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2024-28 AQUATIC PLANT MANAGEMENT PLAN

LOST LAND, TEAL, TEAL RIVER FLOWAGE, AND GHOST LAKES
SAWYER COUNTY
WDNR WBICS: 2418600, 2417000, 2416900, & 2423000

August 2023

QUIET LAKES IMPROVEMENT ASSOCIATION
HAYWARD, WI

AQUATIC PLANT MANAGEMENT PLAN

Lost Land Lake, Teal Lake, Teal River Flowage & Ghost Lake

August 2023

Prepared by:

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Acknowledgements:

Members of the Quiet Lakes Improvement who contributed to discussions and recommendations presented in this plan.

Distribution List

No. of Copies	Sent to
1	Norm Bratteig, President Quiet Lakes Improvement Associaiton
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1.0 Introduction

Lost Land, Teal, and Ghost Lakes and the Teal River Flowage comprise the "quiet lakes" in northeastern Sawyer County. The connected waters of Teal Lake, Lost Land Lake, and the Teal River Flowage, as well as nearby Ghost Lake are collectively known as the "Quiet Lakes" due to a Spider Lake Township ordinance that limits watercraft speed to a maximum of 10 mph. The Quiet Lakes are located in Sawyer County north of U.S. Highway 77 approximately 20 miles east of Hayward, Wisconsin.

None of the four lakes is considered impaired due to water quality issues.

Eurasian watermilfoil (EWM) was first discovered in Lost Land Lake in 2013. Additional testing showed that what was found was a hybrid milfoil crossed between native Northern watermilfoil and EWM. For the rest of this document the non-native milfoil in the Quiet Lakes will be referred to as E/HWM. During the 2016 whole lake aquatic plant survey completed by Flambeau Engineering, only Lost Land Lake actually had E/HWM in it. None was found in Teal, Teal River Flowage, or Ghost Lake. Around 2019-20, E/HWM had spread to Teal Lake and the Teal River Flowage, though neither lake has been officially listed with the WDNR as having E/HWM.

Management of E/HWM began shortly after it was found in Lost Land Lake. Initially, small-scale aquatic herbicide applications was completed, but the results of treatment were not entirely satisfactory to the lake association at that time, so when the last Aquatic Plant Management (APM) Plan was developed in 2017-18, management actions focused on mechanical harvesting using an Eco-Harvester (Figure 1) purchased by the lake association in 2019. The last APM Plan expired at the end of 2022. In 2022, a project was started to update the 2018-22 APM Plan. Aquatic plant survey work included a whole-lake, point-intercept (PI), aquatic plant survey and E/HWM bedmapping in Lost Land and Teal Lakes. That information was used to update the APM Plan in 2023 to cover the next five years (2024-28) of management.

Figure 1: Eco-Harvester https://weedersdigest.com/eco-harvester-aquatic-weed-harvester/

1.1 Quiet Lakes Improvement Association

The Quiet Lakes Improvement Association is known officially as the "Teal, Lost Land, and Ghost Lakes Improvement Association, Inc." Their mission is: To provide a forum for communication that fosters support and volunteer action to maintain ecosystem integrity. Permanent and seasonal residents and tourism business owners who live on or within one mile of Teal Lake, Teal River Flowage, Lost Land Lake, or Ghost Lake are eligible and encouraged to become members of the Quiet Lakes Improvement Association (QLIA), as are renters and campers who spend at least 30 days per year on or adjacent to these three lakes. Dues for 2023 are $50 per year for individuals or families, collected and applied on a calendar-year basis (January 1).

The QLIA relies on a dedicated team of volunteers who help manage and monitor the lakes. The following committees are supported by the QLIA:

- Aquatic Invasive Species and Eco-Harvester Operations
- Water Quality Monitoring – Lost Land Lake
- Water Quality Monitoring – Teal Lake
- Shoreland Habitat Enhancement and Navigation Safety
- Fishery Management
- Fundraising Committee
- Welcome Committee

The organization goes by the name "Quiet Lakes" due to an ordinance passed in the Town of Spider Lake that limits the speed that any watercraft on Lost Land or Teal Lake can travel to 10mph or less. Town of Spider Lake Ordinance #12 was last updated in December 2021. This means no fast moving personal watercraft, water skiing or tubing, and no fast moving fishing boats flying around the lakes.

2.0 Aquatic Plant Management Summary

Continuing a combination of chemical and manual control methods to curb the spread of E/HWM 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 lakes. 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. 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.

2.1 Implementation Goals

This Aquatic Plant Management Plan establishes the following goals for aquatic plant management in the Quiet Lakes with a focus on Lost Land and Teal:

1. **E/HWM Management.** Limit the spread of E/HWM through environmentally responsible methods to benefit the native plant community while maintaining E/HWM at manageable levels.
2. **AIS Education, Monitoring, and Prevention.** Continue to educate property owners and lake users on all aquatic invasive species through public outreach and education programs to help identify AIS and discuss the issues related to them. Efforts should include watercraft inspection at the most used landings on Lost Land Lake and improved signage should be installed on all other landings. AIS monitoring should be completed regularly on each lake.
3. **Research and Monitoring.** Develop a better understanding of the lake and the factors affecting lake water quality through continued and expanded monitoring efforts. Monitoring of AIS and other aquatic plants will help to determine the effectiveness of management actions.
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.

3.0 Public Use and Stakeholder Input

3.1 Public Use

Because of the 10mph speed limit, Ghost, Lost Land, and Teal Lakes; and the Teal River Flowage are not overrun by large boats, personal watercraft, or water skiers and tubers. They are however frequently by those people who like a quieter, less hectic approach to lake enjoyment – kayaks, paddle boards, and pontoons. They are frequently fished due to the abundance of musky and other sport fish that are present. The recreational aspect of the lakes is supported by several private resorts, cabin rentals, and vacation rental properties.

The system of lakes is within the boundaries of the Chequamegon Nicolet National Forest, is home to the Ghost Lake State Natural Area, and Teal Lake has a half dozen state-owned islands within it.

Public use is hindered to some degree by the amount of E/HWM present in the system. Additionally, these lakes may serve as source points of EWM to other waterbodies including the Spider Lake system just to the west of Lost Land Lake.

3.2 Stakeholder Input

Since this project to prepare a new APM Plan for the Quiet Lakes, funded by two lake management planning grants several meetings have been held to inform the constituency about the project. In August 2021, during the Summer Picnic sponsored by the QLIA, the consultant working with the QLIA presented information about applying for WDNR surface water grants to support management planning and implementation for control of aquatic plants. In August 2022, the consultant working with the QLIA presented findings from the 2022 whole-lake, point-intercept, aquatic plant survey and preliminary findings from the E/HWM bed mapping survey completed by ERS. This presentation started the group thinking about the potential costs to implement management on the level that was likely going to be required for Lost Land and Teal Lakes.

In July 2023, the consultant presented at the Annual Meeting of the QLIA attended by over 60 people. The consultant discussed the parameters necessary to determine if aquatic plant management is needed on the lake, determined if the constituency wanted to move forward with aquatic plant management, and discussed possible goals for management. Preliminary aquatic plant management planning information including the possible management actions for the 260 plus acres of E/HWM in Lost Land Lake and the 44.5 acres in Teal Lake was also presented. With the amount of E/HWM in the lakes, application of aquatic herbicides is almost a guarantee if the infestation is going to be brought under control. Information about the different herbicides that could be used and how they could be used was discussed, as was the expected costs of each of the possible management scenarios.

In early August 2023, the constituency will be given the opportunity to review the entire APM Plan and make comments and ask questions. During the 2023 Picnic another consultant will be present to discuss the grant process necessary to support management implementation in 2024.

In addition, the development of the new APM Plan has been discussed with the WDNR and other stakeholders.

4.0 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. Lost Land, Teal, Teal River Flowage, and Ghost Lakes are all part of the Upper Chippewa River Basin and West Fork Chippewa River Sub-basin.

4.1 Upper Chippewa River Basin and West Fork Chippewa River Sub-basin

The Upper Chippewa basin is located in west-central and northwestern Wisconsin. The mainstem Chippewa River is formed by the confluence of the West Fork Chippewa River (rising from the 14,500 acre Chippewa Lake, southeastern Bayfield County) and East Fork Chippewa River (rising from the wetlands of the town of Knight in Iron County). Despite its proximity to Lake Superior, the Chippewa basin feeds the Mississippi River. Hydrologically, the Upper Chippewa basin is divided from the Lower Chippewa basin for management purposes and includes portions of Iron, Ashland, Sawyer, Rusk, Price, Vilas, Chippewa and Taylor counties. Over 3,000 stream and river miles flow through the basin and 156,200 acres of freshwater lakes, 22,711 acres of flowages, and more than 150 acres of freshwater springs. Nearly all of the 182,257 acre West Fork Chippewa River Watershed is located within the Chequamegon National Forest. The watershed is dominated by forest (58%) and wetlands (33%). The village of Clam Lake is the only community in the watershed, and the only developed area along the West Fork of the Chippewa River.

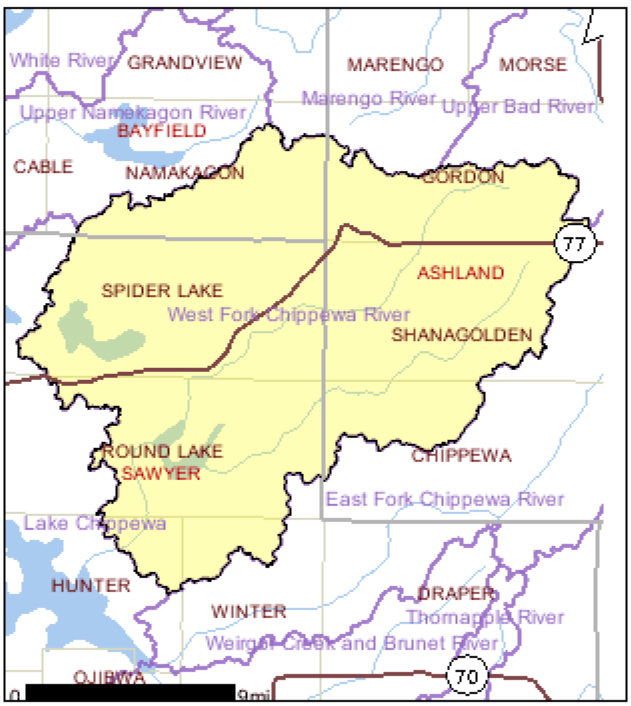

Figure 2: Map of the West Fork Chippewa River Sub-basin (https://apps.dnr.wi.gov/water/watershedDetail.aspx?code=UC23&Name=West%20Fork%20Chippewa%20River)

Within the Upper Chippewa River Basin, all four bodies of water are part of the West Fork of the Chippewa River sub-basin. Lost Land, Teal, and the Teal River Flowage enter the Chippewa River downstream of Moose Lake via the Teal River (Figure 3). There is no wild rice designated waters downstream of where the Teal River enters the Chippewa River. Ghost enters the Chippewa River upstream of Moose Lake via Ghost Creek (Figure 4). The section of the river that Ghost Creek enters is designated as wild rice water.

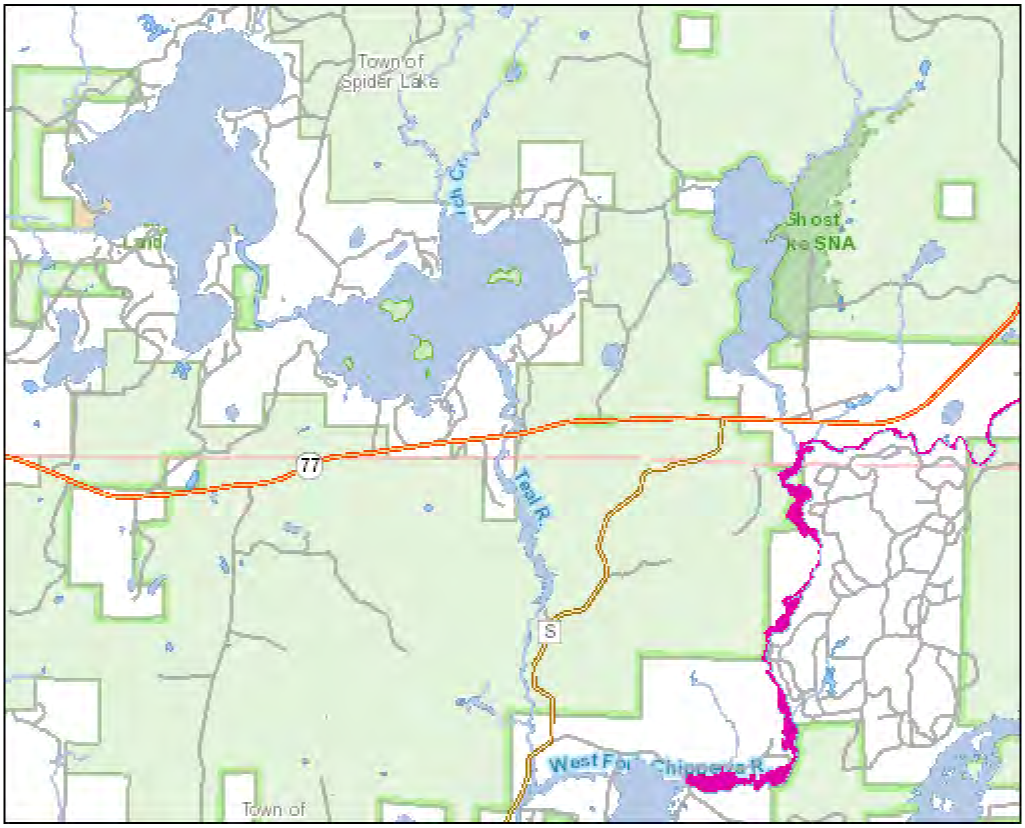

Figure 3: Lost Land, Teal, and Ghost Lakes downstream waters

4.2 Exceptional and Outstanding Resource Waters

Wisconsin has designated many of the state's highest quality waters as Outstanding Resource Waters (ORWs) or Exceptional Resource Waters (ERWs). Waters designated as ORW or ERW are surface waters that provide outstanding recreational opportunities, support valuable fisheries and wildlife habitat, have good water quality and are not significantly impacted by human activities. Teal Lake, Teal River Flowage, and Teal River are all listed as ORWs. ORWs receive the state's highest protection standards. ORWs typically do not have any point sources discharging pollutants directly to the water (for instance, no industrial sources or municipal sewage treatment plants), though they may receive runoff from nonpoint sources. New discharges may be permitted only if their effluent quality is equal to or better than the background water quality of that waterway at all times. No increases in pollutant levels are allowed.

4.2.1 Priority Navigable Waterways

Priority Navigable Waterways (PNW) include lakes less than 50 acres, waters with self-sustaining musky, sturgeon and walleye populations, tributaries to and rivers connecting naturally reproducing populations, and perennial tributaries to trout streams. All of the Quiet Lakes are listed as PNWs for musky, with Teal Lake also listed for walleye.

4.3 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 the Quiet 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 the Quiet 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.

Given that the watershed that the Quiet Lakes are a part of is mostly in a natural state, there are many wetlands around the lakes (Figure 4).

Figure 4: Wetland areas around the Quiet Lakes (https://dnrmaps.wi.gov/H5/?Viewer=SWDV)

4.4 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.

A survey of the CWH present in the lake could be completed by volunteers following guidelines offered in the Lake Shoreland & Shallows Habitat Monitoring Field Protocol prepared by the WDNR. 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).

4.5 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, and 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.

4.5.1 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.

4.5.2 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.

4.5.3 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.

4.5.4 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 10 shows the difference between a natural and unnatural shoreline adjacent to a lake home.[1]

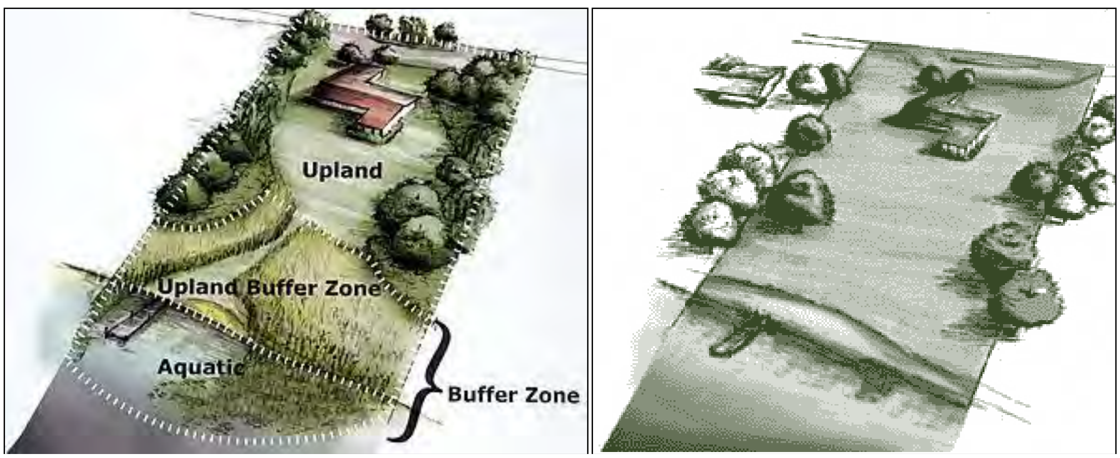

Figure 5: Healthy, AIS resistant shoreland (left) vs. shoreland in poor condition

[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

5.0 Lake Characteristics

Figure 6 (also on the cover) shows all four bodies of water included in the Quiet Lakes. The physical characteristics of a lake including total acres, depth, average depth, and type of bottom substrate are all important factors in determining appropriate aquatic plant management actions.

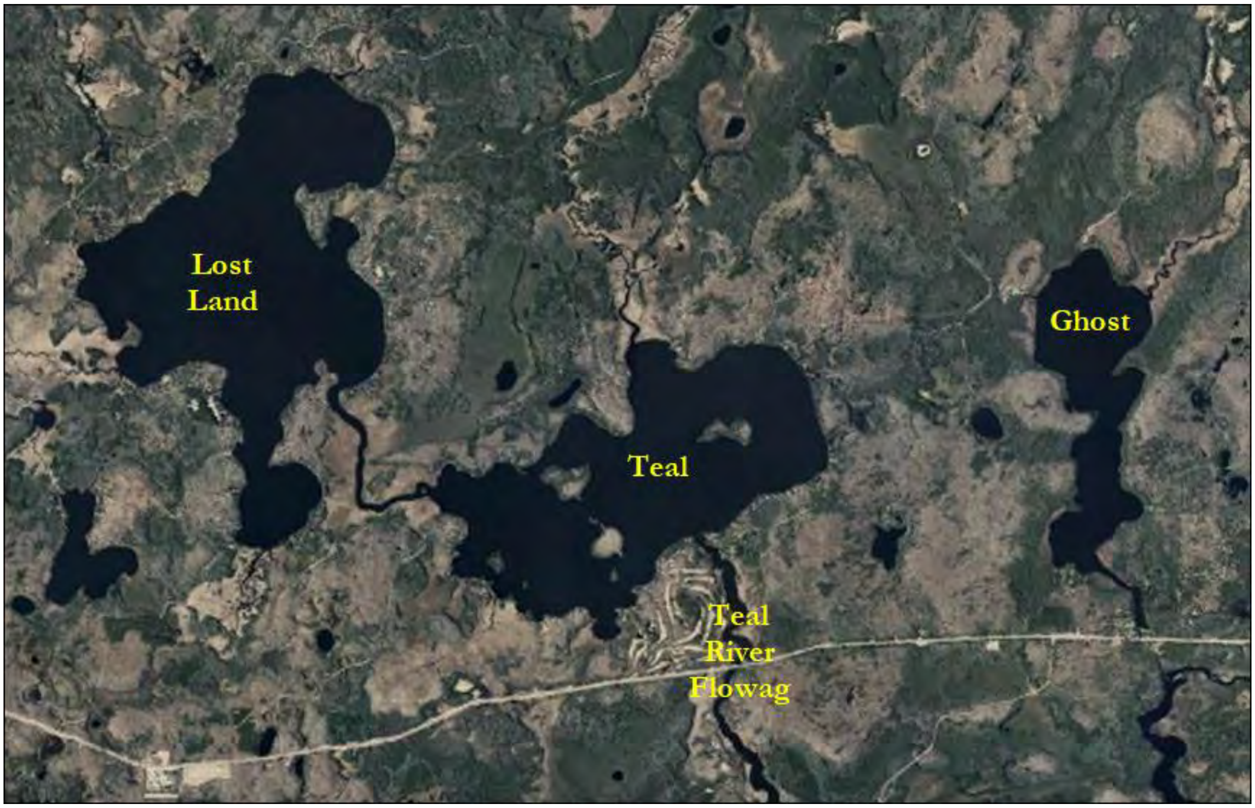

Figure 6: Lost Land, Teal, Teal River Flowage, and Ghost Lakes (Google Earth)

5.1 Physical Characteristics – Size, Shape, Depth, and Substrate

5.1.1 Lost Land Lake

Lost Land Lake is a 1,264 acre shallow lowland drainage lake with a maximum depth of approximately 20ft, a mean depth of 11ft, and an estimated volume of 13,904 acre-feet based on 2022 whole-lake, point-intercept (PI) aquatic plant survey work completed by Endangered Resource Services, Inc. (ERS). On the west side of Landing Camp Bay, the Wisconsin Department of Natural Resources (WDNR) maintains a public access with concrete boat ramp, courtesy dock, and parking space for 6-8 vehicles with trailers. Reel Livin' Resort also has a boat launch used by many property owners and recreational boaters.

Depth readings in 2022 taken at Lost Land Lake's 512 survey points revealed gradual sloping from nearly all the shoreline to deeper water (20ft) in the middle of the lake. Only off the point on the northeast side of the lake did the depth drop off quicker (Figure 7).

Of the 357 points where it was shallow enough to take a rake sample, the lake's bottom substrate was categorized as 17.4% pure sand (62 points), 66.9% organic and sandy muck (239 points) and 15.7% rock (56 points). Most sandy and rocky areas occurred immediately along the shoreline particularly on the east side of the lake. The entirety of the west bay and a majority of the south bay have muck bottoms (Figure 7). Unfortunately, it is the large area of the lake that has an organic and sandy muck bottom that provides the best habitat for E/HWM.

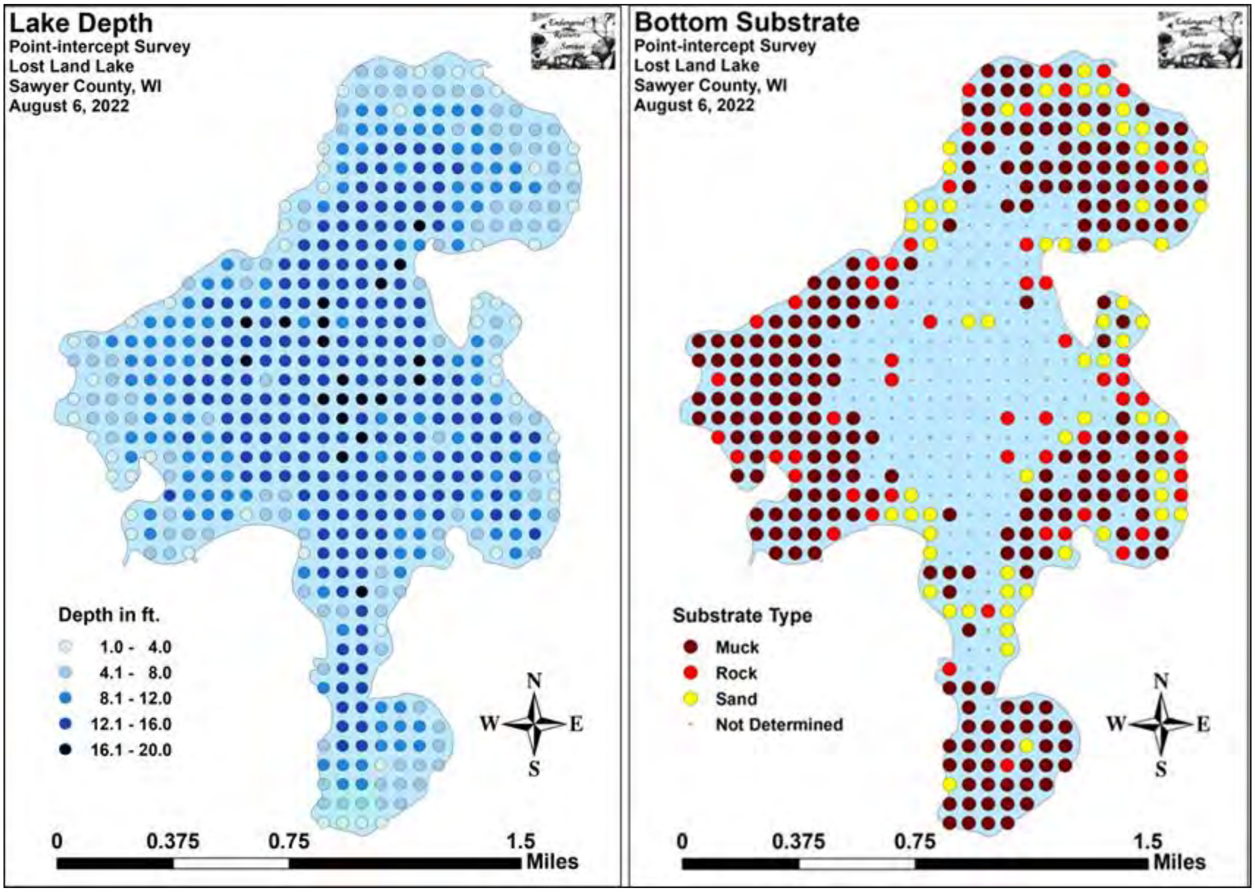

Figure 7: Lost Land Lake depth and bottom substrate (Berg, 2022)

5.1.2 Teal Lake

Lost Land Lake flows into Teal Lake via a shallow, mile-long navigable thoroughfare fringed with dense growth native aquatic plants. Teal Lake is a 1,024 acre shallow lowland drainage lake with a maximum depth of 32ft, a mean depth of 14ft, and an estimated volume of 14,336 acre-feet based on 2022 whole-lake, PI, aquatic plant survey work completed by ERS. The only convenient public boater access to Teal Lake is from Lost Land Lake (Figure 6).

Depth readings in 2022 taken at Teal Lake's 649 survey points revealed that the deepest water is in the north-central portion of the lake with very steep shores dropping off quickly into 30+ feet of water. Depth is fairly uniform in the southwest portion of the lake with shallow water along the shores sloping gradually to 13-18ft of water. The northeast portion of the lake is deeper with steeper shores dropping into up to 25ft of water. Several bays around the lake max out around 12ft. There are five islands in the lake with the eastern most island providing steep shorelines into deep water. The two largest islands in the western half of the lake provide a large flat of shallower water that runs nearly all the way across the lake from NW to SE (Figure 8).

Of the 247 points where it was shallow enough to take a rake sample, the lake's bottom substrate was categorized as 38.3% pure sand (101 points), 30.3% organic and sandy muck (80 points) and 31.4% rock (83 points). Except for the western shore and the northern bay which provide mostly a muck/sandy muck substrate, the rest of the lake bottom is mostly sand and rock (Figure 8). It is these areas of organic or sandy muck that provide the best habitat for E/HWM, much less than what is present in Lost Land Lake.

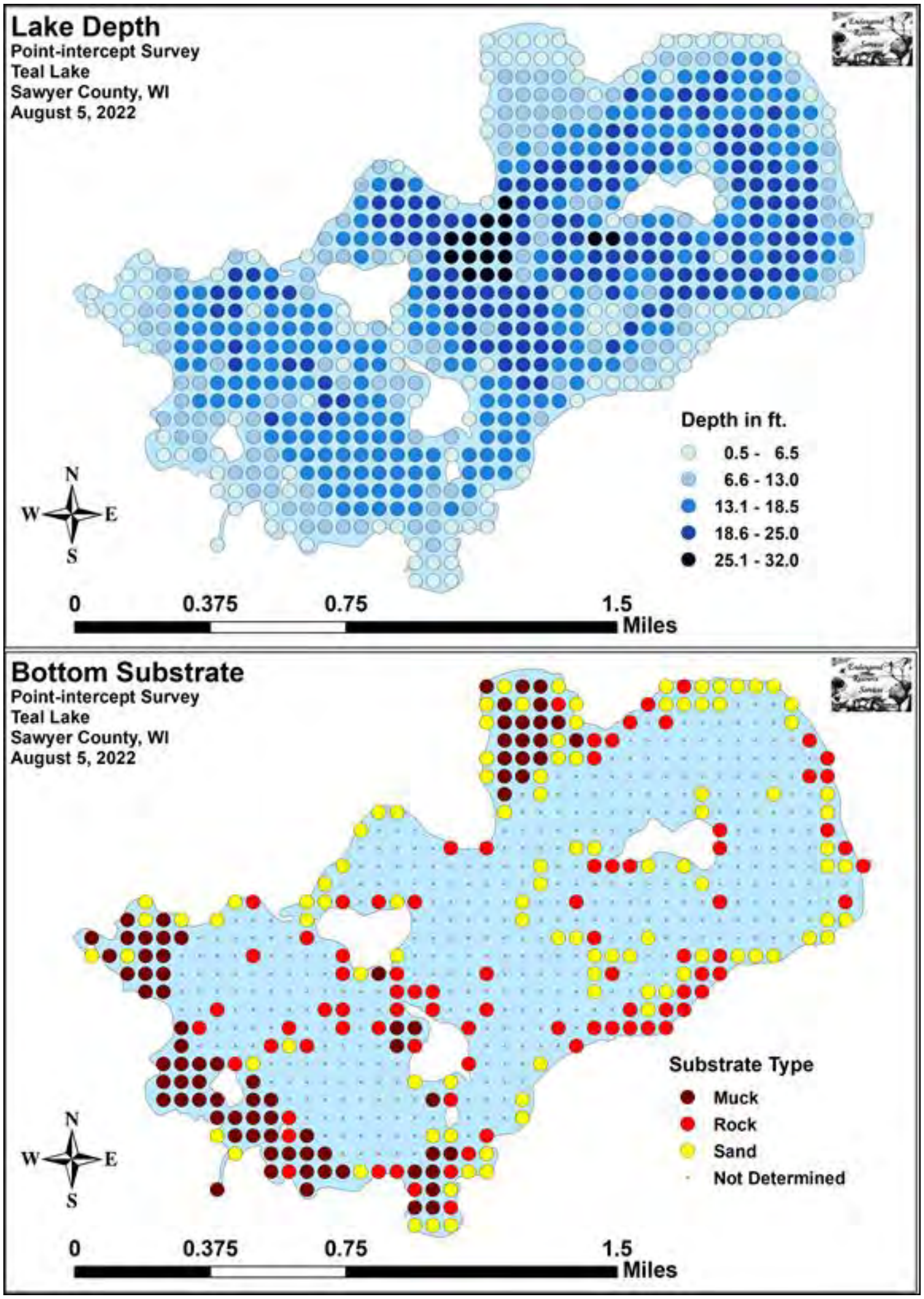

Figure 8: Teal Lake depth and bottom substrate (Berg, 2022)

5.1.1 Teal River Flowage

The Teal River flows south from the outlet of Teal Lake and under Highway 77 where it becomes the upper end of the 66ac Teal River Flowage. This long, narrow impoundment was created by a 3ft rock roller dam built during the logging era and is currently still maintained. This dam has no engineered water control structure; the elevation of the rocks regulates water levels in Teal and Lost Land lakes which drain into the Teal River Flowage. The U.S. Forest Service maintains a little-used sand/gravel boat launching area with space for one or two vehicles with trailers to park on National Forest property just upstream of the rock roller dam – accessible by gravel road off County Road S. The Flowage has a maximum depth of 9ft and a mean depth of 3ft.

The Teal River Flowage was not included in the aquatic plant survey work that was done for this project but reports from a QLIA volunteer suggest it has mostly a rocky bottom with areas along the shore that have more organic or sandy muck. These areas do currently support the growth of E/HWM. A whole-lake, point-intercept, aquatic plant survey should be completed as a part of any APM Plan implementation project for the Quiet Lakes.

5.1.2 Ghost Lake

Ghost Lake is a 372 acre drainage lake impounded by a 15ft dam with a maximum depth of approximately 12ft and an estimated volume of 2,000 acre-feet. The U.S. Forest Service maintains a lightly used public access with concrete boat ramp on the east side of Ghost Lake. Ghost Lake is not connected to Lost Land or Teal Lakes, but all three lakes flow into the west fork of the Chippewa River – Lost Land and Teal via the Teal River; and Ghost via Ghost Creek - upstream of Lake Chippewa (also known as the Chippewa Flowage).

Ghost Lake was not included in this study, primarily because it currently not known to have E/HWM in it. A whole-lake, point-intercept, aquatic plant survey should be completed as a part of any APM Plan implementation project for the Quiet Lakes.

5.2 Water Quality

The Citizen Lake Monitoring Network[2] (CLMN) is a water quality monitoring partnership between the WDNR, the Wisconsin Lakes Partnership, and over a 1,000 citizen volunteers statewide. The goals of the CLMN are to collect high quality data, to educate and empower volunteers, and to share this data and knowledge. Volunteers measure water clarity using the Secchi disk, as an indicator of water quality (based on clarity). They also comment on other parameters including lake level, water color, murkiness, and how they perceive the lake on any given monitoring date using a 1 to 5 scale with 1 being "great, fantastic" and 5 being "really bad". Volunteers may also collect chemistry data; collect temperature and dissolved oxygen data; and monitor for the first appearance of aquatic invasive species near boat landings, other access points, or along the shoreline.

[2] For more information about the CLMN go to: https://dnr.wisconsin.gov/topic/lakes/clmn

5.2.1 Water Clarity

Water clarity is a measurement of how deep sunlight can penetrate into the waters of a lake. It can be measured in a number of ways, the most common being an 8" "Secchi" disk divided into four sections, two black and two white, lowered into the lake water from the surface by a rope marked in measurable increments (Figure 9). The water clarity reading is the point at which the disk when lowered into the water can no longer be seen from the surface of the lake. Water color (e.g. water stained by tannins from nearby bogs and wetlands), particles suspended in the water column (e.g. sediment or algae), and weather conditions (clouds, wind, or sunlight) can impact how far down a Secchi disk can be seen in the water. Some lakes have Secchi disk readings of water clarity of just a few inches, while other lakes have conditions that allow the Secchi disk to be seen for dozens of feet before it disappears from view.

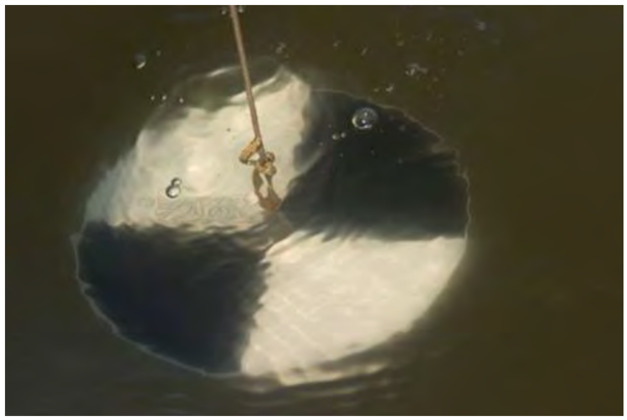

Figure 9: Secchi disk

5.2.2 Total Phosphorus

Phosphorus (P) is essential to plant growth as a vital nutrient for converting sunlight into usable energy during photosynthesis. Under natural conditions, P is typically scarce in water. In the late 1960s, scientists discovered P contributed by human activity to be a major cause of excessive algal growth and degraded lake water quality. P can be attached to sediment particles like clay and silt, and can then build up in the sediments of a lake. When it remains in the sediment, it is generally not available for use by algae; however, various chemical and biological processes can allow sediment P to be released back into the lake water. P concentrations in a lake are generally measures as Total Phosphorus (TP) which combines all the forms of phosphorus in the sample (particulate and dissolved). TP concentration is generally considered excessive when it is >0.017–0.020mg/L. At this level, TP may lead to accelerated aging of the lake and increased productivity.

5.2.3 Chlorophyll-a

Chlorophyll-a (Chl-a) is a photosynthetic green pigment found in algae and other green plants. Its concentration is commonly used as a measure of algal production in a lake. Concentrations >7.0–10.0μg/L indicate eutrophic conditions. Concentrations >20.0–30.0μg/L are generally associated with algal blooms.

5.2.4 Trophic Status

All three parameters are commonly used to determine the state of water quality in a lake. Individual values of each, when measured over time, can show whether or not water quality in a lake is getting better, not changing, or getting worse. All three are related to one another in that excess P can grow algae (measured by Chl-a), which can in turn, impact water clarity. All three are used to determine the fertility/productivity or trophic status of a lake, and can be represented in relation to each other on a Trophic State Index (TSI) scale

(Carlson, A trophic state index for lakes, 1977). The TSI is a numeric index of lake trophic status on a scale of 1 to 100, with higher numbers indicating greater nutrient enrichment (Table 1).

Table 1: Carlson's Trophic State Index values

TSI values	TrophicStatus	Attributes
< 30	Oligotrophic	Clear water, oxygen throughout the year in the hypolimnion
30-40	Oligotrophic	A lake will still exhibit oligotrophy, but some shallower lakes will become anoxic during the summer
40- 50	Mesotrophic	Water moderately clear, but increasing probability of anoxia during the summer
50-60	Eutrophic	Lower boundary of classical eutrophy: Decreased transparency, warm-water fisheries only
60-70	Eutrophic	Dominance of blue-green algae, algal scum probable, extensive macrophyte problems
70-80	Eutrophic	Heavy algal blooms possible throughout the summer, often hypereutrophic
>80	Eutrophic	Algal scum, summer fish kills, few macrophytes

5.2.5 Thermal 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 10).

In most cases, a lake does not remain stratified year-round. Only Teal Lake actually stratifies in the summer months for any long period of time. It is considered a dimictic lake, 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. In Teal Lake, the thermocline, that area that separates the warm surface water from the cooler bottom waters during stratification, usually sets up at around 25-ft in late June and remains so until early September.

Lost Land Lake is larger than Teal, but also shallower and has no sheltered bays or other areas. As a result, it seldom stratifies, and if it does, it only lasts a few hours to a few days. Throughout the entire open water season the lake remains "mixed" with temperature and DO usually remaining fairly consistent surface to bottom.

Both Ghost and the Teal River Flowage also remain mixed most of the season.

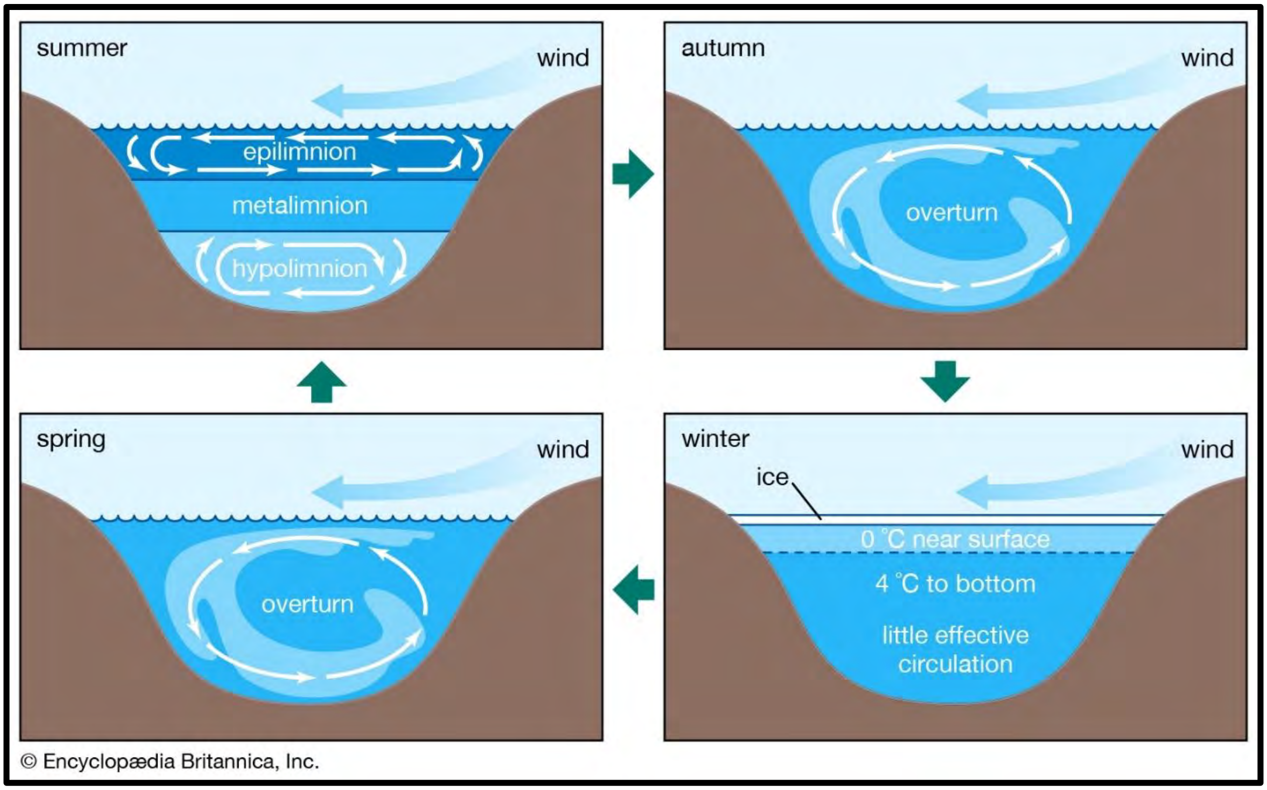

Figure 10: Dimictic stratification and turnover (Williams & Mann, 2022)

5.3 Lost Land Lake

Secchi disk readings of water clarity have been collected in Lost Land Lake since 1993 with a gap between about 2012 and 2018. Over time, Secchi disk readings have averaged a little more than 7-ft, with readings taken after 2018 being a bit better than the readings from the 1990's and 2000's (Figure 11). A linear trend line suggests that water clarity has improved since data collection began (Figure 11). Monthly Secchi readings follow a familiar pattern of better or deeper readings in the spring and fall and lesser readings during the summer months (Figure 12).

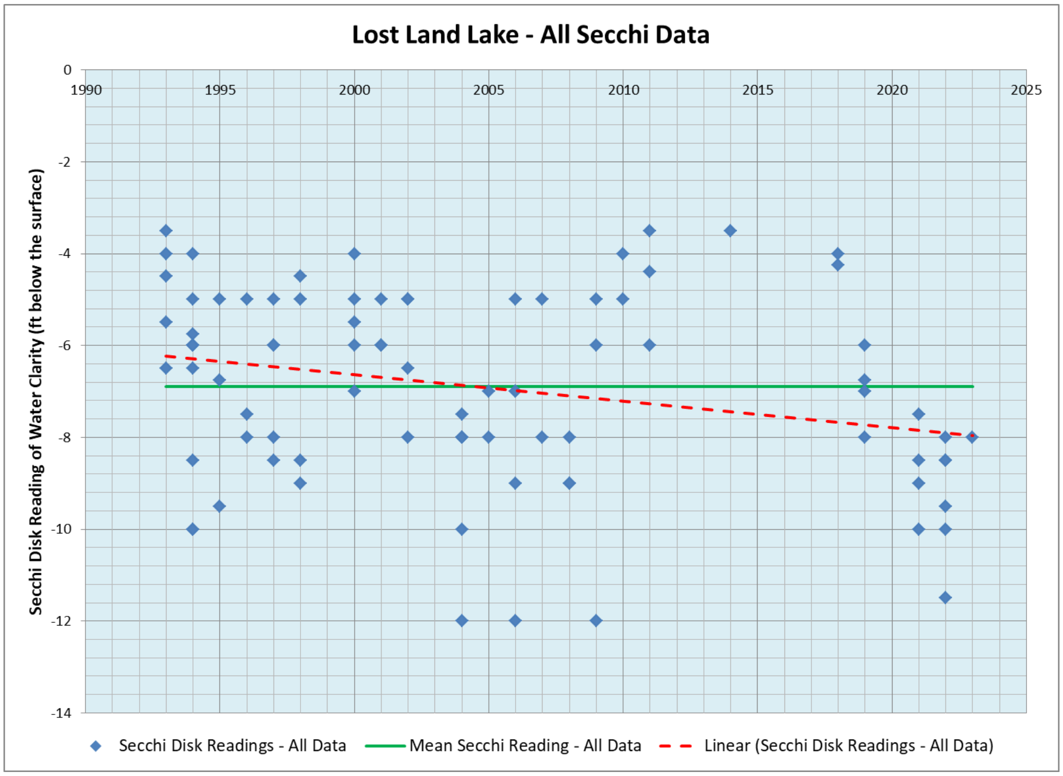

Figure 11: Lost Land Lake Secchi readings of water clarity – all CLMN data

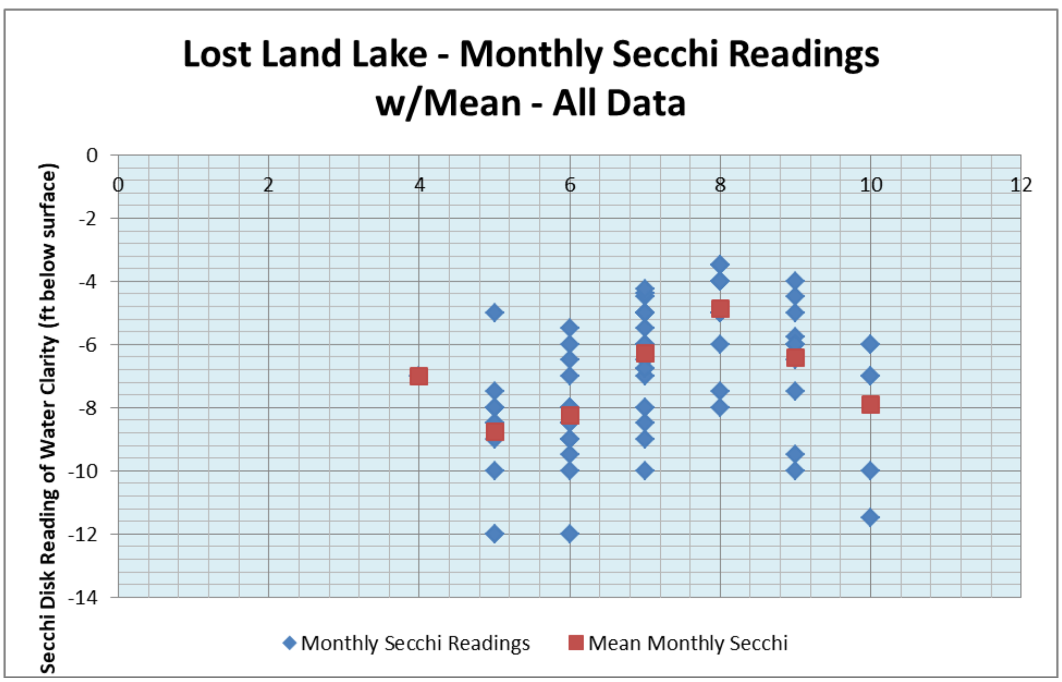

Figure 12: Monthly Secchi disk readings from Lost Land Lake – all CLMN data

Total phosphorus data was collected regularly between 1993 and 2912 and then again between 2019 and 2022. The average annual phosphorus concentration in the lake was about 0.021mg/L from 1993-2012 slightly higher than the level that is considered excessive. The concentration was slightly better from 2019-2022 (<0.020mg/L), but likely not significantly better (Figure 13). Monthly TP values are higher in the spring during snowmelt and spring runoff, then get better in the early summer when the lake water is still cool and there is little algae growth. As the water temperature warms in the summer, TP increases as well. When water temperatures cool down in the fall, TP concentrations go down again (Figure 14).

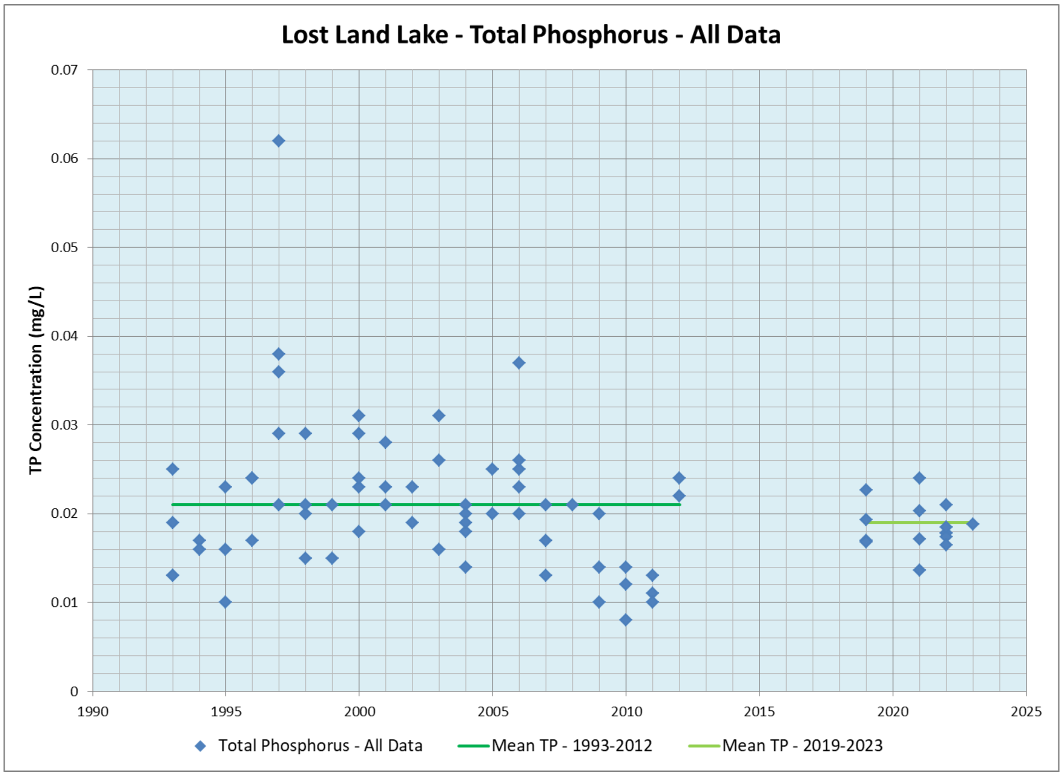

Figure 13: Lost Land Lake total phosphorus concentrations – all CLMN data

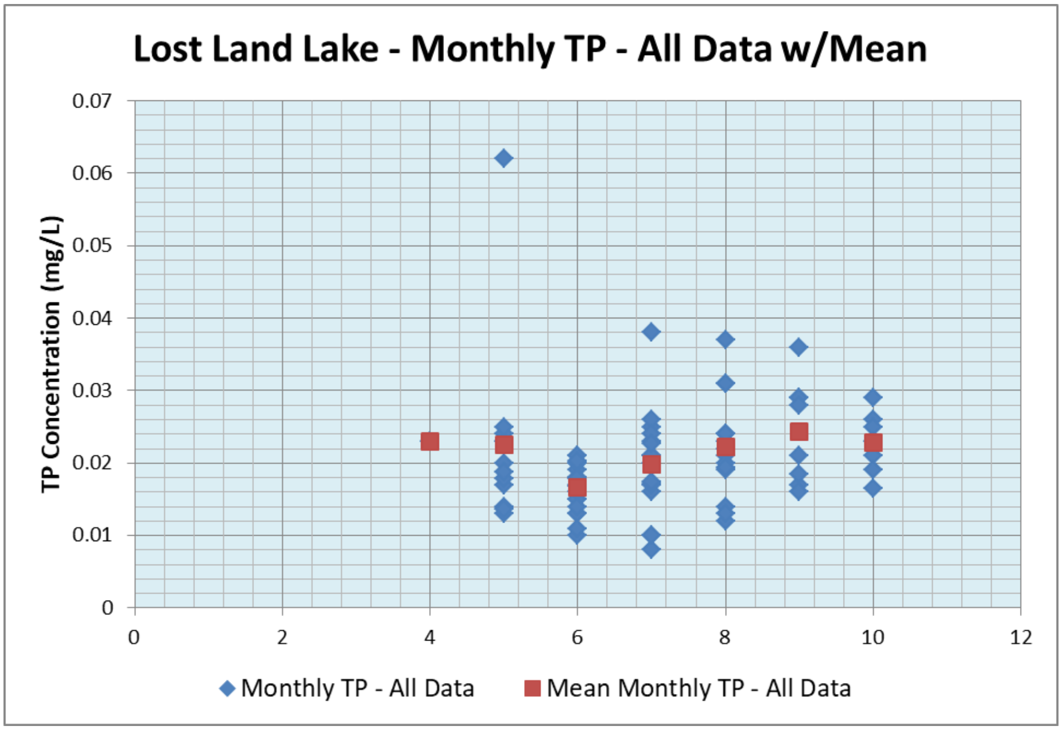

Figure 14: Monthly total phosphorus concentrations from Lost Land Lake – all CLMN data

Chlorophyll-a data has been mixed over time. In the 1990's, the concentration of Chl-a was considered borderline eutrophic (Figure 15). In the early 2000's concentrations were higher, definitely within the eutrophic range, with some measurements exceeding levels that are generally associated with algal blooms (Figure 15). In more recent years (2019-2022) Chl-a concentrations appear to be down again, below levels considered eutrophic. A familiar pattern exists with monthly Chl-a concentrations – Chl-a is low in the spring and early summer, more abundant in the late summer and early fall, then lower again in fall when water temperatures cool down (Figure 16). August appears to be the month with the greatest variability.

Improved water clarity suggests lower Chl-a and lower total phosphorus in the water, and the numbers from Lost Lake support this. One reason for this could be the 260+ acres of E/HWM. Aquatic plants use up available phosphorus in a lake, leaving less phosphorus to be used up by algae. Lakes with abundant aquatic vegetation often present clearer water conditions. The question that is difficult to answer is if a significant amount of the vegetation is removed (managed/killed) will water quality be negatively impacted?

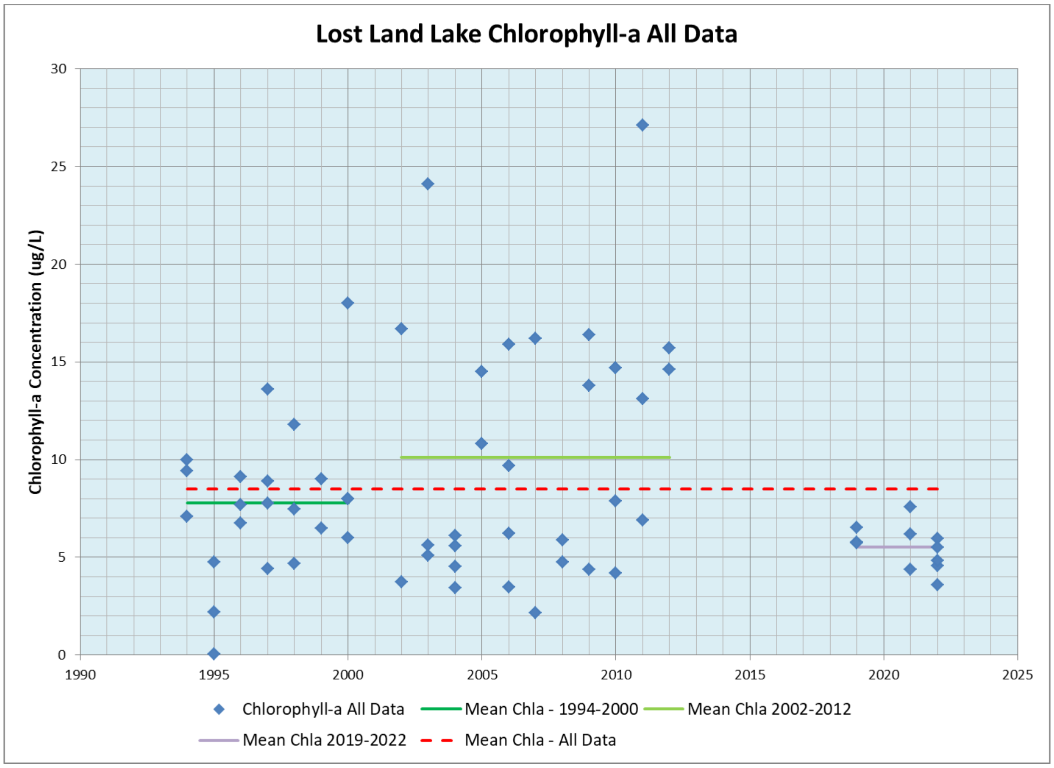

Figure 15: Lost Land Lake chlorophyll-a concentrations – all CLMN data

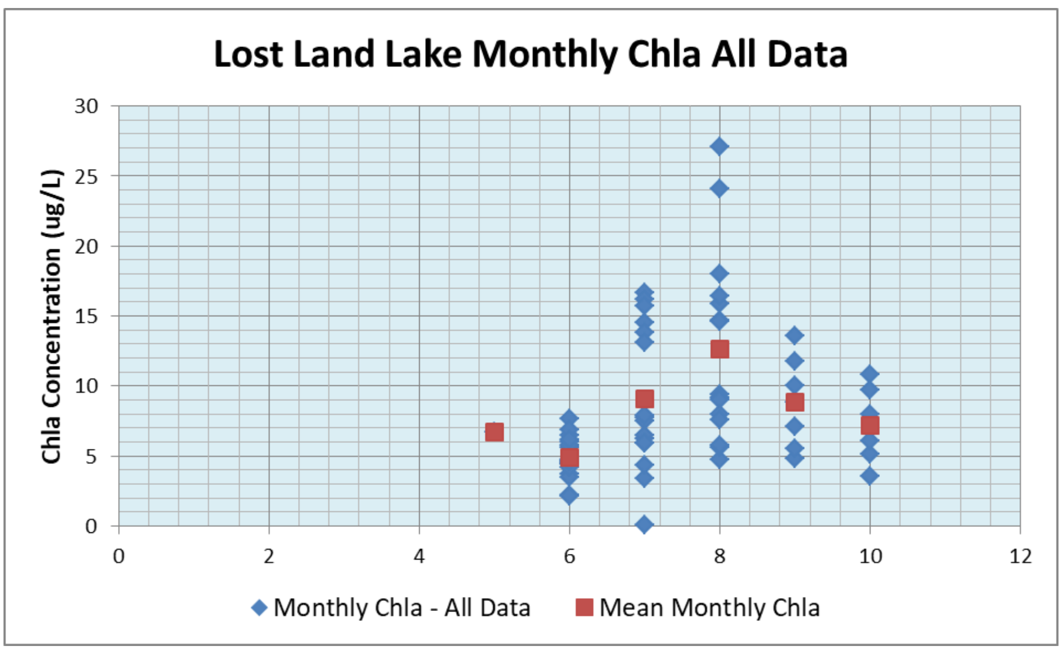

Figure 16: Monthly chlorophyll-a concentrations from Lost Land Lake – all CLMN data

5.4 Teal Lake

Consistent data from 1993 to 2022 exists for Teal Lake. The average Secchi disk reading of water clarity over time is just over 7ft. A linear trend line for all Secchi data suggests that the water clarity may be declining over time, but it is not likely significant (Figure 17). Monthly Secchi readings of water clarity follow a similar pattern as in Lost Lake except that the Secchi disk readings in the summer months exhibit a more extreme pattern of lesser water clarity, likely due to internal loading of phosphorus that enables greater algal growth which in turn leads to lesser water clarity (Figure 18).

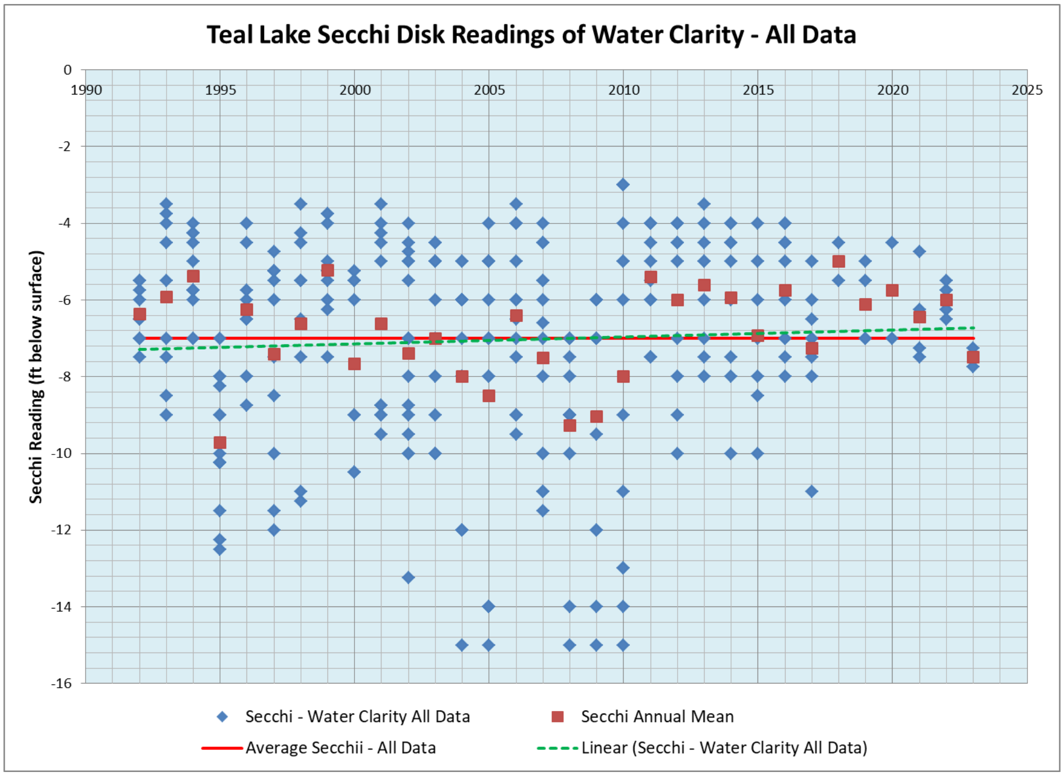

Figure 17: Teal Lake Secchi readings of water clarity – all CLMN data

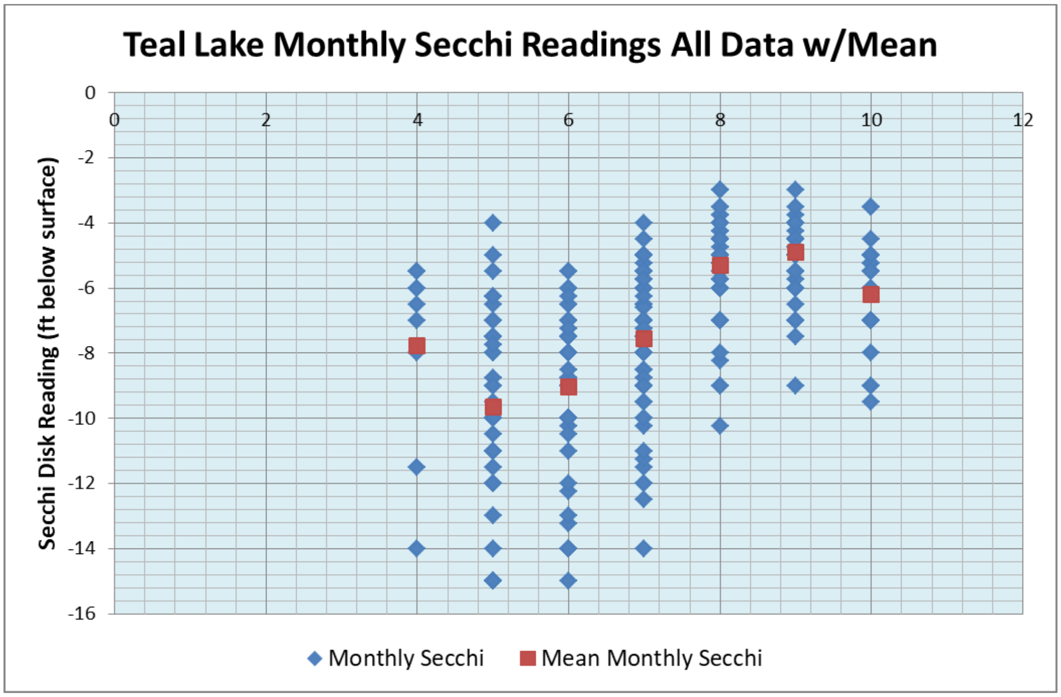

Figure 18: Monthly Secchi disk readings from Teal Lake – all CLMN data

Like water clarity readings, consistent total phosphorus data exists for Teal Lake. Based on all the data collected and reported as part of the CLMN program, TP levels seem to be going down, i.e. getting better (Figure 19). They appear also to be more concentrated, with less variability (Figure 19). Total phosphorus concentrations are highest in the late summer months likely due to increased internal loading and fall turnover mixing in more TP (Figure 20).

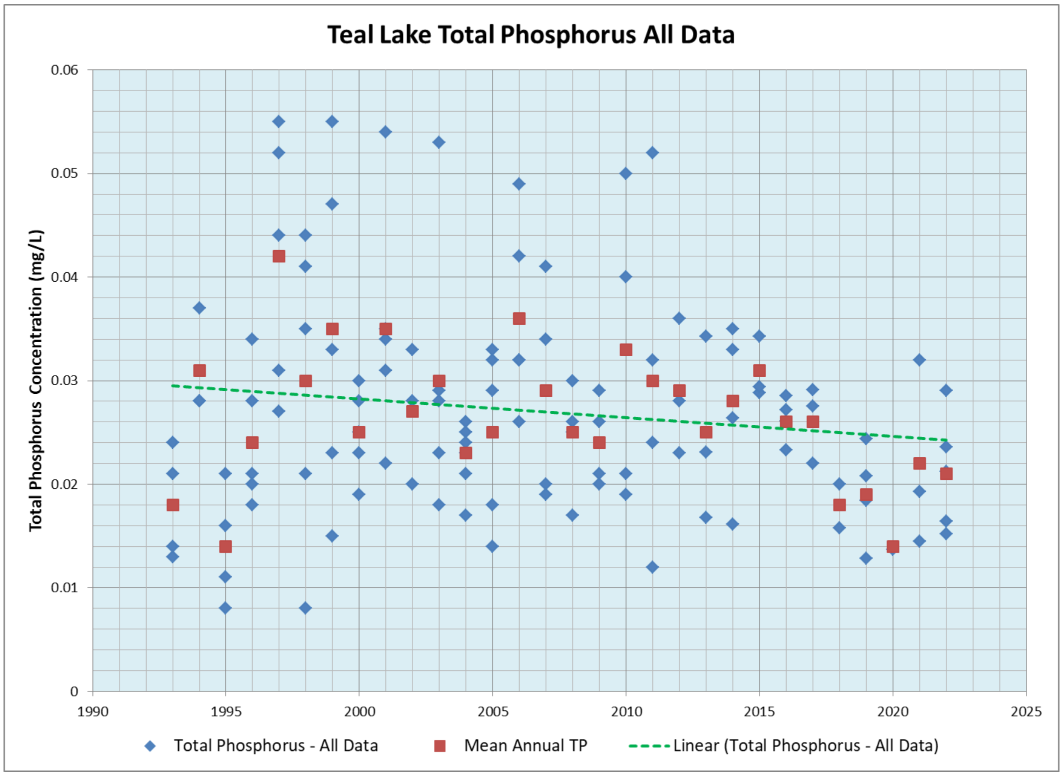

Figure 19: Teal Lake total phosphorus concentrations – all CLMN data

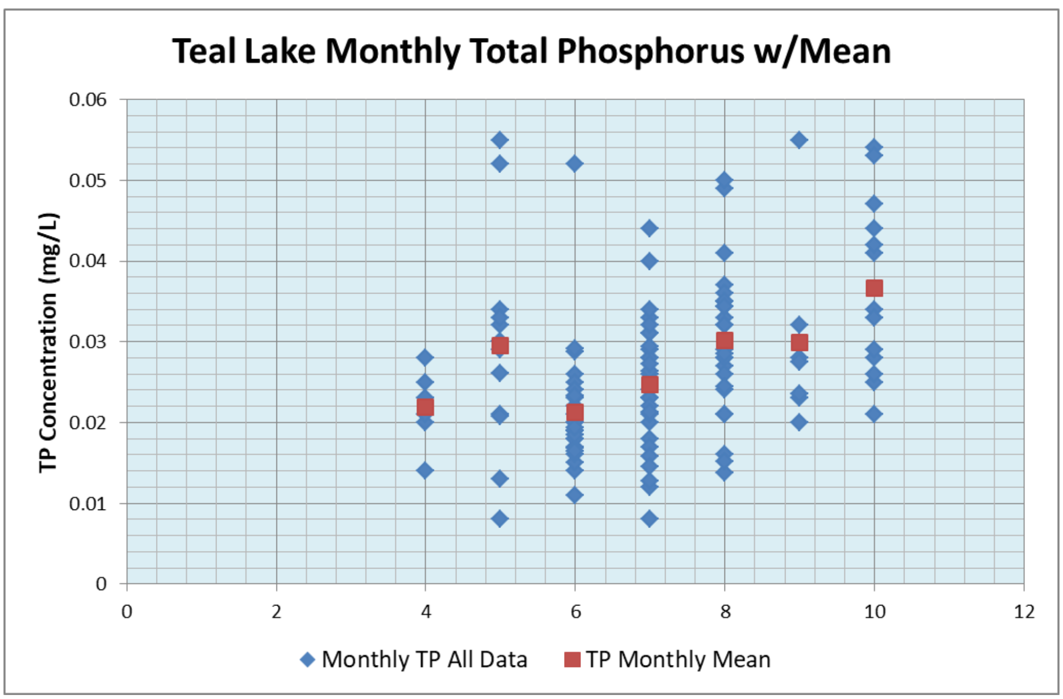

Figure 20: Monthly total phosphorus concentrations from Teal Lake – all CLMN data

Chlorophyll-a concentrations do not appear to have changed much in Teal Lake over time (Figure 21). Monthly data is similar to what is found in Lost Land Lake with August being the month with the variability (Figure 22).

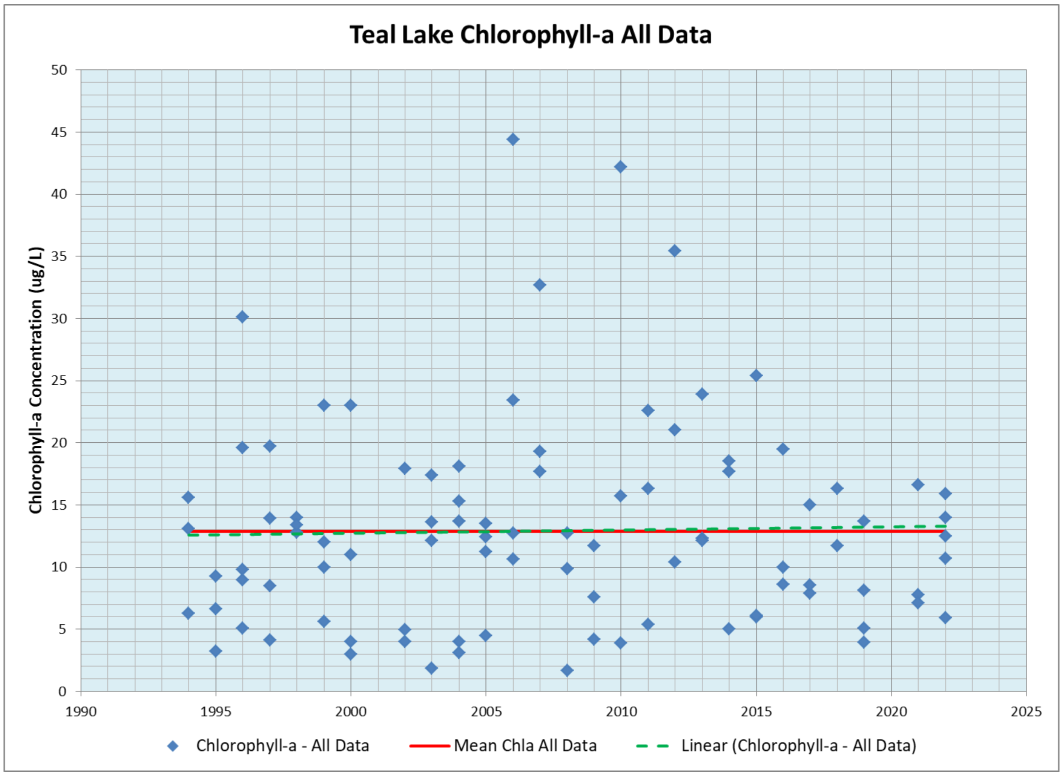

Figure 21: Teal Lake chlorophyll-a concentrations – all CLMN data

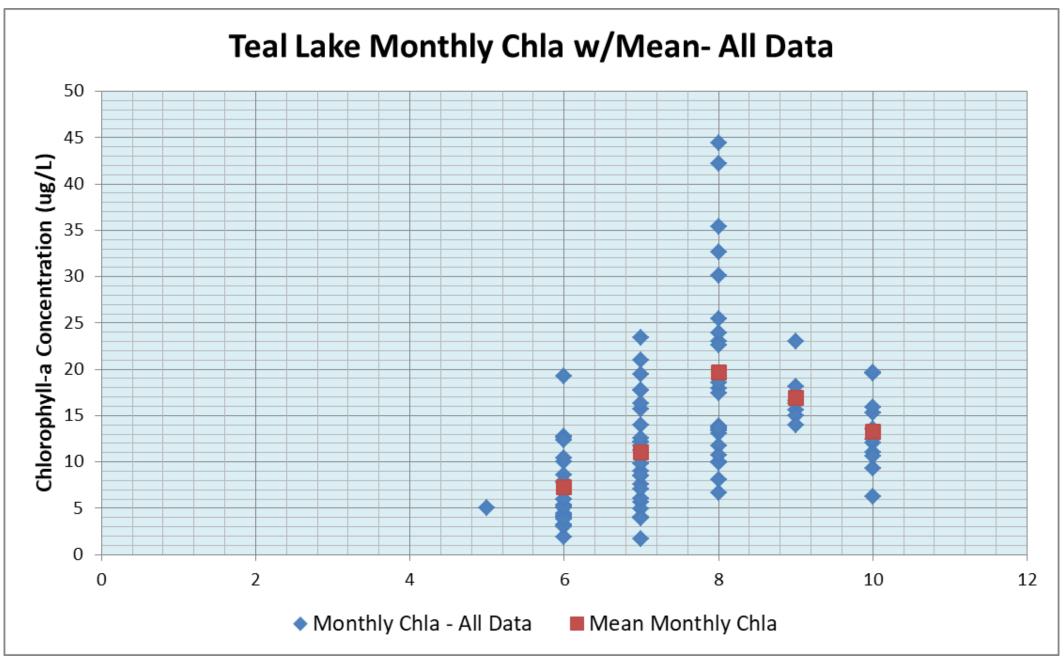

Figure 22: Monthly chlorophyll-a concentrations from Teal Lake – all CLMN data

5.5 Ghost Lake

Water clarity data from Ghost Lake was only collected between 1999 and 2006. Based on those few years, water clarity appears to be better (Figure 23), but more recent data is needed to know if this is a continuing trend. Total phosphorus (Figure 24) and Chl-a (Figure 25) data is also limited, so no trends can be firmly established.

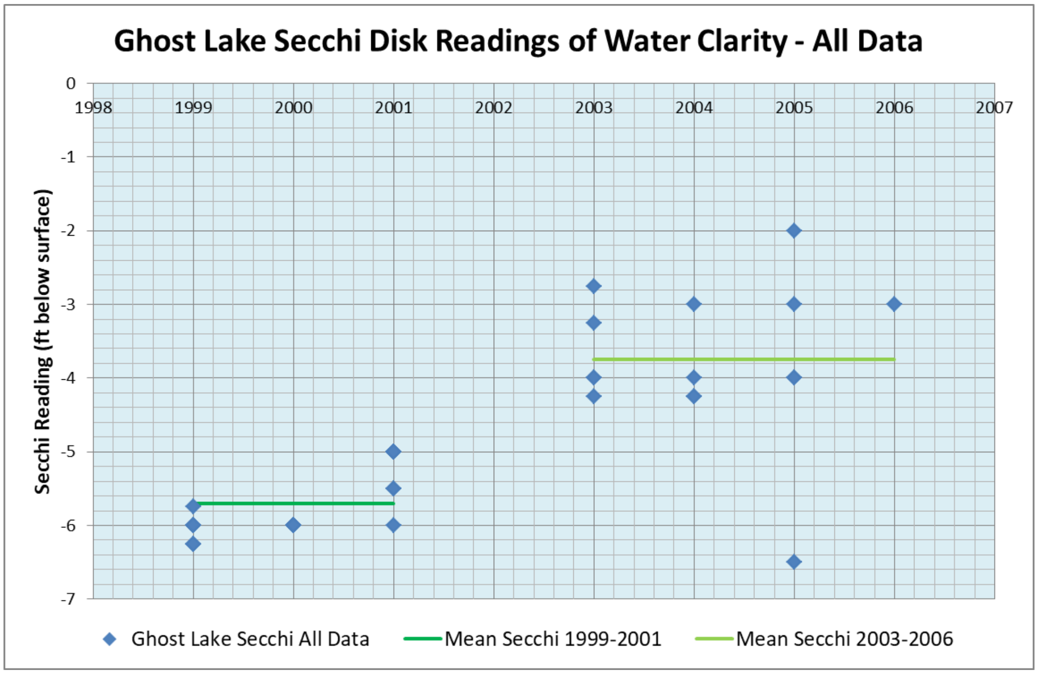

Figure 23: Ghost Lake water clarity – all CLMN data

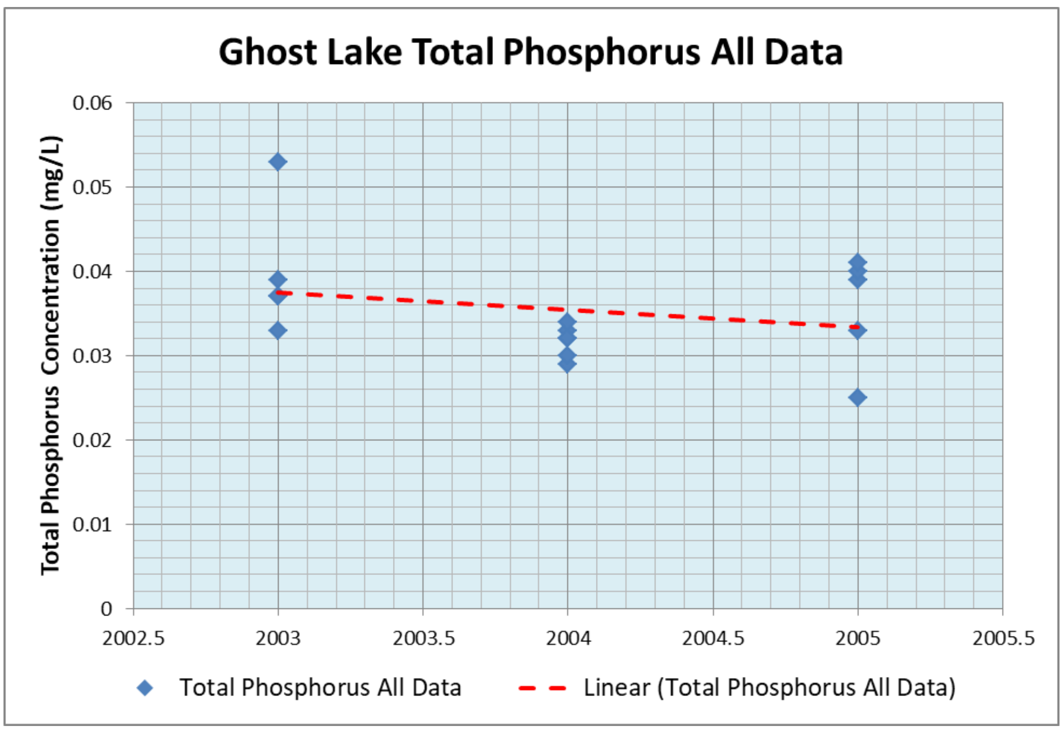

Figure 24: Ghost Lake total phosphorus – all CLMN data

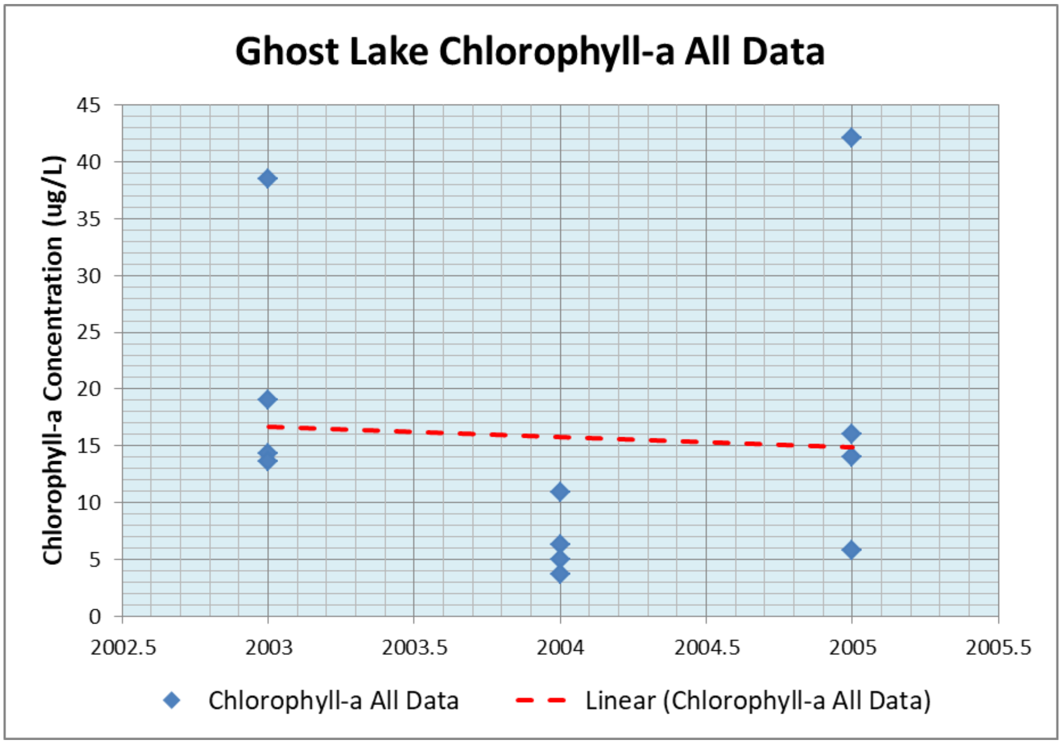

Figure 25: Ghost Lake chlorophyll-a data – all CLMN data

5.6 Teal River Flowage

Between 1995 and 2004 the collection of water quality data from the Teal River Flowage was pretty consistent, but since then, not data has been recorded in the WDNR SWIMS database. Figures 26-28 reflect the data from 1994 to 2004, however, since there is not current data, long-term trends cannot be reliably established.

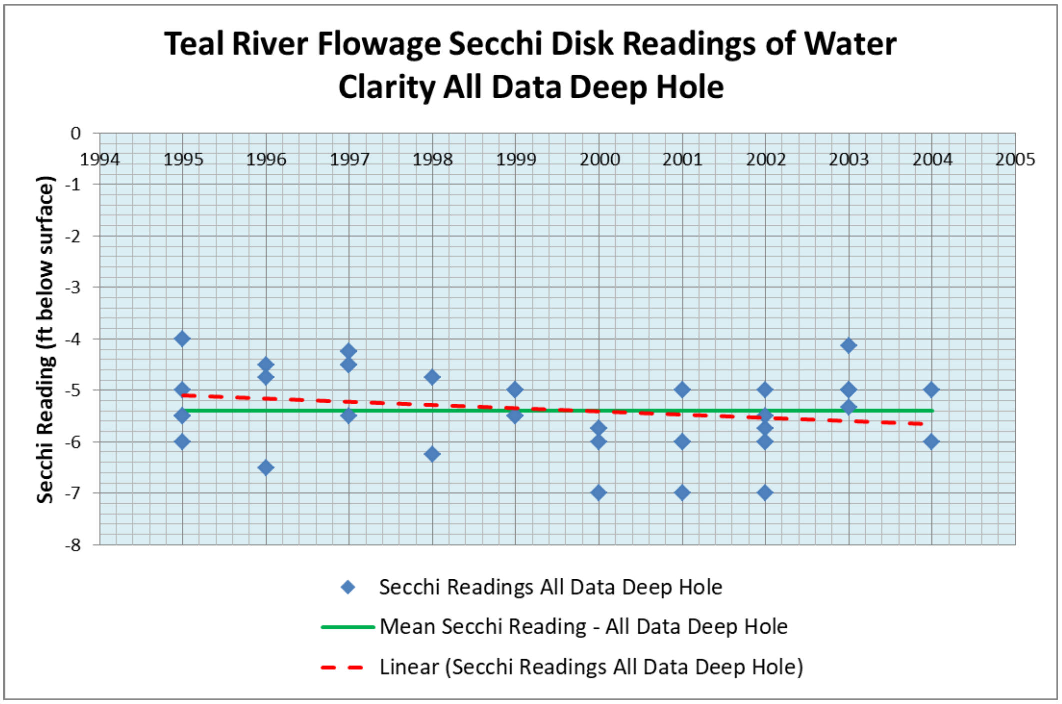

Figure 26: Teal River Flowage water clarity – all CLMN data

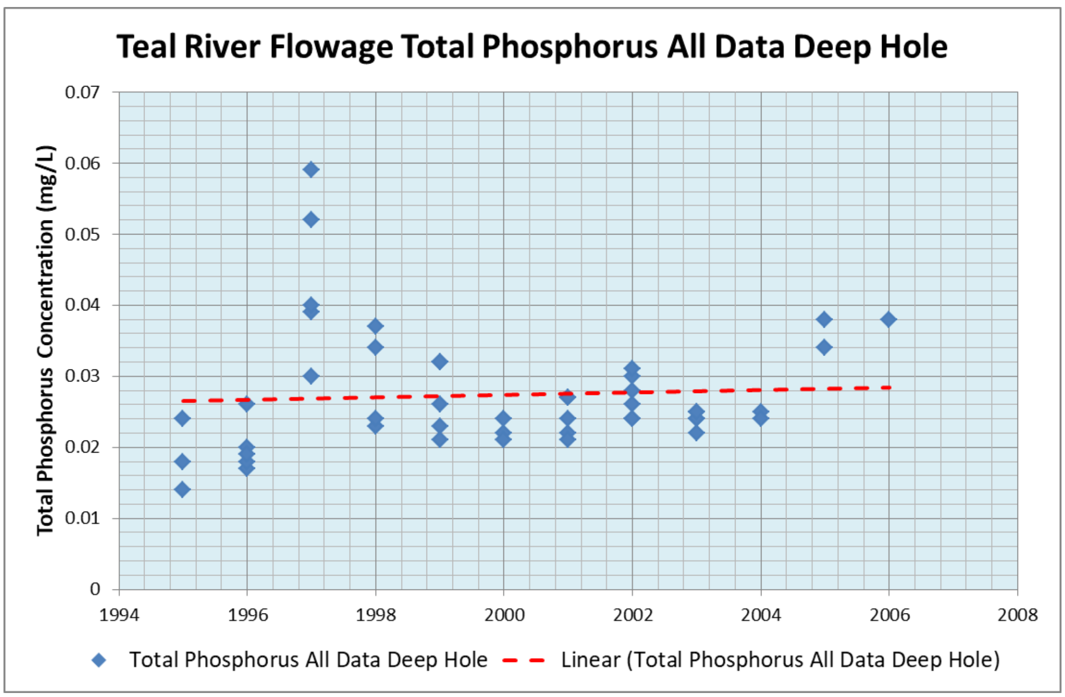

Figure 27: Teal River Flowage total phosphorus – all CLMN data

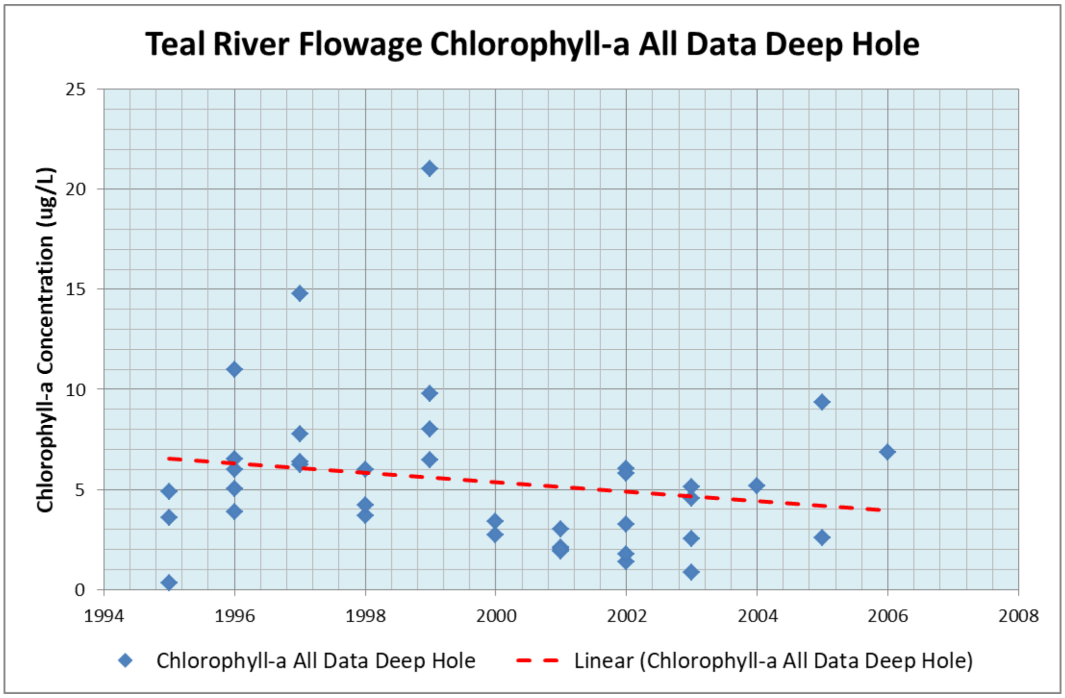

Figure 28: Teal River Flowage chlorophyll-a – all CLMN data

5.7 Trophic State Index – Lake Productivity

Water clarity (based on Secchi disk readings), total phosphorus, and chlorophyll-a are parameters that can be used to determine the productivity or trophic status of a lake. The Carlson trophic state index (TSI) is a frequently used biomass-related index. The trophic state of a lake is defined as the total weight of living biological material (or biomass) in a lake at a specific location and time. Eutrophication is the movement of a lake's trophic state in the direction of more plant biomass. Eutrophic lakes tend to have abundant aquatic plant growth, high nutrient concentrations, and low water clarity due to algae blooms (Figure 29). Oligotrophic lakes, on the other end of the spectrum, are nutrient poor and have little plant and algae growth (Figure 29). Mesotrophic lakes have intermediate nutrient levels and only occasional algae blooms (Figure 29).

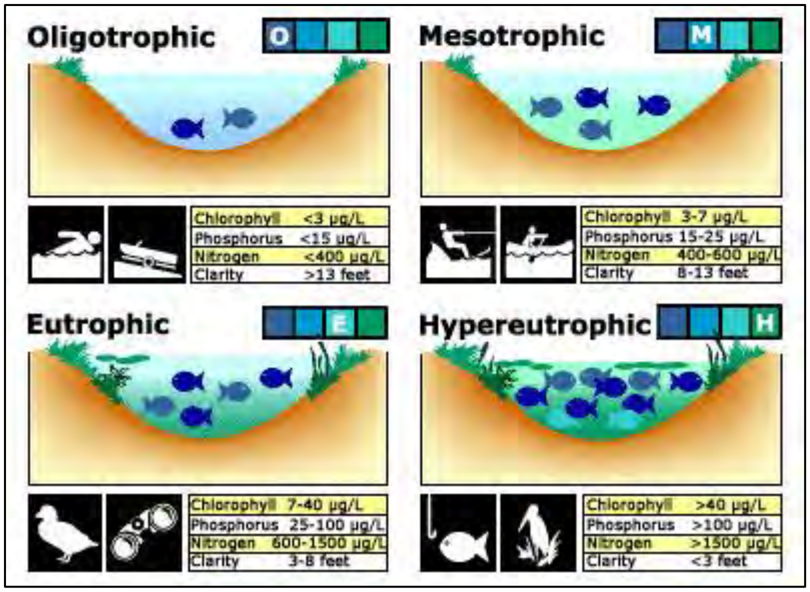

Figure 29: Trophic state in lakes

As discussed in Section 2.1.4, measurements of all three water quality parameters (Secchi - feet, TP & Chla - µg/L) can be converted to values that fit in the TSI range of 0 to 100. By doing so, all three can be compared together to establish trends. The dark blue areas of Figures 30-31 are considered oligotrophic; the light blue mesotrophic; and the green eutrophic. The points in Figures 30-31 represent the summer averages for each parameter and place them all in the 0-100 TSI scale. The TSI data can be used for visualizing trends. In addition, over time, several familiar patterns emerge from the data. Carlson and Havens (2005) discussed the patterns that frequently emerge when looking at long-term trend data and TSI values. These different patterns can give us hints about what is going on in the lake. Table 2 reflects the most common patterns and what they likely mean in a lake.

Table 2: TSI patterns

TSI(Chl) = TSI(TP) = TSI(Sec)	It is likely that algae dominate light attenuation
TSI(Chl) > TSI(Sec)	Large particulates such as Aphanizomenon flakes dominate
TSI(TP) = TSI(Sec) > TSI(Chl)	Non-algal particulate or color dominate light attenuation
TSI(Sec) = TSI(Chl) >= TSI(TP)	The algae biomass in your lake is limited by phosphorus
TSI(TP) > TSI(Chl) = TSI(Sec)	Zooplankton grazing, nitrogen or some factor other than phosphorus is limiting algae biomass

5.7.1 TSI – Lost Land Lake

Early values for Secchi, TP, and Chl-a are mostly in the eutrophic (green) area of Figure 30. Only in the last couple of years does the data appear to drop closer or into the mesotrophic area of Figure 30. Figure 30 shows several different TSI patterns. The most defined is from about 2009-2011 when TP is clearly lower than Secchi and Chl-a suggesting at that time that algae biomass in Lost Land Lake was limited by available phosphorus. In the last few years, that pattern has reversed, TP is higher than both Secchi and Chl-a suggesting that zooplankton grazing, nitrogen or some other factor other than TP is limiting algae biomass.

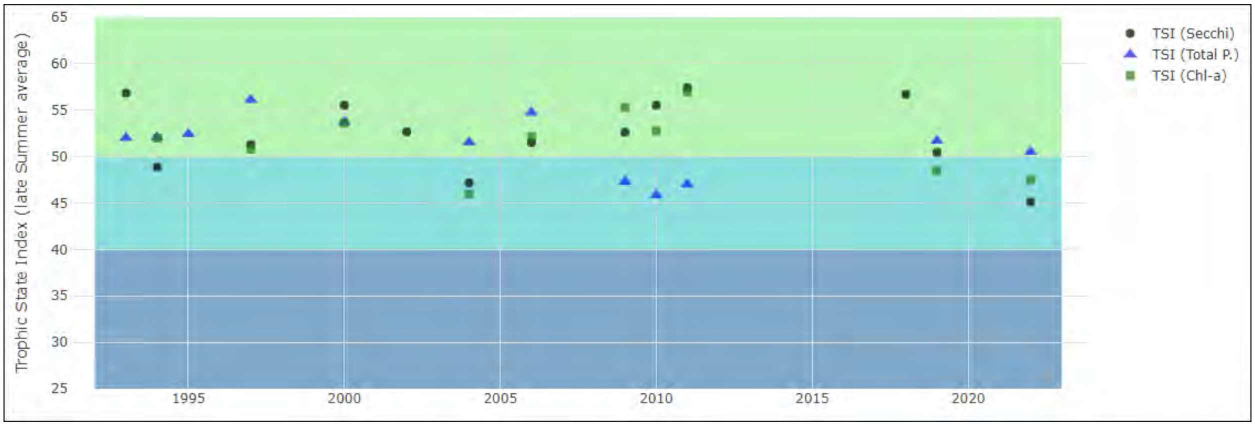

Figure 30: Lost Land Lake TSI graph

5.7.2 TSI – Teal Lake

The Teal Lake TSI graph (Figure 31) shows that over the last 10 years or so that Secchi, TP, and Chl-a are all in the eutrophic range of the scale and pretty much the same. This suggests that algae growth is dominating light attenuation, or in other words, causing the loss of light in the water column due to absorption and scattering. Both situations may limit the available sunlight to grow aquatic plants rooted to the bottom of the lake.

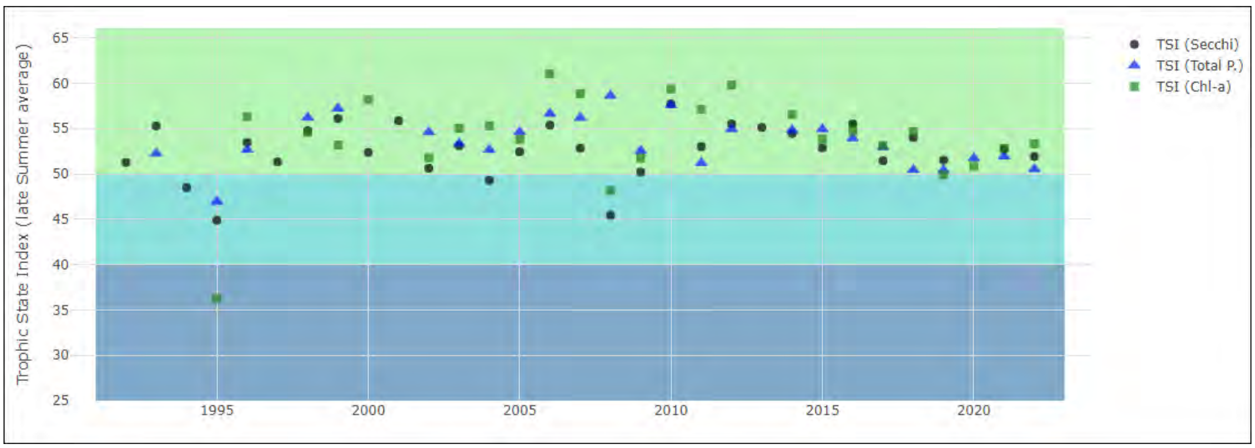

Figure 31: Teal Lake TSI graph

5.7.3 TSI - Ghost Lake and the Teal River Flowage

Since the data from these two lakes is not current, TSI graphs for these lakes were not requested from the WDNR and not included in this report. TSI graphs are likely available, but do not reflect current conditions in the lakes.

5.8 Fisheries

The fisheries information referenced in this section is taken from the 2018 WDNR Fisheries Report for the Quiet Lakes.[3] [4] Lost Land, Teal, Teal River Flowage, and Ghost Lakes are all known as "action" musky fisheries by the WDNR. An action fishery is one where it can be expected that anglers will catch a lot of a specific species, although the fish caught may not be in the trophy class.

[3] Lost Land Lake - https://p.widencdn.net/rdcydm/North_SawyerLostLand2018SpringSummary
[4] Teal Lake - https://p.widencdn.net/cuiak6/North_SawyerTeal2018SpringSummary

5.8.1 Lost Land Lake

The Hayward DNR Fisheries Management Team (with the Governor Thompson Hatchery Team) conducted a fyke netting survey on Lost Land Lake from May 6-9, 2018 to assess the adult walleye, muskellunge, northern pike, yellow perch, and black crappie populations in the lake. An electrofishing survey conducted on May 22, 2018 documented the status of bluegill, smallmouth bass, largemouth bass, and non-game species but also provided information on juvenile walleye. Four miles of shoreline were shocked.

Adult walleye were captured at a moderate rate of 8 per net night with many large females present (53% of all walleye captured were females over 20 inches). This catch rate is a slight improvement over 2010 (4 per net night). Walleye reproduction on Lost Land Lake has been poor in recent years and the population is largely supported by every-other-year stocking events (odd years) (Table 3). The shocking portion of this survey found good catch rates for juvenile walleye, indicating that stocked fish are surviving and contributing to the fishery.

The muskellunge population in Lost Land Lake is supported by a mix of stocking (Figure 3) and natural reproduction. In 2012, 1,300 muskellunge were stocked into Lost Land with implanted radio frequency tags. That 2012 year class now makes up a significant proportion of the muskellunge population, including about 40% of the muskellunge appearing in this survey. The fish stocked in 2012, now six years old, range between 26-37 inches. The largest muskellunge observed in this survey were in the mid-40 inch range. Muskellunge over 50 inches of length are rare in Lost Land Lake, which is not uncommon in smaller lakes with higher density populations. Lost Land is considered to be more of an "action" muskellunge fishery that supports high angler catch rates.

Northern pike were captured at a moderate to low rate with generally poor size. Northern pike may compete with muskellunge in Lost Land Lake to some extent, but pike abundance appears to be mostly stable compared to past surveys. Even so, anglers are encouraged to harvest small northern pike.

Smallmouth bass capture rates were low and similar to past surveys. Habitat in Lost Land Lake is not ideal for smallmouth bass, which prefer deep, rockier lakes. Largemouth bass were captured at a much higher rate and with poor size. The minimum length limit for largemouth bass in Lost Land Lake was removed in 2016 to create a harvest opportunity for anglers. Harvest of small largemouth bass is encouraged.

Panfish size in Lost Land Lake is generally poor for all three major panfish species (bluegill, black crappie, and yellow perch). Several strategies are in place to try to improve panfish size, including the implementation of a reduced panfish bag limit in 2016 and continued walleye stocking efforts that may reduce panfish abundance and increase growth.

Table 3: Fish stocking in Lost Land Lake (https://apps.dnr.wi.gov/fisheriesmanagement/Public/Summary/Index)

Year	Waterbody	Species	Age Class	# Stocked	Avg Length(IN)
2022	LOST LAND LAKE	MUSKELLUNGE	LARGE FINGERLING	1422	13.8
2021	LOST LAND LAKE	WALLEYE	LARGE FINGERLING	6315	6.4
2019	LOST LAND LAKE	WALLEYE	LARGE FINGERLING	6319	6.5
2017	LOST LAND LAKE	WALLEYE	LARGE FINGERLING	6955	3.5
2017	LOST LAND LAKE	WALLEYE	LARGE FINGERLING	6544	7
2015	LOST LAND LAKE	WALLEYE	LARGE FINGERLING	6319	7.5
2013	LOST LAND LAKE	WALLEYE	LARGE FINGERLING	6544	6.4
2012	LOST LAND LAKE	MUSKELLUNGE	LARGE FINGERLING	1304	12.8
2011	LOST LAND LAKE	WALLEYE	LARGE FINGERLING	2500	6.2
2009	LOST LAND LAKE	MUSKELLUNGE	LARGE FINGERLING	1304	9.7
2007	LOST LAND LAKE	MUSKELLUNGE	LARGE FINGERLING	435	12
2005	LOST LAND LAKE	MUSKELLUNGE	LARGE FINGERLING	1044	12.3
2005	LOST LAND LAKE	WALLEYE	FRY	450000	
2005	LOST LAND LAKE	WALLEYE	SMALL FINGERLING	64985	1.6
2003	LOST LAND LAKE	MUSKELLUNGE	LARGE FINGERLING	652	10.9
2003	LOST LAND LAKE	WALLEYE	LARGE FINGERLING	3739	7.8
2001	LOST LAND LAKE	WALLEYE	LARGE FINGERLING	2600	5.95
2001	LOST LAND LAKE	WALLEYE	FRY	500000	
2001	LOST LAND LAKE	MUSKELLUNGE	LARGE FINGERLING	652	10.5
2000	LOST LAND LAKE	MUSKELLUNGE	LARGE FINGERLING	1304	10.6
2000	LOST LAND LAKE	WALLEYE	FRY	500000	
1999	LOST LAND LAKE	WALLEYE	SMALL FINGERLING	157989	1.4
1997	LOST LAND LAKE	MUSKELLUNGE	LARGE FINGERLING	326	11.9
1997	LOST LAND LAKE	WALLEYE	LARGE FINGERLING	544	7.9
1996	LOST LAND LAKE	MUSKELLUNGE	FINGERLING	1304	11.6
1995	LOST LAND LAKE	WALLEYE	FINGERLING	1000	7.2
1994	LOST LAND LAKE	WALLEYE	FINGERLING	33820	2
1993	LOST LAND LAKE	MUSKELLUNGE	FINGERLING	1708	11.3
1992	LOST LAND LAKE	MUSKELLUNGE	FINGERLING	1304	9
1992	LOST LAND LAKE	MUSKELLUNGE	LARGE FINGERLING	200	10
1991	LOST LAND LAKE	MUSKELLUNGE	FINGERLING	1500	10
1990	LOST LAND LAKE	MUSKELLUNGE	FINGERLING	750	11
1989	LOST LAND LAKE	MUSKELLUNGE	FINGERLING	805	9
1988	LOST LAND LAKE	MUSKELLUNGE	FINGERLING	1500	9
1987	LOST LAND LAKE	MUSKELLUNGE	FINGERLING	2250	10
1986	LOST LAND LAKE	MUSKELLUNGE	FINGERLING	1500	11
1985	LOST LAND LAKE	MUSKELLUNGE	FINGERLING	2564	10.33
1984	LOST LAND LAKE	MUSKELLUNGE	FINGERLING	1100	8.5
1983	LOST LAND LAKE	MUSKELLUNGE	FINGERLING	1113	9
1982	LOST LAND LAKE	MUSKELLUNGE	FINGERLING	735	9
1981	LOST LAND LAKE	MUSKELLUNGE	FINGERLING	400	11
1980	LOST LAND LAKE	MUSKELLUNGE	FINGERLING	1500	9
1979	LOST LAND LAKE	MUSKELLUNGE	FINGERLING	2840	7.75
1978	LOST LAND LAKE	MUSKELLUNGE	FINGERLING	1500	11
1977	LOST LAND LAKE	MUSKELLUNGE	FINGERLING	1500	7
1976	LOST LAND LAKE	MUSKELLUNGE	FINGERLING	2500	8.33
1975	LOST LAND LAKE	MUSKELLUNGE	FINGERLING	800	12.33
1974	LOST LAND LAKE	WALLEYE	FINGERLING	50015	3
1973	LOST LAND LAKE	WALLEYE	FINGERLING	162	3
1973	LOST LAND LAKE	MUSKELLUNGE	FINGERLING	401	13
1972	LOST LAND LAKE	MUSKELLUNGE	FINGERLING	800	15
1972	LOST LAND LAKE	WALLEYE	FINGERLING	15690	4.33

5.8.2 Teal Lake

The Hayward DNR Fisheries Management Team (with the Governor Thompson Hatchery Team) conducted a fyke netting survey on Teal Lake from May 7-9, 2018 to assess the adult walleye, muskellunge, northern pike, yellow perch, and black crappie populations in the lake. An electrofishing survey conducted on May 21, 2018 documented the status of bluegill, smallmouth bass, largemouth bass, and non-game species but also provided information on juvenile walleye. Four miles of shoreline were shocked.

Adult walleye were captured at a moderate to high rate in comparison to other lakes in the area. Of note, was the abundance of “cookie cutter” 11-inch males that were present. These fish likely represent a very strong stocked year class, as little natural reproduction has been observed on Teal Lake over the last 10 years. Larger walleye were captured as well with 39% being over 15 inches. Juvenile walleye were captured at a very high rate during the electrofishing portion of this survey. The high catch rate of walleye in the 6-8 inch range during electrofishing indicates good survival of the fingerlings stocked into Teal in the fall of 2017.

Muskellunge were captured at a high rate, which is typical of Teal Lake. Both Teal and Lost Land support dense muskellunge populations that create “action” fisheries. Anglers can expect to encounter more muskellunge in these lakes in comparison to most other lakes, but size tends to be generally smaller. Muskellunge over 42 inches are relatively rare, though a few large fish are caught each year.

Both the walleye and musky populations are supported by WDNR stocking (Table 4).

Northern pike are present in Teal Lake and occur at a low density. Habitat for pike is more suitable in Lost Land Lake where there are more aquatic plants.

Smallmouth bass were captured at a moderate rate with about one in five fish being over 14 inches. Habitat in Teal Lake is more suitable for smallmouth bass compared to Lost Land Lake and the relative abundance of smallmouth in each lake reflects that. Largemouth bass were captured at a similar rate and had generally poor size with few over 15 inches.

Panfish in Teal Lake have generally high relative abundance (perch in particular) and poor size. Several strategies are in place to try to improve panfish size, including the implementation of a reduced panfish bag limit in 2016 and continued walleye stocking efforts that may reduce panfish abundance and increase growth.

Table 4: Teal Lake fish stocking (https://apps.dnr.wi.gov/fisheriesmanagement/Public/Summary/Index)

Year	Waterbody	Location	Species	Age Class	# Stocked	Avg Length(IN)
2021	TEAL LAKE	42N-6W-34	WALLEYE	LARGE FINGERLING	10242	6.6
2019	TEAL LAKE	42N-6W-34	WALLEYE	LARGE FINGERLING	10254	6.3
2017	TEAL LAKE	42N-6W-34	WALLEYE	LARGE FINGERLING	10173	6.5
2015	TEAL LAKE	42N-6W-34	WALLEYE	LARGE FINGERLING	10242	8
2013	TEAL LAKE	42N-6W-34	WALLEYE	LARGE FINGERLING	5245	6.9
2011	TEAL LAKE	42N-6W-34	WALLEYE	LARGE FINGERLING	4795	6.8
2009	TEAL LAKE	42N-6W-34	MUSKELLUNGE	LARGE FINGERLING	1049	10.5
2008	TEAL LAKE	42N-6W-34	WHITE SUCKER	ADULT	720	7.5
2007	TEAL LAKE	42N-6W-34	MUSKELLUNGE	LARGE FINGERLING	350	12
2005	TEAL LAKE	42N-6W-34	MUSKELLUNGE	LARGE FINGERLING	419	12
2005	TEAL LAKE	42N-6W-34	MUSKELLUNGE	LARGE FINGERLING	838	12.3
2003	TEAL LAKE	42N-6W-34	MUSKELLUNGE	LARGE FINGERLING	524	10.9
2001	TEAL LAKE	42N-6W-34	MUSKELLUNGE	LARGE FINGERLING	475	10.5
2000	TEAL LAKE	42N-6W-34	MUSKELLUNGE	LARGE FINGERLING	1000	11.2
1997	TEAL LAKE	42N-6W-34	MUSKELLUNGE	LARGE FINGERLING	256	11.7
1996	TEAL LAKE	42N-6W-34	MUSKELLUNGE	FINGERLING	1024	10.7
1995	TEAL LAKE	42N-6W-34	WALLEYE	LARGE FINGERLING	1500	9
1994	TEAL LAKE	42N-6W-34	WALLEYE	SMALL FINGERLING	24000	2
1994	TEAL LAKE	42N-6W-34	MUSKELLUNGE	LARGE FINGERLING	1000	12
1994	TEAL LAKE	42N-6W-34	WALLEYE	FRY	2000000	
1993	TEAL LAKE	42N-6W-34	MUSKELLUNGE	FINGERLING	1000	11.9
1992	TEAL LAKE	42N-6W-34	MUSKELLUNGE	FINGERLING	1049	10
1991	TEAL LAKE	42N-6W-34	MUSKELLUNGE	FINGERLING	300	11
1991	TEAL LAKE	42N-6W-34	MUSKELLUNGE	FINGERLING	1000	11
1990	TEAL LAKE	42N-6W-34	MUSKELLUNGE	FINGERLING	900	11
1989	TEAL LAKE	42N-6W-34	MUSKELLUNGE	FINGERLING	500	11
1988	TEAL LAKE	42N-6W-34	MUSKELLUNGE	FINGERLING	1725	9
1987	TEAL LAKE	42N-6W-34	MUSKELLUNGE	FINGERLING	1500	9
1986	TEAL LAKE	42N-6W-34	MUSKELLUNGE	FINGERLING	900	9.5
1985	TEAL LAKE	42N-6W-34	MUSKELLUNGE	FINGERLING	2100	11
1984	TEAL LAKE	42N-6W-34	MUSKELLUNGE	FINGERLING	600	10
1983	TEAL LAKE	42N-6W-34	MUSKELLUNGE	FINGERLING	500	9.67
1982	TEAL LAKE	42N-6W-34	MUSKELLUNGE	FINGERLING	500	9
1981	TEAL LAKE	42N-6W-34	MUSKELLUNGE	FINGERLING	410	8
1980	TEAL LAKE	42N-6W-34	MUSKELLUNGE	FINGERLING	1100	11
1979	TEAL LAKE	42N-6W-34	MUSKELLUNGE	FINGERLING	2875	7.75
1978	TEAL LAKE	42N-6W-34	MUSKELLUNGE	FINGERLING	1000	11
1977	TEAL LAKE	42N-6W-34	MUSKELLUNGE	FINGERLING	1000	8
1976	TEAL LAKE	42N-6W-34	MUSKELLUNGE	FINGERLING	1560	8.33
1973	TEAL LAKE	42N-6W-34	MUSKELLUNGE	FINGERLING	300	13
1973	TEAL LAKE	42N-6W-34	WALLEYE	FINGERLING	5040	3
1972	TEAL LAKE	42N-6W-34	MUSKELLUNGE	FINGERLING	550	15

5.8.3 Teal River Flowage and Ghost Lakes

A recent fisheries survey for these two lakes has not been identified, but both lakes are continually stocked with a variety of fish species (Tables 5&6).

Table 5: Ghost Lake fish stocking

Year	Waterbody	Species	Age Class	# Stocked	Avg Length(IN)
2021	GHOST LAKE	WALLEYE	LARGE FINGERLING	3840	6.1
2019	GHOST LAKE	WALLEYE	LARGE FINGERLING	3840	6.4
2017	GHOST LAKE	WALLEYE	LARGE FINGERLING	3838	6.3
2015	GHOST LAKE	WALLEYE	LARGE FINGERLING	3836	7.9
2013	GHOST LAKE	WALLEYE	LARGE FINGERLING	3720	7
2011	GHOST LAKE	WALLEYE	SMALL FINGERLING	13152	1.6
2009	GHOST LAKE	WALLEYE	SMALL FINGERLING	13096	1.75
2007	GHOST LAKE	WALLEYE	SMALL FINGERLING	13078	1.8
2005	GHOST LAKE	WALLEYE	SMALL FINGERLING	37274	1.5
2005	GHOST LAKE	WALLEYE	SMALL FINGERLING	18639	
2003	GHOST LAKE	WALLEYE	SMALL FINGERLING	18595	1.6
2001	GHOST LAKE	WALLEYE	SMALL FINGERLING	34133	1.6
1999	GHOST LAKE	WALLEYE	SMALL FINGERLING	18600	1.3
1997	GHOST LAKE	WALLEYE	SMALL FINGERLING	18600	1.6
1997	GHOST LAKE	LARGEMOUTH BASS	LARGE FINGERLING	18600	1.7
1996	GHOST LAKE	LARGEMOUTH BASS	FINGERLING	18600	1.4
1996	GHOST LAKE	WALLEYE	FINGERLING	18600	1.5
1995	GHOST LAKE	WALLEYE	FINGERLING	18172	2.5
1995	GHOST LAKE	LARGEMOUTH BASS	FINGERLING	29282	1.5
1993	GHOST LAKE	MUSKELLUNGE	FINGERLING	372	8
1992	GHOST LAKE	WALLEYE	FINGERLING	15000	1
1991	GHOST LAKE	MUSKELLUNGE	FINGERLING	372	11
1990	GHOST LAKE	WALLEYE	FINGERLING	7970	4
1989	GHOST LAKE	MUSKELLUNGE	FINGERLING	372	7
1986	GHOST LAKE	MUSKELLUNGE	FINGERLING	200	9
1983	GHOST LAKE	MUSKELLUNGE	FINGERLING	200	8
1981	GHOST LAKE	MUSKELLUNGE	FINGERLING	100	9

Table 6: Teal River Flowage fish stocking

Year	Waterbody	Species	Age Class	# Stocked	Avg Length(IN)
2005	TEAL RIVER FLOWAGE	MUSKELLUNGE	LARGE FINGERLING	30	12.3
2003	TEAL RIVER FLOWAGE	MUSKELLUNGE	LARGE FINGERLING	38	10.9
2001	TEAL RIVER FLOWAGE	MUSKELLUNGE	LARGE FINGERLING	87	10.5
2000	TEAL RIVER FLOWAGE	MUSKELLUNGE	LARGE FINGERLING	62	11.8
1997	TEAL RIVER FLOWAGE	MUSKELLUNGE	LARGE FINGERLING	25	11.7
1996	TEAL RIVER FLOWAGE	MUSKELLUNGE	FINGERLING	100	10.7
1993	TEAL RIVER FLOWAGE	MUSKELLUNGE	FINGERLING	248	11.95
1992	TEAL RIVER FLOWAGE	MUSKELLUNGE	FINGERLING	75	10
1986	TEAL RIVER FLOWAGE	MUSKELLUNGE	FINGERLING	100	8
1983	TEAL RIVER FLOWAGE	MUSKELLUNGE	FINGERLING	100	9
1978	TEAL RIVER FLOWAGE	MUSKELLUNGE	FINGERLING	100	13
1977	TEAL RIVER FLOWAGE	MUSKELLUNGE	FINGERLING	100	11
1976	TEAL RIVER FLOWAGE	MUSKELLUNGE	FINGERLING	100	7
1975	TEAL RIVER FLOWAGE	MUSKELLUNGE	FINGERLING	100	11
1973	TEAL RIVER FLOWAGE	MUSKELLUNGE	FINGERLING	75	13
1972	TEAL RIVER FLOWAGE	MUSKELLUNGE	FINGERLING	150	15

5.9 Aquatic Plant Community

Aquatic plants form the foundation of healthy and flourishing lake ecosystems - both within lakes and rivers and on the shores around them. They not only protect water quality, but they also produce life-giving oxygen. Aquatic plants are a lake's own filtering system, helping to clarify the water by absorbing nutrients like phosphorus and nitrogen that could stimulate algal blooms. Plant beds stabilize soft lake and river bottoms and reduce shoreline erosion by reducing the effect of waves and current. Healthy native aquatic plant communities help prevent the establishment of invasive non-native plants like Eurasian water-milfoil, purple loosestrife or phragmites. Aquatic plants provide important reproductive, food, and cover habitat for fish, invertebrates and wildlife. It is aquatic plants that fashion a nursery for all sorts of creatures ranging from birds to beaver to bass to bugs. In order to maintain healthy lakes and rivers, healthy native aquatic plant communities must be maintained.[5]

In most instances, control of native aquatic plants is discouraged or should be limited to high use recreational areas that are next to piers and docks or within navigational channels. In some cases there may be penalties for improper removal of aquatic plants.

The aquatic plant survey work in 2016 and in 2022 on both Lost Land and Teal Lakes were completed by different consultants, making a true comparison of the data somewhat unreliable, however, it does provide for some basic assumptions.

5.9.1 Lost Land Lake

The area of a lake where aquatic plants can grow is called the littoral zone. In 2016, 234 points out of 512 were visited by the surveyor. Aquatic plants were found growing in as much as 15.0ft of water and 232 out 234 points sampled were within that depth range. Only 180 of the 232 points in the littoral zone actually had vegetation under them however (Table 7). In 2022, all 512 points in the PI grid were sampled with 337 (65.8%) of them in water in water ≤13.0ft, the maximum depth of plants and considered part of the littoral zone; however, only 243 of those points actually had aquatic vegetation under them (Figure 32). The 243 points with vegetation (approximately 47.5% of the entire lake bottom and 72.1% of the littoral zone) was higher than the 180 points with vegetation in 2016 (approximately 35.1% of the entire lake bottom and 77.6% of the 2016 littoral zone) (Table 7).

[5] https://dnr.wisconsin.gov/topic/lakes/plants

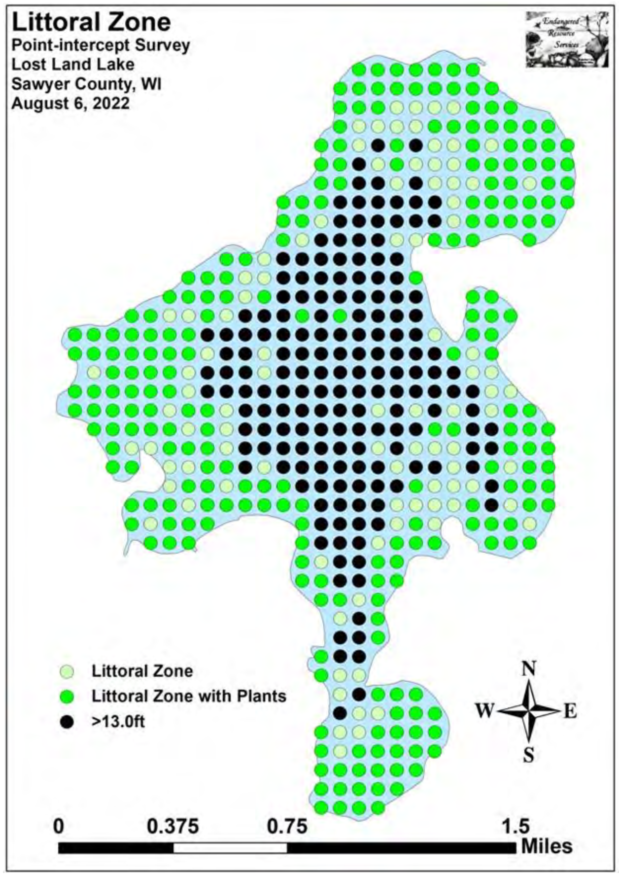

Figure 32: Lost Land Lake littoral (plant growing) zone (Berg, 2022)

5.9.1.1 Simpson Diversity Index (SDI)

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.

The SDI for Lost Land Lake was slightly higher in 2022 than it was in 2016 (Table 7). The number of different plant species identified in the 2016 PI survey totaled 29 when including visuals (Table 7). The number of different plant species identified in the 2022 PI survey totaled 38 when including visuals (Table 7, Figure 33). From 2016 to 2022, there was an increase in mean native species at sites with vegetation from 2.21/site to 2.68/site (Table 7). This difference in plant species is likely due to different aquatic plant surveyors completing the task.

Total rake fullness experienced an increase from a moderate 1.72 in 2016 to a fairly dense 2.45 in 2022 (Table 7, Figure 33). Much of this increase can be attributed to the 83 points with moderate to dense E/HWM.

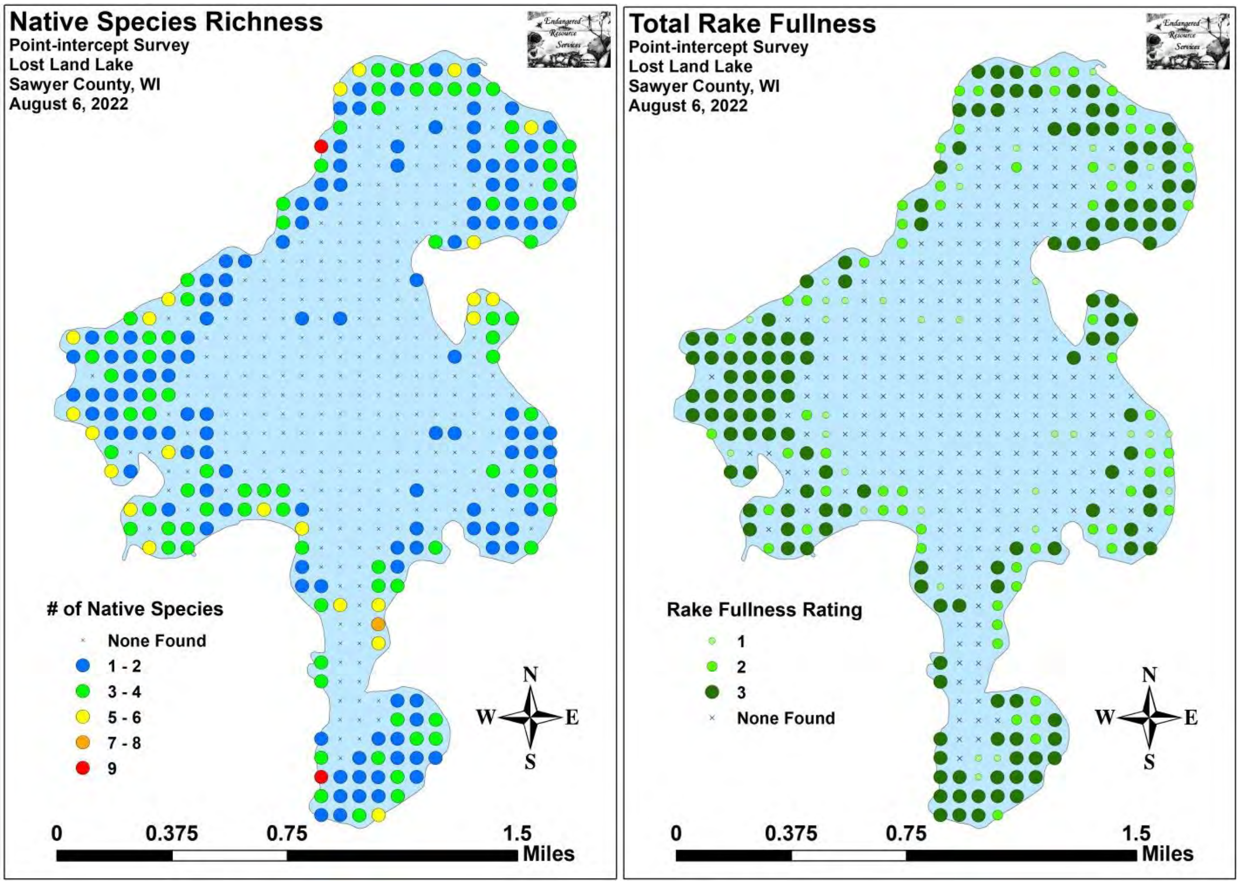

Figure 33: Lost Land Lake native species diversity and density (rake fullness) (Berg, 2022)

Table 7: 2016 and 2022 Lost Land Lake whole-lake point-intercept survey statistics

SUMMARY STATS:	2016	2022
Total number of sites visited	234	512
Total number of sites with vegetation	180	243
Total number of sites shallower than maximum depth of plants	232	337
Frequency of occurrence at sites shallower than maximum depth of plants	77.59	72.11
Simpson Diversity Index	0.91	0.92
Maximum depth of plants (ft)**	15.00	13.00
Number of sites sampled using rake on Rope (R)	0	0
Number of sites sampled using rake on Pole (P)	234	357
Average number of all species per site (shallower than max depth)	1.66	2.23
Average number of all species per site (veg. sites only)	2.23	3.10
Average number of native species per site (shallower than max depth)	1.65	1.88
Average number of native species per site (veg. sites only)	2.21	2.68
Species Richness	28	36
Species Richness (including visuals)	29	38
Species Richness (including visuals and boat survey)	NA	41
Mean depth of plants (ft)	NA	7.36
Median depth of plants (ft)	NA	7.00
Mean rake fullness (veg. sites only)	1.72	2.45

During the 2016 PI survey, E/HWM was identified at 9 of the 512 survey points in the lake. Each survey point equates to approximately 2.5 acres suggesting in 2016 that there was about 22 acres of E/HWM in the lake. In 2022, E/HWM was identified at 123 of the 512 survey point, suggesting over 300 acres of E/HWM

(Figure 34). Of the 123 points with E/HWM in 2022, 83 of them had a rake fullness rating of 2 or 3 suggesting more than 200 acres of dense growth E/HWM.

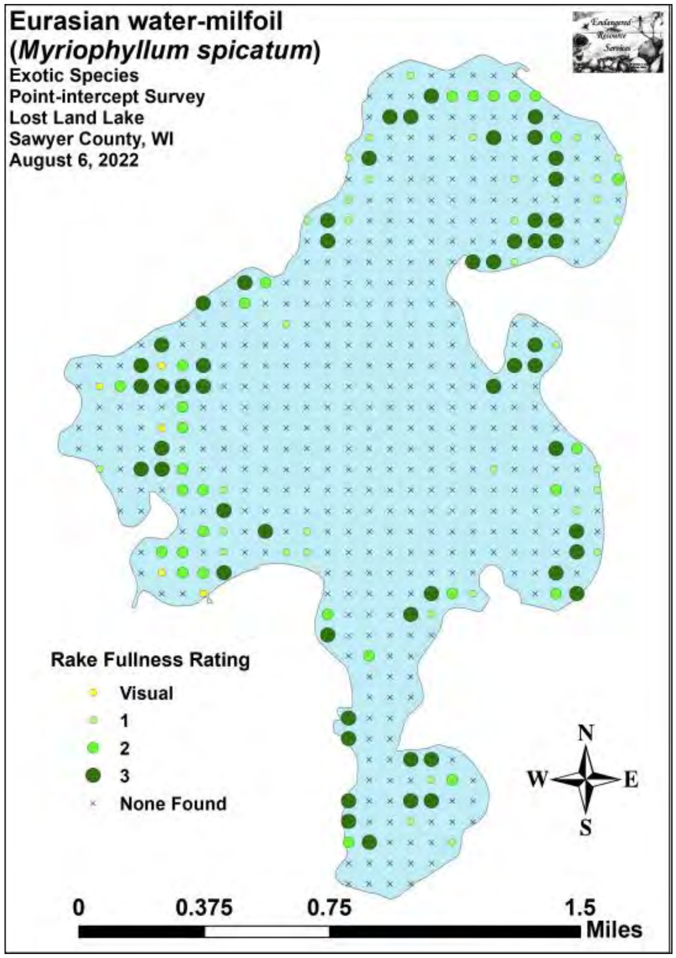

Figure 34: 2022 E/HWM from the summer PI survey (ERS)

5.9.1.2 Floristic Quality Index (FQI)

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. Lost Land Lake is in the Northern Lakes and Forests Ecoregion.

The 2016 point-intercept survey found a total of 26 native index plants in the rake that produced a mean C of 6.4 and a FQI of 32.6 (Table 8). In 2022, the survey found 35 native index species that produced a mean C of 7.0 and an FQI of 41.4 (Table 9). Nichols (1999) reported an average mean C for the Northern Lakes and Forest Region of 6.7 putting Lost Land Lake slightly above average (in 2022) for this part of the state. The FQI value was well above the median FQI of 24.3 for the Northern Lakes and Forest Region (Nichols 1999).

Table 8: 2016 Floristic Quality Index and Mean C – Lost Land Lake

Species	Common Name	C
Bidens beckii	Water marigold	8
Brasenia schreberi	Watershield	6
Ceratophyllum demersum	Coontail	3
Chara	Muskgrasses	7
Elodea canadensis	Common waterweed	3
Isoetes sp.	Quillwort	8
Littorella uniflora	Littorella	10
Myriophyllum sibiricum	Northern water-milfoil	6
Najas flexilis	Slender naiad	6
Nitella	Nitella	7
Nuphar variegata	Spatterdock	6
Nymphaea odorata	White water lily	6
Pontederia cordata	Pickerelweed	8
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton foliosus	Leafy pondweed	6
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 zosteriformis	Flat-stem pondweed	6
Schoenoplectus tabernaemontani	Softstem bulrush	4
Sparganium fluctuans	Floating-leaf bur-reed	10
Typha sp.	Cattail	1
Utricularia vulgaris	Common bladderwort	7
Vallisneria americana	Wild celery	6
N		**26**
mean C		**6.38**
FQI		**32.56**

Table 9: 2022 Floristic Quality Index and Mean C – Lost Land Lake

Species	Common Name	C
Bidens beckii	Water marigold	8
Brasenia schreberi	Watershield	6
Ceratophyllum demersum	Coontail	3
Chara sp.	Muskgrass	7
Elatine minima	Waterwort	9
Eleocharis acicularis	Needle spikerush	5
Elodea canadensis	Common waterweed	3
Heteranthera dubia	Water star-grass	6
Isoetes echinospora	Spiny-spored quillwort	8
Myriophyllum sibiricum	Northern water-milfoil	6
Najas flexilis	Slender naiad	6
Najas gracillima	Northern naiad	7
Nitella sp.	Nitella	7
Nuphar variegata	Spatterdock	6
Nymphaea odorata	White water lily	6
Pontederia cordata	Pickerelweed	8
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton gramineus	Variable pondweed	7
Potamogeton natans	Floating-leaf pondweed	5
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
Potamogeton vaseyi	Vasey's pondweed	10
Potamogeton zosteriformis	Flat-stem pondweed	6
Sagittaria cristata	Crested arrowhead	9
Sagittaria graminea	Grass-leaved arrowhead	9
Schoenoplectus acutus	Hardstem bulrush	6
Schoenoplectus subterminalis	Water bulrush	9
Sparganium emersum	Short-stemmed bur-reed	8
Sparganium fluctuans	Floating-leaf bur-reed	10
Utricularia purpurea	Large purple bladderwort	9
Utricularia vulgaris	Common bladderwort	7
Vallisneria americana	Wild celery	6
N		35
mean C		7.0
FQI		41.4

5.9.1.3 Make-up of the Lost Land Lake Aquatic Plant Community

Sixteen aquatic plant species were found at 10 or more points each during the 2022 PI survey. The most common species, found on the rake at 118 points, was E/HWM. The second most common aquatic plant species in the lake in 2022, found at 83 points, was Slender naiad (Figure 35). Five different pondweed species were found at more than 25 points each, the most abundant being Flat-stem and Small pondweed (Figure 36). Only three of the species found at more than 25 points each in 2022 were found at more than 25 points in 2016 – Common waterweed, Wild celery, and Flat-stem pondweed (Figure 37).

At least 15 native aquatic plant species were identified in the 2022 PI survey that were not in the 2016 survey. Again this is more likely due to the different consultants completing the surveys. The differences for all species from 2016 and 2022 are included in Figure 38. Significant changes are reflected in Figure 39.

Figure 35: Left - E/HWM (non-native); Right - Slender naiad (native) (Berg, 2022)

Figure 36: Left – Flat-stem pondweed (native); Right – Small pondweed (native) (Berg, 2022)

Figure 37: Common waterweed, Wild celery, and Flat-stem pondweed

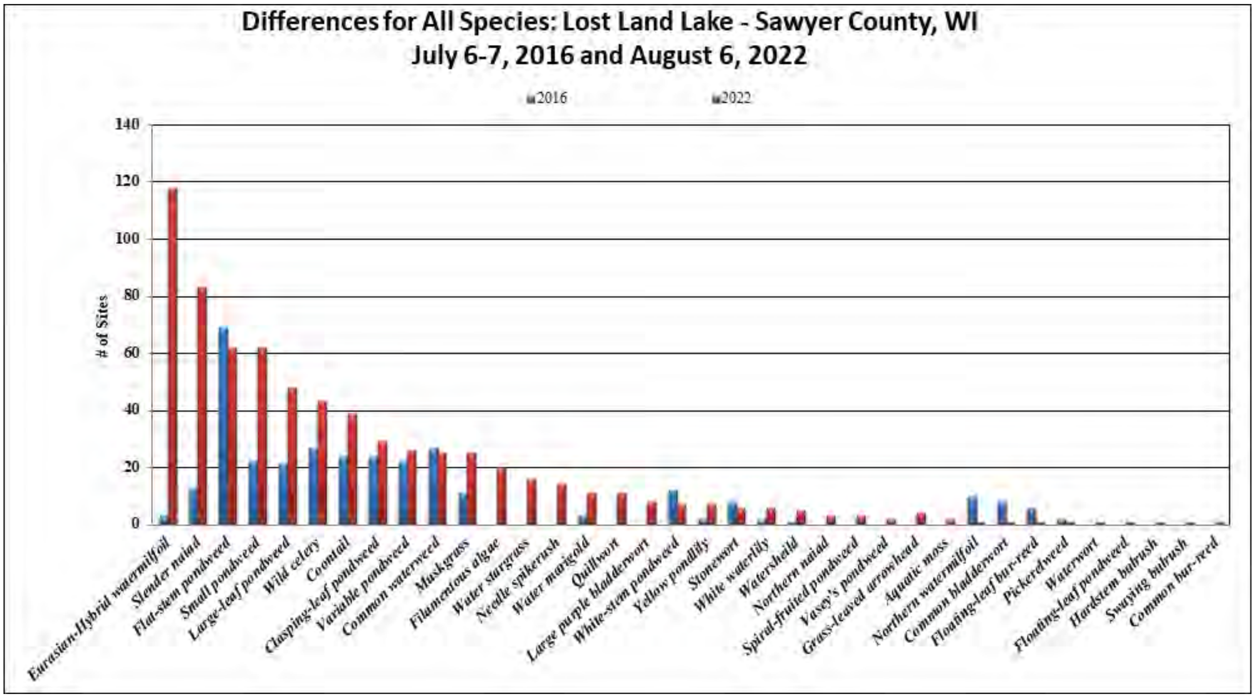

Figure 38: Aquatic plant distribution changes in Lost Land Lake from 2016-2022 (Berg, 2022)

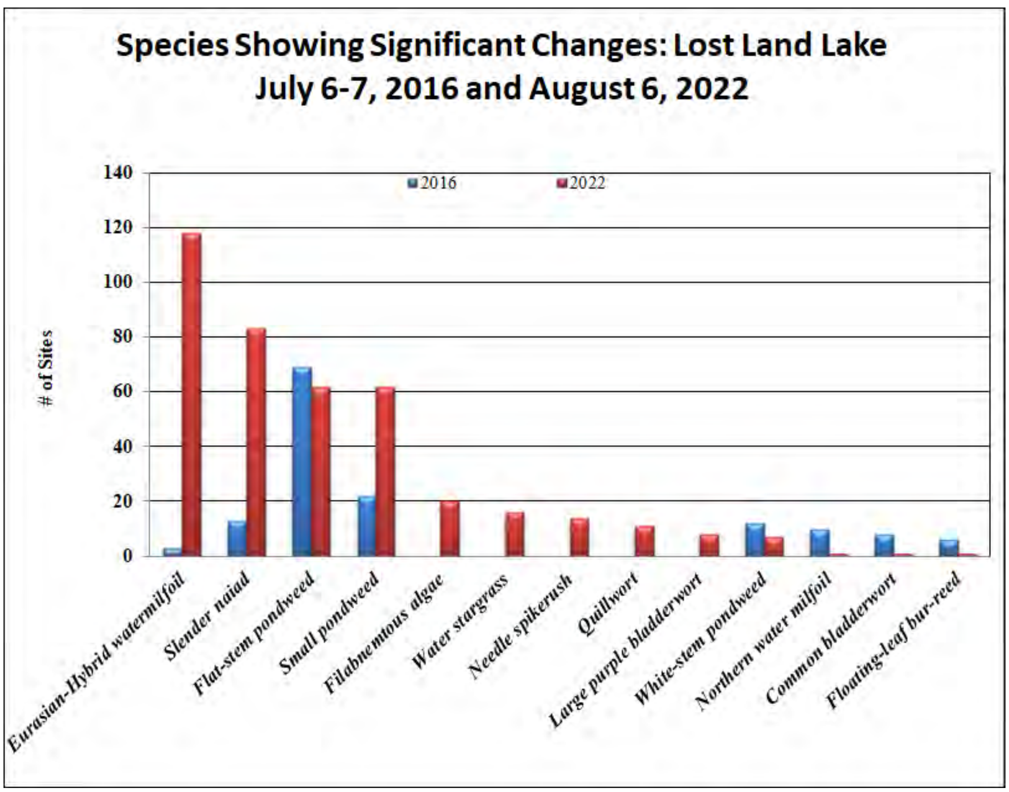

Figure 39: Significant changes in aquatic plant distribution from 2016-2022 (Berg, 2022)

5.9.1.4 EWM Comparisons

The summer PI survey data from 2016 and 2022 in Teal Lake reflects nearly a 15-fold increase in the amount of bed-forming E/HWM (Figure 34). As previously mentioned, E/HWM was found at only 9 points during the summer PI survey. In 2022, this number increased to 123 points nearly a 14-fold increase in E/HWM. In 2016, dense, bed-forming E/HWM covered about 21 acres according to the WDNR (Figure 40). In 2022, 21 E/HWM beds covering 263.39 acres (20.84% of the lake's surface area) were mapped (Figure 40). Most beds occurred in muck bottom bays where EWM dominated the plant community in 3-11ft of water, were canopied or near canopy, and likely caused minor to moderate navigation impairment as the majority occurred along highly developed shorelines.

Management actions implemented between 2017 and 2022 that included application of a diquat-based aquatic herbicide (2017) and 4 years of pulling using the Eco-Harvester did not reduce the amount of E/HWM in Lost Land Lake. One of the issues with using any type of mechanical harvesting to remove EWM is the spreading of fragments to other areas of the lake. It is impossible to say that use of the Eco-Harvester made matters worse in Lost Land Lake, because by its very nature, EWM and E/HWM spread through fragmentation. Fragmentation is done naturally by the plant, and caused by the use of boats and other aquatic recreational gear, but it is highly likely that the Eco-Harvester also contributed.

Without an annual monitoring program, it is impossible to know if E/HWM has hit "saturation" or if it will continue to spread into additional areas on the lake. However, if it is assumed that E/HWM eventually will establish itself anywhere there is a organic/sandy muck bottom, then at 239 points in the 2022 PI Survey, each representing 2.5 acres of the lake – it is possible for E/HWM to expand to nearly 600 acres of the 1260 acre lake.

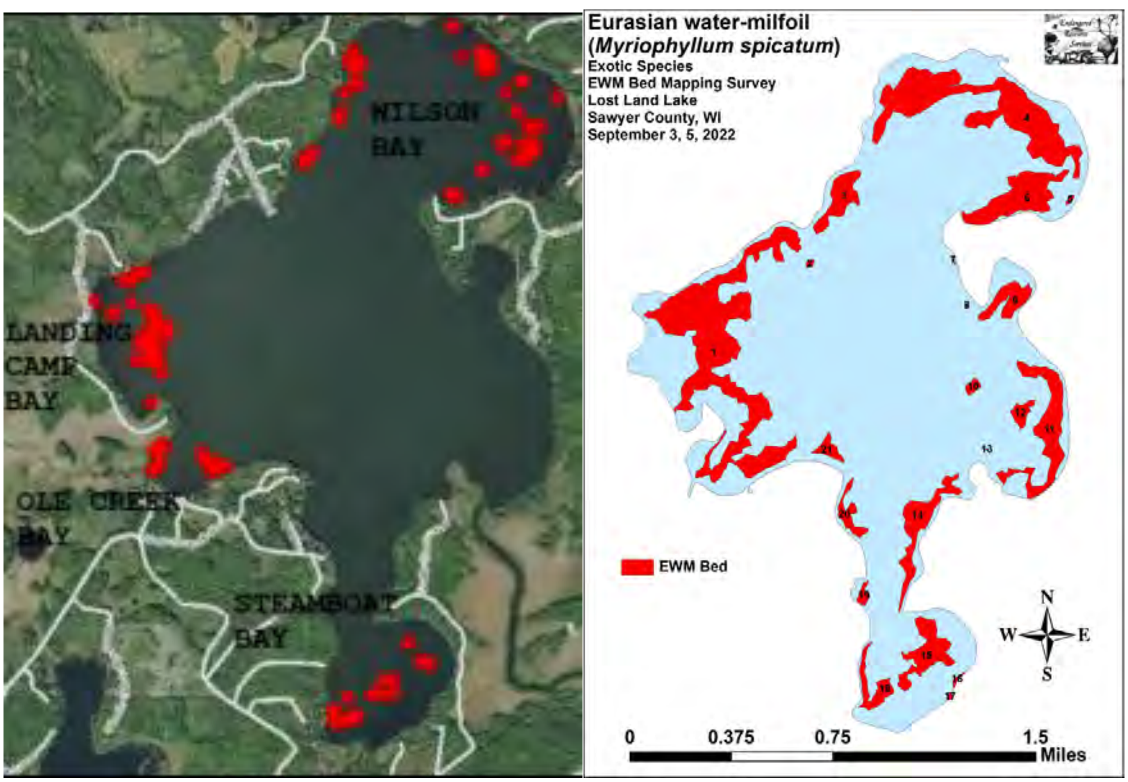

Figure 40: 2016 Summer E/HWM beds (left), 2022 Summer E/HWM beds (right)

5.9.1.5 Other Exotic Plant Species

Other than E/HWM, there was no evidence of other aquatic invasive species in Lost Land Lake in 2022.

5.10 Teal Lake: Aquatic Plant Community

In 2016, 460 points out of 649 sample sites were visited by the surveyor. Aquatic plants were found growing in as much as 12.0ft of water and 256 out 649 points sampled (39.4%) were within that depth range. Only 109 of the 256 points in the littoral zone actually had vegetation under them however. In 2022, all 649 points in the PI grid were sampled with 247 (38.1%) of them in water ≤12.50ft, the maximum depth of plants and considered part of the littoral zone. However, only 147 of those points actually had aquatic vegetation under them (Figure 41). The 147 points with vegetation (approximately 22.7% of the entire lake bottom and 59.5% of the littoral zone) was higher than the 109 points with vegetation in 2016 (approximately 16.8% of the entire lake bottom and 42.6% of the 2016 littoral zone).

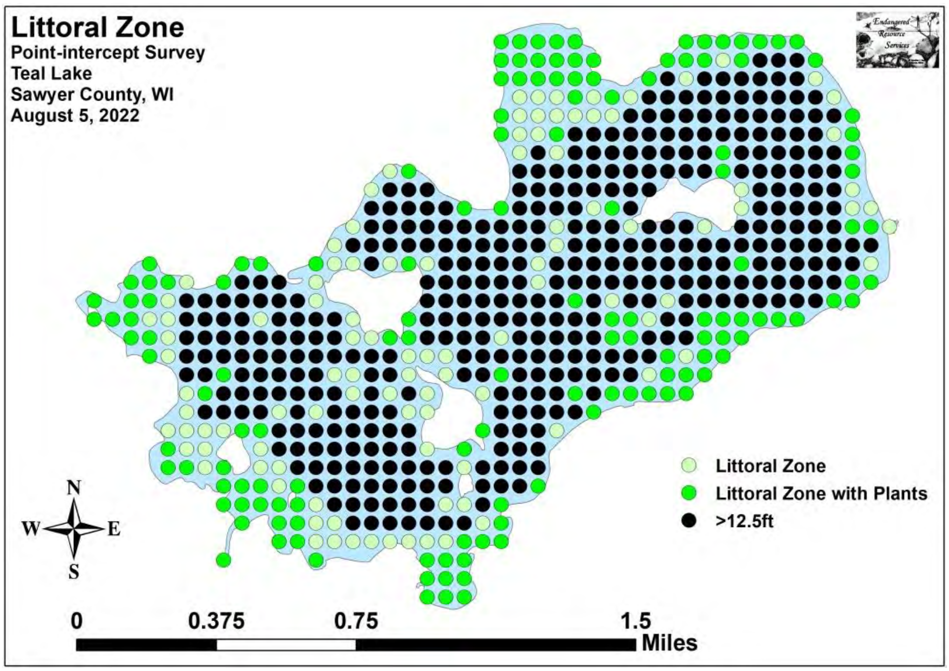

Figure 41: Teal Lake littoral (plant growing) zone (Berg, 2022)

5.10.1.1 Simpson Diversity Index

Plant diversity was very high in 2022 with a Simpson Diversity Index (SDI) Value of 0.94 (up from 0.91 in 2016) (Table 10, Figure 42). The number of different plant species identified in the 2016 PI survey totaled 26 when including visuals. The number of different plant species identified in the 2022 PI survey totaled 38 when including visuals. From 2016 to 2022, there was an increase in mean native species at sites with vegetation from 2.06/site to 3.09/site (Table 10). This difference in plant species is likely due to different aquatic plant surveyors completing the task.

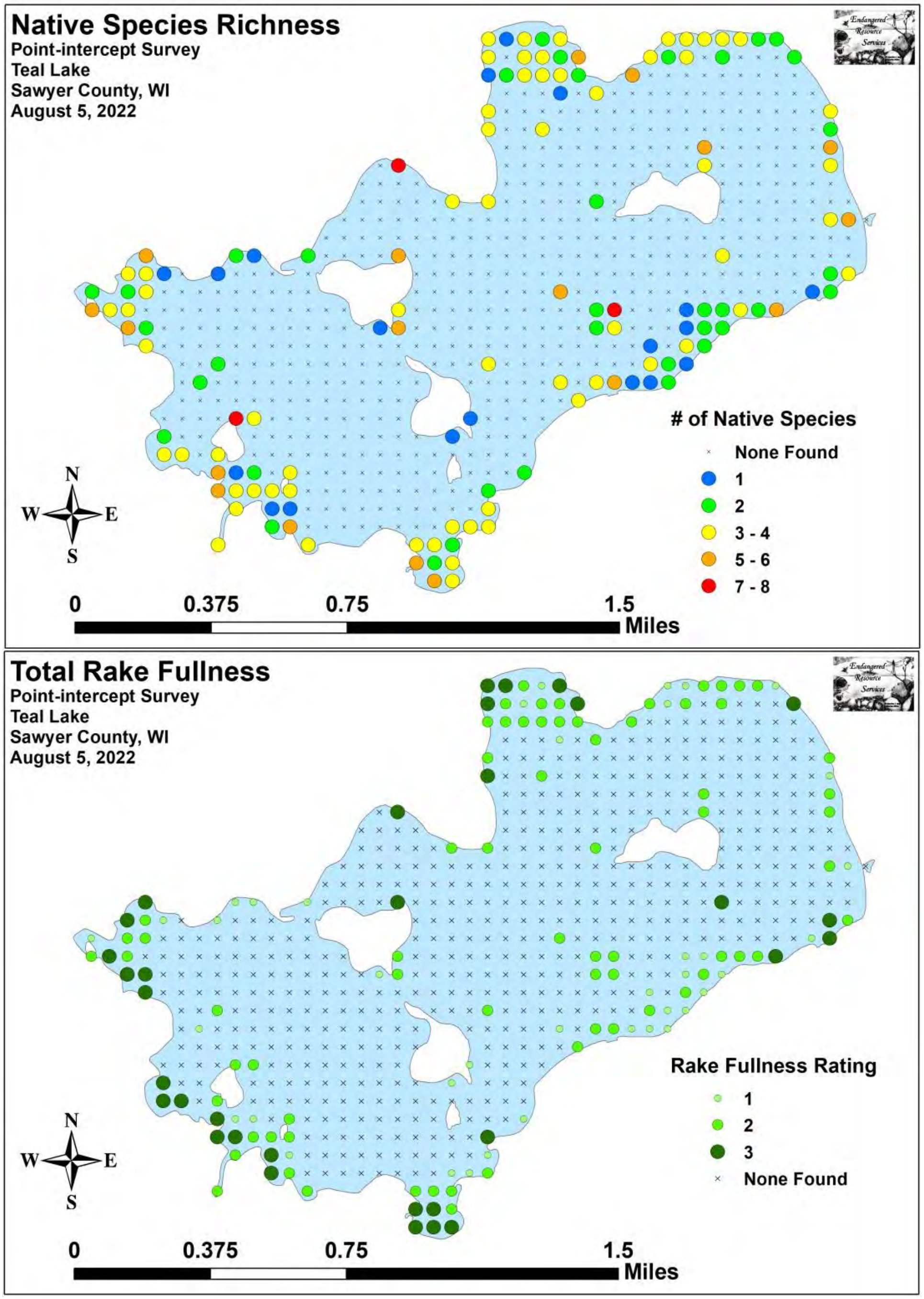

Figure 42: Teal Lake native species diversity and density (rake fullness) (Berg, 2022)

Table 10: 2016 and 2022 Teal Lake whole-lake point-intercept survey statistics

SUMMARY STATS: Teal Lake	2016	2022
Total number of sites visited	460	649
Total number of sites with vegetation	109	142
Total number of sites shallower than maximum depth of plants	256	247
Frequency of occurrence at sites shallower than maximum depth of plants	42.58	57.49
Simpson Diversity Index	0.91	0.94
Maximum depth of plants (ft)**	12	12.50
Number of sites sampled using rake on Rope (R)	0	0
Number of sites sampled using rake on Pole (P)	649	264
Average number of all species per site (shallower than max depth)	0.88	1.86
Average number of all species per site (veg. sites only)	2.06	3.23
Average number of native species per site (shallower than max depth)	0.88	1.76
Average number of native species per site (veg. sites only)	2.06	3.09
Species Richness	23	37
Species Richness (including visuals)	26	38
Species Richness (including visuals and boat survey)		40
Mean depth of plants (ft)	5.73	5.34
Median depth of plants (ft)	5	5.00
Mean rake fullness (veg. sites only)	1.59	1.96

During the 2016 PI survey, E/HWM was not identified in Teal Lake. In 2022, E/HWM was identified at 26 of the 142 survey points with vegetation. Each point in the Teal Lake PI survey represents about 1.6 acres, suggesting over 40 acres of E/HWM in 2022 (Figure 43).

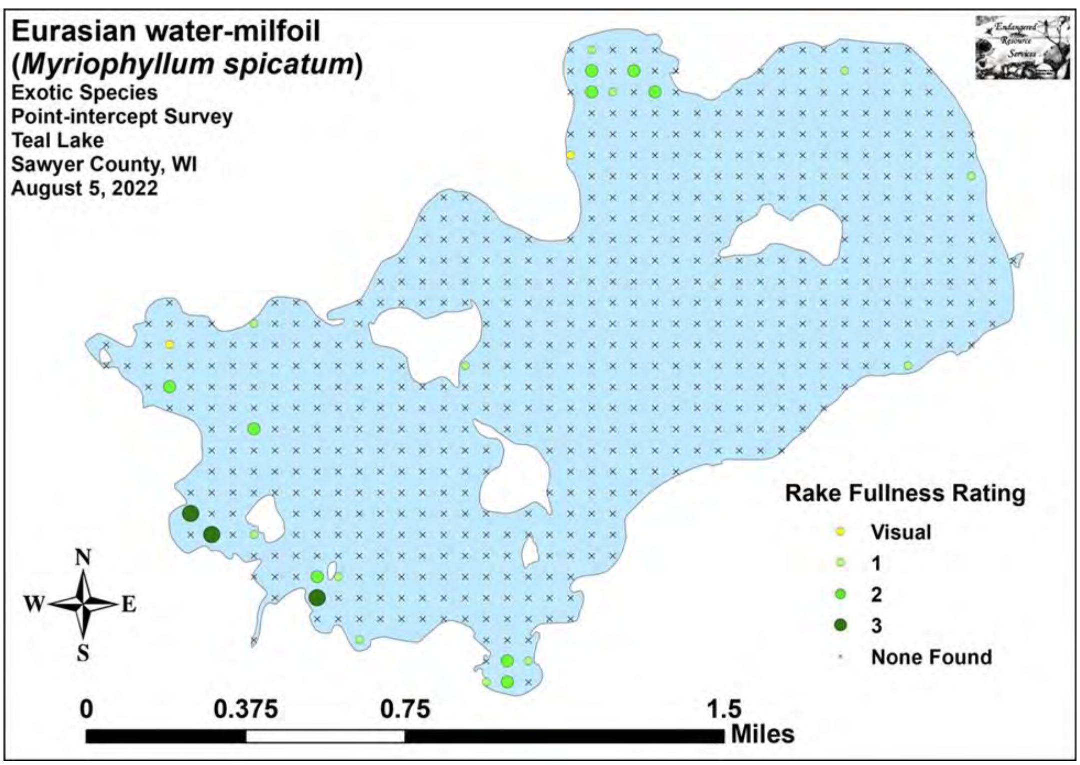

Figure 43: 2022 E/HWM from the summer PI survey (ERS)

5.10.1.2 Floristic Quality Index

The 2016 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 30.9 (Table 11). In 2022, the survey found 36 native index species that produced a mean C of 6.6 and an FQI of 39.3 (Table 12). Nichols (1999) reported an average mean C for the Northern Lakes and Forest Region of 6.7 putting Teal 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).

Table 11: 2016 Floristic Quality Index and Mean C – Teal Lake

Species	Common Name	C
Brasenia schreberi	Watershield	6
Ceratophyllum demersum	Coontail	3
Chara sp.	Muskgrass	7
Elodea canadensis	Common waterweed	3
Juncus pelocarpus	Brown-fruited rush	8
Myriophyllum sibiricum	Northern water-milfoil	6
Najas flexilis	Slender naiad	6
Nitella sp.	Nitella	7
Nuphar variegata	Spatterdock	6
Nymphaea odorata	White water lily	6
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton epihydrus	Ribbon-leaf pondweed	8
Potamogeton foliosus	Leafy pondweed	6
Potamogeton gramineus	Variable pondweed	7
Potamogeton natans	Floating-leaf pondweed	5
Potamogeton praelongus	White-stem pondweed	8
Potamogeton pusillus	Small pondweed	7
Potamogeton richardsonii	Clasping-leaf pondweed	5
Potamogeton robbinsii	Fern pondweed	8
Potamogeton zosteriformis	Flat-stem pondweed	6
Sparganium fluctuans	Floating-leaf bur-reed	10
Utricularia vulgaris	Common bladderwort	7
Vallisneria americana	Wild celery	6
N		23
mean C		6.4
FQI		30.9

Table 12: 2022 Floristic Quality Index and Mean C – Teal Lake

Species	Common Name	C
Bidens beckii	Water marigold	8
Brasenia schreberi	Watershield	6
Ceratophyllum demersum	Coontail	3
Chara	Muskgrasses	7
Eleocharis acicularis	Needle spikerush	5
Elodea canadensis	Common waterweed	3
Equisetum fluviatile	Water horsetail	7
Isoetes echinospora	Spiny-spored quillwort	8
Myriophyllum sibiricum	Northern water-milfoil	6
Myriophyllum verticillatum	Whorled water-milfoil	8
Najas flexilis	Slender naiad	6
Najas gracillima	Northern naiad	7
Nitella	Nitella	7
Nuphar variegata	Spatterdock	6
Nymphaea odorata	White water lily	6
Pontederia cordata	Pickerelweed	8
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton epihydrus	Ribbon-leaf pondweed	8
Potamogeton foliosus	Leafy pondweed	6
Potamogeton gramineus	Variable pondweed	7
Potamogeton natans	Floating-leaf pondweed	5
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
Potamogeton vaseyi	Vasey's pondweed	10
Potamogeton zosteriformis	Flat-stem pondweed	6
Schoenoplectus tabernaemontani	Softstem bulrush	4
Sparganium emersum	Short-stemmed bur-reed	8
Sparganium eurycarpum	Common bur-reed	5
Sparganium fluctuans	Floating-leaf bur-reed	10
Typha latifolia	Broad-leaved cattail	1
Utricularia purpurea	Large purple bladderwort	9
Utricularia vulgaris	Common bladderwort	7
Vallisneria americana	Wild celery	6
N		**36**
mean C		**6.6**
FQI		**39.3**

5.10.1.3 Make-up of the Teal Lake Aquatic Plant Community

Like Lost Land Lake, sixteen aquatic plant species were found at 10 or more points each during the 2022 PI survey. The most common species, found on the rake at 63 points, was Slender naiad. The second most common aquatic plant species in the lake in 2022, found at 53 points, was wild celery (Figure 44). Three different pondweed species were found at more than 25 points each, with Large-leaf pondweed and Small pondweed tied at 35 points each (Figure 45). Only one of the species found at 25 or more points in 2022 was found at more than 25 points in 2016 – Wild celery (Figure 44). E/HWM was found on the rake at 24 points in 2022. It was not found on the rake, or in any other survey in 2016.

At least 14 native aquatic plant species were identified in the 2022 PI survey that were not in the 2016 survey. Again this is more likely due to the different consultants completing the surveys. The differences for all species from 2016 and 2022 are included in Figure 46. Significant changes are reflected in Figure 47.

Figure 44: Left – Slender naiad (native); Right – Wild celery (native) (Berg, 2022)

Figure 45: Left – Large-leaf pondweed (native); Right – Small pondweed (native) (Berg, 2022)

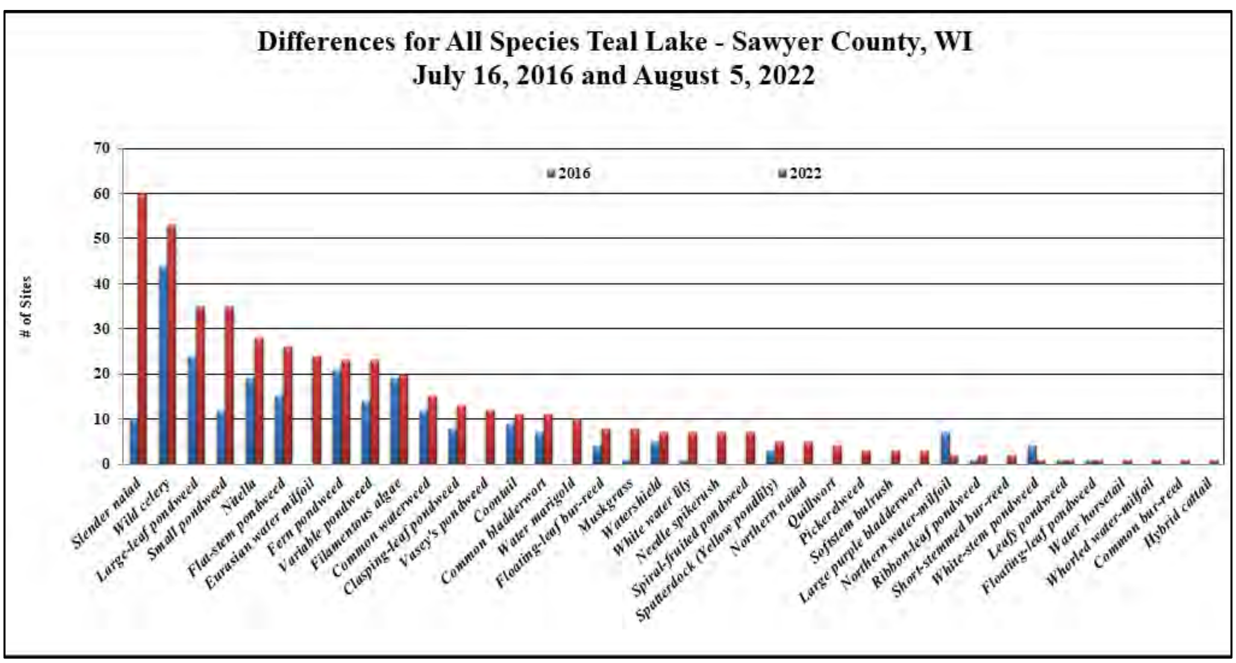

Figure 46: Aquatic plant distribution changes in Teal Lake from 2016-2022 (Berg, 2022)

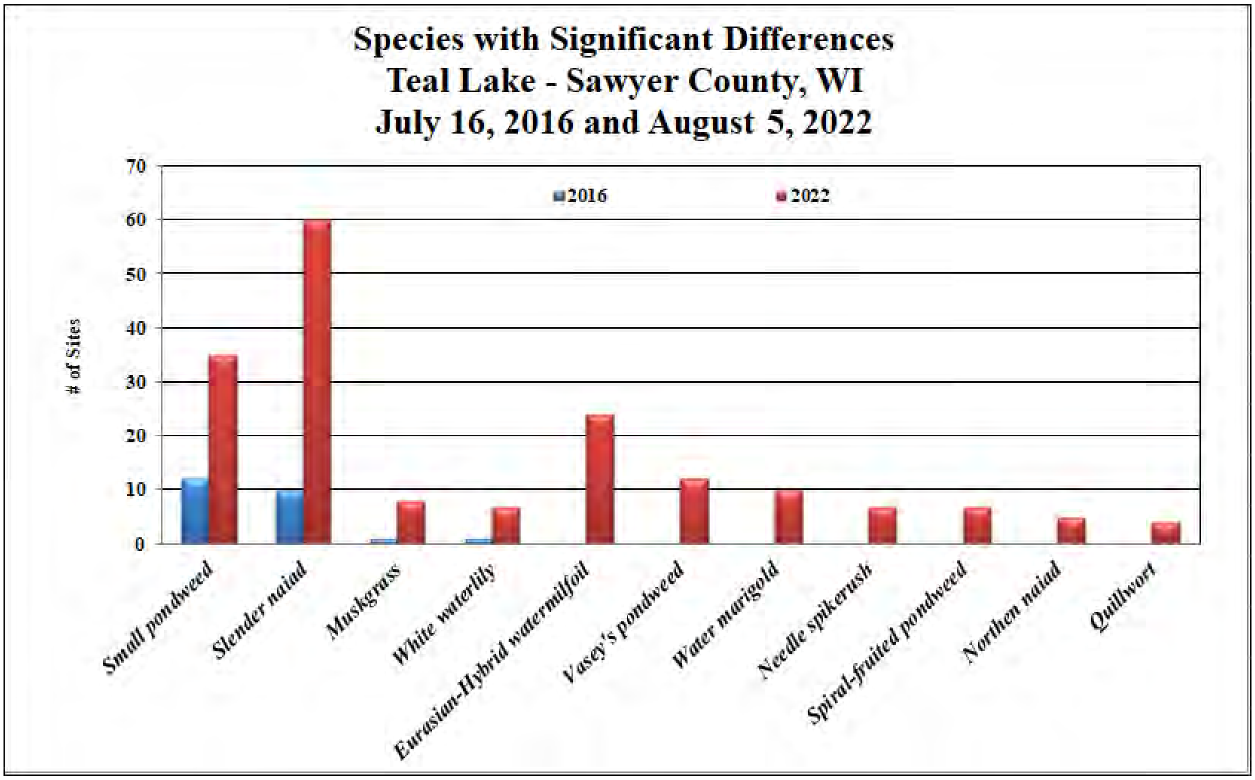

Figure 47: Significant changes in aquatic plant distribution from 2016-2022 (Berg, 2022)

5.10.1.4 EWM Comparisons

As previously mentioned, E/HWM was not identified in Teal Lake during the 2016 summer point-intercept survey. One of the main goals in the last APM Plan was to prevent the spread of EWM into Teal Lake. There is not an account of when EWM was first found in Teal Lake, in fact it is not even listed as being in Teal Lake on the WDNR lakes webpage, but it is assumed that it came in from Lost Land Lake soon after the completion of the 2017 Plan.

Fall E/HWM bedmapping in Teal Lake identified 35 E/HWM beds covering 44.36 acres (4.33% of the lake's surface area) (Figure 48). Most beds occurred in muck bottom bays where E/HWM dominated the plant community in 3-8ft of water, were canopied or near canopy, and likely caused minor to moderate navigation impairment as the majority occurred along highly developed shorelines.

Like on Lost Land Lake, without an annual monitoring program, it is impossible to know if EWM has hit "saturation" or if it will continue to spread into additional areas on the lake. Though given the amount of littoral zone yet to be colonized by E/HWM, it is reasonable to assume that E/HWM will continue to expand. Likewise, there's no way of knowing if the current harvesting program is reducing levels on the system. However, a reputable volunteer (Keil, personal communication, June 2023) on Teal Lake who has been monitoring the results of the Eco-harvesting program on her own, had these things to say.

1. *In the areas that have been the worst in the past and where we have been able to do some serious harvesting the past couple of years, one of two situations was found:*
   a. *The milfoil - while still there and still thick in some of the very worst areas - was still far below the surface of the water (18"-24", or more, below the surface on average). This means that while it is still a problem in those areas, it is significantly farther behind in its growth than in years past. This finding is significant and is*

consistent with the research papers I have read on the effects of harvesting, meaning it seems like the harvesting is seriously hampering the Milfoil's growth rate in years past year

b. *The milfoil was hardly present in some areas where it had been very thick in years past, and now the native plants are dominant.*

2. *In areas that have been thick in the past but where wind/weather/water levels have NOT allowed us to harvest as much, it was found that the milfoil was very thick and was at or very near the surface already. That means that in these areas that have NOT seen significant harvesting, the milfoil is growing much more vigorously, again consistent with other research findings.*

It is this volunteer's contention that these result reflect *what was hoped for when eco-harvesting began, that adequate harvesting using these methods and controlling (to the degree possible) the fragments does stand a good chance of helping Teal to at least manage - and maybe even get ahead - of the milfoil problem to a reasonable degree.* She goes on to say that *the results seem to be confirming published research that aggressive harvesting really hampers the milfoil's growth rate year-over-year, thereby giving the natives a fighting chance. Of course this result plays out over the course of a few years; not in one season, but the effect seems to be real.*

Eco-harvesting is and continues to be one management action to be implemented to control the spread of E/HWM. It should not, however, be the only management action implemented. Other forms of physical removal including diver removal and DASH could improve physical removal results. In large areas, applying aquatic herbicides to reduce the bed size and density to a point where physical removal can again be effective is important as well.

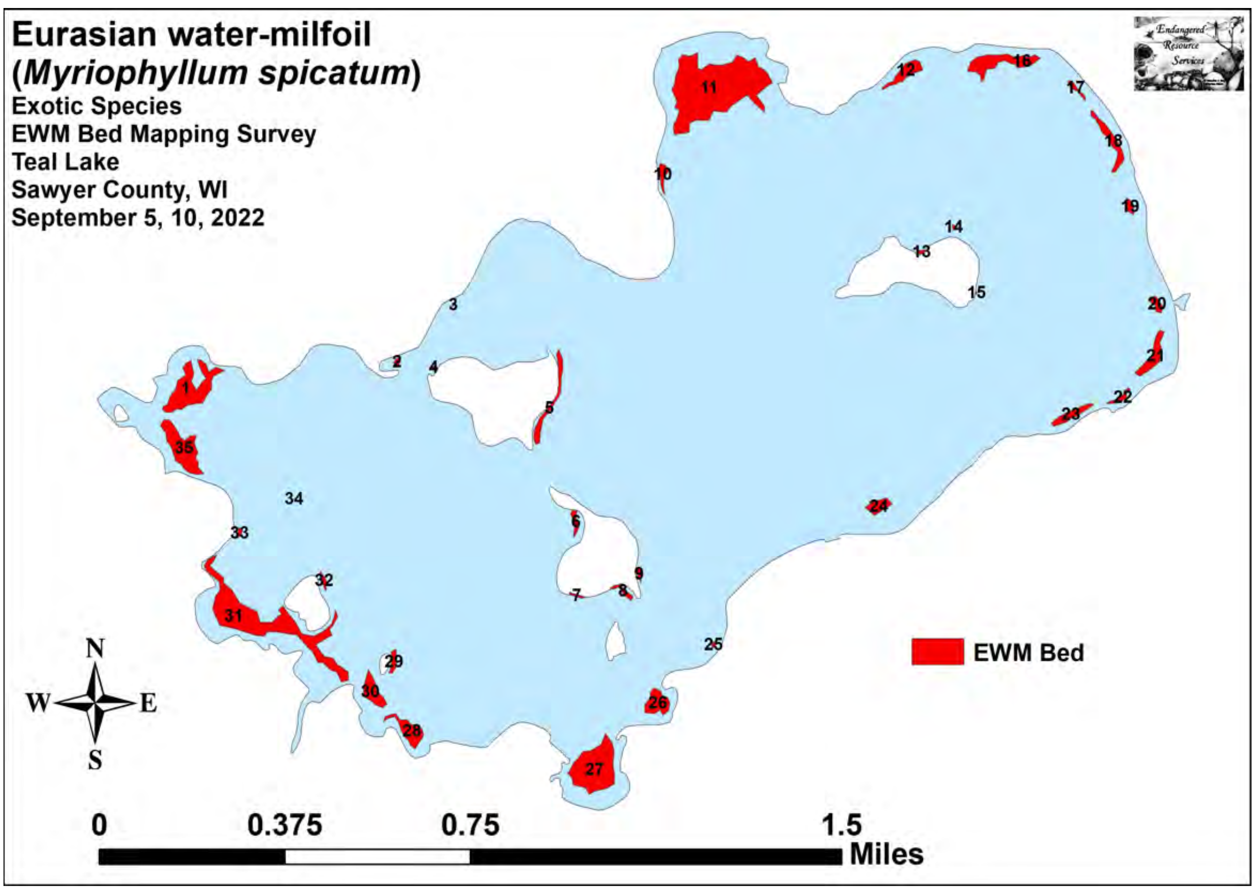

Figure 48: 2022 E/HWM fall bedmapping results (ERS)

5.10.1.5 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 Teal Lake during the 2016 or 2022 surveys.

5.11 Ghost Lake and Teal River Flowage Aquatic Plant Community

A whole-lake, PI survey was last completed on Ghost Lake in 2016. This project did not include a PI survey for Ghost Lake. It also did not include a PI survey for the Teal River Flowage. It is recommended that AIS monitoring surveys be completed on Ghost Lake in an attempt to determine if E/HWM or any other AIS has been introduced to the lake. During the 2016 survey work, no E/HWM was found in Ghost Lake. It is assumed that there is still no E/HWM in the lake.

A PI survey on the Teal River Flowage was also not completed as a part of this project. And even though a formal meandering, bedmapping survey specifically looking for E/HWM was not included in this project, a volunteer familiar with the Flowage and E/HWM completed a meandering survey on August 5, 2023. E/HWM was identified along the east and west shores of the Flowage in moderate to dense beds in some locations and sparsely mixed in with any native aquatic plant species in other locations. In total, 15 beds were mapped covering approximately 27.75 acres about half of which was considered dense and topped out by the surveyor (Figure 49). E/HWM was not present during 2016 survey work, but it is expected that it came in from Teal Lake at least a couple of years ago.

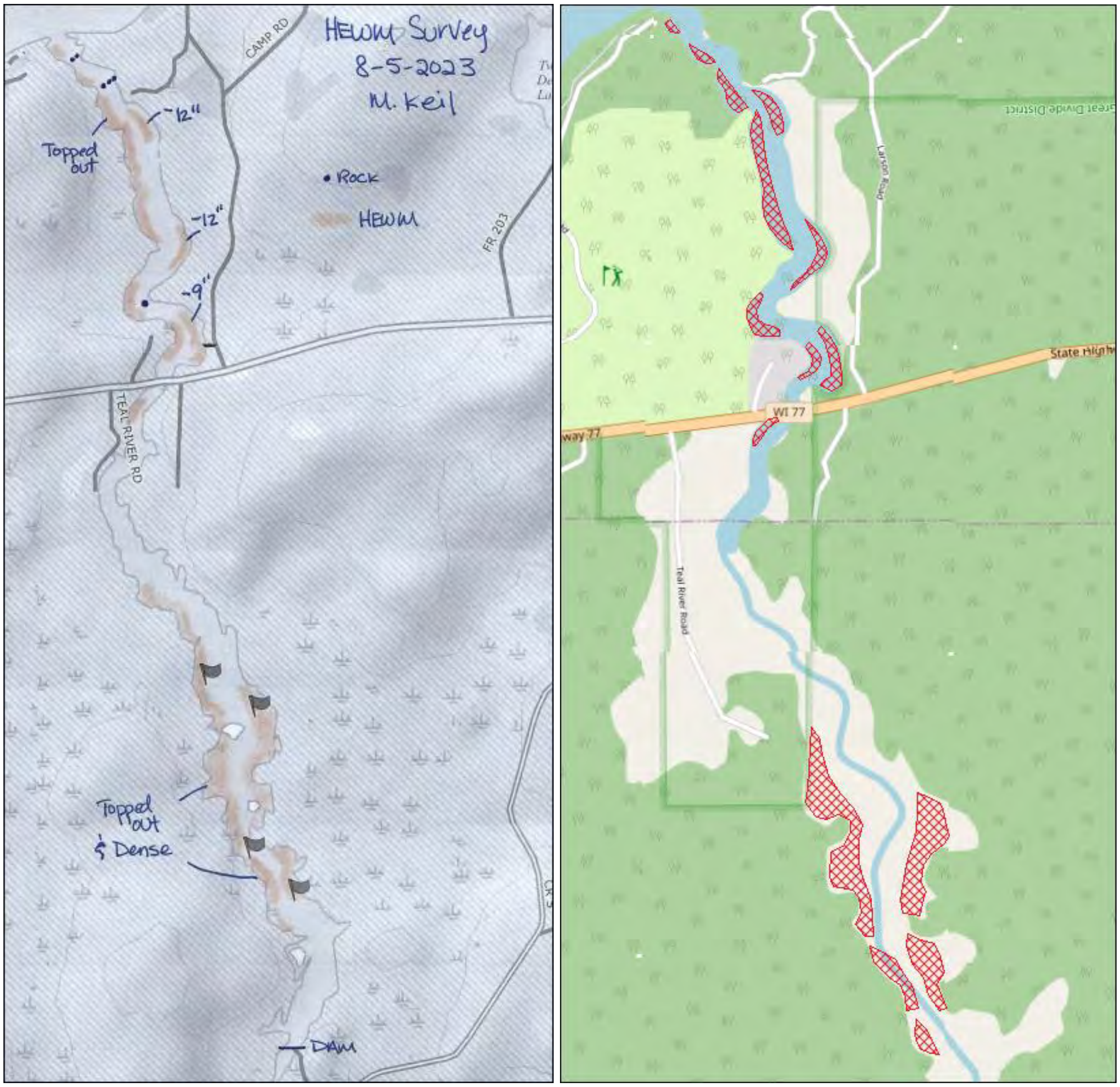

Figure 49: August 2023 E/HWM bedmapping completed by Michelle Keil (left) and GIS mapping of her data to estimate acreage (right)

During her August 5, 2023 survey the volunteer Michelle Keil, made the following observations:

1. Should there be any decision made to manage the E/HWM in the river, the Eco-Harvester would not be a good method to use. The river is too narrow to maneuver that harvester very well, too shallow, has too many big rocks (not marked), and has no good launch or offload points.
2. There were many really nice, dense beds of native milfoil in the area, especially south of Hwy 77 on the east side of the river. There were also some very nice beds of large-leaf pondweed and other natives.
3. Most of the River is lined with lily pads on both sides, with the E/HWM generally forming bands along (but not much in) the lily pads between them and the main channel of the river.
4. The E/HWM beds mostly occur in areas of mucky bottom.
5. The E/HWM prefers areas of lower water flow and in the backwater areas of the river.

5.12 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, none of the Quiet Lakes are considered wild rice water. There is however, wild rice in the west fork of the Chippewa River downstream of where Ghost Creek enters the river from Ghost Lake (See Figure 3 in Section 4.1).

6.0 Aquatic Invasive Species

To date, only hybrid watermilfoil (E/HWM) 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.

6.1 Non-native, Aquatic Invasive Plant Species

Hybrid Eurasian watermilfoil is the most problematic non-native, aquatic invasive species in the lakes. It is a submerged vegetation species (rooted to the bottom of the lake and growing under the surface of the water) that has the potential to outcompete more desirable native aquatic plants. Curly-leaf pondweed is another submerged aquatic invasive species that is problematic in some lakes. It has not been identified in Lost Land or Teal Lakes to date. Purple loosestrife, yellow flag iris, 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.

6.1.1 Eurasian Watermilfoil

EWM (Figure 50) 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 50: EWM complete root and stem and floating fragment with adventitious roots

6.1.1.1 Hybrid Watermilfoil

Hybrid watermilfoil is a cross between a native milfoil (Northern watermilfoil) and the original non-native milfoil (Eurasian watermilfoil) (Figure 51). In WI, the original non-native watermilfoil and the hybrid watermilfoil are considered equally bad. Because a hybrid milfoil takes characteristics from each of its parent plants, there are many different strains of hybrid watermilfoil. In many cases, it is difficult to tell whether a milfoil found in a lake is native or non-native, particularly if it is a hybrid. Defining characteristics like leaflet count (Figure 52) are often rendered inconclusive. The only way to officially recognize a newly found watermilfoil in a lake as a hybrid is to have it tested in a laboratory setting to confirm it. Hybrids don't just take on the looks of its parent plants, it can take on or modify growing characteristics like density and aggressive growth. The watermilfoil in both Lost Land and Teal Lakes has been identified as an aggressive strain of hybrid milfoil.

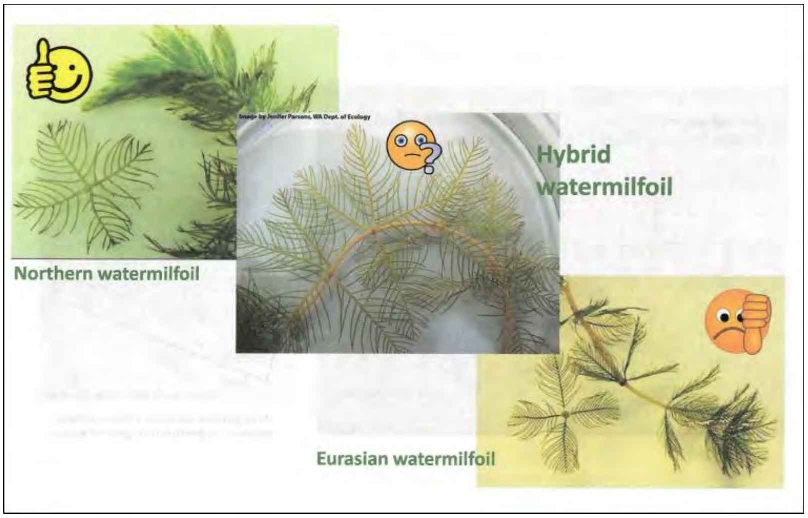

Figure 51: Native, hybrid, and non-native watermilfoil

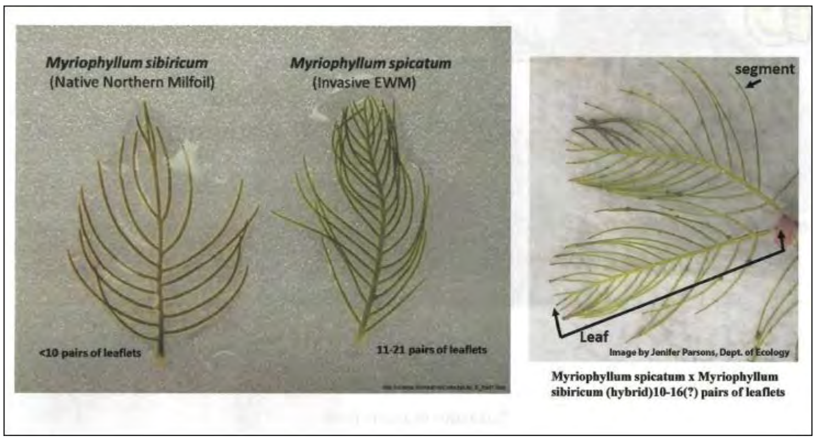

Figure 52: Leaflet count on native, non-native, and hybrid watermilfoil

6.1.2 Purple Loosestrife (*Lythrum salicaria)*

Purple loosestrife (Figure 53) 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.

Figure 53: Purple loosestrife

6.1.3 Yellow Flag Iris (Iris pseudacorus)

Yellow flag iris (Figure 54) is a showy perennial plant that can grow in a range of conditions from drier upland sites, to wetlands, to floating aquatic mats. A native plant of Eurasia, it can be an invasive garden escapee in Wisconsin's natural environments. Yellow flag iris can produce many seeds that can float from the parent plant, or plants can spread vegetatively via rhizome fragments. Once established it forms dense clumps or floating mats that can alter wildlife habitat and species diversity. All parts of this plant are poisonous, which results in lowered wildlife food sources in areas where it dominates. This species has the ability to escape water gardens and ponds and grow in undisturbed and natural environments. It can grow in wetlands, forests, bogs, swamps, marshes, lakes, streams and ponds. Dense areas of this plant may alter hydrology by trapping sediment and/or blocking flow.

Yellow iris has broad, sword-shaped leaves that grow upright, tall and stiff. They are green with a slight blue-grey tint and are very difficult to distinguish from other ornamental or native iris species. Flowers are produced on a stem that can grow 3-4 feet tall among leaves that are usually as tall or taller.

The flowers are showy and variable in color from almost white to a vibrant dark yellow. Flowers are between 3-4 inches wide and bloom from April to June. Three upright petals are less showy than the larger three downward pointing sepals, which may have brown to purple colored streaks.

Seeds are produced in fruits that are 6-angled capsules, 2-4 inches long. Each fruit may have over 100 seeds that start pale before turning dark brown. Each seed has a hard outer casing with a small air space underneath, which allows the seeds to float.

The roots are thick, fleshy pink-colored rhizomes spread extensively in good conditions, forming thick mats that can float on the surface of the water.

When not flowering, yellow flag iris could be easily confused with the native blue flag iris (*Iris versicolor*) as well as other ornamental irises that are not invasive. Blue flag iris is usually smaller and does not tend to form as dense clumps or floating mats. When not flowering or showing fruiting bodies, yellow flag iris may be confused with other wetland plants such as cattails (*Typha* spp.) or sweet flag (*Acorus* spp.) species.

Small populations may be successfully removed using physical methods. Care should be taken if hand-pulling plants as some people show skin sensitivity to plant sap and tissues. All parts of the plant should be dug out – particularly rhizomes and disposed of in a landfill or by burning. Cutting the seed heads may help decrease the plant spreading.
Aquatic formulas of herbicides may be used to control yellow flag iris, however, permits may be needed. Foliar spray, cut stem/leaf application and hand swiping of herbicide have all shown effectiveness. It is unknown if there is any yellow flag iris on the shores of the two lakes, but monitoring for it will occur.

Figure 54: Yellow flag iris

6.1.4 Curly-leaf Pondweed (Potamogeton crispus)

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 55). 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 56). 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 56). To date, no CLP has been found in either lake.

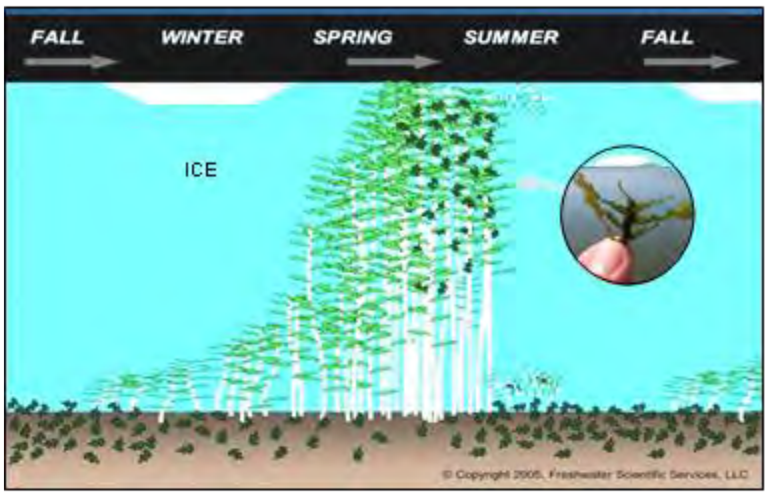

Figure 55: Diagram showing annual CLP life-cycle in northern lakes (Freshwater Scientific Services, 2008).

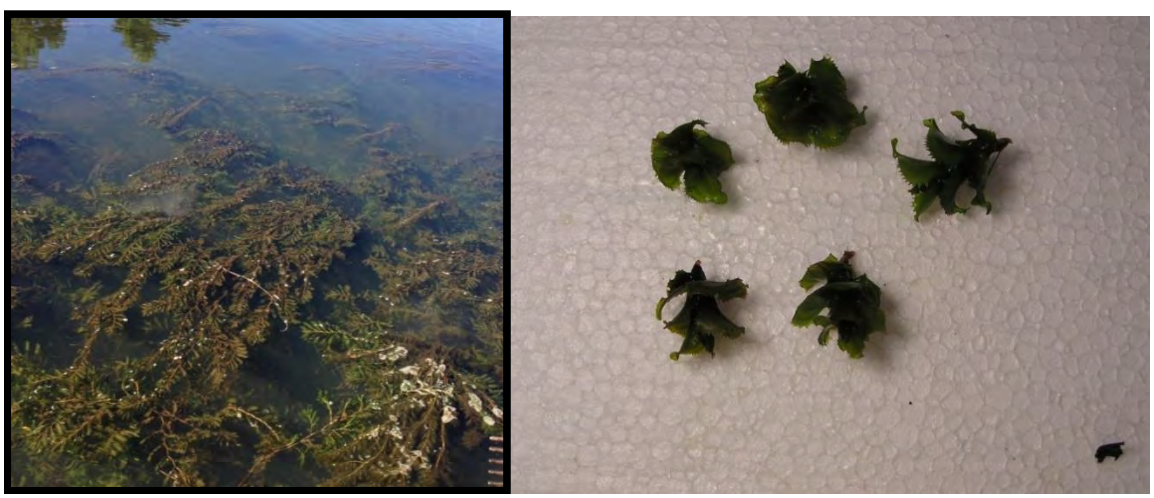

Figure 56: CLP plants and turions

6.2 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.

6.2.1 Chinese and Banded Mystery Snails

The Chinese mystery snails and the banded mystery snails (Figure 57) 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 57: Chinese (left) and Banded (right) Mystery Snails

6.2.2 Rusty Crayfish

Rusty crayfish (Figure 58) 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.

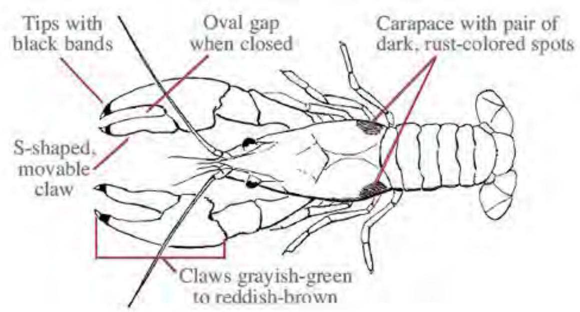

Figure 58: Rusty Crayfish and identifying characteristics

6.2.3 Zebra Mussels

Zebra mussels (Figure 59) 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 59: Zebra Mussels

6.3 AIS Prevention Strategy

Other than QLIA volunteers completing aquatic invasive species (AIS) monitoring, there is no official strategy for AIS prevention for the lakes. A search of the Town of Spider Lake webpage shows no AIS Prevention Strategy for the Town either. At the present time, the AIS of greatest concern in the Quiet Lakes is E/HWM. There may be isolated locations with purple loosestrife and/or yellow iris, and both Chinese and Banded Mystery Snails have been identified in the system. To date, there have been no other AIS identified in the lakes. Curly-leaf pondweed and zebra mussels probably posed the greatest potential for introduction into the Quiet lakes. Rusty crayfish are also in a number of lakes in Sawyer County.

The State of Wisconsin has an AIS Management Plan that has three main goals in it.[6] AIS control, education, monitoring, planning, and prevention are also mentioned in the Sawyer County Land and Water Resource Plan.[7] Both the Town of Spider Lake and the QLIA should consider developing their own AIS Strategy. Such a strategy could help in early identification of any new AIS introduction, guide education and planning, and support management when necessary.

[6] WI AIS Management Plan Final Online 6.19.19 (1) (2).pdf

[7] https://www.sawyercountygov.org/DocumentCenter/View/231/Resource-Management-Plan-2017-2026-PDF

7.0 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. Past management of E/HWM in Lost Land and Teal Lakes has been limited to use of the Eco-Harvester, physical removal, and very limited use of aquatic herbicides. These management methods have provided only minimal control and have not prevented E/HWM from spreading to all available habitat in Lost Land Lake and much of the available habitat in Teal Lake and the Teal River Flowage. Management of E/HWM may also help to make Lost Land Lake, in particular, less of source lake for AIS getting into other nearby lakes. As such, there is a need for management in Lost Land and Teal Lakes for sure, likely on a large or whole-lake scale. Once this level of management has been completed, then it may be possible to go back to smaller-scale management actions that include an integrated approach to management.

7.1 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 60). 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.

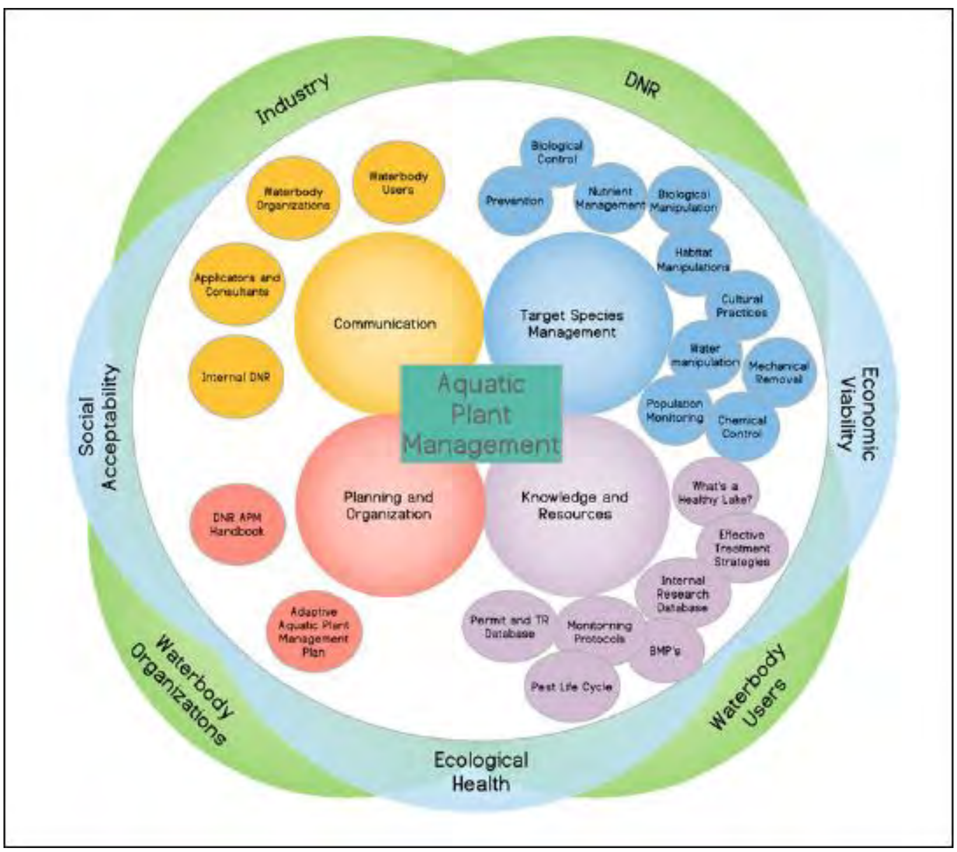

Figure 60: Wisconsin Department of Natural Resources: Wisconsin Waterbodies – Integrated Pest Management March 2020

In most cases, an IPM approach to aquatic plant management is the best way to protect and enhance the native plant community and control an invasive species while maintaining functional use of the lake. Unfortunately, for Lost Land, with 260 plus acres of E/HWM covering more than 35% of the littoral zone of the lake, a large-scale management action is going to have to occur first, with the goal of reducing the amount of E/HWM in the lake to a level where a more integrated approach to control can be implemented. Teal Lake is in a similar, but not as dire a situation. With 44 plus acres of E/HWM that covers about 10% of the littoral zone, a not-quite-as-largescale initial management action will need to be implemented before a more integrated approach to control can be implemented.

8.0 Management Alternatives – Large-scale

Nuisance aquatic plants can be managed a variety of ways in Wisconsin. The best management strategy will be different for each lake and depends on which nuisance species needs to be controlled, how widespread the problem is, and the other plants and wildlife in the lake. The eradication of non-native aquatic invasive plant species such as E/HWM is generally not feasible, but preventing it from becoming a more significant problem is an attainable goal. It is important to remember however, that regardless of the plant species targeted for control, sometimes no manipulation of the aquatic plant community is the best management option. Plant management activities can be disruptive to a lake ecosystem and should not be done unless it can be shown they will be beneficial and occur with minimal negative ecological impacts.

Management alternatives for nuisance aquatic plants can be grouped into four broad categories:

- Manual and mechanical removal
- Chemical application
- Biological control
- Physical habitat alteration.

Manual and mechanical removal methods include pulling, cutting, raking, harvesting, suction harvesting, and other means of removing the physical plant from the water. Chemical application is typified by the use of herbicides that kill or impede the growth of the aquatic plant. It is illegal to put any chemical into waters of Wisconsin without a chemical application permit from the WDNR. Some forms of physical removal, specifically suction harvest and mechanical harvesting also require a WDNR permit. Biological control methods include organisms that use the plant for a food source or parasitic organisms that use the plant as a host, killing or weakening it. Biological control may also include the use of species that compete successfully with the nuisance species for available resources. This activity may require a WDNR permit. Physical habitat alteration includes dredging, installing lake-bottom covers, manipulating light penetration, flooding, and drawdown. These activities may require WDNR permits. They may also include making changes to or in the watershed of a body of water to reduce nutrients going in.

When a new AIS infestation is confirmed, management usually begins at the small-scale level with physical removal, DASH, or very limited use of aquatic herbicides. In the case of Lost Land and Teal Lakes, with a well-established AIS infestation it means first knocking it back to a smaller, more manageable level with a large-scale management action like harvesting or application of herbicides before switching back to a more integrated approach. Informed decision-making related to aquatic plant management implementation requires an understanding of plant management alternatives and how appropriate and acceptable each alternative is for a given lake. The following sections describe possible large-scale management actions for Lost Land and Teal Lakes. Section 9.0 discusses more common smaller scale management actions.

8.1 Application of Aquatic Herbicides

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, in most cases, 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 and the many pondweeds in Wisconsin lakes will not be affected. The selectivity of a particular herbicide can also be influenced by the method, timing, formulation, and concentration used.

8.1.1 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 EWM 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.

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.

8.1.2 Whole-Lake Herbicide Application

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. 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. If a whole-lake chemical treatment is completed after the establishment of a thermocline in lakes that stratify, the volume of water included in the calculation of herbicide concentration is less as it only includes the volume of water above the thermocline, or epilimnion of the lake.

Because exposure time is expected to be so much longer, effective herbicide concentrations for whole-lake treatments are significantly less than required for small-scale or even large-scale treatments. If the herbicide exposure time of the target aquatic plant can be extended to days or weeks, like with a whole-lake application, the concentration of the herbicide applied can be lowered. For 2,4-D-based herbicides, the target concentration may be as little as 0.25-0.5 ppm instead of the 2-4 ppm that is typically used in small or large-scale. Whole-lake treatments are typically conducted when the target plant is spread throughout the majority of the lake or basin.

8.1.3 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. ProcellaCOR targets a growth hormone specific to E/HWM and similar plant species. Its active ingredient is florpyrauxifen-benzyl, and it can be used at much lower dosages than previous herbicides used to treat E/HWM. It is also very fast acting (2-4 hours of contact time with the target plant) and kills the entire plant, making it an effective control measure on smaller beds or in deeper water. 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 has mostly been used for smaller scale herbicide control projects, but can be used for larger projects.

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. 2,4-D-based herbicides come in both liquid and granular forms, with liquid forms being much less expensive than granular forms. 2,4-D-based herbicides are much less expensive than ProcellaCOR, however, due to a required contact time with the target plant of 16-36 hours, it is less effective on smaller areas or in areas of deep or moving water. In Wisconsin, it is recommended that 2,4-D-based products not be used in areas <5.0 acres. In most lakes, its effective control time is only one to two years before the target species grows back again. Application of liquid 2,4-D-based products is in the hundreds of gallons, sometimes thousands of gallons in large-scale or whole-lake treatment projects.

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. Sonar is not specific to particular plants so may negatively impact the entire aquatic plant community. Sonar is generally applied during a whole-lake application and is expected to be in the lake at very low concentrations for weeks or months once applied. It may require additional "bump" treatments later in the same season to increase the concentration of the herbicide to expected levels. Plant control may last 3-5 years.

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 both have 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 (CLP) 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.

8.1.3.1 Applying Several Herbicides at Once

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.

8.1.4 Pre and Post Treatment Aquatic Plant Surveying

When introducing new chemical treatments to lakes where the treatment size is >10 acres or greater than 10% of the lake littoral area, 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.

8.1.5 Chemical Concentration Testing

Chemical concentration testing is often done in conjunction with treatment to track the fate of the chemical herbicide applied. 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.

8.1.6 Overuse of Aquatic Herbicides

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.

ProcellaCOR, 2,4-D, and triclopyr are all classified as auxin herbicides (WSSA Group 4; HRAC Group O). Weed populations may develop biotypes that are resistant to different herbicides with the same mode of action. If herbicides with the same mode of action are used repeatedly in the same field, resistant biotypes may eventually dominate the weed population and may not be controlled by these products. To delay development of herbicide resistance, the following practices are recommended:

- Alternate use of products containing ProcellaCOR EC with other products with different mechanisms of action.
- ProcellaCOR EC can be tank mixed or used sequentially with other approved products to broaden the spectrum of weed control, provide multiple modes of action and control weeds that ProcellaCOR EC does not control.
- Herbicides should be used based on an IPM program.
- Monitor treated areas and control escaped weeds.

8.1.6.1 Concerns Related to Whole-lake/Large-scale Chemical Treatments

In 2020, the WDNR published a paper (Mikulyuk, et al., 2020) comparing the ecological effects of the invasive aquatic plant EWM with the effects of lake-wide herbicide treatments used for EWM control using aquatic plant data collected from 173 lakes in Wisconsin, USA. First, a pre–post analysis of aquatic plant communities found significant declines in native plant species in response to lake-wide herbicide treatment. Second, multi-level modeling using a large data set revealed a negative association between lake-wide herbicide treatments and native aquatic plants, but no significant negative effect of invasive EWM alone. Taken together, their results indicate that lake-wide herbicide treatments aimed at controlling EWM had larger effects on native aquatic plants than did the target of control-EWM.

This study reveals an important management tradeoff and encourages careful consideration of how the real and perceived impacts of invasive species like EWM in a lake and the methods used for their control are balanced.

8.2 Mechanical Management and Harvesting

Mechanical management involves the use of devices not solely powered by human means to aid removal. This includes gas and electric motors, ATV's, boats, tractors, etc. Using these instruments to pull, cut, grind, or rotovate aquatic plants is illegal in Wisconsin without a permit. Diver Aided Suction Harvest (DASH) is considered mechanical removal. To implement mechanical removal of aquatic plants a Mechanical/Manual Aquatic Plant Control permit is required annually, although the WDNR is now offering multi-year harvesting permits in some instances. The permit application is reviewed by the WDNR and other entities and awarded if required criteria are met. Once an annual permit for mechanical harvesting has been approved, harvesting can occur in the approved areas as often as necessary to manage the vegetation.

8.2.1 Large-scale Mechanical Harvesting

Aquatic plant harvesters are floating machines that cut and remove vegetation from the water (Figure 61). The size and harvesting capabilities, of these machines vary greatly. As they move, harvesters cut a swath of aquatic plants that is between 4 and 20 feet wide, and depending on the machine, up to 10 feet deep. The on-board storage capacity of a harvester ranges from 100 to 1,000 cubic feet (by volume) or 1 to 8 tons (by weight). An average harvester can cut between 2 and 8 acres of aquatic vegetation per day. The average lifetime of a mechanical harvester is 10 years.

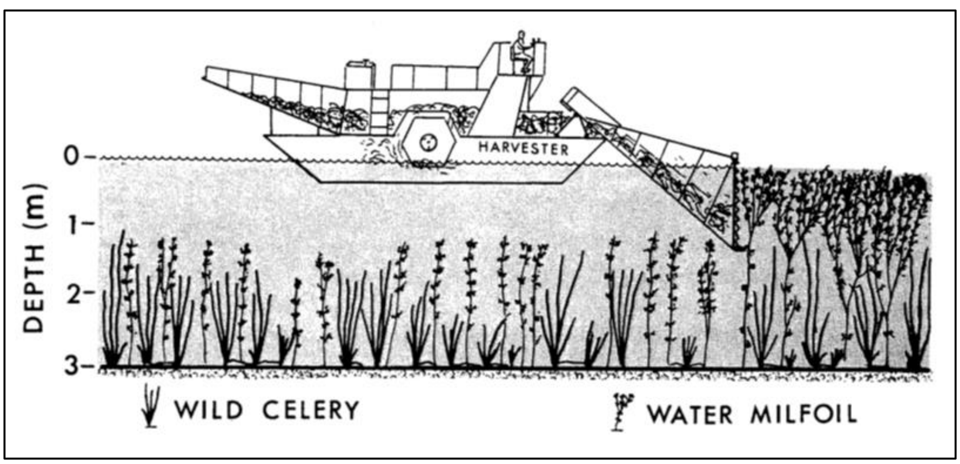

Figure 61: How a mechanical harvester works (Engle, 1987)

The results of mechanical harvesting - open water and accessible boat lanes - are immediate, and can be enjoyed without the restrictions on lake use which follow some herbicide treatments. In addition to the human use benefits, the clearing of thick aquatic plant beds may also increase the growth and survival of some fish. By eliminating the upper canopy, harvesting reduces the shading caused by aquatic plants. The nutrients stored in the plants are also removed from the lake, and the build-up of organic material that normally occurs as a result of the decaying of this plant matter is reduced. Additionally, repeated harvesting may result in thinner, more scattered growth.

Disposal sites are a key component when considering the mechanical harvesting of aquatic plants. The sites must be on shore and upland to make sure the plants and their reproductive structures don't make their way back into the lake or to other lakes. The number of available disposal sites and their distance from the targeted harvesting areas will determine the efficiency of the operation, in terms of time and cost.

Timing is also important. The ideal time to harvest, in order to maximize the efficiency of the harvester, is just before the aquatic plants break the surface of the lake. It is also important to inspect the equipment before it enters and after it is removed from a lake. These machines may carry plant fragments with them when transported from lake to lake, facilitating the spread of aquatic invasive species from one body of water to another.

Large-scale mechanical harvesting is commonly used for control of CLP, and in the absence of other management alternatives or conditions that prevent the use of other management alternatives, can also be an effective way to reduce E/HWM biomass in a water body.

8.2.1.1 The Eco-Harvester

The Eco-Harvester is an example of a smaller-scale mechanical harvester (Figure 62). It has a 4-ft wide harvest head, and in the case of the Eco-Harvester, a static cutting head. According to marketing materials, the blue drum on the front of the Eco-Harvester turns slowly as the harvester is moving through the water gently pulling plant material, roots and all from the bottom of the lake. A non-static cutting head can be attached to the Eco-Harvester making it a more common mechanism that cuts the plant material at a set depth, rather than pulling it.

There are several other versions of small-scale, mechanical harvesters (See Section 9.2).

Figure 62: Eco-Harvester

8.2.1.2 Harvesting Totals and Estimated Costs (Owning versus Contracting Services)

Costs per acre vary with numbers of acres harvested, accessibility of disposal sites to the harvested areas, density and species of the harvested plants, and whether a private contractor or public entity does the work. Private contractors generally charge $500 to $800 per acre or $2000 to $3000 per day. The purchase price of new harvesters ranges from $100,000 to $350,000. Used harvesters are often available at a reduced cost but may come with additional mechanical repairs to make them fully operable. There are several harvester manufacturers in the United States (including at least two in Wisconsin) and some lake groups may choose to operate and purchase their own machinery rather than contracting for these services.

In the last several years, more companies have started offering contracted mechanical harvesting, DASH, and physical removal services. Several companies are located in the northern half of Wisconsin including TSB Lakefront Restoration and Diving (New Auburn, WI) and Aquatic Plant Management (Minocqua, WI). Several other companies exist in southeastern WI, the Twin Cities area, and even in northern Illinois. Most of the services they offer run about $2,500-$3,500.00 per day.

There are benefits and drawbacks for both contracted harvesting and purchasing a harvester outright. With contracted harvesting, the cost per acre can vary depending on vegetation density, distance between the area being harvesting and the off-loading site, and the distance to the designated disposal site. Another issue is timing. When contracted harvesting takes place, is likely going to be dependent on the availability of the contractor, not necessarily on when the best time to complete harvesting is. With contracted harvesting there may be reduced costs due to no cash outlay for purchasing, maintaining, and storing the harvester. Contractors generally carry their own insurance, further reducing the costs. And finally, there are reduced costs or no costs if, in any given year, there is less or no harvesting completed.

Purchasing is the more expensive option due to not only the initial cost of purchase, but also insurance, storage, maintenance, and an operator's salary (unless volunteer operated). However, there are many benefits to purchasing. Purchasing a harvester eliminates the potential for new AIS to be introduced to the lake from the contractor, the cost per acre tends to go down the longer a harvester is operational, and these costs will not increase dramatically if the amount of vegetation being harvested increases. This also allows harvesting to be done during the best times as well as providing a way to maintain navigation channels throughout the summer. The biggest drawbacks to purchasing a harvester are the increased up-front cost and the annual costs associated with maintaining the harvester. Even during years with less harvesting, the maintenance, storage, and other miscellaneous costs will remain around the same as those costs would be during years that require large amounts of harvesting.

8.2.1.3 Harvester Concerns

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 E/HWM in a lake by creating more fragments that can go on to establish new sites elsewhere.

9.0 Management Alternatives – Small-scale

As mentioned in Section 11.0, management alternatives can be divided into four general categories:

- Chemical control
- Mechanical/physical control
- Biological control
- Aquatic plant habitat manipulation

When implementing AIS management on a smaller scale, more management alternatives are available and likely more effective at helping to maintain AIS infestations at low levels.

9.1 Manual/Physical Removal

Manual or physical removal of aquatic plants by means of a hand-held rake or cutting implement; or by pulling the plants from the lake bottom by hand is allowed by the WDNR without a permit per NR 109.06. As a general rule though, these activities can only occur in a zone that is no more than 30-ft wide and adjacent to a pier or lake use area (Figure 63). There is no limit as to how far out into the lake the 30-ft zone can extend, however clearing large swaths of aquatic plants not only disrupts lake habits, it also creates open areas for non-native species to establish. Physical/manual removal limits disturbance to the lake bottom, is inexpensive, and can be practiced by many lake residents.

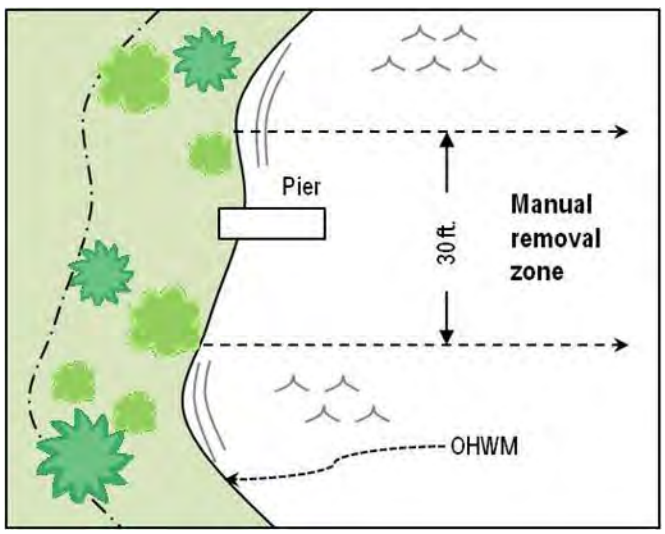

Figure 63: Aquatic vegetation manual removal zone

Manual or physical removal can be effective at controlling individual plants or small areas of plant growth. It limits disturbance to the lake bottom, is inexpensive, and can be practiced by many lake residents. In shallow, hard bottom areas of a lake, or where impacts to fish spawning habitat need to be minimized, this is the best form of control. If water clarity in a body of water is such that aquatic plants can be seen in deeper water, pulling AIS while snorkeling or scuba diving is also allowable without a permit according to the conditions in NR 106.06(2) and can be effective at slowing the spread of a new AIS infestation within a lake when done properly.

9.1.1 Diver Assisted Suction Harvest (DASH)

Diver Assisted Suction Harvesting (DASH) is a removal method that requires a scuba diver to pull the target plant species from the bottom and feed it into a suction tube where it is transported to a collection basin on a boat or pontoon at the surface. DASH is considered mechanical harvesting as it requires the assistance of a mechanical system to implement (Figure 64). DASH increases the ability of a diver to remove the offending vegetation from a larger area, faster, but also requires a Mechanical Harvesting permit from the WDNR. The cost to implement DASH is also more expensive than employing a diver alone. A DASH boat consists of a pontoon boat equipped with the necessary water pump, catch basin, suction hose, and other apparatus (Figure 64). Cost estimates to build a custom DASH boat range from $15,000.00 to $20,000.00. Contracted DASH services usually run in the $2,000.00 to $3,000.00 per day range.

Clear water and appropriate bottom sediments maximize the efficiency of DASH operations. Its use may minimize the frequency of AIS management using aquatic herbicides.

Figure 64: DASH – Feeding EWM into the underwater Suction Hose (Marinette Co.); and a sample DASH Pontoon Boat (Beaver Dam Lake Management District)

9.2 Small-Scale Mechanical Harvesting

There are a wide range of small-scale mechanical harvesting techniques, most of which involve the use of boat mounted rakes, scythes, and electric cutters. As with all mechanical harvesting, removing the cut plants is required. Commercial rakes and cutters range in prices from $200 for rakes to around $3000 for electric cutters with a wide range of sizes and capacities. Using a weed rake or cutter that is run by human power is allowed without a permit, but the use of any device that includes a motor, gas or electric, would require a permit. Dragging a bed spring or bar behind a boat, tractor or any other motorized vehicle to remove vegetation is also illegal without a permit. Although not truly considered mechanical management, incidental plant disruption by normal boat traffic is a legal method of management. Active use of an area is often one of the best ways for riparian owners to gain navigation relief near their docks. Most aquatic plants won't grow well in an area actively used for boating and swimming. It should be noted that purposefully navigating a boat to clear large areas is not only potentially illegal it can also re-suspend sediments, encourage AIS growth, and cause ecological disruptions.

An Eco-Harvester (from Section 8.2.1.1) is an example of a small-scale mechanical harvester. A more recent option for small-scale mechanical harvesting of aquatic plants is using a "mini" harvester that is remote-controlled. Weeders Digest currently offers two versions of a remote controlled mini mechanical harvester, the WaterBug and the WaterGator.

The WaterBug (Figure 65) is 5.4' wide by 11' 9" long but weighs only 370 lbs. and boasts a storage bunk capacity of 600 lbs. This makes it easy for one person to use as it fits on a compact trailer that can be pulled behind a 4-wheeler or garden tractor. It floats in as little as 4" of water and can cut and skim 34" wide, is adjustable to 15-16" water depth by remote control (can be set manually to a depth of 24"), and features long-lasting batteries that can operate 5 hours on a single charge.

Figure 65: WaterBug remote-controlled aquatic plant harvester (https://lakeweedharvester.com/waterbug/)

The WaterGator (Figure 66) features the same technology as the WaterBug including a harvesting camera that shows the operator what the WaterGator sees on the remote viewing screen. The WaterGator cuts, skims, and collects aquatic vegetation. It is easy for any user to operate, and it is extremely versatile, with a cutting range reaching 3-1/2 feet deep, and a generous cutting and skimming width of 42 inches. It has a storage bunk capacity of 1,200 lbs. double that of the WaterBug. The WaterGator is battery powered, and provides the operator with 8-plus hours of run time on a single charge. The WaterGator is designed for larger ponds, lake shores, channels, and other medium size bodies of water.

The cost of a WaterBug is estimated at around $17,000.00. The cost of a WaterGator is about double that at $35,000.00. Table 5 compares the two different machines.

Figure 66: WaterGator remote-controlled aquatic plant harvester (https://lakeweedharvester.com/watergator/)

One Lake District in Barron County, WI purchased a WaterGator in 2022 to help them implement an aquatic plant harvesting program, in their case, navigation and access lanes through dense growth watershield and other native vegetation. Prior to the purchase of a WaterGator, this group used a pontoon-mounted, cutting bar to cut vegetation, and then used rakes to collect the cut material. After a full season of use, the main operator had this to say about the WaterGator.

"The harvester worked well, given how its' made but it could easily use some improvements. The paddle wheels seem undersized in that they don't seem to really bite the water as efficiently as they might so it takes too long to get from one location on the lake to another and it flounders around when there's a breeze. But maybe a better operator could help. One time I took the pontoon boat and pushed the harvester across the lake and I've rigged a harness for towing. I'd like to see us putting on an operator's platform. With the glare from the sky, it's hard to see where to cut, with the view through the TV camera in many instances. And I have to wonder if the relatively smooth belt is as efficient as a different type might be. No problem picking up lilies but watershield seems to pile up in front of the take-up belt so at times I stop and tilt the belt up in order to get the watershield to load onto it and consequently get dumped into the storage bunk/belt. So it's not everything I hoped for but a definite step in the right direction."

Joel Meyer, Kirby Lake Management District

The company that builds and markets both the WaterBug and WaterGator is located in the Twin Cities area of MN. They promote the two mini harvesters as able to "cut, skim, and collect" aquatic vegetation. If permitted by the WDNR, either machine could provide some level of nuisance relief for CLP, removal of surface mats of filamentous algae, and aesthetic improvements of a shoreline.

9.3 Small-scale Herbicide Application

The determining factor in designating chemical treatments as small-scale is the size of the area being treated. Small-scale herbicide application involves treating areas less than 10 acres in size. Small-scale chemical application is usually completed in the early season (April through May). Recent research related to 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 an 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.

9.3.1 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 (Figure 67). The surface edge of the curtain is generally supported by floatation devices. The bottom of the curtain is held in place by some form of weighting. The curtain or barrier, sometimes thousands of feet of it, is installed around the proposed treatment area with the purpose of holding the herbicide in place longer by preventing dilution and drift away from the treated area (Figure 68).

Figure 67: Limno-curtain material on a roll before installation (photo from Marinette Co. LWCD)

Figure 68: 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 69 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.

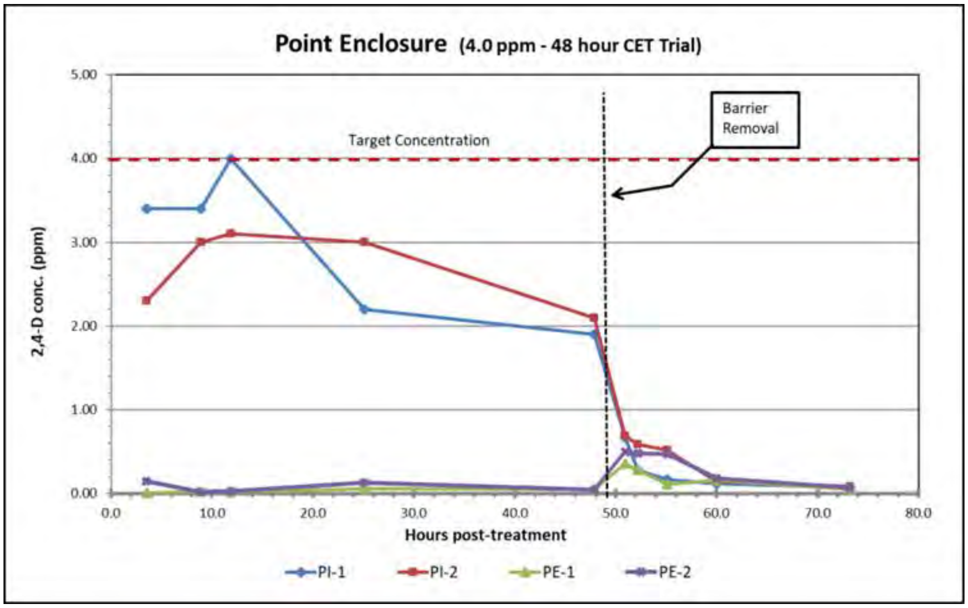

Figure 69: Herbicide concentration results from 2020 Thunder Lake limno-curtain trial (Marinette Co LWCD)

Similar studies have been completed on other lakes with similar results. The Town of Barnes built a limno-curtain before the 2022 management season. One thousand feet of curtain was built and installed around three separate roughly 2.0 acre treatment areas in Tomahawk Lake in succession in late May 2022. The process of initial curtain installation, herbicide applications, moving the curtain to different treatments areas, herbicide concentration testing, and removing the curtain after the management action was completed covered a period of 10 days in late May.

9.4 Biological Control

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.

9.4.1 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 70). 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 70: 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 Lost Land and Teal Lakes. If weevils are already present, it is not inconceivable that a weevil rearing project could be instigated.

9.4.2 Purple Loosestrife Bio-Control with Galerucella Beetles

Galerucella beetles are currently approved for the control of purple loosestrife in Wisconsin (Figure 71). 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 71: Galerucella beetle

Using Galerucella beetles for control of purple loosestrife in and around the Quiet Lakes 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.

9.5 Native Plant Restoration

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 exists that will help restore native plant communities after the invasive species is controlled Gettsinger et al. (1997). Dense growth E/HWM in Lost Land Lake has been the rule for at least several years, so how great a native plant propagule bank exists is unknown. In Teal Lake, where dense growth E/HWM is not as widespread, there may be more of a native plant bank.

9.6 Habitat Manipulation

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, 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 repeatedly 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.

9.7 No Management

When evaluating the various management techniques, the assumption is erroneously made that doing nothing is environmentally neutral. In dealing with non-native species like CLP and EWM, the environmental consequences of doing nothing may be high, possibly even higher than any of the effects of management techniques. Unmanaged, these species can have severe negative effects on water quality, native plant distribution, abundance and diversity, and the abundance and diversity of aquatic insects and fish (Madsen J. , 1997). Nonindigenous aquatic plants are the problem, and the management techniques are the collective solution. Non-native plants are a biological pollutant that increases geometrically, a pollutant with a very long residence time and the potential to "biomagnify" in lakes, rivers, and wetlands (Madsen J. , 2000).

10.0 Aquatic Plant Management Discussion

Both Lost Land and Teal 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 – Hybrid watermilfoil. Nuisance conditions and navigation impairment occur throughout the open water season in both lakes, but in particular, Lost Land, as a direct result of the E/HWM infestation. The main goal of this Aquatic Plant Management Plan is to reduce the large amount of E/HWM in both lakes to a level where an integrated approach to management can keep it below a designated level. Once reduced, any amount of E/HWM can and should be managed using a combination of manual/physical removal, DASH, and chemical control methods. But large-scale management is needed first.

10.1 Aquatic Plant Management Goals from the 2017 APM Plan

The following four objectives were set for the 2017 APM Plan. It was expected that these goals would be met by using a stop-gap chemical treatment in 2017, and then implementing mechanical "pulling" with an Eco-Harvester aquatic plant harvester either in 2018 or 2019. Actual Eco-harvesting began in 2019.

- Objective 1: No new aquatic invasive species (AIS) in any of our lakes
- Objective 2: Maintain a Simpson Diversity Index (SDI) ≥ 0.90 and a Floristic Quality Index (FQI) ≥ 30 in Teal and Lost Land lakes
- Objective 3: No spread of HEWM from Lost Land Lake to connected waters (Teal Lake and Teal River Flowage) or other area waters (including Ghost Lake)
- Objective 4: Reduced frequency (fewer sites) and coverage (area per site) of dense beds of HEWM in Lost Land Lake

Unfortunately, only Objective 2 was met. The SDI and FQI for both Lost Land and Teal Lakes remained above the thresholds set in the 2017 APM Plan. No other objective was met. E/HWM is now in Teal Lake and the Teal River Flowage, both are new infestations not found in the 2016 PI survey work. E/HWM has not however, been found in Ghost Lake as of yet. Lost Land Lake has gone from 20+ acres of dense, surface matted, E/HWM in 2016 to well over 250 acres in 2022. Teal Lake has upwards of 45 acres of E/HWM. E/HWM in the Teal River Flowage was not quantified in either the 2022 PI survey or E/HWM bedmapping, but based on a volunteer survey completed in July 2023 it pretty much lines both shores of the Flowage.

Clearly, management actions in addition to the use of the Eco-Harvester need to be implemented in order to reduce the amount of E/HWM in the lakes.

10.2 Application of Aquatic Herbicides in Lost Land Lake

Multiple approaches large-scale application of aquatic herbicides to reduce the total amount of E/HWM in Lost Land and Teal Lakes have been discussed with the QLIA, WDNR, herbicide suppliers, and other stakeholders. With any application of aquatic herbicides some collateral damage can be expected. Each management scenario will be discussed in the following sections.

10.2.1 Whole-lake Application of a Liquid 2,4-D Herbicide

One common method of providing whole-lake relief from dense-growth E/HWM is the application of a liquid 2,4-D product at a low concentration to the entire lake. Based on the entire volume of the lake (Lost Land Lake does not stratify for any long period of time during the summer) to reach a WDNR-recommended lake-wide concentration of herbicide of 0.35ppm (mg/L), 3,357 gallons of 2,4-D Amine 4® would have to be applied to the lake (Table 13). This total amount of herbicide would be applied directly to the 260 plus acres of E/HWM in the lake for an estimated direct application rate of 2.3ppm.

Table 13: Whole-lake Application of 2,4-D Amine 4® and estimated cost for Lost Land Lake

2,4-D Amine 4 (liquid)					
Conc (ppm)	Gal/acft (label)		Lake Volume		
4.00	2.84		Surface Area (ac)	Mean Depth (ft)	Total (acft)
0.35	0.249		1260	10.7	13482.0
			Application		
			Volume (acft)	Gal/acft	Total (gal)
			13482	0.249	3357.0
Estimated Cost w/Application					
$45/gallon (NAS)			$45/gallon	3357 gallons	$151,065.81

Along with E/HWM, desirable native aquatic plant species may be negatively affected including native milfoils, coontail, naiads, elodea, duckweeds, lilies, and bladderworts. All of these species except duckweeds are present in Lost Land Lake but only the naiads make up more than 10.0% of the relative frequency of all vegetation in the lake.

The relative frequency of an aquatic plant species in a lake shows the species relative to all other species found in the lake. It is expressed as a percentage, and the total of all species' relative frequencies will add up to 100%. Organizing species from highest to lowest relative frequency value gives an idea of which species are most important within the aquatic plant community (Table 14). E/HWM has a relative frequency in the lake of 15.7%. The remaining native aquatic plants impacted by 2,4D herbicides have a combined relative frequency of 22.9% for a total of 38.6%.

Table 14: Aquatic plants impacted by 2,4D herbicides (yellow)

Plant Species	Relative Frequency (%)
*Hybrid watermilfoil	15.7
Najas spp. (naiads)	11.4
Fern-leaf pondweed	10.8
Small pondweed	8.2
Flat-stem pondweed	8.2
Large-leaf pondweed	6.4
Wild celery	5.7
Coontail	5.2
Clasping-leaf pondweed	3.9
Variable pondweed	3.5
Common waterweed	3.3
Muskgrass	3.3
Water stargrass	2.1
Needle spikerush	1.9
Water marigold	1.5
Quillworts	1.5
Bladderwort spp.	1.2
White-stem pondweed	0.9
Spatterdock (yellow lily)	0.9
White water lily	0.8
Nitella	0.8
Watershield	0.7
Arrowhead spp.	0.6
Spiral-fruited pondweed	0.4
Vasey's pondweed	0.3
Bullrush spp.	0.2
Bureed spp.	0.2
Waterwort	0.1
Floating-leaf pondweed	0.1
Pickerel weed	0.1
Northern watermilfoil	0.1
*non-native, invasive	

10.2.2 Whole-lake Application of Sonar® (fluridone)

Whole-lake Sonar applications have been used in MN more frequently than in WI. The MN-DNR has used Sonar at 2-4ppb (µg/L) on several MN lakes as a whole-lake treatment for EWM in the last 10 years (Personal communication, Keegan Lund July 2023). Their data suggests that at these low levels, fluridone can be an effective management tool with minimal negative impacts to native aquatic plants while fully controlling EWM for 3-5 years. Sonar is applied to the entire surface of the lake early in the season and is expected to maintain 2-4ppb up to 90 days. After a couple of weeks or a month, if herbicide concentration testing indicates that the 2-4ppb is not being maintained, an herbicide "bump" application is completed to bring the concentration back to expected values. It may be necessary to do a "bump" treatment more than once in a season to maintain the expected concentration. According to data collected by the MN-DNR two native aquatic species saw significant declines after a whole-lake treatment with Sonar (common waterweed and coontail). Along with E/HWM, these three species have a relative frequency in the lake of 24.2%.

While not wholly supportive of whole-lake fluridone applications, the WDNR has not ruled them out. One of their greatest concerns is that at higher application concentrations of fluridone, it has been shown that many more aquatic plant species are negatively impacted. This sentiment is echoed by a well-respected aquatic plant survey specialist that works on the Quiet Lakes and on many other lakes in MN and WI (Personal communications – Scott Van Egeren (WDNR) and Matt Berg (ERS), July 2023).

In a conversation with the company that markets Sonar, the following application notes were made based on the volume of Lost Land Lake (Table 15).

Table 15: Whole-lake Sonar AS herbicide application and estimated costs for Lost Land Lake

Sonar AS (fluridone) Application on Lost Land Lake				
Application	Concentration	Gallons	Cost/Gallon w/application	Total Cost
Initial Application	4ppb	36.52	$3,000.00	$109,560.00
1st Bump Application (30 days)	2ppb	18.26	$3,000.00	$54,780.00
2nd Bump Application (60 days)	2ppb	18.26	$3,000.00	$54,780.00
		73.04		$219,120.00

Both the application of a liquid 2,4-D herbicide and the application of fluridone would be whole-lake application completed in their entirety in the first year of management. Applying liquid 2,4-D herbicide with the intent to only kill a portion of the total E/HWM present just encourages the build-up of herbicide resistance in the untreated plants. In both cases follow-up aquatic plant survey work and herbicide concentration testing would be required.

10.2.3 Whole-lake Application of ProcellaCOR®

ProcellaCOR has most often been used to complete herbicide treatments of in the range of a few tenths of an acre to up to 20 or 30 acres. There are few examples of whole-lake applications of ProcellaCOR on significantly higher acreage. As a result, how much herbicide should be applied is unclear. The EPA approved label for ProcellaCOR suggests application rates of 1.0 to 25.0 pdus/acft, but only 4-7 pdus/acft for E/HWM. If ProcellaCOR is applied only to the 264 acres of E/HWM at the lowest label rate (1 pdu/acft), ≈2,060 pdus would be needed. At a cost of $65.00 per pdu with application, the estimated cost is $133,848.00 (Table 16). If the amount of herbicide to be applied has to be higher, the estimated costs are reflected in Table 16.

Table 16: Whole-lake ProcellaCOR herbicide application and estimated costs for Lost Land Lake

Whole-lake Application of ProcellaCOR					
E/HWM (acres)	Mean Depth (ft)	Total acft	1.0pdu/acft	1.5pdus/acft	2.0pdus/acft
264	7.8	2059.2	2059.2	3088.8	4118.4
1 pdu = 3.2 oz		Ounces of herbicide	6589.44	9884.16	13178.88
		Gallons of herbicide	51.48	77.22	102.96
Estimated cost w/application: $65.00/pdu			$133,848.00	$200,772.00	$267,696.00

Of the three herbicides in these first three management scenarios, ProcellaCOR is the most selective. The plants most likely to be negatively impacted by ProcellaCOR include E/HWM and northern watermilfoil. Other species that could be negatively impacted include white water lily, spatterdock, pickerel weed, and arrowhead spp.

10.2.4 Partial Lake Treatments with ProcellaCOR

With ProcellaCOR, it may be possible to treat a portion of the lake in each of several years, rather than applying herbicides to the entire 264 acres in a single year. The benefits of doing this include spreading the total cost of management over multiple years instead of just one. The risks of doing this include possible build-up of herbicide resistant plants and re-infestation of treated areas by fragments drifting in from untreated areas, dissatisfied property owners, and increased costs. Overall, the costs of applying ProcellaCOR would likely go up, as the individual areas treated would be "melded" into one large treatment area with corners and dips smoothed out. In addition, the concentration of ProcellaCOR might be increased to accommodate smaller areas. Table 17 and Figure 72 reflect an example of a four-part ProcellaCOR treatment over four years (2024-2027) in Lost Land Lake.

Table 17: Estimated - Preliminary 4-part (four year) ProcellaCOR treatment in Lost Land Lake

Four Part P-COR Application 2024-2027									
Bed	Acres	Mean Depth	Ac-ft	1.0pdu/acft	1.5pdus/acft	2.0pdus/acft	Ounces of Herbicide	Gallons of Herbicide	Expected Cost
Year One									
Camp Road	148.3	8	1186.4	1186.4	1779.6	2372.8	3,796 to 7,593	29.7 to 59.3	$77,116.00 to $154,232.00
Year Two									
North Bay	148.1	8	1184.8	1184.8	1777.2	2369.6	3,791 to 7,583	29.6 to 59.2	$77,012.00 to $154,024.00
Year Three									
Outlet Bay	83.5	8	668	668	1002	1336	2,138 to 4,276	16.7 to 33.4	$43,420.00 to $86,840.00
Year Four									
South Bay	80.1	8	640.8	640.8	961.2	1281.6	2,051 to 4,101	16.0 to 32.0	$41,652.00 to $83,304.00
TOTALS	**460**		**3680**	**Estimated cost w/application: $65.00/pdu**				**Total Project Cost**	**$239,200.00 to $478,400.00**

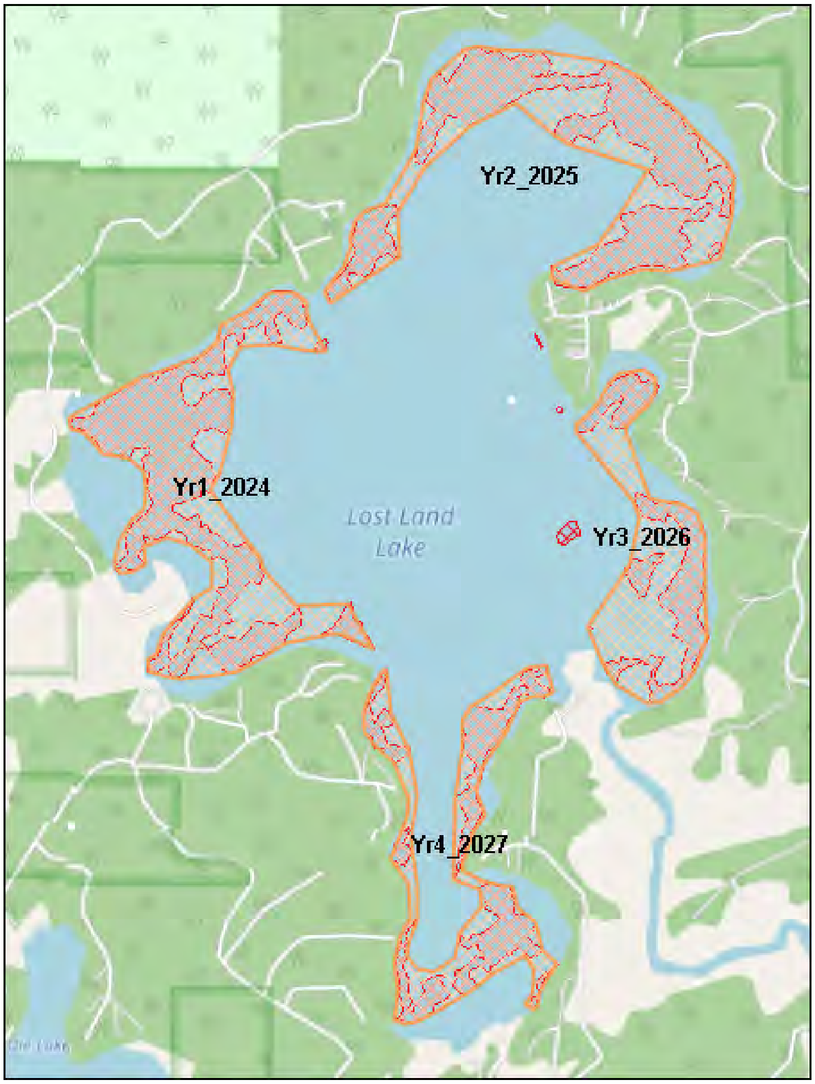

Figure 72: Four-part ProcellaCOR treatment on Lost Land Lake

The shortest distance to cordon off an area to help maintain an herbicide treatment would be about 2,500ft, so it does not seem feasible to actually separate the treated area from the rest of the lake.

10.3 Large-scale Mechanical Harvesting in Lost Land Lake

If there is great hesitation to use aquatic herbicides under the previous scenarios, the alternative would be large-scale mechanical harvesting. Unfortunately, this management method would not be as easy to set up and implement in a short period of time. If contracted services were used, the QLIA would first have to identify a company that could offer mechanical harvesting services on the scale that would be necessary to tackle 260 plus acres of E/HWM in Lost Land Lake. Alternatively, the QLIA could determine those areas most in need of relief and only contract for harvesting in those areas. This could include navigation channels, near boat landings, in front of resorts, and potentially to provide access to private properties. They would have to line up a place to dispose of large quantities of harvested materials and arrange for pick-up of lose fragments washed into the shoreline that are either raked up by property owners or cleaned up by the QLIA.

If the QLIA chose to purchase a large-scale mechanical harvester for their own use, the process would likely take at least two years to complete. Moreover, with 260 plus acres of E/HWM, a single harvester with a 12ft cutting head may not be enough. One lake organization that this consultant works with, mechanically harvests up to 260 acres of CLP each year. They have three 10ft harvesters, and in some years, they still struggle to keep up with the growth and harvesting demand. With a single harvester, break downs would severely hamper successful harvesting operations.

If the QLIA owned a harvester, they would still need to line up a disposal site, purchase equipment to transport harvested materials to the dump site, and provide for their own maintenance, storage, operation, and insurance.

10.4 Application of Aquatic Herbicides in Teal Lake

The amount of E/HWM in Teal Lake is much less than what is in Lost Land – 45 acres as compared to 264 acres. It is also more concentrated in a few areas, rather than spread throughout the entire littoral zone of the lake like it is in Lost Land. While an application of aquatic herbicides would still be considered large-scale, and likely have a lake-wide impact, it would not be "purposely" applied with the intent of establishing a pre-determined concentration of herbicide throughout the entire volume of the lake. Even if it was, calculation of the volume would not include the entire volume of the lake, but rather that portion of lake volume above the thermocline.

Since 2014, only seven dissolved oxygen profiles have been completed during the summer period when Teal Lake would likely be stratified. From those seven profiles, the thermocline sets up at about 24ft between mid-June and mid-September. Based on the 2022 whole-lake, point-intercept survey completed by ERS; the average depth of water above the thermocline is 13.6ft, making the volume of lake water above the thermocline 13,926acft. This value is about 96% of the entire volume of the lake (14,541acft) based on 2022 PI survey results.

10.4.1 Large-scale Application of ProcellaCOR

A herbicide application proposal to treat all 44.5ac of E/HWM in Teal Lake with ProcellaCOR was prepared by SePRO, the company that markets the herbicide. Based on an average depth of 6.0ft for all the E/HWM beds in Teal Lake established during the PI survey, a total of 267acft of water would be treated with ProcellaCOR at 4.5pdus/acft (Table 18). Lessor or greater amounts might be needed and are also reflected in Table 18.

Table 18: Whole-lake ProcellaCOR herbicide application and estimated costs for Teal Lake

Large-scale Application of ProcellaCOR					
E/HWM (acres)	Mean Depth (ft)	Total acft	4.0pdu/acft	4.5pdus/acft	5.0pdus/acft
44.5	6	267	1068	1201.5	1335
1 pdu = 3.2 oz		Ounces of herbicide	3417.6	3844.8	4272
		Gallons of herbicide	26.7	30.0375	33.375
Estimated cost w/application: $65.00/pdu			$69,420.00	**$78,097.50**	$86,775.00

10.4.2 Alternatives to all E/HWM Beds Treated with ProcellaCOR

There are several alternatives to applying ProcellaCOR to every bed and every acres of E/HWM in Teal Lake. Some of the mapped beds are fairly large, or close enough to other beds that when combined, larger treatments areas could be established. When using a liquid 2,4-D-based herbicide, the preferred treatment area is >5.0acres. Several areas could be combined to meet or exceed this preferred area size. These larger areas could be chemically treated with the maximum label rate of 2,4D Amine 4 (4.0ppm). Smaller areas could be chemically treated with ProcellaCOR with 4-5pdus/acft of water.

Even when using ProcellaCOR, an herbicide that has been shown to be effective on smaller beds, combining multiple small beds that are in close proximity of each other to make larger beds is preferred. If an individual bed is not in close proximity to other beds, then this consultant recommends only treating the area if it is at least 0.20 acres in size. Any area smaller than this, is likely best managed through physical removal, in this case with DASH or with the Eco-Harvester. Tables 19-21 reflect how this consultant would combine beds within Teal Lake to make better conditions for management – application of herbicides and DASH. Figure 73 reflects the areas included in the 3-part Teal Lake E/HWM alternative management proposal.

Table 19: 2024 Teal Lake E/HWM Management Part 1 – Application of 2,4D Amine 4® (liquid 2,4D)

2024 Teal Lake Liquid 2,4D Herbicide Application							
Bed #	Acres	Comb Acres	2,4D Acres	Mean Depth (ft)	Acre feet	App Rate (4.0ppm)	Gallons Applied
1	3.4	6.1	8.3	5.5	45.7	2.84gal/acft	129.646
35	2.7						
10	0.4	12.6	17.3	5	86.5	2.84gal/acft	245.66
11	12.2						
26	1.2	5.7	7.6	6	45.6	2.84gal/acft	129.504
27	4.5						
28	1.2	10.4	14.7	6	88.2	2.84gal/acft	250.488
29	0.3						
30	1.1						
31	7.8						
	34.8	34.8	47.9		266.0		755.298
755.30	$45.00	$33,988.41					

Table 20: 2024 Teal Lake E/HWM Management Part 2 – Application of ProcellaCOR®

2024 Teal Lake ProcellaCOR Herbicide Application							
Bed #	Acres	Comb Acres	P-COR acres	Mean Depth (ft)	Acrefeet	Application (pdus/acft)	Total pdus
5	1.03	1.03		5	5.15	4.5	23.2
6	0.27	0.27		5	1.35	4.5	6.1
8	0.26	0.26		5	1.3	4.5	5.9
12	0.95	4.5	9.72	5.2	50.544	4.5	227.4
16	2.06						
17	0.2						
18	1.06						
19	0.23						
20	0.32	2.33	3.92	6	23.52	5	117.6
21	1.03						
22	0.26						
23	0.72						
24	0.63	0.63		6	3.78	5	18.9
	9.02	9.02			85.644		399.0
						Ounces	1277.0
399	$65.00	$25,935.00				Gallons	10.0

Table 21: 2024 Teal Lake E/HWM Management Part 3 – Contracted DASH Services

2024 DASH		
Bed #	Acres	Mean Depth (ft)
2	0.1	5
3	0.01	6
4	0.04	5
7	0.09	5
9	0.13	5
13	0.06	4
14	0.04	4
15	0.01	4
25	0.05	6
32	0.15	5
33	0.09	5
34	0.01	8
	0.78	
3 days (estimated)		$2600/day

Figure 73: 2024 Teal Lake 3-part E/HWM management proposal. Purple areas = combined beds for 2,4D treatment. Yellow areas = combined beds for ProcellaCOR treatment. Black areas = DASH beds. Red areas = original beds for ProcellaCOR treatment.

Combining all three parts of management in 2024 (liquid 2,4D, ProcellaCOR, and DASH) the estimated cost is represented in Table 22. This total cost is ≈ $10,374.00 less expensive than using only ProcellaCOR on all mapped beds, but would require a greater amount of coordination and organization on the part of the QLIA and their supporters.

Table 22: Total Estimated Costs for 2024 Teal Lake 3-part E/HWM Management

Esitmated Total 2024 Teal Lake E/HWM Management Costs	
2,4D	$33,988.41
P-COR	$25,935.00
DASH	$7,800.00
	$67,723.41

Other alternatives would include removing additional beds from the herbicide application plan and instead, focus management on using physical removal/DASH and/or the Eco-Harvester.

10.5 E/HWM Management in the Teal River Flowage and Ghost Lake

At the present time, no management of E/HWM is included in this APM Plan. After the population of E/HWM in Lost Land and Teal Lakes are reduced, attention could be shifted to the Teal River Flowage. Management of E/HWM would be more difficult in the Flowage due to water movement (herbicides) and rocks and shallow water (harvesting).

Should regular monitoring in Ghost Lake identify E/HWM, many of the same management alternatives discussed for Lost Land and Teal Lakes could be implemented.

10.6 General E/HWM Management Guidelines

Once the amount of E/HWM in both lakes has been reduced to much lower levels, and/or if a new infestation is found in Ghost Lake, a more traditional approach to management can be implemented. In general, E/HWM 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 E/HWM in the lakes can be managed at any time if, aquatic herbicides are not used. Non-chemical management actions that can be used at any time include hand pulling, rake removal, snorkel/scuba diver removal, DASH, and mechanical pulling via the Eco-Harvester.
    a. Both DASH and use of the Eco-Harvester require a mechanical harvesting permit from the WDNR.
3) Chemical management of E/HWM may be implemented if prior year mapping identifies any single area that is ≥0.20 acres, or multiple areas that total more than an acre.
    a. On E/HWM beds that are candidates for chemical treatment **AND** <5.0 acres, ProcellaCOR® should be used.
        i. If a limno-barrier or curtain is used, then other herbicides can be considered.
    b. On E/HWM beds from 5.0-10.0 acres, ProcellaCOR, 2,4D-based, or triclopyr-based herbicides can be used based on the financial resources available.
        i. If possible, installation of a limno-barrier or curtain could be used to help contain the treatment area, particularly if a 2,4D or triclopyr herbicide is used.
    c. When E/HWM beds in either 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 E/HWM beds in either lake exceed a littoral frequency ≥25% and it is clear that targeted treatments will no longer be effective, whole-lake, low dose herbicide applications can be considered.

i. Sonar (fluridone), liquid 2,4-D, and ProcellaCOR could all be used in a low dose application.

e. The same area will not be chemically treated with the same herbicide, two years in a row.

4) Mechanical Harvesting of E/HWM could be substituted or added to the management actions currently being used if the QLIA were to decide not to use aquatic herbicides once the amount of E/HWM has been reduced.

a. Develop the capacity to purchase, maintain, and operate at least one mechanical harvester with at least a 10ft wide cutting head.

i. Recreational Boating Facilities Grant Program (up to 50% of the cost to purchase the harvester and necessary equipment)

b. Identify at least one dumping site for harvested plant material and provide the necessary equipment to transport material from the harvester to the dumping site.

c. Mechanical harvesting requires a mechanical harvesting permit from the WDNR.

10.7 2024 E/HWM Management Recommendations

10.7.1 Lost Land Lake

The WDNR has some reservations about completing whole-lake E/HWM chemical treatments using Sonar (Personal Communication, S. Van Egeren 2023). They also have reservations about chemically treating the entire body of Lost Land Lake in the same year (Personal Communication, M. Wolter 2023). With this in mind, a staggered approach (3-4 years) to E/HWM management using ProcellaCOR is recommended by this Consultant. However, it is not this Consultant's decision to make. The purpose of this APM Plan was to lay out possible management scenarios that would likely receive consideration by the WDNR and other Stakeholders, and likely approval. The final decision on how management of E/HWM in Lost Land Lake is implemented is up to the QLIA and the WDNR, with input from other Stakeholders.

10.7.2 Teal Lake

This consultant recommendation for Teal Lake is to use a three stage approach to management of E/HWM in the first year of management that combines the use of ProcellaCOR, liquid 2,4D, and physical removal via the Eco-Harvester. At a little more than 40 acres of E/HWM, this approach addresses all of the E/HWM in the lake in a single year, minimizing the opportunity for E/HWM to build up a resistance to the herbicide used. However, like in Lost Land Lake, it is not this Consultant's decision to make.

10.7.3 Grant Application

In both cases, a decision does need to be made prior to September 15, 2023 in order to include estimates for control work in a WDNR Surface Water Large-scale AIS Population Control grant application for funds to support management beginning in 2024.

11.0 Aquatic Plant Management Goals

This Aquatic Plant Management Plan establishes the following goals for aquatic plant management in the Quiet Lakes:

5. **E/HWM Management.** Limit the spread of E/HWM through environmentally responsible methods to benefit the native plant community while maintaining E/HWM at manageable levels.

6. **AIS Education, Monitoring, and Prevention.** Continue to educate property owners and lake users on all aquatic invasive species through public outreach and education programs to help identify AIS and discuss the issues related to them. Efforts should include watercraft inspection at the most used landings on Lost Land Lake and improved signage should be installed on all other landings. AIS monitoring should be completed regularly on each lake.

7. **Research and Monitoring.** Develop a better understanding of the lake and the factors affecting lake water quality through continued and expanded monitoring efforts. Monitoring of AIS and other aquatic plants will help to determine the effectiveness of management actions.

8. **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.

11.1 Goal 1 - EWM Management

After several years of E/HWM management using only the Eco-Harvester, the amount of E/HWM, particularly in Lost Land Lake has increased to a total acreage and density that is difficult to manage using more traditional, smaller scale, actions. Once the larger infestation is brought down to a much lower level, then a combination of more traditional methods that include use of the Eco-Harvester, physical removal, DASH, and limited use of herbicides can probably keep the level low.

The amount of E/HWM in Teal Lake has likely not yet begun to negatively impact lake use or the health of the native aquatic plant community, however, if left to continue spreading, it could. Results from the 2022 whole-lake PI survey indicated that aquatic plants grew to a maximum depth of 12.5ft. The area of the lake that is ≤12.5ft is about 390 acres. E/HWM currently is found in approximately 45 of those 390 acres (11.5%); it has plenty of room to expand if left unmanaged. Similar to Lost Land, an initial large-scale management action (likely the application of an aquatic herbicide) would reduce the current amount of E/HWM in the lake. Once that was completed, more traditional approaches to management including use of the Eco-Harvester, physical removal, DASH, and limited use of herbicides can probably keep the level low.

11.1.1 Pre and Post Treatment and Treatment Readiness Surveys

Initial management of E/HWM to reduce the population will be based on PI survey data and bed mapping from 2022. However, during and after the initial management action, pre and post-treatment aquatic plant survey work should be completed. For Lost Land Lake that likely means repeating the whole-lake PI survey in the summer of 2024 and again in the year following initial application. If the treatment is spread out over several years, then whole-lake PI surveys should be done in each year.

For Teal Lake, it likely means setting up a sub-set of pre and post-treatment survey points based on the size of the treatment areas and completing plants surveys in the year of management and at least in the year following initial management.

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.

11.1.2 Fall Bed Mapping

After the first management action is implemented on both lakes, future management actions would be based on annual 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 E/HWM is completed. With the fall bed mapping survey data, proposed treatment maps can be created.

11.2 Goal 2 – Education, Monitoring, and Prevention

Aquatic invasive species (AIS) can be transported via a number of vectors, but most invasions are associated with human activity.

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 well-established.

It is recommended that the QLIA 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 of each lake (and the Teal River Flowage) looking for invasive 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 QLIA 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 QLIA 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 QLIA 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.

11.3 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* are collected. If the necessary equipment is available to collect dissolved oxygen profiles, these are encouraged at least monthly as well.

Volunteer have been collecting water clarity and water quality data on the Quiet Lakes fairly regularly over the last decade or so. This level of monitoring should continue and potentially be expanded when large-scale control of vegetation is implemented. Water sampling could be done for a period of several weeks to a month or more after treatment to see if water quality changes. Temperature and DO profiles should also be increased during and after any large-scale management action to control aquatic plants. 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.

Results of water quality and aquatic plant monitoring should be shared with the lake community and relative stakeholders at the annual meeting, and other events or via digital means to promote a greater understanding of the lake ecosystem and potentially increase participation in planning and management.

11.4 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 QLIA and its 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, Sawyer County, other Stakeholders, 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.

12.0 Timeline of Activities and Potential Funding

The activities in this APM Plan are designed to be implemented over a 5-year period beginning in 2024. 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. A 5-year timeline of activities and whether they are likely to be eligible for grant funding is included as an additional support document for this APM Plan.

12.1 Potential Funding – WDNR Surface Water Grant Program

There are several WDNR grant programs that may be able to assist the QLIA in implementing the new APM Plan for the Quiet Lakes. 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.

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