2023-2027 AQUATIC PLANT MANAGEMENT PLAN

Lower Vermillion Lake

Vermillion Lakes Association

October 2022

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Acknowledgements:

Members of the Vermillion Lakes Association who contributed to discussions and recommendations presented in this plan.

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Executive Summary

Lower Vermillion Lake is home to many species of birds, game fish, and a diverse aquatic plant community. Unfortunately, invasive Eurasian watermilfoil *Myriophyllum spicatum* (EWM) has become established in the lake, threatening its biodiversity, recreation, and overall health. As such, management of EWM is necessary to protect this valuable resource and maintain its status as a high-quality waterbody. An integrated management approach that relies on a combination of manual and chemical control methods is recommended to continue for Lower Vermillion Lake.

The general public and the Vermillion Lakes Association (VLA) take an active role in managing the Vermillion Lakes while protecting environmental integrity and recreational opportunities. The group makes it a priority to manage both Upper and Lower Vermillion Lakes in a manner that supports shoreland and watershed restoration, as well as water quality and habitat improvement. This plan is specific to Lower Vermillion Lake so that the VLA, assisted by their consultant and guided by the Wisconsin Department of Natural Resources, can make management decisions regarding EWM and the overall aquatic plant community while prioritizing the lake's ecological integrity. Therefore, the primary goal of this plan is to protect and improve Lower Vermillion Lake's ecosystem and native plant community for the benefit of all lake users through management efforts to control EWM.

This goal will be accomplished through the following objectives:

1. **EWM Management.** Limit the spread of EWM and its impacts on the native aquatic plant community and lake use through environmentally responsible management methods.

2. **CLP Management.** Limit the spread of CLP and its impacts on the native aquatic plant community and lake use through environmentally responsible management methods.

3. **Education and Awareness.** Continue to educate property owners and lake users on aquatic invasive species through public outreach and education programs to help contain EWM within the lake and prevent its spread further in the lake, as well as to other water bodies.

4. **Research and Monitoring.** Develop a better understanding of the lake and the factors affecting lake water quality through continued and expanded monitoring efforts.

5. **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.

Aquatic Plant Management (APM) Strategy

We recommend the continuation of a combination of chemical and manual control methods to curb the spread of EWM in Lower Vermillion Lake and prevent it from dominating the lake. The overall goal of this Aquatic Plant Management (APM) Plan 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 VLA. This plan is intended to be a living document that will be evaluated annually to determine if it is meeting stated goals and community expectations, and can it be revised if necessary. The VLA sponsored the development of this APM Plan aided by a WDNR Surface Water Planning grant.

APM plans developed for northern Wisconsin lakes are evaluated according to Northern Region APM Strategy goals developed by the WDNR (Appendix A). APM plans and the associated management permits (chemical or harvesting) are reviewed by the WDNR. 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 VLA in conjunction with the current state of the lake formed the framework for the development of this APM Plan. This plan is designed to be implemented over the course of 5 years with goals and objectives to be met throughout that time frame.

Public Input into the Development of this APM Plan

A completed draft of this APM Plan was sent to the President of the VLA and posted on the LEAPS Client webpage on June 27, 2022. The APM Plan was then sent to all the constituents on the lake via email with instructions given for at least a 21 day review and comment period. Upon completion of that review, updates were made to the APM Plan resulting in a final draft sent to the WDNR in late July 2022 with a request for review and approval of management actions and approval for eligibility for WDNR Surface Water grants to support planning, implementation, and evaluation of the actions in the APM Plan.

Prior to the completed draft being sent to the Constituency, several meetings were held over the last 18 months where the development of the APM Plan, plant survey results, proposals for EWM management, and constituent input was solicited as it relates to the APM Plan.

Lake Information

Background

Lower Vermillion Lake (WBIC: 2098200) is a deep lowland, hard water drainage lake located on the headwaters of the Vermillion River in Barron County near Cumberland, Wisconsin (Figure 1). The lake has a surface area of approximately 215 acres, a maximum depth of 55 feet, and a average depth of 24 feet. Water quality data collected citizen volunteers has determined that Lower Vermillion Lake is mesotrophic with moderately clear water. Aquatic vegetation is abundant, supporting a fishery of northern pike, walleye, largemouth bass, and panfish.

Upper Vermillion Lake is situated just upstream, northeast of Lower Vermillion Lake. The two lakes are connected by the Vermillion River that flows from the southern bay of Upper Vermillion into the north side of the east side of the lake (Figure 1). The river then flows through Lower Vermillion and out of its most southern bay (Figure 1). Lower Vermillion can be accessed by a public boat launch on the northwest end of the lake on 9th Street (Figure 1). Citizen volunteers monitor the water quality of the lake at the Deep Hole sampling station (Station ID: 033185) in the middle of the northern end of the lake (Figure 1).

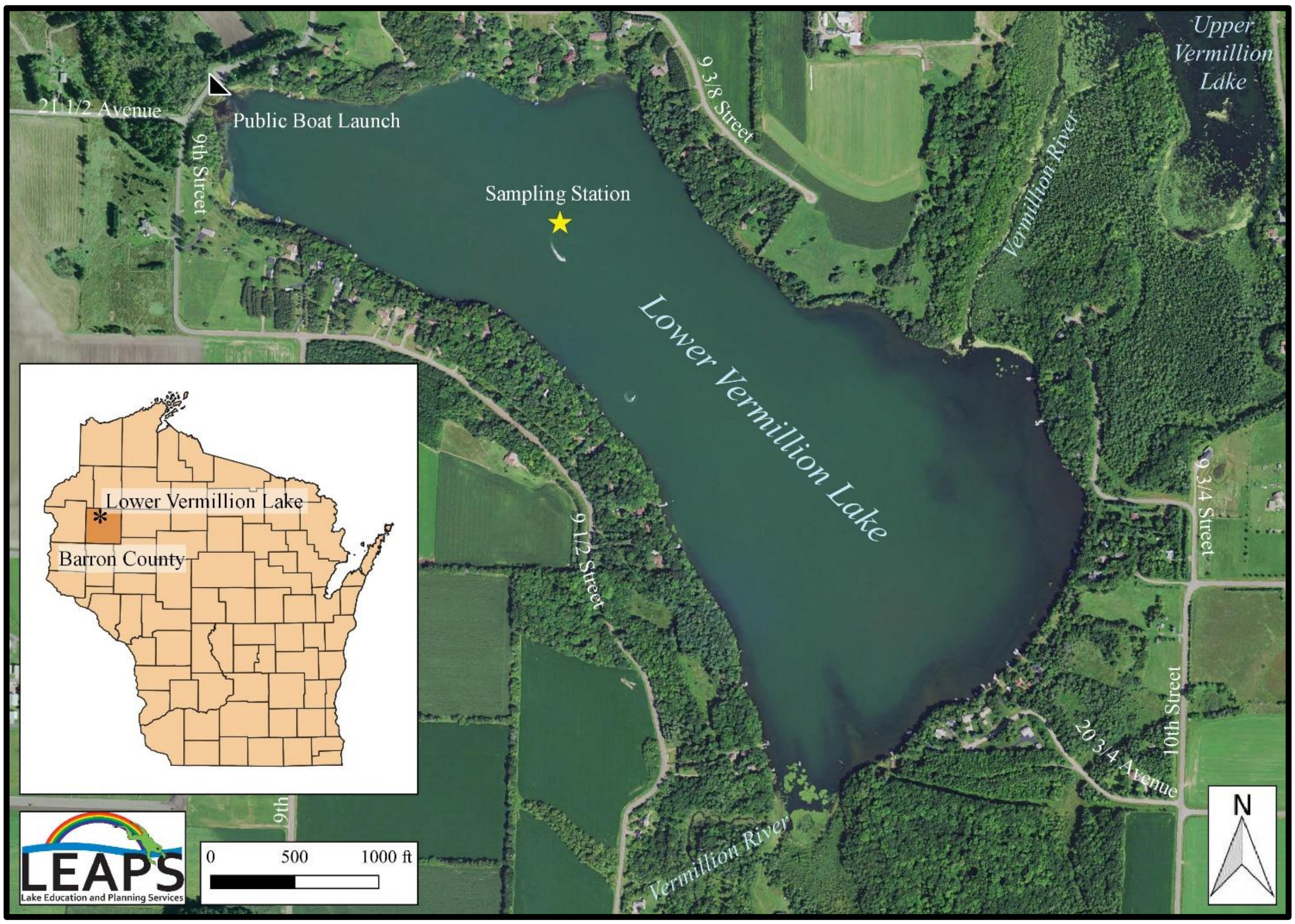

Figure 1. Location of Lower Vermillion Lake, Barron County, Wisconsin

The lake's central basin is a deep bowl with steep north/south sides that drop sharply into 50+ft of water mid-lake, while the northwest bay near the boat landing/creek inlet slopes more gradually from west to east into the main basin. On the lake's east side, the expansive crescent-shaped bay, where the Vermillion River both enters and exits the lake, slopes gradually but steadily from the southeast to the northwest into the main basin. The two additional small bays on the north/northwest side of the lake offer limited shallow habitat as they quickly slope into deep water (Figure 2). The bottom material in the littoral zone is a fairly even split of rock, sand, and muck (Figure 2). Thick nutrient-rich organic muck covers the northwest bay near the boat landing and in the river inlet and outlet, while sand and sandy muck dominated the rest of the eastern bay. The majority of the gravel and cobble substrates occurred along the north and south shorelines where wave action and steep drop-offs appeared to be keeping the bottom free of fine sediment.

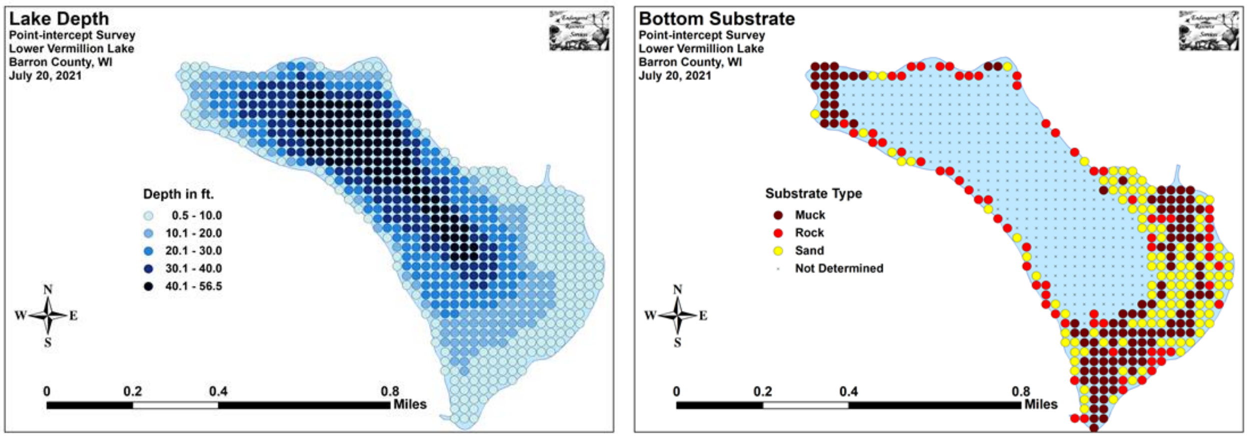

Figure 2. 2021 Lower Vermillion Lake depth and bottom substrate (Berg, 2021)

Public Use

Lower Vermillion Lake is used for a wide range of recreational activities, including:

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

These activities in Lower Vermillion Lake can all be hindered by EWM. Additionally, Lower Vermillion 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.

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. Lower Vermillion Lake is part of the Vermillion River watershed (25,891 acres), which is part of the larger Yellow River Watershed (118,943 acres) that makes up a portion of the Lower Chippewa River Basin. The Yellow River Watershed is largely agricultural (51.3%) with some forested areas (31.4%) and several large wetland complexes (9.0%; Figure 3). Development (6.1%) is mostly concentrated around the small city of Barron. The Vermillion Lakes are located near the headwaters of the Vermillion River, which is primarily agricultural (64.0%) with some forest cover (21.8%) and smaller amounts of wetlands and development (6.4% and 5.8%, respectively; Figure 4). Most of the agriculture at both watershed scales is located below the Vermillion Lakes, although the lakes likely receive runoff directly from agricultural areas (Figure 3; Figure 4). Within 300 feet of the lake is mostly forest with a low amount of development and some agricultural fields (Figure 5).

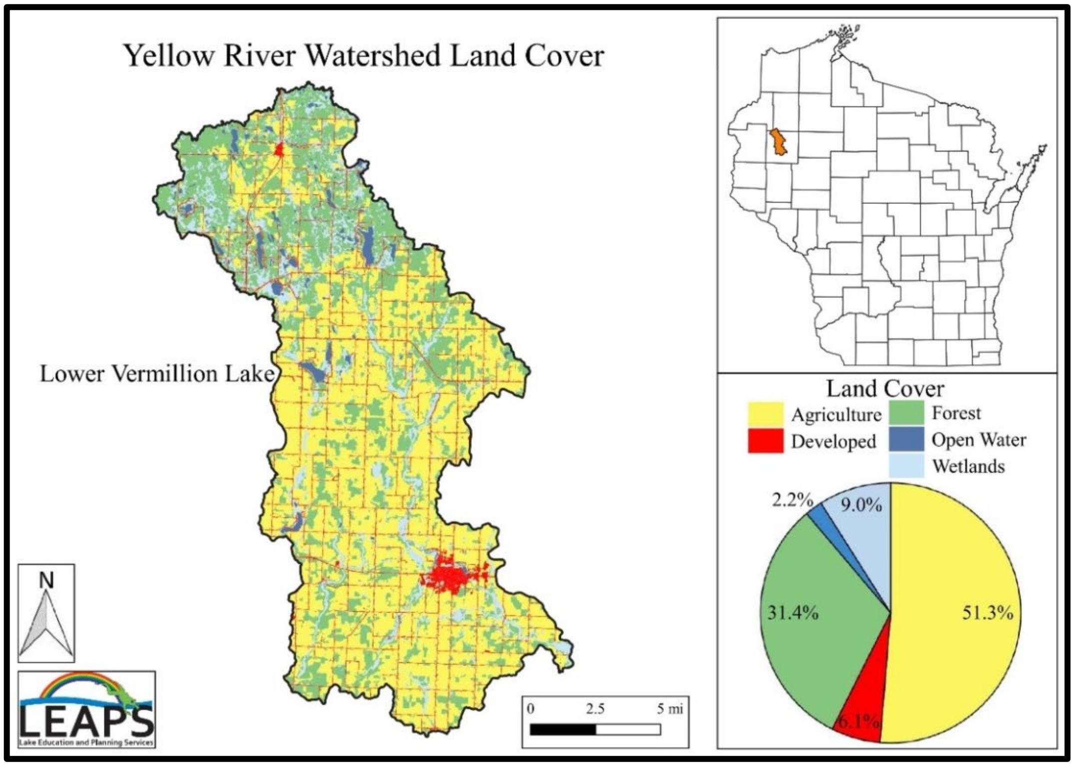

Figure 3. Yellow River Watershed land cover (NLCD, 2019)

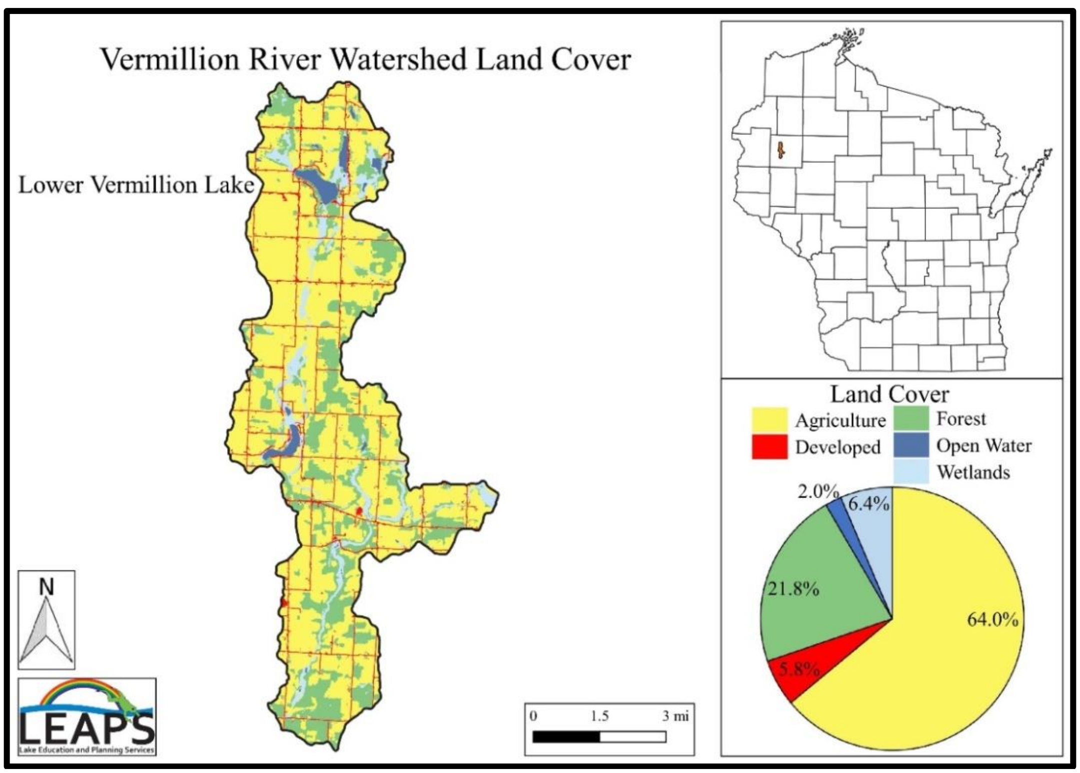

Figure 4. Vermillion River Watershed land cover (NLCD, 2019)

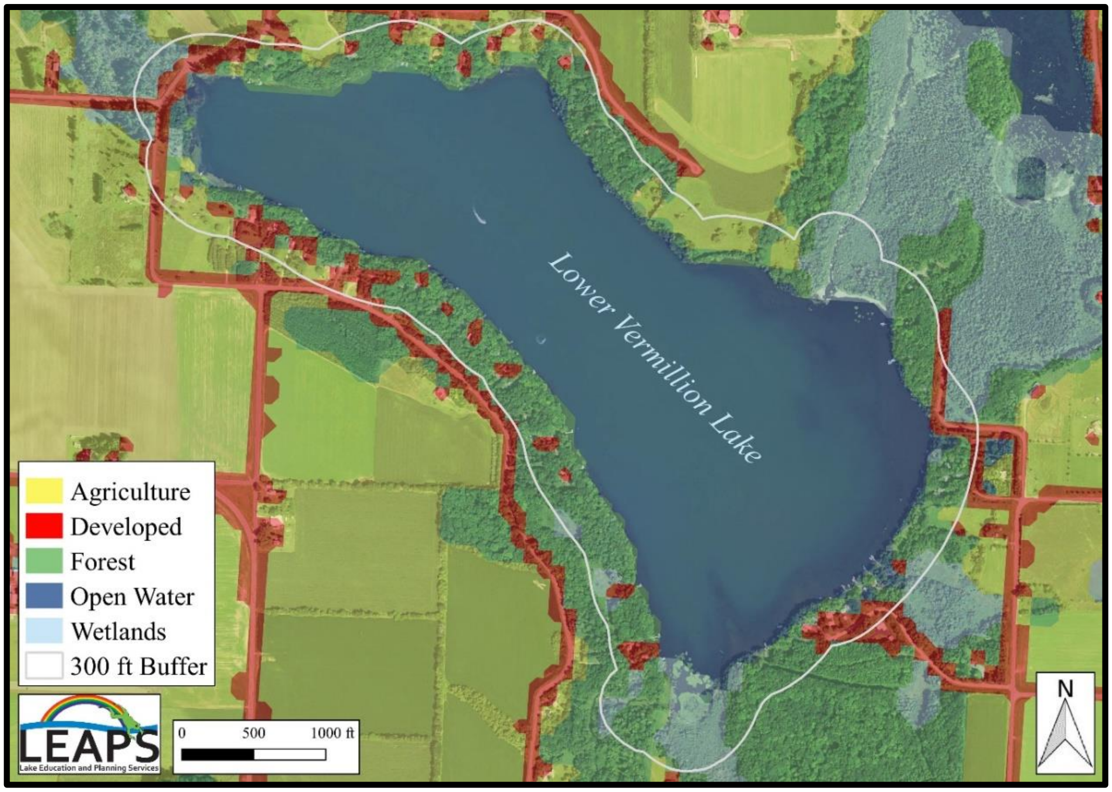

Figure 5. Land cover around Lower Vermillion Lake (NLCD, 2019)

Wetlands

A wetland is 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. Wetlands have many functions which benefit the ecosystem surrounding Lower Vermillion Lake. Wetlands with a higher floral diversity of native species support a greater 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.

Wetlands also provide flood protection within the landscape. Due to the dense vegetation and location within the landscape, wetlands are important for retaining stormwater from rain and melting snow moving towards surface waters and retaining floodwater from rising streams. This flood protection minimizes impacts to downstream areas. Wetlands provide water quality protection because wetland plants and soils have the capacity to store and filter pollutants ranging from pesticides to animal wastes.

Wetlands also provide shoreline protection to Lower Vermillion Lake because shoreline wetlands act as buffers between land and water. They protect against erosion by absorbing the force of waves and currents and by anchoring sediments. This shoreline protection is important in waterways where boat traffic, water current, and wave action cause substantial damage to the shore. Wetlands also 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. Aesthetics, recreation, education and science are also all services wetlands provide. Wetlands contain a unique combination of terrestrial and aquatic life and physical and chemical processes.

While there are not a lot of wetlands in the Lower Vermillion Lake watershed, those that do exist are located in strategic areas and help protect the water quality of Lower Vermillion Lake. A large wetland complex along the west shore reduces the amount of runoff directly into the lake from one of the two tributaries. There is another large wetland complex that lines the river that connects Upper and Lower Vermillion Lakes (Figure 6). This area helps filter water that comes into Lower Vermillion from Upper Vermillion.

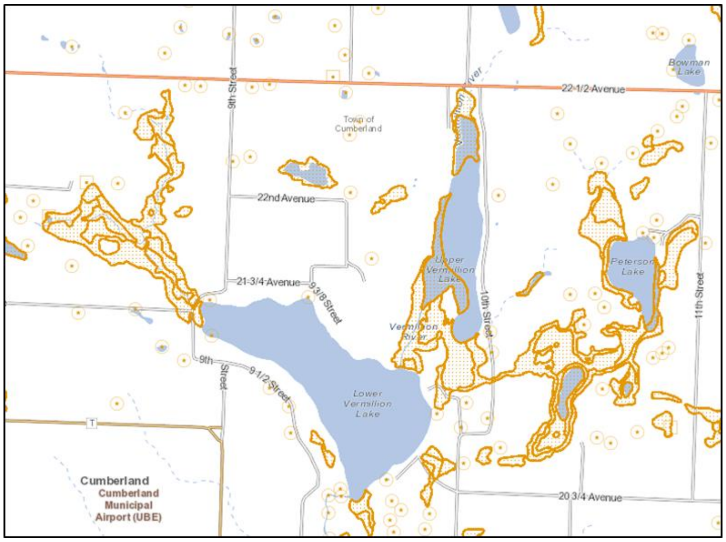

Figure 6. Vermillion Lakes Wetlands (Wisc. Wetlands Inventory January 11, 2017)

Soils

Soils are classified into four main hydrologic soil groups (A, B, C, and D) to indicate their potential for producing runoff based off of the rate of infiltration. Group A soils have a high infiltration rate which makes the potential amount of runoff very low. These soils are, generally very sandy and allow water to pass through unimpeded. Conversely, group D soils have a very low infiltration rate making their runoff potential fairly high. Group D soils are generally very dense with high amounts of organic material. This causes water to move slowly through group D soils often resulting in standing water on flat surfaces and flowing water over sloped surfaces. Group D soils are generally found within wetland areas, but they can be problematic in areas that lack the hydrophytic vegetation found within those areas.

There are also three sub groups (A/D, B/D, and C/D) these indicated the infiltration rate of the soils with respect to the water table. If the water table is high and blocking infiltration, these soils are considered to have a high runoff potential and placed into group D, but when the water table is lower, these soils are similar to the first grouping (A, B, or C). Most of the soils, 85.2%, within the Upper Vermillion Lake watershed fall into either group A or B (Table 1) (NRCSa, 2017). These soils have a high to moderate infiltration rate, so they have a fairly low runoff potential.

Table 1. Hydrologic soil profile of Lower Vermillion Lake watershed

Soil Group	Percentage of Watershed	Infiltration Rate
A	10.2	High
B	75	Moderate
C	1	Slow
D	0	Very Slow
A/D	5.7	High when drained Very slow when undrained
B/D	2.1	Moderate when drained. Very slow when undrained
C/D	0	Slow when drained. Very slow when undrained
Water	6	N/A

Shoreland Land Cover and Use

How the shoreline of a lake is managed can have big impacts on the water quality and health of that lake. Natural shorelines prevent polluted runoff from entering lakes, help control flooding and erosion, provide fish and wildlife habitat, may make it harder for AIS to establish themselves, muffle noise from watercraft, and preserve privacy and natural scenic beauty. Many of the values lake front property owners appreciate and enjoy about their properties - natural scenic beauty, tranquility, privacy, relaxation - are enhanced and preserved with good shoreland management. And healthy lakes with good water quality translate into healthy lake front property values.

Shorelands may look peaceful, but they are actually the hotbed of activity on a lake. At least 90% of all living things found in lakes - from fish, to frogs, turtles, insects, birds, and other wildlife - are found along the shallow margins and shores. Many species rely on shorelands for all or part of their life cycles as a source for food, a place to sleep, cover from predators, and to raise their young. Shorelands and shallows are the spawning grounds for fish, nesting sites for birds, and where turtles lay their eggs. There can be as much as 500% more species diversity at the water's edge compared to adjoining uplands.

Lakes are buffered by shorelands that extend into and away from the lake. These shoreland buffers include shallow waters with submerged plants (like coontail and pondweeds), the water's edge where fallen trees and emergent plants like rushes might be found, and upward onto the land where different layers of plants (low ground cover, shrubs, trees) may lead to the lake. A lake's littoral zone is a term used to describe the shallow water area where aquatic plants can grow because sunlight can penetrate to the lake bottom. Shallow lakes might be composed entirely of a littoral zone. In deeper lakes, plants are limited where they can grow by how deeply light can penetrate the water.

Shorelands are critical to a lake’s health. Activities such replacing natural vegetation with lawns, clearing brush and trees, importing sand to make artificial beaches, and installing structures such as piers, can cause water quality decline and change what species can survive in the lake.

Protecting Water Quality

Shoreland buffers slow down rain and snow melt (runoff). Runoff can add nutrients, sediments, and other pollutants into lakes, causing water quality declines. Slowing down runoff will help water soak (infiltrate) into the ground. Water that soaks into the ground is less likely to damage lake quality and recharges groundwater that supplies water to many of Wisconsin's lakes. Slowing down runoff water also reduces flooding, and stabilizes stream flows and lake levels.

Shoreland wetlands act like natural sponges trapping nutrients where nutrient-rich wetland sediments and soils support insects, frogs, and other small animals eaten by fish and wildlife.

Shoreland forests act as filters, retainers, and suppliers of nutrients and organic material to lakes. The tree canopy, young trees, shrubs, and forest understory all intercept precipitation, slowing runoff, and contributing to water infiltration by keeping the soil's organic surface layer well-aerated and moist. Forests also slow down water flowing overland, often capturing its sediment load before it can enter a lake or stream. In watersheds with a significant proportion of forest cover, the erosive force of spring snow melts is reduced as snow in forests melts later than snow on open land, and melt water flowing into streams is more evenly distributed. Shoreland trees grow, mature, and eventually fall into lakes where they protect shorelines from erosion, and are an important source of nutrients, minerals and wildlife habitat.

Natural Shorelands Role in Preventing AIS

In addition to removing essential habitat for fish and wildlife, clearing native plants from shorelines and shallow waters can open up opportunities for invasive species to take over. Like tilling a home garden to prepare it for seeding, clearing shoreland plants exposes bare earth and removes the existing competition (the cleared shoreland plants) from the area. Nature fills a vacuum. While the same native shoreland plants may recover and reclaim their old space, many invasive species possess "weedy" traits that enable them to quickly take advantage of new territory and out-compete natives.

The act of weeding creates continual disturbance, which in turn benefits plants that behave like weeds. The modern day practice of mowing lawns is an example of keeping an ecosystem in a constant state of disturbance to the benefit of invasive species like turf grass, dandelions, and clover, all native to Europe. Keeping shoreline intact is a good way to minimize disturbance and minimize opportunities for invasive species to gain a foothold.

Threats to Shorelands

When a landowner develops a waterfront lot, many changes may take place including the addition of driveways, houses, decks, garages, sheds, piers, rafts and other structures, wells, septic systems, lawns, sandy beaches and more. Many of these changes result in the compaction of soil and the removal of trees and native plants, as well as the addition of impervious (hard) surfaces, all of which alter the path that precipitation takes to the water.

Building too close to the water, removing shoreland plants, and covering too much of a lake shore lot with hard surfaces (such as roofs and driveways) can harm important habitat for fish and wildlife, send more nutrient and sediment runoff into the lake, and cause water quality decline.

Changing one waterfront lot in this fashion may not result in a measurable change in the quality of the lake or stream. But cumulative effects when several or many lots are developed in a similar way can be enormous. A lake’s response to stress depends on what condition the system is in to begin with, but bit by bit, the cumulative effects of tens of thousands of waterfront property owners "cleaning up" their shorelines, are destroying the shorelands that protect their lakes. Increasing shoreline development and development throughout the lake's watershed can have undesired cumulative effects.

Shoreland Preservation and Restoration

If a native buffer of shoreland plants exists on a given property, it can be preserved and care taken to minimize impacts when future lake property projects are contemplated. If a shoreline has been altered, it can be restored. Shoreline restoration involves recreating buffer zones of natural plants and trees. Not only do quality wild shorelines create higher property values, but they bring many other values too. Some of these are aesthetic in nature, while others are essential to a healthy ecosystem. Healthy shorelines mean healthy fish populations, varied plant life, and the existence of the insects, invertebrates and amphibians which feed fish, birds and other creatures. Figure 7 shows the difference between a natural and unnatural shoreline adjacent to a lake home.

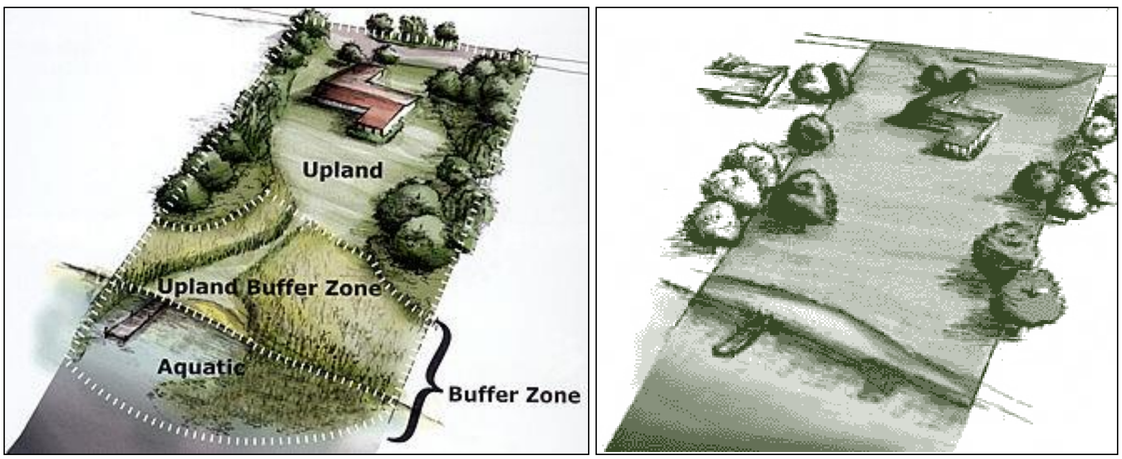

Figure 7. Healthy, AIS Resistant Shoreland (left) vs. Shoreland in Poor Condition

Much of the shoreline of Lower Vermillion Lake is natural however where development is greater, improvements to the shoreline would help maintain water quality in the lake. Turf grass, mowed lawns to the edge of the lake, exposed earth, and rip rap increase the amount of runoff from roof tops, driveways, lawns and pathways to the lake. The WDNR encourages the installation of relatively simple best management practices including rain gardens, native plantings, and runoff diversion projects through its Healthy Lakes Initiative. VLA could sponsor some of these projects for individual property owners who are interested in improving their shorelines.[1]

2016 Shoreland Habitat Assessment

As a part of the 2016-17 lake management planning project, a shoreland habitat assessment was completed on Lower Vermillion Lake. During the assessment each property was given a priority ranking in terms of the projects that could be done and the benefits to the lake they could provide. The priority rankings that accompany each parcel evaluation were developed based on the parameters that were most prevalent on the lake. They help to determine the needs of the lake, and the individual properties assessed. Each parameter was given a priority value, and those values were summed for each property.

The maximum possible score for Lower Vermillion Lake was 11 points, but the highest scoring parcel only scored 8 points. From here, four levels of concern were established: green, pale green, yellow, and white.

[1] For more information about the Wisconsin Healthy Lakes and Rivers Initiative go to: https://healthylakeswi.com/

These colors correspond to the ability of each property to support best management practices (BMPs) that could reduce the negative impacts of the property to the lake. Green properties have potential for several BMPs, pale green properties could be improved by implementing one or more BMPs, yellow properties may have potential to implement BMPs but are generally already in a condition that helps protect the lake, and white properties generally have little in the way of BMPs that could be implemented to protect the lake. Table 2 summarizes the survey results for the entire lake.

Table 2: Score ranges and priority rankings for the 93 parcels surrounding Lower Vermillion Lake

Color	Overall Score	Priority	Number of Parcels
Green	7-8 Points	High	7
Pale Green	4-6 Points	Moderate	12
Yellow	2-3 Points	Low	10
White	0-1 Points	No Concern	64

A document was provided to the VLA that included all of the parcel evaluations. Each individual parcel evaluation includes numbers used to determine its overall priority, a photograph of the parcel, and management recommendations.

Generally speaking, the high and moderate priorities would do well with rain gardens, rock infiltration systems, native plantings, and/or runoff diversions. The projects suggested come primarily from the WDNR's Healthy Lakes Initiative which means most of them are eligible for grant funding through the WDNR. Since this survey was completed, few projects to improve shoreland habitat and its ability to reduce runoff have been implemented.

Trophic State

Trophic state and water quality are often used synonymously; however, they are not the same. Trophic state describes the biological condition of a lake using a scale that is based on water clarity, total phosphorus, and chlorophyll-*a* (Carlson, 1977). Water quality is typically based on a perception of the lake, which may be subjective for different lake users. People who use the lake for primarily swimming usually classify lakes with clear water as having better water quality while the same lake might be classified as having poor water quality by a fisherman because the low productivity limits fish growth.

By combining data for water clarity, phosphorus, and chlorophyll-*a* in Lower Vermillion Lake, the trophic state as defined by Carlson's Trophic Status Index (1977) is able to be determined (Figure 8). Eutrophic lakes typically have large amounts of aquatic plant growth, higher nutrient concentrations, low water clarity due to algae blooms, and oxygen-depleted bottom waters. On the other end of the spectrum, oligotrophic lakes are nutrient-poor, have clear and cold water, and oxygen throughout the water column continually. Mesotrophic lakes fall in the middle and have intermediate nutrient levels, occasional algal blooms, and may experience bottom water oxygen depletion in the summer (Red circles in Figure 9 represent Lower Vermillion Lake ranges).

The specific measurements of water quality and trophic status in Lower Vermillion Lake have fluctuated over time. Secchi depth (a measure of water clarity) in Lower Vermillion is available from 2000-2021 (excluding 2004-2012; Table 3). Secchi depths ranged from 3.8 to 15.0 feet with an overall average of 8.8 feet, which classifies Lower Vermillion as a mesotrophic system (Table 3; Figure 9; Figure 10). Chlorophyll-*a* in those same years ranged from 0.6 to 31.6 µg/L, averaging 9.2 µg/L (trophic state value 49), which classifies Lower Vermillion as eutrophic (Figure 8; Figure 9). Total phosphorus has ranged from 14.0 µg/L to 48.9 µg/L and averaged 27.3 µg/L, which also classifies the lake as eutrophic.[2]

Lower Vermillion Lake was placed on the Wisconsin 303d Impaired Water List in 2022 because phosphorus and chlorophyll levels were both above listing thresholds as outlined in 2022 WisCALM.[3]

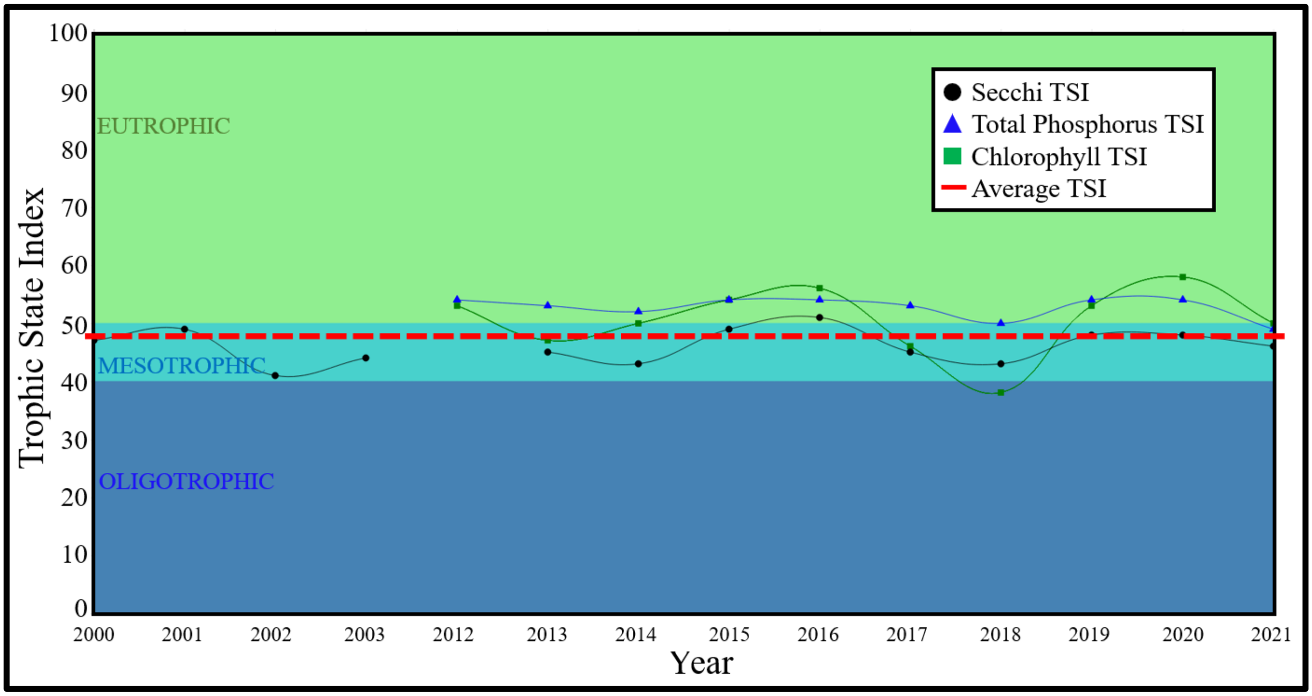

Figure 8. Vermillion Lake trophic status index data (WDNR)

[2] More information can be found at: https://dnr.wi.gov/lakes/waterquality/Station.aspx?id=033185.
[3] More information can be found at https://dnr.wisconsin.gov/topic/SurfaceWater/WisCALM.html

TSI	Chlorophyll-a (ug/L)	Secchi Depth (ft)	Total Phosphorus (ug/L)	Classification	Attributes	Fisheries and Recreation
<30	<0.95	>26	<6	ULTRAOLIOGOTROPHIC	clear water, many algal species, oxygen throughout the year in bottom water, cold water	oxygen-sensitive, cold water fish species in deep lakes
30-40	0.95 - 2.6	13 - 26	6 - 12	OLIGOTROPHIC	clear water, many algal species, oxygen throughout the year in bottom water except possibly in shallow lakes, cold water	oxygen-sensitive, cold water fish species in deep lakes only
40-50	2.6 - 7.3	6.5 - 13	12 - 24	MESOTROPHIC	water moderately clear, but increasing chance of low dissolved oxygen in deep water during the summer	walleye may dominate
50-60	7.3 - 20	3 - 6.5	24 - 48	EUTROPHIC	decreased clarity, fewer algal species, oxygen-depleted bottom waters during the summer, plant overgrowth evident	warm-water fisheries (pike, perch, bass, etc.)
60-70	20 - 56	1.5 - 3	48 - 96	EUTROPHIC	blue-green algae become dominant and algal scums are possible, extensive plant overgrowth problems possible	thick aquatic vegetation and algal scums may discourage swimming and boating
70-80	56 - 155	0.75 - 1.5	96 - 192	HYPEREUTROPHIC	heavy algal blooms possible throughout summer, dense plant beds, but extent limited by light penetration (blue-green algae block sunlight)	summer fish kills possible, rough fish dominant
>80	>155	<0.75	192 - 384	HYPEREUTROPHIC	Algal scums, few plants	

Figure 9. Lower Vermillion Lake trophic state summary

Circled values indicate the average water quality measurements and corresponding TSI scores for Lower Vermillion Lake from data collected by citizen volunteers. This figure is adapted from Carlson and Simpson 1996, information from the WDNR, and publicly available CLMN water quality data.

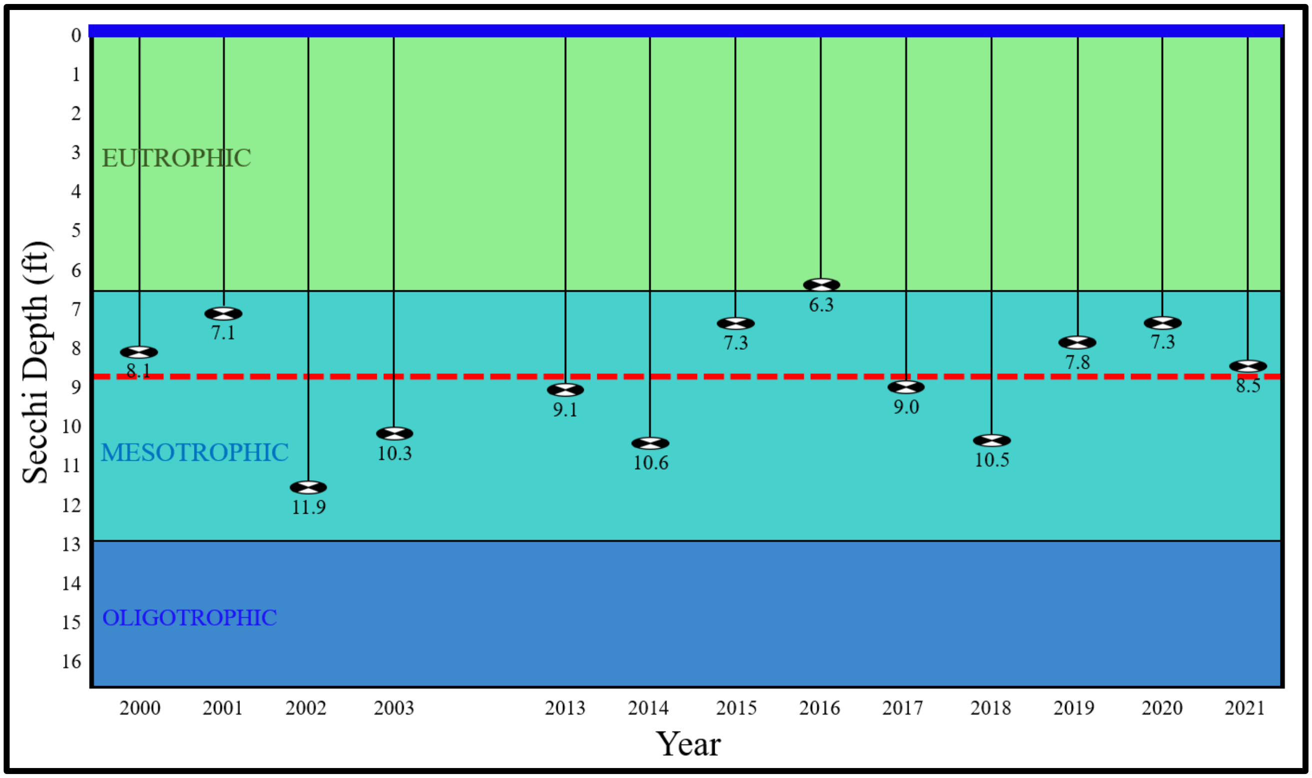

Figure 10. Lower Vermillion Lake Secchi disk readings 2000-2021

Table 3. Lower Vermillion Lake Secchi disk readings 2000-2021

Year	Secchi Mean	Secchi Min	Secchi Max	Secchi Count
2000	8.1	5.0	9.8	4
2001	7.1	5.0	10.5	5
2002	11.9	10.0	15.0	9
2003	10.3	9.5	11.0	2
2013	9.1	8.0	9.8	5
2014	10.6	8.0	14.8	3
2015	7.3	5.3	10.3	3
2016	6.3	3.8	8.5	4
2017	9.0	7.0	11.5	3
2018	10.5	6.8	14.8	4
2019	7.8	6.0	10.0	4
2020	7.3	4.5	13.8	5
2021	8.5	6.0	10.8	4

Oxygen and Thermal Stratification

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; Figure 11).

In most cases, a lake does not remain in a stratified state year-round. Monitoring data indicates that Lower Vermillion Lake is dimictic, meaning that at least twice a year (spring and fall) stratification is replaced by a mixing event called "overturn" or "turnover" where all waters in the lake (top and bottom) naturally mix, recharging levels of dissolved oxygen and distributing necessary nutrients throughout the water in the lake. Smaller and often limited "mixing" events can occur in the summer months due to large storm events or heavy recreational use. Monitoring data for Lower Vermillion shows that stratification occurs between 12-15 feet, and hypoxia (low oxygen) regularly occurs at depths below 30 feet during summer months (June-September).

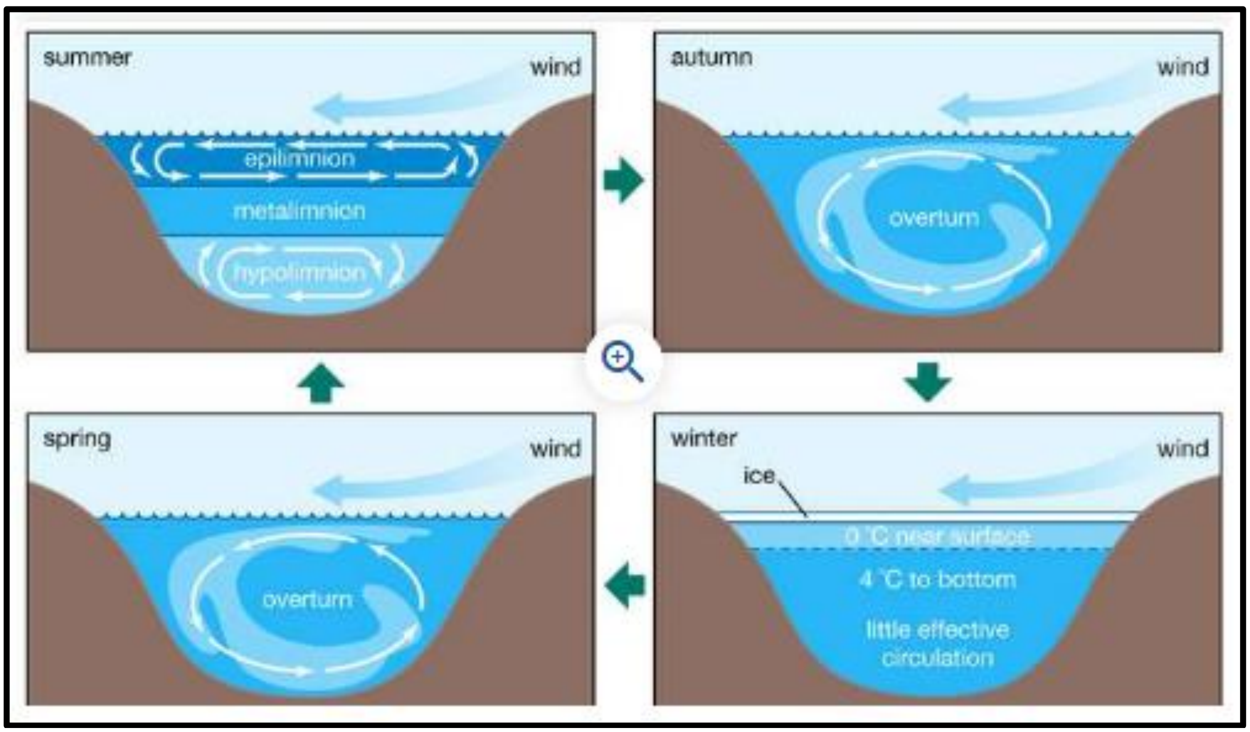

Figure 11. Seasonal thermal stratification in lakes (Encyclopedia Britannica)

Fishery and Wildlife Habitat

The fish population in Lower Vermillion Lake consists of northern pike, walleyes, largemouth bass, perch, bluegills, black crappies, pumpkinseeds, bullheads and white suckers. The lake is surrounded by open farmland, upland hardwood, white pine and a tamarack-tag alder swamp in the middle narrows section. Wetland adjoining the lake provides habitat for muskrats, otters, beavers, swans, nesting puddle ducks, mergansers, coot and loon. Canada geese also use the lake at times during migratory seasons, particularly in the late fall and early winter when literally 1000's of geese are seen resting in the open water near the west end of the lake. The water here stays free of ice much longer than the rest of the lake due to tributary input.

Every body of water has areas of aquatic vegetation that offers critical or unique fish and wildlife habitat. Such areas can be identified by the WDNR and identified as Sensitive Areas per Ch. NR 107. Figure 12 shows the sensitive areas identified by the (WDNR, 2006) in Lower Vermillion Lake. Aquatic habitat areas provide the basic needs (e.g. habitat, food, nesting areas) for waterfowl, fish, and wildlife. Disturbance to these areas during mechanical harvesting should be avoided or minimized, and chemical treatment may be limited unless it can be shown that by chemically treating an area, the native aquatic plant community will be maintained or improved. Areas of rock and cobble substrate with little or no fine sediment are considered high quality walleye spawning habitat. No dredging, structures, or deposits should occur in these sensitive areas. Further details for each sensitive area can be found in the Lower Vermillion Lake Sensitive Area Designation (WDNR, 2006).

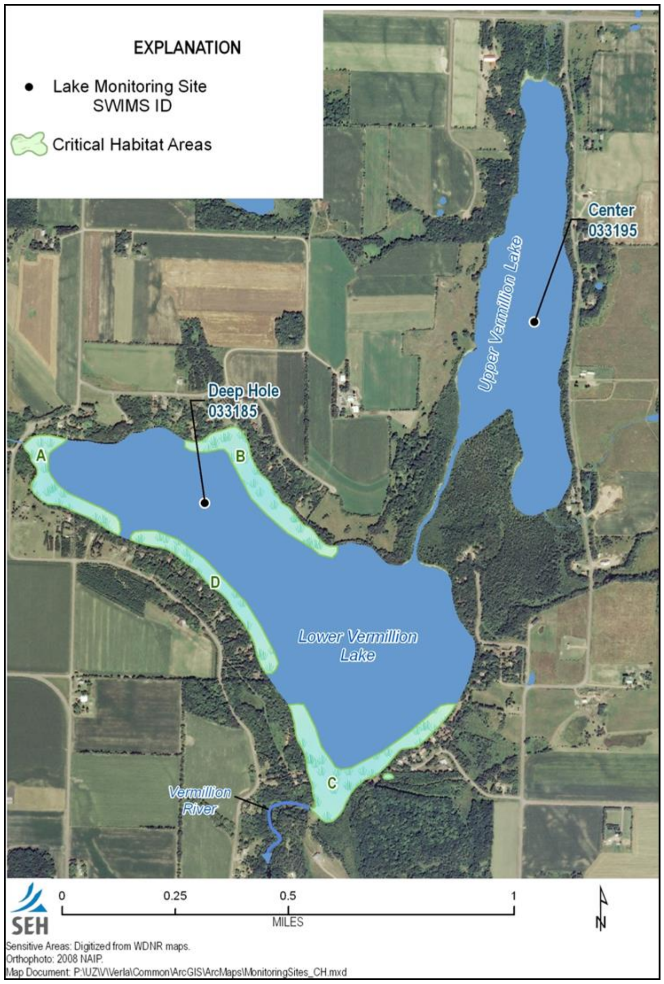

Figure 12: Sensitive Areas and Water Quality Sampling Sites in Lower Vermillion Lake

WDNR records show that Lower Vermillion Lake has been regularly stocked with walleye fingerlings since 1974, with the last stocking occurring in 2011. Fall recruitment and juvenile surveys show that these stocking efforts have been relatively successful. While large numbers are not collected in these surveys, there is a wide size distribution which indicates fairly high recruitment.

Overall, there are a wide variety of warm water fisheries that can be found within Lower Vermillion Lake. The 2010 late spring fisheries assessment showed bluegills, pumpkinseed, yellow perch, rock bass, largemouth bass, northern pike, and walleye (Figure 13). The largest fisheries within Lower Vermillion Lake were the panfish, but there was also a good amount of bass and other predatory fish.

2005 Fall Recruitment Survey				
Species	Relative Abundance (Catch per Mile)	Minimum Length (inches)	Maximum Length (inches)	Average Length (inches)
Largemouth Bass	19.33	4	19.5	11.64
Northern Pike	19.33	7.5	30.5	17.8
Walleye	1	8	21.5	15.25

2010 Fall Juvenile Fisheries Assessment				
Species	Relative Abundance (Catch per Mile)	Minimum Length (inches)	Maximum Length (inches)	Average Length (inches)
Largemouth Bass	29.67	2	16.5	10.95
Northern Pike	17	8	25.5	18.37
Walleye	1	10.5	26.5	19.42

2010 Late Spring Bass/ Panfish Assesment				
Species	Relative Abundance (Catch per Mile)	Minimum Length (inches)	Maximum Length (inches)	Average Length (inches)
Bluegill	306	2.5	8.5	4.81
Largemouth Bass	67.33	5.5	17	12.25
Northern Pike	1	21	32	25.58
Pumpkinseed	2	7	7.5	7.5
Rock Bass	10	5	7.5	6.9
Walleye	0.33	NA	NA	7.5
Yellow Perch	28	2.5	6	3.91

2010 Early Spring Fisheries Assessment				
Species	Relative Abundance (Catch per Mile)	Minimum Length (inches)	Maximum Length (inches)	Average Length (inches)
Largemouth Bass	30.33	9.5	18	13.15
Walleye	4	12	28	20.08

Figure 13: Summaries of recent fisheries surveys on Lower Vermillion Lake

The Natural Heritage Inventory (NHI) database contains recent and historic observations of rare species and plant communities. Each species has a state status including Special Concern (SC), Threatened (THR) or Endangered (END). There is one ecological landscape (hardwood swamp), one plant species (Vasey's pondweed [SC]), one fish species (least darter [SC]), and two reptile species (prairie skink [SC] and wood turtle [THR]) that are all present in the same township and range as Lower Vermillion Lake (T35N R13W) (WDNR, 2017).

The only invasive animal species that has been verified within Lower Vermillion Lake is the Chinese mystery snail. There is not a lot known about the direct impacts that these snails have on the natural systems they invade, but there is some evidence that they cause some decline in native snail populations. Chinese mystery snails also occasionally experience mass die off which result in aesthetic issues with large amounts washing up on shore and subsequently rotting along the shoreline.

Coarse Woody Habitat (Wolter, 2012)

Coarse woody habitat (CWH) in lakes is classified as trees, limbs, branches, roots, and wood fragments at least 4 inches in diameter that enter a lake by natural (beaver activity, toppling from ice, wind, or wave scouring) or human means (logging, intentional habitat improvement, flooding following dam construction). CWH in the littoral or near-shore zone serves many functions within a lake ecosystem including erosion control, as a carbon source, and as a surface for algal growth which is an important food base for aquatic macro invertebrates. Presence of CWH has also been shown to prevent suspension of sediments, thereby improving water clarity. CWH serves as important refuge, foraging, and spawning habitat for fish, aquatic invertebrates, turtles, birds, and other animals. The amount of littoral CWH occurring naturally in lakes is related to characteristics of riparian forests and likelihood of toppling. However, humans have also had a large impact on amounts of littoral CWH present in lakes through time. During the 1800's the amount of CWH in northern lakes was increased beyond natural levels as a result of logging practices. But time changes in the logging industry and forest composition along with increasing shoreline development have led to reductions in CWH present in many northern Wisconsin lakes.

CWH is often removed by shoreline residents to improve aesthetics or select recreational opportunities (swimming and boating). Jennings, et al. (2003) found a negative relationship between lakeshore development and the amount of CWH in northern Wisconsin lakes. Similarly, Christensen, et al. (1996) found a negative correlation between density of cabins and CWH present in Wisconsin and Michigan lakes. While it is difficult to make precise determinations of natural densities of CWH in lakes it is believed that the value is likely on the scale of hundreds of logs per mile. The positive impact of CWH on fish communities have been well documented by researchers, making the loss of these habitats a critical concern. One study determined that black crappie selected nesting sites that were usually associated with woody debris, silty substrate, warmer water, and protected from wind and waves (Pope & Willis, 1997).

Fortunately, the 2016 shoreline survey conducted on Lower Vermillion found a large amount of course woody habitat. Most of this debris has been left undisturbed providing a large amount of spawning ground for fish, and habitat for a large variety of other animals. There is a good amount of CWH within the lake, but if individual property owners wish to install CWH projects along their shorelines, these could be funded through WDNR grant funding if VLA wishes to sponsor them.

Plant Community

The rich plant community of Lower Vermillion Lake provides many beneficial functions to the lake. The plant community helps maintain its clear water status by limiting the amount of nutrients that can be used by algae (a key determinant in pushing Lower Vermillion Lake towards becoming more eutrophic). It also supports a productive game fish community by sheltering young, small fish and providing ambush opportunities for game fish species like northern pike (*Esox Lucius)*. The native plants also help protect the shoreline of Lower Vermillion Lake from erosion by absorbing and mitigating waves before they can reach the vulnerable shore. Overall, maintaining the health of the plant community of Lower Vermillion Lake is critical in maintaining the quality of the water and the quality of the lake as a whole.

All data referenced in this section is taken from the final 2021 whole-lake, point-intercept, aquatic plant survey report from Matt Berg of Endangered Resource Services (Berg, 2021).

2009, 2016, & 2021 Warm-water, Whole-Lake, Point-intercept Aquatic Plant Surveys

Figure 14 reflects the area of the littoral or plant growing zone in Lower Vermillion Lake in each year a whole-lake, point-intercept survey was completed. During the 2021 warm-water point-intercept survey, plants were found growing to 14.0ft (up from 13.5ft in 2016/down from 16.0ft in 2009). The 189 points with vegetation (approximately 28.2% of the entire lake bottom and 76.5% of the littoral zone) was a non-significant decline from 2016 when plants were present at 212 points (31.6% of the bottom/90.2% of the littoral zone). However, it represented a significant decline from the 2009 survey when plants were found growing at 232 points (34.6% of the bottom/88.9% of the littoral zone). Growth in 2021 was slightly skewed to deep water as the mean plant depth of 4.4ft was more than the median depth of 4.0ft. Both of these values were sharply lower than in 2016 and 2009 when the means were 5.6ft/5.5ft and the medians were 5.0ft.

These values suggest that aquatic vegetation is moving back from deeper water into more shallow water, and has been doing so since at least the first PI survey completed in 2009.

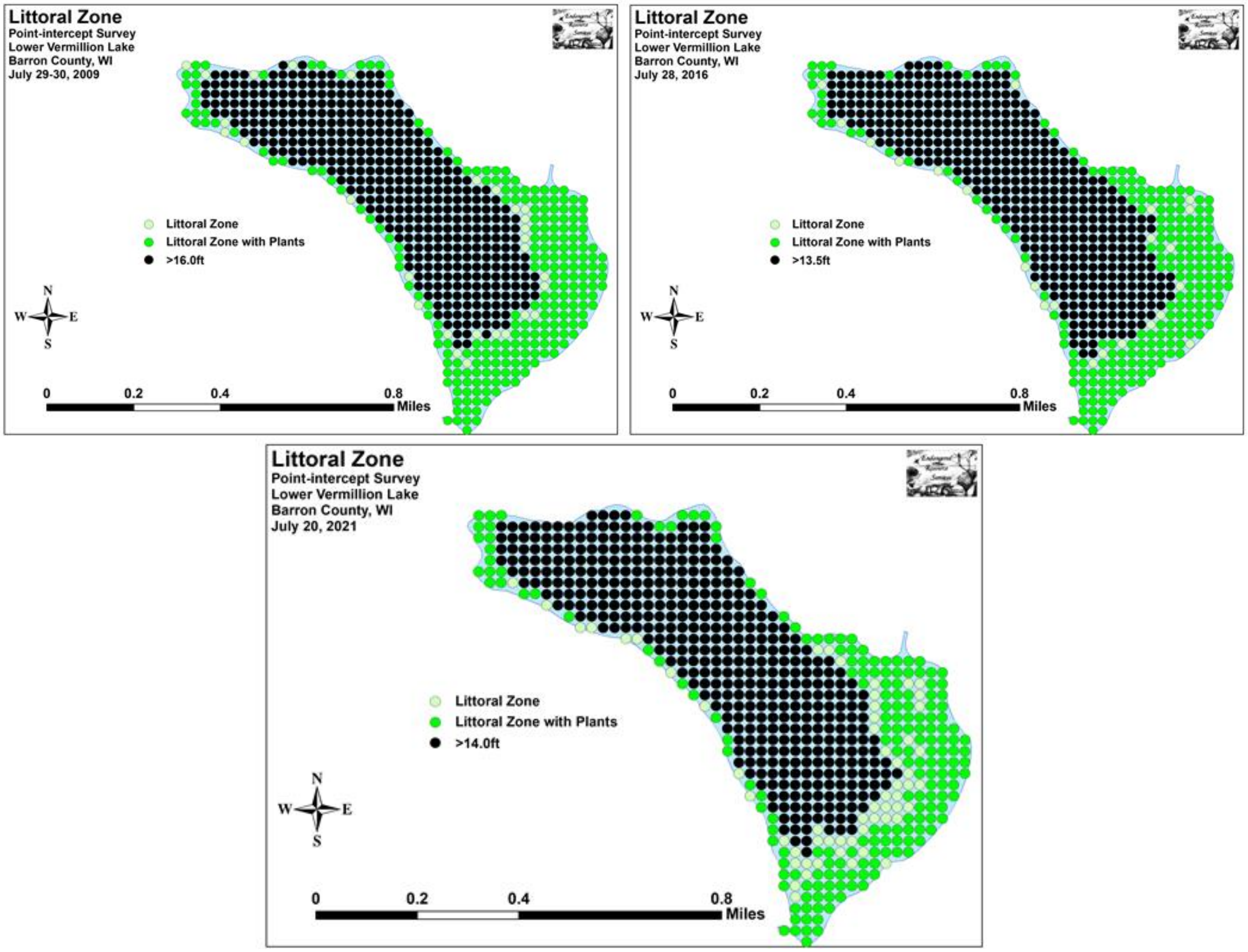

Figure 14. 2009, 2016, and 2021 Littoral Zone (Berg, 2021)

Plant diversity was very high in 2021 with a Simpson Index value of 0.89 – but still down from 0.91 in 2016 and 0.93 in 2009. Species richness was moderate with 34 species found in the rake (similar to 35 in 2016/33 in 2009) although this total increased to 44 species when including visuals and plants seen during the boat survey. This number was also up slightly from the 43 total species documented in 2019m and 42 species in 2009. Although total richness increased, mean native species richness at sites with native vegetation experienced a highly significant decline from 3.52/site in 2009 to 3.01/site in 2016 and a further highly significant decline to 2.34/site in 2021 (Figure 15).

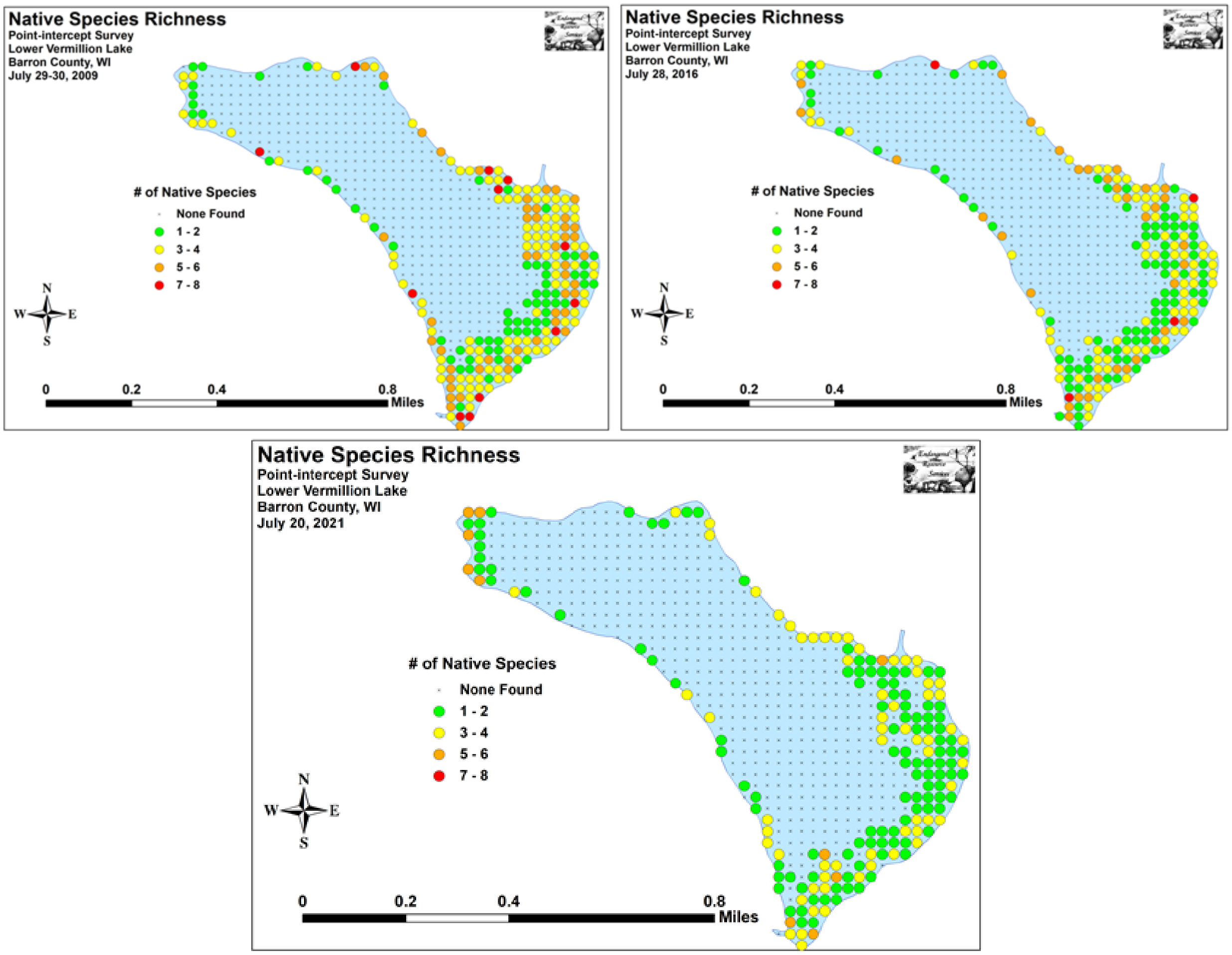

Figure 15. 2009, 2016, and 2021 Native Species Richness (Berg, 2021)

Total rake fullness experienced a highly significant decline from a moderately high 2.43 in 2009 to a low/moderate 1.85 in 2016. In 2016, it was noted that these declines appeared to have been a lakewide phenomenon - potentially due to the poor water clarity experience in 2016 when Secchi readings averaged 6ft – the lowest value since surveys began in 2000. In 2021, this trend reversed as a highly significant increase to a moderate mean rake of 2.14 was found (Figure 16).

A comparison of statistical values from 2009, 2016, and 2021 is given in Table 4.

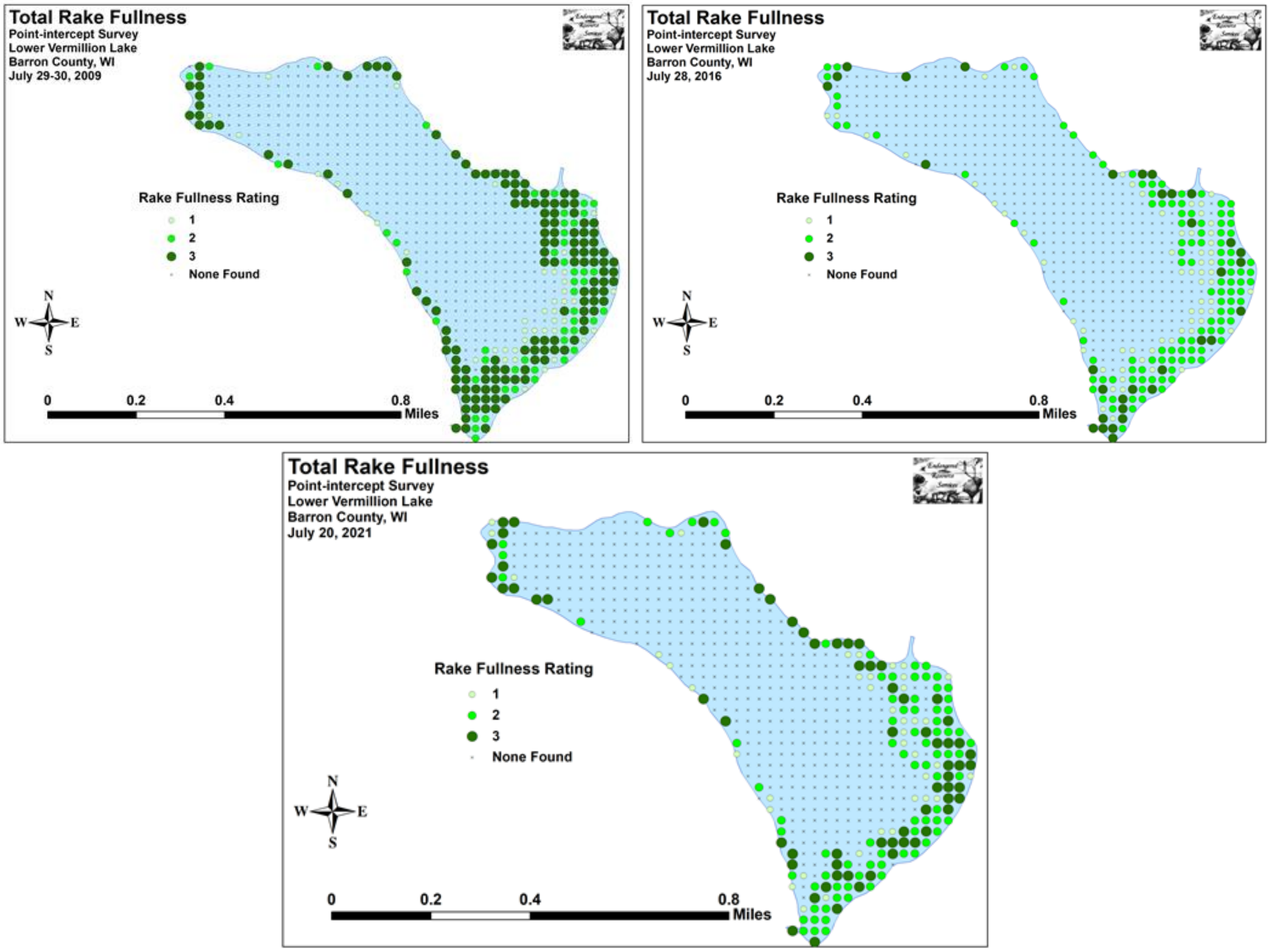

Figure 16. 2009, 2016, and 2021 Total Rake Fullness (Berg, 2021)

Table 4: Aquatic Macrophyte P/I Survey Summary Statistics. July 29-30, 2009, July 28, 2016, and July 20, 2021

Summary Statistics:	2009	2016	2021
Total number of points sampled	671	671	671
Total number of sites with vegetation	232	212	189
Total number of sites shallower than the max. depth of plants	261	235	247
Freq. of occurrence at sites shallower than max. depth of plants	88.9	90.2	76.5
Simpson Diversity Index	0.93	0.91	0.89
Maximum depth of plants (ft)	16.0	13.5	14.0
Mean depth of plants (ft)	5.5	5.6	4.4
Median depth of plants (ft)	5.0	5.0	4.0
Ave. number of all species per site (shallower than max depth)	3.15	2.73	1.79
Ave. number of all species per site (veg. sites only)	3.55	3.02	2.34
Ave. number of native species per site (shallower than max depth)	3.11	2.72	1.75
Ave. number of native species per site (sites with native veg. only)	3.52	3.01	2.34
Species richness	33	35	34
Species richness (including visuals)	33	38	40
Species richness (including visuals and boat survey)	42	43	44
Mean rake fullness (veg. sites only)	2.43	1.85	2.14

Comparison of Native Macrophyte Species in 2009, 2016, & 2021

The July 2009 survey found Coontail, Flat-stem pondweed, Slender naiad, and Wild celery were the most common macrophyte species. They were present at 49.14%, 47.84%, 29.74%, and 29.74% of survey points with vegetation respectively and accounted for 44.11% of the total relative frequency. Muskgrass (8.14%), Clasping-leaf pondweed (6.08%), Northern water-milfoil (5.47%), and Fries' pondweed (5.47%) also had relative frequencies over 4.0%.

In July 2016, Coontail, Flat-stem pondweed, Wild celery, and Fries' pondweed were the most common species. Present at 51.42%, 41.51%, 33.02%, and 29.72% of sites with vegetation, they accounted for 51.48% of the total relative frequency. Slender naiad (9.36%) and Muskgrass (6.71%) also had relative frequencies over 4.0%.

Lakewide, 12 species showed significant changes in distribution from 2009 to 2016 (Figure 17). Northern water-milfoil, Stiff pondweed, White-stem pondweed, and Illinois pondweed suffered highly significant declines; Clasping-leaf pondweed and Water star-grass experienced moderately significant declines; and Muskgrass, Curly-leaf pondweed, and Spiny-spored quillwort demonstrated significant declines. Conversely, filamentous algae saw a highly significant increase; and Fries' pondweed and Forked duckweed showed significant increases.

When considering the changes from 2009 to 2016, the decline in Northern water-milfoil may have been at least partially tied to the herbicide treatment of EWM as these two sister species are both sensitive to 2-4,D. The expansion of filamentous algae and Forked duckweed might also have been in response to nutrients being released from decomposing plants posttreatment; however, monocots like the many pondweeds that experienced declines, are not expected to be impacted by the treatment. These losses may have simply been tied to the poor water clarity observed in 2016 or some other change in annual growing conditions.

The 2021 survey identified Coontail (44.44% of points with vegetation), Wild celery (40.74%), Slender naiad (32.80%), and Muskgrass (29.10%) as the most common species with a combined relative frequency of 62.90%. Clasping-leaf pondweed (5.20%) and Sago pondweed (4.07%) also had relative frequencies over 4.00%.

From 2016 to 2021, eight species underwent significant changes in distribution (Figure 17). Flat-stem pondweed, Fries' pondweed, Small pondweed, and Forked duckweed suffered highly significant declines; and Variable pondweed saw a significant decline. Conversely filamentous algae saw a highly significant increase; Curly-leaf pondweed underwent a moderately significant increase; and Muskgrass had a significant increase.

The majority of the changes seen from 2016 to 2021 appear to have occurred on the outer edge of the littoral zone. The especially poor clarity documented during the July 2021 survey may be the best explanation of why species like Small pondweed and Fries' pondweed had already set turions and senesced. It might also be at least a partial reason for why the Flat-stem pondweed population crashed.

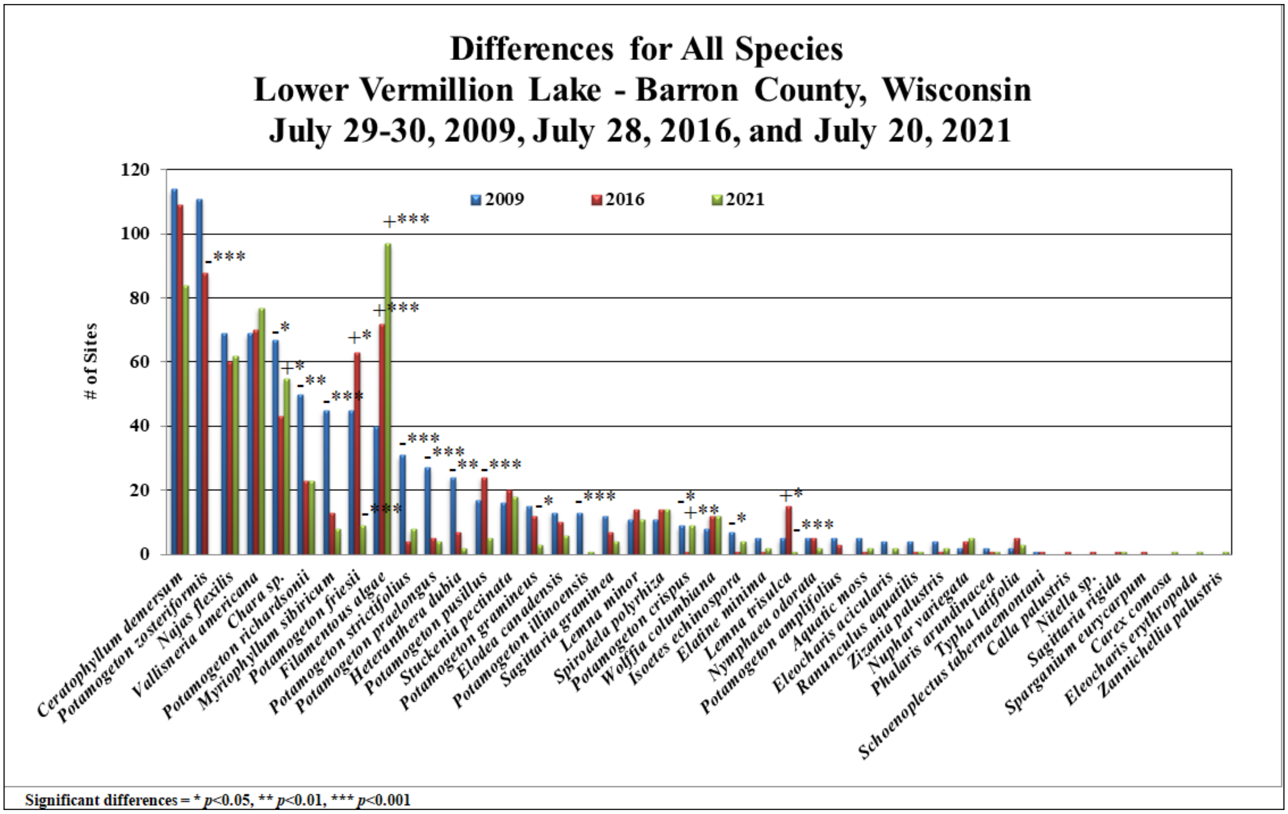

Figure 17. Macrophytes Showing Significant Changes from 2009-2016-2021 (Berg, 2021)

Coontail, the most common macrophyte species in 2009, 2016, and 2021, was present in most areas with sandy and organic muck (Figure 18). From 2009 to 2016, it saw a non-significant decline in distribution (114 sites in 2009/109 sites in 2016) and a highly significant decline in density (mean rake fullness of 1.83 in 2009/1.40 in 2016). In 2021, a non-significant decline in distribution to 84 sites was documented; however, the density underwent a moderately significant increase to a mean rake fullness of 1.67.

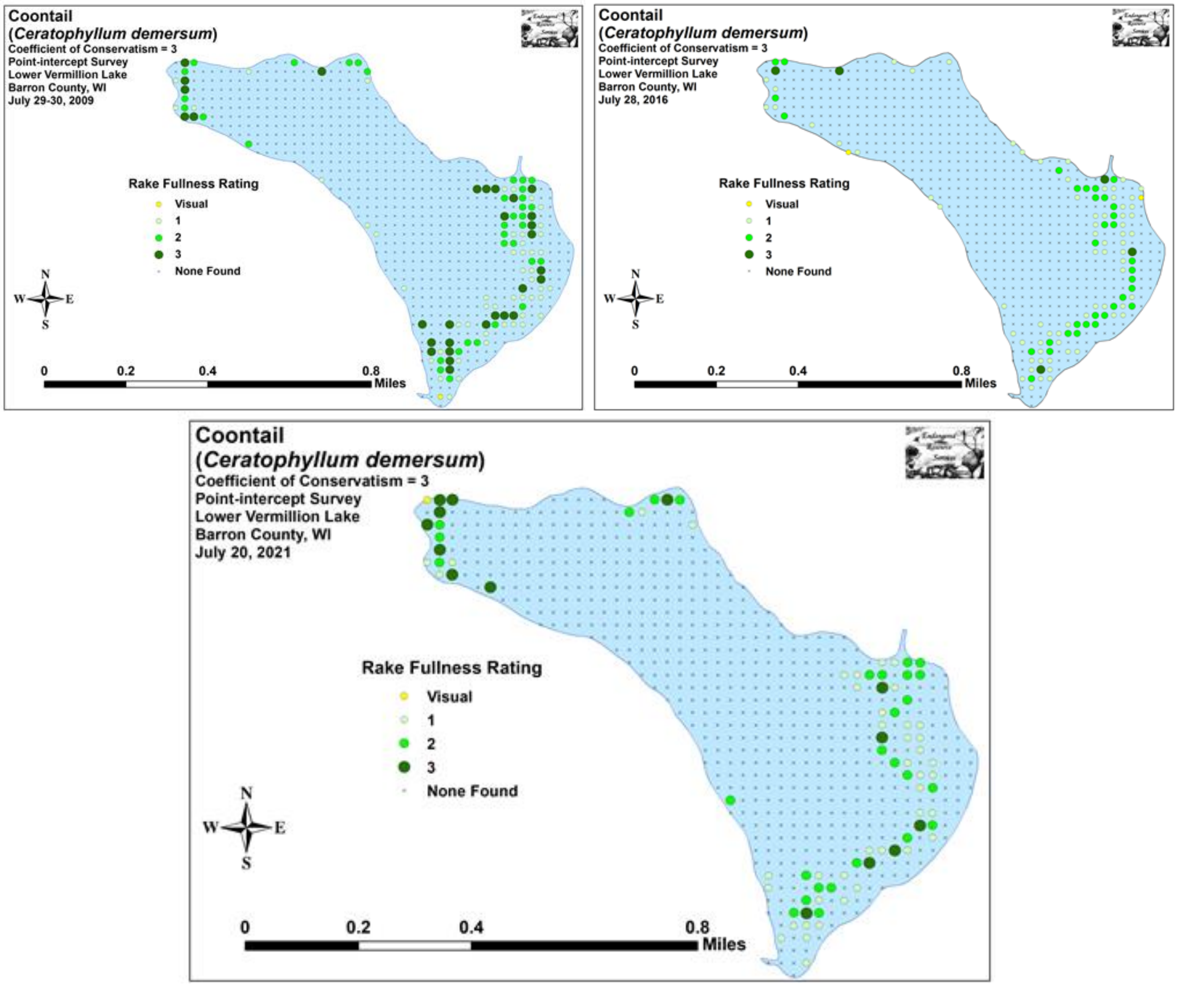

Figure 18. 2009, 2016, and 2021 Coontail Density and Distribution (Berg, 2021)

Flat-stem pondweed was the second most common species in both 2009 and 2016 (Figure 19). Similar to Coontail, it experienced a non-significant decline in distribution (111 sites in 2009/88 sites in 2016) and a highly significant decline in density (mean rake of 1.95 in 2009/1.40 in 2016). The 2021 survey documented a complete population crash as the species was not found in the rake at any points. The reason for these highly significant declines in both density and distribution is unknown. There was no chemical management in Lower Vermillion Lake in 2021, and only 4.64 acres of EWM was treated in 2020. CLP was chemically managed in 2020 with three beds covering 2.26 acres on the west side of the lake included.

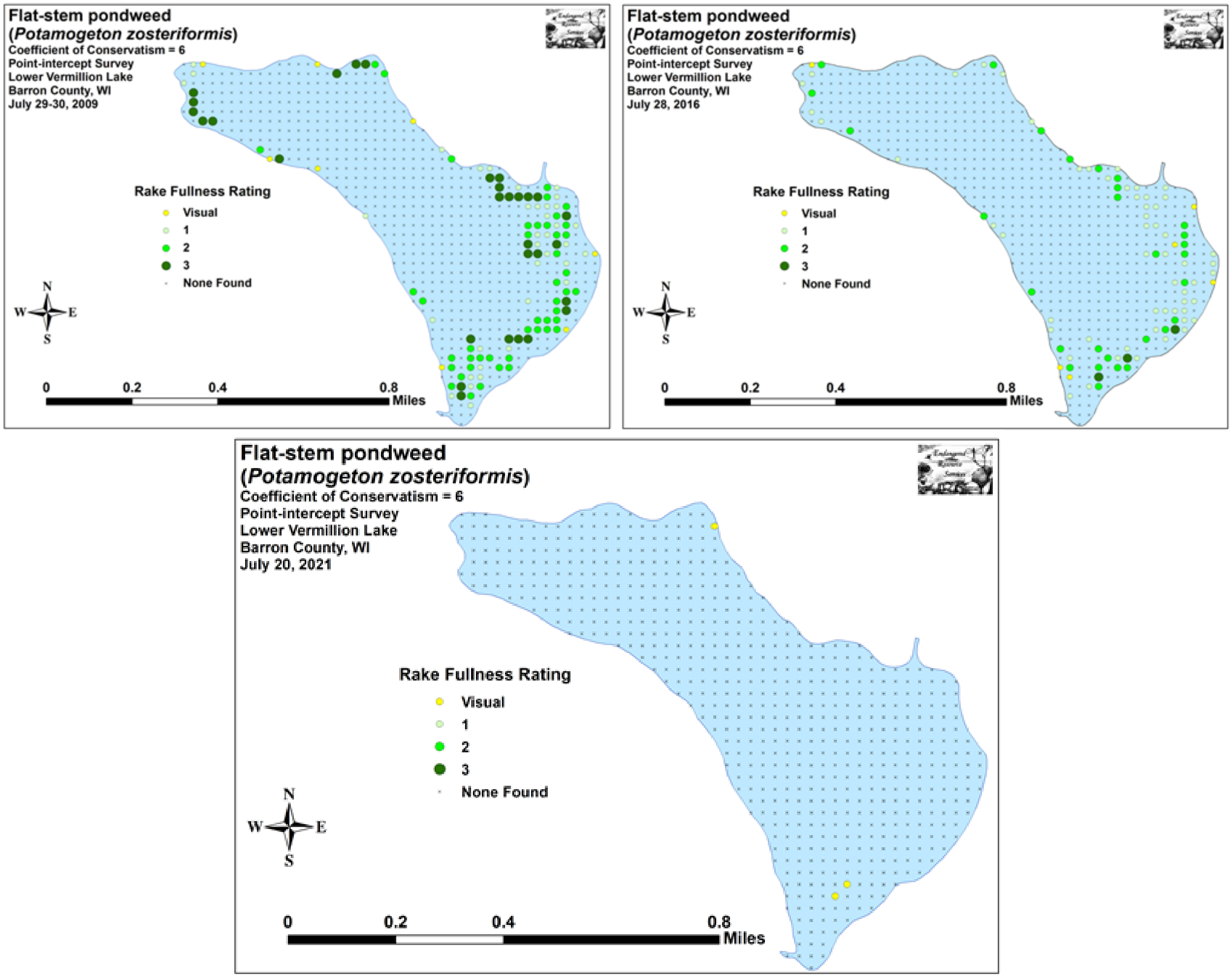

Figure 19. 2009, 2016, and 2021 Flat-stem Pondweed Density and Distribution (Berg, 2021)

Wild celery was the third most common species in both 2009 and 2016 (Figure 20). Over this time, it was almost unchanged (p=0.46) in distribution (69 sites in 2009/70 sites in 2016) but saw a moderately significant decline in density (mean rake of 1.70 in 2009/1.37 in 2016). In 2021, it was the second most widely-distributed species after undergoing a non-significant increase in distribution (77 sites) and a significant increase in density (mean rake of 1.61).

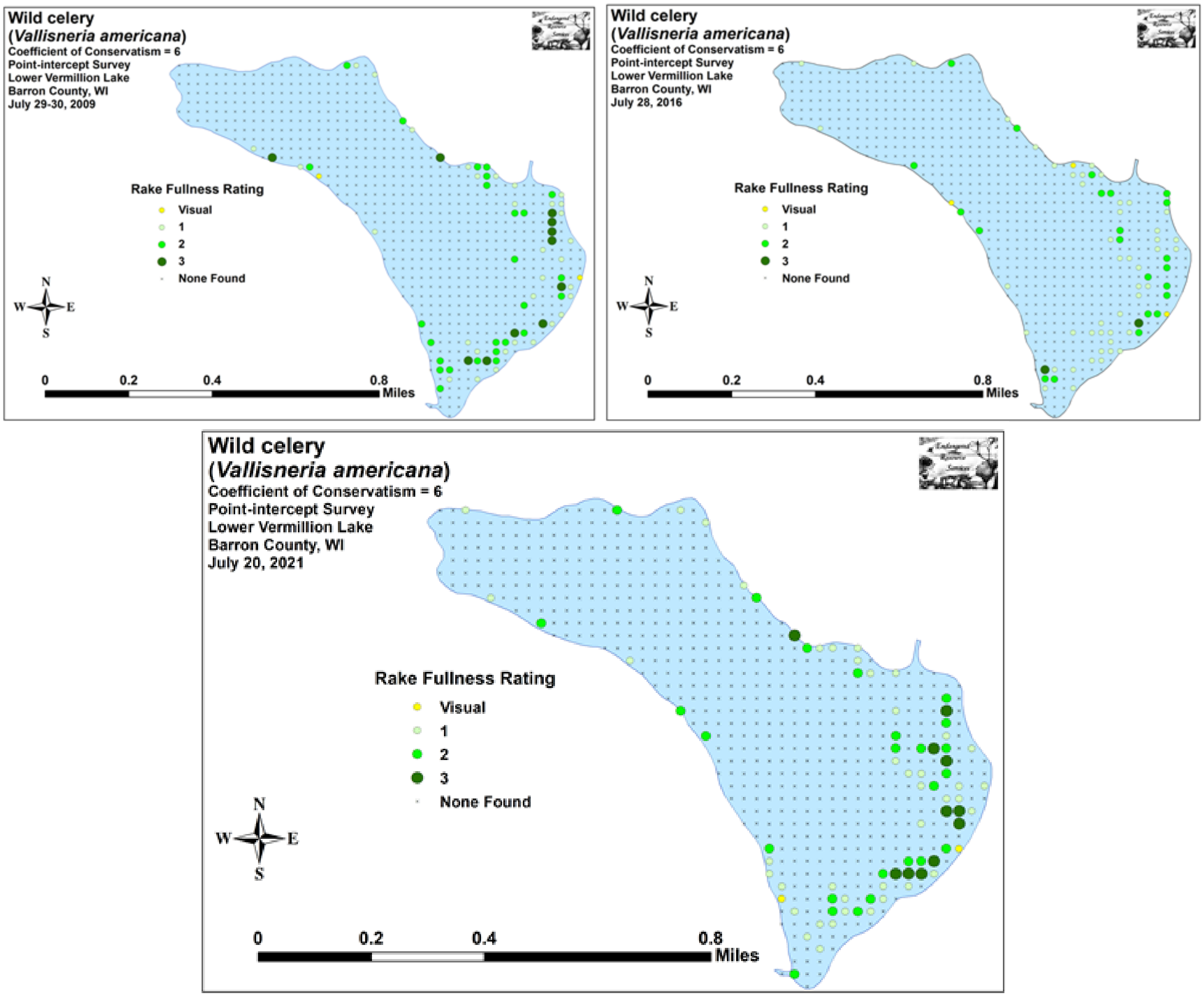

Figure 20. 2009, 2016, and 2021 Wild Celery Density and Distribution (Berg, 2021)

Northern watermilfoil (NWM) is one native aquatic plant species that is generally negatively impacted by chemical treatments to kill its cousin, EWM. NWM was the seventh most common species during the 2009 survey when it dominated many areas of the east bay (Figure 21). After experiencing highly significant declines in both distribution (45 sites in 2009/13 sites in 2016) and density (mean rake fullness of 1.73 in 2009/1.00 in 2016), it was just the 13^{th} most common species in 2016. The 2021 survey documented a further non-significant decline in distribution (eight sites) and a nearly significant increase (p=0.05) in density (mean rake 1.50). Despite the decline in distribution, it increased its community rank to the 12^{th} most common species.

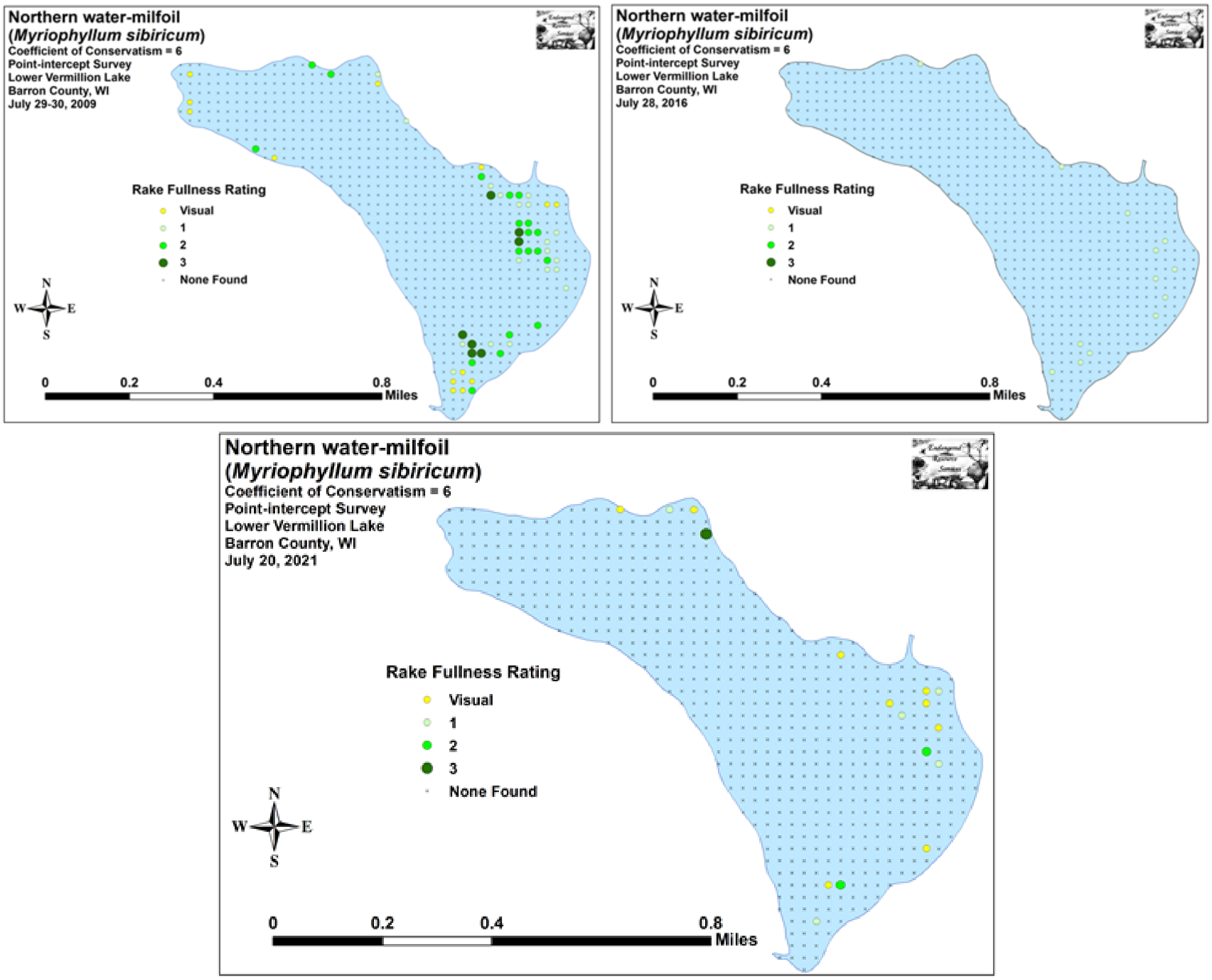

Figure 21. 2009, 2016, and 2021 Northern Water-milfoil Density and Distribution (Berg, 2021)

The FQI index measures the impact of human development on a lake's aquatic plants. The 124 species in the index are assigned a Coefficient of Conservatism (C) which ranges from 1-10. The higher the value assigned, the more likely the plant is to be negatively impacted by human activities relating to water quality or habitat modifications. Plants with low values are tolerant of human habitat modifications, and they often exploit these changes to the point where they may crowd out other species. Statistically speaking, the higher the FQI index value, the healthier the lake's macrophyte community is assumed to be. Table 5 represents the FQI index measures from all three whole-lake, point-intercept surveys. Nichols (1999) reported an average mean C for the North Central Hardwood Forests Region of 5.6 putting Lower Vermillion Lake above average for this part of the state. The FQI was also well above the median FQI of 20.9 for the North Central Hardwood Forests (Nichols, 1999).

Table 5 – Number of Species (N), Coefficient of Conservatism (C), and Floristic Quality Index (FQI) comparisons from 2009, 2016, and 2021

	2009	2016	2021
# of Species (N)	31	33	32
Mean C	6	6.2	6
FQI	33.4	35.5	33.9

Comparison of Northern Wild Rice in 2009, 2016, & 2021

Wild rice is an aquatic grass which grows in shallow water in lakes and slow flowing streams. This grass produces a seed which is a nutritious source of food for wildlife and people. The seed matures in August and September with the ripe seed dropping into the sediment, unless harvested by wildlife or people. It is a highly protected and valued natural resource in Wisconsin. Only Wisconsin residents may harvest wild rice in the state. According to the WDNR Surface Water Data Viewer, Lower Vermillion Lake is not wild rice water.

However, in 2009, Northern wild rice was documented at four points (mean rake 1.75) in a patchwork bed that covered nearly one acre in the southeast outlet bay (Figure 22). The 2016 survey found rice at a single point, and it was noted that the population had shrunk to just a few hundred goose-cropped plants that were scattered along the shoreline. In 2021, rice occurred at two points with a mean rake of 1.75, and a general thickening of the total bed relative to 2016 levels was observed (Figure 23).

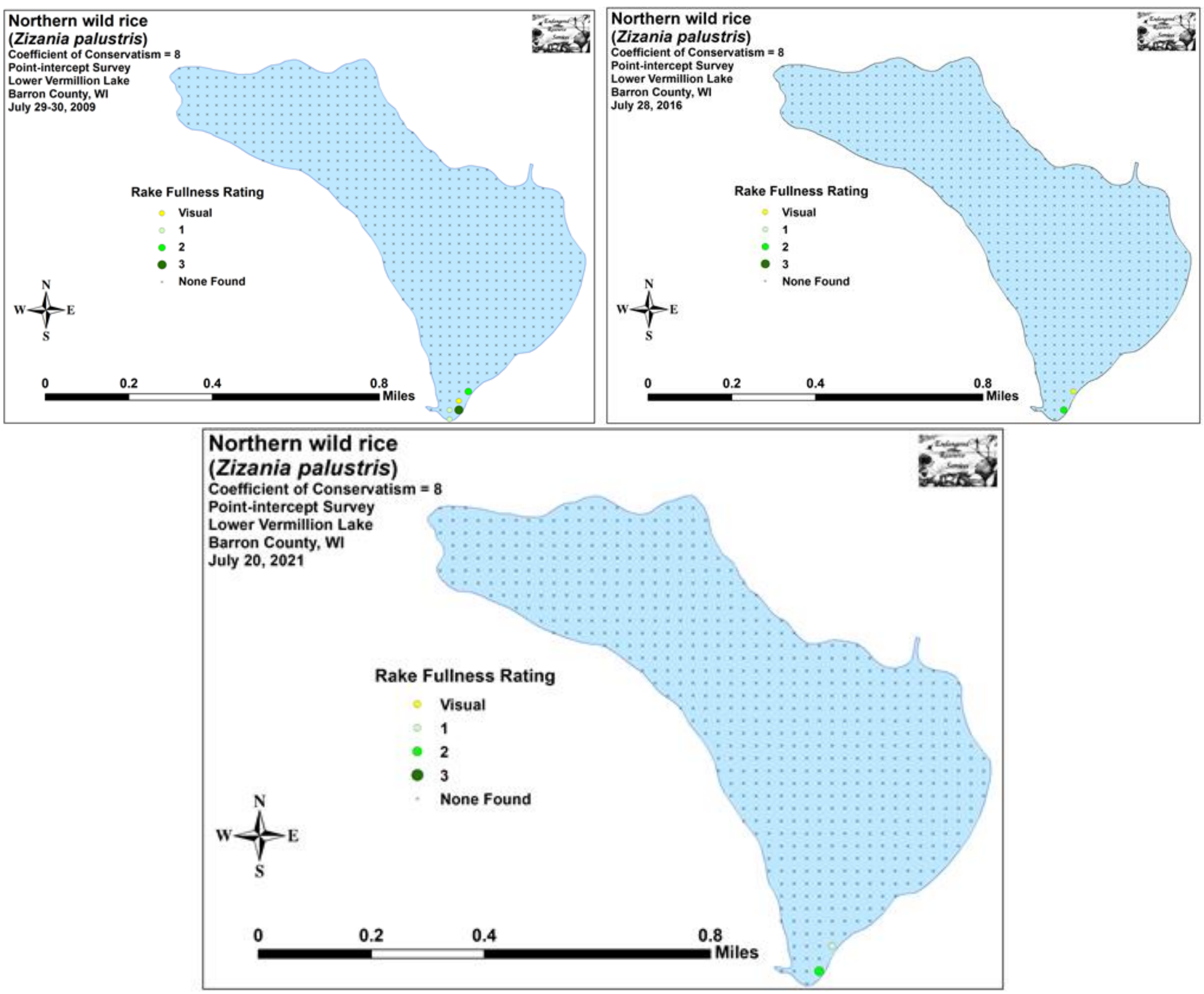

Figure 22. 2009, 2016, and 2021 Northern Wild Rice Density and Distribution (Berg, 2021)

Figure 23. Maximum Northern wild rice Density in the Southeast Outlet Bay 7/20/21 (Berg, 2021)

Comparison of Filamentous Algae in 2009, 2016, & 2021

Filamentous algae (Figure 24) are normally associated with excessive nutrients in the water column from such things as runoff, internal nutrient recycling, and failed septic systems. In 2009, these algae were located at 40 points with a mean rake fullness of 1.80 (Figure 24). The 2016 survey documented them at 72 points with a mean rake of 1.39 – a highly significant increase in distribution, but a moderately significant decline in density (Figure 24). The 2021 survey found a further highly significant increase in distribution to 97 sites, and a non-significant increase in density to a mean rake of 1.49 (Figure 24).

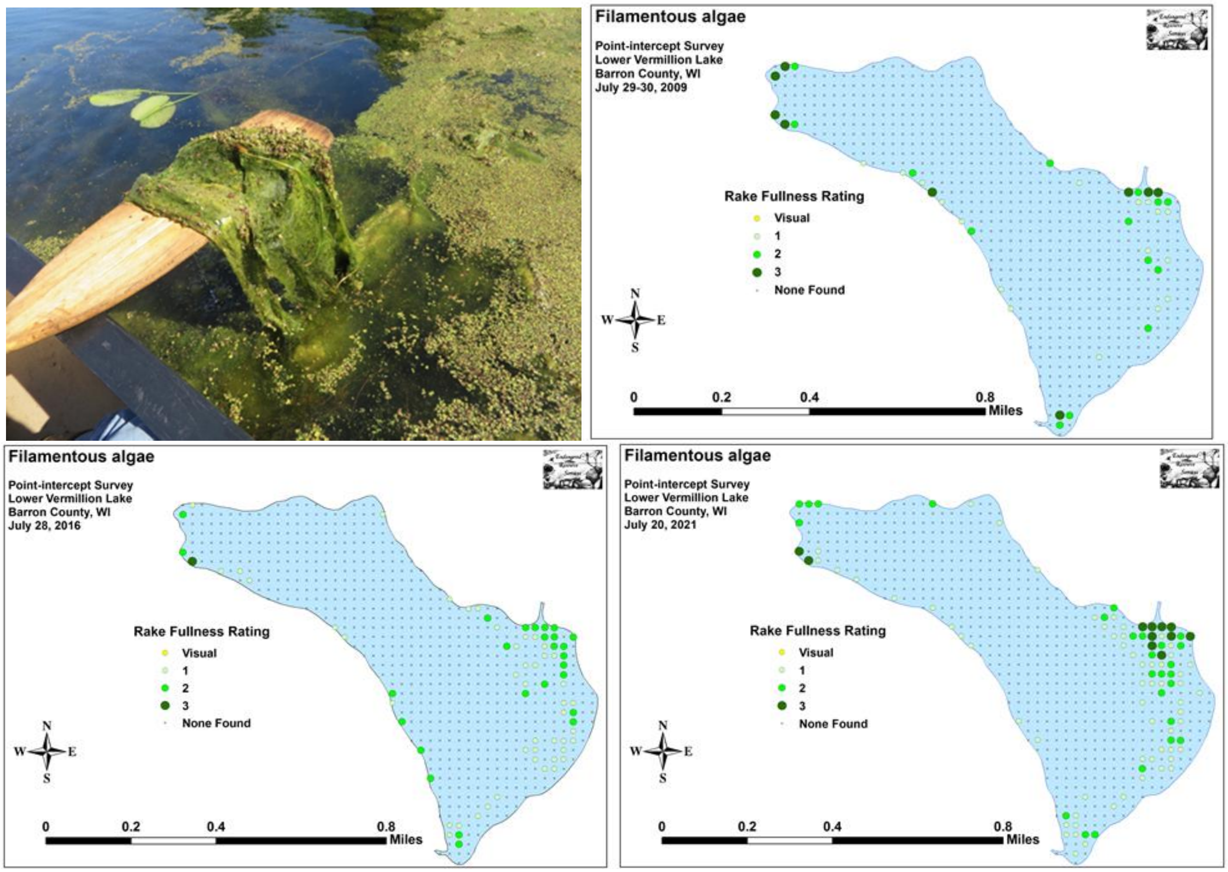

Figure 24. Filamentous algae; and 2009, 2016, and 2021 Filamentous Algae Density and Distribution

Changes in the Aquatic Plant Community

As mentioned, between 2016 and 2021, several pondweed species including Friess, Small, Variable, and Flat-stem suffered significant declines, with Flat-stem going from the second most common aquatic plant species in the lake in both the 2009 and 2016 PI surveys, to almost non-existent in the lake in 2021. All eight native pondweeds identified in the 2009 PI survey experienced a decline through 2021. Of the 42 species that were found on the rake on at least one point in the three surveys, 29 of them decreased, 6 were unchanged, and 8 increased. The species in the lake that increased in abundance included water celery, filamentous algae, sago pondweed, large duckweed, common watermeal, spatterdock, cattail, and waterwort. The species that were unchanged included small duckweed, curly-leaf pondweed, arrowhead, sedge, spikerush, and horned pondweed. Even though the abundance of coontail went down from 2009 to 2021, its density increased.

The reasons for these changes in aquatic vegetation may best be explained by a reduction in water clarity in the lake over time. CLMN reports are somewhat misleading in that the graphs produced for water clarity are based only on July and August Secchi disk readings. Figure 10 reflects the summer Secchi disk averages over time. Figure 25 reflects the average of all Secchi disk readings taken in each year from 2013 to 2022. This figure clearly shows a decline in water clarity over this time period. It is also interesting to note that the worst water clarity was measured in 2016 and 2020. The year 2021 had the third worst water clarity over this time period. The correlation of this poor water clarity in the years that the last two PI surveys were completed is worth noting. In addition, the aquatic plant surveyor suggested in his report that most of the changes in the aquatic plant community in 2021 appeared to be on the deep water edges of the littoral zone.

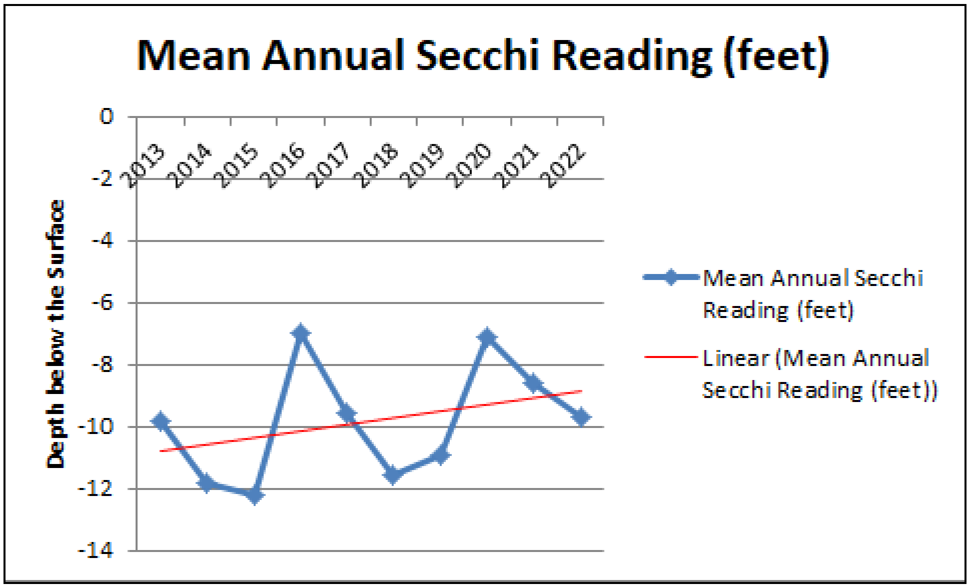

Figure 25: Annual average of all Secchi disk readings collected between 2013 and 2022

Curly-leaf Pondweed Mapping Surveys

Following the establishment of the spring 2021 littoral zone at approximately 10.5ft, we sampled for Curly-leaf pondweed was sampled for at all points in and adjacent to this zone. CLP was present in the rake at 33 sample points with 34 additional visual sightings (Figure 26). This extrapolated to 4.9% of the entire lake and 16.4% of the spring littoral zone having at least some CLP present. The nine points with a rake fullness of a 2 or a 3 (Figure 26) suggested 1.3% of the entire lake and 4.3% of the spring littoral zone had a significant infestation.

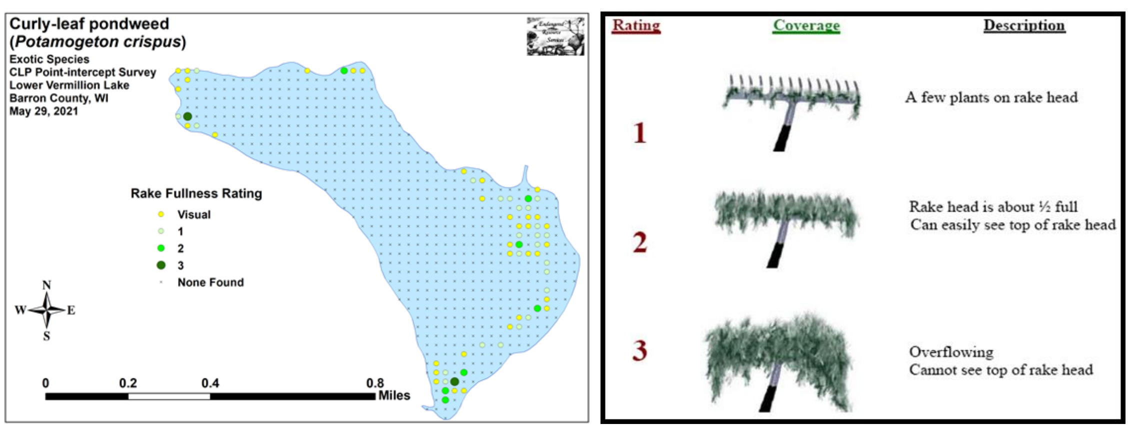

Figure 26. 2021 Late Spring CLP Density and Distribution (Left); Rake Fullness Ratings (right)

The 2009 spring survey found CLP at 56 sites which approximated to 8.3% of the entire lake and 26.7% of the estimated 11.0ft spring littoral zone having CLP present. Of these, a rake fullness value of 3 at 11 points, a 2 at 18 points, and a value of 1 at 27 points was recorded for a mean rake fullness of 1.71. This extrapolated to 4.3% of the lake and 13.8% of the littoral zone having a significant infestation (rake fullness of 2 or 3). CLP was also recorded as a visual at two points (Figure 27).

In 2016, CLP was found at 24 survey points with 21 additional visual sightings (3.6% of the entire lake/11.3% of the 11.5ft spring littoral zone). Three points rated a rake fullness value of 3, four points a 2, and the remaining 17 points a 1 for a mean rake fullness of 1.42 (Figure 27). The combined seven points with a rake fullness of a 2 or a 3 suggested 0.9% of the lake and 3.3% of the littoral zone had a significant infestation.

The 2022 frequency of occurrence in the littoral zone value was higher than the 2016 value, but still less than the frequency of occurrence in 2009; and, generally speaking, 2021 was a year that produced heavy growth of CLP across northern Wisconsin.

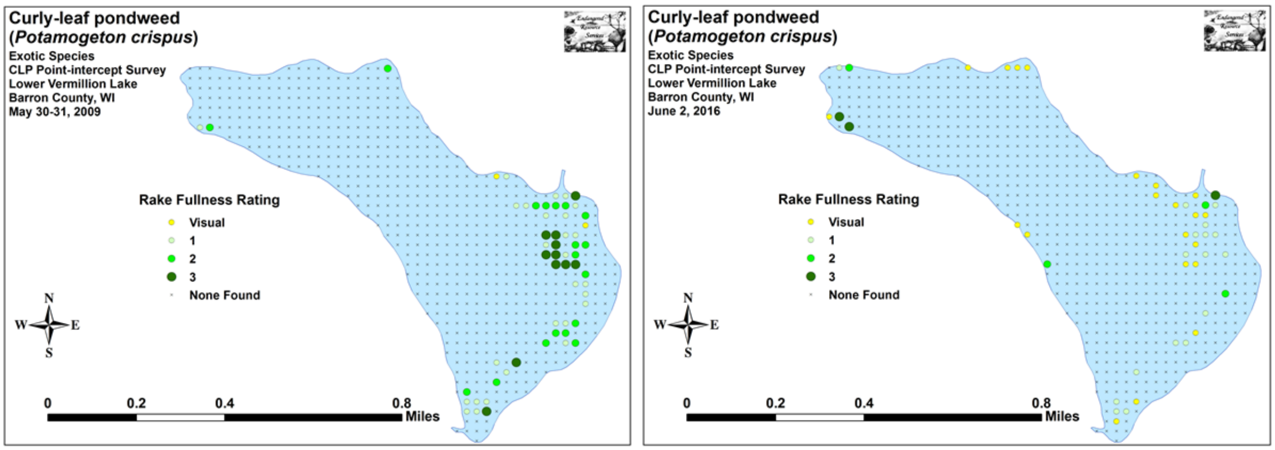

Figure 27. 2009 and 2016 Late Spring CLP Density and Distribution (Berg, 2021)

In 2021, a CLP bed mapping survey identified eight CLP beds that covered 10.85 acres – approximately 5.0% of the lake's surface area was mapped (Figure 28). By definition, a "bed" was determined to be any area where visually estimated CLP made up >50% of the area's plants, was generally continuous with clearly defined borders, and was canopied, or close enough to being canopied that it would likely interfere with boat traffic. After a bed is located, GPS coordinates are taken around the perimeter of the bed at regular intervals. The estimated the rake density range and mean rake fullness of the bed, the maximum depth of the bed, whether it was canopied, and the impact it was likely to have on navigation (**none** – easily avoidable with a natural channel around or narrow enough to motor through/**minor** – one prop clear to get through or access open water/**moderate** – several prop clears needed to navigate through/**severe** – multiple prop clears and difficult to impossible to row through) was estimated. The amount of CLP identified in 2021 represented a 7.19-acre increase (+196%) from the nine CLP beds on 3.66 acres (1.7% coverage) mapped in 2016. It was also sharply higher than the single CLP bed on 1.10 acres (0.6% coverage) that was found during the original 2009 survey (Figure 7).

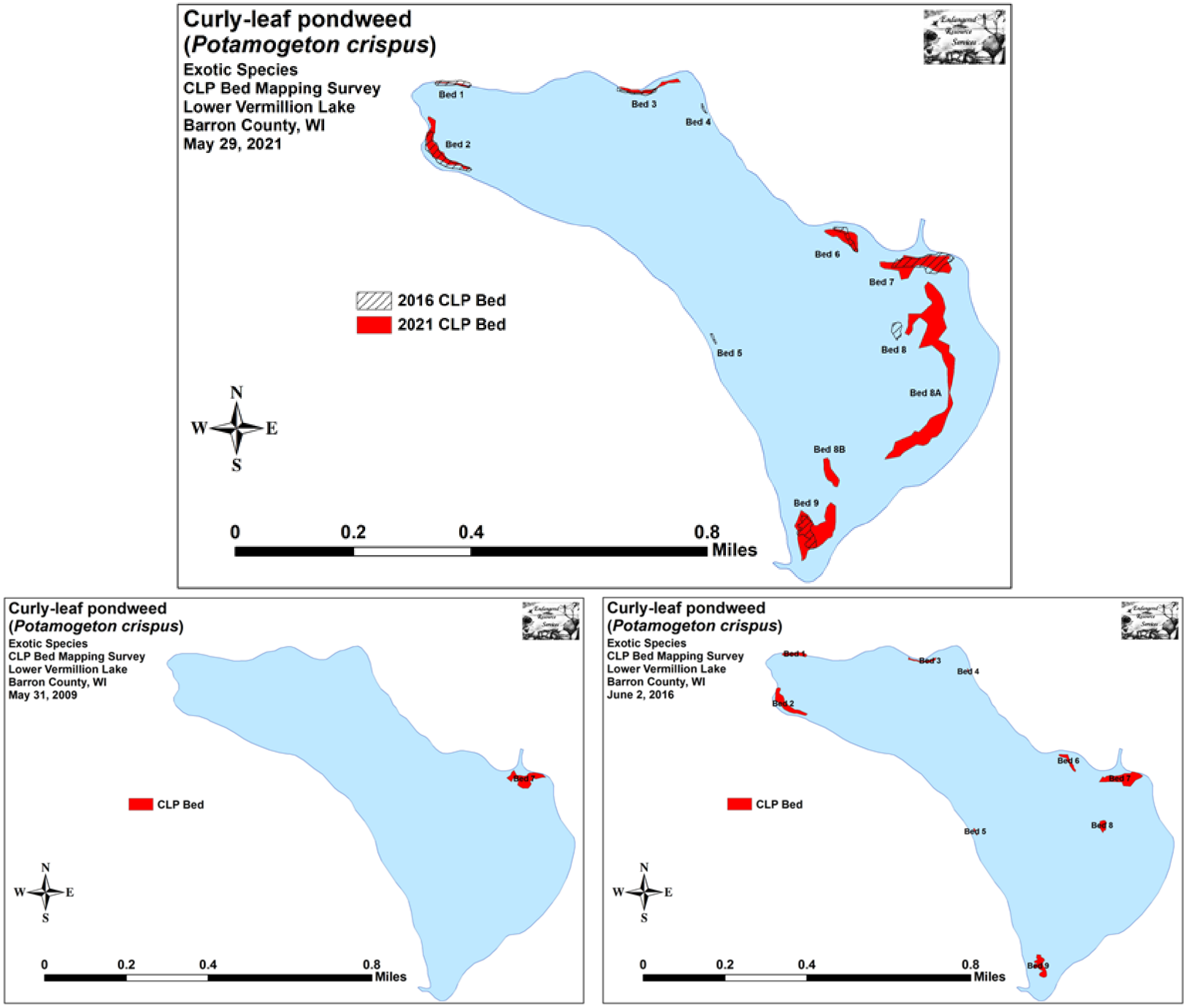

Figure 28. 2021 (top), 2009, and 2016Late Spring Curly-leaf Pondweed Beds (Berg, 2021)

Although at face value this increase in CLP bed coverage might appear troubling, more overall CLP was found during the 2009 point-intercept survey than either the 2016 or 2021 surveys. CLP was common and present throughout the lake in 2009, but it was seldom invasive or bed forming. In 2016, CLP was more restricted, but tended to occur at greater densities when it was present. The 2021 survey found CLP beds were common, but they tended to be patchy and seemed unlikely to cause more than minor navigation impairment. During each survey, it was noted that these beds tended to hold schools of both adult and juvenile panfish potentially making them important early-season vertical habitat.

Eurasian Watermilfoil Mapping Surveys

Following the establishment of the spring 2021 littoral zone at approximately 10.5ft, Eurasian watermilfoil was sampled for at all points in and adjacent to this zone. During this survey, EWM was present at two points each with a rake fullness of 1 (Figure 29). This suggested that only 0.3% of the lake and 1.0% of the spring littoral zone had EWM present. EWM was also recorded as a visual at a single point and nine additional plants were marked inter-point along the southwest shoreline of the lake’s northwest bay. EWM was not found in the rake during the 2009 or the 2016 spring surveys. None of the categorical increases that were documented in 2021, either pooled or separated, were significant.

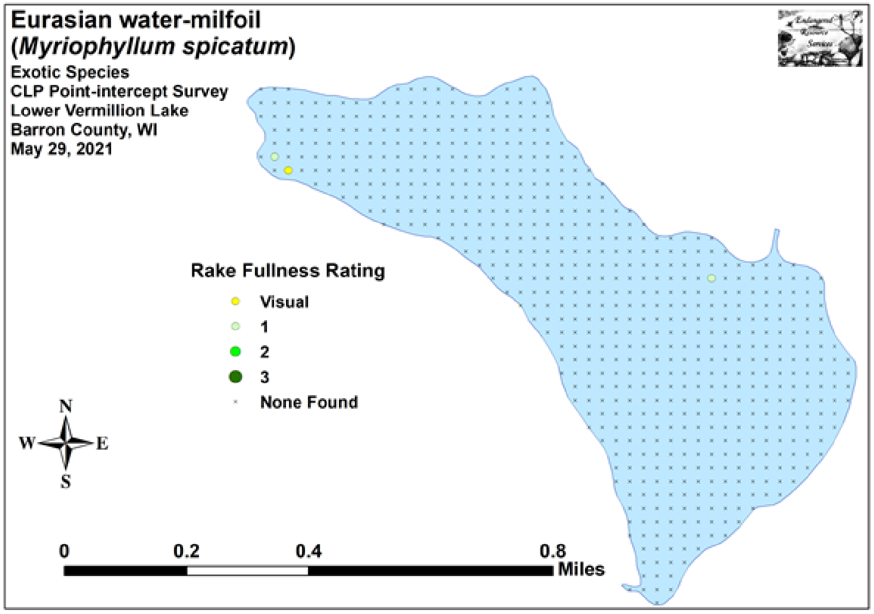

Figure 29. 2021 Late Spring EWM Density and Distribution (Berg, 2021)

The 2021 spring EWM bed mapping survey only identified the points previously mentioned along the southwest shoreline of the lake's northwest bay (Figure 30).

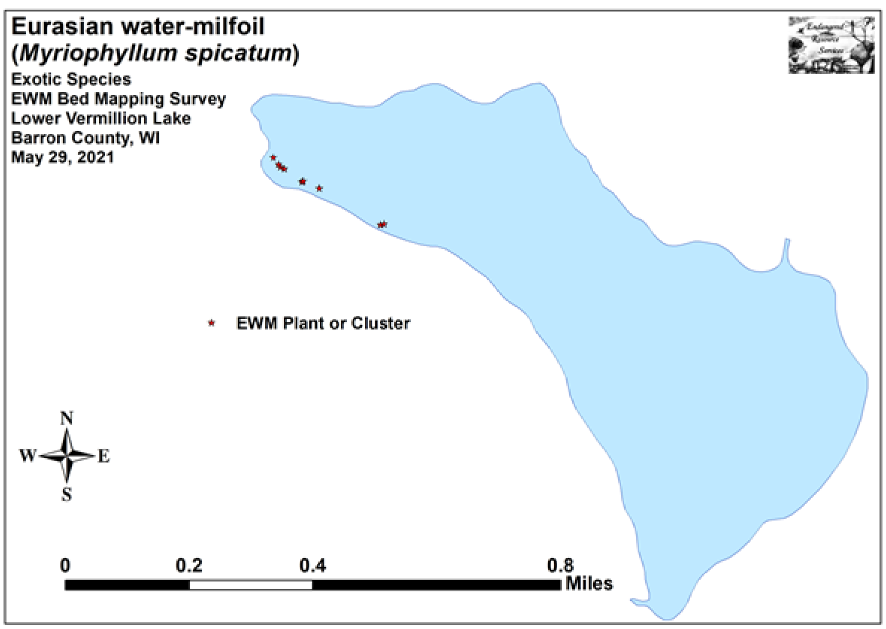

Figure 30. 2021 EWM Spring Bed Mapping Results (Berg, 2021)

The GPS coordinates of all EWM plants found during the 2021 spring bed mapping survey were shared with a SCUBA diver that was hired by the VLA in 2021 to do manual removal.

Over the course of the 2021 summer (June, July, & August), EWM was manually removed from six different areas on the lake (Figure 31). It was reported by Lutra Biological, LLC (the dive company) that they were able to remove almost all of the plants in the June and July dives, however Beds 1, 2, and 4 which were initially located in shallower areas of the lake, had spread outwards in August producing dense EWM in 6-12 ft of water where it was scattered among patches of Coontail. Because of this increase in density and distribution, Lutra reported that it would be “simply impossible" to remove all the plants found in the August dive.

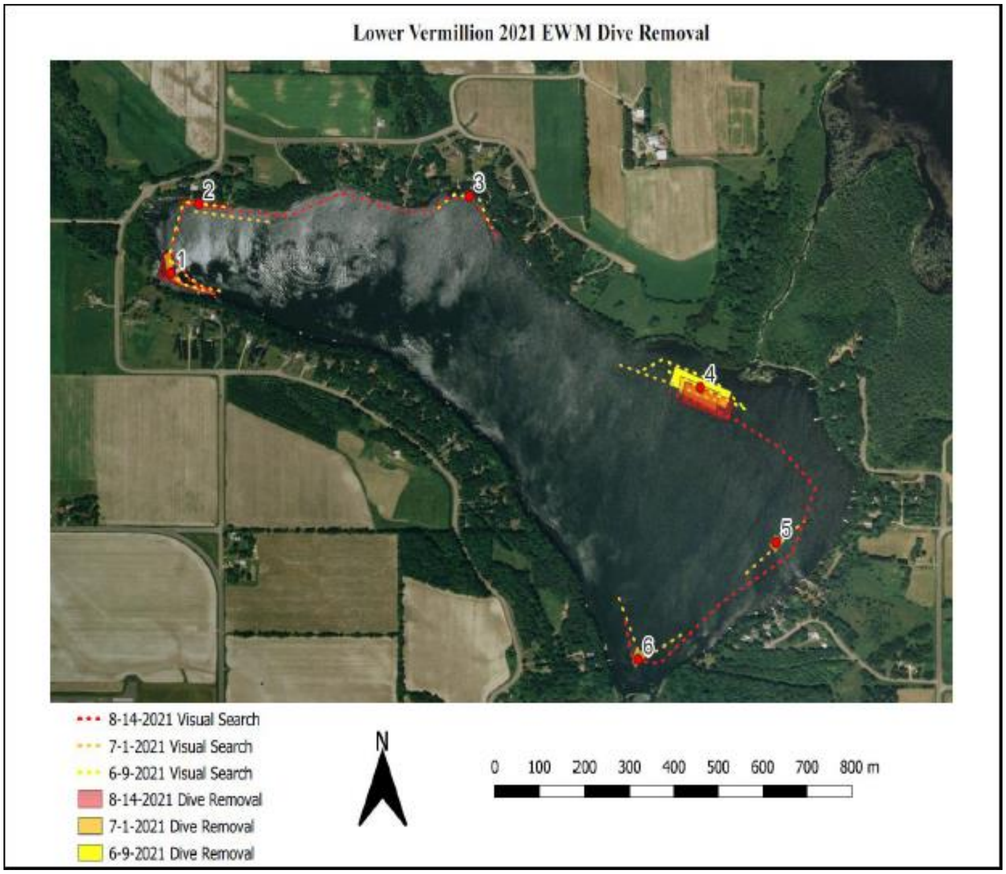

Figure 31. EWM Diver Removal Areas – June, July, and August (Berg, 2021a)

On September 26, 2021, following diver removal efforts in June, July, and August of 2021, a fall EWM bed mapping survey was completed to help determine the effectiveness of these efforts and to determine where active management might be considered in 2022. During this survey, 12.0 miles of transects within the lake’s littoral zone were searched for EWM. Water clarity was poor due to a significant algae bloom that limited visibility to 3-4 ft. Collectively, 10 small EWM beds totaling 0.72 acres were mapped. This was a significant increase over what was mapped in the spring of 2021, the fall of 2019, and the fall of 2017 (Figures 32&33).

Table 6 reflects fall EWM bed mapping results on Lower Vermillion Lake since it started in 2012.

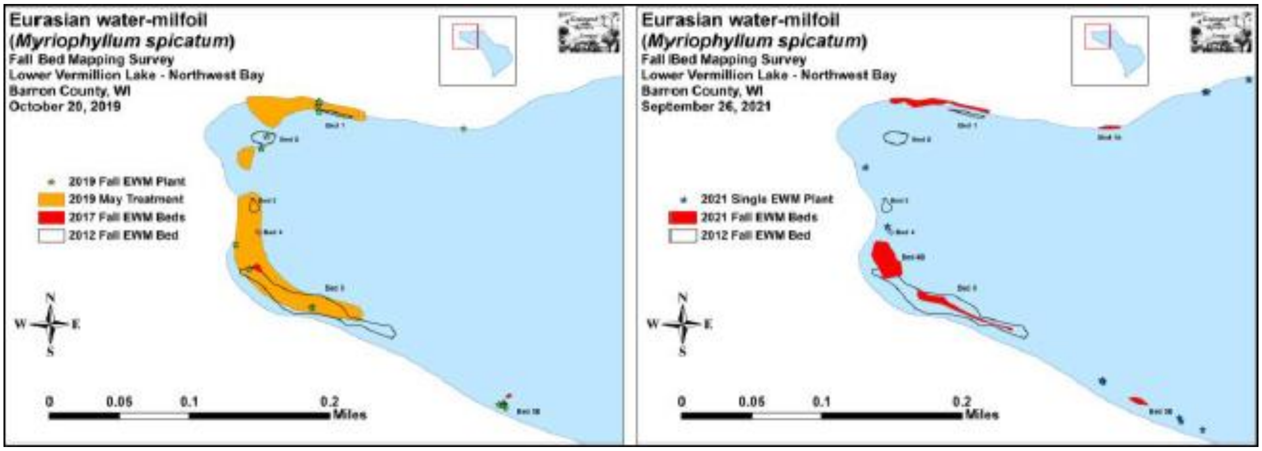

Figure 32. Fall 2019 and 2021 Close-up of EWM in the Northwest Bay (Berg, 2021a)

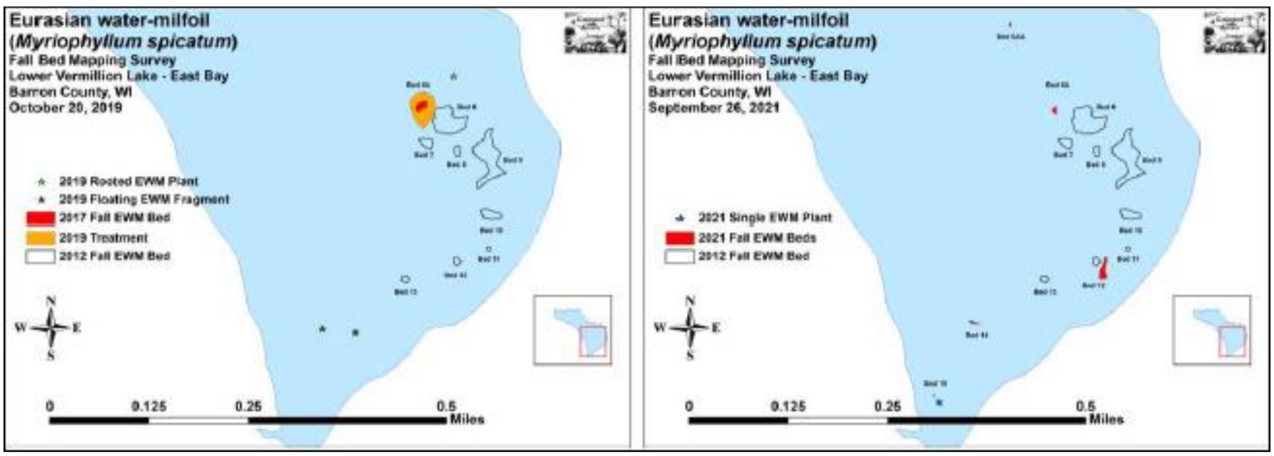

Figure 33. Fall 2019 and 2021 Close-up of EWM in the East Bay (Berg, 2021a)

Table 6. Fall EWM Bed Mapping Survey Summary – Lower Vermillion Lake (Berg, 2021a)

Bed Number	2021 Fall Bed Acreage	2019 Fall Bed Acreage	2017 Fall Bed Acreage	2016 Fall HDA Acreage	2015 Fall Bed Acreage	2014 Fall Bed Acreage	2013 Fall Bed Acreage	2012 Fall Bed Acreage	2019-21 Change in Acreage	Range and Est. 2021 Mean Rake	2021 Bed Characteristics And Field Notes
1	0.14	0	0	<0.01	0	0.01	0.02	0.02	0.14	<<<1-2; <1	Regular towers
1AA	0.02	0	0	0	0	0	0	0	0.02	<<<1-2; <1	Regular towers
2	0	0	0.17	0.21	0.47	0.39	0.43	0.07	0	<<<1	1 EWM plant – RR*
3	0	0	0.02	0	0	0.01	<0.01	0.03	0	0	No EWM found
4 and 4B	0.25	0	0.01	0	0.05	0.04	0	0.01	0.25	<<<1-3; 1	Regular towers
5	0.13	0	0.02	0.01	0.89	0.54	0.22	0.70	0.13	<<<1-1; <1	Scattered towers
5B	0.02	0	0.01	0.03	0.26	0.13	0	0	0.02	<<1-2; 1	Regular towers
6	0	0	0	0	0	0.06	0.04	0.68	0	0	No EWM found
6A	0.03	0	0.09	0	0	0	0	0	0.03	<<1-3; 2	Small, canopied mat
6AA	0.01	0	0	0	0	0	0	0	0.01	<1-3; 1	Regular towers
7	0	0	0	0	0.11	0.01	0	0.10	0	0	No EWM found
8	0	0	0	0	0	0	0	0.06	0	0	No EWM found
9	0	0	0	0	0	<0.01	0	0.80	0	0	No EWM found
10	0	0	0	0	0	0	0	0.14	0	0	No EWM found
11	0	0	0	0	0	0	0	0.01	0	0	No EWM found
12	0.10	0	0	0	0	0	0	0.05	0.10	<<<1-3; 1	Scattered dense towers
13	0	0	0	0	0	0	0	0.03	0	0	No EWM found
14	0.01	0	0	0	0	0	0	0	0.01	<<<1-3; 1	Regular towers
15	<0.01	0	0	0	0	0	0	0	<0.01	<<<1-2; <1	Regular towers – RR*
Total	**0.72**	**0.00**	**0.31**	**0.25**	**1.77**	**1.18**	**0.71**	**2.70**	**+0.72**		

Eurasian Watermilfoil Management History

EWM was first discovered within Lower Vermillion Lake in the summer of 2008. This discovery resulted in the creation of the VLA to combat this new threat to the lake. In the fall of 2008, the newly formed VLA authorized a manual diver removal effort as well as an herbicide application for approximately 2.7 acres on the western shoreline adjacent to the boat landing. Since that time, the VLA has used an integrated approach to managing EWM that included the use of herbicides (liquid and granular), physical removal (rake and diver), and Diver-Aided Suction Harvest (DASH) in 2022.

From 2013 to 2021, the amount of bed-forming EWM visible in the lake during a fall survey did not exceed 2.0 acres. This record is attributed to the multiple years of EWM management using aquatic herbicides augmented by some individual property owner physical removal. The use of herbicides to control EWM has only caused a documented decline in one native species – Northern watermilfoil. Table 7 reflects EWM management efforts prior to the last APM Plan that covered the years 2013-2017. Table 8 reflects EWM management efforts during the implementation of the last APM Plan that covered the years 2018-2022.

In 2020, after several years of effective EWM management had reduced the amount of visible, bed-forming EWM to “zero” based on 2019 fall bed mapping, the VLA and their consultant decided to forego any use of herbicide to instead focus on physical removal aided by a scuba diver. The diver spent the better part of three days – one each in June, July, and August of 2021 completing physical removal. Diver removal worked well in June and July, but by August, EWM in at least three of six areas that were dived on (Figure 31) had reached underwater levels far greater than could be removed by a diver. Fall bed mapping in 2021 showed that EWM may have been reduced in some areas, but it was still found in abundance in all areas. Much of this EWM was in deeper water and would not have been expected to reach the surface. Poor water quality conditions in September 2021 when the fall survey was completed also hampered the documentation of greater areas of visible EWM.

During diver removal in August of 2021, it also became clear that diver removal alone was not going to “control” all the EWM, so a chemical treatment plan was drawn up for 2022 based on diver documentation of EWM. A new AIS Control grant was also applied for to support chemical management in 2022. The grant-funded project was not awarded and the 2022 chemical treatment permit was denied. As a result, the VLA contracted with a company that provides Diver Assisted Suction Harvest (DASH) to remove EWM in 2022. The service was contracted for four full days of harvest.

In their final report for DASH services in 2022, the contractor stated the following:

“This area of the lake presented serious challenges to the dive team. This area contained the largest/densest EWM growth in the entire lake. The EWM growth was embedded within extremely dense native aquatic plant colonies, which greatly reduced the efficiency and effectiveness of the DASH efforts. There was a very high number of fragments present on the lakebed, scattered in and around the native plant growth. The native plant density prevented the dive team from being able to remove a significant amount of these fragments. Due to the obscured fragments, it is reasonable to assume that regrowth and possible expansion of these colonies in 2023 is likely. Overall, when considering the goal of year-to-year reductions in EWM density/distribution, DASH does not seem to be the most suitable management technique for this area of the lake.”

These comments pertained specifically to the EWM beds on the west side of the lake on both the north and south shorelines. DASH removal on the east side of the lake was much more efficient and complete. Based on this, it is unlikely that DASH alone will be able to maintain small localized beds, at least in the west side of the lake. DASH services will likely continue to be used on the east side of the lake and to do "clean-up" after management with aquatic herbicides in the west side of the lake.

Table 7. EWM management in Lower Vermillion Lake prior to the last APM Plan

Year	# of Beds	Total Area Treated (acres)	Range of Bed Size	Herbicide	Concentration	Results- AIS	Results- Native Plants	Grant Funding Support
2011	1	0.44	NA	Granular 2,4-D	200 lbs/acre	Slight decrease in EWM growth based on fall bed mapping	NA - no post-treatment survey completed	EDRR
2012	1	1.30	NA	Granular 2,4-D	3.0 ppm	EWM discovered in the East Basin	No significant changes	EDRR
2013	7	8.16	0.03-3.16	Liquid 2,4-D Granular 2,4-D	3.0 ppm 4.0 ppm	EWM- Significant decrease	Northern watermilfoil- significant decrease, Small and Clasping-leaf pondweed- Significant increase, All other- No changes	EDRR
2014	2	4.34	1.22-3.12	Liquid 2,4-D Granular 2,4-D	3.0 ppm 4.0 ppm	No significant changes	White-stem pnodweed- Signifincant decrease, Significant increases in 6 other species	EDRR
2015	2	1.63	0.67-0.96	Granular 2,4-D	3.0-3.5 ppm	No significant changes	NA - No pre/post treatment survey completed	None
2016	4	3.00	0.32-1.44	Liquid 2,4-D Granular 2,4-D	3.5 ppm 4.0 ppm	Highly effective	NA - no pre/post treatment survey completed	None
2017	3	1.51	0.10-0.96	Granular 2,4-D	4.0 ppm	EWM in treated areas gone, with plants still present outside of treated area	NA - no pre/post treatment survey completed	None

Table 8. EWM Management in Lower Vermillion Lake during the last APM Plan

Year	# of Beds	Total Area Treated (acres)	Range of Bed Size	Herbicide	Concentration	Results- AIS	Results- Native Plants	Grant Funding Support
2018	2	4.54	0.67-3.87	Liquid 2,4-D Granular 2,4-D	3.0 ppm 4.0 ppm	EWM- decreased from 1 point, 13 visuals (pre) to 1 point, 0 visuals (post); fall bed mapping was not done	slight decrease in NWM	ACEI
2019	4	1.21	0.1-0.67	Liquid 2,4-D Granular 2,4-D	4.0 ppm 3-4.0 ppm	1point, multiple visuals (pre), 2 points, fewer visuals (post); Fall EWM bedmapping - no beds 24 individual plants	no decline is any species as a result of EWM treatment	ACEI
2020	2	4.64	1.08-3.56	Liquid 2,4-D	4.0 ppm	1point, multiple visuals (pre), 1 points, fewer visuals (post); No fall EWM bedmapping	significant decrease in NWM	ACEI
2021	Diver Removal (6 beds)	NA	NA	NA	NA	Little to no impact, all areas where diving took place had EWM in the fall. Three of the six beds had too much EWM to effectively remove with divers. Fall bed mapping - 10 beds 0.72 acres	no decrease in any plant species	ACEI
2022	DASH Removal (Chemical treatment was proposed and denied)	TBD	TBD	NA	NA	Lots of EWM around the lake in a June survey. Late season yet TBD	TBD	ACEI

Curly-leaf Pondweed Management History

Curly-leaf pondweed (CLP) has been present in Lower Vermillion Lake longer that EWM. Generally, there are several areas that are impacted by dense growth CLP – the west end (2016 & 2021), the area adjacent to the Vermillion River inlet from Upper Vermillion Lake (2009, 2016, & 2021), and in areas of the east basin (2016 & 2021) (Figures 34-36).

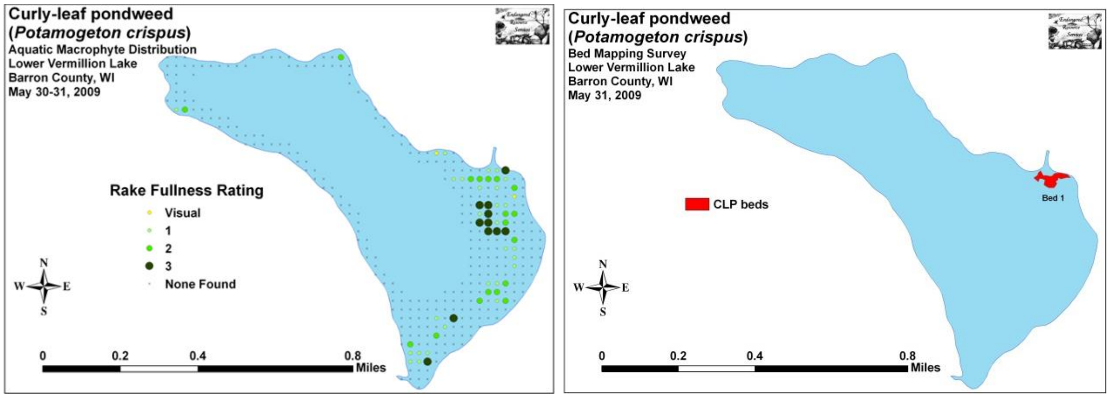

Figure 34. 2009 CLP PI and Bed Mapping Survey Results

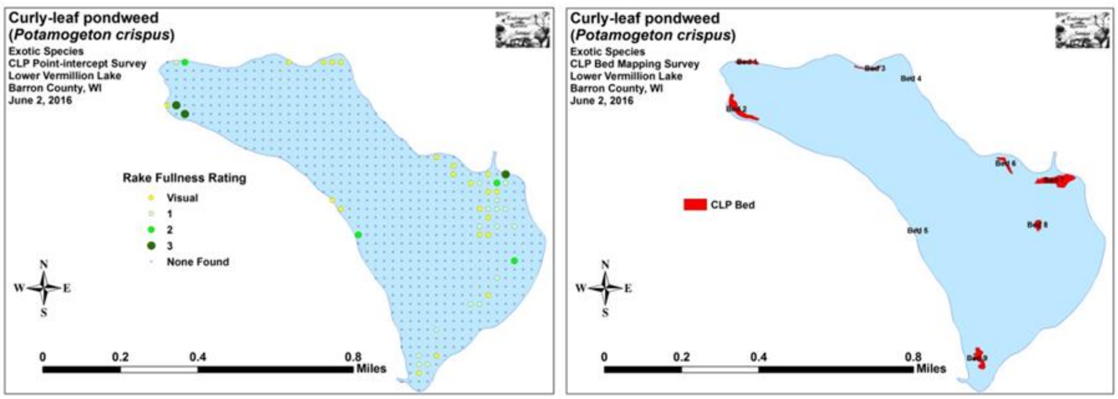

Figure 35. 2016 CLP PI and Bed Mapping Survey Results

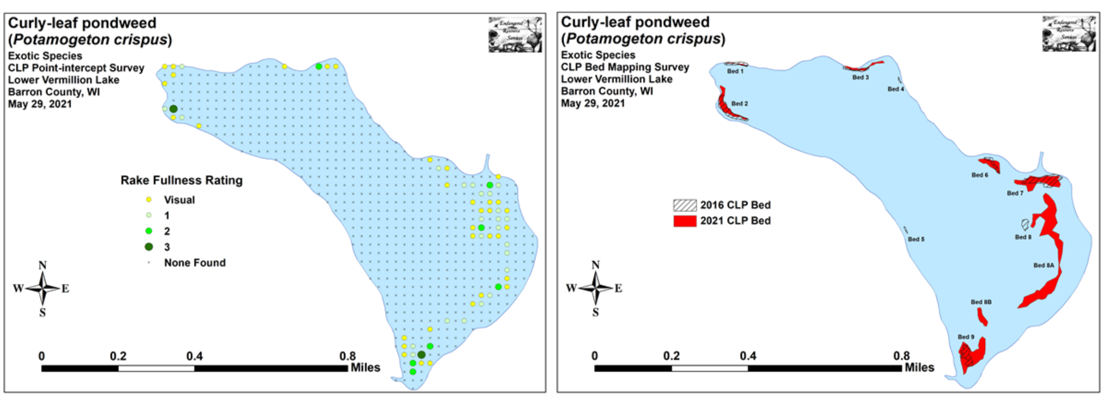

Figure 36. 2021 CLP PI and Bed Mapping Survey Results

Included in the last APM Plan for Lower Vermillion Lake (2018-2022) was CLP management using herbicides. When using herbicides to control CLP, it is recommended by the State to treat at least three years in a row in order to reduce the number of turions produced each year. Chemical management of CLP was completed over three years (2018-2020) using both liquid and granular endothall (Table 9). In the first two years of active management, the CLP treatments were very effective at reducing the amount of CLP in the lake. However, the third year of chemical treatment was not effective, with more CLP being found post-treatment than was present during the pre-treatment survey. The best explanation for this lack of success in the third year is treating too early based on the level of CLP growth (Figure 37). These results are reflected in the 2021 survey results, when the amount of CLP in the lake reached a high with 8 beds covering 10.85 acres or 5.0% of the lake's surface area documented. However, 2021 was a year where CLP growth was excessive across northern Wisconsin. No CLP management has been completed since 2020.

Table 9. CLP Management under the guidance of the 2018-22 APM Plan

Year	# of Beds	Total Area Treated (acres)	Range of Bed Size	Herbicide	Concentration	Results- AIS	Results- Native Plants	Grant Funding Support
2018	3	2.65	0.56-1.42	Liquid endothal Granular endothal	2.0 ppm 2.0 ppm	CLP in the treated areas disappeared	Flat-stem pondweed and small pondweed decreased	ACEI
2019	4	2.62	0.3-1.15	Liquid endothal Granular endothal	2.5 ppm 4.0 ppm	CLP in the treated areas disappeared	Flat-stem pondweed decreased	ACEI
2020	3	2.26	0.49-1.12	Liquid endothal	2.0 ppm	CLP in the treated areas increased (treatment less effective)	no decrease in any plant species	ACEI
2021	NA	NA	NA	NA	NA	NA	NA	NA
2022	NA	NA	NA	NA	NA	NA	NA	NA

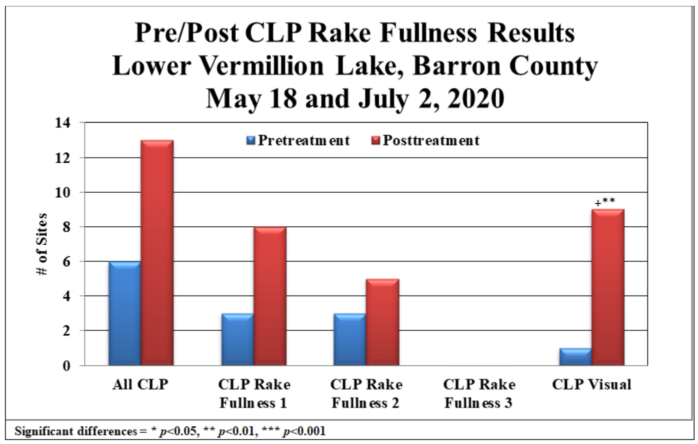

Figure 37. 2020 Pre and Post-Chemical Point-intercept Survey Results

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 38). 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.

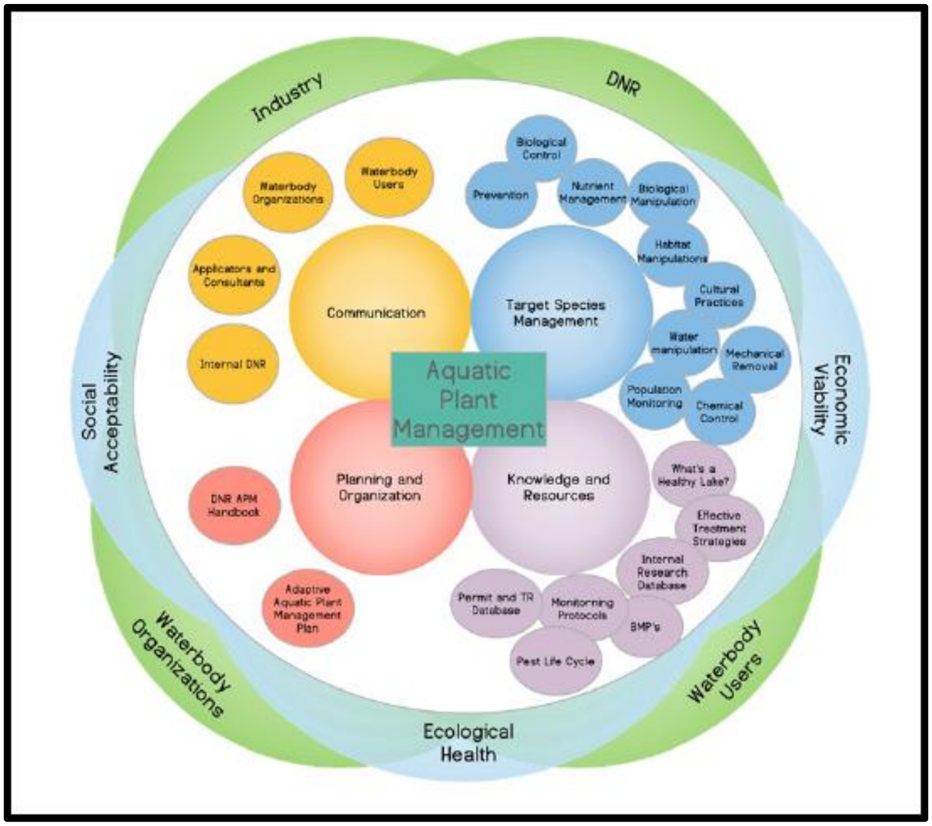

Figure 38: Wisconsin Department of Natural Resources: Wisconsin Waterbodies – Integrated Pest Management March 2020

Aquatic Plant Management Alternatives

Protecting native plants and limiting CLP and EWM through IPM is a primary focus of plant management in Lower Vermillion Lake due to its diverse plant community and the benefits it offers. 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 IPM 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 both CLP and EWM using a rake or through hand-pulling will be completed by educated landowners who monitor their own shorelines or by a trained AIS Management Team sponsored by the VLA. There is no limit to how much CLP and EWM can be physically removed from the lake and it does not require a permit under most circumstances. Landowners should continually monitor near their docks and swimming areas in the open water season and remove rooted CLP and EWM plants as well as floating fragments that wash into their shoreline. Native vegetation can only be cleared without a permit in an area up to 30-ft wide and adjacent to a property owner's dock, but the area can reach out into the lake as far as necessary to get to the nuisance vegetation. Physical removal using a rake or through hand-pulling has essentially no cost and can be practiced by many lake residents. It can however, be labor intensive, particularly when tackling large areas of CLP and EWM.

Pulling CLP and/or 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 VLA volunteers and/or resource professionals retained by the VLA. These efforts will focus on smaller beds not treated with chemical herbicides in areas not directly adjacent to any landowner's property.

Diver Assisted Suction Harvest: Recommended

Diver Assisted Suction Harvesting (DASH) is a hand removal method that requires a diver to handfeed the offending vegetation into an underwater suction tube once removed from the lake bottom. DASH is considered mechanical harvesting as it requires the assistance of a mechanical system to implement (Figure 38). DASH increases the ability of a diver to remove the offending vegetation from a larger area, faster, but also requires a Mechanical Harvesting permit from the WDNR. The cost to implement DASH is also more expensive than employing a diver alone. A DASH boat consists of a pontoon boat equipped with the necessary water pump, catch basin, suction hose, and other apparatus (Figure 39). Estimates made to build a custom DASH boat range from $15,000.00 to $20,000.00. Contracted DASH services usually run in the $2,000.00 to $3,000.00 per day range.

Removal of EWM using DASH was completed in large-scale in 2022 on Lower Vermillion Lake. A contracted DASH service spent four days in July removing EWM from Lower Vermillion Lake. The DASH crew removed 168 large onion bags of EWM from the lake for a total of about $12,000.00. Unfortunately, a lot of EWM was missed or has already come back in the areas where DASH was implemented.

Figure 39. DASH – Feeding EWM into the underwater Suction Hose (Marinette Co.); and a sample DASH Pontoon Boat (Beaver Dam Lake Management District)

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 or DASH 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.

Characteristics like the size, depth, location, and density of aquatic vegetation directly impact how effective the use of aquatic herbicides can be. Spring application of herbicides is preferred to reduce negative effects on native plants and fish habitat. Larger areas respond better to chemical treatments than do small areas. Deep water and shallow water on the edge of deeper drop-offs will require differing amounts of herbicides to be effective than will shallow flats. Most important for the use of an aquatic herbicide is how long it is expected that the herbicide will be in contact with the target plant species. Shorter contact times require higher concentration of herbicide, some form of artificial containment system to hold the herbicide in place longer, and/or perhaps a different type of herbicide altogether. Where longer contact times are possible, herbicide concentrations can be less, an artificial containment area may not be needed, and there are more herbicide choices.

Application of herbicide requires a Chemical Application permit from the WDNR. It is illegal in WI to put any chemical into the waters of the state without a permit, no exception. Herbicides must be applied by a licensed applicator. It is possible for a member of a lake organization to complete the requirements to become a licensed applicator, but in most cases, the lake organization will contract with a company specializing in herbicide application.

There are several chemical herbicide options currently available in the State of Wisconsin (as approved by the Environmental Protection Agency). There are two classes of aquatic chemical herbicides currently in use:

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.

Micro and Small-scale Herbicide Application

The determining factor in designating chemical treatments as micro or small-scale is the size of the area being treated. Small-scale herbicide application involves treating areas less than 10 acres in size. The dividing line between small-scale and micro treatments is not clearly defined, but is generally considered to be less than an acre. Small-scale chemical application is usually completed in the early season (April through May). Recent research related to micro and small-scale herbicide application generally shows that these types of treatment are less effective than larger scale treatments due to rapid dilution and dispersion of the herbicide applied. Some suggested ways to increase the effectiveness is to increase the concentration of herbicide used, use a contact herbicide like diquat that does not require as long a contact time to effective, or in some manner contain the herbicide in the treated area by artificial means such as installing a limno-barrier or curtain.

Small-scale Limno-Barrier Application

Small-scale herbicide applications can be made more effective by installing a limno-barrier or curtain around a treatment area to help hold the applied herbicide in place, longer. By doing so, the herbicide/target species contact time is increased. The curtain is generally a continuous sheet of plastic that extends from the surface to the bottom of the lake (Figure 40). The surface edge of the curtain is generally supported by floatation devices. The bottom of the curtain is held in place by some form of weighting. The curtain or barrier, sometimes thousands of feet of it, is installed around the proposed treatment area with the purpose of holding the herbicide in place longer by preventing dilution and drift away from the treated area (Figure 41).

Figure 40. Limno-curtain material on a roll before installation (photo from Marinette Co. LWCD)

Figure 41. Limno-curtain installed on Thunder Lake (photo from Marinette Co. LWCD)

In the Thunder Lake, Marinette County limno-curtain trial completed in 2020, a curtain was installed around two small areas (0.9 and 2.9 acres) of dense growth EWM prior to chemical treatment. Liquid 2,4-D was applied at 4.0ppm inside the barrier. The barriers stayed in place until 48 hours after treatment. Herbicide concentration testing (see following section) was completed within the treated areas to determine how long the herbicide stayed in place and at what concentration. Figure 42 reflects what happened to the herbicide that was applied within the barrier in Thunder Lake. Herbicide concentrations stayed relatively high for a longer period of time (48 hrs). Once the curtain was removed, the herbicide dissipated rapidly. Similar studies have been completed on other lakes with similar results.

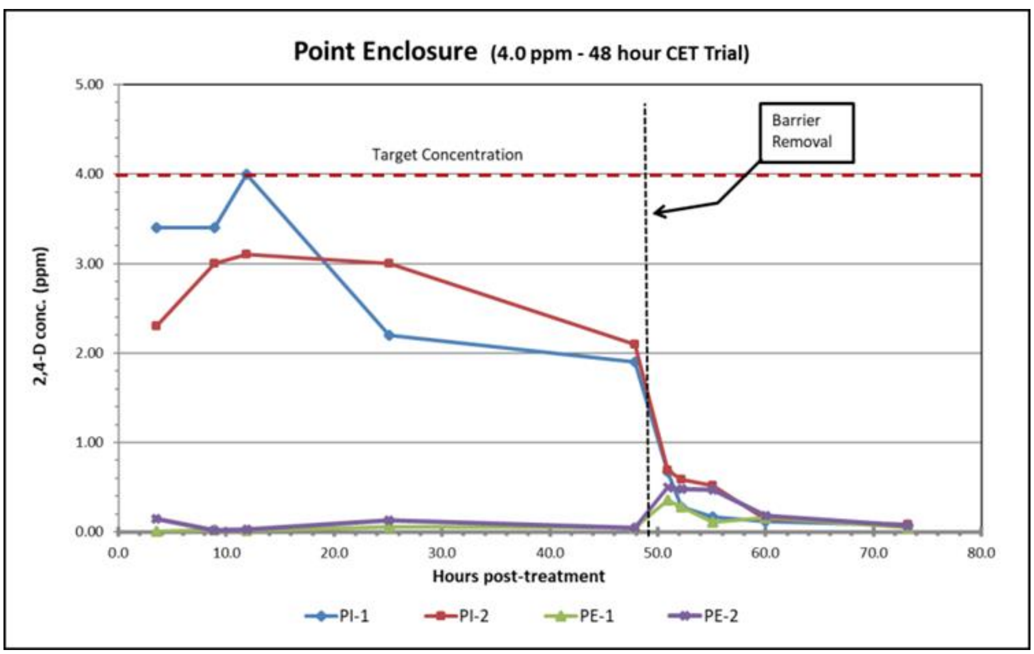

Figure 42. Herbicide concentration results from 2020 Thunder Lake limno-curtain trial (Marinette Co LWCD)

A limno-curtain of several hundred to a thousand feet in length could be used to surround smaller chemical treatment areas, particularly along the south, west, and north shore of the lake. To use a curtain for this purpose in Lower Vermillion would likely require that the curtain be moved to surround different treatment locations over a period of a week or more. As an example, a 1,000 foot limno-curtain was installed around 3 difference treatment areas, each about 2 acres in size, over a period of 10 days in Tomahawk Lake, Bayfield County in 2022. First one area was treated and the curtain left in place for 48 hours. Then the curtain was moved to surround the second treatment area, it was treated, and again the curtain was left in place for 48 hours. This process was repeated a third time before the entire proposed treatment was complete. The process was extremely time-consuming and required a substantial amount of volunteer and consultant help to make happen.

Large-scale Herbicide Application

Large-scale herbicide application involves treating areas more than 10 acres in size. Like small-scale applications, this is usually completed in the early-season (April through May) for control of non-native invasive species like CLP and EWM to minimize impacts on native species. It is generally accepted that lower concentration of herbicide can be used in large-scale applications as the likelihood of the herbicide staying in contact with the target plant for a longer time is greater. If the volume of water treated is more than 10% of the volume of the lake, or the treatment area is ≥160 acres, or 50% of the lakes littoral zone, effects can be expected at a whole-lake scale. Large-scale herbicide application can be extended in some lakes to include whole basin or even whole lake treatments. The bigger the treatment area, the more contained the treatment area, and the depth of the water in the treatment area, are factors that impact how whole basin or whole lake treatments are implemented.

Whole-Lake or Whole-Basin Herbicide Application

Whole-lake or whole-basin treatments are those where the herbicide may be applied to specific sites, but the goal of the strategy is for the herbicide to reach a target concentration when it equally distributes throughout the entire volume of the lake (or lake basin). The application rate of whole-lake treatments is dictated by the volume of water in with which the herbicide will reach equilibrium. Because exposure time is expected to be so much longer, effective herbicide concentrations for whole-lake treatments are significantly less than required for spot treatments. Whole-lake treatments are typically conducted when the target plant is spread throughout the majority of the lake or basin.

If the herbicide exposure time of the target aquatic plant can be extended, the concentration of the herbicide applied can be lowered. If the contact time between the applied herbicide and the target plant in a whole body of water or protected bay can be increased to, or is already expected to be several days to a week or more, the concentration of herbicide like 2,4-D can be in the range of 0.25-0.5 ppm instead of the 2-4 ppm that is typically used in small-scale, spot, or micro treatments.

Planning to treat the whole lake can be further designed to minimize the herbicide needed to affect the desired outcome. The method used to implement whole-lake treatments changes with the type of lake. Herbicide applied to a shallow, mixed lake is expected to mix throughout the entire volume of the lake. In deep water lakes that stratify, herbicide can be applied at such a time when it is expected that it will only mix with the surface water above the thermocline in an area known as the epilimnion.

All large-scale or whole-lake/whole-basin herbicide applications require a WDNR approved APM Plan, pre- and post-treatment aquatic plant surveying, and likely chemical concentration/residual monitoring.

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 protocol for pre and post treatment survey is applicable for chemical treatment of CLP and EWM.

The WDNR protocol assumes that an APM 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.

In the year prior to an actual treatment, the area to be treated must have a mid-season/summer/warm water point intercept survey completed that identifies the target plant and other plant species that are present. A pre-treatment readiness aquatic plant survey is done in the year the herbicide is to be applied, prior to application to confirm the presence and level of growth of the target species. A post-treatment survey should be scheduled when native plants are well established, generally mid-July through mid-August and can be done in the year following application. If treating CLP a post treatment survey needs to be completed before seasonal growth ends (i.e. mid-June). For the post-treatment survey, repeat the PI for all species in the treatment polygons, as was done the previous summer. For whole-lake scale treatments, a full lake-wide PI survey should be conducted.

Chemical Concentration Testing

Chemical concentration testing is often done in conjunction with treatment to track the fate of the chemical herbicide used. 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. It may also be required to determine if the herbicide stays clear of areas that should be protected from herbicide impacts (like in beds of wild rice). 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. Water samples are collected prior to treatment and for a period of hours and/or days following chemical application.

Chemical concentration testing has generally been required in Lower Vermillion Lake because of the presence of wild rice near the outlet of the lake and downstream of the lake on the Vermillion River.

Recommended Aquatic Herbicides for EWM

The following herbicides are recommended for control of EWM in Lower Vermillion Lake.

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 (4 hours), making it an effective control measure on smaller beds, 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. And while it is more expensive to use than 2,4-D equivalents, it has been shown to provide two or more years of control without re-application.

Triclopyr

Triclopyr is a selective, systemic herbicide used to control like EWM by mimicking plant hormones. Liquid triclopyr (Renovate®) or granular triclopyr combined with granular 2,4D (Renovate Max G®) may be an option for larger treatment areas, however neither triclopyr nor 2,4D based herbicides are recommended for small-scale (<5ac) EWM treatments as required contact times are often in the 16-24 hour range and difficult to attain due to dilution. It can be more effective if a limno-barrier is used. Triclopyr products are generally more expensive than 2,4D products.

2,4D (liquid)

2,4D is a commonly used systemic herbicide that targets plants like EWM. Shredder Amine 4®, also referred to as 2,4D Amine 4® is a liquid formulation of 2,4D. It has been successfully used on Lower Vermillion Lake to control EWM, and is a viable option again in the future if EWM beds that are included in a management plan reach or exceed several acres in size. Like triclopyr, 2,4D requires a contact time of 16-24 hours to be effective. And like triclopyr, it can be more effective is a limno-curtain is used.

ProcellaCOR, triclopyr, and 2,4D target dicot species or plants like EWM, Northern and other native milfoils, several related species, and lily pads. Monocot species like CLP, Flat-stem and other native pondweed are generally not affected by these herbicides.

It may be beneficial to alternate the use of different herbicides in an effort to reduce the ability of target plants to build up a resistance to an herbicide that is applied too often.

Recommended Aquatic Herbicides for CLP

The following herbicides have also been used effectively for control of CLP in Lower Vermillion Lake.

Endothall (liquid)

Endothall is a non-selective contact herbicide. As such, it is not species specific and will negatively impact any aquatic plant it comes in contact with. This herbicide is most often used to control CLP very early in the season when other native aquatic plants have not begun to actively grow. Like the herbicides used for EWM, how effective the treatment is depends on many characteristics including but not limited to depth, water movement, and size of the treatment area. Because it is a contact herbicide, at high enough concentrations it can also be used to manage EWM, but not generally by itself. It may be combined with an herbicide like 2,4D to treat CLP and EWM simultaneously. The manufacturer of Aquathol K, the most common trade name for an endothall based herbicide recommends that CLP treatment areas be at least 5.0 acres in size for the product to be effective.

Diquat (liquid)

Diquat is another non-selective herbicide that is commonly used to control emergent and submersed aquatic vegetation including CLP and EWM. It is faster-acting than endothall, triclopyr, or 2,4D but can have reduced effectiveness in water containing suspended sediment. Also, as a contact herbicide, it will negatively impact any aquatic plant species it comes in contact with – it is not species specific.

Each of the aquatic herbicides mentioned in the previous sections come with various restrictions for use. There may or may not be restrictions for swimming, fish, fish consumption, wildlife, irrigation, and/or drinking water. However, every one of the herbicide mentioned has been approved for control of vegetation in an aquatic setting by the Environmental Protection Agency and the WDNR. Working with an accredited applicator and/or a consultant specializing in aquatic plant management will help ensure those that could be affected by a chemical treatment will be informed.

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 is 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 Lower Vermillion Lake for CLP or EWM due to the risk of releasing EWM fragments and further spreading it throughout the lake.

Biological Control: Not Recommended

Biological control uses one or more living organisms to control, or suppress, another living organism. Milfoil weevils *Euhychiopsis 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. The milfoil weevil is native to North America and is likely present at some level in the lake. Survey work could be completed to determine their presence or absence, however attempting to artificially increase their population as a biological control method is not recommended.

Habitat Manipulation: Not Recommended

Habitat manipulation can take the form of flooding, dredging and drawdowns. None of these options are recommended or viable in Lower Vermillion Lake. Flooding and drawdowns are not possible because there are no water level control structures on or near the lake that could be used to manipulate the water levels. Dredging is not recommended for management of aquatic plants because the high-water quality and valuable habitat of the lake would be jeopardized by removing large quantities of substrate and bottom materials. However, dredging could be utilized to improve deteriorating conditions at the public landing on the lake.

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 Lower Vermillion Lake due to the potential for greater expansion of EWM in the lake and the negative implications it would likely have on both public and property owner use and access on the lake. CLP management is recommended, but is second to the management of EWM. If the two species can be managed together that would be best. Additionally, limiting the spread of CLP and EWM within the lake through management protects the ecological integrity of the lake long-term.

Aquatic Plant Management Discussion

Lower Vermillion Lake supports a valuable aquatic plant community and a quality fishery valued by the lake community and the general public. The lake currently has two non-native, invasive, aquatic plant species in CLP and EWM. Both of these species can and are creating nuisance conditions and navigational impairment throughout the open water season. They can, although to date the data doesn't reflect this, out-compete native aquatic plant species for distribution and density possibly reducing diversity within the lake. The main goal of this Aquatic Plant Management Plan is to control both CLP and EWM in the lake in a sound, ecological manner that continues to support lake use, but also prevents both the invasive species and the management done to control them from causing greater harm to the native aquatic plant community.

Because EWM continues to spread within Lower Vermillion Lake, it is imperative that property owners be aware of this and that they know what EWM looks like in the water. If property owners would survey the area of the lake immediately adjacent to their docks and boat lifts on a regular basis, and then physically remove offending plants when identified, spread and establishment can be reduced.

In general, small-scale herbicide application since 2010 has helped to keep EWM in check but it has not been successful at preventing it from re-growing in treated areas as it continues to move along the shorelines from west to east, and is now well established in areas of the larger and shallower east basin. WDNR data indicates that chemically treating small areas is less effective than treating larger areas, particularly when using 2,4D or triclopyr based herbicides. While EWM in these small-scale treated areas may be knocked down for a season, it is seldom knocked out for multiple seasons.

No management using aquatic herbicides has been completed since 2020 when a spring treatment that covered 4.64 acres was completed. The 2020 chemical treatment successfully reduced the amount of EWM in the lake to just a few individual plants. As a follow-up to the successful herbicide treatment, a WDNR control of an established infestation grant was applied for and awarded starting in 2021 to complete diver removal. Diver removal was completed on several dates in in 2021, but the amount of EWM identified in the 2021 fall survey still reached 0.72 acres. As mentioned, while the divers were underwater in 2021, they discovered enough additional EWM that had not reached the surface to prompt a request for management using aquatic herbicides in 2022. This request was denied by the WDNR because the parameters of the treatment proposal did not meet the criteria that was in the existing APM Plan.

As a result, the VLA contracted with a DASH service in 2022 to provide 4 days of diver-assisted suction harvest. In these four days 168 large onion bags were filled with EWM removed from the lake (Figure 44). The total acreage covered by the DASH divers was estimated to be around 1.5 acres.

Figure 43: Onion bags full or EWM pulled from Lower Vermillion Lake

The area covered by the DASH divers does not represent that area of the lake where the EWM present actually makes it to the surface or close enough to the surface such that it can be identified in a bedmapping survey. Deep water, poor water clarity, and EWM plants that are sparsely spread through a larger area teaming with native aquatic vegetation all make it difficult to accurately map these areas.

EWM Management

From 2011 to 2022, EWM bedmapping surveys have identified on average, 8 beds of EWM per year, with a low of no beds in 2019 and 2020 when only individual points with EWM were mapped, to a high of 20 beds in 2022 (Table 10). The individual sizes of these beds ranged from <0.01 to 1.14 acres, with a mean size of 0.52 acres.

Table 10: 2011 to 2022 EWM beds based on fall bed-mapping surveys

2011 to 2022 Fall EWM Beds				
Year	# of Beds	Max Bed Size (acres)	Mean Bed Size (acres)	Beds (acres)
2011	2	0.49	0.42	0.84
2012	13	0.8	0.21	2.7
2013	5	0.43	0.14	0.71
2014	9	0.54	0.13	1.18
2015	5	0.89	0.35	1.77
2016	4	0.21	0.06	0.25
2017	7	0.09	0.05	0.31
2018	4	0.31	0.23	0.53
2019	NA	NA	NA	NA
2020	NA	NA	NA	NA
2021	10	0.25	0.07	0.72
2022	20	1.14	0.12	2.4
MEANS	**8**	**0.52**	**0.18**	**1.14**

Under the following recommendations, EWM management can and should occur when any amount of EWM is found, even just individual plants.

Physical Removal and/or DASH to Control EWM in Lower Vermillion Lake

Physical methods, including hand-pulling, rake removal, snorkel, divers, and/or diver-assisted suction harvest (DASH) can be implemented at any time for any amount of EWM. Hand-pulling rake removal, snorkel, and diver removal of EWM does not require a permit to implement. Implementation of DASH requires a mechanical harvesting permit from the WDNR. Implementing hand-pulling, rake removal, snorkel, diver, and/or DASH removal of EWM will depend only on the resources, financial and human, available to the VLA in any given year. These management alternatives can be used in any combination to remove EWM from the lake regardless of the size of the bed.

Herbicide Use to Control EWM in Lower Vermillion Lake

While it appears that since the first whole-lake PI survey in 2009, the aquatic plant community as a whole has suffered a decline in quality, it is difficult to determine if either of the invasive species in the lake or the management of those species caused this decline. The species with the greatest decline in the number of points where each was found from 2009 to 2021 are Flat-stem pondweed (-111), Northern watermilfoil (-37), Friess pondweed (-36), Coontail (-30), and Clasping-leaf pondweed (-27). While it is possible that EWM treatments using 2,4-D based herbicides could have negatively impacted Northern watermilfoil and coontail, the other three are not supposed to be impacted by the use of this herbicide. It is also possible that the three pondweeds could have been negatively impacted by the endothall based herbicide that was used to control CLP. However, chemical treatments using both of these herbicides have been limited over that time, and not completed at all since 2020. It is also difficult to determine if the amount of CLP or EWM in the lake is negatively impacting native aquatic vegetation because management actions have kept EWM below 1.0 acres in all but four of the last 12 years.

The use of aquatic herbicides in tandem with physical removal by property owners and divers, and DASH has and will continue to keep EWM at very low levels and under control on Lower Vermillion Lake. There is no undeniable proof that the use of these herbicides is having a significant negative impact on native aquatic vegetation. The use of herbicides will be limited in nature and used only when the level of EWM in a given area exceeds what is effectively managed by other means. Through careful management planning that includes abundant aquatic plant surveys, appropriate timing, and calculated herbicide application rates, the current use of aquatic herbicides can be continued without negatively impacting native aquatic vegetation, while at the same time minimizing possible negative impacts of EWM to the lake.

Herbicides that are 2,4-D or triclopyr-based, and ProcellaCOR can be used effectively to control EWM in Lower Vermillion Lake. Herbicides that are 2,4-D based have been already been used in the lake. Triclopyr and ProcellaCOR have not. With the knowledge of management using herbicides that exists right now, ProcellaCOR is likely the best alternative for all treatment areas. In larger-scale (>5 acres) applications the cost of ProcellaCOR might be somewhat restrictive so it might be feasible to consider other herbicides. Using different herbicides at different times may actually improve efficacy as there is some research that suggests EWM can build up a resistance to herbicides that are used repeatedly in the same areas at the concentrations traditionally used for submerged aquatic plant control (Poovey, 2007) (Glomski, 2010).

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

1) 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.
    a. Non-chemical management actions include hand pulling, rake removal, and snorkel/scuba diver removal, and/or DASH removal.

   b. DASH is considered mechanical removal, is more expensive than diver removal, and requires a WDNR permit.
3) Chemical management of EWM may be implemented if prior year bed mapping identifies a single bed of EWM that is at least 1.0 acres in size, or if two or more smaller areas can be reasonably combined to create an area at least 1.0 acres in size.
   a. An individual bed or combination of beds can be chemically treated if it is at least 1.0 acres in size and ProcellaCOR is the intended herbicide.
   b. If 2,4-D based herbicides are to be used, the size of the treatment area must be at least 5.0 acres in size.
   c. Using herbicides on smaller areas will only be done if certain herbicides, like ProcellaCOR, are approved for smaller treatment areas by the WDNR, or if a limno-curtain is deployed during a proposed chemical treatment.
4) Herbicides applied to EWM beds that reach or exceed 10.0 acres or 10% of the littoral zone will be considered large-scale chemical treatments. With a large-scale chemical treatment, the following activities will be added in support of that treatment.
   a. Pre and post-treatment, point-intercept surveys will be completed.
   b. Herbicide concentration testing will be completed unless deemed unnecessary by the WDNR.
5) The same area will not be chemically treated with the same herbicide, two years in a row.

Curly-leaf Pondweed Management

CLP is widespread in Lower Vermillion Lake and has likely been there for many years prior to the introduction of EWM. The amount of CLP growth is highly dependent on the growing conditions each spring. For example, spring growing conditions in 2021 were exceptional for CLP in northern Wisconsin leading to more than 10.0 acres in Lower Vermillion Lake. In other years, the amount of CLP in the lake may only be a couple of acres. The density of the CLP changes with the type of growing season as well.

Because dense growth CLP is located in the same areas of Lower Vermillion Lake that EWM has been identified and treated, and because research indicates that when different herbicides are combined to manage CLP and EWM simultaneously, there can a synergistic effect that can lead to better results with lower concentrations of both herbicides Madsen et al (2010); and because reducing the amount of CLP in Lower Vermillion Lake may improve lake health, combining CLP and EWM treatments using different herbicides should be considered if resources are available. If endothall-based herbicides are planned, the area must be at least 5.0 acres in size.

Harvesting of CLP is not a recommended management action simply because of the amount of EWM present in the same areas as the most problematic CLP. Mechanical harvesting of EWM is also not a recommended management action. Mechanical harvesting, in its truest form, would only serve to increase the amount of EWM fragments already moving around in the lake.

DASH can be an effective management tool for CLP. DASH removal of both CLP and EWM could be completed if it were done earlier in June or even late May.

In general, CLP management in Lower Vermillion Lake will be based on the following criteria.

1) June bed mapping must be completed in the year prior to a planned chemical treatment.
2) Any amount of CLP in the lake can be managed at any time if chemical management is not used.
   a. Non-chemical management actions include hand pulling, rake removal, and snorkel/scuba diver removal, and/or DASH removal

b. DASH is considered mechanical removal, is more expensive than diver removal, and requires a WDNR permit.

3) Chemical management of CLP may be completed if prior year mapping identifies any area that is ≥5.0 acres, mixed in with EWM or stand-alone.
    a. A WDNR permit is required.
    b. Treatment should be completed no later than late May (weather and water temperature related).
    c. Endothall-based herbicides should be used.
    d. Applied herbicide concentrations should be based on current research and existing lake characteristics.
    e. Consecutive years of CLP management in the same area are acceptable, but not required.
        i. Multiple years of CLP management in the same areas is often recommended to reduce the number of viable turions in the sediment underneath the target areas.
    f. Installation of a limno-barrier can make these treatments more effective, and may allow smaller treatments to be completed.

Overuse of Aquatic Herbicides

Concerns exist when chemical 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), fish and other wildlife might possibly be affected, and concerns over recreational use in chemically treated water may be raised. By using several different aquatic herbicides interspersed with physical removal efforts between treatments, many of these concerns are minimized.

Aquatic Plant Management Plan

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

1. **EWM Management.** Limit the spread of EWM and its impacts on the native aquatic plant community and lake use through environmentally responsible management methods.

2. **CLP Management.** Limit the spread of CLP and its impacts on the native aquatic plant community and lake use through environmentally responsible management methods.

3. **Education and Awareness.** Continue to educate property owners and lake users on aquatic invasive species through public outreach and education programs to help contain EWM within the lake and prevent its spread further in the lake, as well as to other water bodies.

4. **Research and Monitoring.** Develop a better understanding of the lake and the factors affecting lake water quality through continued and expanded monitoring efforts.

5. **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

An integrated management approach 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. The overall goal for EWM management is to minimize the number and size of EWM beds identified in a fall survey. Any EWM can be managed. When beds of EWM are at least an acre in size, the use of herbicides can be considered. EWM management options to be utilized include small-scale physical removal, diver removal, DASH, targeted use of aquatic herbicides through small and large-scale application, and possibly whole-lake/basin application of herbicide.

To monitor changes in the amount of EWM in the system, late season bed mapping surveys should be completed annually.

Pre and Post Treatment Survey and Fall Bed Mapping

Management of EWM will be based on pre- and post-treatment surveys or management readiness surveys performed by either trained VLA volunteers or resource professionals retained by the VLA. Pre and post-treatment surveys are point-intercept based. A pre-treatment survey is best completed in the year prior to the 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 or is a smaller area being funded in part by a WDNR grant. 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 treatment proposal and are recommended in any year chemical treatment is to occur.

Bed mapping or reconnaissance surveys are completed in the 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. Using bed mapping survey data, proposed treatment maps can be created.

Herbicide Concentration Testing

Regardless of the size of a treatment area and the herbicide used for management of CLP or EWM, collecting herbicide concentration data is one way to track how the herbicide "acts" in the lake. With the presence of Northern wild rice in the lake and immediately downstream in the Vermillion River it is likely the WDNR at the request of St. Croix Tribal Resources will require concentration testing as a part of every proposed herbicide application. Concentration testing also provides a way to determine if the expected application concentrations were met and for how long a measureable amount of the herbicide remained in the water.

Goal 2. CLP Management

CLP continues to be a nuisance in Lower Vermillion Lake and has the potential to negatively impact native aquatic plants and water quality. There are likely many contributing factors to an apparent worsening of water clarity in the lake and an abundance of CLP that dies and decays in early July could be one. Dense growth CLP in certain areas of the lake also creates navigation impairment. An overall goal for CLP management in Lower Vermillion Lake is to keep the amount of CLP that can be mapped below 5.0 acres of the littoral zone in any given year. CLP management options that can be utilized include small-scale physical removal, diver removal, DASH, and targeted use of aquatic herbicides when an individual CLP bed reaches or exceeds 5.0 acres. Pre- and post-treatment aquatic plant surveys and/or readiness surveys and herbicide concentration testing will be considered under the same guidelines in place for EWM.

To monitor changes in the amount of CLP in the system, early season bed mapping surveys should be completed annually.

Other AIS will continue to be monitored for, but no specific management is recommended at this time.

Goal 3. Education and Awareness

Aquatic invasive species (AIS) can be transported via a number of vectors, but most invasions are associated with human activity. Maintaining signs and continuing watercraft inspection at the public boat landing should be done to educate lake users about what they can do to prevent the spread of AIS.

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 VLA 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 recommended that the VLA 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. Furthermore, it is recommended that the VLA continue to tie AIS and lake health to the condition of the shoreland around the lake and the watershed of the lake. Shoreland and habitat improvement projects reduce runoff into the lake, provide greater habitat that may be more resistant to the invasion of AIS, and help maintain water quality.

Helping property owners understand how their activities impact the aquatic plants and water quality of the lakes is crucial to fostering a responsible community of lakeshore property owners. The VLA should distribute, or re-distribute informational materials and provide educational opportunities on aquatic invasive species and other factors that affect Lower Vermillion Lake. At least one annual activity (picnic at the lake, public workshop, guest speakers, etc.) should be sponsored and promoted by the VLA that is focused on AIS.

Goal 4. Research and Monitoring

Long-term data can be used to identify the factors leading to changes to water quality, such as aquatic plant management activities, changes in the watershed land use, and the response of the lakes to environmental changes. The CLMN Water Quality Monitoring Program supports volunteer water quality monitors across the state following a clearly defined schedule. In the first level of the program, Secchi disk readings are encouraged 2-3 times a month from ice out to ice on. In the CLMN expanded monitoring program, water samples are collected for analysis of TP two weeks after ice out, and once each in June, July and August. Water samples are collected and processed for chlorophyll-*a* once each in June, July, and August. Temperature profiles are encouraged anytime a Secchi reading is taken, but recommended to be done at the same time water samples for TP and chlorophyll-*a*. If the necessary equipment is available to collect dissolved oxygen profiles these are encouraged at least monthly as well.

Lower Vermillion Lake is included in the CLMN expanded monitoring program. This involvement will continue through the duration of this plan. 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.

To monitor any changes in the plant community, it is recommended that whole-lake point intercept aquatic plant surveys be completed at five-year intervals. This will allow managers to adjust the APM Plan as needed in response to how the plant community changes as a result of management and natural factors like water level.

Goal 5. Adaptive Management

This APMP is a working document guiding management actions on Lower Vermillion Lake for the next five years. This plan will follow an adaptive management approach following the IPM strategy, adjusting management actions based on results and related data collection. 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 VLA 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 VLA, Barron County, Tribal Resources, 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.

Timeline of Activities

The activities in this APM Plan are designed to be implemented over a 5-year period beginning in 2023. 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 VLA. Some activities in the timeline are eligible for grant support to complete. An Implementation Matrix (Appendix B) provides more detail about the activities to be completed and possible sources of funding to aide implementation.

Potential Funding

There are several WDNR grant programs that may be able to assist the VLA 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.

More information about WDNR grant programs can be found at:
https://dnr.wisconsin.gov/aid/SurfaceWater.html

Outside Resources to help with Future Planning

Many of the actions recommended in this plan cannot be completed solely by the VLA. They will continue to need the help of an outside consultant or other outside resource. Multiple outside resources and expertise exist to help guide implementation. The following is a list of outside resources that the VLA will need to partner with to implement the actions in this plan.

Barron County

Soil and Water Conservation

In most cases, the Soil and Water Conservation Department for a given county has a mission is to administer land and water conservation projects to meet local priorities, conditions, and the needs of county land users. County management plans and often state-funded, cost-share programs are administered for the purpose of implementing conservation practices. Conservation Departments are responsible for administering programs such as: Aquatic Invasive Species Program; Environmental Reserve Fund; short-term, grant-funded programs; providing technical assistance for all types of conservation practices; implementing information and education programs; updating various soil and water resource inventories; and nurturing partnerships with other county, state, and federal agencies.

https://www.barroncountywi.gov/index.asp?SEC=89D075CD-5873-4056-8599-65155CFB943F

Cooperative Extension

County-based Extension educators are University of Wisconsin (UW) faculty and staff who are experts in agriculture and agribusiness, community and economic development, natural resources, family living, and youth development. Extension county-based faculty and staff live and work with the people they serve in communities across the State. Extension specialists work on UW System campuses where they access current research and knowledge. Collaboration between county and campus faculty is the hallmark of Cooperative Extension in Wisconsin.

https://www.barroncountywi.gov/index.asp?SEC=50C303EF-0521-438F-B290-5C0373F46D27

University and Collegiate

Lake Superior Research Institute – UW-Superior

The Lake Superior Research Institute (LSRI) at UW-Superior was created in 1967 and formally recognized by the UW Board of Regents in 1969. LSRI's mission is to conduct environmental research and provide services that directly benefit the people, industries, and natural resources of the Upper Midwest, the Great Lakes Region, and beyond; provide non-traditional learning and applied research opportunities for undergraduate students; and foster environmental education and outreach in the Twin Ports and surrounding communities.

Areas of expertise include: analytical chemistry; aquatic invasive species monitoring and outreach; benthic and zooplankton taxonomy; habitat restoration; microbiology; sediment and aquatic toxicology; quality assurance and data management; watershed management and planning; and wetland assessment and monitoring. Current research includes: aquatic and sediment toxicity testing, aquatic invasive species ecology, ballast water management system testing, beach monitoring and microbial source testing, biological monitoring and inventory of aquatic and terrestrial communities, endangered species management planning, habitat restoration, and mercury analysis in biota.

https://www.uwsuper.edu/lsri/index.cfm

Mary Griggs Burke Center for Freshwater Innovation

The Mary Griggs Burke Center for Freshwater Innovation (Burke Center) at Northland College in Ashland, WI focuses on scientific research, communication, and thought leadership on water issues in the Great Lakes region and beyond. The Burke Center specializes in "translating" science to the general public, government agencies, NGOs, agriculture, and the private sector, helping to edify water policy in a wide variety of geographies and subject areas. Two such areas are Integrated Ecosystem Management and Environmental Monitoring and Assessment.

Effective management of freshwater ecosystems is dependent on an understanding of how human activities and value sets intersect with the environmental processes that sustain water resource integrity. Their work focuses on integrating approaches from the natural and social sciences to conduct and develop integrated assessments and management plans for freshwater ecosystems.

Public decision-making surrounding water resources is dependent on a range of data that describe the condition of freshwater ecosystems and the current—and potential future—stressors that may impact their integrity. Their work focuses on the use of environmental monitoring and analytical technologies to develop long-term data sets to support public decision-making for freshwater resources. The Burke Center is involved in multiple projects that collect and analyze a variety of data including bacteria, e-coli, zooplankton, aquatic plants, wild rice, water quality, etc.

https://www.northland.edu/centers/mgbc/

Center for Land Use Education

The Center for Land Use Education (CLUE) is a joint venture of the College of Natural Resources at the UW-Stevens Point and the UW-Madison Division of Extension. It is a focal point for land-use planning and management education. Through applied research, teaching and outreach, CLUE specialists and faculty support students, local government officials, communities and K-12 audiences on a variety of land and water topics including planning and zoning, land divisions, fragmentation, sustainability, bio- and renewable energy, food systems, shorelands and wetlands. By providing up-to-date and comprehensive training on planning and zoning tailored to address specific local needs, CLUE specialists are able to assist towns, villages, cities and counties in making sound land use decisions.

https://erc.cals.wisc.edu/programs/center-for-land-use-education/

Center for Watershed Science and Education

The Center for Watershed Science and Education (CWSE) at UW-Stevens Point supports watershed understanding and stewardship across and beyond the state of Wisconsin. The center includes specialists with expertise in groundwater, lakes, streams, water chemistry and analysis, and data science. The center helps individuals, organizations and private and public water resources professionals understand water quality and quantity in private wells, groundwater, lakes and rivers. Through their programming, center staff provides guidance on sampling and data collection, education on water quantity and quality, and interpretation and evaluation of monitoring results. The center also performs applied research and creates data visualization tools to improve watershed understanding.

Current research explores the movement of nitrate-nitrogen in soil and groundwater, the quantity and chemistry of groundwater, changes in lake water quality and the occurrence of pharmaceuticals and new pesticides in the water.

https://erc.cals.wisc.edu/programs/center-for-watershed-science-and-education/

Center for Limnological Research and Rehabilitation

The Center for Limnological Research and Rehabilitation (CLRR) at UW-STOUT focuses on eutrophication issues and management solutions for freshwater systems. They provide limnological research services to the surrounding community, including: diagnosing eutrophication-related problems in lakes and reservoirs; conducting comprehensive hydrologic and limnological monitoring programs; identifying and quantifying important phosphorus sources that drive cyanobacterial blooms; and developing and implementing management plans to sustainably rehabilitate degraded aquatic systems.

Their laboratory facilities provide an array of analytical capabilities for the examination of nutrients (primarily phosphorus species) and algae in water and sediment. They have a variety of field monitoring equipment for quantifying tributary flow and phosphorus loads discharging into lakes, boats and sampling equipment for monitoring lake chemistry and biology, and coring capabilities for the examination of aquatic sediment. In particular, they have unique expertise for determining important mobile phosphorus fractions in aquatic sediments and nutrient exchanges between sediments and the overlying water.

https://www.uwstout.edu/directory/center-limnological-research-and-rehabilitation

Natural Resources Education Program

NRE Water Programming

Natural Resource Educators (NRE) are providing leadership on nutrient reduction and water quality projects across the state. Key efforts include outreach to increase local capacity to reduce nonpoint source pollution in the Lower Fox, Wisconsin, St. Croix, Red Cedar and Rock River watersheds and the Lower Fox River Demo Farm Network initiative. Projects are carried out in collaboration with federal, state and local partners as well as producer-led watershed initiatives. The Demo Farm initiative works with farmers and their advisers to conduct on-farm demonstrations that measure and share the effectiveness of conservation practices to reduce erosion and sediment runoff, control phosphorus runoff and address other nonpoint sources of pollution.

NRE Forestry Programming

ERC-based Natural Resources Educators and key partners are leading classes (Learn About Your Land and Your Land, Your Legacy) and other efforts to engage landowners in the sustainable management of Wisconsin's privately-owned forests. NREs create content for landowners on a variety of topics in publication, video, and website formats.

https://erc.cals.wisc.edu/programs/regional-natural-resources-education-program/

Aquatic Invasive Species Outreach

Wisconsin's aquatic invasive species (AIS) program focuses on preventing the introduction of new invasive species to Wisconsin, containing the spread of invasives that are already in the state, and managing established populations when possible. In close cooperation with the Wisconsin Department of Natural Resources and Extension Lakes program, UW– Madison Division of Extension education efforts focus on working with resource professionals and citizens statewide to teach boaters, anglers and other water users the steps they should take to prevent transporting aquatic invasives to new waters. Efforts also address other potential mechanisms of introduction, including aquarium pet release and water gardening.

https://erc.cals.wisc.edu/programs/aquatic-invasive-species-outreach/

UW-Extension Lakes Program

Based at UW-Stevens Point, the Extension Lakes Program seeks to preserve Wisconsin's legacy of lakes through education, communication and collaboration. The program works with over 800 local lake associations and lake districts in Wisconsin, assisting them through education and capacity building. Lakes also partners with the Wisconsin DNR to coordinate a number of programs and projects to assist those concerned with the future of our lakes, including the Citizen Lake Monitoring Network, the Clean Boats, Clean Waters program and the Lake Leaders Institute. The *Lake Tides* newsletter reaches thousands of readers throughout the region.

https://erc.cals.wisc.edu/programs/extension-lakes-program/

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APPENDIX A

AQUATIC PLANT MANAGEMENT STRATEGY
Northern Region WDNR

AQUATIC PLANT MANAGEMENT STRATEGY
Northern Region WDNR

ISSUES

- Protect desirable native aquatic plants.
- Reduce the risk that invasive species replace desirable native aquatic plants.
- Promote "whole lake" management plans
- Limit the number of permits to control native aquatic plants.

BACKGROUND

As a general rule, the Northern Region has historically taken a protective approach to allow removal of native aquatic plants by harvesting or by chemical herbicide treatment. This approach has prevented lakes in the Northern Wisconsin from large-scale loss of native aquatic plants that represent naturally occurring high quality vegetation. Naturally occurring native plants provide a *diversity of habitat* that *helps maintain water quality*, helps *sustain the fishing* quality known for Northern Wisconsin, supports common lakeshore wildlife from loons to frogs, and helps to provide the *aesthetics* that collectively create the "up-north" appeal of the northwoods lake resources.

In Northern Wisconsin lakes, an inventory of aquatic plants may often find 30 different species or more, whereas a similar survey of a Southern Wisconsin lake may often discover less than half that many species. Historically, similar species diversity was present in Southern Wisconsin, but has been lost gradually over time from stresses brought on by cultural land use changes (such as increased development, and intensive agriculture). Another point to note is that while there may be a greater variety of aquatic vegetation in Northern Wisconsin lakes, the vegetation itself is often *less dense*. This is because northern lakes have not suffered as greatly from nutrients and runoff as have many waters in Southern Wisconsin.

The newest threat to native plants in Northern Wisconsin is from invasive species of aquatic plants. The most common include Eurasian Water Milfoil (EWM) and CurlyLeaf Pondweed (CLP). These species are described as *opportunistic invaders*. This means that these "invaders" benefit where an opening occurs from removal of plants, and without competition from other plants may successfully become established in a lake. Removal of native vegetation not only diminishes the natural qualities of a lake, it *may increase the risk that an invasive species can successfully invade onto the site where native plants have been removed*. There it may more easily establish itself without the native plants to compete against. This concept is easily observed on land where bared soil is quickly taken over by replacement species (often weeds) that crowd in and establish themselves as new occupants of the site. While not a providing a certain guarantee against invasive plants, protecting and allowing the native plants to remain may reduce the success of an invasive species becoming established on a lake. Once established, the invasive species cause far more inconvenience for all lake users, riparian and others included; can change many of the natural features of a lake; and often lead to *expensive annual control plans*.
Native vegetation may cause localized concerns to some users, but as a natural feature of lakes, they generally do not cause harm.

To the extent we can maintain the normal growth of native vegetation, Northern Wisconsin lakes can continue to offer the water resource appeal and benefits they've historically provided. A regional position on removal of aquatic plants that carefully recognizes how native aquatic plants benefit lakes in Northern Region can help prevent a gradual decline in the overall quality and recreational benefits that make these lakes attractive to people and still provide abundant fish, wildlife, and northwoods appeal.

GOALS OF STRATEGY:

1. Preserve native species diversity which, in turn, fosters natural habitat for fish and other aquatic species, from frogs to birds.
2. Prevent openings for invasive species to become established in the absence of the native species.
3. Concentrate on a "whole-lake approach" for control of aquatic plants, thereby fostering systematic documentation of conditions and specific targeting of invasive species as they exist.
4. Prohibit removal of wild rice. WDNR – Northern Region will not issue permits to remove wild rice unless a request is subjected to the full consultation process via the Voigt Tribal Task Force. We intend to discourage applications for removal of this ecologically and culturally important native plant.
5. To be consistent with our WDNR Water Division Goals (work reduction/disinvestment), established in 2005, to "not issue permits for chemical or large scale mechanical control of native aquatic plants – develop general permits as appropriate or inform applicants of exempted activities." This process is similar to work done in other WDNR Regions, although not formalized as such.

BASIS OF STRATEGY IN STATE STATUTE AND ADMINISTRATIVE CODE

State Statute 23.24 (2)(c) states:
"The requirements promulgated under par. (a) 4. may specify any of the following:
1. The **quantity** of aquatic plants that may be managed under an aquatic plant management permit.
2. The **species** of aquatic plants that may be managed under an aquatic plant management permit.
3. The **areas** in which aquatic plants may be managed under an aquatic plant management permit.
4. The **methods** that may be used to manage aquatic plants under an aquatic plant management permit.
5. The **times** during which aquatic plants may be managed under an aquatic plant management permit.
6. The **allowable methods** for disposing or using aquatic plants that are removed or controlled under an aquatic plant management permit.
7. The requirements for plans that the department may require under sub. (3) (b).

State Statute 23.24(3)(b) states:
"The department may require that an application for an aquatic plant management permit contain a plan for the department's approval as to how the aquatic plants will be introduced, removed, or controlled."

Wisconsin Administrative Code NR 109.04(3)(a) states:

“The department may require that an application for an aquatic plant management permit contain an aquatic plant management plan that describes how the aquatic plants will be introduced, controlled, removed or disposed. Requirements for an aquatic plant management plan shall be made in writing stating the reason for the plan requirement. In deciding whether to require a plan, the department shall consider the potential for effects on protection and development of diverse and stable communities of native aquatic plants, for conflict with goals of other written ecological or lake management plans, for cumulative impacts and effect on the ecological values in the body of water, and the long- term sustainability of beneficial water use activities.”

APPROACH

1. After January 1, 2009* no individual permits for control of native aquatic plants will be issued. Treatment of native species may be allowed under the auspices of an approved lake management plan, and only if the plan clearly documents “impairment of navigation” and/or “nuisance conditions”. Until January 1, 2009, individual permits will be issued to previous permit holders, only with adequate documentation of “impairment of navigation” and/or “nuisance conditions”. No new individual permits will be issued during the interim.

2. Control of aquatic plants (if allowed) in documented sensitive areas will follow the conditions specified in the report.

3. Invasive species must be controlled under an approved lake management plan, with two exceptions (these exceptions are designed to allow sufficient time for lake associations to form and subsequently submit an approved lake management plan):
    a. Newly-discovered infestations. If found on a lake with an approved lake management plan, the invasive species can be controlled via an amendment to the approved plan. If found on a lake without an approved management plan, the invasive species can be controlled under the WDNR’s Rapid Response protocol (see definition), and the lake owners will be encouraged to form a lake association and subsequently submit a lake management plan for WNDR review and approval.
4. Individuals holding past permits for control of *invasive* aquatic plants and/or “mixed stands” of native and invasive species will be allowed to treat via individual permit until January 1, 2009 if “impairment of navigation” and/or “nuisance conditions” is adequately documented, unless there is an approved lake management plan for the lake in question
5. Control of invasive species or “mixed stands” of invasive and native plants will follow current best management practices approved by the Department and contain an explanation of the strategy to be used. Established stands of invasive plants will generally use a control strategy based on Spring treatment. (typically, a water temperature of less than 60 degrees Fahrenheit, or approximately May 31st, annually).
6. Manual removal (see attached definition) is allowed (Admin. Code NR 109.06).

DOCUMENTATION OF IMPAIRED NAVIGATION AND/OR NUISANCE CONDITIONS

Navigation channels can be of two types:

- Common use navigation channel. This is a common navigation route for the general lake user. It often is off shore and connects areas that boaters commonly would navigate to or across, and should be of public benefit.

- Individual riparian access lane. This is an access lane to shore that normally is used by an individual riparian shore owner.

Severe impairment or nuisance will generally mean vegetation grows thickly and forms mats on the water surface. Before issuance of a permit to use a regulated control method, a riparian will be asked to document the problem and show what efforts or adaptations have been made to use the site. (This is currently required in NR 107 and on the application form, but the following helps provide a specific description of what impairments exist from native plants).

Documentation of *impairment of navigation* by native plants must include:

a. Specific locations of navigation routes (preferably with GPS coordinates)
b. Specific dimensions in length, width, and depth
c. Specific times when plants cause the problem and how long the problem persists
d. Adaptations or alternatives that have been considered by the lake shore user to avoid or lessen the problem
e. The species of plant or plants creating the nuisance (documented with samples or a from a Site inspection)

Documentation of the *nuisance* must include:

a. Specific periods of time when plants cause the problem, e.g. when does the problem start and when does it go away.
b. Photos of the nuisance are encouraged to help show what uses are limited and to show the severity of the problem.
c. Examples of specific activities that would normally be done where native plants occur naturally on a site but cannot occur because native plants have become a nuisance.

DEFINITIONS

Manual removal: Removal by hand or hand-held devices without the use or aid of external or auxiliary power. Manual removal cannot exceed 30 ft. in width and can only be done where the shore is being used for a dock or swim raft. The 30 ft. wide removal zone cannot be moved, relocated, or expanded with the intent to gradually increase the area of plants removed. Wild rice may not be removed under this waiver.

Native aquatic plants: Aquatic plants that are indigenous to the waters of this state.

Invasive aquatic plants: Non-indigenous species whose introduction causes or is likely to cause economic or environmental harm or harm to human health.

Sensitive area: Defined under s. NR 107.05(3)(i) (sensitive areas are areas of aquatic vegetation identified by the department as offering critical or unique fish and wildlife habitat, including seasonal or life stage requirements, or offering water quality or erosion control benefits to the body of water).

Rapid Response protocol: This is an internal WDNR document designed to provide guidance for grants awarded under NR 198.30 (Early Detection and Rapid Response Projects). These projects are intended to control pioneer infestations of aquatic invasive species before they become established.

APPENDIX B

Implementation Matrix

APPENDIX C

Management Discussion