AQUATIC PLANT MANAGEMENT PLAN

Horseshoe Lake

Horseshoe Lake Property Association

November 2021

2022-2026 AQUATIC PLANT MANAGEMENT PLAN

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Executive Summary

Horseshoe Lake is a 194-acre, clear water lake in north-central Washburn County, Wisconsin. This lake has a diverse plant community and boasts exceptional water clarity. Unfortunately, Eurasian watermilfoil *Myriophyllum spicatum* (EWM), an invasive plant species, was found in Horseshoe Lake in May 2011. This plan has been developed as part of an ongoing effort to control EWM in Horseshoe Lake while also preserving the native plant community.

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 four broad goals, each with a number of objectives and actions, over the course of the next five years. Any major change in activities or management philosophy will be presented to the HLPA and the WDNR for approval. The goals for this plan are as follows:

1. **EWM Management.** Limit the severity of the EWM infestation by monitoring for new infestations and managing current ones.

2. **Preservation, Protection, and Restoration**. Protect and restore the native plant species community in and around the lake to decrease susceptibility to the introduction of new aquatic invasive species.

3. **AIS Education, Prevention, and Planning.** Continue public outreach and education programs designed to give shoreline property owners the knowledge to participate in EWM management and planning in Horseshoe Lake.

4. **Adaptive Management.** Follow an adaptive management approach that measures and analyzes the effectiveness of control activities and modify the management plan as necessary to meet goals and objectives.

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.

Aquatic Plant Management (APM) Summary

A continuation of a combination of diver removal and chemical treatments to control the infestation of EWM is recommended. Additionally, this plan will focus on early detection and rapid response to other aquatic invasive species (AIS) introductions should they occur. The overall goal of aquatic plant management in Horseshoe Lake is to protect this outstanding resource from degradation by maximizing prevention of new invasions and through the containment and control of existing aquatic invasive species while maintaining recreational use of the lake.

This 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 as described in the goals of the HLPA. Although this plan sets forth a five-year implementation schedule, it is not intended to be a static document; rather, it is a living document which will be evaluated annually to determine if it is meeting stated goals and community expectations and can be revised if necessary. The HLPA sponsored the development of this APM Plan, funded through a WDNR Aquatic Invasive Species Education, Prevention, and Planning Grant and in-kind donations by HLPA volunteers.

APM plans developed for northern Wisconsin lakes are evaluated according to Northern Region APM Strategy goals developed by the WDNR that went into effect in 2007. All existing and new APM Plans and the associated management permits (chemical or harvesting) are reviewed by the WDNR. See http://www.sehinc.com/files/online/PotatoC.pdf for more information. Additional review may be completed by the Voigt Intertribal Task Force (VITF) in cooperation with the Great Lakes Indian Fish and Wildlife Commission (GLIFWC). WDNR aquatic plant management planning guidelines, the Northern Region Aquatic Plant Management Strategy, and the goals of the HLPA in conjunction with the current state of the lake formed the framework for the development of this APM plan.

Additionally, this plan includes Integrated Pest Management (IPM) – an ecosystem-based management strategy that focuses on long-term prevention and/or control of a species of concern. To determine the best course of action for individual lakes, IPM considers all the available control practices such as: prevention, biological control, biomanipulation, nutrient management, habitat manipulation, substantial modification of cultural practices, pesticide application, water level manipulation, mechanical removal and population monitoring. The most effective, long-term approach to managing a species of concern is to use a combination of methods, and further information on these topics and recommended uses for Horseshoe Lake are outlined in this plan.

Introduction

Physiography

Horseshoe Lake (WBIC 2470000) is a 194-acre, oligotrophic seepage lake located in north-central Washburn County, Wisconsin (Figure 1). Water quality data collected by Citizen Lake Monitoring volunteers has determined that the lake is oligotrophic with high water clarity and overall water quality. The plant community is abundant and diverse, and it supports a fishery of panfish, largemouth bass, northern pike, and walleye. The two sub-basins are connected by a narrow channel, and there is a public boat landing located on the southern end of the east basin (Figure 1).

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 5-8ft deep, approximately 10-acre flats occur on either side of the channel where the two basins meet. In the East Basin, there is greater underwater topography. An expansive 5-7ft 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 17.5ft mid-lake (Figure 2). Sand was the dominate substrate type along the shoreline of the majority of the lake. This quickly transitioned to sandy muck at most depths beyond 6ft. The only dark organic muck occurred in the southeast bay in the western basin. Collectively, these conditions extrapolated to 80.9% of the bottom being covered in muck and sandy muck, 18.9% with pure sand, and 0.2% with rock (Figure 2). The littoral zone extended to 18ft, but plants were scattered throughout with just over 65.8% of the lake's available substrate being colonized (Berg, 2011).

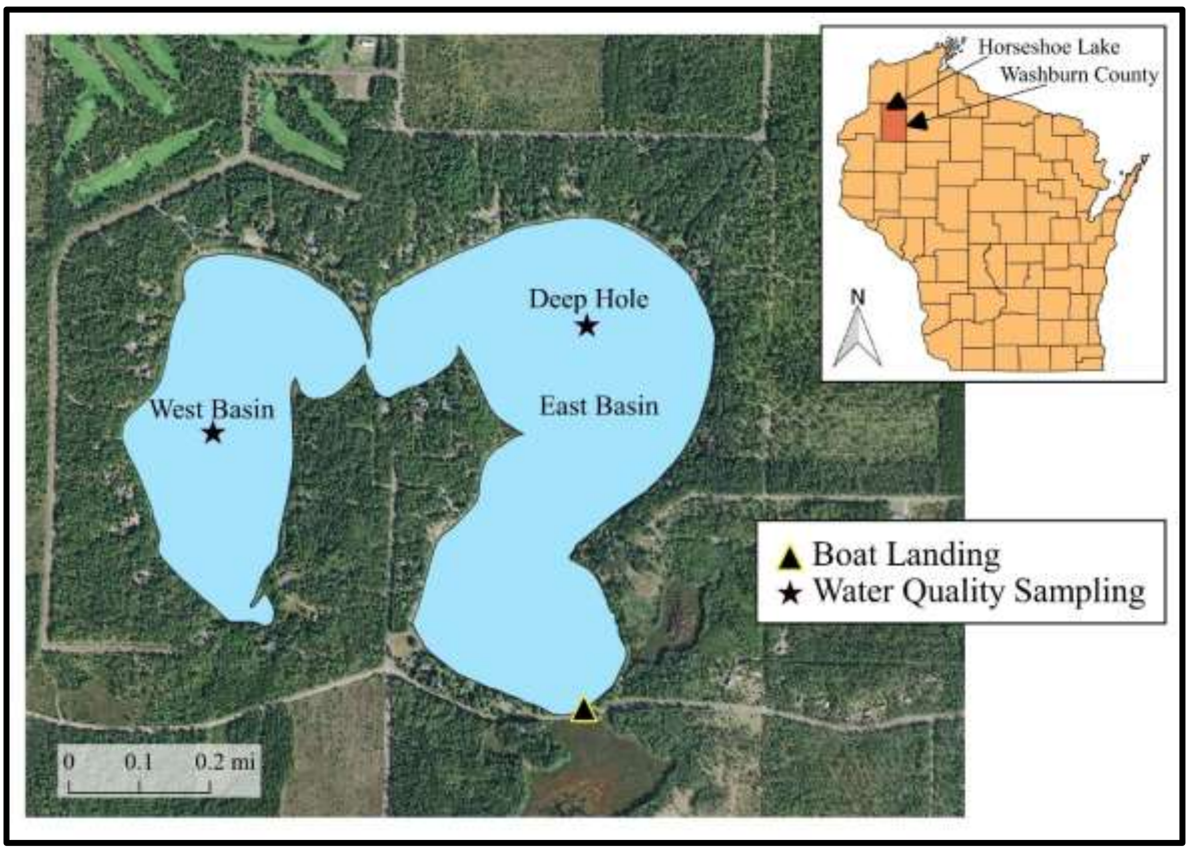


Figure 1. Location of Horseshoe Lake and general information

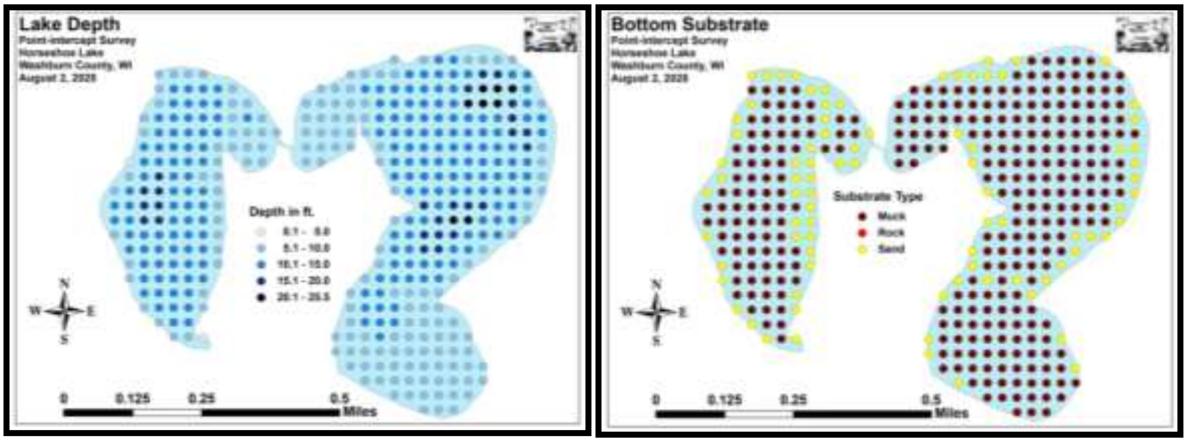


Figure 2. Depth and substrate of Horseshoe Lake (Berg, 2020)

Watershed Land Cover

A watershed is an area of land from which water drains to a common surface water feature such as a stream, lake, or wetland. Horseshoe Lake is within the Chicog Creek watershed that flows into the larger Totagatic River watershed, which then flows into the Namekagon River watershed. The Chicog Creek watershed is mostly forested with some large wetland complexes and some land used for crops and hay (Figure 3). Within 500 feet of the lake is mostly forest and wetlands with a low amount of development. As a seepage lake with no inlet or outlet, very little stream and surface water run-off is contributed to the lake; instead, rain and groundwater are the major sources of water. As such, the water levels are subject to major fluctuations.

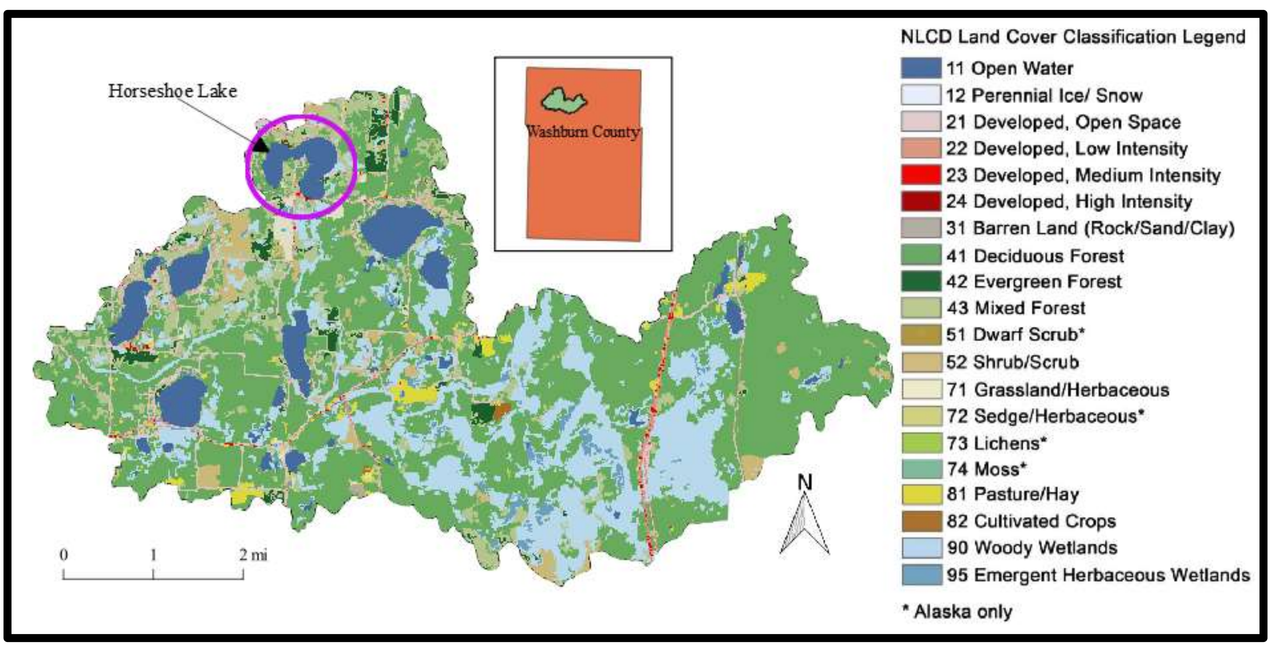
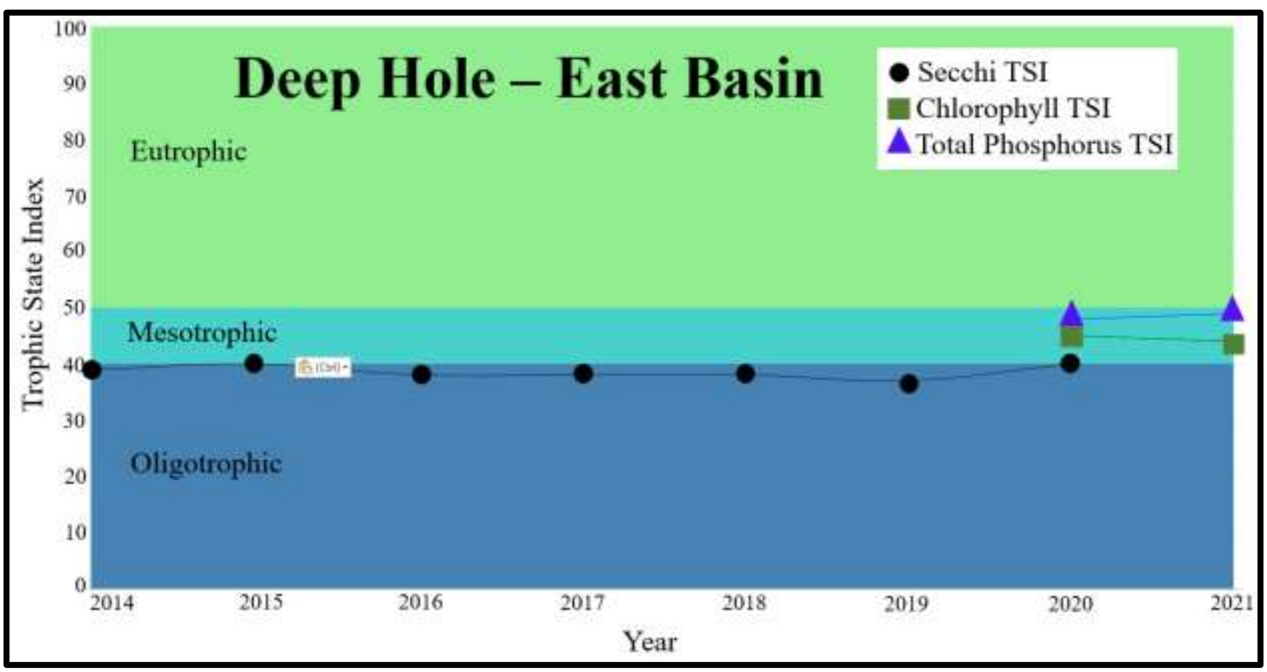


Figure 3. Horseshoe Lake, Chicog Creek watershed land cover (NLCD, 2016)

Trophic Status

In Horseshoe Lake, water quality measures of water clarity (using a Secchi disk), chlorophyll-*a* (Chl-*a*; a measure of algal biomass), and total phosphorus (TP; the nutrient that largely supports aquatic life) were measured from 2014-2020. The Carlson's Trophic Status Index (TSI; Carlson, 1977), a commonly used measurement of water quality, uses these data to determine the trophic status of the lake as a proxy for water quality. Horseshoe's two basins – east and west – each have a monitoring site where volunteers collect Citizen Lake Monitoring Network (CLMN) data. The East Basin sampling site is called the Deep Hole (Station 10042003; 21 feet deep), and the West Basin sampling site is called the West Basin (Station 10042010; 15 feet deep) (Figure 1). The combined TSI of Horseshoe Lake in both basins over the last five years is 39, which is classifies the lake as oligotrophic (nutrient-poor and clear; Figure 4) with excellent water quality.

The specific measurements of water quality and trophic status in Horseshoe Lake in each basin have fluctuated over time. Secchi depth (a measure of water clarity) in Horseshoe is available from 2014-2020. Secchi depths in the Deep Hole ranged from 12 to 16.5 feet (July-August) with an overall average of 14.4 feet, which classifies the East Basin as oligotrophic. In the West Basin, Secchi depths ranged from 9 to 14 feet (July-August) with an overall average of 11.4 feet which classifies the West Basin as mesotrophic (moderately clear water; Figure 4). Chlorophyll-*a* in the Deep Hole (data available from 2020) ranged from 2.42 to 3.93 µg/L, averaging 3.27 µg/L (trophic state value 45), which classifies the East Basin as mesotrophic (Figure 4). Chlorophyll-*a* in the West Basin (data available from 2014-2018 and 2020) ranged from 1.64 to 4.97 µg/L, averaging 2.84 µg/L (trophic state value 42), which classifies the West Basin as mesotrophic (Figure 4). Total phosphorus (data available from 2020) in the Deep Hole ranged from 10.2 µg/L to 14.9 µg/L, averaging 12.4 µg/L (trophic status value 48), which classifies the East Basin as mesotrophic as well. Total phosphorus (data available from 2014-2018 and 2020) in the West Basin ranged from 8.6 µg/L to 19.6 µg/L, averaging 14.0 µg/L (trophic status value 48), which classifies the West Basin as mesotrophic as well (Figure 4). More information can be found at: https://dnr.wi.gov/lakes/lakepages/LakeDetail.aspx?wbic=2470000&page=waterquality.



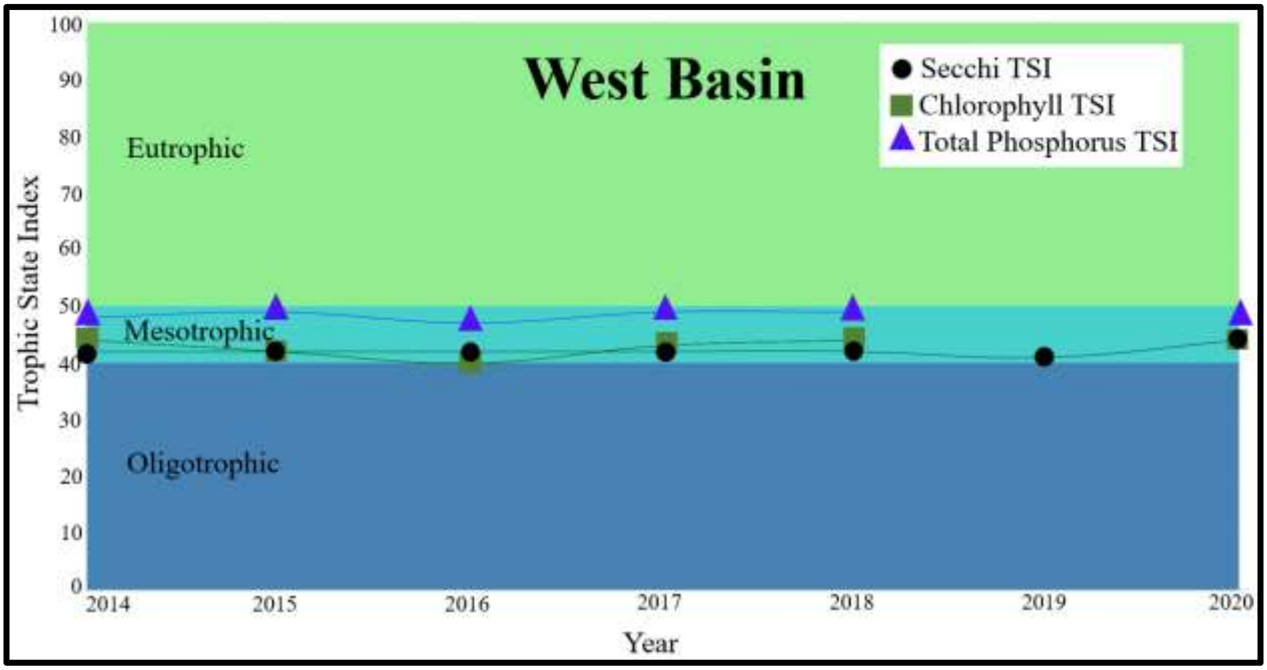


Figure 4. Horseshoe Lake trophic status

When comparing TSI values for total phosphorus, chlorophyll-*a*, and Secchi depth in Horseshoe Lake, a relationship between them stands out. TSI values for total phosphorus are generally higher than both TSI values for chlorophyll-*a* and Secchi depth, which are fairly equal (Figure 4). These values suggest that zooplankton (very small animals that eat algae), nitrogen, or some factor other than phosphorus is limiting algae biomass. Nitrogen concentrations have not been monitored in Horseshoe Lake, and at present, there is no reason to suspect that levels would be an issue.

Oxygen

Dissolved oxygen is essential for the survival of most aquatic animals, just like atmospheric oxygen is essential for most terrestrial animals. Surface waters (also called the epilimnion) exchange oxygen with the atmosphere and are usually oxygen-rich. In deeper lakes, or smaller lakes that are generally sheltered from prevailing winds, the water in the lake stratifies (or separates) into distinct zones during the summer months, impacting water quality and affecting biota. These zones are the epilimnion (usually oxygen-rich surface waters), the thermocline (the layer separating the surface and bottom waters), and the hypolimnion (oxygen-depleted bottom waters). Shallow seepage lakes, like Horseshoe, typically do not stratify, and CLMN temperature profiles confirm that Horseshoe does not stratify. These means that the lake has sufficient oxygen to support life at all depths, and the lake is relatively uniform in temperature from top to bottom.

Public Use

There is one public boat landing that provides public access to the lake located on the south end of the East Basin off Old Bass Lake Road (Figure 1). The landing is a gravel ramp maintained by the Town of Minong. Users of the lake enjoy a wide range of recreational activities, including:

- Fishing for panfish species, largemouth bass, northern pike, and walleye
- Using nonmotorized boats while photographing or viewing nature
- Using motorized boats for recreational enjoyment of the lake
- Swimming

These activities can all be hindered by EWM. Additionally, Horseshoe Lake may serve as a source point of EWM to other waterbodies if boats and trailers are not properly inspected. Therefore, management of this invasive species is necessary to allow full recreational use of the lake and prevent further spread into un-infected lakes.

Need for Management

Horseshoe Lake's somewhat limited plant community is characterized by sensitive, fine-leaved species typical of low nutrient systems and dependent on water clarity, quality, chemistry, and generally positive shoreline practices. The lake currently supports ten extremely high-quality species (C value of 9 or 10), but several of them are very limited in both numbers and distribution making them vulnerable to lake-wide extinction. These plants are the basis of the ecosystem, and they are as important to the aquatic environment as trees are to a forest. Because of this, preserving them is critical to maintaining a healthy lake. As the basis of the food pyramid, they provide habitat for other aquatic organisms, are important food sources for waterfowl and other wildlife, stabilize the shoreline, and work to improve water clarity by absorbing excess nutrients from the water.

Unfortunately, the introduction of Eurasian watermilfoil 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 should be high priority management goals moving forward (Figure 5). The sooner these beds can be found, the greater the chances the infestation can continue to be economically maintained at its current low level.

As there are no similar looking native milfoils in the lake, any suspicious looking plants that are found in the future should be immediately investigated to determine species. If any lake resident or boater discovers a plant they even suspect may be EWM, they are invited to contact Matthew Berg, ERS, LLC Research Biologist at 715-338-7502 mberg@grantsburg.k12.wi.us and/or Pamela Toshner/Alex Smith, Regional Lakes Management Coordinators in the Spooner DNR office at 715-635-4073 for identification confirmation. If possible, a specimen, a jpg, and the accompanying GPS coordinates of the location it was found at should be included.

Figure 5. Tower of EWM in Bed 1 – June 2011 (Berg, 2011)

Warm-Water Point-Intercept Macrophyte Survey Results – 2020

The following results are an excerpt from the Endangered Resources Services, LLC (ERS) Warm-water Point-intercept Macrophyte Survey Report for Horseshoe Lake (WBIC: 2470000) in Washburn County, Wisconsin initiated by the HLPA and LEAPS under the WDNR Grant #AEPP 61320. The survey was performed August 2, 2020 by ERS, and all analyses were written and prepared by Matthew Berg from ERS. For the whole report, contact Matthew Berg at 715-338-7502 or mberg@grantsburg.k12.wi.us.

Depth readings taken at the lake's 387 survey points revealed that most of the western side of the lake drops off rapidly from shore into at least 8ft of water before leveling out in the 10-14ft range (Figure 2). The only interruption to this otherwise gently-sloped bowl is the 17-19ft hole on the west side midlake. Where the two basins meet, two 7-10ft deep 10-acre flats occur on either side of the channel. The eastern basin has a more varied underwater topography. An expansive 6-10ft flat covers the southeast bay near the boat landing, while most of the rest of the basin bottoms out in 10-15ft of water. Two notable exceptions are the lake's deep holes which reach 25.5ft in the northeast bay and 22ft midlake (Berg 2020).

The lake's substrate was characterized as 78.3% organic and sandy muck (303 points) and 21.7% sand (84 points). Pure sugar sand lined the margins of the majority of the lake, but this transitioned to a thin sandy or marly muck at most depth over 8ft. The only nutrient-rich organic muck occurred in the nook bay in the southeast corner of the west basin (Figure 3; Berg 2020).

In August 2020, plants were found growing to 22.0ft (Table 1). Despite a rise in lake levels of more than 2.5ft over the past ten years, the total of 253 points with vegetation (approximately 65.3% of the entire lake and 65.9% of the littoral zone) was almost identical to 2011 when plants were found at 254 points (65.6% of the bottom/65.8% of the then 18.0ft littoral zone; Figure 6). Growth in 2020 was slightly skewed to shallow water as the mean plant depth of 11.3ft was less than the median depth of 11.5ft. Both these values were higher than in 2011 when the mean was 8.9ft and the median was 9.0ft (Figure 7).

Table 1: Aquatic Macrophyte P/I Survey Summary Statistics
Horseshoe Lake, Washburn County
August 2-3, 2011 and August 2, 2020

Summary Statistics:	2011	2020
Total number of points sampled	387	387
Total number of sites with vegetation	254	253
Total number of sites shallower than the maximum depth of plants	386	384
Frequency of occurrence at sites shallower than maximum depth of plants	65.8	65.9
Simpson Diversity Index	0.91	0.89
Maximum depth of plants (ft)	18.0	22.0
Mean depth of plants (ft)	8.9	11.3
Median depth of plants (ft)	9.0	11.5
Average number of all species per site (shallower than max depth)	1.33	1.24
Average number of all species per site (veg. sites only)	2.03	1.89
Average number of native species per site (shallower than max depth)	1.33	1.24
Average number of native species per site (sites with native veg. only)	2.03	1.89
Species richness	27	23
Species richness (including visuals)	35	24
Species richness (including visuals and boat survey)	41	33
Mean rake fullness (veg. sites only)	1.70	1.60

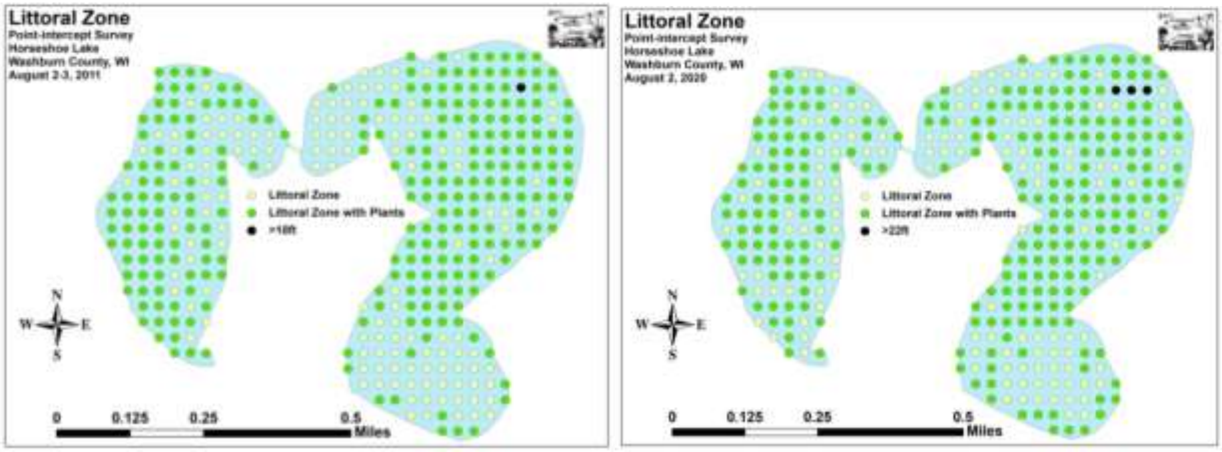


Figure 6: 2011 and 2020 Littoral Zone

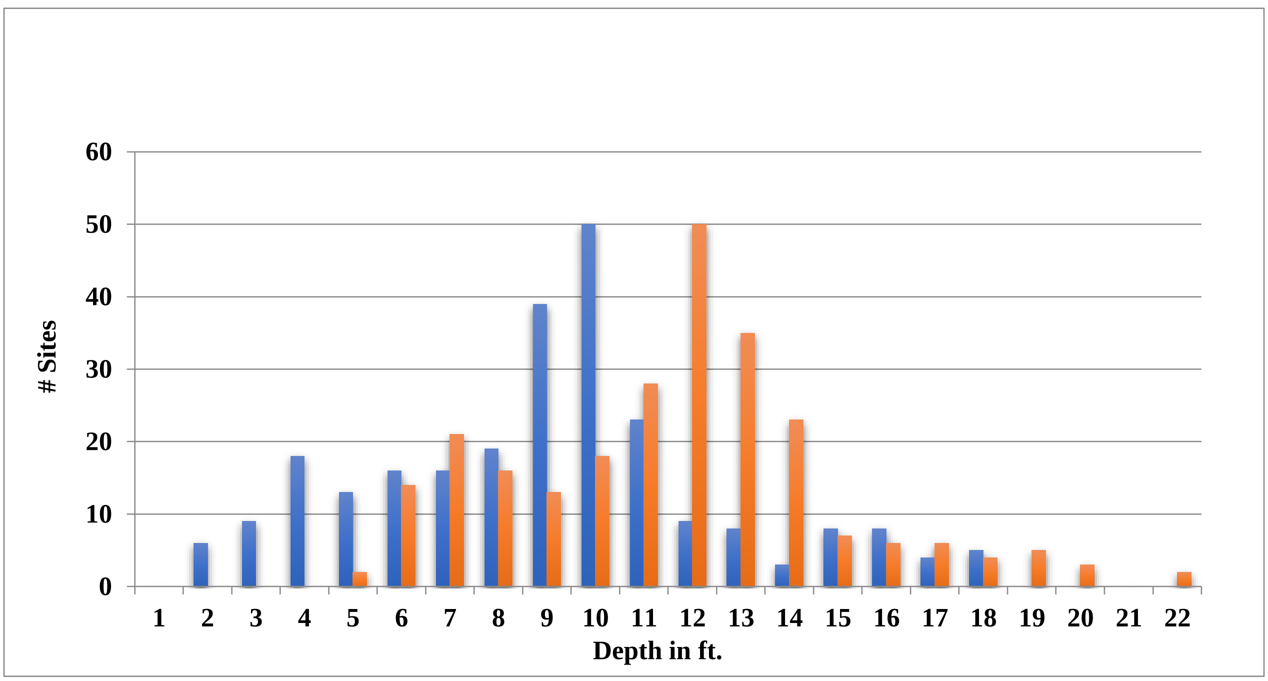


Figure 7. Maximum Depth of Plant Colonization Horseshoe Lake, Washburn County August 2-3, 2011 and August 2, 2020

Plant diversity was high in 2020 with a Simpson Index value of 0.89 – down slightly from 0.91 in 2011. Species richness was relatively low with 23 species found in the rake, although this total increased to 33 species when including visuals and plants seen during the boat survey (down from 27/41 in 2011). Along with the decline in overall richness, mean native species richness at sites with native vegetation experienced a nearly significant decline (p=0.08) from 2.03/site in 2011 to 1.89/site in 2020 (Figure 6) (Appendix IV).

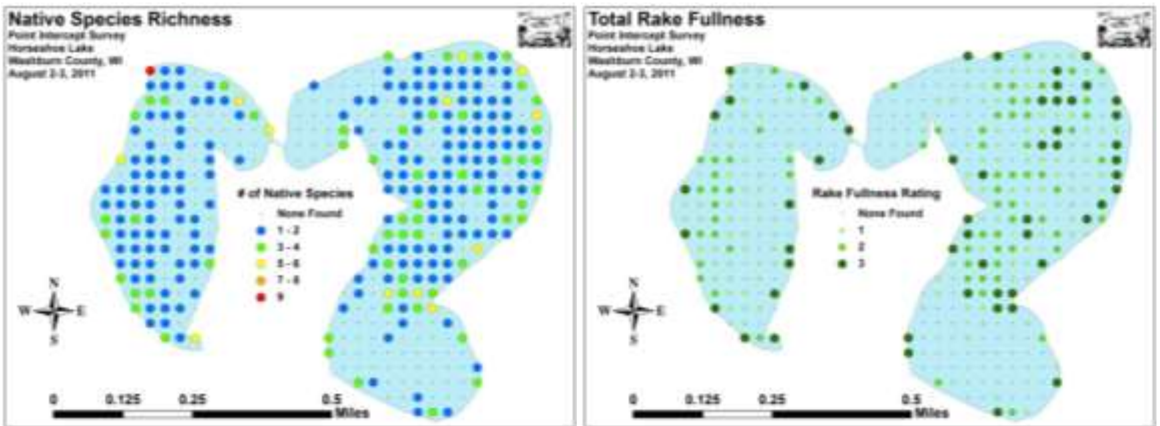


Figure 8. Native Species Richness and Total Rake Fullness (Berg, 2011)

Total rake fullness also experienced a nearly significant decline (p=0.06) from a low/ moderate 1.70 in 2011 to 1.60 in 2020. Both the declines in richness and density appeared to be tied to the loss of emergent and shallow submergent species following the rise in lake levels (Figure 9).

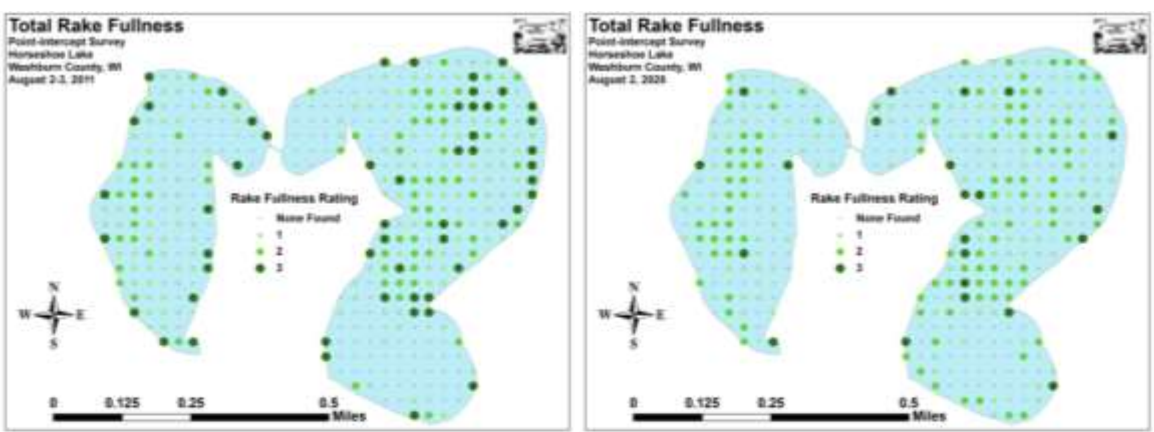


Figure 9: 2011 and 2020 Total Rake Fullness

The Horseshoe Lake ecosystem is home to a moderately rich and highly diverse plant community that is fairly typical of mesotrophic lakes with good water clarity. This community can be subdivided into four distinct zones (emergent, shallow submergent, floating-leaf, and deep submergent) with each zone having its own characteristic functions in the aquatic ecosystem. Depending on the local bottom type (sand, rock, sandy muck or nutrient-rich organic muck), these zones often had somewhat different species present.

In shallow areas, beds of emergent plants prevent erosion by stabilizing the shoreline, break up wave action, provide a nursery for baitfish and juvenile gamefish, offer shelter for amphibians, and give waterfowl and predatory wading birds like herons a place to hunt. These areas also provide important habitat for invertebrates like dragonflies and mayflies.

Elevated lake levels in 2020 eliminated the majority of the emergent community originally documented in 2011. Beds showed dramatic reductions in size, and, although they will likely return when the water recedes, many species disappeared altogether. On exposed sandy shorelines, a few small stands of Common rush (*Juncus effusus*) and Prairie chordgrass (*Spartina pectinata*) were found. Away from the immediate shoreline, they were replaced by narrow beds of Creeping spikerush (*Eleocharis palustris*) and Hardstem bulrush (*Schoenoplectus acutus*).

Common rush (Eggers 2008)

Prairie chordgrass (Lewallen 2001)

Creeping spikerush (Legler 2016)

Hardstem bulrush (Dziuk 2015)

Pure sugar sand dominated the majority of the lake's nearshore (<6ft deep) substrate. These areas naturally tend to have low total biomass as the nutrient-poor substrate provides habitat most suited to fine-leaved "isoetid" species like Needle spikerush (*Eleocharis acicularis*), Brown-fruited rush (*Juncus pelocarpus*), Dwarf water-milfoil (*Myriophyllum tenellum*), Slender naiad (*Najas flexilis*), Northern naiad (*Najas gracillima*), and Variable pondweed (*Potamogeton gramineus*).

Needle spikerush (Fewless 2005)

Brown-fruited rush (Koshere 2002)

Dwarf water-milfoil (Koshere 2002)

Slender naiad (Cameron 2013)

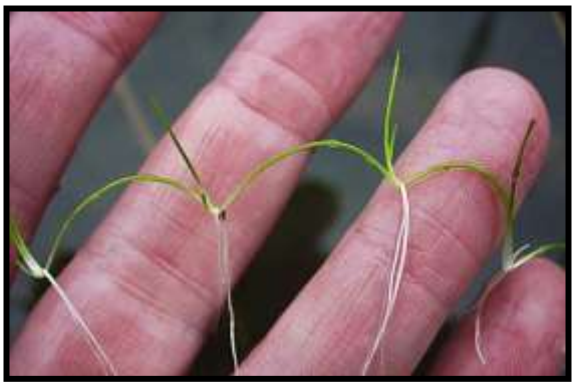
Northern naiad (Kallor 2016)

Variable pondweed – form with small submergent leaves (Cameron 2019)

In the most pristine shoreline areas on the lake, these shallow sandy habitats also support an often limited number of uncommon to rare species. These plants, which are extremely sensitive to human disturbance, included Waterwort (*Elatine minima*), Pipewort (*Eriocaulon aquaticum*), Creeping spearwort (*Ranunculus flammula*), and Small purple bladderwort (*Utricularia resupinata*). All of these "turf" species, along with the emergents, stabilize the bottom and prevent wave action erosion.

Waterwort (Fewless 2005)

Pipewort (Fewless 2005)



Creeping spearwort "stolons" (Fewless 2005)

Small purple bladderwort (Cameron 2019)

Few substrates in the lake had enough nutrients to provide habitat for floating-leaf species, and even when present, individuals tended to be few in number and spindly in growth form. The most nutrient-rich substrates on the entire lake occurred in the nook bay, in the bay immediately southwest of the channel, and near the public boat landing. In these areas, some Watershield (*Brasenia schreberi*), Spatterdock (*Nuphar variegata*), White water lily (*Nymphaea odorata*), Water smartweed (*Polygonum amphibium*), Floating-leaf pondweed (*Potamogeton natans*), and, with its flowing ribbon-like leaves, Narrow-leaved bur-reed (*Sparganium angustifolium*) were found.

Watershield (WED 2019)

Spatterdock (CBG 2014)

White water lily (Falkner 2009)

Water smartweed (Someya 2009)

Floating-leaf pondweed (Petroglyph 2007)

Narrow-leaved bur-reed (Schouh 2006)

Other species that only occasionally produce floating-leaves like Large-leaf pondweed (*Potamogeton amplifolius*), Variable pondweed, Spiral-fruited pondweed (*Potamogeton spirillus*), and Vasey's pondweed (*Potamogeton vaseyi*) seldom had them unless they were growing near shore over substrate with at least a thin layer of muck. The protective canopy cover this entire group provides is often utilized by panfish and bass.

Large-leaf pondweed (Fewless 2010)

Variable pondweed with floating leaf (Koshere 2002)

Spiral-fruited pondweed (Cameron 2019)

Vasey's pondweed (Skawinski 2010)

Entangled amongst these floating-leaf species, the carnivorous Creeping bladderwort (*Utricularia gibba*) was occasionally found. Rather than drawing nutrients up through roots like other plants, bladderworts trap zooplankton and minute insects in their bladders, digest their prey, and use the nutrients to further their growth.

Creeping bladderwort (Eyewed 2010)

Bladders for catching plankton and insect larvae (Wontolla 2007)

Sand and marly-muck areas in water over 6ft deep were often completely devoid of plants, and, even when present, rake samples frequently included just a single individual. In this environment, Large-leaf pondweed, White-stem pondweed (*Potamogeton praelongus*), Crested arrowhead (*Sagittaria cristata*), and Wild celery (*Vallisneria americana*) were documented. The roots, shoots, and seeds of all these submergent species are heavily utilized by both resident and migratory waterfowl for food. They also provide important habitat for the lake's fish throughout their lifecycles; as well as support a myriad of invertebrates like scuds, dragonfly and mayfly nymphs, and snails.

Large-leaf pondweed (Martin 2002)

White-stem pondweed (Fewless 2005)

Crested arrowhead (Fewless 2004)

Wild celery (Dalvi 2009)

In areas from 6-10ft with more sandy muck, these species tended to become more common and stands thickened into small beds. This habitat also supported Muskgrass (*Chara* sp.), Common waterweed (*Elodea canadensis*), Small pondweed (*Potamogeton pusillus*), and, rarely, Eurasian water-milfoil.

Muskgrass (Fischer 2014)

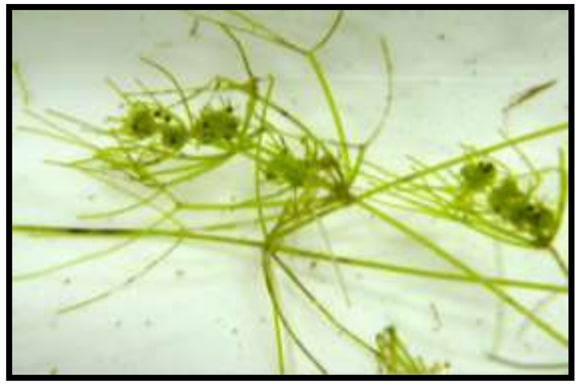
Common waterweed (Pinkka 2013)

Small pondweed (Villa 2011)

Eurasian water-milfoil (Berg 2007)

At depths over 10ft, this environment was dominated by Muskgrass and Fern pondweed (*Potamogeton robbinsii*). A few patches of the colonial algae Nitella (*Nitella* sp. likely flexilis) was also found. Predatory fish like the lake's Northern pike are often found along the edges of these deepwater beds waiting in ambush.


Fern pondweed (Apipp 2011)


Nitella (USGS 2008)

Comparison of Native Macrophyte Species in 2011 and 2020:

In August 2011, Slender naiad, Muskgrass, Fern pondweed, and Wild celery were the most common macrophyte species found at 28.35%, 27.95%, 25.20%, and 23.23% of survey points with vegetation respectively; and, collectively, they accounted for 51.65% of the total relative frequency (Table 2). Variable pondweed (7.18%), Crested arrowhead (6.41%), Brown-fruited rush (5.63%), Small purple bladderwort (5.24%), and Dwarf water-milfoil (5.05%) were the only other species with relative frequencies over 4.0.

The August 2020 survey identified Muskgrass, Fern pondweed, Wild celery, and Slender naiad as the most common macrophyte species. Present at 32.41%, 30.83%, 26.88%, and 18.18% of sites with vegetation (Table 3), they encompassed 57.32% of the total relative frequency. Crested arrowhead (9.41%), Variable pondweed (6.28%), and White-stem pondweed (5.65%) also had relative frequencies over 4.0.

Lake wide, eight species showed significant changes in distribution from 2011 to 2020 (Figure 8). Similar to the emergents, isoetid species lost much of their shallow-water habitat following the rise in lake levels. Because of this, it wasn't surprising that Brown fruited rush suffered a highly significant decline; and Slender naiad, Small purple bladderwort, Pipewort, and Creeping spearwort demonstrated significant declines. Filamentous algae also experienced a moderately significant decline, but for no obvious reason. Conversely, White-stem pondweed enjoyed a moderately significant increase, and Northern naiad saw a significant increase as the percentage of the lake in their preferred habitat expanded.

Table 2: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Horseshoe Lake, Washburn County
August 2-3, 2011

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Najas flexilis	Slender naiad	72	13.98	28.35	18.65	1.07	1
Chara sp.	Muskgrass	71	13.79	27.95	18.39	1.46	8
Potamogeton robbinsii	Fern pondweed	64	12.43	25.20	16.58	1.69	3
Vallisneria americana	Wild celery	59	11.46	23.23	15.28	1.34	2
Potamogeton gramineus	Variable pondweed	37	7.18	14.57	9.59	1.14	1
Sagittaria cristata	Crested arrowhead	33	6.41	12.99	8.55	1.12	11
Juncus pelocarpus f. submersus	Brown-fruited rush	29	5.63	11.42	7.51	1.86	13
Utricularia resupinata	Small purple bladderwort	27	5.24	10.63	6.99	2.04	1
Myriophyllum tenellum	Dwarf water-milfoil	26	5.05	10.24	6.74	2.15	0
Eleocharis acicularis	Needle spikerush	19	3.69	7.48	4.92	1.68	1
Eriocaulon aquaticum	Pipewort	16	3.11	6.30	4.15	1.81	9
Potamogeton amplifolius	Large-leaf pondweed	16	3.11	6.30	4.15	1.06	1
Potamogeton praelongus	White-stem pondweed	11	2.14	4.33	2.85	1.27	1
Potamogeton pusillus	Small pondweed	10	1.94	3.94	2.59	1.40	6
	Filamentous algae	9	*	3.54	2.33	1.00	0
Elodea canadensis	Common waterweed	6	1.17	2.36	1.55	1.67	1
Ranunculus flammula	Creeping spearwort	4	0.78	1.57	1.04	1.75	2
Eleocharis palustris	Creeping spikerush	2	0.39	0.79	0.52	1.00	3
Leersia oryzoides	Rice cut-grass	2	0.39	0.79	0.52	1.00	0
Najas gracillima	Northern naiad	2	0.39	0.79	0.52	1.50	0
Nitella sp.	Nitella	2	0.39	0.79	0.52	1.00	2

* Excluded from relative frequency analysis

Table 2 (continued): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Horseshoe Lake, Washburn County
August 2-3, 2011

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Carex cryptolepis	Small yellow sedge	1	0.19	0.39	0.26	1.00	0
Carex lasiocarpa	Narrow-leaved woolly sedge	1	0.19	0.39	0.26	2.00	0
Dulichium arundinaceum	Three-way sedge	1	0.19	0.39	0.26	1.00	0
Elatine minima	Waterwort	1	0.19	0.39	0.26	2.00	0
Juncus brevicaudatus	Narrow-panicle rush	1	0.19	0.39	0.26	2.00	0
Polygonum amphibium	Water smartweed	1	0.19	0.39	0.26	2.00	0
Sparganium angustifolium	Narrow-leaved bur-reed	1	0.19	0.39	0.26	3.00	0
Cladium mariscoides	Smooth sawgrass	**	**	**	**	**	1
Glyceria canadensis	Rattlesnake manna-grass	**	**	**	**	**	1
Juncus effusus	Common rush	**	**	**	**	**	1
Myriophyllum spicatum	Eurasian water-milfoil	**	**	**	**	**	2
Nymphaea odorata	White water lily	**	**	**	**	**	1
Potamogeton spirillus	Spiral-fruited pondweed	**	**	**	**	**	3
Schoenoplectus acutus	Hardstem bulrush	**	**	**	**	**	1
Utricularia gibba	Creeping bladderwort	**	**	**	**	**	1
Brasenia schreberi	Watershield	***	***	***	***	***	***
Lycopus uniflorus	American water-horehound	***	***	***	***	***	***
Nuphar variegata	Spatterdock	***	***	***	***	***	***
Potamogeton natans	Floating-leaf pondweed	***	***	***	***	***	***
Schoenoplectus pungens	Threesquare	***	***	***	***	***	***
Spartina pectinata	Prairie cordgrass	***	***	***	***	***	***

** Visual Only   *** Boat Survey Only

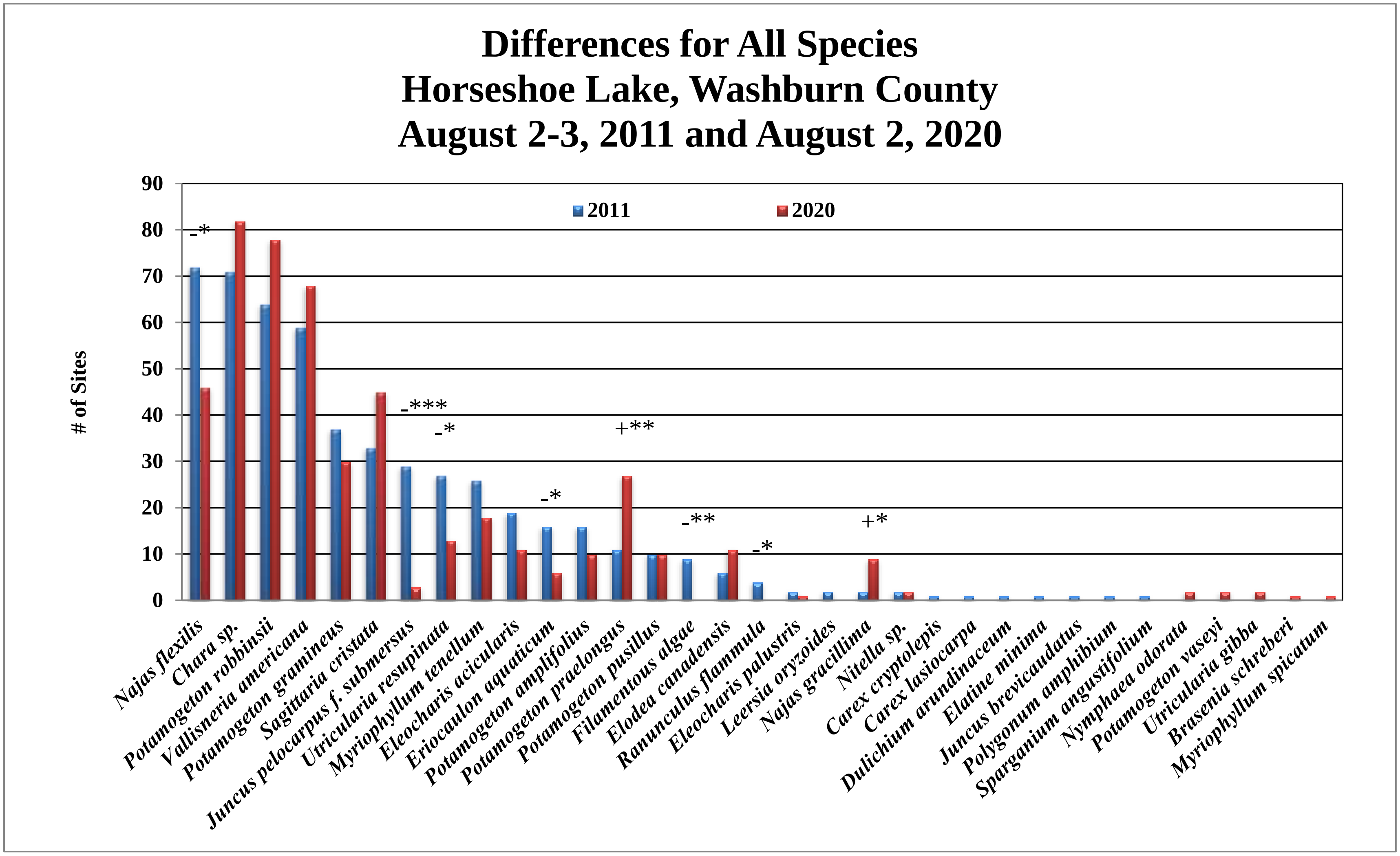
Table 3: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Horseshoe Lake, Washburn County
August 2, 2020

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Chara sp.	Muskgrass	82	17.15	32.41	21.35	1.50	0
Potamogeton robbinsii	Fern pondweed	78	16.32	30.83	20.31	1.59	0
Vallisneria americana	Wild celery	68	14.23	26.88	17.71	1.25	0
Najas flexilis	Slender naiad	46	9.62	18.18	11.98	1.11	0
Sagittaria cristata	Crested arrowhead	45	9.41	17.79	11.72	1.16	0
Potamogeton gramineus	Variable pondweed	30	6.28	11.86	7.81	1.27	0
Potamogeton praelongus	White-stem pondweed	27	5.65	10.67	7.03	1.30	1
Myriophyllum tenellum	Dwarf water-milfoil	18	3.77	7.11	4.69	1.50	0
Utricularia resupinata	Small purple bladderwort	13	2.72	5.14	3.39	1.77	0
Eleocharis acicularis	Needle spikerush	11	2.30	4.35	2.86	1.45	0
Elodea canadensis	Common waterweed	11	2.30	4.35	2.86	1.27	0
Potamogeton amplifolius	Large-leaf pondweed	10	2.09	3.95	2.60	1.00	2
Potamogeton pusillus	Small pondweed	10	2.09	3.95	2.60	1.50	0
Najas gracillima	Northern naiad	9	1.88	3.56	2.34	1.33	0
Eriocaulon aquaticum	Pipewort	6	1.26	2.37	1.56	2.50	0
Juncus pelocarpus f. submersus	Brown-fruited rush	3	0.63	1.19	0.78	2.00	0
Nitella sp.	Nitella	2	0.42	0.79	0.52	1.00	0
Nymphaea odorata	White water lily	2	0.42	0.79	0.52	1.00	2
Potamogeton vaseyi	Vasey's pondweed	2	0.42	0.79	0.52	1.50	0
Utricularia gibba	Creeping bladderwort	2	0.42	0.79	0.52	1.50	0
Brasenia schreberi	Watershield	1	0.21	0.40	0.26	2.00	2
Eleocharis palustris	Creeping spikerush	1	0.21	0.40	0.26	1.00	0
Myriophyllum spicatum	Eurasian water-milfoil	1	0.21	0.40	0.26	3.00	0

Table 3 (continued): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Horseshoe Lake, Washburn County
August 2, 2020

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Schoenoplectus acutus	Hardstem bulrush	**	**	**	**	**	2
Elatine minima	Waterwort	***	***	***	***	***	***
Juncus effusus	Common rush	***	***	***	***	***	***
Nuphar variegata	Spatterdock	***	***	***	***	***	***
Polygonum amphibium	Water smartweed	***	***	***	***	***	***
Potamogeton natans	Floating-leaf pondweed	***	***	***	***	***	***
Potamogeton spirillus	Spiral-fruited pondweed	***	***	***	***	***	***
Ranunculus flammula	Creeping spearwort	***	***	***	***	***	***
Sparganium angustifolium	Narrow-leaved bur-reed	***	***	***	***	***	***
Spartina pectinata	Prairie cordgrass	***	***	***	***	***	***

** Visual Only   *** Boat Survey Only



Significant differences = * *p*<0.05, ** *p*<0.01, * *p*<0.001**

Figure 10: Macrophyte Changes from 2011-2020

Slender naiad, the most common species in 2011 and the fourth most common in 2020, was present throughout the lake at most points with sandy muck in 7-11ft of water (Figure 11). Although it suffered a significant decline **(*p*=0.01)** in distribution from 72 sites in 2011 to 46 sites in 2020, its mean rake fullness underwent a non-significant increase (*p*=0.25) from 1.07 in 2011 to 1.11 in 2020. Visual analysis of the maps showed this decline in distribution was essentially a lakewide phenomenon with the loss of habitat in deep water. Offsetting this was some expansion nearer the shore; especially in the west basin.

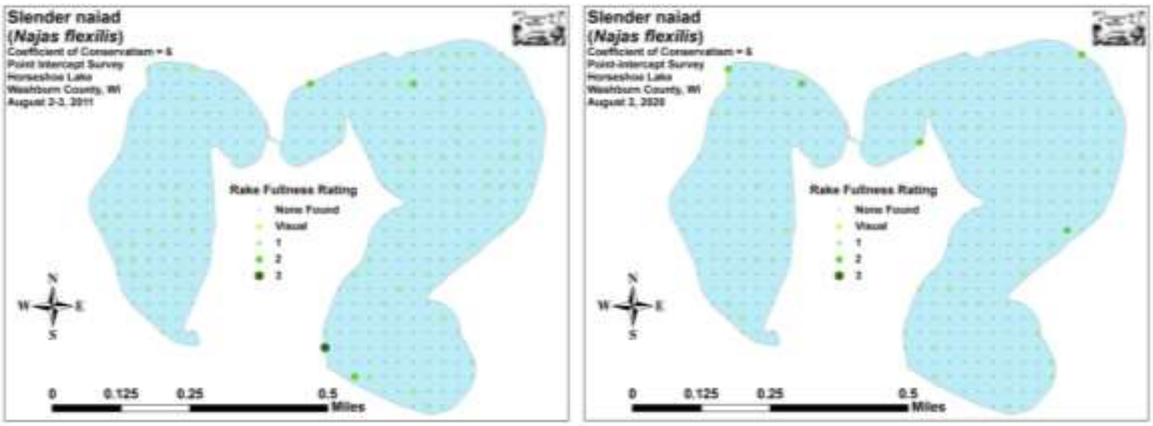


Figure 11: 2011 and 2020 Slender Naiad Density and Distribution

Muskgrasses were the second most common macrophyte in 2011 and the most common in 2020. Although the shallow-water species (likely *Chara aspera*) nearly disappeared from the lake along with much of the rest of the isoetid community, the deep-water species (likely *Chara globularis* or *contraria*), colonized most of the deeper areas in the western basin (Figure 12). Collectively, they experienced a non-significant increase (*p*=0.30) in distribution from 71 sites in 2011 to 82 sites in 2020. The accompanying increase in density from a mean rake fullness of 1.46 in 2011 to 1.50 in 2020 was also not significant (*p*=0.35).

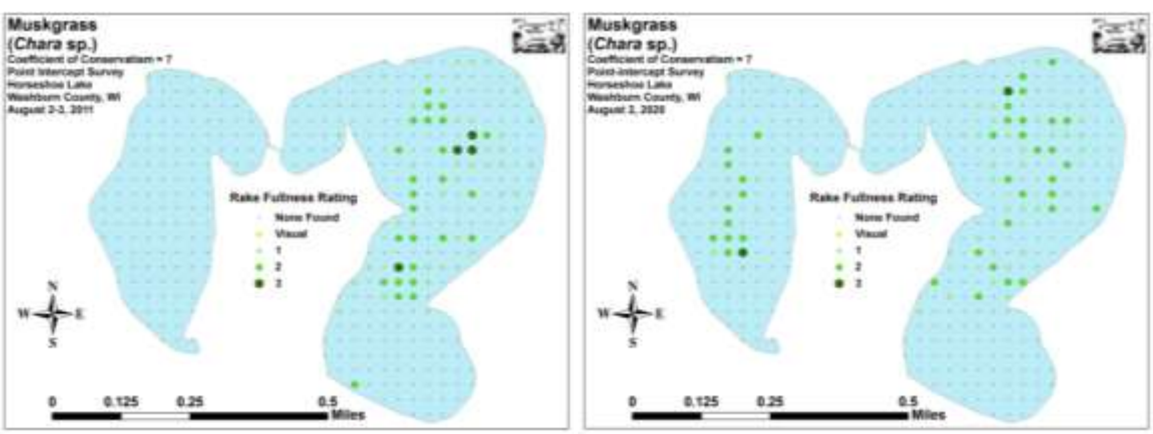


Figure 12: 2011 and 2020 Muskgrass Density and Distribution

Fern pondweed also expanded into the deeper areas of the west basin as its community rank increased from the third most common species in 2011 to the second most common in 2020 (Figure 13). However, neither this total increase in distribution (64 sites in 2011/78 sites in 2020), nor the decline in mean rake fullness (1.69 in 2011/1.59 in 2020) were significant (p=0.18/p=0.22).

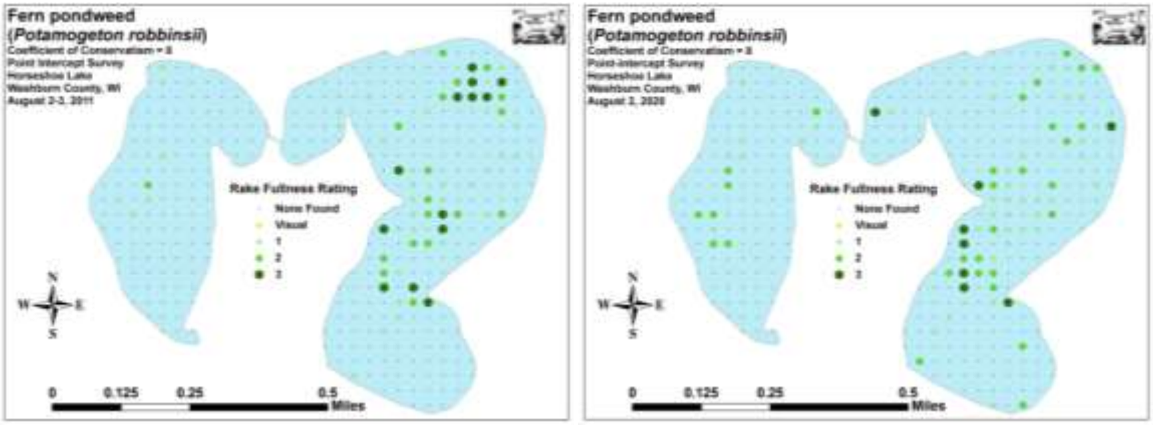


Figure 13: 2011 and 2020 Fern Pondweed Density and Distribution

Wild celery adapted fairly well to changing water levels (Figure 14). Its increase from the fourth most widely-distributed species (59 sites in 2011) to the third most (68 sites in 2020) was not significant (p=0.36). Similarly, the decline in density (mean rake fullness of 1.34 in 2011/1.25 in 2020) was not significant (p=0.16).

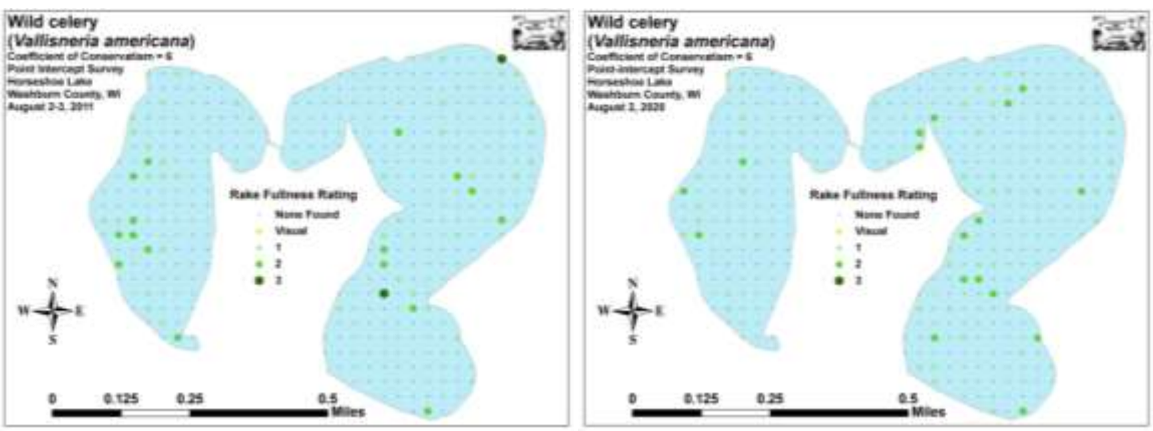


Figure 14: 2011 and 2020 Wild Celery Density and Distribution

Comparison of Floristic Quality Indexes in 2011 and 2020:

In 2011, a total of 23 **native index species** in the rake during the point-intercept survey were identified (Table 4). They produced a mean Coefficient of Conservatism of 7.4 and a Floristic Quality Index of 35.4.

Table 4: Floristic Quality Index of Aquatic Macrophytes
Horseshoe Lake, Washburn County
August 2-3, 2011

Species	Common Name	C
Chara sp.	Muskgrass	7
Dulichium arundinaceum	Three-way sedge	9
Elatine minima	Waterwort	9
Eleocharis acicularis	Needle spikerush	5
Eleocharis palustris	Creeping spikerush	6
Elodea canadensis	Common waterweed	3
Eriocaulon aquaticum	Pipewort	9
Juncus pelocarpus f. submersus	Brown-fruited rush	8
Myriophyllum tenellum	Dwarf water-milfoil	10
Najas flexilis	Slender naiad	6
Najas gracillima	Northern naiad	7
Nitella sp.	Nitella	7
Polygonum amphibium	Water smartweed	5
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton gramineus	Variable pondweed	7
Potamogeton praelongus	White-stem pondweed	8
Potamogeton pusillus	Small pondweed	7
Potamogeton robbinsii	Fern pondweed	8
Ranunculus flammula	Creeping spearwort	9
Sagittaria cristata	Crested arrowhead	9
Sparganium angustifolium	Narrow-leaved bur-reed	9
Utricularia resupinata	Small purple bladderwort	9
Vallisneria americana	Wild celery	6
N		**23**
Mean C		**7.4**
FQI		**35.4**

During the 2020 point-intercept survey, 22 **native index plants** were found in the rake. They produced a mean Coefficient of Conservatism of 7.3 and a Floristic Quality Index of 34.1 (Table 5). Nichols (1999) reported an average mean C for the Northern Lakes and Forest Region of 6.7 putting Horseshoe Lake well above average for this part of the state. The FQI was also much above the median FQI of 24.3 for the Northern Lakes and Forest Region (Nichols 1999). Six exceptionally high value species of note included Pipewort (C = 9), Dwarf water-milfoil (C = 10), Crested arrowhead (C = 9), Creeping bladderwort (C = 9), and the State Species of Special Concern** Vasey's pondweed (C = 10) and Small purple bladderwort (C = 9).

Table 5: Floristic Quality Index of Aquatic Macrophytes Horseshoe Lake, Washburn County August 2, 2020

Species	Common Name	C
Brasenia schreberi	Watershield	6
Chara sp.	Muskgrass	7
Eleocharis acicularis	Needle spikerush	5
Eleocharis palustris	Creeping spikerush	6
Elodea canadensis	Common waterweed	3
Eriocaulon aquaticum	Pipewort	9
Juncus pelocarpus f. submersus	Brown-fruited rush	8
Myriophyllum tenellum	Dwarf water-milfoil	10
Najas flexilis	Slender naiad	6
Najas gracillima	Northern naiad	7
Nitella sp.	Nitella	7
Nymphaea odorata	White water lily	6
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton gramineus	Variable pondweed	7
Potamogeton praelongus	White-stem pondweed	8
Potamogeton pusillus	Small pondweed	7
Potamogeton robbinsii	Fern pondweed	8
Potamogeton vaseyi	Vasey's pondweed	10
Sagittaria cristata	Crested arrowhead	9
Utricularia gibba	Creeping bladderwort	9
Utricularia resupinata	Small purple bladderwort	9
Vallisneria americana	Wild celery	6
N		**22**
Mean C		**7.3**
FQI		**34.1**

Comparison of Filamentous Algae in 2011 and 2020:

Filamentous algae are normally associated with excessive nutrients in the water column from such things as runoff or internal nutrient recycling. In 2011, filamentous algae was documented at nine points with a mean rake fullness of 1.00 (Figure 15). During the 2020 survey, no filamentous algae was found. Although this was a moderately significant decline **(p=0.003)** in distribution, the reasons for it are unclear. Because all the points in 2011 were located in the western basin around the deep hole, it suggests that shoreline runoff was not the cause. It may simply be that changes in lake levels led to a local plant die-off and this produced a short-term increase in algal levels in this area. It may also be that the increased numbers of macrophytes seen in this area during the 2020 survey were able to utilize the majority of available nutrients.

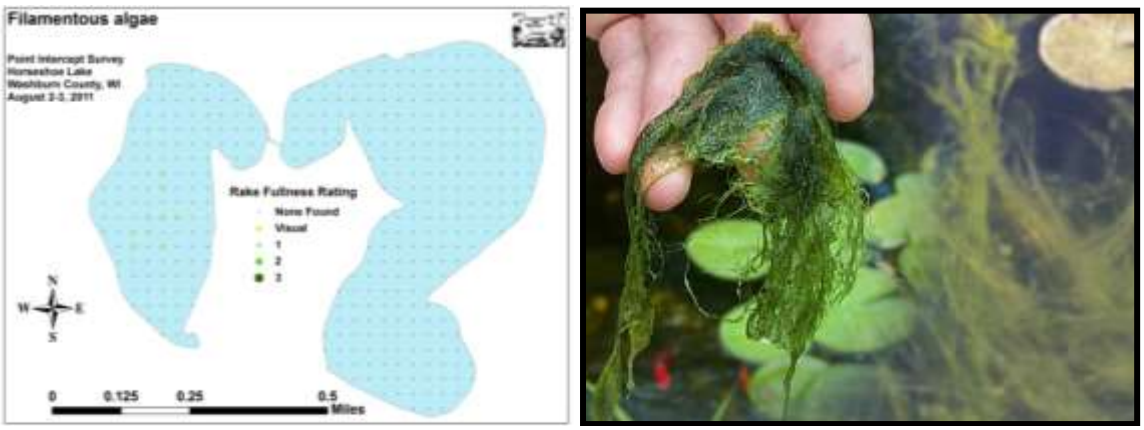


Figure 15: 2011 Filamentous Algae Density and Distribution

Comparison of Midsummer Eurasian Water-milfoil in 2011 an 2020:

In August 2011, no Eurasian water-milfoil was found in the rake at any point, but it was recorded as a visual at two sites (Figure 16). During the 2020 August survey, EWM was present at a single point in the middle of the newly discovered bed in the northwest bay. Away from this immediate area, there was no evidence of EWM anywhere else in the system. Because of the low number of detections during each survey, none of these changes were significant (Figure 17).

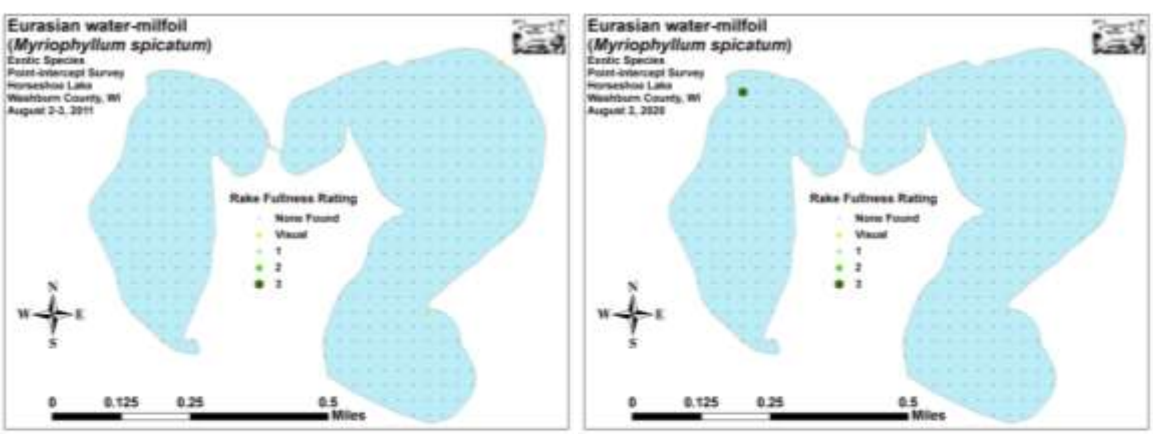


Figure 16: 2011 and 2020 Eurasian Water-milfoil Density and Distribution

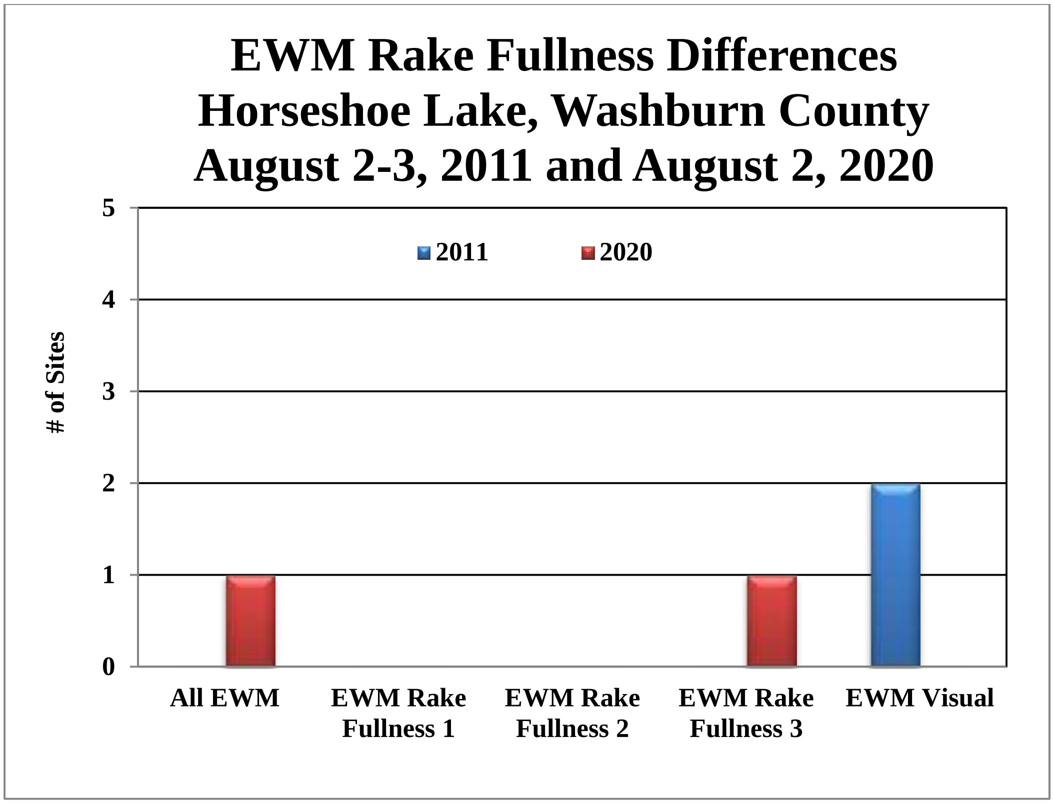


Figure 17: Changes in EWM Rake Fullness from 2011-2020

Other Exotic Plant Species:

Other than Eurasian water-milfoil, there was no evidence of any other exotic plant species; however, freshwater jellies (*Craspedacusta sowerbyi*) an exotic animal, were abundant.

For general information on aquatic invasive species:
https://dnr.wi.gov/topic/invasives/species.asp?filterBy=Aquatic&filterVal=Y

Common regulated aquatic invasive species in WI:
https://dnr.wi.gov/topic/Invasives/documents/NR40Aquatics.pdf

Invasive Species Rule NR 40:
https://dnr.wisconsin.gov/topic/invasives/classification.html

Reporting invasive species:
https://dnr.wisconsin.gov/topic/Invasives/report.html

Preventing the spread of AIS:
https://dnr.wisconsin.gov/topic/Invasives/prevention.html

Eurasian watermilfoil fact sheet:
https://dnr.wisconsin.gov/topic/Invasives/fact/EurasianWatermilfoil.html

EWM Management History

EWM was first discovered in Horseshoe Lake in 2011. Once discovered, the Horseshoe Lake Property Association (HLPA) authorized a June 2011 scuba removal of the known bed and a meandering littoral zone survey to look for evidence of further spread. Additional survey results found that the established population of EWM warranted a "rapid response" herbicide application of diquat on September 15th, 2011, and a post treatment swim-over survey was conducted on October 8th. The following year, 2012, it was found that the initial beds had expanded, and an additional treatment of 2,4-D herbicide was used (Figure 18; Table 6). In 2013, no EWM was found. In 2014 and 2015, only a few EWM plants were found and were hand removed. In 2016, a treatment of 2,4-D was authorized on the northeast bed in the east basin and a new bed on the west side midpoint of east basin. In 2017, no EWM was found. In 2018, EWM was again found in the south end of the west basin. In 2019, 3.65 acres of EWM were treated with ProcellaCOR. In 2020, several plants in a 0.10 acre patch were hand removed. In 2021, an additional 1.16 acres of EWM was treated with ProcellaCOR in the northwest bay of the east basin, and divers were hired to hand remove smaller beds and individual plants located near the channel.

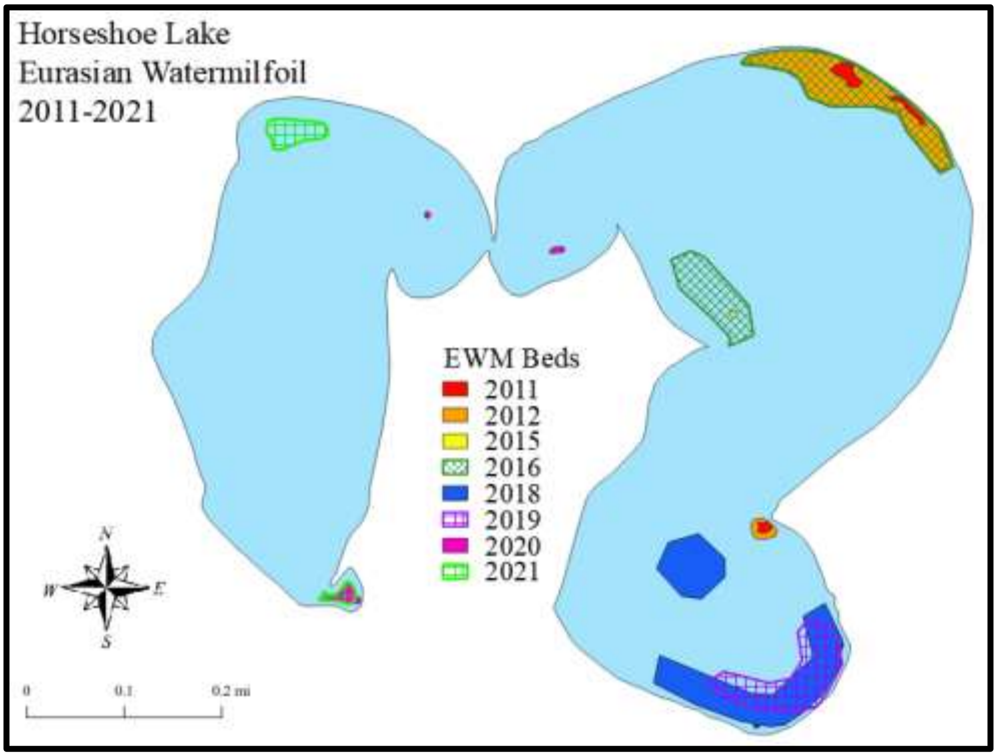


Figure 18. 2011-2021 EWM Beds

Table 6. EWM treatment history in Horseshoe Lake

Year	Acres Treated	Herbicide	Rate (lbs/acre)	Rate (gal/acre)
2011	0.51	Diquat		
2012	3.73	2,4-D		
2016	3.73	2,4-D		
2018	3.65	Liquid 2,4-D	-	51.83
2019	3.55	ProcellaCOR	-	0.30
2021	1.16	ProcellaCOR	-	0.92

Integrated Pest Management

Integrated Pest Management (IPM) is an ecosystem-based management strategy that focuses on long-term prevention and/or control of a species of concern. IPM considers all the available control practices such as: prevention, biological control, biomanipulation, nutrient management, habitat manipulation, substantial modification of cultural practices, pesticide application, water level manipulation, mechanical removal and population monitoring (Figure 19). In addition to monitoring and considering information about the target species' life cycle and environmental factors, groups can decide whether the species' impacts can be tolerated or whether those impacts warrant control. Then, an IPM-based plan informed by current, comprehensive information on pest life cycles and the interactions among pests and the environment can be formed.

After monitoring and considering information about the target species' life cycle and environmental factors, groups can decide whether the species' impacts can be tolerated or whether those impacts warrant control. If control is needed, data collected on the species and the waterbody will help groups select the most effective management methods and the best time to use them.

The most effective, long-term approach to managing a species of concern is to use a combination of methods. Approaches for managing pests are often grouped in the following categories:

- **Assessment** – is the use of learning tools and protocols to determine a waterbodies' biological, chemical, physical and social properties and potential impacts. Examples include: point-intercept (PI) surveys, water chemistry tests and boater usage surveys. This is the most important management strategy on every single waterbody.
- **Biological Control** – is the use of natural predators, parasites, pathogens and competitors to control target species and their impacts. An example would be beetles for purple loosestrife control.
- **Cultural controls** – are practices that reduce target species establishment, reproduction, dispersal, and survival. For example, a Clean Boats, Clean Waters program at boat launches can reduce the likelihood of the spread of species of concern.
- **Mechanical and physical controls** – can kill a target species directly, block them out, or make the environment unsuitable for it. Mechanical harvesting, hand pulling, and diver assisted suction harvesting are all examples.
- **Chemical control** – is the use of pesticides. In IPM, pesticides are used only when needed and in combination with other approaches for more effective, long-term control. Groups should use the most selective pesticide that will do the job and be the safest for other organisms and for air, soil, and water quality.

(Additional information on each method is outlined in the following section).

IPM is a process that combines informed methods and practices to provide long-term, economic pest control. A quality IPM program should adapt when new information pertaining to the target species is provided or monitoring shows changes in control effectiveness, habitat composition and/or water quality.

While each situation is different, eight major components should be established in an IPM program:

1. Identify and understand the species of concern
2. Prevent the spread and introduction of the species of concern
3. Continually monitor and assess the species' impacts on the waterbody
4. Prevent species of concern impacts
5. Set guidelines for when management action is needed
6. Use a combination of biological, cultural, physical/mechanical and chemical management tools
7. Assess the effects of target species' management
8. Change the management strategy when the outcomes of a control strategy create long-term impacts that outweigh the value of target species control.

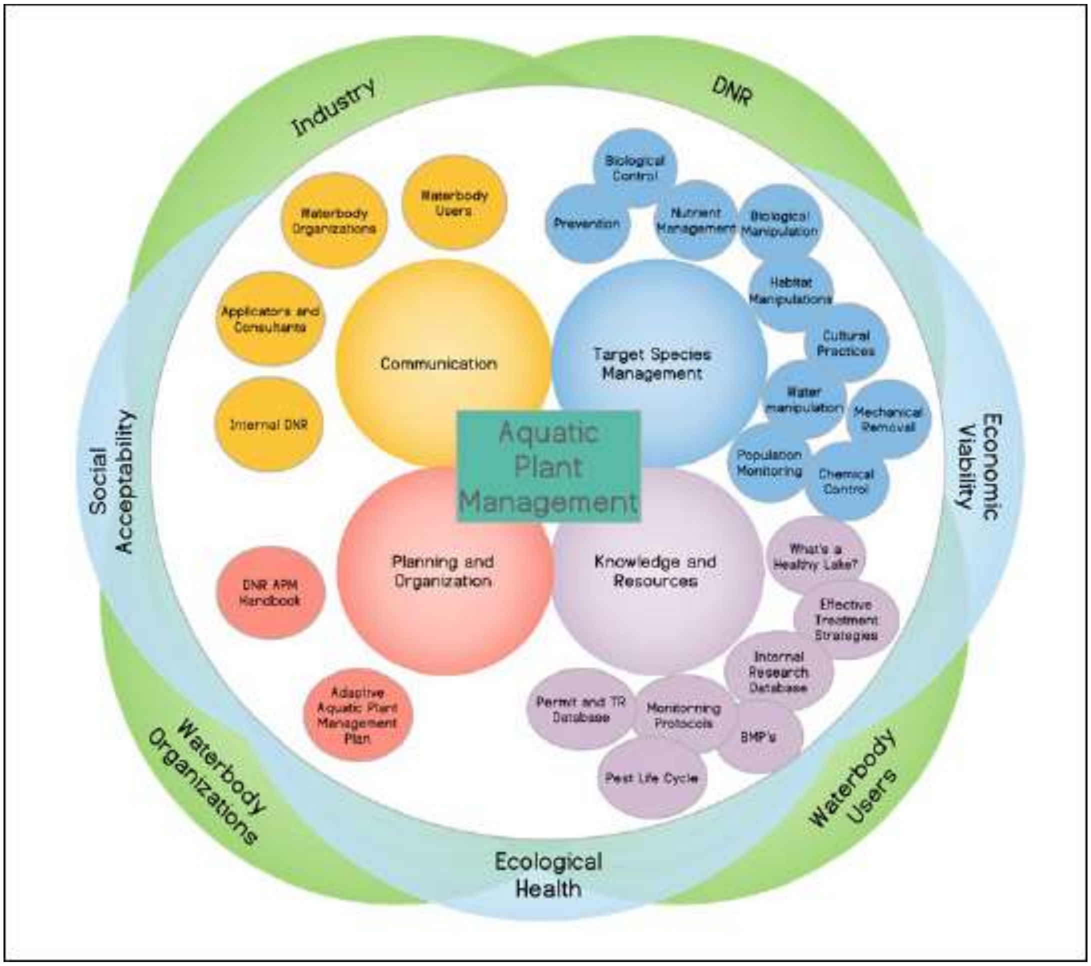


Figure 19: Wisconsin Department of Natural Resources: Wisconsin Waterbodies – Integrated Pest Management March 2020

Aquatic Plant Management Alternatives

Protecting native plants and limiting EWM is a primary focus of plant management in Horseshoe Lake due to its diverse plant community and the benefits it offers, including providing fish and wildlife habitat, keeping other aquatic invasive plant species at bay, maintaining water quality, protecting the shoreline from erosion, improving lake aesthetics, and increasing land owner privacy. Controlling EWM and its spread is a difficult task. Generally, control methods for nuisance aquatic plants can be grouped into four broad categories:

- Chemical control: use of herbicides
- Mechanical/physical control: pulling, cutting, raking and harvesting
- Biological control: the use of species that compete successfully with the nuisance species for resources
- Aquatic plant habitat manipulation: dredging, flooding, and drawdowns

In many cases, an integrated approach to aquatic plant management is the best way to protect and enhance the native plant community while maintaining functional use of the lake.

Physical/Manual Removal: Recommended

Physical removal of EWM will be completed by educated landowners who monitor their own shorelines or by a trained EWM Management Team sponsored by the HLPA. There is no limit as to how far out into the lake this management activity can occur (see https://docs.legis.wisconsin.gov/code/admin_code/nr/100/109.pdf for more information). It limits disturbance to the lake bottom, is inexpensive, and can be practiced by many lake residents. Landowners should also continually monitor near their docks and swimming areas in the open water season and remove rooted plants as well as floating fragments that wash into their shoreline.

Pulling EWM 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 waterbody when done properly. Diver removal will be completed by HLPA volunteers and/or resource professionals retained by the HLPA. These efforts will focus on smaller beds not treated with chemical herbicides in areas not directly adjacent to any landowner's property.

As there are no similar looking native milfoils in the lake, any suspicious looking plants that are found in the future should be immediately investigated to determine species. If any lake resident or boater discovers a plant they suspect may be EWM, they are invited to contact Matthew Berg, ERS, LLC Research Biologist at 715-338-7502 mberg@grantsburg.k12.wi.us and/or Pamela Toshner/Alex Smith, Regional Lakes Management Coordinators in the Spooner DNR office at 715-635-4073 for identification confirmation. If possible, a specimen, a jpg, and the accompanying GPS coordinates of the location it was found at should be included.

Chemical Herbicide Treatments: Recommended

Herbicides will be used to manage existing EWM and any existing or new areas with moderate to severe growth density and deemed too large for effective physical removal. Determining which herbicide to use (as approved by the state of Wisconsin) and at what concentration will be determined on a yearly basis during the treatment planning phase. Spring application of herbicides is preferred to reduce negative effects on native plants, but mid-season applications are occasionally appropriate. There are two main classes of aquatic herbicides that attack plants in different ways:

1) Systemic: moves through the entire plant. It is absorbed through the leaves or stem and moves through the entire plant and usually results in the death of the plant within two or more weeks

2) Contact: kills the plant at the point of contact. The entire plant may not be damaged, and the roots may still be viable for regrowth. Mostly used when an immediate removal of a plant is required.

There are several chemical herbicide options currently available in the State of Wisconsin (as approved by the Environmental Protection Agency):

ProcellaCOR®

ProcellaCOR® is a relatively new systemic, selective herbicide that can be used to target EWM with limited impact to most native species. It is also very fast acting, making it an effective control measure on smaller beds like those located in Horseshoe Lake, especially ones in high boat traffic areas and/or deeper water. In addition, applications rates are measured in ounces, not gallons, as is common with almost all other liquid herbicides. While it is more expensive to use than 2,4-D equivalents, it has been shown to provide 2 or more years of control without re-application. ProcellaCOR® is recommended for future EWM management implementation.

Triclopyr

Triclopyr is a selective, systemic herbicide used to control broadleaf plants like EWM by mimicking plant hormones. Liquid triclopyr (Renovate®) or granular triclopyr combined with granular 2,4-D (Renovate Max G®) may be an option in Horseshoe Lake. However, neither triclopyr nor 2,4-D based herbicides are recommended for small-scale (<3 acres) EWM treatments.

2,4-D (liquid)

2,4-D is a commonly used systemic herbicide that targets dicot plants (or broad-leaved plants) like EWM. Monocots (like pondweed species and water celery) are generally not affected by 2,4-D. Shredder Amine 4®, also referred to as 2,4-D Amine 4® is a liquid formulation of 2,4-D. Use of 2,4-D on Horseshoe has been shown to be less effective than ProcellaCOR and does not provide as long of a relief period. The use of liquid 2,4-D products are supported by the WDNR, but not as strongly recommended for Horseshoe Lake

2,4-D (granular)

Granular 2,4-D, under the trade name Navigate® or Sculpin G® works much like its liquid counterpart. It is also thought to provide a longer contact time than the liquid form. However, under current WDNR guidelines for aquatic plant management, the use of granular 2,4-D products is not supported for management and is thus not recommended for Horseshoe Lake.

Fluridone (liquid)

Fluridone is also a non-selective, systemic herbicide often used for whole-lake treatment. It is slow-acting and can be selective to EWM at low concentrations; however, the contact time must be very long in order for this to be effective, which may not be practical in Horseshoe Lake depending on wind and weather during and after applications. At the present time, whole-lake management of EWM is not a recommendation in this plan. As such, Fluridone is not appropriate for use in Horseshoe Lake.

Endothall (liquid)

Endothall is a non-selective contact herbicide. This herbicide is generally recommended when EWM growth needs to be suppressed to allow native plants to recover and potentially reclaim the area. It is not recommended for cases when eradication is the goal. In Horseshoe Lake, Endothall is not likely to be a viable option in the future in order to protect the native plant community and prevent EWM from re-growing in treated areas.

Diquat (liquid)

Diquat is another non-selective herbicide that is commonly used to control emergent and submersed aquatic vegetation. It is fast-acting and has no restrictions for swimming, fish, or wildlife, but there may be irrigation and drinking water restrictions for up to 5 days. Again, a non-selective contact herbicide is generally not going to be an option in Horseshoe Lake where the native plant community is so valuable and the risk of stressing the native plants and allowing EWM to re-grow would be detrimental to the lake.

Mechanical Harvesting: Not Recommended

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 (Booms, 1999). Plants are cut at a designated depth, but the root of the plants are often not disturbed. Cut plants will usually grow back after time, and re-cutting several times a season is often required to provide adequate annual control (Madsen, 2000). Harvesting activities in shallow water can re-suspend bottom sediments into the water column releasing nutrients and other accumulated compounds (Madsen, 2000). Even the best aquatic plant harvesters leave some cutting debris in the water to wash up on the shoreline or create loose mats of floating vegetation on the surface of the lake. This “missed” cut vegetation can potentially increase the amount of EWM in a lake by creating more fragments that can go on to establish new sites elsewhere. A major benefit, however, of aquatic plant harvesting is the removal of large amounts of plant biomass from a water body. Mechanical harvesting is not recommended in Horseshoe Lake due to the risk of releasing EWM fragments and further spreading it further throughout the lake.

Biological Control: Not Recommended

Biological control uses one or more living organisms to control, or suppress, another living organism. Milfoil weevils *Euhrychiopsis lecontei* are one method used to manage EWM. Weevils are an alternative to chemical treatments and potentially damaging mechanical harvesting. However, they are expensive to rear, easily predated on by sunfish, and only suppress – not eliminate – EWM. Biological control is not recommended in Horseshoe Lake due to the density of EWM in some beds and the healthy sunfish population.

Habitat Manipulation: Not Recommended

Habitat manipulation can take the form of flooding, dredging and drawdowns. None of these options are recommended or viable in Horseshoe Lake. Flooding and drawdowns are not possible because there are no water level control structures on or near Horseshoe Lake that could be used to manipulate the water levels. Dredging is also not recommended because the high-water quality and valuable habitat of Horseshoe Lake would be jeopardized by removing large quantities of substrate and bottom materials.

No Management: Not Recommended

Regardless of the target plant species, native or non-native, sometimes no management 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 occur without ecological impacts. This management alternative is not recommended for Horseshoe Lake because management thus far has kept EWM relatively under control and ‘off years’ of no management have seen significant increases in EWM. Additionally, limiting the spread of EWM within the lake through management protects the ecological integrity of the lake long-term.

Aquatic Plant Management Discussion

Horseshoe Lake supports a valuable aquatic plant community with a number of uncommon species and a quality fishery valued by the lake community and the general public. The lake currently has only one known fully aquatic invasive species – Eurasian watermilfoil. Nuisance conditions and navigation impairment occur throughout the open water season as a direct result of the EWM infestation. The main goal of the Aquatic Plant Management Plan is to control EWM in a sound, ecological manner. If the resources available to manage EWM are limited, Figure 20 provides a method to determine priority. Referred to as FLIPS, it involves evaluating each areas of EWM in the lake in any given year based on when it was first discovered and managed (Formation), where it is located (Location), whether it causing issues (Impairment), whether it was mapped in a previous year (Prior Year), and whether it is negatively impacting the native aquatic plant community (Sensitive Area).

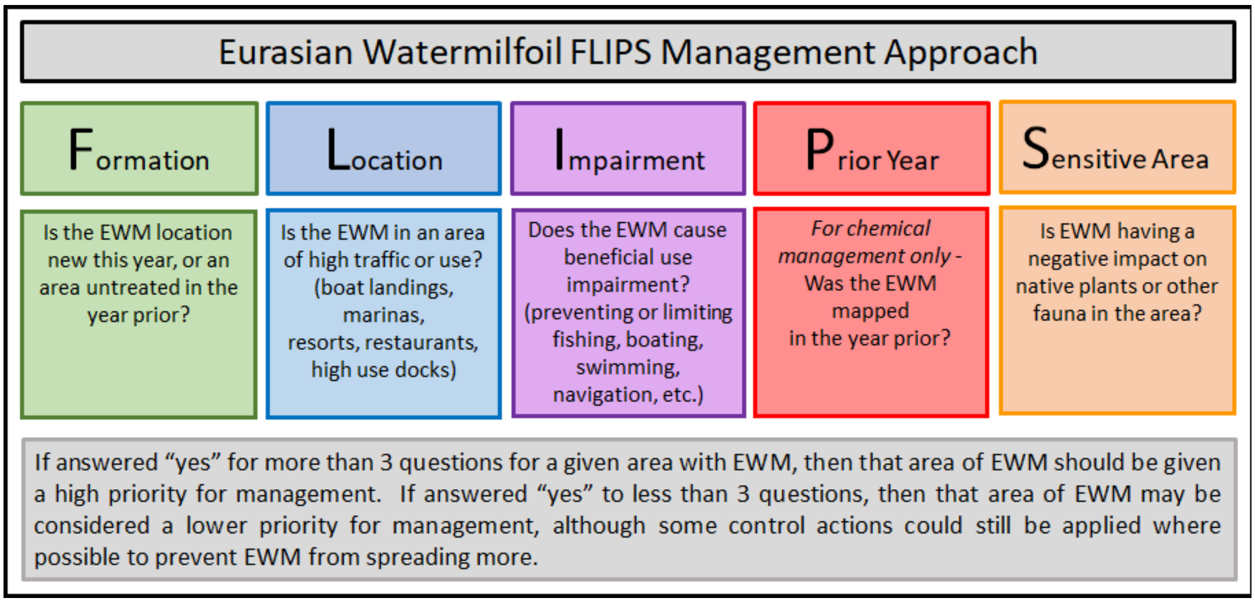


Figure 20: FLIPS Management Priority Matrix

A combination of manual/physical removal and chemical control methods are recommended for Horseshoe Lake. Mechanical harvesting, biological control (for EWM), habitat manipulation, and taking no management actions are not recommended at this time.

Any EWM discovered in the lake, even single plants, should be managed if possible. However, different methods should be employed. Figure 21 provides a framework to determine what EWM management actions should be implemented.

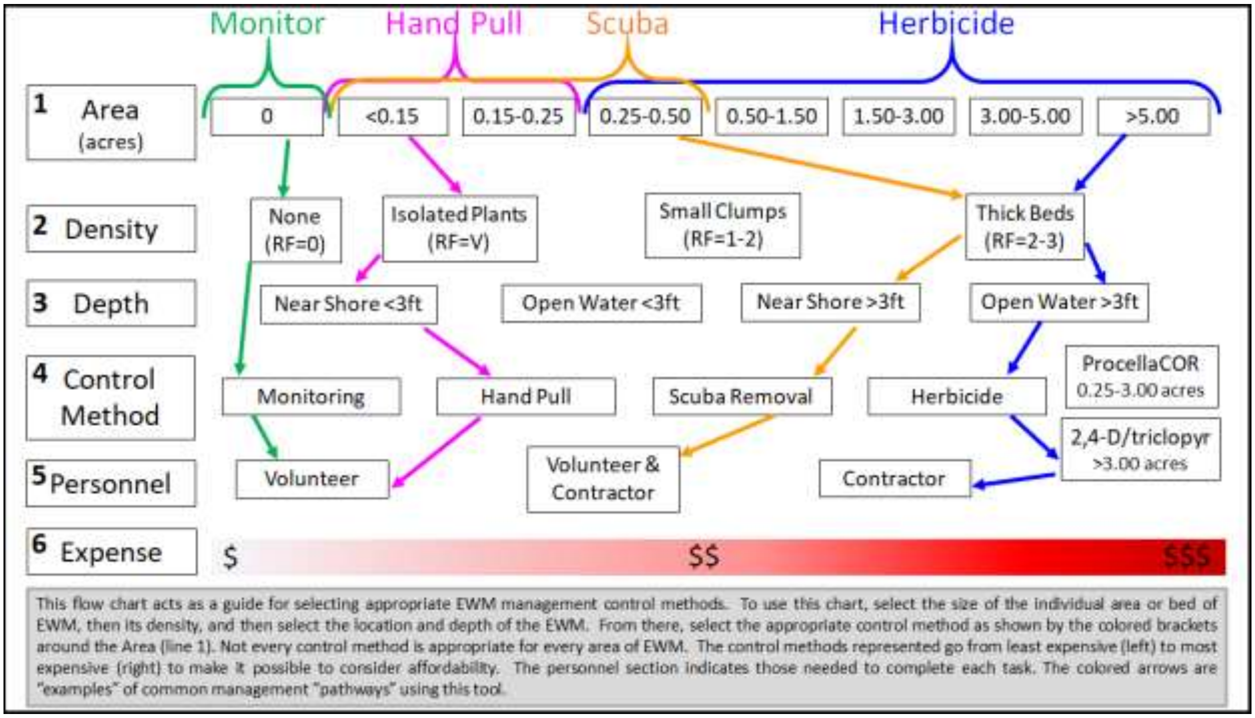


Figure 21: Management Planning Matrix

In general, EWM management in Horseshoe Lake will be based on the following criteria.

1) Late summer or fall EWM bedmapping will be completed every year.
2) Any amount of EWM in the lake can be managed at any time if chemical management is not used. Non-chemical management actions include hand pulling, rake removal, and snorkel/scuba diver removal, and/or DASH removal (still considered diver removal, but more expensive).
3) Chemical management of EWM may be implemented if prior year mapping identifies any area of EWM that is ≥0.25 acres.
    a. On EWM beds that are candidates for chemical treatment **AND** ≤3.0 acres, ProcellaCOR® should be used.
    b. On EWM beds >3.0 acres, ProcellaCOR, 2,4D-based, or triclopyr-based herbicides can be used based on the financial resources available.
4) Chemical management of EWM should not be completed on the same area in back to back years.

Concerns exist when herbicide treatments using the same herbicide are done over multiple and subsequent years. Target plant species may build up a tolerance to a given herbicide, making it less effective. Susceptible plant species may be damaged and/or disappear from the lake (ex. water lilies), issues with fish and other wildlife might occur, and concern over recreational use in chemically treated water may be voiced. By using several different aquatic herbicides interspersed with physical removal efforts between treatments, many of these concerns are minimized. Given the treatment history of Horseshoe Lake, small spot treatments are not likely to be causing great environmental harm. If there are any negative impacts to native plants in treated areas, plants would be available from other areas of the lake to re-colonize that location. It is also likely that an extensive seed bank of native plants throughout the lake would aide in the recovery of any area impacted by management actions.

Aquatic Plant Management Plan

This Aquatic Plant Management Plan establishes the following goals for aquatic plant management in Horseshoe Lake:

1. **EWM Management.** Limit the severity of the EWM infestation by monitoring for new infestations and managing current ones.

2. **Preservation, Protection, and Restoration.** Protect and restore the native plant species community in and around the lake to decrease susceptibility to the introduction of new aquatic invasive species.

3. **AIS Education, Prevention, and Planning.** Continue public outreach and education programs designed to give shoreline property owners the knowledge to participate in EWM management and planning in Horseshoe Lake.

4. **Adaptive Management.** Follow an adaptive management approach that measures and analyzes the effectiveness of control activities and modify the management plan as necessary to meet goals and objectives.

Goal 1. EWM Management

Despite years of treatment, EWM continues to be a nuisance 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 to provide relief for navigation impairment caused by EWM. EWM management options to be utilized include small-scale physical removal, diver removal and/or DASH, and targeted use of aquatic herbicides (see previous section). Other AIS will continue to be monitored for, but no specific management is recommended at this time.

Pre and Post Treatment Survey and/or Spring Management Readiness Surveys

Management of EWM will be based on pre-treatment surveys and post-treatment surveys or management readiness surveys performed by either trained HLPA volunteers or resource professionals retained by the HLPA. Pre and post-treatment surveys are point-intercept based. A pre-treatment survey is best completed in the year prior to the year of planned chemical management. Post-treatment surveys should be performed within the same year of treatment and in at least the year following treatment. If resources are available, they can be completed in more than just the year after treatment, particularly if it is expected that management impacts will last more than two years.

Management readiness surveys are visual and rake-based surveys completed prior to actual management in the same year only to determine if a given management area is ready to be treated. Ready is defined as having target plants present in sufficient quantity and growth to go through with the proposed chemical treatment. Proposed treatment areas may be modified based on the results of the readiness survey but still must follow restrictions in the WDNR-approved chemical application permit.

Pre and post treatment surveys are 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. Readiness surveys provide a quick check and balance on a proposed treatment proposal and are recommended in any year chemical treatment is to occur.

Fall Bed Mapping

Fall bed mapping or reconnaissance surveys are completed in the late summer or fall each year to help identify potential areas for management in the following year. These are visual and rake-based, meandering surveys of the lake's littoral zone. GPS tracking of individual plants, small clumps, and beds of EWM is completed. With the fall bed mapping survey data, proposed treatment maps can be created.

Goal 2. Preservation, Protection, and Restoration

Horseshoe Lake's sensitive and high-quality aquatic plant species may be vulnerable to lake-wide extinction. Because of their high importance to the ecosystem, preserving them is critical to maintaining a healthy lake. Motor start-ups in shallow water and the grounding of personal watercrafts can lead to the tearing of the underwater "turf" of native vegetation which can then float away and create obstacles for watercrafts. It also results in the release of nutrients from the lake bottom into the water column which promotes algal growth. These exposed bare patches of substrate also present EWM with an ideal place to establish. To prevent this, residents are encouraged to use lifts for their watercraft whenever possible, and try to avoid starting their motors in water less than 5ft in depth.

Currently, most shoreline property owners on the lake practice good shoreline management and maintain healthy connections to the lake. These management practices are strongly encouraged to continue as they protect the shoreline from erosion, provide habitat for a multitude of species, and help maintain Horseshoe's high water quality. Additionally, the current natural shoreline helps absorb excess nutrients and run off from the landscape which may be detrimental to the lake's highly sensitive species. These practices also may help to discourage new establishments of EWM because it prefers higher nutrient areas.

Such things as internal loading from sediments, failed septic systems, and lawn and field fertilizer runoff are common causes of excess nutrients in surface water. Educating lake residents about reducing nutrient input directly along the lake is one of the easiest ways to limit algal growth and maintain or even improve water clarity and quality. Not mowing down to the lakeshore, bagging grass clippings, and switching to a phosphorus-free fertilizer or eliminating fertilizer altogether would all be positive steps to this end. Wherever possible, restoring shorelines, building rain gardens, and establishing buffer strips of native vegetation would also enhance water clarity/quality by preventing erosion and runoff. Education events on these practices are encouraged in the future.

Goal 3. AIS Education, Prevention, and Planning

Aquatic invasive species (AIS) can be transported via a number of vectors, but most invasions are associated with human activity. It is recommended that that the HLPA continue Clean Boats Clean Waters watercraft inspection and maintain and update signage at the boat launch as necessary.

Early detection and rapid response efforts increase the likelihood that a new aquatic invasive species will be addressed successfully while the population is still localized and levels are not beyond that which can be contained and eradicated. Once an aquatic invasive species becomes widely established in a lake, complete eradication becomes extremely difficult, so attempting to partially mitigate negative impacts becomes the goal. The costs of early detection and rapid response efforts are typically far less than those of long-term invasive species management programs needed when an AIS becomes established.

It is recommended that the HLPA continue to implement a proactive and consistent AIS monitoring program. At least three times during the open water season, trained volunteers should patrol the shoreline and littoral zone looking for Eurasian watermilfoil (and other species like curly-leaf pondweed, purple loosestrife, Japanese knotweed, giant reed grass, zebra mussels). Free support for this kind of monitoring program is provided as part of the UW-Extension Lakes/WDNR Citizen Lake Monitoring Network (CLMN) AIS Monitoring Program. Any monitoring data collected should be recorded annually and submitted to the WDNR SWIMS database.

Providing education, outreach opportunities, and materials to the lake community will improve general knowledge and likely increase participation in lake protection and restoration activities. It is further recommended that the HLPA continue to cultivate an awareness of the problems associated with AIS and enough community knowledge about certain species to aid in detection, planning, and implementation of management alternatives within their lake community. It is also recommended that the HLPA continue to strive to foster greater understanding and appreciation of the entire aquatic ecosystem including the important role plants, animals, and people play in that system.

Understanding how their activities impact the aquatic plants and water quality of the lakes is crucial in fostering a responsible community of lakeshore property owners. To accomplish this, the HLPA should distribute, or re-distribute, informational materials and provide educational opportunities on aquatic invasive species and other factors that affect Horseshoe Lake. At least one annual activity (picnic at the lake, public workshop, guest speakers, etc.) should be sponsored and promoted by the HLPA that is focused on AIS. Maintaining signs, continuing aquatic invasive species monitoring, and active inspections of watercraft at the public launch should be done to educate lake users about what they can do to prevent the spread of AIS. Results of water quality monitoring should be shared with the lake community at the annual meeting, or another event, to promote a greater understanding of the lake ecosystem and potentially increase participation in planning and management.

Goal 4. Adaptive Management

This APM Plan is a working document guiding management actions on Horseshoe Lake for the next five years. This plan will follow an adaptive management approach by adjusting actions as the results of management and data obtained deem fit. This plan is therefore a living document progressively evolving and improving to meet environmental, social, and economic goals, to increase scientific knowledge, and to foster good relations among stakeholders. Annual and end-of-project assessment reports are necessary to monitor progress and justify changes to the management strategy, with or without state grant funding. Project reporting will meet the requirements of all stakeholders, gain proper approval, allow for timely reimbursement of expenses, and provide the appropriate data for continued management success. Success will be measured by the efficiency and ease in which these actions are completed.

The HLPA and their retainers will compile, analyze, and summarize management operations, public education efforts, and other pertinent data into an annual report each year. The information will be presented to members of the HLPA, Washburn County, and the WDNR and made available in hardcopy and digital format on the internet. These reports will serve as a vehicle to propose future management recommendations and will therefore be completed prior to implementing following year management actions (approximately March 31st annually). At the end of this five-year project, all management efforts (including successes and failures) and related activities will be summarized in a report to be used for revising the Aquatic Plant Management Plan.

Public Participation and Input

The Horseshoe Lake Property Association was formed in 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 are the primary topic of discussion. Through these media outlets, the HLPA provides information, and solicits public input. Throughout this planning project, input from members of the HLPA and general lake use community has been sought. Input from the HLPA and general public was sought and incorporated into this plan.

Timeline of Activities

The activities in this APM Plan are designed to be implemented over a 5-year period beginning in 2022. The plan is intended to be flexible to accommodate future changes in the needs of the lake and its watershed, as well as those of the HLPA. Some activities in the timeline are eligible for grant support to complete.

Potential Funding

There are several WDNR grant programs that may be able to assist the HLPA in implementing its new APM Plan. AIS grants are specific to actions that involve education, prevention, planning, and in some cases, implementation of AIS management actions. Lake Management Planning grants can be used to support a broad range of management planning and education actions. Lake Protection grants can be used to help implement approved management actions that would help to improve water quality.

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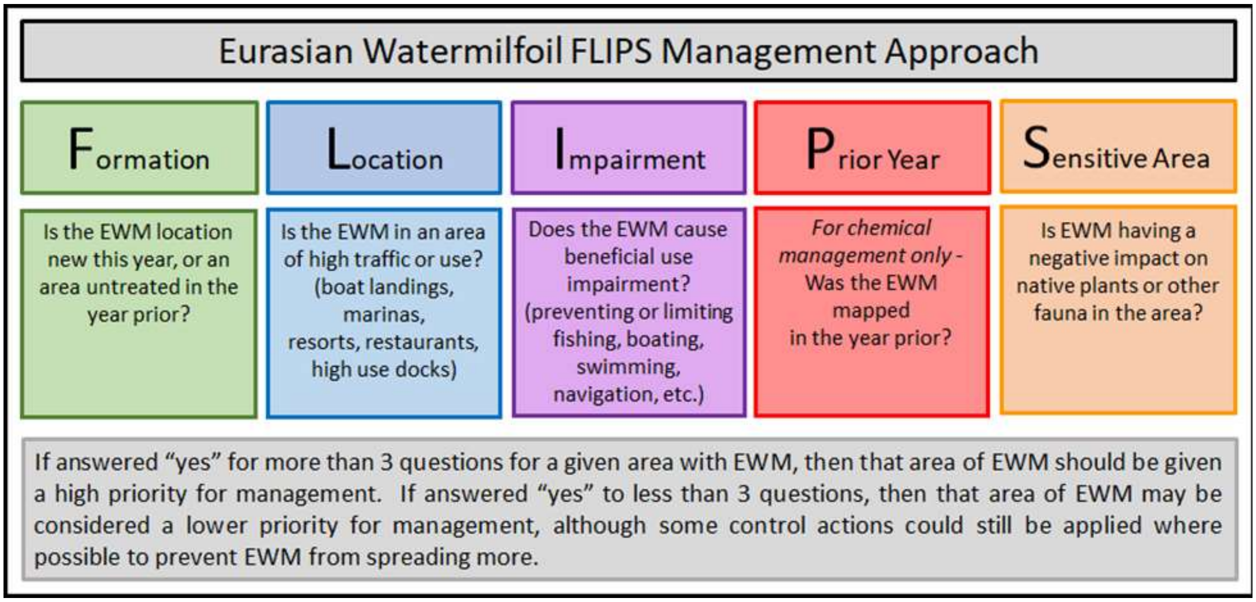
Implementation Schedule

5-year Timeline of Recommended Actions in the 2022-26 Horseshoe Lake Aquatic Plant Management Plan									
Goal	**Objective**	**Recommendation**	**Grant Eligible**	**Facilitator**	**2022**	**2023**	**2024**	**2025**	**2026**
Native Species Preservation, Protection, and Restoration	Restoration of the shoreland	Education and information material	yes	HLPA, Consultant, WDNR, Outside Resources	x	x	x	x	x
		Professional site planning services	yes		x	x	x	x	x
		Sponsor training sessions	yes		x	x	x	x	x
		Riparian owner recognition	yes		x	x	x	x	x
	Protect native habitat	Habitat evaluation/sensitive area survey	yes	HLPA, Consultant, WDNR	x	x			
		Protect and/or improve native habitat	yes		x	x	x	x	x
		Plant management that minimizes disturbance	yes		x	x	x	x	x
Prevention	Monitor for AIS	In-lake and shoreline AIS monitoring program (CLMN)	yes	HLPA, WDNR, UWEX	x	x	x	x	x
		Follow AIS Rapid Response Plan	yes		x	x	x	x	x
		Train landowners to monitor for AIS	yes		x	x	x	x	x
	Record all monitoring data	Submit CLMN data to SWIMS	yes	HLPA	x	x	x	x	x
Management	Annual plant management planning	Contract with Resource Professional for planning services	yes	HLPA, Consultant	x	x	x	x	x
	Manual removal	Encourage manual removal	no	HLPA, Consultant	x	x	x	x	x
		Provide weed rakes or razors for use by landowners	no	HLPA	x	x	x	x	x
		Evaluate larger manual removal project for harvesting	no	HLPA, Consultant	x	x	x	x	x
	Chemical treatment	Control and limit spread of EWM	yes	HLPA, Consultant	x	x	x	x	x
Education and Awareness	Public particpartion and communication program	Annual newsletter	yes	HLPA	x	x	x	x	x
		Annual public event planning and implementation	yes		x	x	x	x	x
		Webpage	yes		x	x	x	x	x
	Promote wildlife monitoring programs	Education materials	yes	HLPA, UWEX, CBM	x	x	x	x	x
	Promote riparian owner participation in nutrient runoff best management practices	Education materials	yes	HLPA, Washburn Co, WDNR	x	x	x	x	x
Research and Monitoring	CLMN expanded monitoring at the Deep Hole	Secchi, Temp, DO, TP, CHL	no	HLPA, Consultant, CLMN	x	x	x	x	x
		October sampling for TP and CHL	yes		x	x	x	x	x
		DO and temperature profiling year round	yes		x	x	x	x	x
	Complete a Comprehensive Lake Management Plan	Contract with a Resource Professional to develop plan	yes	HLPA, Consultant, WDNR		x	x		
Adaptive Management	Annual Project Activity and Assessment Reports	Annual plant management planning	yes	HLPA, Consultant	x	x	x	x	x
		Document sharing	yes		x	x	x	x	x
	End-of-project Summary Report	Overall review of project successes and failures	yes	HLPA, Consultant					x
		Revise/rewrite APM Plan	yes						x
		Whole-lake PI survey	yes						x
		Provide for document sharing	yes						x
HLPA-Horseshoe Lake Property Association; WDNR, Wisconsin Department of Natural Resources; UWEX, University of Wisconsin Extension; CLMN, Citizen Lake Monitoring Network; CBM, Citizen-based Monitoring Network									

2022 Horseshoe Lake, Washburn County Preliminary EWM ProcellaCOR Treatment Proposal 11/5/2021

2022 Horseshoe Lake, Washburn County Preliminary EWM ProcellaCOR Treatment Plan 11-5-2021 (LEAPS)								
Treatment Location	**Acre**	**Mean Depth**	**Acre-feet**	**PDU Rate**	**PDU / Site**	**Fl OZ/Site**	**Parts-per-billion**	**Part-per-million**
Narrows-N	0.65	5.5	3.58	4	14.3	45.3	7.7	0.0077
Narrows-S	0.79	5.5	4.345	4	17.4	55.1	7.7	0.0077
Totals	**1.44**		**7.92**		**31.7**	**100.4**		
ProcellaCOR	PDU = 3.17 oz			fl. Ounces	gallons			
	# of PDU	31.7		100.4	0.78			
	Cost/PDU	$70.00						
	Total Cost	$2,217.60						

<u>Using the Management Planning Guide in the APM Plan to Determine Management Actions in 2022</u>



F – Yes The two areas of EWM are not new, but they have never been chemically treated before.

L – Yes The two areas are in a main navigation area that goes between the two basins of the lake.

I – No The two areas are probably not causes significant impairment.

P – Yes The areas have been mapped in the past.

S – No At the current level of EWM in these areas, it is probably not negatively impacting native vegetation.

Management Guidance Pathway

Level 1 – 0.5-1.5 acres

Level 2 – Small Clumps

Level 3 – Open water >3.0ft

Level 4 – Herbicide – ProcellaCOR (0.25-3.0 acres)

Level 5 – Contracted

Level 6 – More expensive than diver removal.