizes impacts to downstream areas. Wetlands provide groundwater recharge and discharge by allowing the surface water to move into and out of the groundwater system. The filtering capacity of wetland plants and substrates help protect groundwater quality. Wetlands can also stabilize and maintain stream flows, especially during dry months.

Wetland plants and soils provide water quality protection by storing and filtering pollutants ranging from pesticides to animal wastes. Wetlands also provide shoreline protection by acting as buffers between the land and water. Wetland plants protect against erosion by absorbing the force of waves and currents and by anchoring sediments. This is important in waterways where high boat traffic, water currents, and wave action may cause substantial damage to the shore.

There are a few small (two acres or less) wetlands scattered throughout the watershed. Although these wetlands may not appear to provide significant functional values when assessed individually, they may be very important components of a larger natural system. Not only do small wetlands provide habitat functions, they also store phosphorus and nitrogen and trap pollutants such as heavy metals and pesticides. Draining these small wetlands, which often do not appear on maps, not only requires the proper permits, but can also release the once-stored pollutants and nutrients into lakes and streams.

7.1.2 Critical Habitat

Every body of water has areas of aquatic vegetation or other features that offer critical or unique aquatic plant, fish and wildlife habitat. Critical Habitat areas include important fish and wildlife habitat, natural shorelines, physical features important for water quality (for example, springs), areas of natural scenic beauty, and navigation thoroughfares. These areas, which can be located within or adjacent to the lake, are selected because they are particularly valuable to the ecosystem or would be significantly and negatively impacted by most human induced disturbances or development. Critical Habitat areas include both Sensitive Areas and Public Rights Features. Sensitive Areas offer critical or unique fish and wildlife habitat, are important for seasonal or life-stage requirements of various animals, or offer water quality or erosion control benefits. Public rights features include: physical features of waterbodies that ensure protection of water quality, reaches of bank, shore or bed that are mostly natural in appearance (not man-made or artificial) or that screen man-made or artificial features, navigation thoroughfares or areas traditionally used for navigation during normal recreational activities such as boating, angling, hunting, or enjoyment of natural scenic beauty.

Critical Habitat Areas on Horseshoe Lake have not been officially identified or mapped, however, areas of ecological importance have been identified via plant surveying (high value aquatic plants) and fishery assessments (spawning habitat). Management activities completed on the lake should be limited only to the amount necessary to maintain and protect these ecologically sensitive areas from negative impacts that may be caused by the presence of EWM.

It is particularly important to maintain vegetated shoreland buffers not just in the ecologically significant areas, but throughout the lake. Also, stumps and woody habitat, which provide fish cover, should not be removed from the near-shore area. In the event of a treefall into the lake, unless it is causing a navigational impairment it should be left in the lake. It may take decades or longer for woody debris to decay in a lake, thus having limited impacts on water quality, but tremendous impact on creating desirable habitat. Because much of Horseshoe Lake contains such features, the WDNR document *Guidelines for Protecting, Maintaining, and Understanding Lake Sensitive Areas*, which provides excellent guidance on how to approach management activities in ecologically sensitive areas, is included as Appendix B of this plan.

7.1.3 Rare and Endangered Species and Habitat

The Wisconsin Natural Heritage Inventory (NHI) program is part of an international network of programs that focus on rare plants and animals, natural communities, and other rare elements of nature. It is important for lake managers to consider impacts to these valuable species and communities, nearly all of which can be directly affected by aquatic plant management. Choosing the proper management techniques and the proper timing of management activities can greatly reduce or prevent negative impacts. Each species has a state status including Special Concern, Threatened, or Endangered. Species are listed by township: Horseshoe Lake and its watershed are in the Town of Minong (T42N, R12&13W).

Five Special Concern species (the least darter fish, *Etheostoma microperca*; the gray wolf, *Canis lupus*; bald eagle, *Haliaeetus leucocephalus*, Franklin's ground squirrel *Spermophilus franklinii*, and prairie sagebrush *Artemisia frigid*); and three Threatened species (Blanding's turtle *Emydoidea blandingii*, wood turtle *Glyptemys insculpta*, and Northern bur-reed *Sparganium glomeratum*) are listed for the Town of Minong (data current as of November 2011). Descriptions of these species can be found at:
http://dnr.wi.gov/topic/EndangeredResources/biodiversity.html/ (last accessed 2013-03-05).

In addition, small purple bladderwort (*Utricularia resupinata*), listed as Species of Special Concern in Wisconsin, was identified during the 2011 warm-water aquatic plant survey for Horseshoe Lake. Species of Special Concern are those species where limited abundance or distribution is suspected but not yet proved. The main purpose for classifying plants in this category is to focus attention on them before they become threatened or endangered. Management efforts in waters where the plant is located should be careful not to negatively impact its presence.

7.1.4 Wildlife

At least one volunteer on Horseshoe Lake is participating in Sigurd Olson Institute Loon Ranger/Loon Watch program. Other than limited EWM management, there is no other wildlife habitat monitoring or management occurring on Horseshoe Lake.

7.1.5 Fishery

The WDNR was very involved with manipulating the fishery in Horseshoe lake over a twelve year study period ending in the early 1990's. They were trying to see if activities like walleye stocking (Table 4) and direct removal of bullheads and stunted panfish could help improve the quality of stunted panfish populations. The problem has been that panfish (except crappie) grow so slowly that most live out their life time without reaching decent size. Walleye like to feed on bluegill but efforts to develop a walleye population high enough (even with experimental stocking of very large walleye fingerlings (10 inches or bigger) to make a difference in thinning out stunted panfish did not succeed. Direct removal of bullheads and panfish did cause a significant growth spurt in remaining panfish but the effects only lasted a couple years. With fewer panfish and bullheads and only a small walleye population more of the eggs laid survived so things quickly went back to as stunted as before. Regular stocking of walleye continued through at least 2005, but it is believed that the actual population is still very low (Horseshoe Lake Property Association Webpage, www.horseshoelake.org).

A bass size limit went into effect in 1989 in order to increase predation on stunted panfish. Currently bass are more abundant than they were in the early 1990's and suffer from slow growth.

During the 12 years the WDNR was studying the lake, crappie were never very abundant. Crappie populations typically are cyclical with a peak in fishing every 4 or 5 years and then several years of low populations.

Table 4
Horseshoe Lake Walleye Stocking Records.

Year	Age Class	Number Stocked	Average Fish Length (in)
2005	Small Fingerling	9700	1.70
2003	Small Fingerling	9836	1.60
1999	Small Fingerling	9700	1.30
1997	Small Fingerling	9700	1.60
1995	Fingerling	9676	2.50
1993	Fingerling	10428	4.50
1992	Fingerling	14254	3.00
1991	Fingerling	5000	3.00
1990	Yearling	1000	7.00
1990	Fingerling	10080	3.00
1989	Fingerling	12725	5.67
1988	Fingerling	20032	2.33
1987	Fingerling	75510	3.00
1986	Fry	194000	1.00
1986	Fingerling	19952	3.00
1985	Fingerling	10106	3.00
1984	Fingerling	15050	3.00
1982	Fry	200000	
1980	Fingerling	2000	7.00
1979	Fingerling	1998	5.00
1978	Fingerling	1579	7.00

Source: WDNR Horseshoe Lake Webpage, 2012

7.2 Aquatic Plant Communities

Aquatic plants play an important role in lakes. They anchor sediments, buffer wave action, oxygenate water, and provide valuable habitat for aquatic animals. The amount and type of plants in a lake can greatly affect nutrient cycling, water clarity, and food web interactions. Furthermore, plants are very important for fish reproduction, survival, and growth, and can greatly impact the type and size of fish in a lake.

Unfortunately, healthy aquatic plant communities are often degraded by poor water clarity, excessive plant control activities, and the invasion on non-native nuisance plants (6). These disruptive forces alter the diversity and abundance of aquatic plants in lakes and can lead to undesirable changes in many other aspects of a lake's ecology (Figure 14). Consequently, it is very important that lake managers find a balance between controlling nuisance plant growth and maintaining a healthy, diverse plant community.

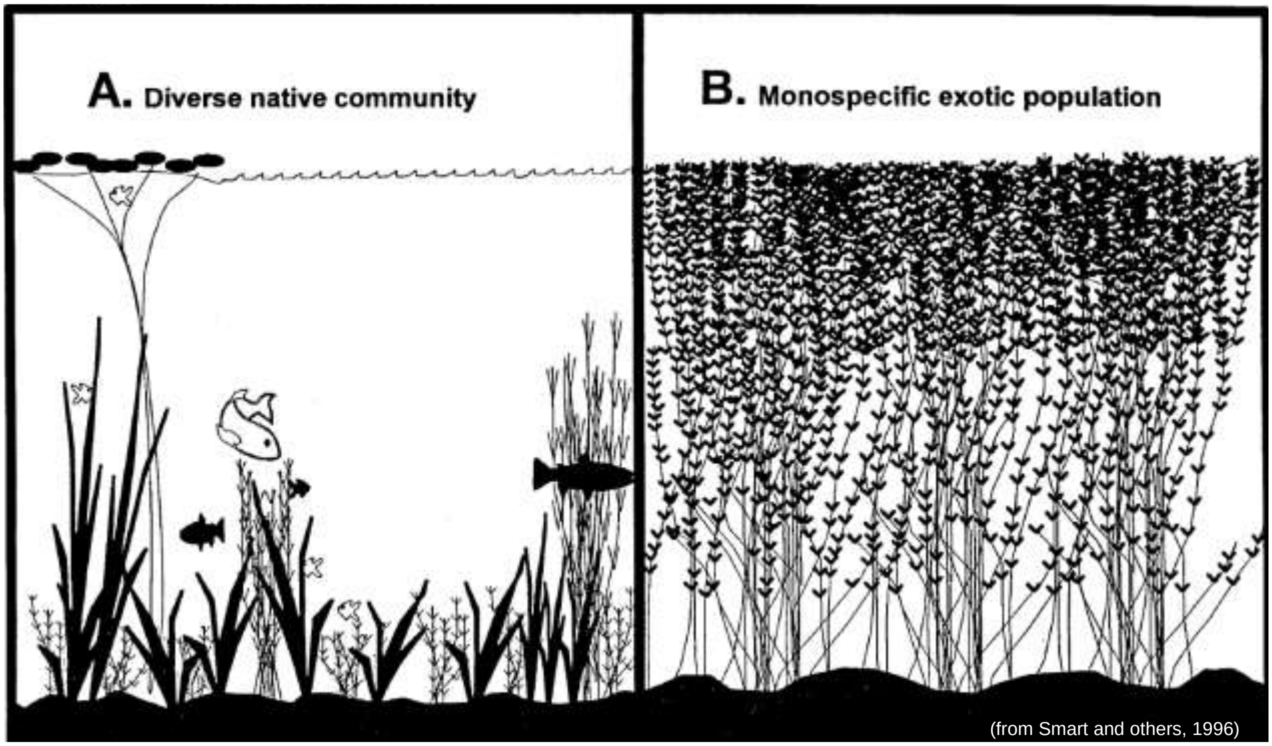


Figure 14 – Submersed Aquatic Plant Communities

7.3 Aquatic Plant Survey in Horseshoe Lake

An extensive summer point-intercept survey of the aquatic plant community in Horseshoe Lake was completed in early August, 2011 by Endangered Resources Services, LLC (ERS). The data collected through the survey followed the WDNR point intercept whole-lake survey protocol and provides information on the diversity, distribution and density of the aquatic plant community in Horseshoe Lake. Detailed statistical assessments of the 2011 data (available in the Aquatic Plant Survey Report completed by ERS in 2011) establish baseline conditions for evaluating any changes in the plant community that may occur over the coming years due to management actions, and help guide responsible aquatic plant management planning. Generally, aquatic plant management plans can be developed using data from a plant survey up to 5 years old. The 2011 survey was requested by the WDNR for the development of this plan.

7.4 2011 Point Intercept Aquatic Plant Survey Results

Aquatic plants need sunlight and appropriate substrate to growth in a lake. The area of a lake where aquatic plants get enough energy from the sun to grow, and has appropriate substrate for growth is called the littoral zone. In 2011, the littoral zone in Horseshoe Lake extended to 18ft, but plants were only widely scattered throughout with just over 65.8% of the lake's available substrate being colonized (Figure 15). *Essentially the entire lake bottom was in the littoral zone, though not all of it had aquatic plant growth.*

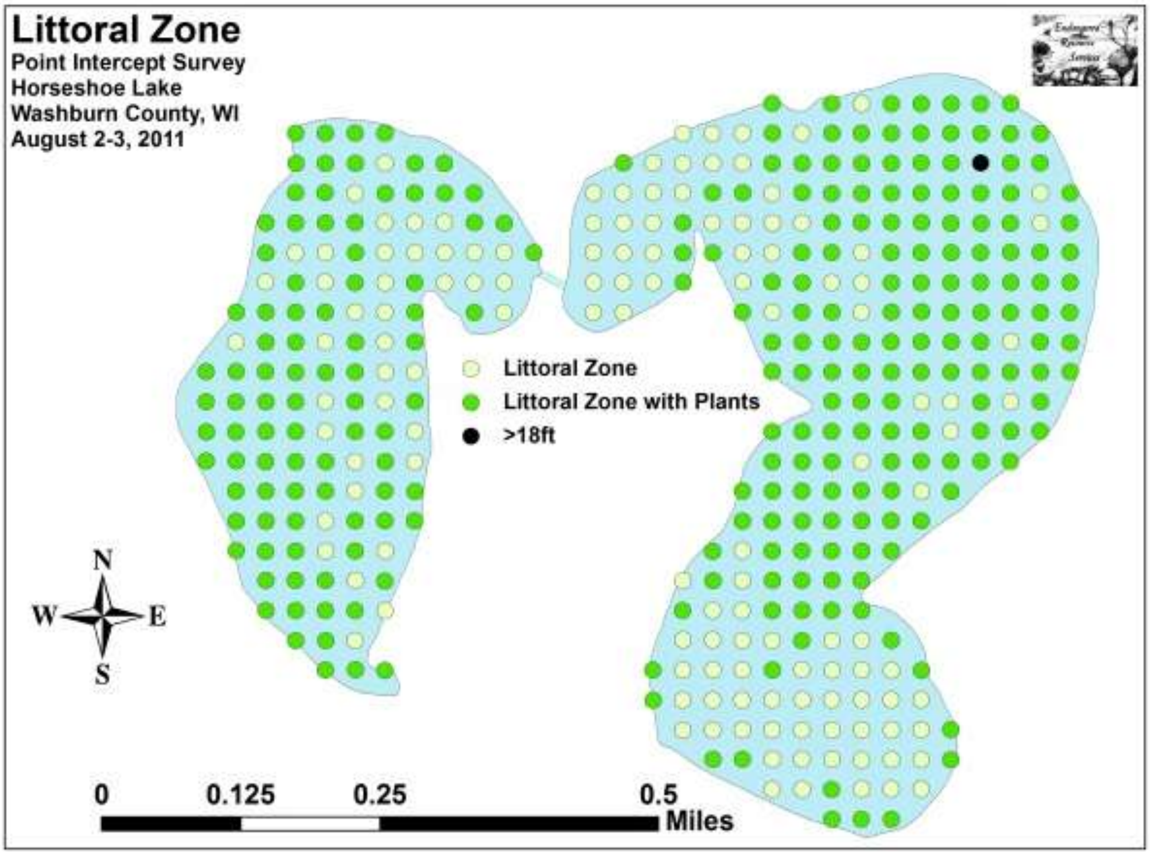


Figure 15 – Horseshoe Lake Littoral (plant growing) Zone

Overall plant density was moderate with a mean rake fullness of 1.70 on a 1-3 scale (Figure 16). *Plant density was as much a product of bottom type as depth*, meaning plants only grew where bottom substrate and water clarity supported it.

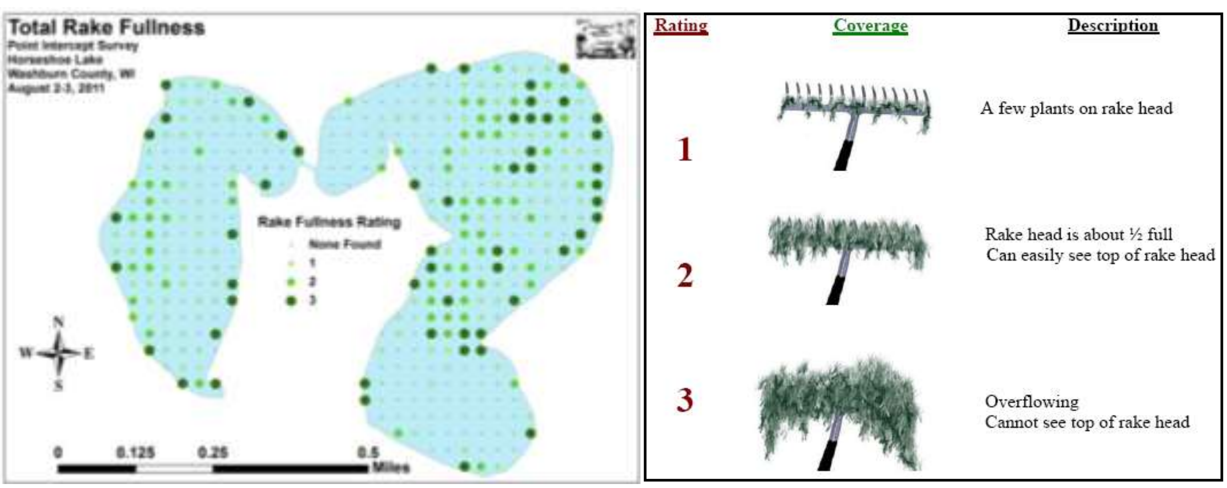


Figure 16 – Plant Density in Horseshoe Lake and Rake Density Guide

Overall diversity was high with a Simpson Diversity Index value of 0.91. The Simpson's Diversity Index represents the probability that two individually and randomly selected plants in the lake will be different species. The index value ranges from 0 -1 where 0 indicates that all the plants sampled are the same species to 1 where none of the plants sampled are the same species. The greater the index value, the higher the diversity in a given location. Although many natural variables like lake size, depth, dissolved minerals, water clarity, mean temperature, etc. can affect diversity, in general, a more diverse lake indicates a healthier ecosystem. Perhaps most importantly, plant communities with high diversity also tend to be more resistant to invasion by exotic species.

Species richness was also relatively high for such a small lake with 41 total species found growing in and immediately adjacent to the lake; however, the average number of native species per site was low with only 2.03 species/vegetative site (Figure 17). Slender naiad, Muskgrass, Fern pondweed, and Wild celery were the most common species. *They were found at 28.35*%, 27.95%, 25.20% and 23.23% of survey points with vegetation respectively. Collectively*, they accounted for 51.65%* of the total relative frequency. Although many other species were relatively common and widely distributed, only Variable pondweed (7.18), Crested arrowhead (6.41), Brown-fruited rush (5.63), Small purple bladderwort (5.24), and Dwarf water milfoil (5.05) had relative frequencies over 5%. Aquatic moss, a non-vascular plant, was actually the most common macrophyte being found at 66.30% of vegetative sites, but because it is non-vascular, WDNR plant survey protocol excludes Aquatic moss from all statistical calculations including species richness, relative frequency, and establishment of the lake's littoral zone.

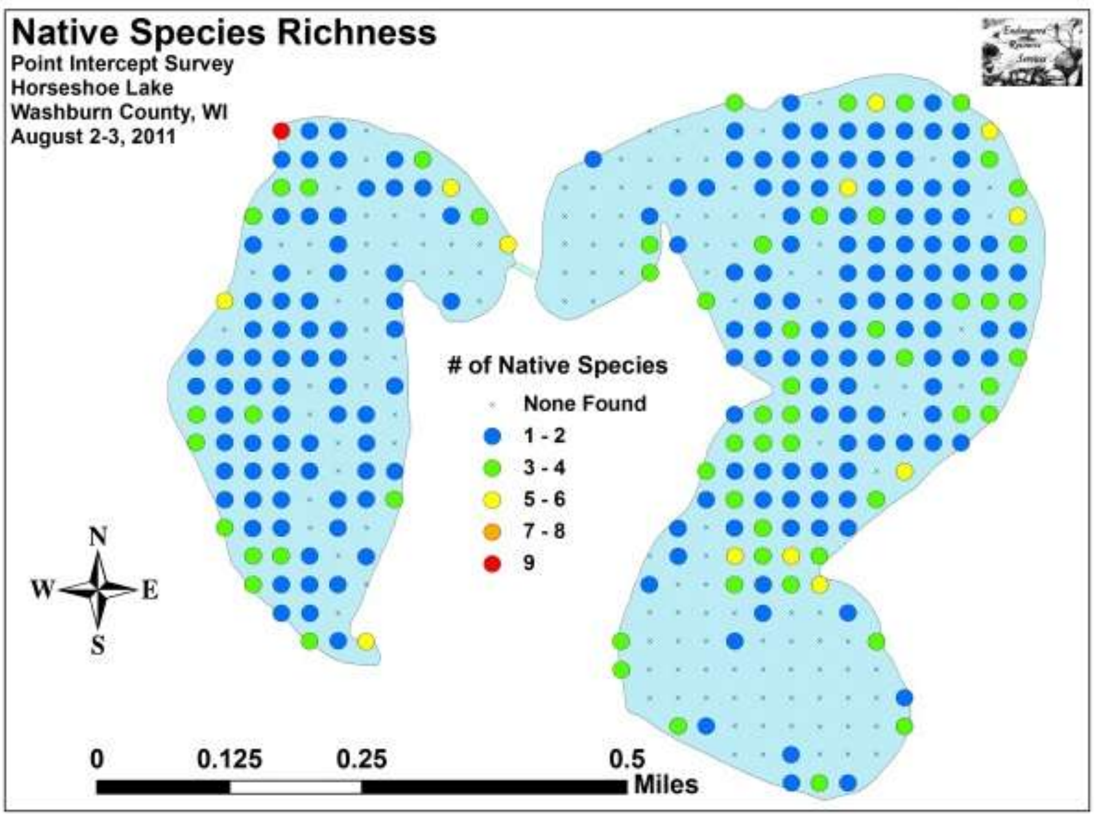


Figure 17 – Native Species Richness in Horseshoe Lake

A total of 23 native index plants were identified on the rake during the point intercept survey. Native index plants are those plants that are native and vascular in nature, so not all vegetation in the lake is included. The plants that are included however provide valuable information about the health of the vegetation in a given lake. Plants on the native index are given a rating from a 1-10 called a Coefficient of Conservatism (C). The average C from all the plants on the list identified in the lake and a Floristic Quality Index (FQI) value provide a measurement of how sensitive an aquatic plant community in a given lake is to human disturbances and give an indication of how impacted the lake already is by human disturbances. The higher the values, the more undisturbed a body of water is, and the more sensitive to human disturbances (like development and management) the lakes' aquatic plant community is.

The plants identified in Horseshoe Lake generate an average C of 7.4 and an FQI of 35, well above the median C and FQI for the Northern Lakes and Forest Region (Nichols 1999) where Horseshoe Lake is located. These high values are likely the result of the many pristine shoreline areas and variety of habitats that Horseshoe Lake offers. Specifically, index plants like Three-way sedge (*Dulichium arundinaceum*) (C = 9), Dwarf water milfoil (C = 10), Waterwort (*Elatine minima*) (C = 9), Pipewort (C = 9), Creeping spearwort (C = 9), Crested arrowhead (C = 9), Narrow-leaved bur-reed (*Sparganium angustifolium*) (C = 9), and the State Species of Special Concern ** Small purple bladderwort (C = 9) would not be present if Horseshoe Lake had not enjoyed a history of apparent good water clarity and quality. Two other high value species, Narrow-leaved woolly sedge (*Carex lasiocarpa*) (C = 9) and Smooth Sawgrass (C = 10) were found growing on the lake's shoreline.

There were no native water milfoils identified in the lake in 2011. This should make it easier to identify suspicious plants that may be EWM. If any lake resident or boater discovers a plant they even suspect may be EWM, they are encouraged to report it to one of the contacts included in the Rapid Response Plan included with this APM Plan.

More information about these and other plants that make up the aquatic plant community of Horseshoe Lake can be found in the 2011 ERS Plant Survey Report.

7.5 Wild Rice

Wild rice is not present in Horseshoe Lake. When wild rice is present in a lake, it is afforded numerous protections due to its ecological and cultural significance and management is therefore focused on harvest goals and protection of the resource rather than removal. Any activity included in a comprehensive lake or aquatic plant management plan that could potentially impact the growth of wild rice in any body of water that has in the past, currently has, or potentially could have wild rice in the future requires consultation with the Tribal Nations. This consultation is usually completed by the WDNR in cooperation with GLIFWC during their review of lake management documents.

Wild rice is an annual aquatic grass that produces seed that is a nutritious source of food for wildlife and people (Figure 18). As a native food crop, it has a tremendous amount of cultural significance to the Wisconsin and Minnesota Native American Nations. Wild rice pulls large amounts of nutrients from the sediment in a single year and the stalks provide a place for filamentous algae and other small macrophytes to attach and grow. These small macrophytes pull phosphorous in its dissolved state directly from the water. Wild rice can benefit water quality, provide habitat for wildlife, and help minimize substrate re-suspension and shoreland erosion.

In Wisconsin, wild rice has historically ranged throughout the state. Declines in historic wild rice beds have occurred statewide due to many factors, including dams, pollution, large boat wakes, and invasive plant species. Renewed interest in the wild rice community has led to large-scale restoration efforts to reintroduce wild rice in Wisconsin's landscape. Extensive information is available on wild rice from GLIFWC and the WDNR.

Figure 18 – Wild Rice

8.0 Aquatic Invasive Species

Except for EWM, no other aquatic invasive species have been identified in Horseshoe Lake. However several aquatic invasive species are present in nearby lakes and could pose a risk to Horseshoe Lake. The following sections provide more information about potential AIS threats to Horseshoe Lake.

8.1 Curly-leaf Pondweed (*Potamogeton crispus*)

Curly-leaf pondweed is a submerged aquatic perennial that is native to Eurasia, Africa, and Australia. It was introduced to United States waters in the mid-1880s by hobbyists who used it as an aquarium plant and was planted in Michigan lakes as a food source for ducks. Curly-leaf pondweed has been documented throughout the U.S. In some lakes, curly-leaf pondweed coexists with native plants and does not cause significant problems; in other lakes, it becomes the dominant plant and causes significant problems (7). Dense growth can interfere with late spring and early summer recreation and the release of nutrients into the water column from the decaying curly-leaf during the height of the growing season can fuel algal blooms. Phosphorus release rates from the senescence of monotypic curly-leaf beds have been reported as high as nearly 10 pounds per acre and averages about 5 pounds per acre (8) (9) (10).

The leaves of curly-leaf pondweed are reddish-green, oblong, and about 3 inches long, with distinct wavy edges that are finely toothed (Figure 19). The stem of the plant is flat, reddish-brown and grows from 1 to 3 feet long. Curly-leaf is commonly found in alkaline and high nutrient waters, preferring soft substrate and shallow water depths. It tolerates low light and low water temperatures.

Figure 19 – Curly-leaf Pondweed

Curly-leaf pondweed spreads through burr-like winter buds called turions (Figure 20). These plants can also reproduce by seed, but this plays a relatively small role compared to the vegetative reproduction through turions. New plants form under the ice in winter, making curly-leaf one of the first nuisance aquatic plants to emerge in the spring, often starting to grow late in the fall and staying green under the ice. Growth is accelerated in spring when light and temperature conditions are best suited for growth. Turions begin to grow in June and by late June and early July, the warm water conditions cause curl-leaf to senesce, dropping turions to the sediment while the rest of the plant decays (Figure 20).

Figure 20 – Curly-leaf Life Cycle

8.2 Habitat Suitable for EWM and CLP Growth

Both CLP and EWM can establish themselves in a wide array of habitats, but like most species there appears to be a niche where both do exceptionally well. Both plants seem to do best in relatively alkaline, phosphorus rich lakes, and nuisance growth is generally restricted to moderately fertile lakes or fertile locations in less fertile lakes. EWM will grow in low alkaline lakes but not generally as vigorously (11). EWM grows best on fine-textured, inorganic sediments with an intermediate density. It grows relatively poorly on highly organic sediments which intrinsically have a low sediment density and on coarse substrates like sand and gravel which have a high sediment density (11). Both plants begin their growth early in the season when water temperatures may be too cold to support other plant growth. While CLP usually completes its life stages by early summer, EWM persists and actually does better under higher temperatures during the summer.

8.3 Purple Loosestrife (*Lythrum salicaria*)

Purple loosestrife is a perennial herb 3 to 7 feet tall with a dense bushy growth of 1 to 50 stems. The stems, which range from green to purple, die back each year. Showy flowers vary from purple to magenta, possess 5 to 6 petals aggregated into numerous long spikes, and bloom from July to September. It is easiest to distinguish in late July and August as it has a very distinctive flowering head. Leaves are opposite, nearly linear, and attached to four-sided stems without stalks. It has a large, woody taproot with fibrous rhizomes that form a dense mat (Figure 21).

Figure 21 – Purple Loosestrife

The plant's reproductive success across North America can be attributed to its wide tolerance of physical and chemical conditions characteristic of disturbed habitats, and its ability to reproduce prolifically by both seed dispersal and vegetative propagation. The absence of natural predators, like European species of herbivorous beetles that feed on the plant's roots and leaves, also contributes to its proliferation in North America. This plant's optimal habitat includes marshes, stream margins, alluvial flood plains, sedge meadows, and wet prairies. It is tolerant of moist soil and shallow water sites such as pastures and meadows, although established plants can tolerate drier conditions.

Purple loosestrife has also been planted in lawns and gardens, which is often how it has been introduced to many wetlands, lakes, and rivers. By law (NR 40), purple loosestrife is a nuisance species in Wisconsin. It is illegal to sell, distribute, or cultivate the plants or seeds, including any of its cultivars.

8.4 Rusty Crayfish and Chinese Mystery Snail

Rusty crayfish are omnivores, meaning they forage on both plant and animal material. Originally from parts of the United States south of Indiana, they are larger and more aggressive than species of crayfish native to Wisconsin (Figure 22). Rusty crayfish prefer hard bottoms and tend to avoid soft sediment or mucky areas of lakes. When introduced they tend to replace native populations of crayfish, and then multiply rapidly. As omnivores they eat many things, including plant material, fish eggs, minnows, invertebrates and other crustaceans. In some lakes, they have devastated the aquatic plant community. Often, after reaching large populations, the number of rusty crayfish in the system declines rapidly. Some research suggests that this is because of a parasite infecting the crayfish. Management of this invasive species is limited, focusing on trapping or removal by residents.

Little is known about the ecological impact of Chinese mystery snails (Figure 22) except that large die-offs are particularly offensive to the nose and impair lake aesthetics. Management is limited and basically consists of landowner removal and disposal of snails and empty shells washed up on shore.

Figure 22 – Rusty Crayfish (left) and Chinese Mystery Snail (right)

9.0 Aquatic Plant Management Alternatives

Problematic aquatic plants in a lake can be managed in a variety of ways. The eradication of non-native aquatic invasive plant species such as EWM is generally not feasible, but preventing them from becoming a more significant problem is an attainable goal. Aquatic invasive species can negatively impact the native plant species that are beneficial to the lake ecosystem. Targeted early- and mid-season removal or treatment can minimize some of these impacts by preventing the AIS from becoming the dominant plant species in the lake which allows for the growth of more desirable native aquatic plants.

Control methods for nuisance aquatic plants can be grouped into five broad categories:

- Chemical control
- Manual removal
- Mechanical removal
- Biological control
- Physical habitat alteration

Chemical application is typified by the use of herbicides. Manual and mechanical removal methods include pulling, cutting, raking, harvesting and other means of removing the plants from the water. Biological control methods include organisms that use the plants for a food source or parasitic organisms that use the plants as hosts. Biological control may also include the use of species that compete successfully with the nuisance species for resources. Physical habitat alteration includes dredging, flooding, and drawdown. In many cases, an integrated approach to aquatic plant management that utilizes a number of control methods is necessary.

Regardless of the target plant species, native or non-native, sometimes no manipulation of the aquatic plant community is the best management option. Plant management activities can be disruptive to areas identified as critical habitat for fish and wildlife and should not be done unless it can be shown that it will be beneficial and occur with minimal negative ecological impacts.

Not all plant management alternatives can be used in a particular lake. What other states accept for aquatic plant management may not be acceptable in Wisconsin. What is acceptable and appropriate in southern Wisconsin lakes may not be acceptable and appropriate in northern Wisconsin lakes. Informed decision-making on aquatic plant management options requires an understanding of plant management alternatives and how appropriate and acceptable each alternative is for a given lake. Possible aquatic plant management alternatives are described below, beginning with the most appropriate options for Horseshoe Lake.

9.1 Chemical Control

Aquatic herbicides are chemicals specifically formulated for use in water to kill or control aquatic plants. Herbicides approved for aquatic use by the United States Environmental Protection Agency (EPA) have been reviewed and are considered compatible with the aquatic environment when used according to label directions. Some individual states, including Wisconsin, also impose additional constraints on their use.

9.1.1 How Chemical Control Works

Aquatic herbicides are sprayed directly onto floating or emergent aquatic plants or are applied to the water in either a liquid or pellet form. Herbicides affect plants through either systemic or direct contact action. Systemic herbicides are capable of killing the entire plant. Contact herbicides cause the parts of the plant in contact with the herbicide to die back, leaving the roots viable and possibly able to re-grow.

Herbicides can be classified as broad-spectrum (kill or injure a wide variety of plant species) or selective (effective on only certain species). Non-selective, broad spectrum herbicides will generally affect all plants that they come in contact with. Selective herbicides will affect only some plants. Depending on the chemical used, dicots (like Eurasian water milfoil, native water milfoils, and coontail), or monocots (such as common waterweed and the many pondweeds) will be affected, but not generally both. Greater selectivity of a particular herbicide can be achieved by modifying the method and/or timing of application, formulation, and concentration used.

Applying some systemic and contact herbicides together has a synergistic effect leading to increase selectivity and control (12). Single applications of the two could result in reduced environmental loading of herbicides and monetary savings via a reduction in the overall amount of herbicide used and of the manpower required for application.

9.1.2 Toxicity of Chemicals

The toxicity of a chemical is determined by several factors: dose or concentration, persistence in the environment, and fate in animal tissue. Before any herbicide can be used in a specific environment, the EPA runs up to 140 different kinds of tests and analyses including acute toxicity (how much to cause immediate death), chronic toxicity (how much to cause death over a longer period of time), carcinogenicity (ability to cause cancer), and mutagenicity (ability to cause genetic defects) (13). The toxicity of the herbicides tested applies if it were drank right out of the jug, or injected directly into a subject. When an herbicide is applied to a body of water it is going to be greatly diluted, making for extremely low concentrations (13).

Chemical compounds like 2,4-D, triclopyr, fluridone, and glysophate (see Section 9.2) have very specific sites of action and only affect processes that occur in plants, and not in humans and animals (13). The toxicity of these chemicals is very low suggesting that huge volumes of the chemical would have to be ingested to have negative consequences.

Herbicides can be removed from the environment they are applied to by three primary mechanisms: adherence to particles in the water the settle out to the bottom, microbial degradation of the herbicide in the sediment; and photo-degradation as the herbicide is exposed to the sunlight (13). With the few herbicides approved by the EPA for use in aquatic environments, breakdown into innocuous (non-toxic) compounds occurs in a few hours to at most a few weeks (13).

Different chemicals have different solubility in water and fat. Solubility is the propensity to dissolve in a given medium (like water or fat). If a chemical is fat soluble, if can build up in fatty tissue over time causing possible harm. Mercury is a chemical that has been shown to build up in fatty tissue over time, which is why many lakes and rivers have fish consumption advisories. The longer a fish is a system where mercury is introduced, the more mercury builds up in that fishes fatty tissue. When we eat that fatty tissue the mercury is transferred to our fatty tissues and can cause problems at high enough concentrations. Other chemicals have high solubility in water, and may have zero solubility in fats, meaning they cannot accumulate in fatty tissue. Water soluble chemicals can be taken into animal bodies (like inadvertently swallowing lake water while swimming) but the chemical would stay in the water ingested, not transferred to fatty tissues, and thus be discarded through urination (13).

Of concern is whether or not a given aquatic herbicide has been shown to cause cancer or mutations. The EPA uses an alphabetical system (A-E) to categorize the potential of a chemical to be carcinogenic. "A" compounds have been shown through tests to cause cancer. "E" compounds have been shown through tests to not cause cancer (13). All aquatic herbicides approved by the EPA except one (Copper sulfate) have been given a rating of "D" (2,4-D) or "E" (endothall, diquat, fluridone, and glysophate) meaning existing data suggests or confirms that the compound is non-carcinogenic.

Herbicides are chemicals, and even though extensive testing has and continues to be done to determine the best and safest use of them, when misused they can cause many problems, many of which are not associated with human health at all. All herbicides that are approved for use in an aquatic environment have restrictions for use that are clearly spelled out on the label of the product. Responsible use by the applicator, understanding of the label restrictions, and appropriate planning is necessary to use them safely to achieve desired goals. When used wisely, aquatic herbicides can be a safe and effective tool to aid in lake improvement management (13).

9.2 EPA-approved Aquatic Herbicides in Wisconsin

There are currently six aquatic herbicides registered for use in Wisconsin. A brief summary of each is presented below.

9.2.1 2,4-D

There are two formulations of 2,4-D approved for aquatic use. The granular formulation contains the low-volatile butoxy-ethyl-ester formulation of 2,4-D (2,4-D BEE; trade names include AquaKleen® and Navigate®). The liquid formulation contains the dimethylamine salt of 2,4-D (2,4-D DMA). Trade names include DMA*4. 2,4-D is a relatively fast-acting, systemic, selective herbicide used for the control of Eurasian water milfoil and other dicots. 2,4-D has been shown to be selective to Eurasian water milfoil when used at the labeled rate, leaving native aquatic species relatively unaffected. It is not effective against elodea or hydrilla. 2,4-D can impact early season wild rice growth so should not be used in areas where the target species and wild rice cohabitate (14).

9.2.2 Triclopyr

Common trade names for triclopyr are Renovate 3 and Garlon 3A. There are two formulations of triclopyr. It is the TEA formation of triclopyr that is registered for use in aquatic or riparian environments. Triclopyr, applied as a liquid, is a relatively fast-acting, systemic, selective herbicide used for the control of Eurasian water milfoil and other dicots. It is also available in a granular formulation under the trade name Renovate OTF. Triclopyr can be effective for spot treatment of Eurasian water milfoil and is relatively selective to Eurasian water milfoil when used at the labeled rate. Many native aquatic species are unaffected by triclopyr. Triclopyr is very useful for purple loosestrife control since native grasses and sedges are unaffected by this herbicide. Triclopyr degrades quickly in an aquatic environment making its use most effective in systems with low water-exchange where contact with target plants can be maintained for longer periods of time. It does not appear to significantly affect pondweeds and coontail.

9.2.3 Fluridone

Trade names for fluridone products include Sonar® and Whitecap®. Fluridone is a slow-acting systemic herbicide used to control Eurasian water milfoil and other underwater plants. It may be applied as a pellet or as a liquid. Fluridone can show good control of submersed plants where there is little water movement and an extended time for the treatment. Its use is most applicable to whole-lake or isolated bay treatments where dilution can be minimized. It is not effective for spot treatments of areas less than five acres. It is slow-acting and may take six to twelve weeks before the dying plants fall to the sediment and decompose. When used to manage Eurasian water milfoil, fluridone may be applied several times during the spring/summer to maintain a low, but consistent concentration in the water. Granular formulations of fluridone are proving to be effective when treating areas of higher water exchange or when applicators need to maintain low levels over long time periods. Although fluridone is considered to be a broad spectrum herbicide, when used at very low concentrations, it can be used to selectively remove Eurasian water milfoil. Some native aquatic plants, especially pondweeds, are minimally affected by low concentrations of fluridone.

9.2.4 Diquat

A trade name for diquat is Reward®. Diquat is a fast-acting non-selective contact herbicide which destroys the vegetative part of the plant but does not kill the roots. It is applied as a liquid. Typically diquat is used primarily for short term (one season) control of a variety of submersed aquatic plants. It is very fast-acting and is suitable for spot treatment. However, turbid water or dense algal blooms can interfere with its effectiveness. Diquat is strongly attracted to clay particles in the water and thus is not effective in lakes or ponds with muddy water or plants covered with silt. For this reason, care must be taken to not disturb bottom sediments during application.

9.2.5 Endothall

Trade names for endothall include Aquathol K or Super K, and Hydrothol 191. Endothall is a fast-acting non-selective contact herbicide which destroys the vegetative part of the plant but generally does not kill the roots. Endothall may be applied in a granular or liquid form. Typically endothall compounds are used primarily for short term (one season) control of a variety of aquatic plants. However, there has been some recent research that indicates that when used in low concentrations, endothall can be used to selectively remove exotic weeds; leaving some native species unaffected. Because it is fast acting, endothall can be used to treat smaller areas effectively. Endothall is not effective in controlling Canadian waterweed or Brazilian elodea. Endothall can impact early season wild rice growth so should not be used in areas where the target species and wild rice cohabitate (14).

9.2.6 Glyphosate

Trade names for aquatic products with glyphosate as the active ingredient include Rodeo®, AquaMaster®, and AquaPro®. This systemic broad spectrum herbicide is used to control floating-leaved plants like water lilies and shoreline plants like purple loosestrife. It is generally applied as a liquid to the leaves. Glyphosate does not work on underwater plants such as Eurasian water milfoil. Although glyphosate is a broad spectrum, non-selective herbicide, a good applicator can somewhat selectively remove targeted plants by focusing the spray only on the plants to be removed. Plants can take several weeks to die and a repeat application is often necessary to remove plants that were missed during the first application.

9.2.7 Copper Complexes

Copper sulfate and chelated coppers have been widely used as non-selective, fast-acting, contact herbicides or algaecides. These chemicals have been used to control aquatic plants and algae, often in conjunction with endothall and diquat. Copper compounds are primarily used for algae control but can be effective against certain submerged plant species. Copper can build up in sediments, can be toxic to fish and invertebrates, and certain species of algae can build up a resistance (15). The use of copper compounds to control algae was once widely accepted in Wisconsin, but in recent years it has not been supported as a viable control method because of the potential negative impacts inherent in its use.

9.2.8 Timing and Impacts

When properly applied, herbicides can control aquatic vegetation without harming fish and other wildlife. A WDNR permit is required for the use of aquatic herbicides and a certified pesticide applicator is required for application on most Wisconsin lakes. Full-season control is often achieved with herbicide application and control may extend into the following year. Because the plants remain in the lake and decay, treating too much plant matter can lead to a depletion of dissolved oxygen. Also, algal blooms may occur as nutrients are released into the water by the decaying plants. Spring and early summer are preferred for application because exotic species such as CLP and EWM are actively growing, whereas many native plants are not, fish spawning has ceased, and recreational use is generally low thereby limiting human contact.

9.2.9 Pre and Post Treatment Aquatic Plant Surveying

When introducing new chemical treatments to lakes where the treatment size is greater than ten acres or greater than 10% of the lake littoral area and more than 150-ft from shore, the WDNR requires pre and post chemical application aquatic plant surveying. The purpose of the pre and post surveys is to satisfy grant funded treatments conditions where restoration is a goal or where performance results are needed. The protocol for pre and post treatment survey is applicable for chemical treatment of CLP or EWM.

The WDNR protocol assumes that an Aquatic Plant Management Plan has identified specific goals for non-native invasive species and native plants species. Such goals could include reducing coverage by a certain percent, reducing treatments to below large-scale application designations, and/or reducing density from one level to a lower level. A native plant goal might be to see no significant negative change in native plant diversity, distribution, or density. Results from pre and post treatment surveying are used to improve consistency in analysis and reporting, and in making the next season’s management recommendations.

The number of pre and post treatment sampling points required is based on the size of the treatment area. Ten to twenty acres generally requires at least 100 sample points. Thirty to forty acres requires at least 120 to 160 sampling points. Areas larger than 40 acres may require as many as 200 to 400 sampling points. Regardless of the number of points, each designated point is sampled by rake recording depth, substrate type, and the identity and density of each plant pulled out, native or invasive.

9.2.10 Residual Testing

Chemical concentration or residual testing is often done in conjunction with treatment to track the fate of the chemical herbicide used in a particular lake. Residual testing is completed to determine if target concentrations are met, to see if the chemical moved outside its expected zone, and to determine if the chemical breaks down in the system as expected.

Water samples are collected prior to treatment and for a period of hours and/or days following chemical application (for example: 1,3,6,12, and 18 hours after application; and 1, 4, 7, 14, and 21 days after application). Monitoring sites are located both within and outside of the treatment area, particularly in areas that may be sensitive to the herbicide used, where chemical drift may have adverse impacts, where movement of water or some other characteristic may impact the effect of the chemical, and where there may be impacts to drinking and irrigation water.

9.3 Manual Removal

Except for wild rice, manual removal of aquatic plants by means of a hand-held rake or by pulling the plants from the lake bottom by hand is allowed by the WDNR without a permit per NR 109 (Appendix C). The zone of manual removal cannot exceed 30 shoreland feet and all raked or pulled plant material must be taken completely out of the lake and removed from the shoreline (Figure 23). Plant fragments can be composted or added directly to a garden.

Although up to 30 feet of shoreland vegetation can be removed, removal should only be done to the extent necessary. Clearing large swaths of macrophytes not only disrupts lake habits, it also creates open areas for non-native species to establish. If an aquatic invasive species such as CLP is the target species, then removal by this means is unrestricted as long as native plants are not damaged or eliminated.

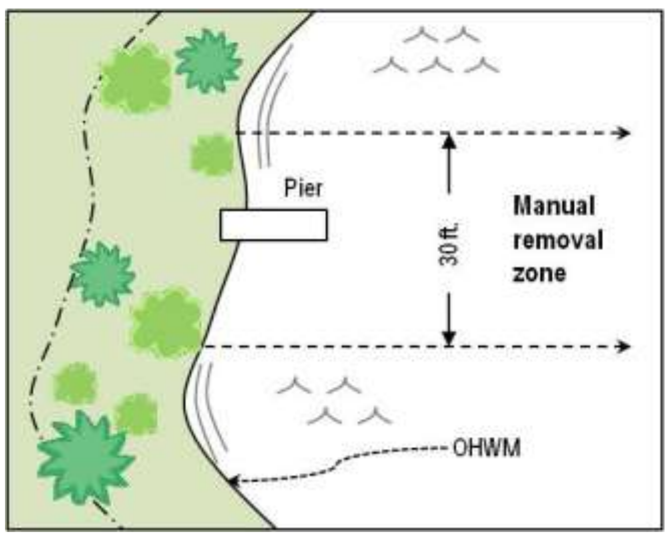


Figure 23 – Aquatic Vegetation Manual Removal Zone

Manual removal can be effective at controlling individual plants or small areas of plant growth. It limits disturbance to the lake bottom, is inexpensive, and can be practiced by many lake residents. In shallow, hard bottom areas of a lake, or where impacts to fish spawning habitat need to be minimized, this is the best form of control. Pulling aquatic invasive species while snorkeling or scuba diving in deeper water is also allowable without a permit and can be effective at slowing the spread of a new aquatic invasive species infestation within a lake when done properly.

9.3.1 Larger-scale Manual Removal

Larger scale hand or diver removal projects have had positive impacts in temporarily reducing or controlling aquatic invasive species. Typically hand or diver removal is used when a AIS has been newly identified and still exists as single plants or isolated small beds, but at least in one lake in New York State, it was used as a means to control a large-scale infestation of EWM. Kelting and Laxson (16) reported that from 2004 to 2006 an "intensive management effort" which involved "the selective removal of Eurasian water milfoil using diver hand harvesting of the entire littoral zone of the lake at least twice each summer for three years" followed by three years of maintenance management successfully reduced the overall distribution of EWM in the lake.

Overall costs ranged from a high of $796 per hectare of EWM removed during the three years of intensive management effort, to about $300 per hectare during the three year maintenance period (16). In the first two years of intensive management effort, the cost per kg of EWM removed was relatively low. As the efforts proved to be successful at knocking down the distribution and density of the EWM, the cost per kilogram of EWM went up as it took an equal amount of time and money to find and remove a much lower amount of EWM. The authors also commented that during the maintenance period the amount of EWM trended back up, indicating that limiting intensive management effort allowed for the EWM to make a comeback (16).

Several lake groups have and continue to use large-scale physical removal of EWM. Horseshoe Lake in Barron County uses diver removal on small or isolated areas of EWM, and uses chemical herbicides on larger, more expansive EWM beds. Early in the management phase, Sand Lake in Barron County attempted diver removal, but stopped using divers as the EWM expanded too rapidly for the divers to keep up with.

In 2011, the Red Cedar Lakes Association (RCLA) in Barron County performed diver removal on a dense, isolated one acre bed of CLP in Red Cedar Lake. This large-scale effort engaged a group of about 10 local high school students (members of the Conservation Club) and an RCLA representative. Water depths and inexperience made removal difficult; however, the effort was fairly successful and the divers were able to remove a large boat load of CLP.

9.4 Mechanical Removal

Mechanical removal of aquatic plants involves the use of motorized accessories to assist in vegetation removal. Mechanical control can be used for both small- and large-scale control efforts. WDNR permits are required regardless of the size of the area to be managed with mechanical control.

9.4.1 Small-Scale Mechanical Management

There are a wide range of small-scale mechanical management techniques, most of which involve the use of boat mounted rakes, scythes, and electric cutters. As with all mechanical harvesting, removing the cut plants is required. Commercial rakes and cutters range in prices from $200 for rakes to around $3000 for electric cutters with a wide range of sizes and capacities. Harvesting rakes could be purchased by the HLPA and rented out to cover costs or its use offered as a service by the association.

Although not truly considered mechanical management, plant disruption by normal boat traffic is a legal method of management. Active use of an area is often one of the best ways for riparian owners to gain navigation relief near their docks. Most macrophytes won't grow well in an area actively used for boating and swimming. It should be noted that purposefully navigating a boat in circles to clear large areas is not only potentially illegal it can also re-suspend sediments, encourage aquatic invasive species growth, and cause ecological disruptions.

9.4.2 Large-scale Mechanical Harvesting

The most common form of mechanical control is the use of large-scale mechanical weed harvesters on the lake. The harvesters are generally driven by modified paddle wheels and include a cutter that can be raised and lowered, a conveyor system to capture and store the cut plants, and the ability to off-load the cut plants. The depth at which these harvesters cut generally ranges from skimming the surface to as much as five-feet deep.

Large-scale plant harvesting in a lake is similar to mowing the lawn. Plants are cut at a designated depth, but the root of the plant is often not disturbed. Plant composition can be modified by cutting away dense cover which may increase sunlight penetration enough to stimulate growth of underlying species (Figure 24) (17). Cut plants will usually grow back after time, just like the lawn grass. Re-cutting during the growing season is often required to provide adequate annual control (18). Harvesting activities in shallow water can re-suspend bottom sediments into the water column releasing nutrients and other accumulated compounds (18). Some research indicates that after cutting, reduction in available plant cover causes declines in fish growth and zooplankton densities. Other research finds that creating deep lake channels by harvesting increases the growth rates of some age classes of bluegill and largemouth bass (19).

Harvesters can remove thousands of pounds of vegetation in a relatively short time period. They are not, however, species specific. Everything in the path of the harvester will be removed including the target species, other plants, macro-invertebrates, semi-aquatic vertebrates, forage fishes, young-of-the-year fishes, and even adult game fish found in the littoral zone (20).

9.4.3 Other Mechanical Management

Cutting without plant removal, grinding and returning the vegetation to the water body, and rotovating (tilling) are also methods employed to control nuisance plant growth in some lakes. Cutting is just like harvesting except the plants are left in the waterbody. Grinding incorporates cutting and then grinding to minimize the biomass returned to the lake. Smaller particles disperse quicker and decay more rapidly. Rotovating works up bottom sediments dislodging and destroying plant root crowns and bottom growth.

Bottom rollers and surface sweepers are devices usually attached to the end of a dock or pier and sweep through an area adjacent to the dock. Continued disruption of the bottom area causes plants to disappear and light sediments to be swept out. The use of rollers may disturb bottom dwelling organisms and spawning fish. Plant fragmentation of nuisance weeds may also occur. In soft bottom areas, sediment disturbance can be significant. These devices are generally not permitted in Wisconsin. A permit under Section 30.12(3) is required which governs the placement of structures in navigable waters.

Another common method for removing aquatic plants from a beach or dock area is for riparian owners to hook a bed spring, sickle mower blade, or other contraption to the back of a boat, lawn mower, or ATV and drag it back and forth across the bottom. This type of management is considered mechanical and would require a harvesting permit.

Suction dredging is a form of mechanical harvesting where diver-operated suction tubes connected to barge- or pontoon-mounted pumps and strainer devices with hoses, are used to vacuum plants uprooted by hand. This management technique is considered harvesting because plants are removed directly from the sediments by divers operating this device. The suction tube is then used to transfer the uprooted plant to the surface without fragmentation. Suction dredging is mostly used for control of isolated, new infestations of AIS.

9.5 Biological Control

Biological control (biocontrol) for aquatic plant management involves using animals, fungi, insects, or pathogens as a means to control nuisance plants. The goal of biocontrol is to weaken, reduce the spread, or eliminate the unwanted population so that native or more desirable populations can make a comeback. A special permit is required in Wisconsin before any biocontrol measure can be introduced into a new area.

Biological control of nuisance plants in aquatic systems has both positive and negative attributes. One positive is that control agents are often host specific, so effects to non-target species may be reduced. Control agents can also reproduce in response to increases in nuisance species density often without reapplication of the agent. Development and registration (where necessary) of biological control agents is generally less expensive than chemical agents.

Biocontrol can have many potential disadvantages. A substantial risk is involved when new species are introduced as bio-control agents. To be considered successful, these species are expected to persist indefinitely in the environment where they are used, and may spread to new locations. Therefore, if there are any adverse effects resulting from the bio-control agent, these effects may be difficult or impossible to control. Other drawbacks include unpredictable success and rates of control that are slower than with other methods. Resistance in host species is unlikely to develop but can occur. Finally, agents that work in one area may not be suitable in all ecosystems. Climate, interference from herbicidal application, hydrological conditions, and eutrophication of the system can influence the effectiveness of bio-control agents. As is the case with other forms of invasive species management, the growth of nuisance weeds can be suppressed with the use of bio-control agents, but not fully eliminated (18).

9.5.1 Biological Controls in Wisconsin

Many herbivorous insects have been and continue to be studied for their impacts on unwanted aquatic plant species. An herbivorous aquatic moth (*Acentria ephemerella*), two native herbivorous weevils (*Euhrychiopsis lecontei* and *Phytobius* spp.), and a midge species (*Cricotopus* spp.) have been associated with the decline of EWM in lakes. Several species of insect are being used to control purple loosestrife infestations very effectively, notably two *Galerucella* spp. The Galerucella beetles are easy to rear and can be extremely effective at reducing large populations of purple loosestrife. After nearly 20 years of use, Galerucella appear to have no negative effect on the areas in which they are introduced.

There are currently no biological controls for CLP, but research to identify and establish biological controls are on-going. Studying naturalized and native herbivores and pathogens that impact nuisance aquatic and wetland plants increases the number of potential biological control agents that could be incorporated into invasive plant management programs. The groundwork has been laid for conducting future biological control research and experimentation. Although not all of the native and naturalized organisms researched can be successful, the information and expertise is now available for potential insects and pathogens to be collected, analyzed, and studied. A continuation of the work that has been started is needed to make available for the future more successful native bio-control agents (21).

There are several forms of biological control that have been used in other states, but are not approved for use in Wisconsin. The grass carp (*Ctenopharyngodon idella*), also known as the white amur, feeds on aquatic plants and has been used as a biological tool to control nuisance aquatic plant growth in other states. In addition to grass carp, common carp and tilapia (a fish species) have been added to ecosystems to reduce aquatic vegetation. Wisconsin does not permit the use of these fish for aquatic plant control.

Plant fungi and pathogens are currently still in the research phase. Certain species for control of hydrilla and EWM have shown promise, but only laboratory tests in aquariums and small ponds have been conducted. Methods are not available for widespread application. Whether these agents will be successful in flowing waters or large-scale applications remains to be tested (22).

9.5.1.1 EWM Weevils

While many biological controls have been studied, only one has proven to be effective at controlling EWM under the right circumstances. Euhrychiopsis lecontei are an aquatic weevil native to Wisconsin that feed on aquatic milfoils. Their host plant is typically northern water milfoil; however they prefer EWM when it is available. Milfoil weevils are typically present in low numbers wherever northern or Eurasian water milfoil is found. They often produce several generations in a given year and over winter in undisturbed shorelines around the lake. All aspects of the weevil's life cycle can affect the plant. Adults feed on the plant and lay their eggs. The eggs hatch and the larva feed on the plant. As the larva mature they eventually burrow into the stem of the plant. When they emerge as adults later, the hole left in the stem reduces buoyancy often causing the stem to collapse. The resulting interruption in the flow of carbohydrates to the root crowns, reduce the plants ability to store carbohydrates for over wintering reducing the health and vigor (23).

The weevil is not a silver bullet however. They do not work in all situations. The extent to which weevils exist naturally in a lake, adequate shore land over wintering habitat, the population of bluegills and sunfish in a system, and water quality characteristics are all factors that have been shown to affect the success rate of the weevil.

It may be possible for EWM weevils to be used in Horseshoe Lake if the density and distribution of EWM expands rapidly. However, before undertaking actions to introduce or to supplement an existing population, more data should be collected, including a quantifiable estimation of current weevil densities, a better assessment of the bluegill and sunfish population, and a formal analysis of the over wintering habitat available. Should all these variables prove to be in line with apparent conditions that warrant success, then EWM control with weevils could be attempted.

9.5.2 Biological Manipulation

Biological manipulation is defined as manipulating a particular trophic level in a body of water to make changes in the trophic status of a lake that may benefit management goals. Chase and Knight 2006 (24) suggest that the presence of snails can limit EWM growth. This is an example of biological manipulation of the various trophic levels found in a water body. A trophic level is considered one layer in the many layers that make a lake system work. For example, small often microscopic critters called zooplankton feed on algae, like cows feed on grass. If there a significant decline in zooplankton, perhaps because an over-abundance of small panfish eat them, then it is possible for the levels of algae to go up in a lake. It may be possible to reduce the number of small panfish by introducing larger predator fish. If panfish are reduced, then zooplankton can rebound again impacting the amount of algae in a system. Many snails feed on algae. In their study, Chase and Knight 2006 found that the presence of snails was one variable that helped decrease algae and EWM density while increasing native plant biomass.

Another version of this is to reduce predators on insects that may help to control a given undesirable species. The EWM weevil is a favorite food source for small panfish. Reducing the number of panfish by introducing predators, may support greater survival of the biological control agents introduced.

9.6 Physical Habitat Alteration

EWM is an opportunistic species, meaning it does well in areas that have been disturbed by human activity including shoreline development, clearing vegetation from beaches and near docks, and boat launching areas. Where these disturbed areas exist, potential habitat for EWM also exists. Restoring these areas can be one way of controlling the spread of EWM.

Physical habitat alteration also involves management activities that alter the environment in which aquatic plants are growing. Several techniques are commonly used: drawdown or flooding, dredging, benthic barriers, shading or light attenuation, and nutrient inactivation. While not prohibited in Wisconsin, these plant management alternatives will undergo much greater scrutiny by the WDNR, and in most cases will not be permitted.

9.6.1 Shoreland Improvement and Native Plant Restoration and Enhancement

Native plant restoration, in particular shoreland restoration, is used on many lakes to reduce erosion, increase and improve native habitat, and improve water quality. Restoration not only improves the lake aesthetic enjoyed by so many, it also keeps invasive species ay bay. A study performed in west-central Wisconsin found the mean occurrence of non-native aquatic invasive species to be significantly greater at disturbed shoreline sites than at natural shorelines (25). The study also found that the occurrence of non-native species and filamentous algae increased with the amount of disturbed shoreline on a lake.

To minimize locations in a lake where invasive species like EWM can get established, making improvements to the shoreland and shallow water areas adjacent to that shoreland can be important. Figure 24 demonstrates the difference between a healthy, invasive species resistant, shoreline and a shoreline that invites and invasive species to become established. There are many public and free resources available for planning and implementing shoreland restoration projects.

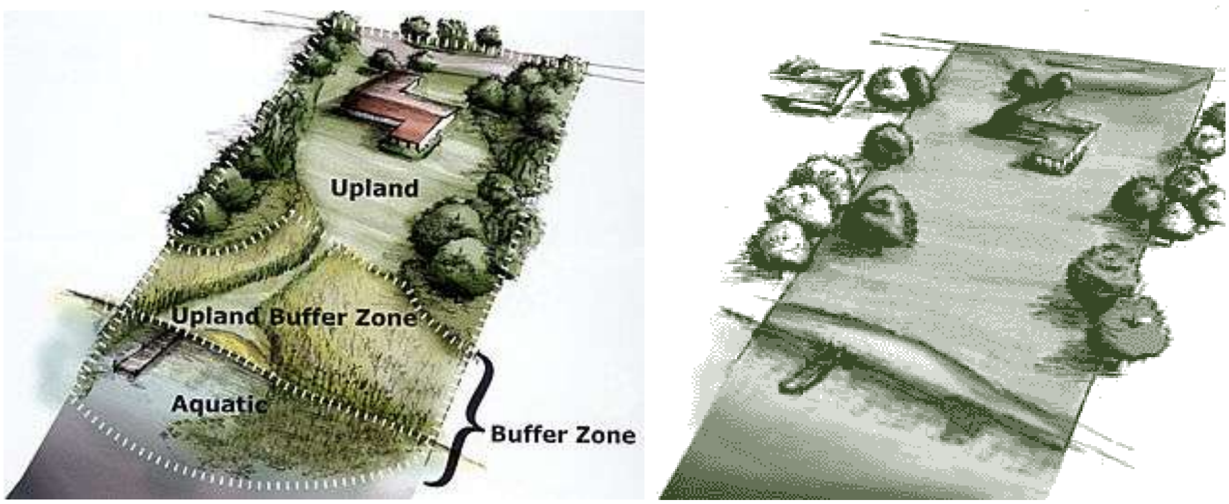


Figure 24 – Healthy, AIS resistant shoreland (left) vs. shoreland in poor condition

In areas where dense growth of invasive species exists, native plants may re-establish naturally once the invasive species is removed if seeds and other propagules are still present. But in some cases, artificially restoring this habitat is required. If desirable native plants do not come back by themselves, it may be possible to collect plant stock from other areas of the lake. It may also be necessary to collect plants from other lakes or to purchase then from commercial vendors. Collecting plants from the same or other water bodies may require a permit. If commercial plants are purchased, care should be taken to not introduce unwanted vegetation at the same time. Because many submergent and floating leaf plants are susceptible to failure during restoration, a good rule of thumb to follow is to plant as many as possible. Emergent plant species may not be as susceptible to failure.

Artificially reintroducing native aquatic plants is often difficult and costly and requires a fairly large source of new plants and substantial short-term labor for collecting, planting, and maintaining the stock. Maintenance of plantings may require protection from fish and birds and temporary stabilization and protection of sediment in the planting area from wind and waves (Figure 25).

Figure 25 – "Buffer Blocker" System for Protecting Native Macrophyte Plantings

There are many sources for more information regarding native aquatic plant restoration. Smart and others (6) discuss numerous techniques for establishing native aquatic plants in reservoirs with an absence of vegetation or low species diversity. The Langlade County, Wisconsin Land Records and Regulations Department has a Shoreland Restoration Web Site which provides a great deal of information for re-establishing native plants: http://lrrd.co.langlade.wi.us/shoreland/index.asp (last accessed: March 2013). A complete review of these techniques and others should be completed before undertaking a planting project.

9.6.2 Nutrient Management to Reduce Less Desirable Aquatic Plant Growth

Research has shown that as human development on the lake shore increases, the amount of native aquatic plant growth near that lake shore decreases. In a Minnesota study of 44 lakes with varying amounts of developed shoreline, the average loss of aquatic plants in developed areas verse undeveloped areas was 66% (26). On a lake wide basis, this loss of aquatic plant growth can lead to higher levels of phosphorus and an increase in the growth of algae, including filamentous algae (Figure 26) that may attach to structures within the littoral zone or form surface mats.

Figure 26 – Surface Mat of Filamentous Algae

Runoff from a developed property may increase the amount of available phosphorus in the littoral zone immediately adjacent to that property causing greater algae growth in place of plant growth. Plant survey work completed in the region suggests at least an anecdotal relationship between developed shorelines (specifically those properties with mowed and apparently fertilized lawns to the edge of the lake) and an increase in more problematic native plant species like coontail and common waterweed, and filamentous algae. While it is not clear if the installation of buffer strips and other runoff reducing best management practices can directly improve conditions within the littoral zone immediately adjacent to a property, it is known that if enough of these best management practices are installed around an entire lake system, nutrient levels within the lake can be reduced (27) (28).

9.6.3 Dredging

Dredging is usually not performed solely for aquatic plant management but to restore lakes that have been filled in with sediments, have excess nutrients, have inadequate pelagic and hypolimnetic zones, need deepening for navigation, or require removal of toxic substances. A WDNR permit is required to perform any dredging in a waterbody or wetland. In deep water, the plants do not receive enough light to survive. This method can be detrimental to desired plants, as all macrophytes would be prevented from growing for many years. This high level of disturbance may also create favorable conditions for the invasion of other invasive species.

9.6.4 Benthic Barriers and Light Reduction

Benthic barriers or other bottom-covering approaches are another physical management technique that has been in use for many years. The basic idea is that the plants are covered over with a layer of a growth-inhibiting substance. Many materials have been used, including sheets or screens of organic, inorganic and synthetic materials, sediments such as dredge sediment, sand, silt or clay, fly ash, and combinations of the above. WDNR approval is required and screens must be removed each fall and reinstalled in the spring to be effective over the long term.

9.6.5 Water Level Manipulation

Dropping the lake level to allow for the desiccation, aeration, and freezing of lake sediments has been shown to be an effective aquatic plant management technique. Repeated drawdowns lasting 4 to 6 months that include a freezing period are the most effective. Control of aquatic plants in these cases can last a number of years. The low lake levels may negatively affect native plants, provides an opportunity for adventitious species such as annuals, often reduces the recreational value of a waterbody, and can impact the fishery if spawning areas are affected. The cost of a drawdown is dependent on the outlet of the lake; if no control structure is present, pumping of the lake can be cost prohibitive whereas costs can be minimal if the lake can be lowered by opening a gate.

Raising water levels to flood out aquatic plants is uncommon and has a number of negative effects including the potential for shoreland flooding, shoreland erosion, and nutrient loading.

9.7 No Manipulation

No manipulation of the aquatic plant community is often the easiest, cheapest, and in some cases most effective aquatic plant management alternative even for non-native invasive species like curly-leaf pondweed. No manipulation should be considered a viable alternative in areas where excess aquatic plant growth does not impact lake uses, where the benefit of management is far out-weighed by the cost of management, where water quality or other lake characteristics limit nuisance growth conditions, and where highly valued native plants would be negatively impacted by treatment.

10.0 Chemical Management of EWM in Horseshoe Lake

Chemical herbicides were used in 2011 (diquat) and 2012 (2,4-D) to treat EWM in Horseshoe Lake, and along with physical removal, will remain one of the most appropriate management methods. The following sections provide more detail into the actual use of chemical herbicides in Wisconsin lakes.

10.1 Liquid vs. Granular Formulations

Rapid dissipation of aquatic herbicides due to various water exchange processes can lead to poor submersed weed control in a variety of situations. The ability to target herbicide placement and maintain the desired concentration in the plant mass within the 3-dimensional aquatic environment is critical to maximize efficacy of herbicides. Additional variables such as temperature and plant density can also alter herbicide distribution. Applications of liquid formulations in areas that are relatively deep with low growing vegetation, potential for rapid water exchange, and/or areas adjacent to or surrounded by a large percentage of untreated water could be impacted greatly by dilution (29). Custom subsurface injection application systems with trailing hoses have been suggested for improved delivery of liquid herbicides in deeper water areas (30).

Granular formulations also have been developed to assist in delivering aquatic herbicides. The active ingredient is added to inert ingredients like clay particles that dissolve more slowly. Theoretically these formulations maintain placement of the herbicide longer or increase the exposure time of the target plant to the herbicide. These formulations often sink to the bottom in and around submersed aquatic plant communities (depending on plant density and frequency) and provide delayed release of the herbicide and are less vulnerable to dilution (29). More recent data collected by the WDNR and Army Corp of Engineers suggests that there is little difference is dispersion rates between granular and liquid herbicides when applied. Unless very small treatment are proposed (1/4 acre or less) or site characteristics such as water movement, depth, location in the lake in some way suggest a granular formulation would do better, it is recommended that a liquid formulation of the chosen herbicide be used.

Granular formulations are generally more expensive than their liquid counterparts. Granular applications are usually based on a specific amount of herbicide being applied to a designated surface area of a body of water. Depth of the treatment area and density of plant growth may also be considered when determining an appropriate treatment concentration. Liquid herbicides can be applied on the surface, but more recently, subsurface injection is more supported by the industry. Liquid application is based on the volume of water in the treatment area, and in general is used when flowing water or additional dilution is not a factor.

10.2 Small-scale Herbicide Application

Small-scale herbicide application involves treating small areas of less than 10 acres combined on a given body of water. Small-scale chemical application is usually completed in the early season (April through May). It is also used as a follow up treatment to retreat areas missed or not impacted by large-scale applications. Pre- and post-treatment aquatic plant surveys and testing for herbicide residuals are not required by the WDNR for small-scale treatments. Even though not required by the WDNR, participating in these activities is recommended as it helps to gain a better understanding of the impact and fate of the chemical used.

10.3 Large-scale Herbicide Application

Large-scale herbicide application involves chemical treatment of more than 10% of a given lakes' surface area or more than 10 acres combined on a given body of water. Like small-scale applications, this is usually completed in the early-season (April through May) for control of non-native invasive species like EWM and CLP while minimizing impacts on native species. Pre- and post-treatment aquatic plant surveying is required by the WDNR when completing large-scale chemical treatments. Residual testing is not required by the WDNR, but highly recommended, as is pre and post treatment aquatic plant surveying to gain a better understanding of the impact and fate of the chemical used.

10.4 Whole Lake (Basin Wide) Herbicide Application

In some cases, chemically treating the entire body of a lake or in the case of Horseshoe an entire lobe or basin of the lake, is prudent management. If the target plant species is wide-spread, or has the potential to be wide spread, or is suspected to be in deeper water where it may be difficult to identify on a consistent basis, but not necessarily dense, then treating an entire body of water or portion of the waterbody with a very low concentration of herbicide that is expected to maintain contact with the target plant for a longer period of time may provide the best results. Whole lake treatments can be done with 2,4-D, triclopyr, or flouridone. They can be done at any time during the growing season of plants, and when concentrations are low enough can have limited impacts to non-target plants.

10.5 Spot Treatments

Spot treatments are used in a manner similar to how small-scale herbicide application is used to follow up a large-scale herbicide application. More commonly used when treating EWM, a spot treatment is defined as treatment of a single plant or small cluster of plants that covers an area no greater than 25-sqft. It is administered by spreading approximately 1/4 cup (approximately 2.0 oz) of granular herbicide by hand from a boat in approximately 5-ft of water, based on a treatment rate of 200 lbs/acre. Target plants are visually located by trained inspectors on the day of treatment. Treatment occurs immediately upon locating a plant or cluster of plants.

This treatment method depends on several things: 1) water clarity in a given lake needs to be sufficient enough to allow for trained inspectors to identify individual plants and small clusters in the water, even when they are not at or near the surface; 2) the spotters must know the difference between the target plant and native plants not only when they are side to side out of the water but also when they are in the water, potentially interspersed with other look-alikes; and 3) since this method of treatment often involves many sites, herbicide application must be completed by a professional applicator.

While there is no specific WDNR protocol set up for spot treatments, the following guidelines are recommended:

- Chemical application must be completed by a commercial applicator
- At least one representative from the Lake Organization or a resource professional must accompany the commercial applicator during treatment
- Inspections and subsequent treatments should be completed between 10:00am & 4:00pm
- Inspections and treatment (if necessary) should be completed at least once a month June – September

- When the observer and applicator do not agree, a rake sample must be retrieved for positive ID
- An appropriate inspection and treatment path should be established prior to beginning inspection/ treatment
- GPS tracking of all movement on the lake should be completed and saved for future reference
- Record GPS coordinates for each individual spot treatment along with the density of the target plant species (single, small cluster, or bed), the depth at spot treatment site, and the presence of other plants within 5-ft of the spot treatment
- Sites determined to be beds and that exceed an area larger than 20 × 20 ft must be recorded as small-scale treatment sites
- A bed is defined as an area where at least 50% of existing aquatic plants are the target species and has a definable boundary
- Aquatic plant inspectors must wear polarized glasses
- Water clarity on the day of treatment (measured by a Secchi disk) should not be less than 75% of the mean depth of plant growth as established by previous plant surveys
- Weather conditions must be appropriate for treatment (mostly sunny, minimal waves)

More recently, the WDNR has discouraged the use of spot treatments as they are not viewed as being very effective long term. Aquatic plants treated in this fashion will often die in the year of treatment, but return the following season as if no treatment was completed. In some cases, annual relief is sufficient, so spot treatments remain a viable treatment alternative. When spot treatments are used, residual testing should be incorporated to determine how long herbicide/plant contact time is maintained and at what concentration. If a sufficient contact time is not established, initial herbicide concentrations may need to be higher. A few lakes have experimented with different methods of herbicide application including binding granular herbicides in cheesecloth or some other medium to slow its dispersion; multiple doses in succession; and barriers to reduce normal water flow through a treated area.

11.0 Documentation of Problems and Need for Management

Horseshoe Lake has a rich, diverse and rare aquatic plant community that is unique to sand bottomed, seepage lakes with good water quality. Unfortunately, the introduction of Eurasian water-milfoil will pose a continued threat to that diversity and the resource as a whole moving forward as it is unlikely that EWM will ever be totally eliminated from the lake. With this reality in mind, working to minimize the spread of EWM within the lake, and quickly identifying and eliminating new beds that appear is a high priority management goal moving forward. Physical removal of EWM by property owners and/or divers is an important management alternative for removal of isolated individual plants or small clumps of EWM in shallow water. Seasonal treatment of larger areas using herbicides is also an important management tool to be used as needed to supplement efforts at physical removal.

Despite what appears to be very positive results following the June 2012 treatment using a granular formulation of 2,4-D (Navigate) and 2013 survey, EWM will very likely continue to show up in Horseshoe Lake. After a 2009 chemical treatment and physical removal of EWM in nearby Gilmore Lake (sponsored by the Gilmore Lake Association), it was thought they had a pretty good handle on the EWM in the system. For two years after 2009, herbicide application was not implemented as an aggressive diver removal program had been implemented. Hundreds of EWM plants were physically removed from the original bed of EWM located in the south west basin of the lake. Even so, it became apparent in the fall of 2011, that the EWM could not be contained in its current location by diver removal alone. A new area with EWM in Little Gilmore Lake was identified in late 2011, and plants in the original bed continued to expand. Herbicide application was again used in 2012 (supplemented by physical removal), and is now the most viable management alternative.

This trend is fairly common in northwest Wisconsin lakes with EWM with Sand, Horseshoe, Echo, and Vermillion Lakes in Barron County all using an integrated approach to managing EWM that includes herbicide application supported by physical removal. Each of these lakes started with relatively small infestations that for several years were well controlled by physical removal. After a year or two however, diver removal alone proved no longer effective for successful, long term control on any of these lakes. The Gordon-St. Croix Flowage Association in Douglas County also started with a one-time chemical application when EWM was first discovered, that was followed up by several years of diving. They too are now using an integrated approach to control many acres of EWM.

Visual monitoring of both the east and west basins should be completed by boat at least on a monthly basis throughout the open water season of the lake. Any individual or small clumps of EWM that are identified should be mapped preferably with a decent GPS unit, and if possible, physically removed. Shoreline surveys for EWM fragments washed up on the shore should also be conducted on a monthly basis through the open water season as this may provide the first indication that there is a bed of EWM somewhere in the lake. These surveys could be completed by trained lake volunteers, a resource professional, or some combination of both.

12.0 Aquatic Plant Management Goals, Objectives, and Actions for Horseshoe Lake

As previously established, management of EWM is necessary in Horseshoe Lake. A combination of management alternatives will be used to help minimize the negative impacts of EWM on native plants and water quality, and provide relief for navigation impairment and nuisance aquatic plant growth caused by EWM. EWM management options to be utilized include small-scale physical removal, diver removal, and targeted use of aquatic herbicides. Other AIS will continue to be monitored for, but no specific management is recommended at this time.

There are six broad goals for aquatic plant management in Horseshoe Lake, each with a number of objectives and actions to accomplish over the course of the next five years. Appendix D is an outline of the aquatic plant management goals and activities, and Appendix E is a five-year timeline for completion of the activities included in this APM Plan. Any major change in activities or management philosophy will be presented to the HLPA and the WDNR for approval. The six goals for this plan are as follows:

1. Native Plant Protection, Preservation, and Enhancement
2. EWM Management and Monitoring
3. AIS Education, Prevention, and Planning
4. Wildlife Appreciation and Awareness
5. Lake Community Understanding and Awareness
6. Aquatic Plant Management Plan Maintenance

This APM Plan will be implemented by the HLPA, their consultants, and through partnerships formed with the WDNR, Washburn County, Minong Township, and other local clubs and organizations. Annual reports and end of project assessments will be completed by the HLPA or its retainers throughout the duration of this 5-year plan.

12.1 Goal One – Native Plant Protection, Preservation, and Enhancement

The objective of any aquatic plant management is to protect and enhance diversity and distribution of native aquatic plants in the lake. Over the course of this management plan, the current diversity and distribution of native plants will not be reduced. An additional objective is to increase native plant diversity within areas designated for EWM management. Success will be measured by comparing post treatment survey results annually. No loss of diversity will be measured when the full lake point intercept aquatic plant survey is repeated in 2015.

12.1.1 Risks Posed by Native Plant Removal

The Horseshoe Lake Property Association will educate riparian owners of the risk posed by removing native vegetation from around their docks and in swimming areas. The removal of native plants opens up space for non-native plants like EWM to establish. If a landowner believes they have to or want to remove native aquatic plants, the HLPA will sponsor training to help make sure that the landowner is familiar with EWM and ask that they continually monitor the cleared area for EWM.

12.1.2 Wild Rice Awareness

Even though wild rice has not currently been identified in Horseshoe Lake, lake residents will be made aware of it and efforts undertaken to educate lake users about wild rice. The objective of this action is to increase awareness of lake users so as not to inadvertently negatively affect waters where wild rice could be present.

12.1.2.1 Lake Community Education

The HLPA will provide lake property owners with educational and informational materials related to the value of wild rice as a resource found in the lakes. Wild rice resources are available from the WDNR, GLIWC, and on the internet. An example of such promotions would be to invite a speaker on wild rice to one of the HLPA annual events or to make a wild rice informational resource available to property owners on-line or on the HLPA webpage.

12.1.2.2 Wild Rice Monitoring

At least once annually in the late summer, HLPA volunteers trained in identifying wild rice will monitor Horseshoe Lake for the presence of wild rice. If found, new locations will be mapped using a hand-held GPS unit.

12.1.3 Critical Habitat Survey

Should the WDNR ever reactivate its Critical Habitat Survey program and chose to do one on Horseshoe Lake, the HLPA will support its completion. During a Critical Habitat Survey, WDNR field staff, compile and review the most current scientific data about the water body. Data is also solicited from local units of government, conservation organizations, federal agencies, local businesses and anyone who may have resource knowledge and information. This information is used to assemble maps to identify targets of focus related to fish, wildlife, endangered resources, and their habitats. Public rights features including lake access and navigation are also identified and added to the data. The resulting maps and supporting data are compiled into a draft Critical Habitat Designation report, which is posted on the Department's website for public review. The WDNR must also give notice of the draft report to the local media, the county clerk, and legislators. If requested or if concerns are anticipated, the WDNR typically holds informational meetings to answer questions and receive comments. Once public comment is received and the report is complete, Critical Habitat Designations are posted on the DNR website.

Critical Habitat designation can be used to guide appropriate management actions that do not negatively impact the most sensitive areas in the lake. It does not necessarily prevent management in those areas, but does insure that adequate consideration is given as to the impacts that management would have.

12.1.4 Aquatic Plant Management Impacts to the Fishery

All lakes have habitat of critical importance to one of more parts of the overall lake ecosystem. The HLPA will manage non-native aquatic plants like EWM in a manner that will not suffer any of these ecosystems. To protect and maintain the current fishery, plant management other than physical removal, will not be implemented in water less than 3-ft deep or in water designated as critical habitat unless said management would improve that habitat.

12.1.5 Woody Debris

The HLPA will promote the protection of woody debris already in Horseshoe Lake, and evaluate the potential to increase woody debris through the use of tree drops or other acceptable fisheries management activities.

12.2 Goal Two – Eurasian Watermilfoil Management and Monitoring

The HLPA and resource professionals retained by the HLPA will continually monitor the littoral zone of Horseshoe Lake in an effort to identify any new EWM sites while they are still in a pioneering or manageable stage. Any new EWM identified will be immediately removed or managed in some way. Zero tolerance will be had for new infestations anywhere outside of the original bed and treatment areas. Within the existing locations, EWM will be reduced to levels below an acre in size by implementing integrated management actions.

12.2.1 Pre and Post Treatment Survey and Fall Bed Mapping

Management of EWM will be based on information obtained annually by either trained HLPA volunteers or resource professionals retained by the HLPA. This information includes annual fall survey and bed mapping of EWM, pre treatment survey of annually proposed treatment areas, and post treatment aquatic plant survey in the areas treated.

Pre and post treatment surveying is not required by the WDNR unless the chemically treated area covers more than 10 acres or 10% of the littoral zone. However, completing these tasks is highly recommended in any treatment program as they provide a means to measure success.

12.2.2 Management Alternatives

The HLPA will undertake EWM management that includes physical removal, diver removal, and the targeted use of aquatic herbicides. Physical removal will be completed by educated landowners who monitor their own shorelines or by a trained EWM Management Team sponsored by the HLPA. Diver removal will be completed by HLPA volunteers and/or resource professionals retained by the HLPA.

Herbicides will be used to manage existing EWM and any existing or new area with moderate to severe growth density and deemed too large for effective physical removal. Effective physical removal will depend on depth and density of EWM growth, water quality, available resources, and the size of the area to be treated. Generally speaking any area with moderate or dense EWM growth that exceeds 1/16 of an acre (approx. 2,700 sq ft) would be a candidate for herbicide control. Specifics for what herbicide to use and when will be determined annually during the proposed treatment phase of planning. Granular or liquid herbicide could be used, as well as one or more different but approved herbicides in Wisconsin. Spring application of herbicides is preferred as this usually has less negative impact on native plants. Mid-season application of herbicides will be implemented if new beds of EWM that meet the previous criteria are discovered post treatment.

Should the EWM in Horseshoe Lake become well established throughout either basin - a whole basin, spring, low dose, herbicide treatment approach will be implemented

12.2.3 Residual Testing

Once an herbicide is used, it is expected that that herbicide will have no unintended impact. One way to determine if this is true is to complete herbicide concentration testing after treatment occurs. Residual testing may be done every hour for the first 6-12 hours immediately following treatment, and may be extended over a period of several weeks at less frequent intervals. Water samples would be collected by HLPA volunteers and then analyzed by a certified lab for the presence of the herbicide used. Though not currently required by the WDNR, it is a good management tool to use at as it helps answer the question “What happens to the herbicide after it is put in the lake?”

As long as EWM management remains below what is considered large-scale management, residual testing will only be completed if supported by grant funding or if Horseshoe Lake is a participant in a WDNR/Army Corp of Engineers concentration testing program.

12.2.4 EWM Weevil Survey

If EWM becomes more prevalent in Horseshoe Lake, it is recommended that the HLPA begin a monitoring program for the Eurasian watermilfoil weevil. Weevil monitoring is a part of the CLMN AIS Monitoring Program, and if conditions warrant, weevils may be reared by volunteers using protocol established by Golden Sands RC&D.

12.3 Goal Three – AIS Education, Prevention, and Planning

The objective of AIS education, prevention, and planning in this plan is to create a lake community that is aware of the problems associated with AIS and has enough knowledge about certain species to aid in detection, planning, and implementation of management alternatives.

An AIS Rapid Response Plan has been developed for Horseshoe Lake as a part of this plan. The Rapid Response Plan contains information on what to do if a suspect AIS is found, who to contact, and what should be done if a positive ID is made. A copy of this plan is in Appendix F.

12.3.1 Watercraft Inspection and Signage

The HLPA will develop an active water craft inspection program modeled after WDNR/UW-Extension Clean Boats, Clean Waters guidelines. It is recommended that the HLPA participate in the annual WDNR 4th of July Landing Blitz. All watercraft inspection data collected annually will be submitted to the WDNR SWIMS database. The HLPA will maintain and update AIS signage located at the Horseshoe Lake public access. The goal of this action is to keep new AIS from being introduced to the lake, and to prevent EWM from being carried out of the lake by an unwary lake user.

12.3.2 In-Lake AIS Monitoring

No AIS other than EWM has been indentified to date in Horseshoe Lake. The objective for AIS monitoring is to have trained HLPA volunteers and resource professionals retained by the HLPA look for and document the presence of any other AIS in the lake. The Citizen Lake Monitoring Network sponsored by the WDNR and UW-Extension offers an AIS Monitoring Program that costs nothing to be a part of. This program provides volunteer training and supplies for EWM, purple loosestrife, Chinese mystery snails, rusty crayfish, zebra mussels, curly-leaf pondweed, and several other species. If new AIS are identified, procedures outlined in the AIS Rapid Response Plan for Horseshoe Lake will be implemented. The success of this objective will be measured by the level of lake volunteer participation, recording of AIS monitoring time, and tracking of results. All data will be recorded annually and submitted to the WDNR SWIMS database.

12.3.3 Lake Community Education Events

The objective of lake community education is to establish and maintain lake community participation in actions implemented to manage the lake. This gives the lake community voice in management decisions, and garners support and understanding for the management decisions made. Success will be measured by the level of satisfaction and involvement HLPA members have for the management efforts undertaken.

In each year of this APM Plan, the HLPA will host/sponsor at least one education event focused on some aspect of AIS. This event could be a lake fair, a workshop targeting a specific topic (watercraft inspection, shoreland restoration, aquatic plant identification, aquatic plant management, wild rice awareness and education, etc), or a special meeting or presentation. This event could be held by itself, or in combination with some other regularly scheduled event like the Town of Minong Lakes Fair or HLPA annual meeting.

12.3.4 Distribution of Information and Education Materials

The HLPA will keep its membership informed as to the events happening in and around the lake. A newsletter will be developed and distributed at least twice annually, the Lake Association webpage will be maintained and updated on a regular basis, and AIS materials will be distributed to lake residents. Lake related documents like this APM Plan and the results of aquatic plant surveys will be posted on the webpage, and a portion of every HLPA annual meeting will be devoted to AIS and EWM management.

12.3.5 I-Lids AIS Sentry

Launching a boat or other watercraft into public waters with an aquatic plant attached to it is illegal in WI. Through statewide education programs and watercraft inspection efforts by the WDNR, local towns and counties, and individual lake associations and lake districts, many Wisconsin boaters are reminded each day during the open water season to clean off their boats and other watercraft before launching them into public waters. They are also reminded to clean off their watercraft prior to leaving a boat launching location as it is also illegal to transport aquatic vegetation and other aquatic organisms on Wisconsin's public roadways. Although many hours of watercraft inspection time is put in at many landings, it is difficult to staff public landings at all times when a boat may be launched, leaving the possibility that a new AIS could be introduced, despite the best efforts of any particular entity.

Recognizing this lapse in prevention efforts, Environmental Sentry Protection, LLC developed a tool that could provide the ongoing diligence needed to protect lakes through education, monitoring, and information gathering. The Internet Landing Installed Device Sensor (I-LIDS, pronounced "eyelids") is a stand-alone video capture system that is designed to provide unattended monitoring of boat launches (or other remote locations) and capture activities of interest that occur over the course of hours or days onto a searchable Web site by date, time, and venue. Positioned low to the ground, it is able to easily view below trailers and boats. It wirelessly transmits a compressed video to a nearby access point. Solar power removes the need to run power to the system. A circuit board monitoring the earth's magnetic field can detect activity 20 feet away and shift from low power consumption to operation of devices such as video, LED lighting for night video, and playback of educational messages.

A digital video camera detects motion and captures video for a preset duration. The I-LIDS uploads these "transactions" to a server along with launch name, date, and time information. A backend server program looks for new transactions and parses meta-data into searchable fields for the Web site and database. By capturing only events when there is motion at the launch, and limiting time of capture (e.g., 15-20-second videos) users can efficiently review and find events of interest. Use of pier footings, stainless steel housing, bullet proof glass, and keyed access for authorized users deters vandalism.

Several I-LIDS cameras have been installed in northwestern WI. WDNR grant funding can be used to offset the cost of installing such a system at a boat landing, however certain monitoring efforts pertaining to the cameras are required. The HLPA is considering purchase and installation of one of these devices to aid in their inspection and education efforts.

13.0 Goal Four – Wildlife Appreciation

The objective of wildlife appreciation planning and implementation is to improve the knowledge of the lake community of how management actions in and around the lake effects the wildlife living there. Success will be measured in the amount of interest and participation HLPA members have in numerous monitoring programs.

13.1.1 Monitoring Program Information and Participation

The HLPA will provide education and informational materials related to wildlife and wildlife monitoring programs during events, in newsletters, on the webpage, and during meetings. Wildlife monitoring information is available from the Sigurd Olson Institute (Loonwatch), the Citizen Based Monitoring Network of Wisconsin (Citizen Science), and other sources. Riparian owner participation will be encouraged and recognized by the HLPA.

13.2 Goal Five – Lake Community Understanding

The objective of this goal is to educate the lake community about how what they do impacts the aquatic plants and water quality in the lake. Success will be measured in the number of projects HLPA members participate in and in the understanding the lake community gains in this endeavor. The completion of at least three shoreland or habitat improvements projects over five years and uninterrupted long-term trend monitoring via the CLMN water quality program would indicate that this objective is being successfully completed.

13.2.1 Shoreland Restoration and Habitat Improvement

It is recommended that the HLPA encourage riparian owner participation in shoreland restoration and habitat improvement programs sponsored by Washburn County, WDNR, and other shoreland improvement programs. Information about these programs will be made available to HLPA members through the newsletter, on the webpage, and/or during HLPA or other sponsored events.

13.2.2 Riparian Owner Best Management Practices

It is recommended in this plan that the HLPA encourage riparian owner participation in best management practices that may reduce shoreland runoff and nutrient loading into the lakes. Informational and educational materials will be made available to HLPA members through the newsletter, on the webpage, and/or during HLPA sponsored events. Best management practices could include but are not limited to the establishment of buffer strips, runoff diversions, rain gardens, septic system maintenance, non-impervious surfaces, and no mow areas.

13.2.3 CLMN Water Quality Monitoring Program

The HLPA will participate in the CLMN Water Quality Monitoring Program. This APM Plan recommends completing all CLMN expanded monitoring parameters (Secchi, temperature, dissolved oxygen, total phosphorus, and chlorophyll a) at two sites, one in the west basin and one in the east basin. In addition to the normal spring, June, July, and August sampling dates this APM Plan recommends adding October sampling as well. October sampling will help to identify changes that maybe brought about late in the season by EWM management actions. October sampling would only be completed if supported by grant funding.

As the HLPA implements aquatic plant management alternatives it is possible that the water quality in the lake could be impacted. Participating in basic, long-term trend water quality monitoring may help identify additional changes due to plant management activities.

To aide in the collection of dissolved oxygen and temperature data, this APM Plan recommends the purchase of an WDNR approved DO/Temp Meter be included in any grant application to support further management.

At some point in the next five years, the HLPA should consider completing comprehensive water quality lake management planning for Horseshoe Lake and its watershed.

13.2.4 Lake Level and Precipitation Monitoring

It is recommended in this APM Plan that water levels in Horseshoe Lake be monitored on a weekly basis. This can be accomplished by installing a staff gage at a property owned by a HLPA volunteer who is a permanent resident on the lake. A staff gage is a measuring tool installed on a permanent structure in the lake or placed in reference to a permanent and unchanging structure on the shore whereby fluctuating water levels can be recorded. Such a structure could include a large rock or a post driven deep (below the frost line) into the lake bed in an area that would not endanger lake users. If such a structure is not present, it may be possible to identify a local bench mark and survey lake level based on that information.

It is recommended that the HLPA install at least one rain gage on the lake and document precipitation as it occurs. Support for this management recommendation can be accessed by HLPA participation in the Community Collaborative Rain, Hail and Snow (CoCoRaHs) Network. CoCoRaHS is a unique, non-profit, community-based network of volunteers of all ages and backgrounds working together to measure and map precipitation (rain, hail and snow). By using low-cost measurement tools, stressing training and education, and utilizing an interactive Web-site (www.cocorahs.org), their aim is to provide the highest quality data for natural resource, education and research applications.

13.3 Goal 6 - Aquatic Plant Management Plan Maintenance

This APM Plan is a working document guiding management actions on Horseshoe Lake over the next five years. Complete annual and end of project activity and assessment reports are necessary to make annual adjustments. The following activities will support APM Plan maintenance.

13.3.1 Successful Reporting and Data Sharing

The objective here is to complete project reporting that meets the needs of the WDNR and HLPA, allows for timely reimbursement of expenses, and provides the appropriate data for continued management success. Success will be measured by the efficiency and ease in which these actions are completed.

13.3.2 End of Year and Annual Management Proposals

The HLPA and their retainers will compile, analyze, and summarize management operations, public education, and other pertinent data annually in report form and make it available to members of the HLPA, Washburn County, Town of Minong, and the WDNR. These reports will also serve as a vehicle to propose following year management recommendations. These reports will be completed by the HLPA and their retainers prior to implementing following year management actions (approximately March 31st annually).

13.3.3 Five Year Redo of the Point Intercept Aquatic Plant Survey

It is recommended that the HLPA complete another whole lake, point intercept aquatic plant survey of the lake in 2016. Results will be compared to 2011 survey results to determine long-term impacts on both target and non-target aquatic plants over the five years of management.

13.3.4 End of Project Five-Year Project Evaluation and Assessment

At the end of this five year project, all management efforts and related activities will be compiled, analyzed, and put in report form. This document will discuss the successes and failures of the existing APM Plan and be the basis for making revisions to a new APM Plan. The report will be compiled by the HLPA and their retainers and made available to HLPA membership, Washburn County, the Town of Minong, and the WDNR. The report will be completed by June 30th in the year after the final year of this APM Plan.

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