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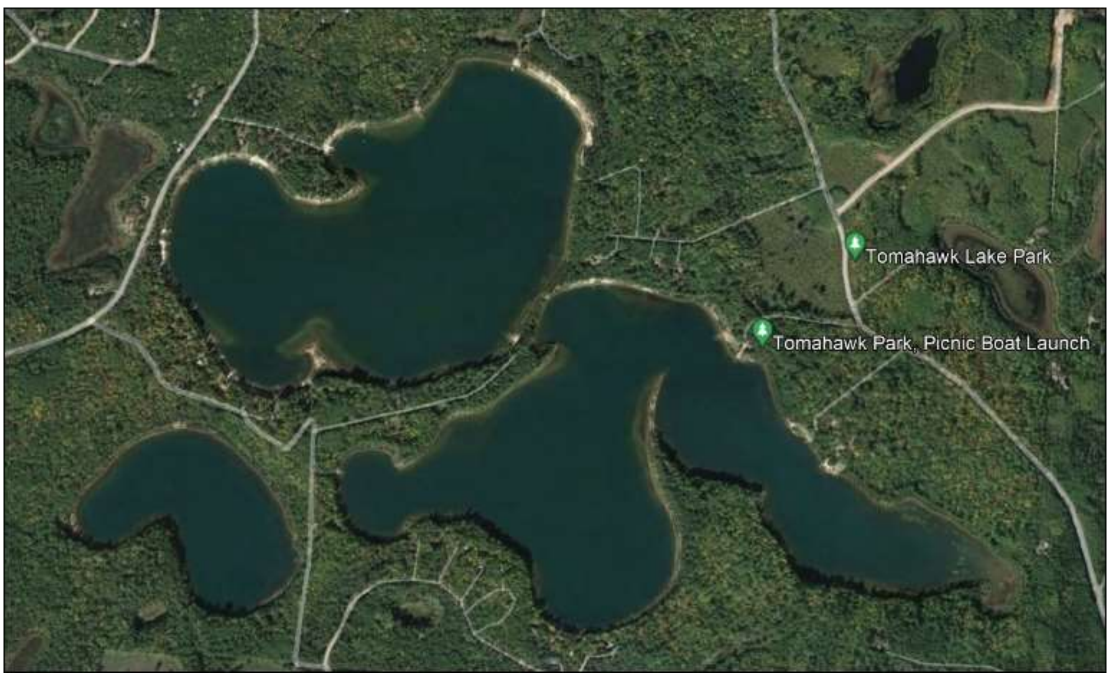
2022-26 AQUATIC PLANT MANAGEMENT PLAN

SAND BAR & TOMAHAWK LAKES
BAYFIELD COUNTY
WDNR WBICS: 2494900 & 2501700

May, 2022



TOWN OF BARNES & FRIENDS OF
THE EAU CLAIRE LAKES AREA
BARNES, WI

AQUATIC PLANT MANAGEMENT PLAN

Sand Bar Lake & Tomahawk Lake

WBIC: 2494900 & 2501700

May 2022

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Acknowledgements:

Members of the Eau Claire Lakes Property Owners Association, the Friends of the Eau Claire Lakes Area, and the Aquatic Invasive Species Committee who contributed to discussions and recommendations presented in this plan.

Distribution List

No. of Copies	Sent to
1	Tom Renz, Chair Town of Barnes, Bayfield County
1	Kevin Shriver, President Friends of the Eau Claire Lakes Area
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EXECUTIVE SUMMARY

Sand Bar and Tomahawk Lakes are exceptionally beautiful with clear water and sandy substrate, and they are home to many species of birds, game fish, and diverse aquatic plant communities. Normally, these lakes are separated by a narrow, privately owned sandbar with established vegetation on it; however, recent high water has allowed the lakes to become connected (image below). Unfortunately, invasive Eurasian watermilfoil *Myriophyllum spicatum* (EWM) has become established in Tomahawk Lake and has been found to be moving into Sand Bar Lake. As such, management of EWM is necessary to protect and restore these valuable resources and maintain their status as high-quality waterbodies. An integrated management approach that relies on a combination of manual and chemical control methods is recommended to continue for these lakes.

The general public and the Friends of the Eau Claire Lakes Area (FOECLA) take an active role in managing the lakes, and their mission is "to protect, preserve and improve the environmental and aesthetic qualities of the Eau Claire Lakes Area watershed, including the lakes, rivers, shorelands, wetlands, forests and attendant wildlife resources." Therefore, the primary goal of this plan is to protect Sand Bar and Tomahawk's ecosystems and native plant communities 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 through environmentally responsible methods to benefit the native plant community while maintaining EWM at manageable levels.
2. **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 waterbodies.
3. **Research and Monitoring.** Develop a better understanding of the lake and the factors affecting lake water quality through continued and expanded monitoring efforts.
4. **Adaptive Management.** Follow an adaptive management approach that measures and analyzes the effectiveness of control activities and modify the management plan as necessary to meet goals and objectives.

Flooded sandbar looking from Tomahawk Lake to Sand Bar Lake taken on 8/31/21 by Megan Mader – LEAPS

1.0 Introduction

2.0 Town of Barnes and Friends of the Eau Claire Lakes Area

2.1 Town of Barnes

Throughout the Town of Barnes Comprehensive Land Use Plan, the term "northwoods character" appears several times. For the purposes of the Land Use Plan, northwoods character is defined as:

"A combination of natural and manmade features that portray the traditional form and preserve the traditional function of the northwoods landscape. In the Town of Barnes, northwoods character is manifested in a backdrop of forests and fields, natural features such as creeks, lakes, and wetlands, and structures such as churches, cabins, and homes. These physical features support traditional northwoods activities such as farming, logging, and outdoor recreation that have been practiced for generations in the Town. Homes in the northwoods are either scattered at low densities or clustered together in small communities surrounded by open space."

2.2 Friends of the Eau Claire Lakes Area

Organized in 1973, Friends of the Eau Claire Lakes Area (FOECLA) is a voluntary group of year-round and seasonal residents and visitors interested in preserving the beautiful environment of the Eau Claire Lakes area. Their mission is to "protect, preserve and improve the environmental and aesthetic qualities of the Eau Claire Lakes Area watershed, including its lakes, rivers and streams, shorelands, wetlands, forests and attendant wildlife resources." This mission has been embraced by others all over the Eau Claire Lakes Area and membership continues to grow.

Since its earliest years, FOECLA has provided leadership in raising awareness of the impacts of aquatic invasive species (AIS) on area lakes. They helped construct the BAISS boat that is used annually to remove Eurasian water-milfoil and curly-leaf pondweed from area lakes. They encouraged the development of and continue to serve on an AIS Committee created by the Town of Barnes to address AIS issues on area lakes.

FOECLA developed and funds an award-winning educational program with the Drummond Public School District that takes middle school students outdoors for hands-on learning. FOECLA sponsors programs and seminars for adults in the community about everything from cooking, to successful fishing, to maintaining septic systems. FOECLA works cooperatively with the Town of Barnes to maintain and fund an effective boat landing watercraft inspection program to protect the lakes from invasive species. FOECLA members volunteer to inspect the shoreline for any signs of invasive species and work with the Wisconsin Department of Natural Resources in control efforts when needed.

3.0 Aquatic Plant Management Summary

Continuing a combination of chemical and manual control methods to curb the spread of EWM in both lakes is recommended. The overall goal of this Aquatic Plant Management (APM) Plan is to protect these outstanding waterbodies from degradation caused by existing aquatic invasive species through containment and control, and maximizing the prevention of new invasions.

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. 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.

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 lakes constituency, 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 (Appendix B).

3.1 Implementation Goals

This Aquatic Plant Management Plan establishes the following goals for aquatic plant management in Sand Bar and Tomahawk Lakes:

EWM Management. Limit the spread of EWM through environmentally responsible methods to benefit the native plant community while maintaining EWM at manageable levels.

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.

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

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.

4.0 Public Participation and Stakeholder Input

4.1 Public Use

Both lakes are used for a wide range of recreational activities, including: fishing for panfish species, bass, northern pike, musky, and walleye; using non-motorized boats while photographing or viewing nature; using motorized boats for recreational enjoyment of the lake; and swimming.

Located on the northeast corner of Tomahawk Lake, Tomahawk Park contains the only public boat launch for the two lakes. Sand Bar is typically land-locked from Tomahawk Lake; however, during periods of high water (as they currently are), the lakes become connected when the narrow sand bar between the two lakes floods. This sand bar is privately owned, but during times of low water, it is commonly used as a portage to gain access from Tomahawk to Sand Bar with small watercrafts. There are several additional plots of land owned by the Town of Barnes that can be used to access Tomahawk Lake, but there are no active plans to develop these sites into boat launches.

All recreation activities in both lakes can be hindered by EWM. Additionally, these lakes 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 lakes and prevent further spread into un-infected lakes.

4.2 Stakeholder Input

5.0 Lake Characteristics

5.1 Sand Bar Lake

Sand Bar Lake (WBIC: 2494900) is a 127-acre seepage lake located in Bayfield County, Wisconsin in the Town of Barnes (Figure 1). The lake falls within the Upper St. Croix and Eau Claire Rivers Watershed but is land-locked with no inflow or outflow except in times of high water when it is connected to Tomahawk Lake (WBIC: 2501700; Figure 1). The approximately 2 miles of shoreline has relatively low development with about 30 homes and cabins (Figure 2). There is no public access or public frontage on the lake, but people commonly portage the small sand bar separating Sand Bar from Tomahawk Lake despite it being privately owned (Figure 2).

Sand Bar is a fairly unique lake for Northern Wisconsin due to its particular position on the landscape; its characteristics create exceptional conditions for its aquatic organisms. As a land-locked lake, the primary source of water to the lake is groundwater, classifying it as a soft water, seepage lake. It regularly stratifies and is oligotrophic with high water clarity that regularly reaches 20 feet and nutrient-poor conditions (WDNR 2022; Berg 2020). Sandy substrate covers the entirety of the lake with a thin layer of muck covering the sandy bottom in depths deeper than 6 feet (Berg 2020; Figure 3). These conditions support a diverse aquatic plant community; across all previous plant community surveys from 2006 to 2020 (n=12), the average number of plant species documented is 17, which is relatively high for a small lake (Berg, 2020). The edges of the lake slope steeply along the east and west shorelines into two basins that reach about 40 feet in depth separated by a shallower flat that extends from the southern shoreline (Figure 3; Berg, 2020). The clear water, uniform substrate, deeper depths, and diverse plant community support a fishery with largemouth bass, cisco, yellow perch, bluegill, pumpkinseed, green sunfish, white sucker, and redhorse.

5.2 Tomahawk Lake

Tomahawk Lake is similar in size at 131 acres and lies to the southeast of Sand Bar across the narrow strip of land that separates the lakes. This lake is also a land-locked, soft water, seepage lake. Tomahawk's shoreline is about 3 miles long with about 13 homes and cabins; 0.26 miles of shoreline are owned by the Town of Barnes (Figure 2). Of the land owned by the Town of Barnes, on the north side of the lake is the Town of Barnes Tomahawk Park. Here there is a public boat landing that allows access to the lake, as well as a public beach and swimming area. Both lakes are of medium popularity for recreation due to their relatively remote location and proximity to several other larger lakes in the area that are very popular. However, both lakes are very serene with high water quality and great fishing opportunities, and the public park on Tomahawk Lake is very charming.

Tomahawk is very similar to Sand Bar in many of its characteristics. Tomahawk also regularly stratifies in the summer months and reaches a maximum depth of 42 feet and has an average depth of about 13 feet. The bottom is also almost entirely sand in the littoral zone with muck in deeper areas and in the "handle" of the tomahawk. Aquatic plant diversity is slightly higher in Tomahawk, averaging about 20 species across the 12 times it has been surveyed from 2006 to 2020 (Berg, 2020). The eastern "handle" of the lake forms a trench that drops off to about 15 feet, and the southern basin that is the "head" of the tomahawk has steep edges that drop to 30-40 feet (Figure 3; Berg 2020). This lake has a similar fish community to Sand Bar with walleye, largemouth bass, and panfish.

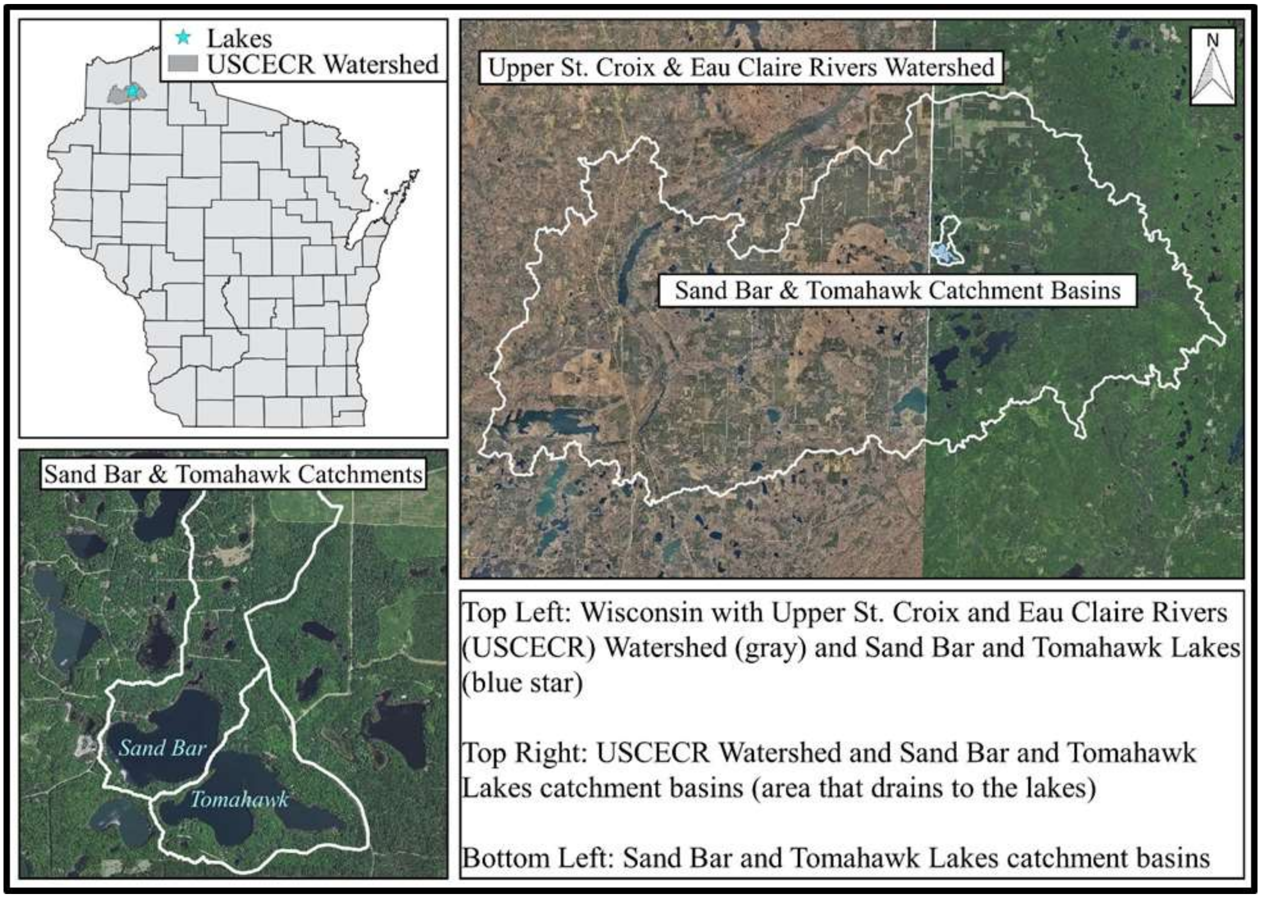

Figure 1: Upper St. Croix and Eau Claire Rivers (USCECR) Watershed with Sand Bar and Tomahawk Lakes catchment basins

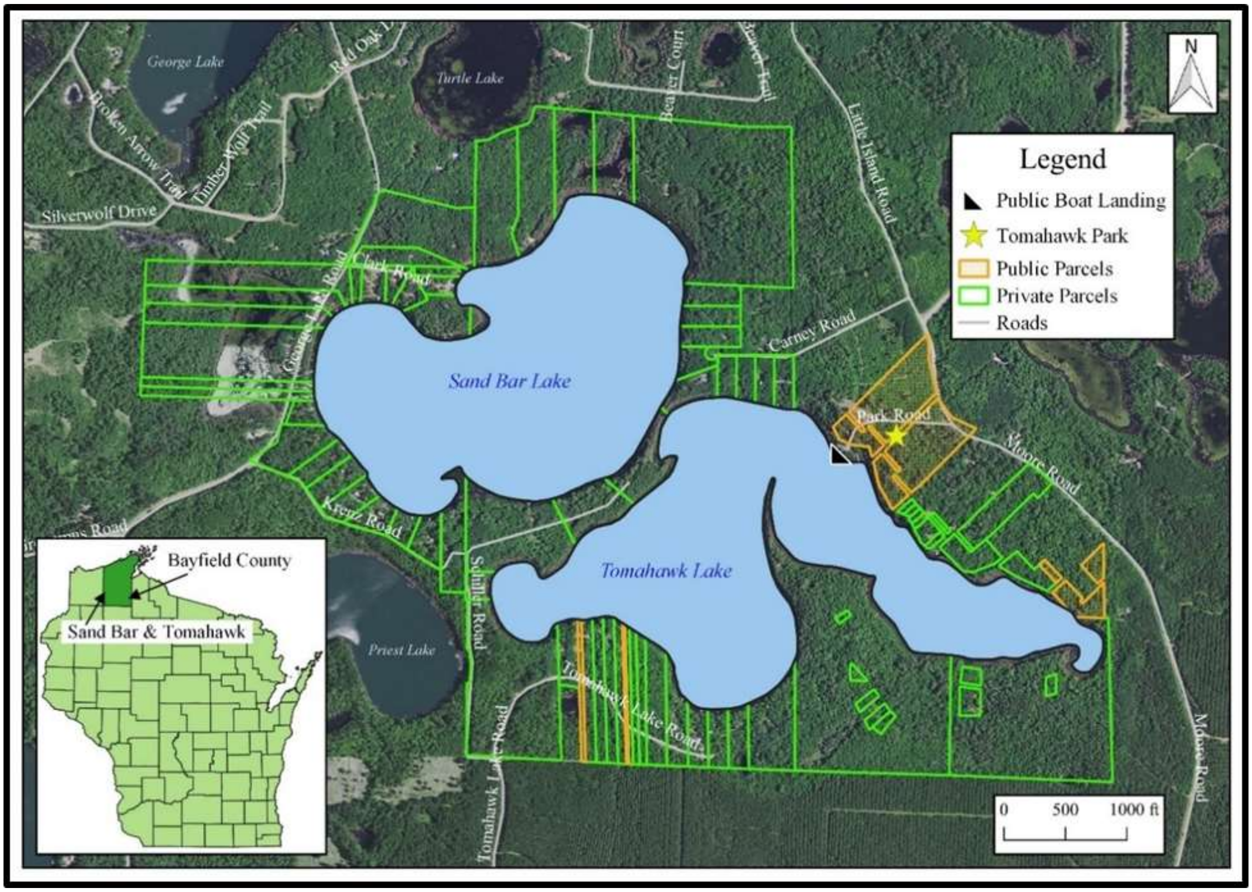

Figure 2: Location and land ownership of Sand Bar and Tomahawk Lakes, Bayfield County, Wisconsin

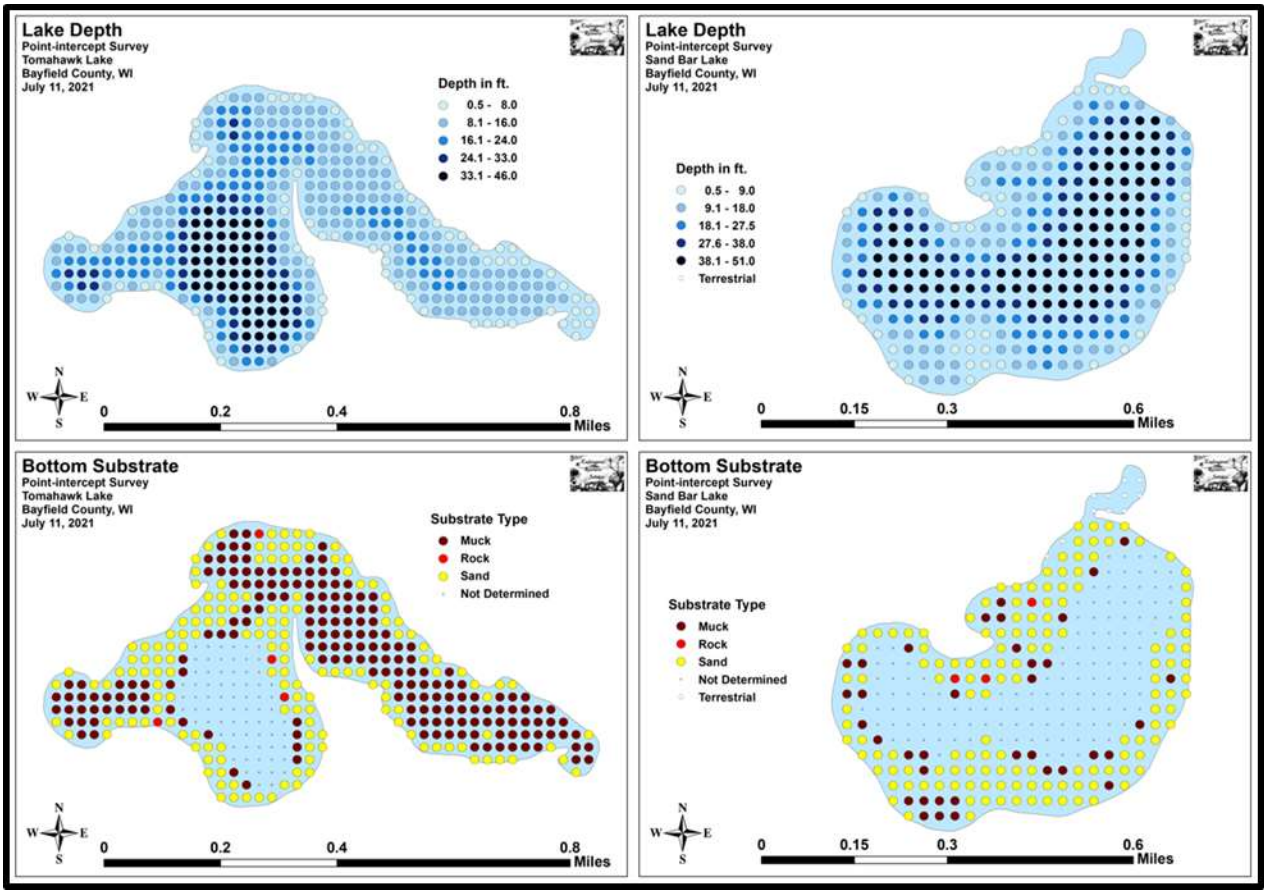

Figure 3: Sand Bar and Tomahawk Lakes depth and bottom substrate (Berg, 2021)

6.0 Watershed

A watershed is an area of land from which water drains to a common surface water feature such as a stream, lake, or wetland. Sand Bar and Tomahawk are part of the 177,850-acre Upper St. Croix and Eau Claire Rivers (USCECR) Watershed that includes all of the St. Croix drainage above the Gordon dam. The watershed is mostly forested (83.90%) with some wetlands (9.49%) and some developed land (6.69%; Figure 4; Figure 5). It contains 153 miles of streams and river (77% are in good condition), 7,654 acres of lakes, and 13964 acres of wetlands.

Because these lakes are land-locked, they do not significantly contribute to the larger USCECR Watershed. Instead, they have smaller catchments that contribute small amounts of surface run off to the lakes (Figure 4). For Sand Bar, this area is approximately 566.36 acres, and Tomahawk's catchment area is about 372.59 acres (Table 1). Combined, this area covers 1.47mi2, which is just a fraction of the USCECR Watershed. Both catchments are mostly forested with some wetlands (including the lakes) and small amounts of development (Figure 4; Figure 5; Table 1). There is also a very small portion of agriculture, as well as areas of barren land than can be attributed to natural sand deposits (Figure 4; Figure 5; Table 1).

Both the USCECR Watershed and the catchment areas fall within the Northwest Sand Ecological Landscape – a large glacial outwash system with flat plains and kettle lakes. The soils are deep sands with little organic material and nutrients. The vegetation is dominated by jack pine and scrub oak forest and barrens with some white and red pine forests.

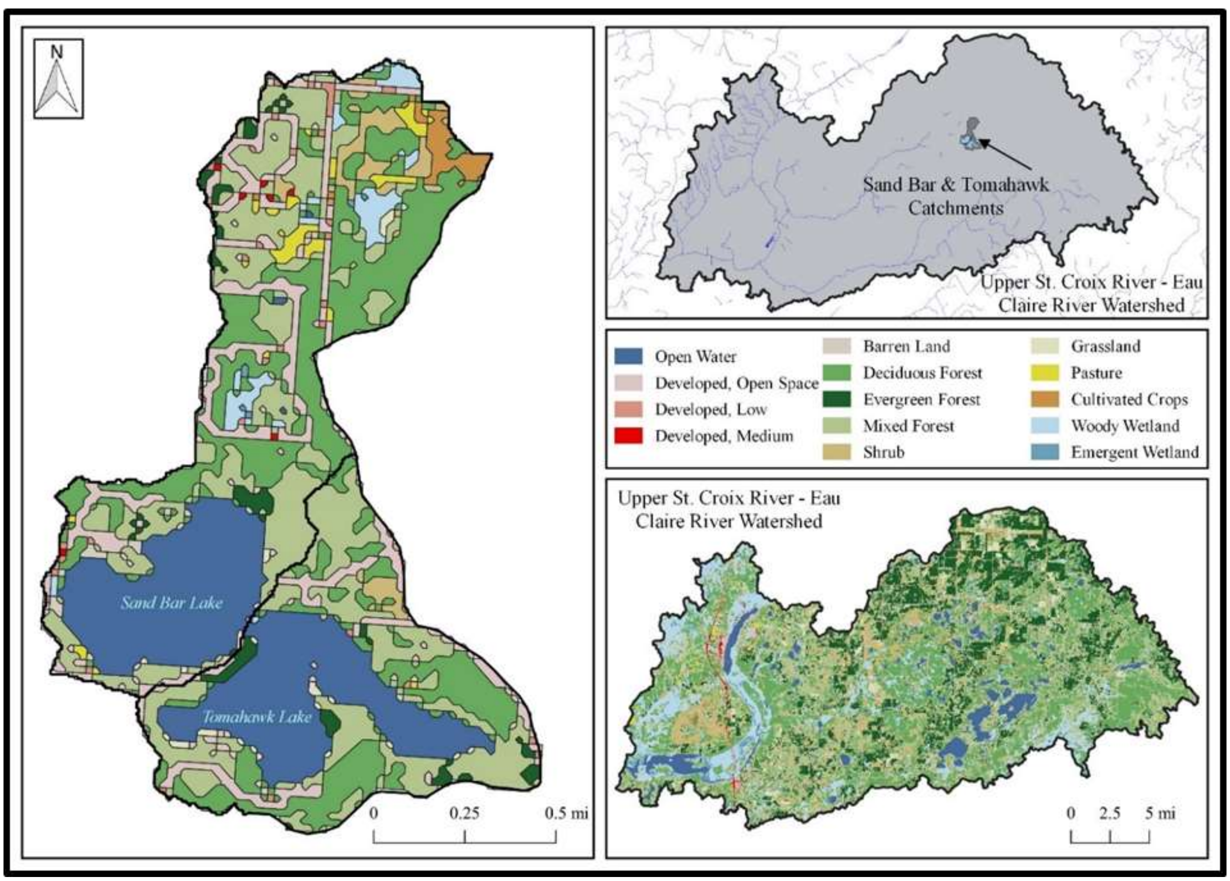

Figure 4: Upper St. Croix and Eau Claire Rivers Watershed (right) and Sand Bar and Tomahawk Lake catchment area land cover (left; NLCD, 2019)

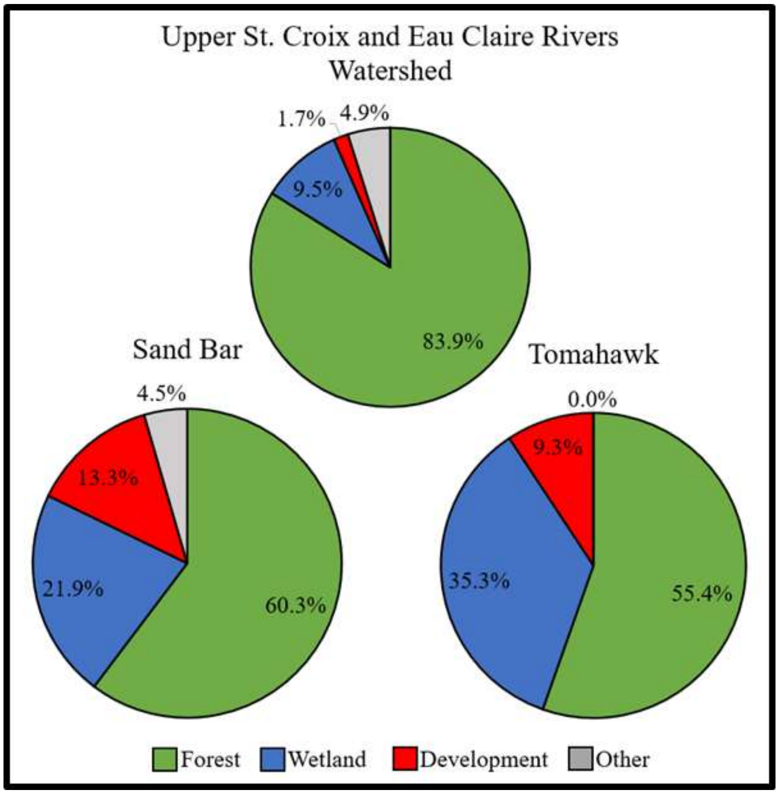

Figure 5: Percent land cover for the Upper St. Croix and Eau Claire Rivers Watershed and the Sand Bar and Tomahawk Lakes catchment basins

Table 1: National Land Cover Dataset (2019) land cover in Tomahawk and Sand Bar Lakes (in acres)

NLCD (2019) Land Cover Classification	Tomahawk	Sand Bar	**Total (acres)**
Mixed Forest	106.43	144.10	**250.53**
Deciduous Forest	79.03	160.16	**239.19**
Open Water	131.43	100.50	**231.93**
Developed, Open Space	33.08	66.86	**99.94**
Shrub/Scrub	5.98	18.93	**24.91**
Woody Wetlands	0.19	22.86	**23.05**
Evergreen Forest	10.37	10.31	**20.68**
Pasture/Hay	0.22	13.99	**14.21**
Cultivated Crops	0.00	12.29	**12.29**
Developed, Low Intensity	1.42	7.00	**8.42**
Grassland/Herbaceous	3.75	2.81	**6.56**
Barren	0.69	4.20	**4.89**
Developed, Medium Intensity	0.00	1.45	**1.45**
Emergent Herbaceous Wetlands	0.00	0.90	**0.90**
Total (acres)	**372.59**	**566.36**	**938.95**

6.1 Fisheries and Wildlife

Tomahawk Lake is in excellent condition; however, its wildlife value is relatively low. The lake is surrounded by largely intact upland forests of aspen, birch, oak, maple, white pine, and Jack pine. It is also subject to water level fluctuations that have left the shoreline dotted with dead trees and stumps that have been flooded. These areas provide good habitat for fish and waterfowl, but they are not permanent and will not be available when water levels recede. Migratory ducks use the lake in the fall, but there are few resident waterfowl that use the lake throughout the summer.

Sand Bar Lake is classified by the WDNR as being in 'good' condition. Its shoreline is mostly bordered by upland conifer species and a few scattered stands of hardwoods. There are few wetlands around the lake to provide habitat for birds and other animals, which lowers the lake's wildlife value.

A Fisheries Information Survey was performed by the WDNR on both lakes in 2004. In Tomahawk Lake, fyke netting and fall electrofishing confirmed results from 1999 that found the lake to have a balanced fishery with quality fishing opportunities (Manz, 2004b). Largemouth bass are the dominant game fish in Tomahawk Lake, and surveys have shown that growth rates are higher than average in other soft water seepage lakes (Manz, 2004b). The lake also provides a high quality panfish fishery (Manz, 2004b).

In Sand Bar Lake, mini fyke nets were used to sample the littoral fish community in August 2004. It was found that the lake has a balanced fishery of northern pike, largemouth bass, and panfish species (Manz, 2004a). Size structures for northern pike and largemouth were good, black crappie sizes were above average, and bluegills were relatively average in size (Manz, 2004a). The lake has a very good fishery with ample opportunities for anglers.

The WDNR recommended that both lakes should continue to be managed for northern pike, largemouth bass, cisco, and panfish with no regulation changes (Manz, 2004a) (Manz, 2004b). Bag limits are two/day for northern pike with a minimum size limit of 26 inches; five/day for bass with a minimum size of 14 inches; and 25 panfish/day with no size restrictions.

EWM is a major concern in the lakes because it alters the native plant composition that the fishery and wildlife depend on. The negative impacts associated with EWM show the importance of developing a long-term management strategy that will 1) slow its spread within Sand Bar and Tomahawk Lake, while also protecting the native plant community, and 2) help stop its spread to other nearby lakes in Bayfield and Douglas County. It is a priority that native plant species be left intact with the objective of protecting and encouraging their growth. As a source of infestation for other lakes in proximity to Sand Bar and Tomahawk Lake, it is also crucial that steps are taken to educate lake users about stopping the spread of EWM and other exotic species to other lakes. Lake residents, local anglers, local township and county governments, local sports clubs, and lake associations should partner together with the goal of dealing with an issue that threatens overall water quality, habitat, and the dependent fishery. The harmful effects of EWM or other exotic species crosses the interest of area anglers, boaters, and lakeshore owners alike.

For more information on Sand Bar and Tomahawk Lake fisheries, contact:
Fisheries Biologist
Wisconsin DNR
6250 S. Ranger Road
Brule, WI 54820
(715) 372 – 8539 ext. 121

6.2 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 Sand Bar and Tomahawk Lakes. 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 provide shoreline protection to Sand Bar and Tomahawk Lakes because they act as buffers between land and water. They protect against erosion by absorbing the force of waves and currents and by anchoring sediments. Shoreline protection is important in waterways where boat traffic, water current, and wave action cause substantial damage to the shore. Wetlands provide groundwater recharge and discharge by allowing the surface water to move into and out of the groundwater system. The filtering capacity of wetland plants and substrates help protect groundwater quality. Wetlands stabilize and maintain stream flows, especially during dry months. Aesthetics, recreation, education and science are all services wetlands provide. Wetlands contain a unique combination of terrestrial and aquatic life and physical and chemical processes.

Sand Bar and Tomahawk Lakes have wetlands all around the lake, most associated with shoreland of both lakes and in the inflow from lakes north in the watershed (Figure 6).

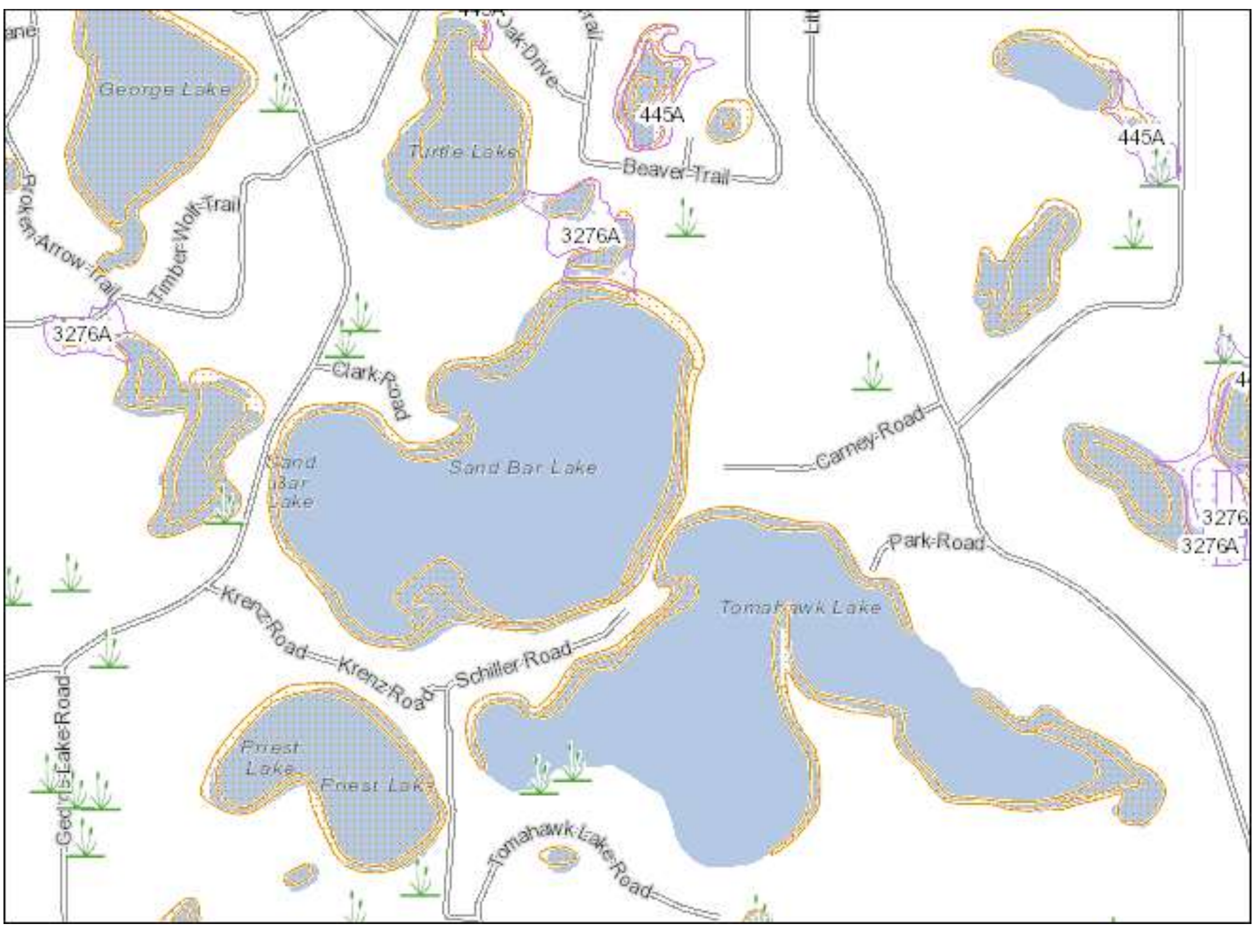

Figure 6: Wetland areas (tan/purple polygons and cattail icons) around Sand Bar and Tomahawk Lakes

6.3 Coarse Woody Habitat

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. The 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 (Wolter, 2012). 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 (Wolter, 2012).

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.

Much of the coarse woody habitat around both lakes is due to high water inundating shoreland woody shrubs and small trees in the nearshore area (Figure 7). The coarse woody habitat created by this source changes with the water level - high water creates more, and low water creates less. The amount of larger coarse woody habitat, the kind created when large trees fall into the lakes, has never been inventoried. After such a survey has been completed, property owners may consider the addition of coarse woody habitat through the installation of Fishsticks. Fishsticks are created by using whole, live trees that are cut down and installed along the shoreline. In most cases, 3-5 40-60ft trees are stacked on top of each other and fastened to the shore. Fishsticks installation is usually completed in the winter when there are good ice conditions that support the use of large equipment (skid steers and trucks).

Figure 7: Coarse woody habitat under high water conditions in Sand Bar and Tomahawk Lake (photo taken by Megan Mader on 8/31/2021)

6.4 Shorelands

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 aquatic invasive species 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. 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, 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.

6.4.1 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.

6.4.2 Natural Shorelands Role in Preventing Aquatic Invasive Species

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 may fill the voided space before natives can return.

6.4.3 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.

Since the July 2019 storm, many property owners have been removing downed trees and repairing damage caused by the storm. The process of doing this created a lot of new disturbed area in the shoreland area. The District has repeatedly recommended, and even supplied resources to property owners to implement practices to minimize runoff and sediment loss into the lake during these repair projects.

6.4.4 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 8 shows the difference between a natural and unnatural shoreline adjacent to a lake home.[1]

[1] More information about healthy shorelines and how they can be restored can be found at the following websites (last accessed 8-26-2021):
https://www.cleanlakesalliance.org/shoreline-health/
https://dnr.wi.gov/topic/ShorelandZoning/documents/WT-748.pdf

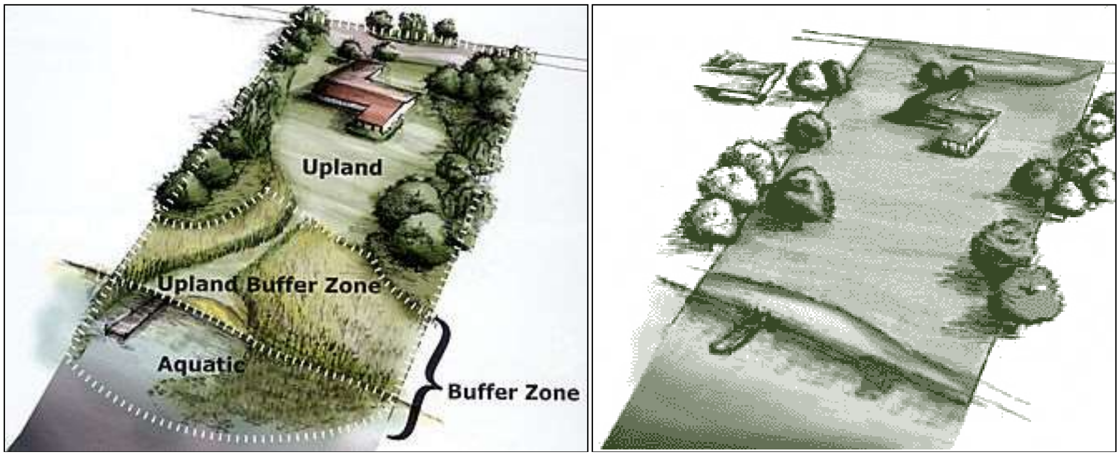

Figure 8: Healthy, AIS resistant shoreland (left) vs. shoreland in poor condition

Despite there being homes and cabins all around the two lakes, much of the shoreland is still in a natural state, a credit to the property owners. However, where there is mowed lawn to the edge of the lake, cleared lots, driveways, and other impervious surfaces, property owners should evaluate whether or not improvements can be made. Fluctuating water levels will always impact the shores of both lakes. Most property owners are aware that they can only do a minimal amount of clearing on the exposed lake bed under low water conditions, similar to what could be done if it were still under water. During periods of high water, more concern is placed on what can be done to protect the shore and upland areas from erosion caused by waves. For many, the answer lies in placing rock riprap along their shore. While this practice is logical and viable and is generally supported by those who work to protect lakes, there are ways to do it that are more environmentally and lake sensitive.

Shoreland protection practices can be placed in two categories: soft armoring and hard armoring (Figure 9). Soft armoring techniques (sometimes called bio-engineering) involve creating a naturally occurring slope with a combination of natural elements which includes rock and vegetation. Soft techniques will absorb the energy of the waves along the shoreline reducing the potential of erosion, strengthen the shoreline long term, prevent ongoing maintenance, maintain and enhance natural habitat, filter nutrients and pollution from upland runoff and help improve water quality (Alberta Environment and Sustainable Resource Development, 2021).

Hard armoring (retaining walls, rock, rip/rap, concrete, gabions) have been traditionally used as erosion protection along shorelines. These methods, however, are difficult to implement and maintain successfully over a long period of time. In addition these techniques are often more expensive then soft armoring techniques and require the use of heavy equipment which causes damage to sensitive areas. Hard techniques (especially vertical retaining or gabion walls) enhance erosion of the shoreline at the base and sides of the wall, disrupt the normal flow and filtration of water from upland, provide almost no natural habitat for wildlife and are most expensive and troublesome to fix[2].

[2] More information about soft and hard armoring shoreland protection strategies go to: https://www.parklandcounty.com/en/live-and-play/resources/Documents/PRC/iceheave/Shoreline-Stabilization-Sample-Plans.pdf (last accessed 8-26-2021).

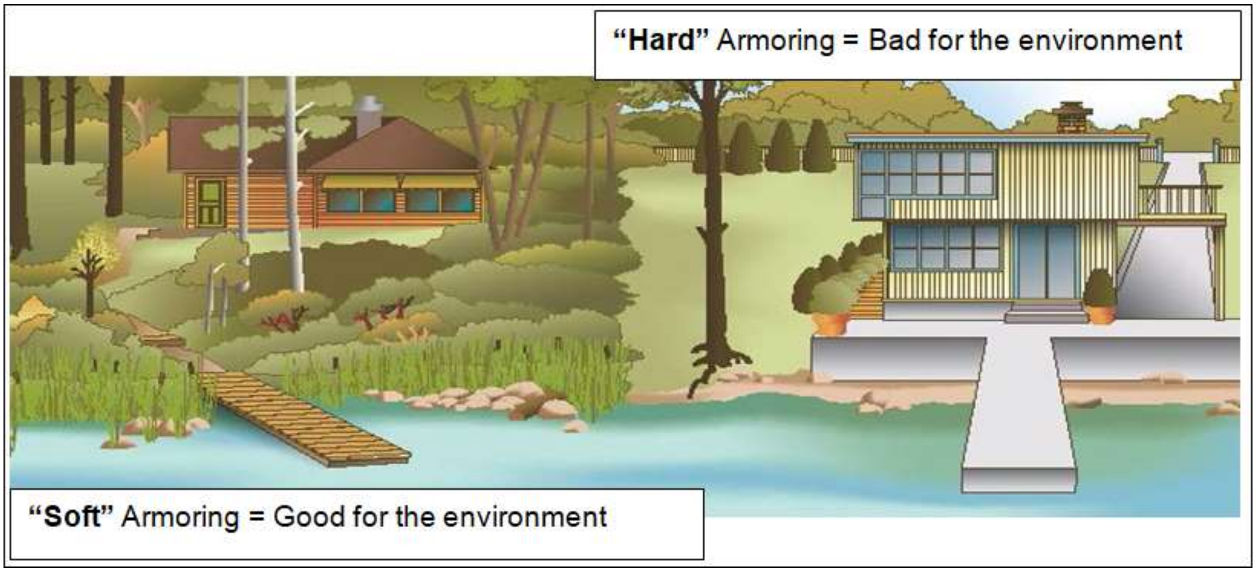

Figure 9: Soft and hard armoring of the shoreland (Alberta Environment and Sustainable Resource Development, 2021)

6.5 Water Quality-Trophic Status

In Sand Bar Lake, water quality measurements of chlorophyll-a (Chl-a; a measure of algal biomass), total phosphorus (TP; the nutrient that supports aquatic life and drives chlorophyll production), and water clarity (using a Secchi disk) were collected intermittently from 2001-2018. Using the Carlson's Trophic Status Index (TSI; Carlson, 1977), a commonly used measurement of water quality, these data can be used to determine the trophic status of the lake as a proxy for water quality. The TSI of Sand Bar Lake averaged 38.5, which classifies the lake as oligotrophic (nutrient-poor and clear water; Figure 10). Secchi readings of water clarity seem to drive this classification, as they are routinely within the oligotrophic range (Figure 10). Total phosphorus data is limited, but levels appear to be in the mesotrophic range and not increasing over time. These data, coupled with borderline mesotrophic to oligotrophic chlorophyll levels, indicate that the lake is stable and not likely to experience extreme algal blooms. However, this relationship may change if nutrient inputs to the lake significantly increase through shoreline development or watershed land use changes. More information can be found at: https://dnr.wi.gov/lakes/waterquality/Station.aspx?id=043118.

In Tomahawk Lake, the same water quality measurements were recorded from 2000-2015 and produced similar results. However, Tomahawk's water clarity is not as good as Sand Bar's, resulting in the lake being classified as more mesotrophic despite comparable levels of TP and Chl-a (Figure 11). This may be a result of greater dissolved organic materials – or tannins – entering the lake from the small catchment area and staining the water. It may also be caused by nutrients running off from the park and boat launch in conjunction with greater boat traffic on Tomahawk stirring up bottom sediments. More information on Tomahawk's water quality can be found at: https://dnr.wi.gov/lakes/waterquality/Station.aspx?id=043119.

In order to better understand the lakes and their condition, it is recommended that water quality monitoring following the Wisconsin Department of Natural Resources Citizen Lake Monitoring Network protocol be re-implemented on a regular basis. These measurements will be especially useful in monitoring water quality as water levels change and to be able to compare to water quality in the future should land use and shoreline development change. Water quality monitoring may also be beneficial in understanding how EWM and its treatment affect the lakes.

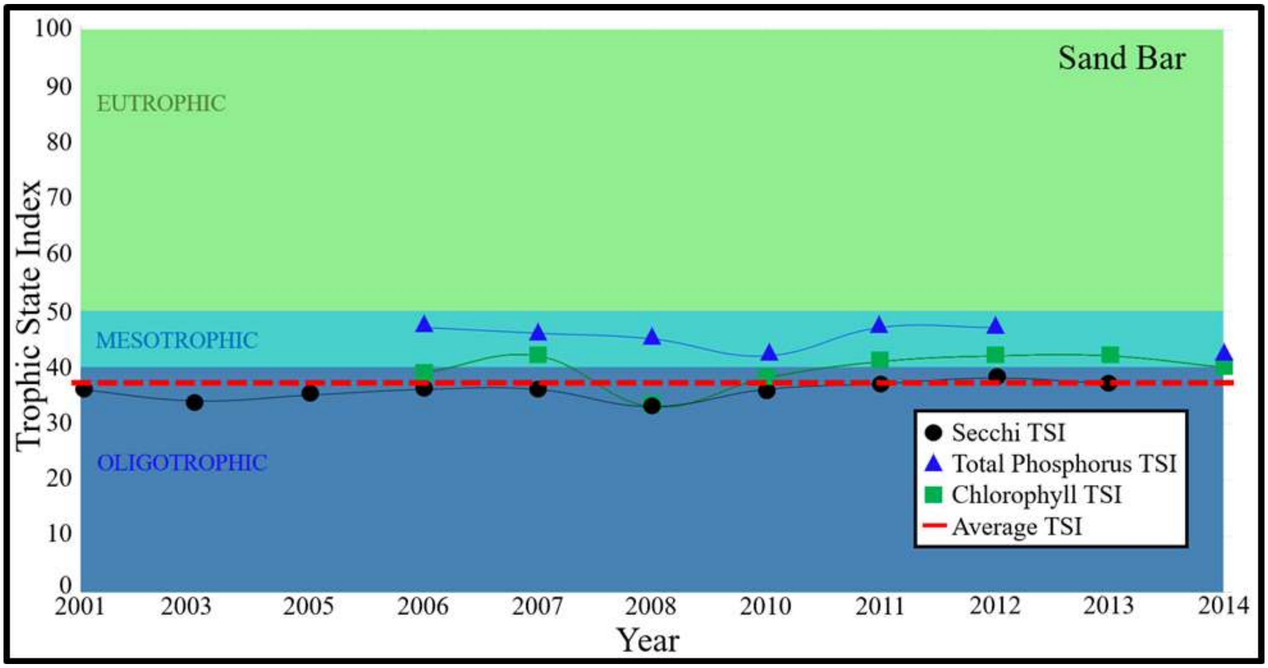

Figure 10: Sand Bar Lake, Bayfield County Trophic State Index (WDNR 2022)

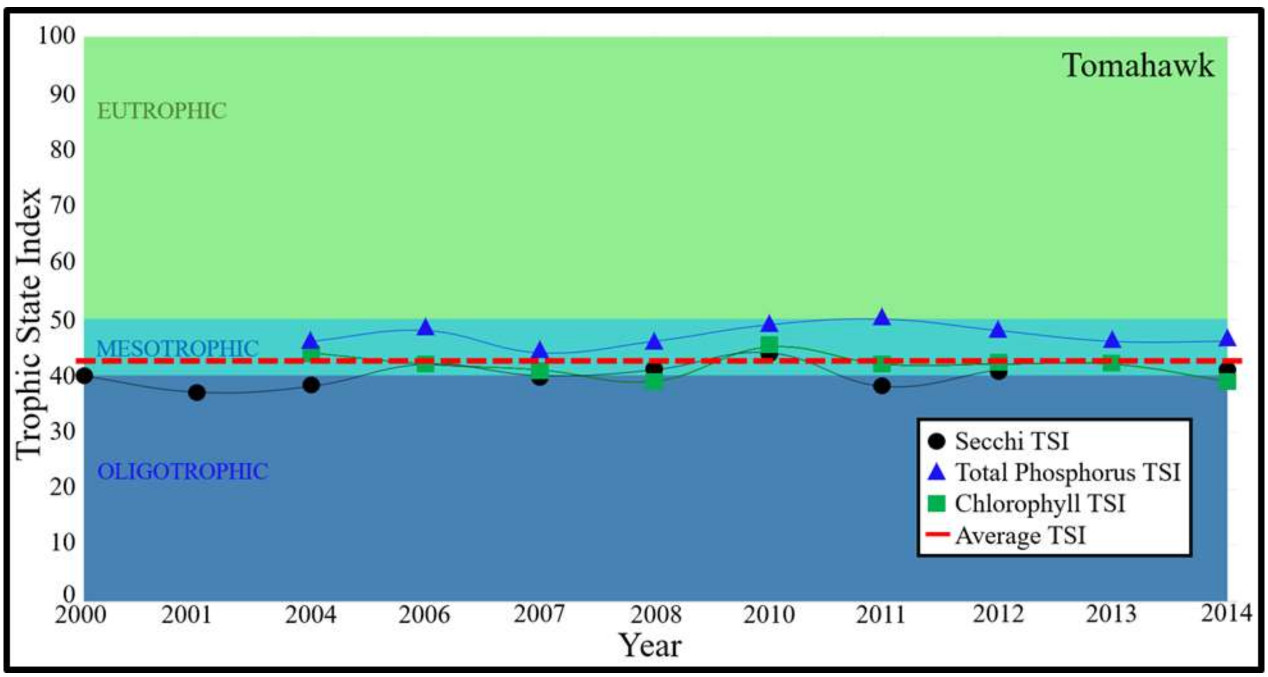

Figure 11: Tomahawk Lake, Bayfield County Trophic State Index (WDNR 2022)

The rich plant communities of Sand Bar and Tomahawk Lakes provides many functions that benefit the health of the lakes. The plant community helps maintain their clear water status by limiting the amount of nutrients that can be used by algae (a key determinant in pushing the lakes towards becoming more mesotrophic). It also supports a productive game fish community by sheltering young, small fish and providing ambush opportunities for game fish species. The native plants also help protect the shorelines from erosion by absorbing and mitigating waves before they can reach the vulnerable shore. Maintaining the health and diversity of the plant communities in the lakes while preventing mass infestation from EWM is critical in maintaining the quality of the water and the quality of the lakes as a whole.

6.5.1 Stratification and Turnover

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 (oxygen-rich surface waters), the thermocline (the layer separating the surface and bottom waters), and the hypolimnion (oxygen-depleted bottom waters) (Figure 12).

In most cases, a lake does not remain stratified year-round. Monitoring data indicates that both lakes are 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 Tomahawk shows that stratification occurs between 10-15ft and hypoxia (low oxygen) regularly occurs at depths below 25 feet during summer months (June-September). Similarly, Sand Bar stratifies between 15-20ft and hypoxia occurs below 30 feet in late summer.

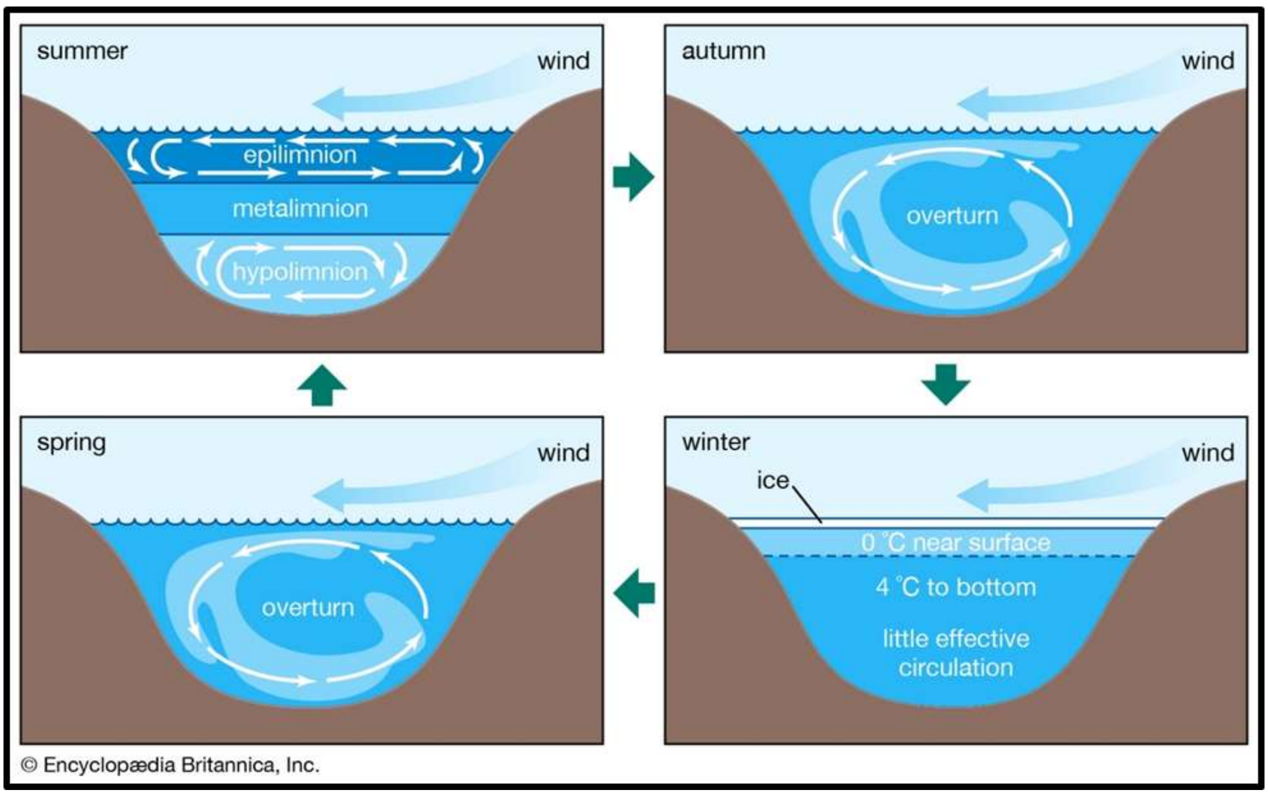

Figure 12: Dimictic stratification and turnover

7.0 Tomahawk Lake: Aquatic Plant Community (Summarized from Berg, 2021b)

The area of a lake where aquatic plants can grow is called the littoral zone. In 2021, aquatic plants were found growing to 19.0ft, down slightly from 20.5ft in 2020 (Figure 13). The 228 points with vegetation (approximately 53.4% of the entire lake bottom and 82.3% of the littoral zone) was almost identical to the 230 points with vegetation in 2020 (approximately 53.9% of the entire lake bottom and 76.7% of the littoral zone)(Figure 13).

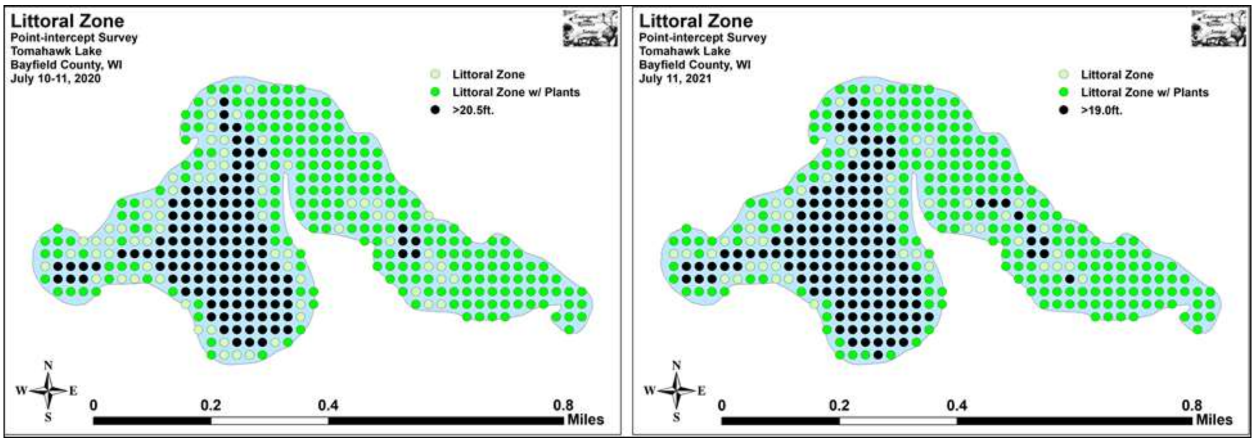

Figure 13: 2020 and 2021 Littoral Zone

7.1 Whole-lake, Point-intercept, Aquatic Plant Surveys

Since EWM was found in Tomahawk Lake in 2004, and due to the fact that several groundbreaking studies and management actions were taken, whole-lake, point-intercept surveys have been completed many times. Through 2015, the PI surveys were conducted by a WDNR survey crew. From 2018 to present PI surveys have been completed by Matt Berg and Endangered Resource Services (ERS). Tables 2&3 reflect the statistics from those surveys.

7.1.1 Simpson Diversity Index

A diversity index allows the entire plant community at one location to be compared to the entire plant community at another location. It also allows the plant community at a single location to be compared over time thus allowing a measure of community degradation or restoration at that site. With Simpson's Diversity Index, the index value represents the probability that two individual plants (randomly selected) will be different species. The index values range from 0 -1 where 0 indicates that all the plants sampled are the same species to 1 where none of the plants sampled are the same species. The greater the index value, the higher the diversity in a given location. Although many natural variables like lake size, depth, dissolved minerals, water clarity, mean temperature, etc. can affect diversity, in general, a more diverse lake indicates a healthier ecosystem. Perhaps most importantly, plant communities with high diversity also tend to be more resistant to invasion by exotic species.

Plant diversity was exceptionally high in 2021 with a Simpson Diversity Index (SDI) Value of 0.90 (down from 0.91 in 2020). Over time, the SDI has fluctuated from a high of 0.92 (2019) to a low of 0.81 (2008) when a whole lake chemical treatment was completed.

7.1.2 Total Species Richness

Total species richness including the boat survey and visuals ranged from a low of 14 (2008) after a whole lake chemical treatment to a high of 36 (2018). Since 2018, species richness has been maintained in the 30's. The last time before 2018 that species richness was this high was in 2007 before the first whole lake chemical treatment. The number of species identified in 2021 was lower that what was identified in 2020, but according to ERS, most of the species that were present in 2020 but absent in 2021 were emergent and shoreline species; especially those found along the north and east-central shorelines. ERS felt that perhaps the continued rise in lake levels has created unfavorable conditions for these nearshore plants.

7.1.3 Floristic Quality Index

This 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 index value, the healthier the lake's macrophyte community is assumed to be. Nichols (1999) identified four eco-regions in Wisconsin: Northern Lakes and Forests, North Central Hardwood Forests, Driftless Area and Southeastern Wisconsin Till Plain. Tomahawk Lake is in the Northern Lakes and Forests Ecoregion.

The 2021 point-intercept survey found a total of 23 native index plants in the rake. They produced a mean Coefficient of Conservatism of 6.4 and a Floristic Quality Index of 30.7 (Table 4). Nichols (1999) reported an average mean C for the Northern Lakes and Forest Region of 6.7 putting Tomahawk Lake slightly below average for this part of the state. The FQI value was, however, above the median FQI of 24.3 for the Northern Lakes and Forest Region (Nichols 1999).

Over time, the average mean C has ranged from a low of 5.9 in 2008 to a high of 6.7 in 2015. The FQI value has ranged from a low of 21.1 in 2010 to a high of 32.3 in 2018. Since 2018 it has been above 30.0 (Tables 2&3).

Table 2: Aquatic Macrophyte P/I Survey Summary Statistics Tomahawk Lake, Bayfield County June/July 2006-2015

Summary Statistics:	June 27, 2006	July 11-13, 2007	July 16, 2008	July 15, 2009	July 15, 2010	July 13, 2011	July 10, 2012	July 17, 2013	July 16, 2014	July 8, 2015
Total number of points sampled	315	313	299	316	328	317	320	317	315	323
Total number of sites with vegetation	256	260	141	161	173	208	240	248	252	223
Total # of sites shallower than the max. depth of plants	301	301	260	298	294	284	298	299	306	315
Freq. of occur. at sites shallower than max. depth of plants	85.0	86.4	54.2	54.0	58.8	73.2	80.5	82.9	82.4	70.8
Simpson Diversity Index	0.89	0.90	0.81	0.83	0.84	0.88	0.87	0.89	0.90	0.91
FQI Species (N)	20	23	11	13	12	16	15	18	19	21
Mean Coefficient of Conservatism (C)	6.6	6.6	5.9	6.5	6.1	6.3	6.5	6.5	6.4	6.7
Floristic Quality Index	29.5	31.7	30.6	23.3	21.1	25.0	25.0	27.6	28.0	30.6
Maximum depth of plants (ft)	20.5	25.5	17.0	26.0	27.0	21.5	25.5	24.0	26.5	27.0
Mean depth of plants (ft)	8.4	8.6	7.8	9.9	9.6	8.2	9.4	8.8	10.0	9.4
Median depth of plants (ft)	7.8	7.0	7.0	9.0	8.0	7.0	8.0	7.3	9.0	8.0
Number of sites sampled using rake on Rope (R)	150	56	9	61	58	56	69	63	63	65
Number of sites sampled using rake on Pole (P)	158	248	250	244	242	250	249	253	250	312
Ave. # of all species per site (shallower than max depth)	2.35	2.48	0.85	0.73	0.95	1.61	1.95	2.27	1.94	1.70
Ave. # of all species per site (veg. sites only)	2.76	2.57	1.57	1.35	1.61	2.19	2.42	2.73	2.35	2.40
Ave. # of native species/site (shallower than max depth)	2.08	2.18	0.85	0.73	0.95	1.60	1.95	2.25	1.94	1.70
Ave. # of native species/site (sites with nat.veg. only)	2.50	2.66	1.57	1.35	1.61	2.18	2.42	2.72	2.35	2.40
Species richness	21	24	11	13	12	18	16	21	21	23
Species richness (including visuals)	26	27	13	16	16	21	18	24	24	25
Species richness (including visuals and boat survey)	34	27	14	16	19	25	22	26	25	28
Mean rake fullness (veg. sites only) *n.m. = Not measured	n.m.*	1.86	1.34	1.27	1.30	1.17	1.23	1.22	1.30	1.22

Table 3: Aquatic Macrophyte P/I Survey Summary Statistics Tomahawk Lake, Bayfield County June/July 2018-2021

Summary Statistics:	July 17, 2018	July 27, 2019	July 10-11, 2020	July 11, 2021
Total number of points sampled	427	427	427	427
Total number of sites with vegetation	282	275	230	228
Total # of sites shallower than the max. depth of plants	350	337	300	277
Freq. of occur. at sites shallower than max. depth of plants	80.6	81.6	76.7	82.3
Simpson Diversity Index	0.90	0.92	0.91	0.90
FQI Species (N)	24	25	26	23
Mean Coefficient of Conservatism (C)	6.6	6.4	6.3	6.4
Floristic Quality Index	32.3	32.2	32.2	30.7
Maximum depth of plants (ft)	24.0	23.5	20.5	19.0
Mean depth of plants (ft)	9.1	10.8	10.5	10.3
Median depth of plants (ft)	9.0	11.0	11.0	11.0
Number of sites sampled using rake on Rope (R)	41	62	63	78
Number of sites sampled using rake on Pole (P)	314	293	276	277
Ave. # of all species per site (shallower than max depth)	1.73	2.16	2.04	2.08
Ave. # of all species per site (veg. sites only)	2.15	2.64	2.66	2.52
Ave. # of native species/site (shallower than max depth)	1.73	2.14	2.00	1.96
Ave. # of native species/site (sites with nat.veg. only)	2.15	2.62	2.62	2.42
Species richness	31	29	30	24
Species richness (including visuals)	31	31	30	24
Species richness (including visuals and boat survey)	36	32	35	25
Mean rake fullness (veg. sites only) *n.m. = Not measured	1.48	1.59	1.83	1.85

Table 4: Floristic Quality Index of Aquatic Macrophytes Tomahawk Lake, Bayfield County July 11, 2021

Species	Common Name	C
Brasenia schreberi	Watershield	6
Ceratophyllum demersum	Coontail	3
Chara sp.	Muskgrass	7
Eleocharis acicularis	Needle spikerush	5
Elodea canadensis	Common waterweed	3
Isoetes echinospora	Spiny-spored quillwort	8
Juncus pelocarpus f. submersus	Brown-fruited rush	8
Lemna minor	Small duckweed	4
Myriophyllum tenellum	Dwarf water-milfoil	10
Najas flexilis	Slender naiad	6
Najas gracillima	Northern naiad	7
Nitella sp.	Nitella	7
Nuphar variegata	Spatterdock	6
Nymphaea odorata	White water lily	6
Polygonum amphibium	Water smartweed	5
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton epihydrus	Ribbon-leaf pondweed	8
Potamogeton foliosus	Leafy pondweed	6
Potamogeton gramineus	Variable pondweed	7
Potamogeton pusillus	Small pondweed	7
Potamogeton robbinsii	Fern pondweed	8
Utricularia vulgaris	Common bladderwort	7
Vallisneria americana	Wild celery	6
N		**23**
Mean C		**6.4**
FQI		**30.7**

7.1.4 Make-up the Aquatic Plant Community

As previously mentioned, most emergent species that were present in 2020 were absent in 2021 – likely due to the continued rise in water levels. In 2020, immediately along sandy shorelines, limited numbers of Bluejoint (*Calamagrostis canadensis*), Broad-leaved woolly sedge (*Carex pellita*), Creeping spikerush (*Eleocharis palustris*), Baltic rush (*Juncus arcticus* var. *balticus*), and Narrow-panicle rush (*Juncus brevicaudatus*) were found. In water from 2-5ft deep, Common reed (*Phragmites australis* var. *americanus*) and Hardstem bulrush (*Schoenoplectus acutus*) were present in scattered low-density beds. During the 2021 survey, Hardstem bulrush was the only remaining species from this group.

During the 2020 survey, in the sandy and organic muck-bottomed areas that were scattered around the eastern and western bays, we also found small numbers of Northern St. John's-wort (*Hypericum boreale*) and Northern blue-flag (Iris versicolor); however, no evidence of any of them was found in 2021. Collectively, emergent species work to stabilize the lakeshore, provide a nursery for baitfish and juvenile gamefish, offer shelter for amphibians, and give waterfowl and predatory wading birds, like herons, a place to hunt.

Just beyond the emergents, in water usually <6ft deep, shallow sugar-sand areas tended to have high species richness. They also tended to have low total biomass as these nutrient-poor substrates provide habitat most suited to fine-leaved "isoetid" turf-forming species like Muskgrass (Chara sp.), Needle spikerush (Eleocharis acicularis), Spiny-spored quillwort (*Isoetes echinospora*), Brown-fruited rush (*Juncus pelocarpus*), Dwarf water-milfoil (*Myriophyllum tenellum*), and Northern naiad (*Najas gracillima*). In 2020, Crested arrowhead (*Sagittaria cristata*) was also found in this environment. These species, along with the emergents, work to stabilize the bottom and prevent wave-action erosion.

The floating-leaf species – Watershield (*Brasenia schreberi*), Spatterdock (*Nuphar variegata*), White water lily (*Nymphaea odorata*), and Water smartweed (*Polygonum amphibium*) – were relatively common in shallow areas that were formerly occupied by emergent species. The protective canopy cover this group provides is often utilized by panfish and bass.

Sandy-muck areas in water from 6-17ft supported a rich collection of generally larger-leaved species including Common waterweed (*Elodea canadensis*), Eurasian water-milfoil, Slender naiad (*Najas flexilis*), Large-leaf pondweed (*Potamogeton amplifolius*), Ribbon-leaf pondweed (*Potamogeton epihydrus*), Leafy pondweed (*Potamogeton foliosus*), Variable pondweed (Potamogeton gramineus), Small pondweed (*Potamogeton pusillus*), Fern pondweed (*Potamogeton robbinsii*), and Wild celery (*Vallisneria americana*). The seeds, shoots, roots, and tubers this group supplies are heavily utilized by resident and migratory waterfowl. They also provide important habitat for baitfish and both juvenile and mature game fish, as well as insects like dragonflies and mayflies during the aquatic nymph stages of their life cycles.

Areas from 17-19ft had almost no vegetation. These deep-water habitats were characterized by only widely-scattered Charophytes like Muskgrass and, growing deeper than any other species, Nitella (*Nitella sp.* – likely *flexilis*).

7.1.5 Aquatic Plant Community Comparisons

In 2020, Muskgrass, Fern pondweed, Variable pondweed, Northern naiad, and Small pondweed were identified as the most common species. Present at 47.83%, 30.87%, 25.65%, 22.61%, and 21.74% of sites with vegetation, they accounted for 55.88% of the total relative frequency. Large-leaf pondweed (7.03%), Slender naiad (6.86%), and Common waterweed (6.37%) also had relative frequencies over 4% (Figure 9).

The 2021 survey found Muskgrass, Variable pondweed, Fern pondweed, Common waterweed, and Small pondweed were the most common species. They were found at 44.74%, 32.02%, 27.63%, 21.93%, and 21.93% of sites with vegetation; and, collectively, they encompassed 58.78% of the total relative frequency. Large leaf pondweed (8.35%), Northern naiad (7.65%), and Eurasian water-milfoil (5.74%) were the only other species with a relative frequency over 4.00%.

Lake wide, three species showed significant changes in distribution from 2020 to 2021. Eurasian water-milfoil underwent a highly significant increase while Common bladderwort (*Utricularia vulgaris*) suffered a moderately significant decline, and Slender naiad saw a significant decline (Figure 14).

Muskgrass – the most widely distributed macrophyte in both 2020 and 2021 – was present in most areas from 2-15ft deep over muck substrates. Found at 110 sites in 2020, it demonstrated a non-significant decline in distribution to 102 sites in 2021. Although its mean rake fullness also shrank from 1.60 in 2020 to 1.57 in 2021, this was also insignificant.

Fern pondweed was the second most common species in 2020 (71 sites – mean rake 1.61) and the third most common in 2021 (63 sites - mean rake 1.62). Neither the decline in distribution nor the increase in density was significant.

Variable pondweed, an important broad-leaved habitat-producing species, was the third most widely-distributed species in 2020 (59 sites/mean rake fullness 1.29). It experienced a nearly-significant increase in distribution and a significant increase in density to become the second most common species in 2021 (73 sites/mean rake 1.45). Visual analysis of the maps suggested most of these increases occurred in the 10-15ft bathymetric ring on the outer edges of this species zone of growth.

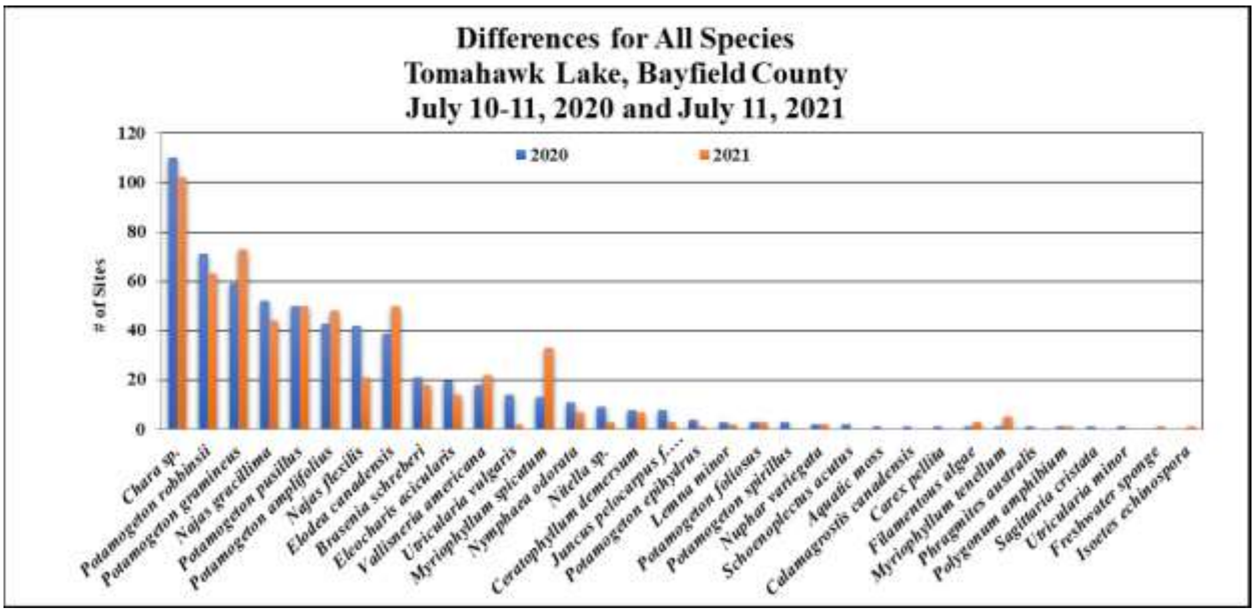

Figure 14: Macrophyte distribution changes from 2020-2021 (Berg, 2021b)

7.2 EWM Comparisons

Active management including the use of aquatic herbicides, physical removal, and DASH has dramatically reduced the EWM infestation in Tomahawk Lake since first mapped in 2006. A whole-lake herbicide treatment in 2008 all but eliminated EWM until it resurfaced again about 2011 leading to management using herbicides in 2013, and again in 2017. Physical removal and DASH between the years where herbicides were used helped maintain EWM at low levels. However, since 2019 the amount of EWM is once again increasing (Figure 15). In 2015, EWM was present at a single point with a rake fullness of 1 (Figure 16). Following the 2017 whole-lake treatment and 2018 "BAISS" suction removal, there was no EWM at or near any survey point during the July 2018 survey. The only evidence of EWM anywhere in the lake was a single floating fragment next to the dock at the public boat landing (Figure 16).

The 2019 survey documented a moderately significant resurgence in total EWM as plants in the rake were found at seven points with seven additional visual sightings (Figure 16). Of these, one rated a 3, one was a 2, and the remaining five were a 1 for a combined mean rake fullness of 1.43. Plants were scattered along the north shoreline from the site of the original infestation northwest of the public boat landing all the way to the tip of the "handle" in the east bay where abundant towers were beginning to merge into beds. A few pioneer plants along the south shoreline of the handle and near the channel to Sand Bar Lake were also documented.

In 2020, EWM saw another nearly significant increase in distribution (Figure 16). Present in the rake at 13 points with three additional visuals, two rated a 3, three a 2, and eight a 1 for a mean rake fullness of 1.54. This suggested that 3.04% of the lake had EWM (up from 1.64% in 2019). This was still well below EWM's high water mark in 2006 and 2007 when WDNR surveyors found it at 81 points (mean rake fullness of 1.56 - 31.64% of vegetative points) and 120 points (mean rake of 1.69 – 46.15% vegetative coverage).

The 2021 survey documented a highly significant increase in EWM distribution (33 sites), a moderately significant increase in rake fullness 3 (Figures 17), and a significant increase in density (mean rake fullness of 2.12) as it rose to become the eighth most common species. Of the 33 sites, fourteen were rated a 3, nine a 2, and ten a 1 with seven additional visual sightings (Figure 18). This suggested that 7.73% of the lake had EWM (+153.85% from 2020) and 5.39% had a significant infestation (rake fullness 2 or 3) (+360.00% from 2020). Again, this was still well below EWM's high water mark in 2006 and 2007, but the steep increase shows EWM is on the rise again.

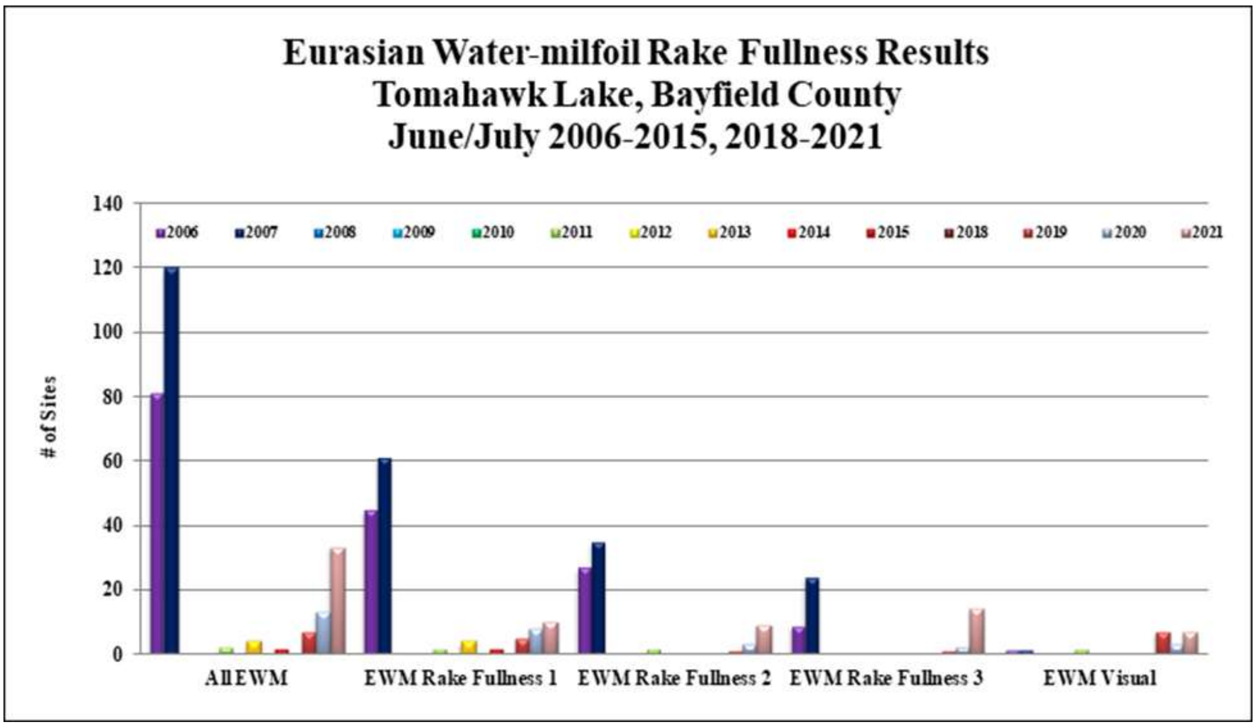

Figure 15: EWM rake fullness results 2006-2015, 2018-2021 (Berg, 2021b)

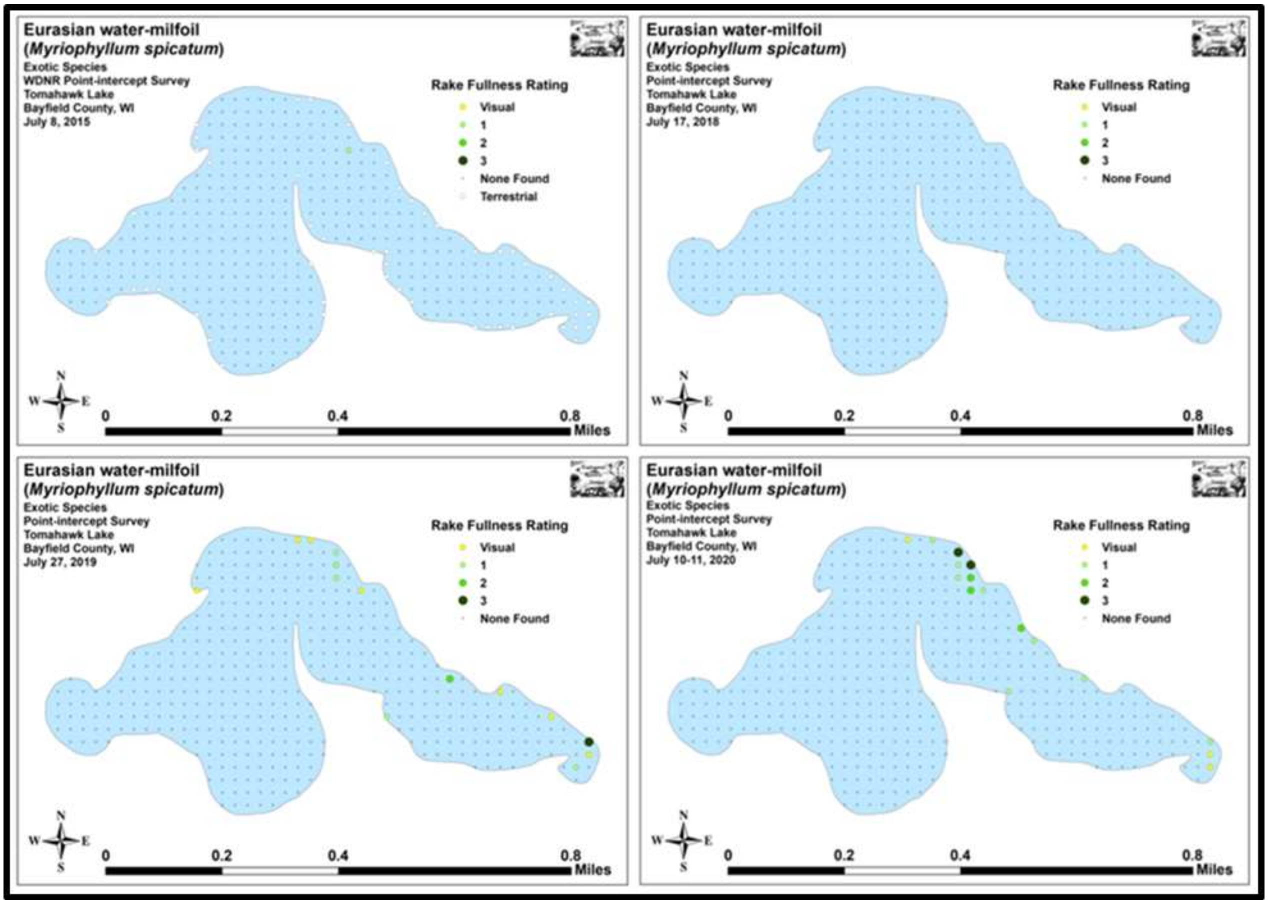

Figure 16: 2015, 2018, 2019, and 2020 EWM density and distribution (Berg, 2021b)

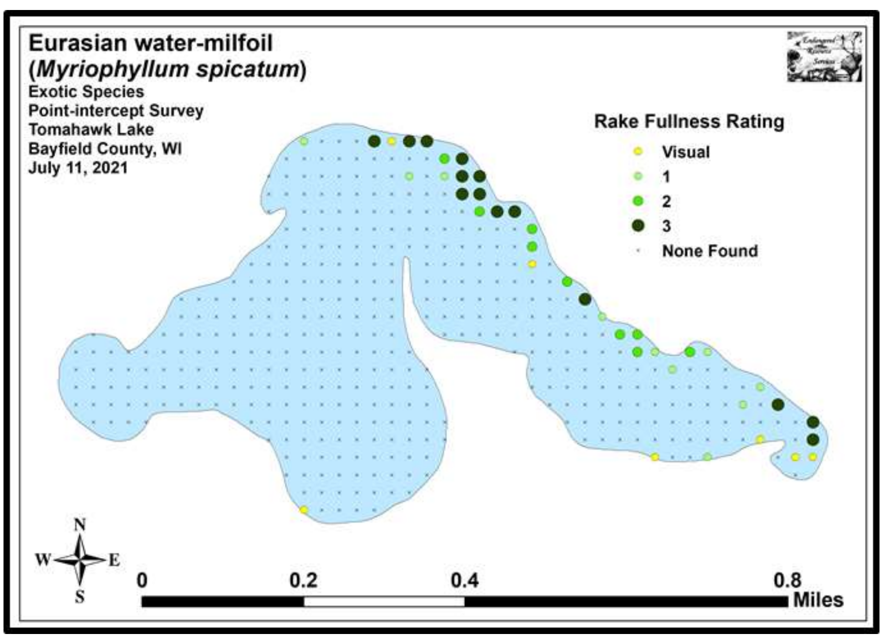

Figure 17: 2021 EWM density and distribution (Berg, 2021b)

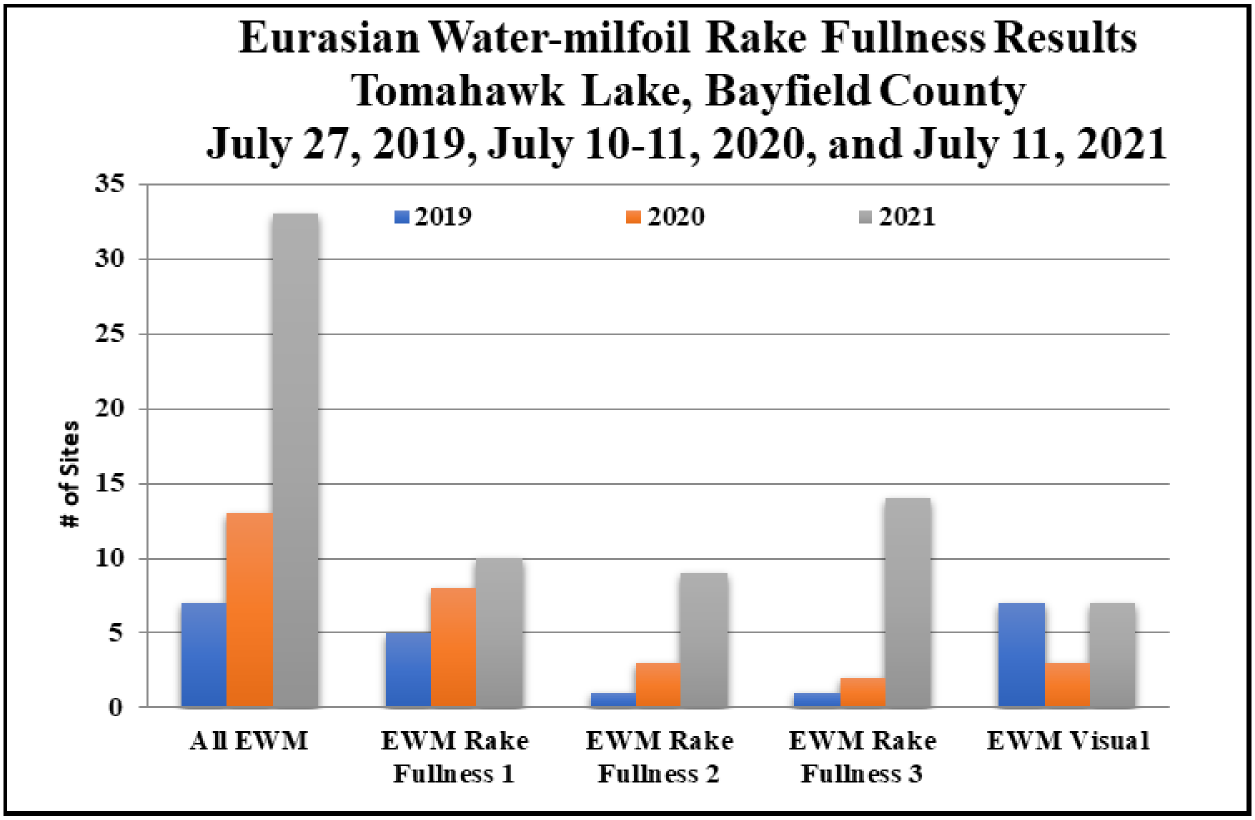

Figure 18: 2019, 2020, and 2021 Changes in EWM Rake Fullness

7.3 Other Exotic Plant Species

Other than EWM, there was no evidence of Curly-leaf pondweed (*Potamogeton crispus*), Purple loosestrife (*Lythrum salicaria*), Reed canary grass (*Phalaris arundinacea*), or any other exotic plant species in or around Tomahawk Lake. The only other plant found that was of potential concern was Common reed which occurred in a single scattered bed on the eastern shoreline of the south bay. In 2020, rising water levels had left only a few leaves above water (Figure 19), and, by 2021, there was no evidence of the bed at all. Although this species can be highly invasive in its exotic form, careful analysis of the plants present showed their leaf sheaths were detached, and the culms (stems) were red in color (Figure 15). These characteristics suggest it is the native subspecies *americanus* which is NOT generally invasive.

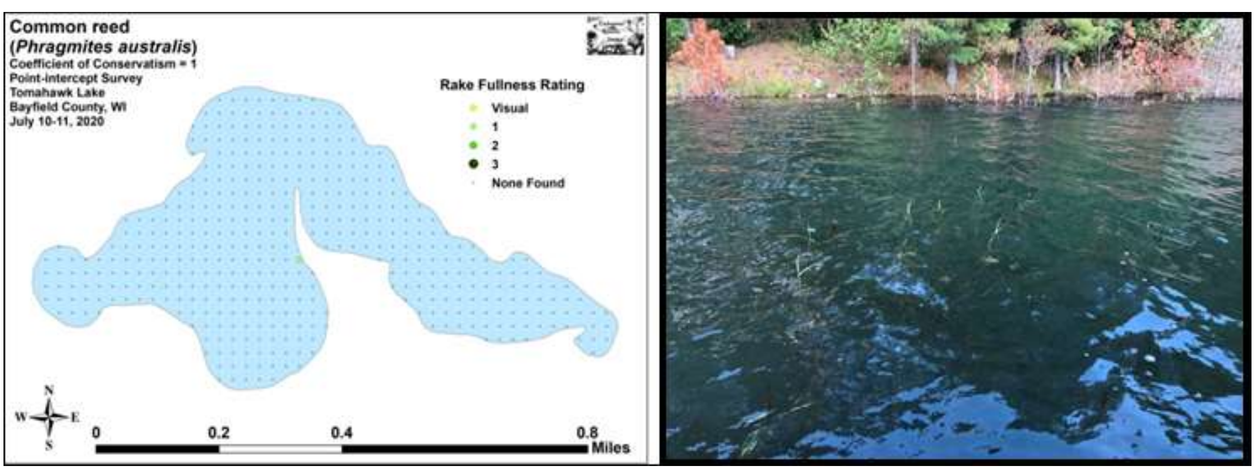

Figure 19: 2020 Common Reed Density and Distribution/Remnants of Bed on the East Shoreline of the South Bay (Berg, 2021b)

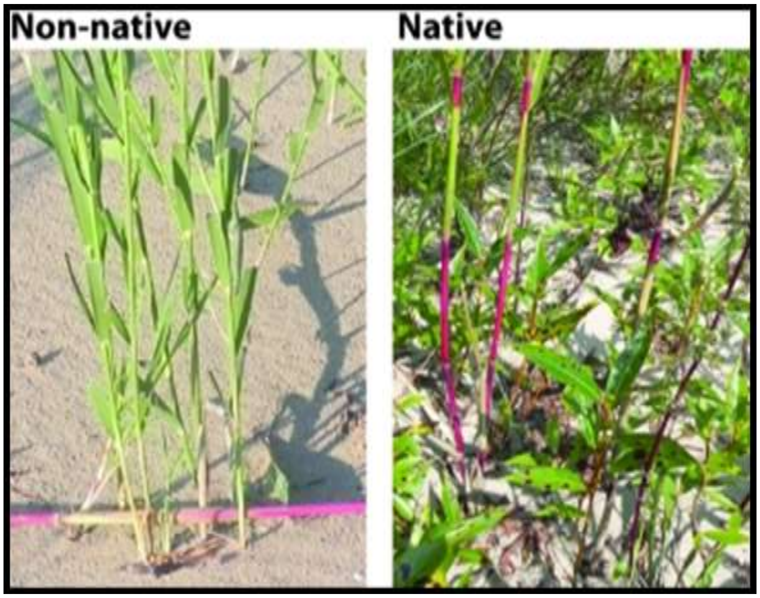

Figure 20: Stem pattern on exotic vs. native common reed (Berg, 2021b)

8.0 Sand Bar Lake: Aquatic Plant Community (Summarized from Berg, 2021a)

The area of a lake where aquatic plants can grow is called the littoral zone. In 2021, aquatic plants were found growing to 19.0ft, down slightly from 21.5ft in 2020 (Figure 21). Despite this littoral decline, the 101 points with vegetation (approximately 32.3% of the entire lake bottom and 87.1% of the littoral zone) was similar to 2020 when there were 108 points with vegetation (34.5% of the entire lake bottom/85.7% of the littoral zone).

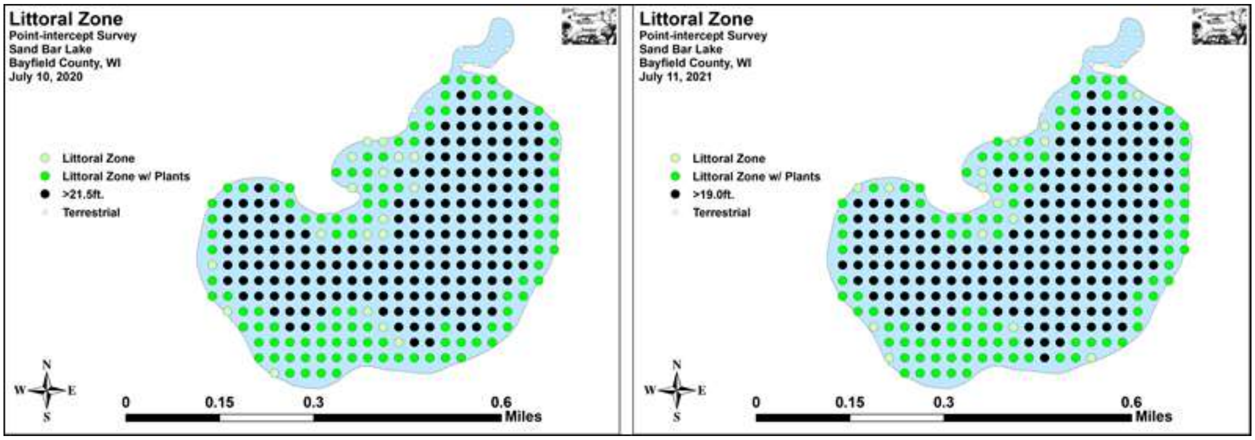

Figure 21: 2020 and 2021 Littoral Zone

8.1 Whole-lake, Point-intercept, Aquatic Plant Surveys

Since EWM was found in Sand Bar Lake in 2004, and due to the fact that several groundbreaking studies and management actions were taken, whole-lake, point-intercept surveys have been completed many times. Through 2015, the PI surveys were conducted by a WDNR survey crew. From 2018 to present PI surveys have been completed by Matt Berg and Endangered Resource Services (ERS). Tables 5&6 reflect the statistics from those surveys.

8.1.1 Simpson Diversity Index

A diversity index allows the entire plant community at one location to be compared to the entire plant community at another location. It also allows the plant community at a single location to be compared over time thus allowing a measure of community degradation or restoration at that site. With Simpson's Diversity Index, the index value represents the probability that two individual plants (randomly selected) will be different species. The index values range from 0 -1 where 0 indicates that all the plants sampled are the same species to 1 where none of the plants sampled are the same species. The greater the index value, the higher the diversity in a given location. Although many natural variables like lake size, depth, dissolved minerals, water clarity, mean temperature, etc. can affect diversity, in general, a more diverse lake indicates a healthier ecosystem. Perhaps most importantly, plant communities with high diversity also tend to be more resistant to invasion by exotic species.

Plant diversity was very high in 2021 with a Simpson Diversity Index (SDI) Value of 0.89 (down from 0.91 in 2020). Over time, the SDI has fluctuated from a high of 0.91 (2019 & 20) to a low of 0.88 (2008, 11, 13, 15).

8.1.2 Total Species Richness

Total species richness including the boat survey and visuals ranged from a low of 16 (2008) to a high of 28 (2018 & 2020). Since 2018, species richness has averaged 26 species. From 2007 to 2015 it averaged 21 species. Prior to 2018, PI surveys captured the scattered nature of Charophytes (valuable habitat producing colonial algae that look like higher plants) on the outer edge of the littoral zone in water from 19-28ft deep. The significant rise in water levels in 2018 appeared to have resulted in the reduction of these deep-water species. Although emergent plants initially took advantage of rising water levels, the rapid additional rise by over 2ft in 2019 and 0.5ft in 2020 almost eliminated the emergent community. With limited light in the ring of dead trees that surrounded the lake, very little plant growth of any kind was found in water <2ft deep.

8.1.3 Floristic Quality Index

This 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 index value, the healthier the lake's macrophyte community is assumed to be. Nichols (1999) identified four eco-regions in Wisconsin: Northern Lakes and Forests, North Central Hardwood Forests, Driftless Area and Southeastern Wisconsin Till Plain. Sand Bar Lake is in the Northern Lakes and Forests Ecoregion.

The 2021 point-intercept survey found a total of 22 native index plants in the rake. They produced a mean Coefficient of Conservatism of 6.6 and a Floristic Quality Index of 31.1 (Table 7). Nichols (1999) reported an average mean C for the Northern Lakes and Forest Region of 6.7 putting Sand Bar Lake just slightly below average for this part of the state. The FQI value was, however, above the median FQI of 24.3 for the Northern Lakes and Forest Region (Nichols 1999).

Over time, the average mean C has ranged from a low of 6.4 in 2012 to a high of 6.8 in 2007. The FQI value has ranged from a low of 24.1 in 2008 to a high of 31.1 in 2021. Since 2018 it has been above 29.0 (Tables 5&6).

Table 5: Aquatic Macrophyte P/I Survey Summary Statistics Sand Bar Lake, Bayfield County June/July 2006-2015

Summary Statistics:	July 9-11, 2007	July 15, 2008	July 16, 2009	July 16, 2010	July 14, 2011	July 11, 2012	July 16, 2013	July 16, 2014	July 9, 2015
Total number of points sampled	190	125	221	182	168	194	185	178	178
Total number of sites with vegetation	131	107	126	119	103	120	100	109	102
Total # of sites shallower than the max. depth of plants	151	121	151	142	159	167	147	156	147
Freq. of occur. at sites shallower than max. depth of plants	86.8	88.4	83.4	83.9	64.8	71.9	68.0	69.9	69.4
Simpson Diversity Index	0.89	0.88	0.89	0.90	0.88	0.89	0.88	0.89	0.88
FQI Species (N)	18	13	14	18	16	16	17	18	18
Mean Coefficient of Conservatism (C)	6.8	6.7	6.6	6.5	6.5	6.4	6.7	6.5	6.5
Floristic Quality Index	28.8	24.1	24.9	27.6	26.0	25.5	27.6	27.6	27.6
Maximum depth of plants (ft)	23.0	21.0	26.0	23.5	27.0	28.0	24.0	26.5	25.0
Mean depth of plants (ft)	8.9	9.2	9.6	8.9	10.0	10.1	9.2	9.7	9.5
Median depth of plants (ft)	7.0	8.5	8.5	7.0	9.0	8.5	8.0	8.0	8.3
Number of sites sampled using rake on Rope (R)	55	24	61	63	61	80	77	74	65
Number of sites sampled using rake on Pole (P)	109	97	96	98	102	104	105	104	113
Ave. # of all species per site (shallower than max depth)	2.80	2.54	2.46	2.49	1.44	1.82	1.78	1.87	1.82
Ave. # of all species per site (veg. sites only)	3.23	2.87	2.95	2.97	2.22	2.53	2.62	2.68	2.63
Ave. # of native species/site (shallower than max depth)	2.54	2.22	2.15	2.06	1.40	1.74	1.77	1.87	1.82
Ave. # of native species/site (sites with nat.veg. only)	2.95	2.61	2.66	2.69	2.21	2.46	2.60	2.68	2.63
Species richness	19	14	15	19	18	18	19	20	20
Species richness (including visuals)	21	14	16	20	19	22	20	23	20
Species richness (including visuals and boat survey)	22	16	18	21	19	26	25	26	23
Mean rake fullness (veg. sites only) *n.m. = Not measured	1.74	1.74	1.60	1.63	1.25	1.30	1.10	1.24	1.10

Table 6: Aquatic Macrophyte P/I Survey Summary Statistics Sand Bar Lake, Bayfield County June/July 2018-2021

Summary Statistics:	July 19, 2018	July 14/27, 2019	July 10, 2020	July 11, 2021
Total number of points sampled	313	313	313	313
Total number of sites with vegetation	142	114	108	101
Total # of sites shallower than the max. depth of plants	178	166	126	116
Freq. of occur. at sites shallower than max. depth of plants	79.8	68.7	85.7	87.1
Simpson Diversity Index	0.90	0.91	0.91	0.89
FQI Species (N)	20	21	20	22
Mean Coefficient of Conservatism (C)	6.5	6.5	6.6	6.6
Floristic Quality Index	29.1	29.7	29.3	31.1
Maximum depth of plants (ft)	28.0	27.5	21.5	19.0
Mean depth of plants (ft)	11.4	12.3	11.1	11.1
Median depth of plants (ft)	9.5	12.0	11.0	11.5
Number of sites sampled using rake on Rope (R)	50	52	28	65
Number of sites sampled using rake on Pole (P)	131	120	114	116
Ave. # of all species per site (shallower than max depth)	1.75	1.77	2.27	2.41
Ave. # of all species per site (veg. sites only)	2.19	2.57	2.65	2.77
Ave. # of native species/site (shallower than max depth)	1.75	1.77	2.27	2.39
Ave. # of native species/site (sites with nat.veg. only)	2.19	2.57	2.65	2.74
Species richness	24	23	20	23
Species richness (including visuals)	25	23	22	23
Species richness (including visuals and boat survey)	28	23	28	27
Mean rake fullness (veg. sites only) *n.m. = Not measured	1.59	1.33	1.59	1.80

Table 7: Floristic Quality Index of Aquatic Macrophytes Sand Bar Lake, Bayfield County July 10, 2021

Species	Common Name	C
Brasenia schreberi	Watershield	6
Ceratophyllum demersum	Coontail	3
Chara sp.	Muskgrass	7
Eleocharis acicularis	Needle spikerush	5
Eleocharis palustris	Creeping spikerush	6
Elodea canadensis	Common waterweed	3
Isoetes echinospora	Spiny-spored quillwort	8
Juncus pelocarpus f. submersus	Brown-fruited rush	8
Myriophyllum tenellum	Dwarf water-milfoil	10
Najas flexilis	Slender naiad	6
Najas gracillima	Northern naiad	7
Nitella sp.	Nitella	7
Polygonum amphibium	Water smartweed	5
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton gramineus	Variable pondweed	7
Potamogeton praelongus	White-stem pondweed	8
Potamogeton pusillus	Small pondweed	7
Potamogeton richardsonii	Clasping-leaf pondweed	5
Potamogeton robbinsii	Fern pondweed	8
Potamogeton spirillus	Spiral-fruited pondweed	8
Ranunculus flammula	Creeping spearwort	9
Vallisneria americana	Wild celery	6
N		**22**
Mean C		**6.6**
FQI		**31.1**

8.1.4 Make-up the Aquatic Plant Community

The Sand Bar Lake ecosystem is home to a sensitive plant community that is characteristic of pristine low-nutrient soft-water seepage lakes. Most emergent species that were present in 2020 were rare or absent in 2021 – likely due to the continued rise in water levels. Immediately along sandy shorelines, limited numbers of Bluejoint (Calamagrostis canadensis), Broad-leaved woolly sedge (*Carex pellita*), Creeping spikerush (*Eleocharis palustris*), Baltic rush (*Juncus arcticus* var. *balticus*), and Hardstem bulrush (*Schoenoplectus acutus*) were found. In 2020, a few Narrow-panicle rush (*Juncus brevicaudatus*) were found (Berg, 2021a).

Just beyond the emergents, in water usually <6ft deep, shallow sugar-sand areas tended to have high species richness. They also tended to have low total biomass as these nutrient-poor substrates provide habitat most suited to fine-leaved "isoetid" turf-forming species like Muskgrass (*Chara sp.*), Needle spikerush (*Eleocharis acicularis*), Spiny-spored quillwort (*Isoetes echinospora*), Brown-fruited rush (*Juncus pelocarpus*), Dwarf water-milfoil (*Myriophyllum tenellum*), Northern naiad (*Najas gracillima*), and Creeping spearwort (*Ranunculus flammula*). These species, along with the emergents, work to stabilize the bottom and prevent wave action erosion.

Shallow muck-bottomed areas were the rarest habitat in the lake. Because of this, the floating-leaf species Watershield (*Brasenia schreberi*), Water smartweed (*Polygonum amphibium*), Ribbon-leaf pondweed (*Potamogeton epihydrus*) (only seen in 2020), and Spiral-fruited pondweed (*Potamogeton spirillus*) were also generally uncommon. The protective canopy cover this group provides is often utilized by panfish and bass.

Sandy-muck areas in water from 6-15ft supported a rich collection of generally larger-leaved species including Eurasian water-milfoil, Slender naiad (*Najas flexilis*), Large-leaf pondweed (*Potamogeton amplifolius*), Variable pondweed (*Potamogeton gramineus*), White-stem pondweed (*Potamogeton praelongus*), Clasping-leaf pondweed (*Potamogeton richardsonii*), Flat-stem pondweed (*Potamogeton zosteriformis*) (only seen in 2020), and Wild celery (*Vallisneria americana*). The seeds, shoots, roots, and tubers this group supplies are heavily utilized by resident and migratory waterfowl. They also provide important habitat for baitfish and both juvenile and mature game fish, as well as insects like dragonflies and mayflies during the aquatic nymph stages of their life cycles.

Areas from 15-19ft had much patchier vegetation. These deep water habitats were dominated by Coontail (*Ceratophyllum demersum*), Common waterweed (*Elodea canadensis*), Small pondweed (*Potamogeton pusillus*), Fern pondweed (*Potamogeton robbinsii*), and, growing deeper than any other species, the Charophytes Muskgrass and Nitella (*Nitella sp.* – likely *flexilis*).

8.1.5 Aquatic Plant Community Comparisons

In 2020, Variable pondweed, Muskgrass, Small pondweed, and Needle spikerush were identified as the most common species. They were present at 44.44%, 31.48%, 29.63%, and 20.37% of sites with vegetation and represented 47.55% of the total relative frequency. Large-leaf pondweed (7.34%), Northern naiad (6.64%), Fern pondweed (5.59%), Common waterweed (5.24%), Dwarf water-milfoil (4.90%), Slender naiad (4.90%), Wild celery (4.90%), and Nitella (4.55%) also had relative frequencies over 4%.

The 2021 survey found Variable pondweed, Muskgrass, Small pondweed, and Wild celery were the most common species. Present at 59.41%, 39.60%, 35.64%, and 19.80% of sites with vegetation, they encompassed 55.71% of the total relative frequency. Common waterweed (6.79%), Needle spikerush (6.43%), Large-leaf pondweed (5.71%), and Fern pondweed (4.29%) were the only other species with a relative frequency over 4.00%.

Lakewide, two species showed significant changes in distribution from 2020 to 2021 (Figure 8). Variable pondweed underwent a significant increase, and, conversely, Nitella suffered a significant decline.

Variable pondweed, the most widely-distributed macrophyte in both 2020 and 2021, was present throughout the littoral zone over sand and sandy-muck substrates. Found at 48 sites in 2020, it demonstrated a significant increase in distribution to 60 sites in 2021. It also saw a highly significant increase in mean rake fullness from 1.19 in 2020 to 1.57 in 2021.

Muskgrass was the second most common species during both surveys. Although its increase in distribution (34 sites in 2020/40 sites in 2021) was not significant, the increase in density from 1.26 in 2020 to 1.48 in 2021 was significant.

Small pondweed was the third most common species during each survey. Present at 32 sites with a mean rake fullness of 1.47 in 2020, it underwent a non-significant increase in distribution and a non-significant decline in density to 36 sites with a mean rake of 1.44 in 2021.

Wild celery was the ninth most common species in 2020 (14 sites) and the fourth most common in 2021 (20 sites). Neither the increase in distribution nor its slight increase in density from a mean rake fullness of 1.00 in 2020 to a mean rake of 1.10 in 2021 were significant.

Common waterweed was the eighth most common species in 2020 (15 sites/mean rake of 1.40) and the fifth most common in 2021 (19 sites/mean rake of 1.42). Despite this increase in community rank, the increases in density and distribution were not significant.

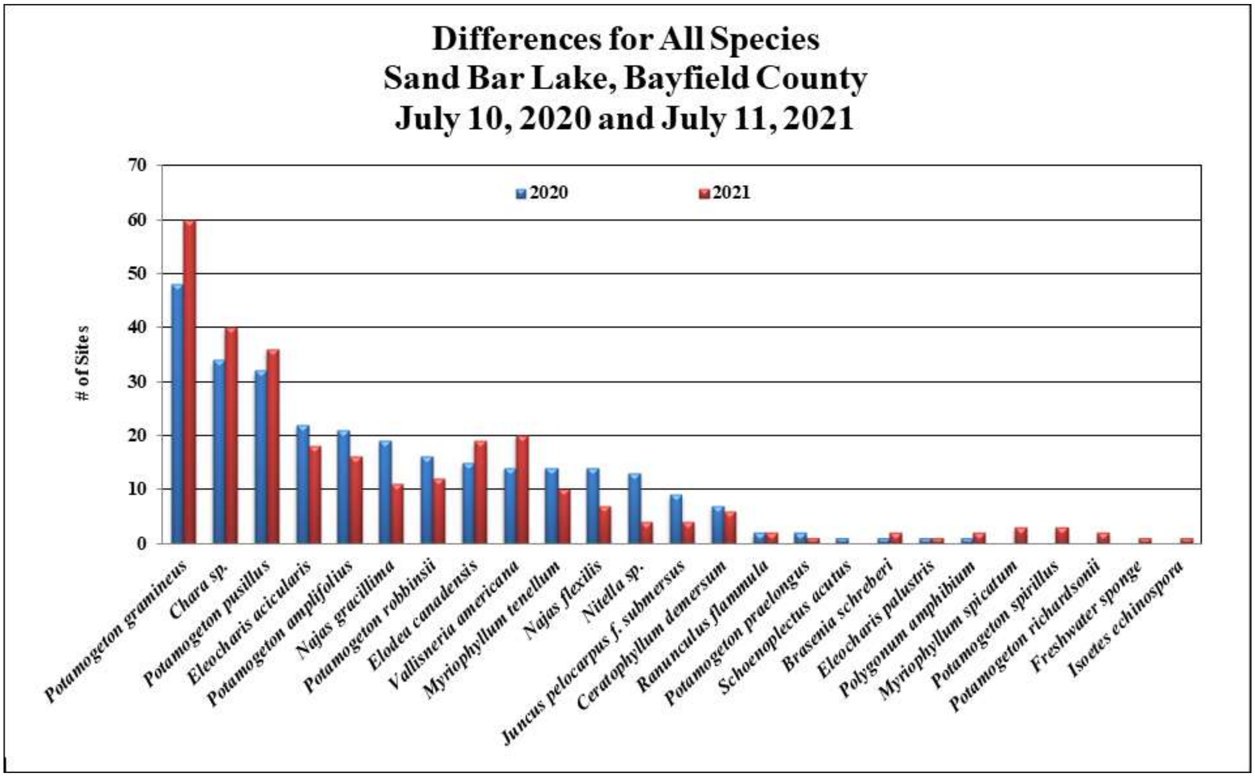

Figure 22: Macrophyte distribution changes from 2020-2021 (Berg, 2021a)

8.2 EWM Comparisons

Active management has dramatically reduced the Eurasian water-milfoil infestation in Sand Bar Lake, but levels are again increasing (Figure 23). In 2015, WDNR biologists did not find any evidence of EWM during the July survey (Figure 24). Following an uptick in plants documented by dive surveys, the 2017 whole-lake treatment and 2018 "BAISS" suction removal again dropped EWM numbers down to the level of being undetectable, with no documentation of EWM at or near any survey point in July 2018, 2019, or 2020 (Figure 24).

In 2021, a single EWM plant was found in the rake at each of three points (0.96% total lake coverage/2.59% littoral presence) (Figure 25). This is still well below EWM's high-water mark in 2009 and 2010 when WDNR surveyors found it at 48 points (mean rake fullness of 1.58 - 38.10% of vegetative points) and 60 points (mean rake of 1.63 – 50.42% vegetative coverage) (Figure 23).

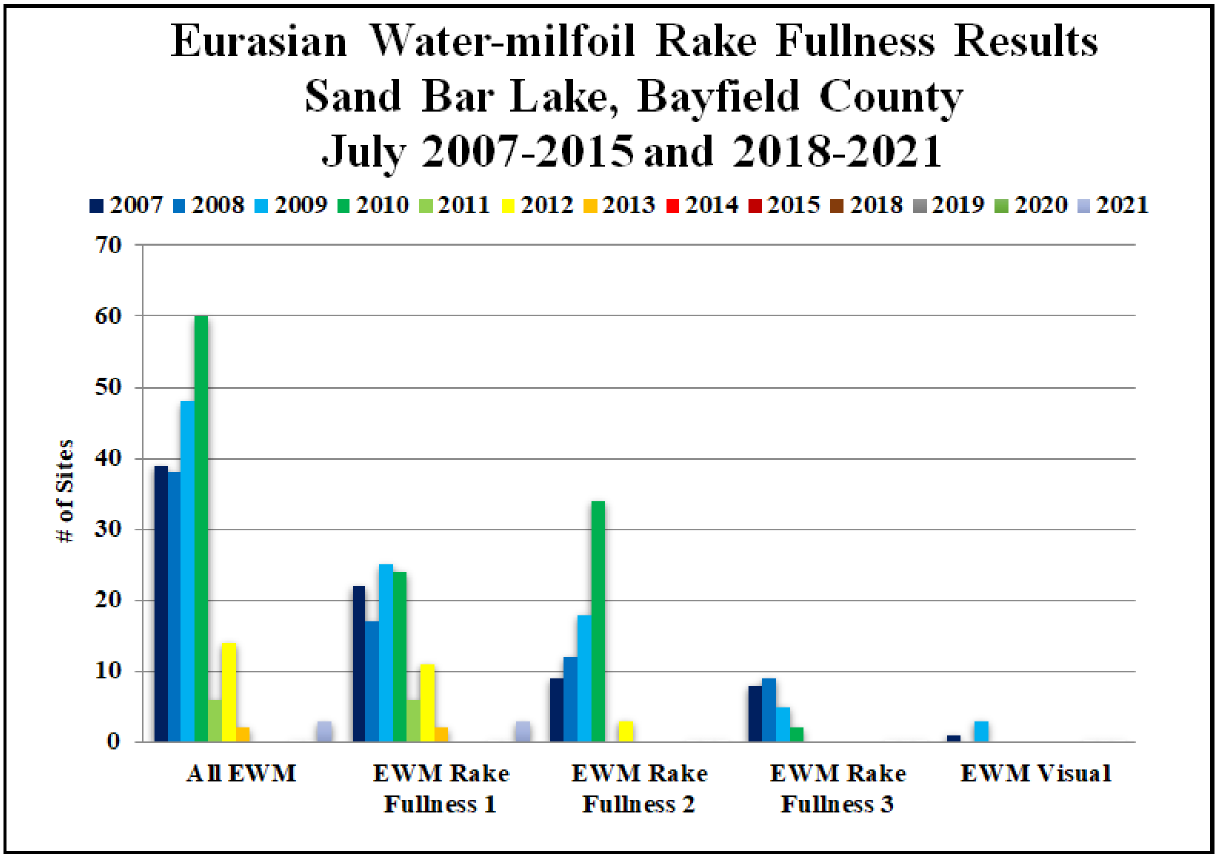

Figure 23: EWM rake fullness results 2007-2015, 2018-2021 (Berg, 2021a)

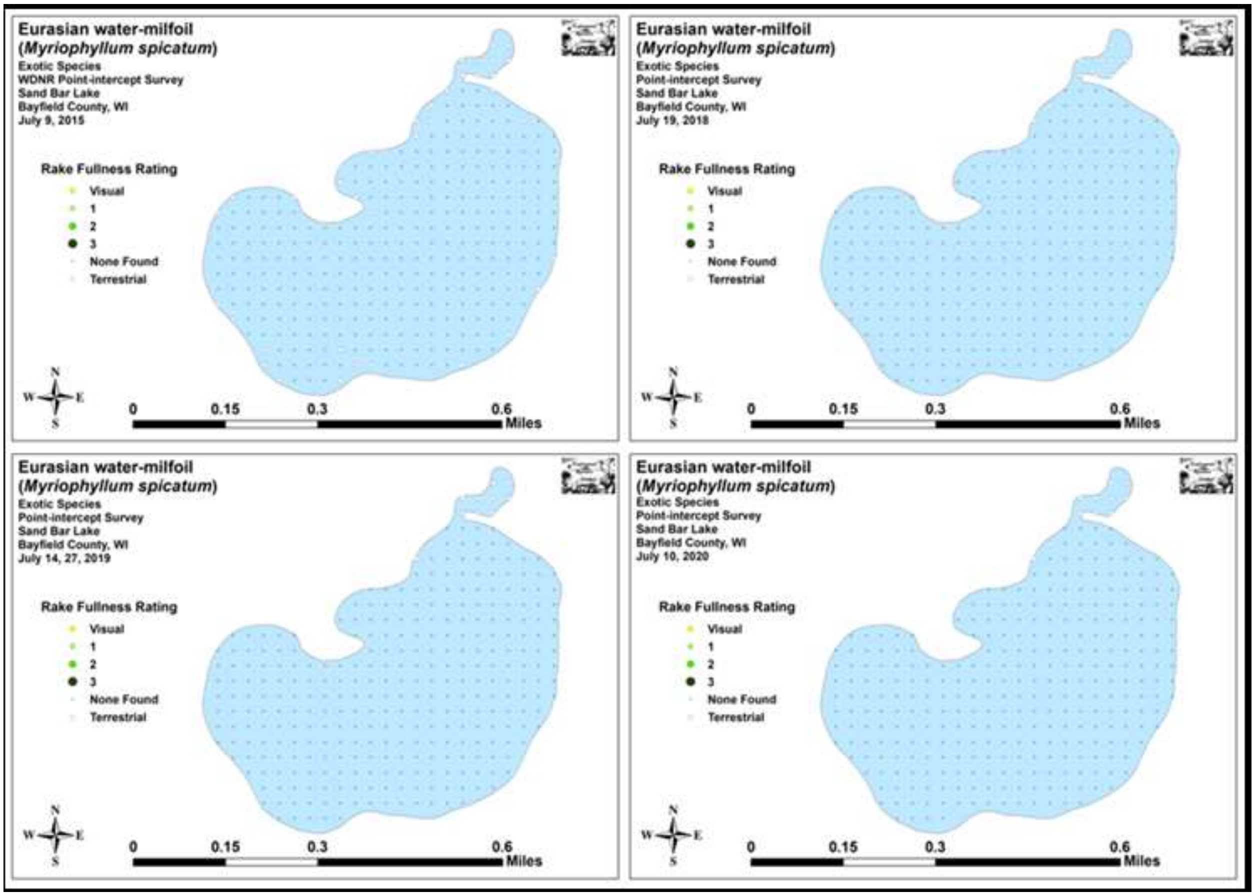

Figure 24: 2015, 2018, 2019, and 2020 EWM density and distribution (Berg, 2021a)

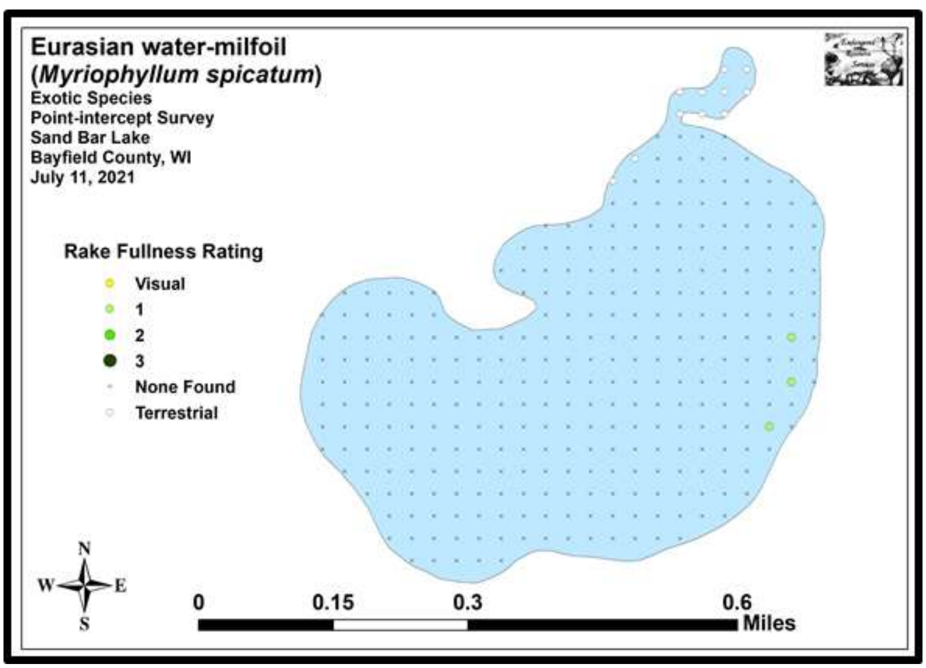

Figure 25: 2021 EWM density and distribution (Berg, 2021b)

8.3 Other Exotic Plant Species

There was no evidence of Curly-leaf pondweed, Purple loosestrife, Reed canary grass, or any other exotic plant species in or around Sand Bar Lake during both the 2020 or 2021 surveys.

8.4 Wild Rice

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, neither lake is considered wild rice water.

9.0 Aquatic Invasive Species

To date, only EWM has been identified in both lakes. There are several other plant and animal non-native invasive species that volunteers and users of the lakes should be aware of. Most of these species are considered aquatic, although some are also considered shoreland or wetland type invasive species.

9.1 Non-native, Aquatic Invasive Plant Species

Eurasian watermilfoil and curly-leaf pondweed are the most problematic non-native, aquatic invasive species in the lake. Both are submerged vegetation species (rooted to the bottom of the lake and growing under the surface of the water) that have the potential to outcompete more desirable native aquatic plants. Purple loosestrife and reed canary grass are shoreland or wetland plants not generally problematic within the lake, but can be very problematic on the shores and in the wetlands adjacent to the lake. More information is given for each non-native species in the following sections.

9.1.1 Eurasian Watermilfoil

EWM (Figure 26) is a submersed aquatic plant native to Europe, Asia, and northern Africa. It is the only non-native milfoil in Wisconsin. Like the native milfoils, the Eurasian variety has slender stems whorled by submersed feathery leaves and tiny flowers produced above the water surface. The flowers are located in the axils of the floral bracts, and are either four-petaled or without petals. The leaves are threadlike, typically uniform in diameter, and aggregated into a submersed terminal spike. The stem thickens below the inflorescence and doubles its width further down, often curving to lie parallel with the water surface. The fruits are four-jointed nut-like bodies. Without flowers or fruits, EWM is difficult to distinguish from Northern water milfoil. EWM has 9-21 pairs of leaflets per leaf, while Northern milfoil typically has 7-11 pairs of leaflets. Coontail is often mistaken for the milfoils, but does not have individual leaflets.

EWM grows best in fertile, fine-textured, inorganic sediments. In less productive lakes, it is restricted to areas of nutrient-rich sediments. It has a history of becoming dominant in eutrophic, nutrient-rich lakes, although this pattern is not universal. It is an opportunistic species that prefers highly disturbed lake beds, lakes receiving nitrogen and phosphorous-laden runoff, and heavily used lakes. Optimal growth occurs in alkaline systems with a high concentration of dissolved inorganic carbon. High water temperatures promote multiple periods of flowering and fragmentation.

Unlike many other plants, EWM does not rely on seed for reproduction. Its seeds germinate poorly under natural conditions. It reproduces by fragmentation, allowing it to disperse over long distances. The plant produces fragments after fruiting once or twice during the summer. These shoots may then be carried downstream by water currents or inadvertently picked up by boaters. EWM is readily dispersed by boats, motors, trailers, bilges, live wells, and bait buckets; and can stay alive for weeks if kept moist.

Once established in an aquatic community, milfoil reproduces from shoot fragments and stolons (runners that creep along the lake bed). As an opportunistic species, EWM is adapted for rapid growth early in spring. Stolons, lower stems, and roots persist over winter and store the carbohydrates that help milfoil claim the water column early in spring, photosynthesize, divide, and form a dense leaf canopy that shades out native aquatic plants. Its ability to spread rapidly by fragmentation and effectively block out sunlight needed for native plant growth often results in monotypic stands. Monotypic stands of EWM provide only a single habitat, and threaten the integrity of aquatic communities in a number of ways; for example, dense stands disrupt predator-prey relationships by fencing out larger fish, and reducing the number of nutrient-rich native plants available for waterfowl.

Dense stands of EWM also inhibit recreational uses like swimming, boating, and fishing. Some stands have been dense enough to obstruct industrial and power generation water intakes. The visual impact that greets the lake user on milfoil-dominated lakes is the flat yellow-green of matted vegetation, often prompting the perception that the lake is "infested" or "dead". Cycling of nutrients from sediments to the water column by EWM may lead to deteriorating water quality and algae blooms in infested lakes.

Figure 26: EWM complete root and stem and floating fragment with adventitious roots

9.1.2 Hybrid Watermilfoil

Like pure Eurasian Water Milfoil, EWM-NWM hybrids grow very quickly and can choke waterways, hampering boat access, fish passage, and water supply intakes. The plants fragment easily, and fragments attached to watercraft can take root in un-infested lakes. Pure Northern Water Milfoil is a species that is native to Wisconsin and it is not considered invasive. At least one study (LaRue, 2012) provides compelling evidence that hybrid lineages between introduced EWM and native NWM are more invasive than pure parental EWM, especially in novel habitats resulting from the application of the herbicide 2,4-D, which is routinely used to control nuisance populations of watermilfoil. Specifically, it was shown that hybrid watermilfoil genotypes exhibited faster vegetative growth and reduced sensitivity to 2,4-D in two laboratory experiments, and that they occurred more frequently than parental watermilfoil species in lakes with a history of 2,4-D treatment. Furthermore, comparisons of multiple, genetically distinct hybrid and EWM demonstrates that increased vegetative growth and reduced 2,4-D sensitivity are generally associated with hybridity in invasive watermilfoils. Hybrid water milfoil (Figure 27) has not been confirmed in either Sand Bar or Tomahawk Lake.

Figure 27: Hybrid EWM

9.1.3 Curly-leaf Pondweed

Curly-leaf pondweed (CLP) is an invasive aquatic perennial that is native to Eurasia, Africa, and Australia. It was accidentally introduced to United States waters in the mid-1880s by hobbyists who used it as an aquarium plant. The leaves are reddish-green, oblong, and about 3 inches long, with distinct wavy edges that are finely toothed. The stem of the plant is flat, reddish-brown and grows from 1 to 3 feet long. By early July, the plant completes its life cycle, dies, and drops to the lake bottom (Figure 28). CLP is commonly found in alkaline and high nutrient waters, preferring soft substrate and shallow water depths. It tolerates low light and low water temperatures.

CLP spreads through burr-like winter buds (turions), which are moved among waterways (Figure 24). These plants can also reproduce by seed, but this plays a relatively small role compared to the vegetative reproduction through turions. New plants form under the ice in winter, making curly-leaf pondweed one of the first nuisance aquatic plants to emerge in the spring. It becomes invasive in some areas because of its tolerance for low light and low water temperatures. These tolerances allow it to get a head start on and out-compete native plants in the spring. In mid-summer, when most aquatic plants are growing, CLP plants are dying off. Plant die-offs may result in a critical loss of dissolved oxygen. Furthermore, the decaying plants can increase nutrients which contribute to algal blooms, as well as create unpleasant stinking messes on beaches. CLP forms surface mats that interfere with aquatic recreation (Figure 29). To date, no CLP has been found in either lake.

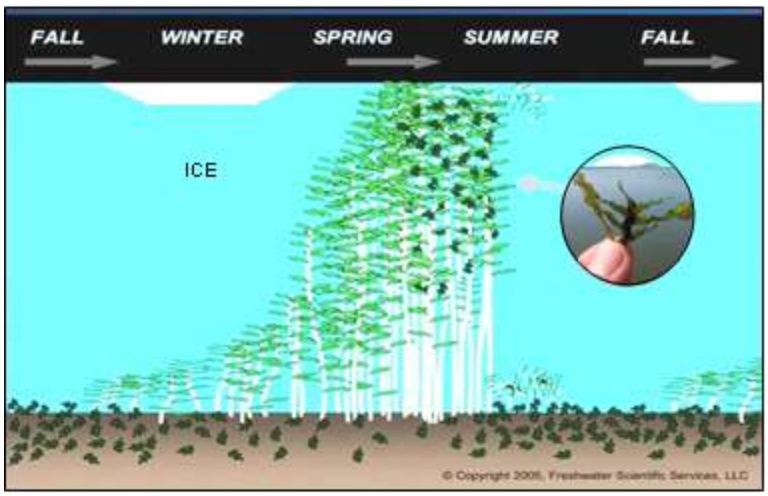

Figure 28: Diagram showing annual CLP life-cycle in northern lakes (Freshwater Scientific Services, 2008).

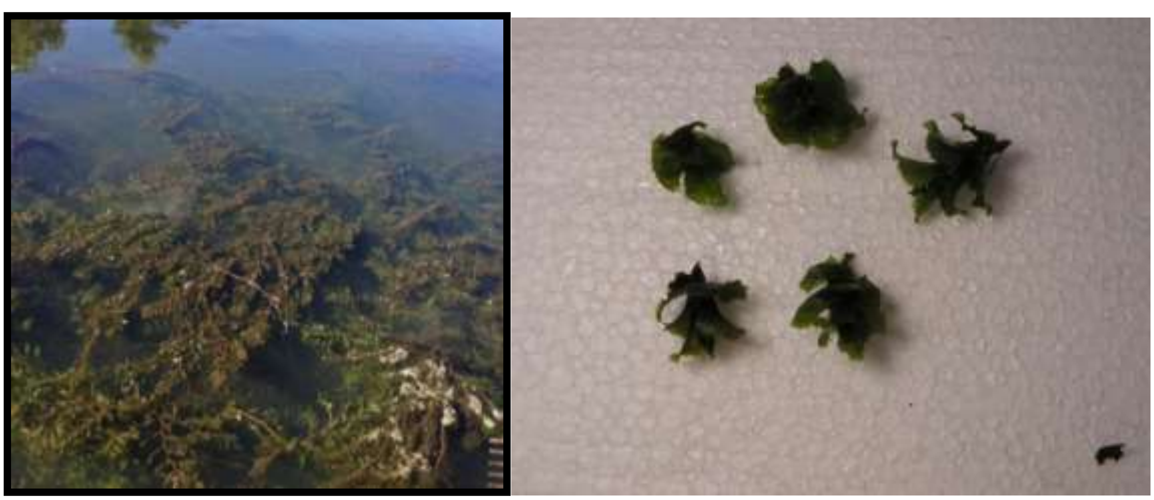

Figure 29: CLP plants and turions (not from Horseshoe Lake)

9.1.4 Purple Loosestrife

Purple loosestrife (Figure 30) is a perennial herb 3-7 feet tall with a dense bushy growth of 1-50 stems. The stems, which range from green to purple, die back each year. Showy flowers that vary from purple to magenta possess 5-6 petals aggregated into numerous long spikes, and bloom from August to September. Leaves are opposite, nearly linear, and attached to four-sided stems without stalks. It has a large, woody taproot with fibrous rhizomes that form a dense mat. By law, purple loosestrife is a nuisance species in Wisconsin. It is illegal to sell, distribute, or cultivate the plants or seeds, including any of its cultivars.

This plant's optimal habitat includes marshes, stream margins, alluvial flood plains, sedge meadows, and wet prairies. It is tolerant of moist soil and shallow water sites such as pastures and meadows, although established plants can tolerate drier conditions. Purple loosestrife has also been planted in lawns and gardens.

Purple loosestrife spreads mainly by seed, but it can also spread vegetatively from root or stem segments. A single stalk can produce from 100,000 to 300,000 seeds per year. Seed survival is up to 60-70%, resulting in an extensive seed bank. Mature plants with up to 50 shoots grow over 2 meters high and produce more than two million seeds a year. Germination is restricted to open, wet soils and requires high temperatures, but seeds remain viable in the soil for many years. Even seeds submerged in water can live for approximately 20 months. Most of the seeds fall near the parent plant, but water, animals, boats, and humans can transport the seeds long distances. Vegetative spread through local perturbation is also characteristic of loosestrife; clipped, trampled, or buried stems of established plants may produce shoots and roots. Plants may be quite large and several years old before they begin flowering. It is often very difficult to locate non-flowering plants, so monitoring for new invasions should be done at the beginning of the flowering period in mid-summer.

Any sunny or partly shaded wetland is susceptible to purple loosestrife invasion. Vegetative disturbances such as water drawdown or exposed soil accelerate the process by providing ideal conditions for seed germination. Invasion usually begins with a few pioneering plants that build up a large seed bank in the soil for several years. When the right disturbance occurs, loosestrife can spread rapidly, eventually taking over the entire wetland or shoreland area. The plant's ability to adjust to a wide range of environmental conditions gives it a competitive advantage; coupled with its reproductive strategy, purple loosestrife tends to create monotypic stands that reduce biotic diversity.

Purple loosestrife has not been identified in or around either lake, but volunteers should continue to be vigilant in looking for it. It has been identified on the Eau Claire Lakes.

Figure 30: Purple loosestrife

9.1.5 Reed Canary Grass

Reed canary grass (Figure 31) is a large, coarse grass that reaches 2 to 9 feet in height. It has an erect, hairless stem with gradually tapering leaf blades. Blades are flat and have a rough texture on both surfaces. Single flowers occur in dense clusters in May to mid-June. They are green to purple at first and change to beige over time. This grass is one of the first to sprout in spring, and forms a thick rhizome system that dominates the subsurface soil. Seeds are shiny brown in color.

Reed canary grass can grow on dry soils in upland habitats and in the partial shade of oak woodlands, but does best on fertile, moist organic soils in full sun. This species can invade most types of wetlands, including marshes, wet prairies, sedge meadows, fens, stream banks, and seasonally wet areas; it also grows in disturbed areas such as bergs and spoil piles.

Reed canary grass reproduces by seed or creeping rhizomes. It spreads aggressively. The plant produces leaves and flower stalks for 5 to 7 weeks after germination in early spring and then spreads laterally. Growth peaks in mid-June and declines in mid-August. A second growth spurt occurs in the fall. The shoots collapse in mid to late summer, forming a dense, impenetrable mat of stems and leaves. The seeds ripen in late June and shatter when ripe. Seeds may be dispersed from one wetland to another by waterways, animals, humans, or machines.

This species prefers disturbed areas, but can easily move into native wetlands. Reed canary grass can invade a disturbed wetland in just a few years. Invasion is associated with disturbances including ditching of wetlands, stream channelization, and deforestation of swamp forests, sedimentation, and intentional planting. Over time, it forms large, monotypic stands that harbor few other plant species and are subsequently of little use to wildlife.

Reed canary grass has not been identified in or around either lake.

Figure 31: Reed canary grass (not from Horseshoe Lake)

9.2 Non-native Aquatic Invasive Animal Species

Several non-vegetative, aquatic, invasive animal species could be introduced to the lakes, but have not been identified at the present time. It is important for lake property owners and users to be knowledgeable of these species in order to identify them if and when they show up.

9.2.1 Chinese and Banded Mystery Snails

Banded mystery snails have been identified in Tomahawk Lake. Chinese snails have not been identified in either lake, but have been identified in the Eau Claire Lakes.

The Chinese mystery snails and the banded mystery snails (Figure 32) are non-native snails that have been found in a number of Wisconsin lakes. There is not a lot yet known about these species, however, it appears that they have a negative effect on native snail populations. The female mystery snail gives birth to live crawling young. This may be an important factor in their spread as it only takes one impregnated snail to start a new population. Mystery snails thrive in silt and mud areas although they can be found in lesser numbers in areas with sand or rock substrates. They are found in lakes, ponds, irrigation ditches, and slower portions of streams and rivers. They are tolerant of pollution and often thrive in stagnant water areas. Mystery snails can be found in water depths of 0.5 to 5 meters (1.5 to 15 feet). They tend to reach their maximum population densities around 1-2 meters (3-6 feet) of water depth. Mystery snails do not eat plants. Instead, they feed on detritus and in lesser amounts algae and phytoplankton. Thus removal of plants in your shoreline area will not reduce the abundance of mystery snails.

Lakes with high densities of mystery snails often see large die-offs of the snails. These die-offs are related to the lake's warming coupled with low oxygen (related to algal blooms). Mystery snails cannot tolerate low oxygen levels. High temperatures by themselves seem insufficient to kill the snails as the snails could move into deeper water.

Many lake residents are worried about mystery snails being carriers of the swimmer's itch parasite. In theory they are potential carriers, however, because they are an introduced species and did not evolve as part of the lake ecosystem, they are less likely to harbor the swimmer's itch parasites.

Figure 32: Chinese (left) and Banded (right) Mystery Snails

9.2.2 Rusty Crayfish

Rusty crayfish have not been identified in either lake, but are in the Eau Claire Lakes.

Rusty crayfish (Figure 33) live in lakes, ponds and streams, preferring areas with rocks, logs and other debris in water bodies with clay, silt, sand or rocky bottoms. They typically inhabit permanent pools and fast moving streams of fresh, nutrient-rich water. Adults reach a maximum length of 4 inches. Males are larger than females upon maturity and both sexes have larger, heartier, claws than most native crayfish. Dark "rusty" spots are usually apparent on either side of the carapace, but are not always present in all populations. Claws are generally smooth, with grayish-green to reddish-brown coloration. Adults are opportunistic feeders, feeding upon aquatic plants, benthic invertebrates, detritus, juvenile fish and fish eggs.

Rusty crayfish reduce the amount and types of aquatic plants, invertebrate populations, and some fish populations--especially bluegill, smallmouth and largemouth bass, lake trout and walleye. They deprive native fish of their prey and cover and out-compete native crayfish. Rusty crayfish will also attack the feet of swimmers. On the positive side, rusty crayfish can be a food source for larger game fish and are commercially harvested for human consumption.

It is illegal to possess both live crayfish and angling equipment simultaneously on any inland Wisconsin water (except the Mississippi River). It is also illegal to release crayfish into a water of the state without a permit.

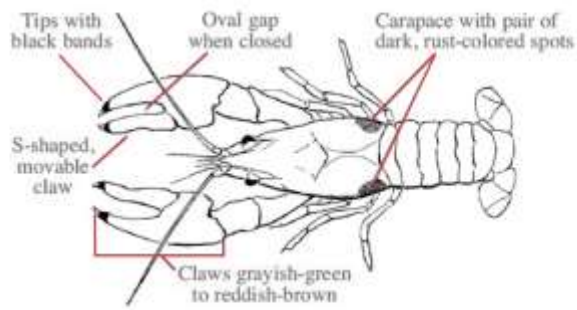

Figure 33: Rusty Crayfish and identifying characteristics

9.2.3 Zebra Mussels

Zebra mussels have not been identified in either lake. The closest populations of zebra mussels are in Lake Superior and Big and Middle McKenzie lakes on the Burnett/Washburn County line just a few miles west of Spooner, WI.

Zebra mussels (Figure 34) are an invasive species that have inhabited Wisconsin waters and are displacing native species, disrupting ecosystems, and affecting citizens' livelihoods and quality of life. They hamper boating, swimming, fishing, hunting, hiking, and other recreation, and take an economic toll on commercial, agricultural, forestry, and aquacultural resources. The zebra mussel is a tiny (1/8-inch to 2-inch) bottom-dwelling clam native to Europe and Asia. Zebra mussels were introduced into the Great Lakes in 1985 or 1986, and have been spreading throughout them since that time. They were most likely brought to North America as larvae in the ballast water of ships that traveled from fresh-water Eurasian ports to the Great Lakes.

Zebra mussels look like small clams with a yellowish or brownish D-shaped shell, usually with alternating dark- and light-colored stripes. They can be up to two inches long, but most are under an inch. Zebra mussels usually grow in clusters containing numerous individuals.

Once zebra mussels are established in a water body, very little can be done to control them. It is therefore crucial to take all possible measures to prevent their introduction in the first place. Recently, the WDNR has supported the installation of Decontamination Stations at public boat landings. The main purpose for these stations is to prevent the spread of zebra mussels by encouraging boaters to spray their watercraft down with a light bleach and water combination. Draining all water from the boat and livewells is also important.

Figure 34: Zebra Mussels (not from Horseshoe Lake)

9.3 AIS Prevention Strategy

In 2020, Bayfield County passed an Ordinance (Title 16, Chapter 2 Aquatic Invasive Species) for the purpose of establishing a local program to prevent the spread of aquatic invasive species in Bayfield County. The Ordinance requires that boaters do the following:

- No person may transport any watercraft and its associated trailer or boating equipment from navigable waters onto a public highway if aquatic plants or animals are attached, or to do so in violation of an order from a law enforcement officer who has reason to believe that aquatic plants or animals are attached, except as provided in Section 16-2-4.
- If a decontamination station is available for use at a public or private access, the boater shall decontaminate per posted directions and/or inspection protocol using the decontamination station provided.
- This section shall not apply to bait used on that particular waterbody in accordance with Wisconsin Department of Natural Resources (DNR) rules and regulations.

Bayfield County also has a county-wide AIS Coordinator who works with area lake groups to complete monitoring, education and training, and management planning and implementation support.

The Town of Barnes created an AIS Committee in 2006 that helps guide AIS management planning and implementation in approximately 27 lakes within the confines of the Town of Barnes, and in several adjacent lakes in neighboring counties. The Committee is made up of both Town of Barnes officials and representatives from the area lakes.

The Friends of the Eau Claire Lakes Area provide volunteer and monetary support for both water quality and AIS monitoring, have representation on the Barnes AIS Committee, and conduct educational and informational activities for students and adults the live in or visit the area.

Sand Bar and Tomahawk currently have EWM. EWM was documented in George Lake several years ago, but with active management, has not been found in the lake for several years since. The Eau Claire Lakes have several different AIS including curly-leaf pondweed, rusty crayfish, Chinese and banded mystery snails, and purple loosestrife. However there are many more AIS that could be introduced to the area lakes. The Town of Barnes and the other entities mentioned will continue to implement a watercraft inspection and AIS Signage program at the public access point on area lakes. Information will be shared with lake residents and users in an effort to expand the watercraft inspection message. In addition to the watercraft inspection program, an in-lake and shoreland AIS monitoring program will be implemented. Both of these programs will follow UW-Extension Lakes and WDNR protocol through the Clean Boats, Clean Waters program and the Citizen Lake Monitoring Network Aquatic Invasive Species Monitoring program.

Additionally, having an educated and informed lake constituency is the best way to keep non-native aquatic invasive species at bay in area lakes. To foster this, lake community events including AIS identification and management workshops; distribution of education and information materials to lake property owners and lake users; newsletters, webpage postings, and general mailing will be completed annually.

10.0 Need for Management

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 significant ecological impacts. Continued monitoring of both Sand Bar and Tomahawk lakes has shown that the EWM in them will reclaim previous underwater territory if not managed. Past management actions have also proven that EWM can be managed in a way that lessens its impact on the ecosystems of the lakes and improves lake usability. As such, there still remains a need for management in both lakes. As has been done in the past, an integrated approach to management should be followed.

10.1 Integrated Pest Management

Integrated Pest Management (IPM) is an ecosystem-based aquatic plant 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 35). 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.

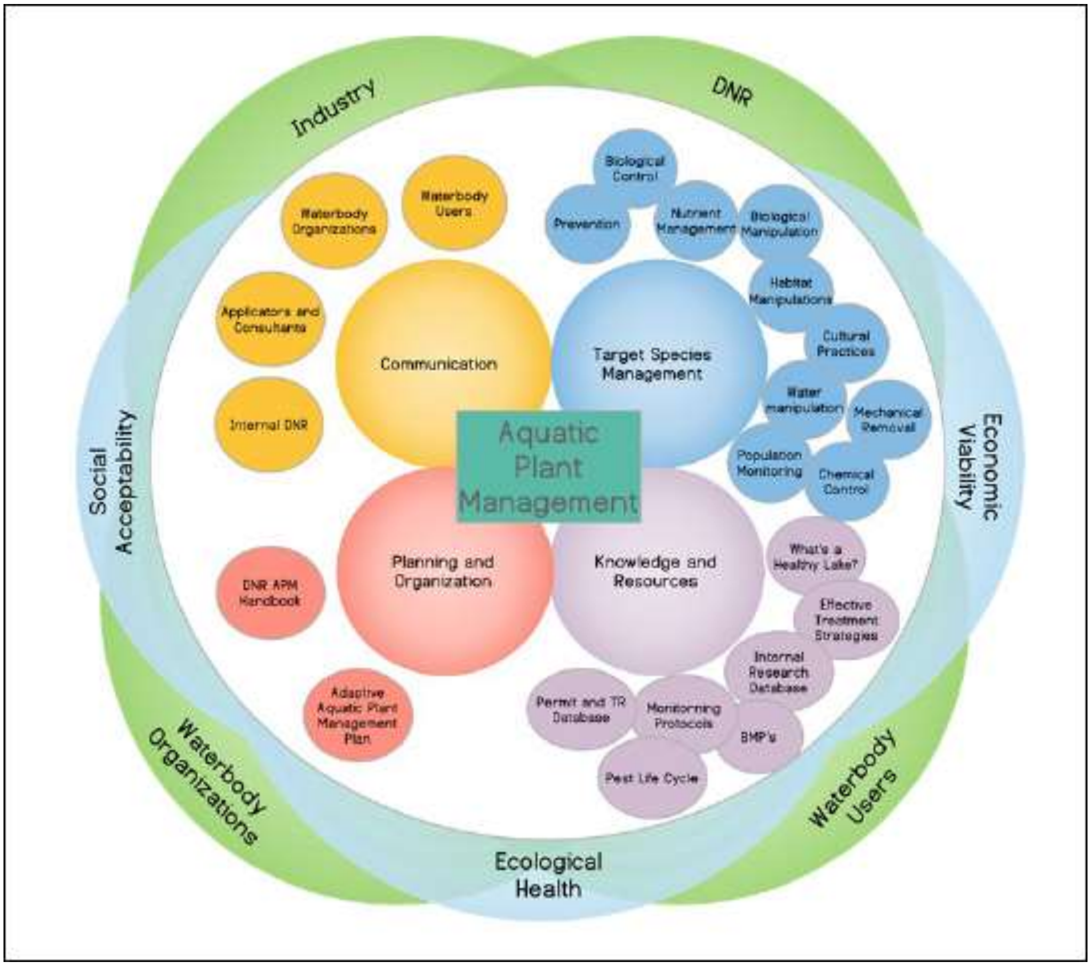

Figure 35: Wisconsin Department of Natural Resources: Wisconsin Waterbodies – Integrated Pest Management March 2020

11.0 Management Alternatives

Protecting native plants and limiting EWM through IPM is a primary focus of plant management in both Sand Bar and Tomahawk due to their diverse and sensitive plant communities and the benefits IPM 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 most 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.

11.1 Physical/Manual Removal: Recommended

Physical removal will be completed by educated landowners who monitor their own shorelines or by a trained EWM Management Team sponsored by the Town of Barnes. There is no limit as to how far out into the lake this management activity can occur, provided the area cleared is no more than 30-ft wide. It limits disturbance to the lake bottom, is inexpensive, and can be practiced by many lake residents. Landowners should also continually monitor near their docks and swimming areas in the open water season and remove rooted plants as well as floating fragments that wash into their shoreline.

Pulling EWM while snorkeling or scuba diving in deeper water is also allowable without a permit and can be effective at slowing the spread of a new aquatic invasive species infestation within a waterbody when done properly. Diver removal will be completed by Town of Barnes volunteers and/or resource professionals retained by the Town of Barnes. These efforts will focus on smaller beds not treated with chemical herbicides in areas not directly adjacent to any landowner's property.

11.1.1 Diver Assisted Suction Harvest (DASH)

Diver Assisted Suction Harvesting (DASH), a hand removal method that requires a diver to handfeed EWM pulled from the bottom into a suction tube where it is transported to a collection basin on a boat or pontoon at the surface, is also recommended. Back in 2016, the Town of Barnes built a DASH boat and has been using it successfully to remove CLP in Middle and Upper Eau Claire lakes and EWM in Sand Bar and Tomahawk lakes. Clear water and appropriate bottom sediments maximize the efficiency of DASH operations and keep it a vital part of control measures implemented by the Town of Barnes and Friends of the Eau Claire Lakes. Its use also minimizes the frequency of AIS management using aquatic herbicides.

11.2 Chemical Herbicide Treatments: Recommended

Aquatic herbicides are granules or liquid chemicals specifically formulated for use in water to kill plants or cease plant growth. Herbicides approved for aquatic use by the U.S. Environmental Protection Agency (EPA) are considered compatible with the aquatic environment when used according to label directions. Some individual states, including Wisconsin, also impose additional constraints on herbicide use.

The WDNR evaluates the benefits of using a particular chemical at a specific site vs. the risk to non-target organisms, including threatened or endangered species, and may stop or limit treatments to protect them.
Aquatic herbicides in liquid form can be sprayed directly onto floating or emergent aquatic plants or injected below the surface by weighted trailing hoses. Granular herbicides are generally broadcast or spread on the surface and then sink to the bottom. Herbicides affect plants through either systemic or direct contact action. Systemic herbicides are capable of killing the entire plant. Contact herbicides cause the parts of the plant in contact with the herbicide to die back, leaving the roots alive and able to re-grow.

Herbicides can be classified as broad-spectrum (kill or injure a wide variety of plant species) or selective (effective on only certain species). Non-selective, broad spectrum herbicides will generally affect all plants that they come in contact with. Selective herbicides will affect only some plants. Often dicots, like EWM, will be affected by selective herbicides whereas monocots, such as common waterweed will not be affected. The selectivity of a particular herbicide can be influenced by the method, timing, formulation, and concentration used.

11.2.1 Common Aquatic Herbicides

ProcellaCOR® is a relatively new systemic, selective herbicide that can be used to target EWM with limited impact to most native species. It is also very fast acting, making it an effective control measure on smaller beds that may be too large for DASH, 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 2 or more years of control without re-application. ProcellaCOR® is recommended for future EWM management implementation.

Sonar® whose active ingredient is fluridone, is a broad spectrum herbicide that interferes with the necessary processes in a plant that create the chlorophyll needed to turn sunlight into plant food through a process called photo-synthesis.

2,4-D and triclopyr are active ingredients in several selective herbicides including 2,4-D Amine 4®, Navigate®, DMA 4®, Renovate®, and Renovate Max G®. These herbicides stimulate plant cell growth causing them to rupture, but primarily in dicots. These herbicides are considered selective as they have little to no effect on monocots in treated areas. Fluridone, glyphosate, 2,4-D, and triclopyr are all considered systemic. When applied to the treatment area, plants in the treatment area draw the herbicide in through the leaves, stems, and roots killing all of the plant, not just the part that comes in contact with the herbicide.

Aquathol whose active ingredient is endothall and Reward whose active ingredient is diquat are considered broad spectrum contact herbicides. They destroy the outer cell membrane of the material they come in contact with and therefore kill a plant very quickly. Neither of these is considered selective and has the potential to kill all of the plant material that they come in contact with regardless of the species. As such, great care should be taken when using these products. Certain plant species like curly-leaf pondweed begin growing very early in the spring, even under the ice, and are often the only growing plant present at that time. This is a good time to use a contact herbicide like Aquathol, as few other plants would be impacted. Using these products later in the season, will kill all vegetation in contact with the herbicide and can provide substantial nuisance relief from a variety of aquatic plants. Endothall based herbicides are the most commonly used herbicides for CLP control, but diquat can be used under the appropriate circumstances.

It is possible to apply more than one herbicide at a time when trying to establish control of unwanted aquatic vegetation. An example would be controlling EWM and CLP at the same time with an early season application, and controlling aquatic plants and algae at the same time during a mid-season nuisance relief application. Applying systemic and contact herbicides together has a synergistic effect leading to increased selectivity and control. Single applications of the two could result in reduced environmental loading of herbicides and monetary savings via a reduction in the overall amount of herbicide used and of the manpower and number of application periods required to complete the treatment.

11.2.2 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 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 herbicide 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.

11.2.2.1 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. 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.

Figure 36: Limno-curtain material on a roll before installation (photo from Marinette Co. LWCD)

Figure 37: 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 23 reflects what happened to the herbicide that was applied. Herbicide concentrations stayed relatively high for a longer period of time (48 hrs). Once the curtain was removed, the herbicide dissipated rapidly.

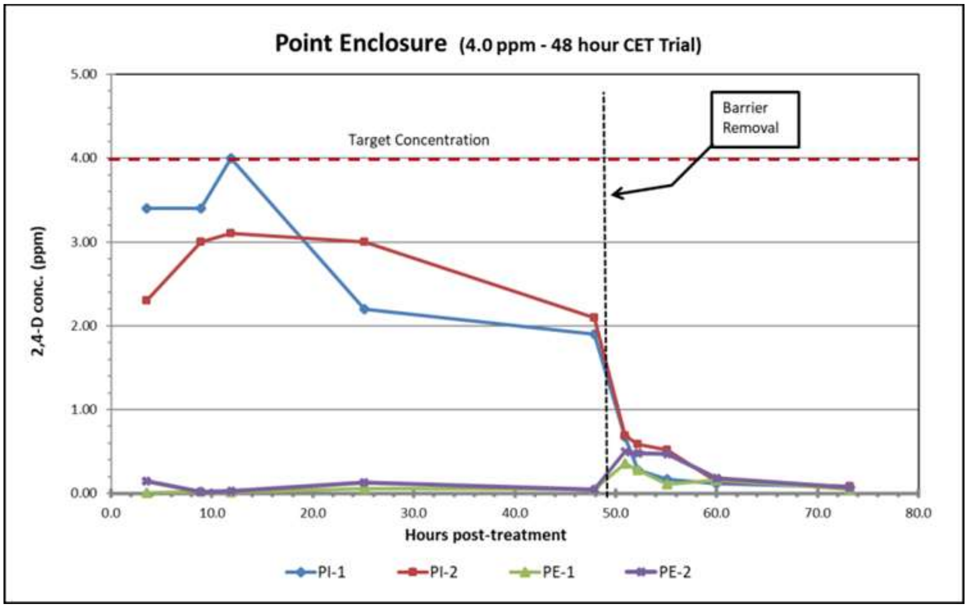

Figure 38: Herbicide concentration results from 2020 Thunder Lake limno-curtain trial (Marinette Co LWCD)

Similar studies have been completed on other lakes with similar results. The Town of Barnes has been building a limno-curtain and intends to implement it for the first time in 2022 in Tomahawk Lake.

11.2.3 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 while minimizing 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 bay 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 bay or whole lake treatments are implemented.

Pre- and post-treatment aquatic plant surveying and having an approved Aquatic Plant Management Plan are required by the WDNR when completing large-scale chemical treatments. Residual testing is not required by the WDNR, but highly recommended to gain a better understanding of the impact and fate of the chemical used.

11.2.4 Whole-Lake 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. Whole-lake herbicide treatments have been completed in both Sand Bar and Tomahawk Lakes to control EWM.

11.2.4.1 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 may require pre and post chemical application aquatic plant surveying. 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 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 is done in the same year as the chemical treatment was completed or in the year after a chemical treatment was completed, sometimes both. A post-treatment survey should be scheduled when native plants are well established, generally mid-July through mid-August. For the post-treatment survey, the same points sampled in the pre-treatment survey will again be sampled. For whole-lake scale treatments, a full lake-wide PI survey should be conducted.

11.2.4.2 Chemical Concentration Testing

Chemical concentration testing is often done in conjunction with treatment to track the fate of the chemical herbicide used. Concentration testing can help 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. 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, days, weeks, or even months following chemical application.

11.2.5 Biological Control: Possibly

Biological control involves using one plant, animal, or pathogen as a means to control a target species in the same environment. The goal of biological control is to weaken, reduce the spread, or eliminate the unwanted population so that native or more desirable populations can make a comeback. Care must be taken however, to insure that the control species does not become as big a problem as the one that is being controlled. A special permit is required in Wisconsin before any biological control measure can be introduced into a new area.

11.2.5.1 EWM Weevils

While many biological controls have been studied, only one has proven to be effective at controlling EWM under the right circumstances. *Euhrychiopsis lecontei* is an aquatic weevil native to Wisconsin that feeds on aquatic milfoils (Figure 39). Their host plant is typically northern watermilfoil; however they seem to prefer EWM when it is available. Milfoil weevils are typically present in low numbers wherever northern or Eurasian water milfoil is found. They often produce several generations in a given year and over winter in undisturbed shorelines around the lake. All aspects of the weevil's life cycle can affect the plant. Adults feed on the plant and lay their eggs. The eggs hatch and the larva feed on the plant. As the larva mature they eventually burrow into the stem of the plant. When they emerge as adults later, the hole left in the stem reduces buoyancy often causing the stem to collapse. The resulting interruption in the flow of carbohydrates to the root crowns reduces the plant's ability to store carbohydrates for over wintering reducing the health and vigor Newman et al. (1996).

Figure 39: EWM weevil

The weevil is not a silver bullet. They do not work in all situations. The extent to which weevils exist naturally in a lake, adequate shore land over wintering habitat, the population of bluegills and sunfish in a system, and water quality characteristics are all factors that have been shown to affect the success rate of the weevil. If it has not been done already, a weevil survey could be completed on both Sand Bar and Tomahawk Lakes. If weevils are already present, it is not inconceivable that a weevil rearing project could be instigated.

11.2.5.2 Purple Loosestrife Bio-Control with Galerucella Beetles

Galerucella beetles are currently approved for the control of purple loosestrife in Wisconsin (Figure 40). The entire lifecycle of Galerucella beetles is dependent on purple loosestrife. In the spring, adults emerge from the leaf litter below old loosestrife plants. The adults then begin to feed on the plant for several days until they begin to reproduce. Females lay their eggs on loosestrife leaves and stems. When the larvae emerge from these eggs they begin feeding on the leaves and developing shoots. When water levels are high these larvae will burrow into the loosestrife stems to pupate into adult beetles. These new adults emerge and begin feeding on the loosestrife again (Sebolt, 1998). Galerucella beetles do not forage on any plants other than purple loosestrife. Because of this the populations, once established, are self-regulating. When the purple loosestrife population drops off, the beetle population also declines. When the loosestrife returns, the beetle numbers will usually increase. These beetles do not eradicate purple loosestrife entirely, but do help to reduce its dominance which will allow other native plants to recover.

Figure 40: Galerucella beetle

Using Galerucella beetles for control of purple loosestrife in and around the Town of Barnes would depend on the amount of purple loosestrife that is identified. Annual monitoring of this invasive species should be completed by trained volunteers. If enough purple loosestrife is identified, beetle rearing could be completed.

11.2.5.3 Other Biological Controls

There are other forms of biological control being used or researched. It was thought at one time that the introduction of plant eating carp could be successful. It has since been shown that these carp have a preference list for certain aquatic plants. EWM is very low on this preference list (Pine & Anderson, 1991). Use of "grass carp" as they are referred to in Wisconsin is illegal as there are many other environmental concerns including what happens once the target species is destroyed, removal of the carp from the system, impacts to other fish and aquatic plants, and preventing escapees into other lakes and rivers. Several pathogens or fungi are currently being researched that when introduced by themselves or in combination with herbicide application can effectively control EWM and lower the concentration of chemical used or the time of exposure necessary to kill the plant Sorsa et al. (1988). None of these have currently been approved for use in Wisconsin and are not recommended for use on either lake.

11.2.6 Native Plant Restoration: Possibly

A healthy population of native plants might slow invasion or reinvasion of non-native aquatic plants. It should be the goal of every management plan to protect existing native plants and restore native plants after the invasive species has been controlled. In many cases, a propagule bank probably exists that will help restore native plant communities after the invasive species is controlled Gettsinger et al. (1997). This is certainly the case in both Sand Bar and Tomahawk Lakes. If EWM can be controlled, enough native plants currently still exist to repopulate treatment areas. The goal of this plan is to enhance, protect, and restore native plant populations while controlling EWM and other non-native invasive species.

11.2.7 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 plant 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 J. , 2000). Harvesting activities in shallow water can re-suspend bottom sediments into the water column releasing nutrients and other accumulated compounds (Madsen J. , 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. Mechanical harvesting is not recommended in either lake, unless all other management methods fail to be effective.

11.2.8 Habitat Manipulation: Not Recommended

Habitat manipulation can take the form of flooding, dredging and drawdowns. It could also include installation of bottom barriers in an effort to prevent aquatic plant growth in small areas. Flooding and drawdowns are not possible because there are no water level control structures on or near the lakes that could be used to manipulate the water levels. Dredging is not recommended because the high-water quality and valuable habitat of the lakes would be jeopardized by removing large quantities of substrate and bottom materials.

Benthic barriers can be an effective treatment for the control macrophytes in small, localized areas of a lake like a dock, boat launch or a swimming beach, but are generally not practical for use in large areas as a consequence of cost and maintenance requirements. Materials have included sand and gravel, but the addition of such fill to lakes is not commonly permitted these days, so barriers in use today include mainly porous screen materials and solid sheeting of inert materials. Barriers can be difficult to install, carry substantial initial capital cost, and are labor intensive (particularly if removed, cleaned and replaced for long-term control). Plant control is virtually complete, however, and can enhance overall lake habitat as well as recreational access and safety. Barriers may impact non-target organisms, especially benthic dwellers, and will affect chemistry at the sediment-water interface, but the impacts are limited to the area of installation. As only small areas of lakes are typically exposed to benthic barriers, lake-wide impacts are not expected and have not been observed.

Benthic barriers have many advantages for plant control in small areas. They are unobtrusive and can be installed in areas that are not easily accessible by harvesters, although they can be difficult to apply to areas with obstructions. They are non-toxic, removable and very effective, and usually do not require extensive permitting. The major drawbacks are that they are expensive on an areal basis and require maintenance to be effective for multiple seasons. Gases can get trapped beneath them and cause them to billow up into the water column, but this can be handled by cutting slits or extra weighting. They may impact invertebrates and fish within the treated area, but act as an attractant to many fish and invertebrates.

It may be possible to install a bottom barrier in the beach area of Tomahawk Lake, but the gains from doing so, probably don't outweigh the efforts needed to do so.

12.0 Aquatic Plant Management Discussion

Both lakes support a valuable aquatic plant community with a number of uncommon species and a quality fishery valued by the lake community and the general public. The lakes currently have only one known fully aquatic invasive species – Eurasian watermilfoil. Nuisance conditions and navigation impairment occur throughout the open water season as a direct result of the EWM infestation. The main goal of the Aquatic Plant Management Plan is to control EWM in a sound, ecological manner.

If the resources available to manage EWM are limited, Figure 41 provides a method to determine priority. Referred to as FLIPS, it involves evaluating each areas of EWM in the lake in any given year based on when it was first discovered and managed (**F**ormation), where it is located (**L**ocation), whether it causing issues (**I**mpairment), whether it was mapped in a previous year (**P**rior year), and whether it is negatively impacting the native aquatic plant community (**S**ensitive area).

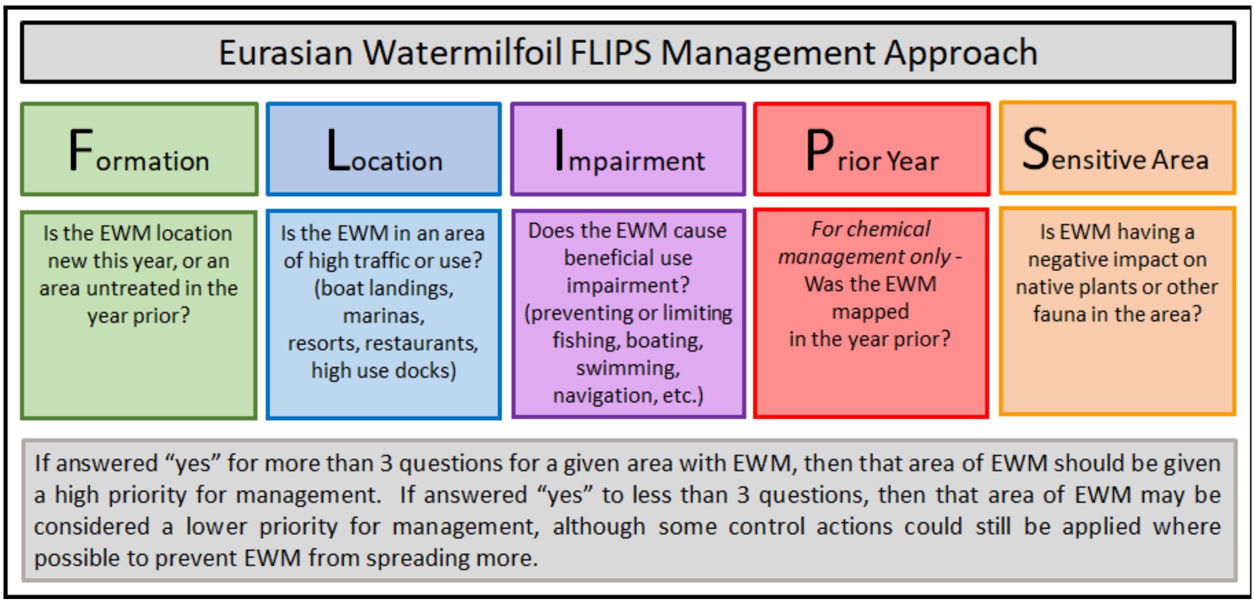

Figure 41: FLIPS Management Priority Matrix

A combination of chemical and manual/physical removal control methods are recommended for Sand Bar and Tomahawk Lakes. Mechanical harvesting, biological control (for EWM), habitat manipulation, and zero management are not recommended at this time.

Any EWM discovered in the lake, even single plants, should be managed if possible. However, different methods should be employed. After an EWM survey has been completed, each bed or high density area should be run through the FLIPS management priority matrix, and if in doing so, one or more areas meet the criteria to consider management; then each area should be run through the management planning matrix (Figure 42).

To utilize the management planning matrix, the user first determines the **Type of Infestation** (level 1); then the **Number of Plants** present (level 2); then **Coverage Area** (level 3); and finally the **Water Depth** in the area (level 4). Each of these levels returns a "symbol" depending on the characteristics of the bed or area of EWM being considered. When all the symbols are combined, look to that management action that contains them all.

There is some overlap in when each different management action should be considered. This is because there is no "canned" or definitive parameter that would say do one action over another. In some cases, two different actions might make sense. In that situation the resources available, WDNR permitting, and the level of support from the constituency will determine the action used.

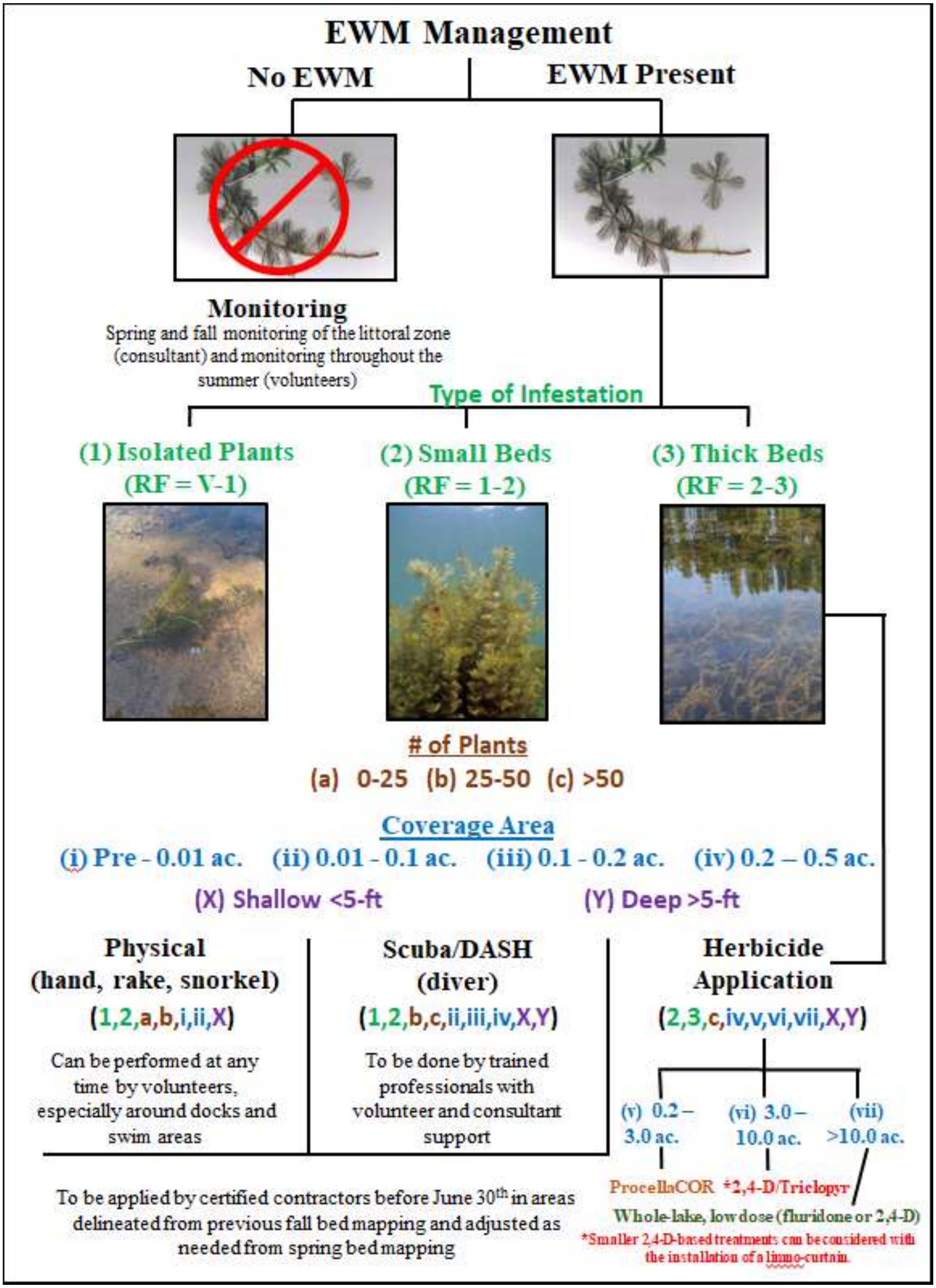

Figure 42: Management Planning Matrix

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

1) Late summer or fall bedmapping will be completed every year. PI surveys could be substituted instead of bed mapping.
2) Any amount of EWM in the lake can be managed at any time if chemical management is not used. Non-chemical management actions include hand pulling, rake removal, and snorkel/scuba diver removal, and/or DASH removal (still considered diver removal, but more expensive).
    a. DASH removal requires a mechanical harvesting permit from the WDNR.
3) Chemical management of EWM may be implemented if prior year mapping identifies any single area that is ≥0.25 acres, or multiple areas that total more than an acre.
    a. On EWM beds that are candidates for chemical treatment **AND** ≤3.0 acres, ProcellaCOR® should be used.
        i. If a limno-barrier or curtain is used, then other herbicides can be considered.
    b. On EWM beds from 3.0-10.0 acres, ProcellaCOR, 2,4D-based, or triclopyr-based herbicides can be used based on the financial resources available.
    c. When EWM beds in the entire lake exceed 10.0 acres, herbicide applications should be considered large-scale.
        i. Pre and post-treatment, point-intercept surveys will be completed.
        ii. Herbicide concentration testing will be completed unless deemed unnecessary by the WDNR.
    d. When EWM beds in the entire lake exceed 10.0 acres and it is clear that targeted treatments will no longer be effective, whole-lake, low dose herbicide applications can be considered.

Chemical management of EWM should not be completed on the same area in back to back years.

Concerns exist when herbicide treatments using the same herbicide are done over multiple and subsequent years. Target plant species may build up a tolerance to a given herbicide making it less effective, susceptible plant species may be damaged and/or disappear from the lake (ex. water lilies), concerns over fish and other wildlife might occur, and concern over recreational use in chemically treated water may be voiced. By using several different aquatic herbicides interspersed with physical removal efforts between treatments, many of these concerns are minimized.

13.0 Lake Management Best Practices (Healthy Lakes and Rivers Initiative)

The Healthy Lakes Initiative is a program that has been set up by the WDNR to provide support through information and grant funding to small scale projects that will help improve both shoreline habitat and lake health. The grants available for these projects are intended for fairly small, inexpensive projects, so there is $1000 limit in grant funding per project. This program is focused on helping individual property owners improve their shoreline. There are five projects that are eligible for Healthy Lakes Grants. The projects that qualify for these grants are installing fish sticks, rain gardens, native plantings, diversions, and rock infiltrations.

13.1 Fish Sticks Installation

Fish Sticks involve taking trees from the inland area of the lake, and installing them in the lake to mimic shore trees that will eventually fall into the lake (Figure 43). The trees used must be taken from a minimum of 35 feet inland and are then secured to the shore with cables for approximately 3 years. This provides habitat for fish, birds, and many other animals. In addition to providing habitat, fish sticks help protect the shoreline from bank erosion. Fish sticks project costs range anywhere from $100 to $1000, averaging about $500. These are very low maintenance because it is only necessary to occasionally check the cables to ensure they are secure. This practice would work well for almost any of the developed parcels on Horseshoe Lake.

Figure 43: Fishsticks installation (left) and after ice out (right)

13.2 Rain Gardens

Rain gardens are shallow depressions that contain loose soil and native plants (Figure 44). These are intended to capture the runoff, allowing the water to be filtered, naturally through the ground instead of flowing directly into the lake. Rain gardens are designed to allow the rainwater to soak into the ground with 1-2 days, to prevent any of the issues created by standing water. The project cost for rain garden range anywhere from $500 to $9,500, but this is very dependent on the size of the rain garden. The maintenance is fairly low, only requiring watering for about two weeks, until the plants have established, and weeding is occasionally needed during the first year. This project is best suited to parcels on a smaller incline to catch rainwater runoff that would otherwise run into the lake.

Figure 44: Rain garden installation (left) and upon completion (right)

13.3 Native Plantings

Native plantings (Figure 45) are intended to establish a buffer zone between the developed portion of a parcel and the lake. The buffer helps filter and slow rainwater runoff so much of it filters into the ground. This buffer zone is created by changing a strip of turf grass, at least ten feet wide, along the shoreline to a natural area composed of native shoreline plants. Similar to rain gardens, these are fairly low maintenance requiring water only until the plants have become established. The only ongoing maintenance is the removal of any invasive species that find their way into the planting. On average, native plantings cost around $1000. This project will work for almost any developed parcel that does not have a sand beach as the primary frontage.

Figure 45: Completed native planting (photo from HealthyLakesWI.com)

13.4 Diversions

Diversions (Figure 46) are placed across a sloping path or driveway to divert runoff water to an area where it can be absorbed into the ground instead of flowing directly into the lake. In addition to helping improve lake health, these can also reduce the effects of erosion on the paths that the diversions are installed on. Diversions are created by entrenching a log or creating a small earthen berm approximately 30 degrees from the angle of the slope. The cost of these range anywhere from $25 to $3,750, but the average diversion costs $200. These are very low maintenance, and only require some debris removal that could get stuck in the diversion and occasionally ensuring everything is still secure and in place. This practice does not work well for the purposes of this particular survey, but it is mentioned here as a nod to projects that could be completed further inland than this survey was meant to assess.


Figure 46: Completed diversion (photo from HealthyLakesWI.com)

13.4.1.1 Rock Infiltration Trenches

Rock infiltrations (Figure 47) are meant for relatively low traffic areas as a way to catch rainwater runoff and divert it into the ground. These consist of a pit which is no more than five feet deep. This pit is lined with filter fabric and filled with small rock. More filter fabric is placed on top and larger rock is then placed over that to hold everything in place. These range in price from $500 to $9,500, on average costing $3800. This requires some maintenance to function properly. It is necessary to remove any debris such as leaves or pine needles that may collect. It is also necessary to occasionally clean out the rock as it collects sediment. This works well around building that can be seen in the riparian zone. The rock infiltrations allow for rainwater coming off of the roof to be collected and filtered without damaging the building it surrounds.

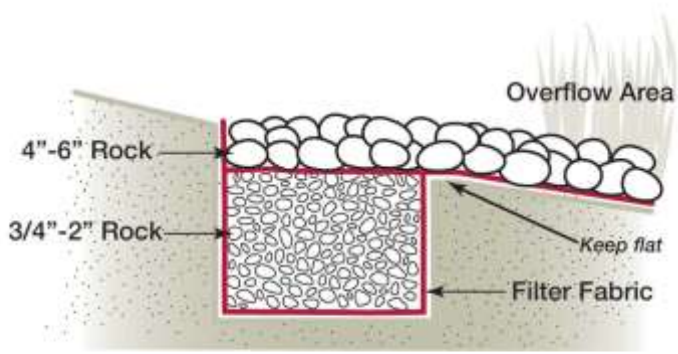

Figure 47: Rock Infiltration Set-up

14.0 Aquatic Plant Management Goals

This Aquatic Plant Management Plan establishes the following goals for aquatic plant management in Sand Bar and Tomahawk Lakes:

1. **EWM Management.** Limit the spread of EWM through environmentally responsible methods to benefit the native plant community while maintaining EWM at manageable levels.

2. **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.

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

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

14.1 Goal 1 - EWM Management

Despite several years of treatment, EWM continues to be a nuisance in the lakes. A combination of management alternatives will be used to help minimize the negative impacts of EWM on native plants and water quality, and to provide relief for navigation impairment caused by EWM. EWM management options to be utilized include small-scale physical removal, diver removal, and targeted use of aquatic herbicides (see previous section). Other AIS will continue to be monitored for, but no specific management is recommended at this time.

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

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

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

Pre and post treatment surveys are not required by the WDNR unless the chemically treated area covers more than 10 acres or 10% of the littoral zone. However, completing these tasks is highly recommended in any treatment program, as they provide a means to measure success. Readiness surveys provide a quick check and balance on a proposed treatment proposal and are recommended in any year chemical treatment is to occur.

14.1.2 Fall Bed Mapping

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

14.2 Goal 2 - Education and Awareness

Aquatic invasive species (AIS) can be transported via a number of vectors, but most invasions are associated with human activity. It is recommended that that the Town of Barnes and other stakeholders continue to maintain and update signage at the boat launch as necessary.

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

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

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

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

14.3 Goal 3 - 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.

It is recommended that the group identify at least one volunteer and sign up for level one (collecting Secchi disk readings of water clarity) of the CLMN program. CLMN expanded monitoring parameters (temperature, dissolved oxygen, total phosphorus, and chlorophyll-*a*) should be added as soon as the lake can be enrolled by the WDNR. The intensity/success of water quality monitoring efforts should be evaluated at least every three years. The background information and trends provided by these data are invaluable for current and future lake and aquatic plant management planning.

To monitor any changes in the plant community, it is recommended that whole-lake point intercept aquatic plant surveys be completed at three to 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.

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

14.4 Goal 4 - Adaptive Management

This APM Plan is a working document guiding management actions on the lakes for the next five years. This plan will follow an adaptive management approach by adjusting actions as the results of management and data obtained deem fit following IPM strategy. 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 group 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 lake group, Bayfield County, and the WDNR and made available in hardcopy and digital format on the Internet. These reports will serve as a vehicle to propose future management recommendations and will therefore be completed prior to implementing following year management actions (approximately March 31st annually). At the end of this five-year project, all management efforts (including successes and failures) and related activities will be summarized in a report to be used for revising the Aquatic Plant Management Plan.

15.0 Timeline of Activities and Potential Funding

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

15.1 Potential Funding – WDNR Surface Water Grant Program

There are several WDNR grant programs that may be able to assist the Town of Barnes 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.

For more information about WDNR Surface Water Grants go to: https://dnr.wisconsin.gov/aid/SurfaceWater.html.

16.0 Goals, Objectives, and Actions for all of the Town of Barnes

While this APM Plan is focused on Sand Bar and Tomahawk Lakes, it is a stated goal of the Town of Barnes and their partners to develop aquatic plant management plans for the other lakes within the Town of Barnes or adjacent municipalities if connected to lakes in the Town of Barnes. AIS prevention is another stated goal that includes all of the lakes in the Town of Barnes. Several objectives and actions are associated with this goal.

16.1 Goal 1 – Develop APM Plans for other lakes in the Town of Barnes

Over the course of the next five years (2022-26), aquatic plant management plans will be developed for most of not all of the lakes included in the Town of Barnes, and those that overlap into Douglas and Sawyer Counties.

Objective 1: Determine a lake priority list for the development of aquatic plant management plans. This list could be based on public access, proximity to lakes with existing AIS, or other criteria.

Action Item: Create a committee to discuss how to prioritize the lakes for development of APM Plans.

Objective 2: Request WDNR surface water grant funding and/or use other sources of funding to complete aquatic management planning on priority lakes.

16.2 Goal 2 – Reduce the threat that a new aquatic invasive species will be introduced and go undetected in other Town of Barnes lakes

Sand Bar and Tomahawk are source lakes for the introduction of EWM into other lakes not only in the Town of Barnes but in all other waters that people may travel to and from. The Town of Barnes and its partners will continue to implement a watercraft inspection program according to WDNR/UW-Extension Lakes protocol. This program will either be paid for by the Town of Barnes and/or their partners or through a small-scale CBCW grant. Watercraft inspection data will be entered into the WDNR SWIMS database annually.

Appropriate AIS signage will be maintained at all public accesses in the Town of Barnes and adjacent waters to improve the AIS awareness of many lake users.

AIS monitoring to track the AIS already present in many Town of Barnes lakes and to monitor for possible new AIS in other lakes will be completed following WDNR/UW-Extension Lakes protocol through the Citizen Lake Monitoring Network (CLMN) AIS Monitoring Program. Zebra mussels, spiny waterflea, hydrilla, banded mystery snails, and other species will be watched for and survey data entered into the WDNR SWIMS database annually.

Objective 1: Implement a Clean Boats Clean Waters (CBCW) water craft inspection program annually.

Action Item: Apply for small-scale CBCW grants annually to support watercraft inspection efforts.

Objective 2: Maintain current and complete AIS Signage at all public accesses in the Town of Barnes annually.

Action Item: Inspect the public access for appropriate AIS signage annually.

Action Item: Repair, replace, and/or install current WDNR AIS signs at the public access.

Objective 3: Reduce the likelihood that new AIS go undetected in lakes in or connected to the Town of Barnes and track existing AIS for additional spread.

Action Item: Participate in CLMN AIS Monitoring at least monthly between May and October each year.

16.3 Goal 3 - Improve the level of knowledge property owners and lake users have related to aquatic invasive species and their impact to the lake.

The Town of Barnes and its partners will continue efforts to educate and inform property owners and lake users about AIS that are already in the lakes, and AIS not already in the lakes. Efforts will include annual education events; distribution of AIS publications, and discussion forums of various types related to management actions and alternatives.

Objective 1: Plan, coordinate, and implement an annual AIS education event(s) alone or in cooperation with other Stakeholders or Partners.

Action Item: Seek out other stakeholders/partners to explore cooperative education and information events.

Objective 2: Distribute information and education materials to property owners and lake users.

Action Item: Research AIS and lake stewardship materials with little or no cost to attain and make available at events including but not limited to Annual Meetings, Lake Fairs, Summer Picnic, etc.

Objective 3: Solicit public input and review of annual AIS management planning efforts.

Action Item: Complete preliminary AIS management planning by January 31 each year and post on the District webpage for public comment.

Action Item: Provide a summary of coming year AIS management plans in a spring newsletter or other media outlets prior to April 30 each year.

Action Item: Present current year AIS management actions at the Annual Meeting(s) held each year.

16.4 Goal 4 - Improve the level of knowledge property owners and lake users have related to how their actions impact the aquatic plant community, lake community, water quality.

An important part of controlling undesirable aquatic plant growth and the production of algae is reducing the amount of nutrients (mainly phosphorus) that enters the lake. The Town of Barnes and its Partners will attempt to reduce the amount of disturbed shoreline around the lakes in the Town of Barnes or connected to lakes in the Town of Barnes by promoting and encouraging the implementation of simple and generally inexpensive best management practices included in the WDNR Healthy Lakes and Rivers Program.

The Town of Barnes and their Partners will continue to collect water quality data through the CLMN Expanded Water Quality Monitoring program on those lakes already included, but also strive to identify volunteers to collect water quality data on other lakes that may at one time have been included in the CLMN program, or that have never been included in the CLMN program.

Objective 1: Reduce the amount of shoreland without a natural buffer in place by 10% through shoreland restoration and other best management practices.

Action Item: Distribute shoreland improvement education and information materials to lake property owners through the newsletter, webpage, and general mailings.

Action Item: Host and/or sponsor annual lake community events that encourage land owner participation in best management practices.

Action Item: Support property owners who wish to complete shoreland restoration or habitat improvement projects through sponsorship of Healthy Lakes grant applications.

Action Item: Recognize property owners who participate in and/or complete shoreland restoration and habitat improvement projects in the newsletter, on the webpage, in local news publications, and/or at the site of the project.

Objective 2: Continue collecting long-term trend water quality data on lakes included in the Town of Barnes.

Action Item: Identify new volunteers to get involved in the CLMN water quality data collection program.

Action Item: Collect CLMN water quality data (water clarity, total phosphorus, chlorophyll a, and dissolved oxygen and temperature) at the appropriate level (regular or expanded) in lakes included in the Town of Barnes.

17.0 Works Cited

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