Half Moon Lake Aquatic Plant Management Plan

Prepared for
Half Moon Lake Protection and Rehabilitation District

November 2023

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Acknowledgments

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Ellen Butler	Chairperson, Half Moon Lake Protection and Rehabilitation District
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Mike Waller	Board Member, Half Moon Lake Protection and Rehabilitation District
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Executive Summary

Eurasian watermilfoil (EWM), an invasive plant not native to Wisconsin, was first observed at the Half Moon Lake boat landing on October 6th, 2021. A bed mapping survey of the EWM on October 30th, 2021 indicated it covered about 0.59 acres (0.24% of the plant inhabitable area) (ERS, 2021). The Half Moon Lake Protection and Rehabilitation District (District) with assistance from Barr Engineering Co., applied for and was awarded a WDNR Rapid Response Grant to help fund EWM management efforts and preparation of an Aquatic Plant Management Plan (APM Plan). The District managed EWM during 2022 and 2023.

EWM removal in 2022 was fairly successful, but not all EWM was removed. Within the 22 acres managed for EWM in 2022, EWM was only visually observed at 1 sample location during fall bed-mapping surveys. However, spread of EWM to areas not managed in 2022 resulted in EWM beds with an extent of 1.0 acre and single EWM plants at two locations during fall 2022. The lengthy Wisconsin Department of Natural Resources (WDNR) permitting process hindered efforts to prevent the spread of EWM. EWM was allowed to spread until late summer when EWM removal was permitted. No EWM removal occurred in the additional EWM areas resulting from this spread.

EWM removal in 2023 was unsuccessful. WDNR did not permit the use of ProcellaCOR to remove EWM from the lake in 2023. A Diver Assisted Suction Harvesting (DASH) permit was issued on June 21 for removal of the EWM documented by the fall 2022 plant surveys and EWM removal occurred on July 17-21, the earliest available DASH removal dates. Removal of EWM in mid-summer was challenging because the EWM was mixed with densely growing native plants in the southern and eastern areas of the lake where most of the DASH removal occurred. In addition, EWM was growing more densely in 2023 than 2022. EWM removal in 2022 averaged 19 cubic feet per acre compared with 46 cubic feet per acre in 2023. The challenges slowed DASH removal and made it difficult to effectively remove the EWM. Consequently, EWM removal only occurred in 7 of the 15 areas intended for DASH removal during the scheduled one week period. An August 2, 2023 bed-mapping survey found a continued presence of EWM in all 7 of the DASH removal areas. DASH removal of some EWM resulted in a decline of EWM extent from 2.57 acres on June 5, 2023 to 1.86 acres on August 2, 2023. Rapid spread of EWM caused its extent to more than double between August 2 (1.86 acres) and October 8 (5.76 acres). An August 24 plant survey documented a significant increase in EWM frequency in the lake between June 5 and August 24 despite DASH removal efforts.

The District plans to continue EWM management to prevent or minimize nuisance conditions in the lake. Because DASH removal of EWM was ineffective in 2023, herbicide treatment will be used for future EWM management. Use of herbicide is consistent with the results of a 2023 survey of Half Moon Lake property owners in which 74 percent of respondents either strongly supported or supported the use of herbicide to remove EWM and 83 percent either strongly oppose or oppose no active management of EWM. When herbicide treatment is used, herbicide, dose, and application methods within each treatment area will be selected to attain EWM control based upon past experience with EWM herbicide treatments and the latest research studies. Herbicides likely to be used for large scale treatments are 2,4-D and fluridone. Herbicides likely to be used for small scale treatment are ProcellaCOR, diquat, and Aquastrike. DASH or

SCUBA removal of EWM could be considered in the future for small areas of EWM if plant density of both EWM and native plants are low and it was feasible to remove root crowns by digging them out should plants break off during the removal process.

While EWM is the primary invasive species of concern, the presence of yellow iris poses a threat to the lake's native plant community on or near the lake's shore. Yellow iris was first observed in Half Moon Lake in 2018 and has been successfully managed since 2021. The Half Moon Lake Protection and Rehabilitation District contracted with an applicator to chemically treat the yellow iris observed along the shoreline of Half Moon Lake in 2021. In 2022-2023, the District completed a boat survey in June to look for yellow iris along the lake's shoreline. When yellow iris was seen, the boat was parked and the homeowner informed of the presence of yellow iris and how to get rid of it (chemical treatment or hand digging). After becoming aware of the presence of yellow iris and how to remove it, homeowners have removed the yellow iris. This management approach has been successful and yellow iris was not observed in Half Moon Lake during July 1, 2022 and July 1, 2023 plant surveys. The District intends to continue its efforts to survey the shoreline, alert homeowners when yellow iris is observed, and encourage homeowners to remove it to prevent or minimize nuisance conditions. Continued management of yellow iris is consistent with the results of a 2023 citizen survey in which 83 percent either strongly oppose or oppose no active management of yellow iris, 59 percent either support or strongly support the use of herbicides to manage yellow iris, and 68 percent either support or strongly support the use of hand digging to manage yellow iris.

Curly-leaf pondweed (CLP) has been observed in Half Moon Lake since 2007. However, its presence has been limited to a few locations in 5 to 10 feet of water over organic muck and there is very little of this type of habitat in the lake. CLP has not yet been managed, but could be managed in the future to keep it to a low occurrence and prevent the accumulation of turions (i.e., similar to seeds). This approach would minimize or prevent nuisance conditions and may avoid the need for long-term annual treatments to reduce an established population that can rebound once larger numbers of turions are present in the sediments. This approach (i.e., to treat or remove small areas of CLP when warranted) is similar to treating small areas of CLP observed after a large-scale treatment to prevent a return of CLP to pre-treatment conditions. A large majority of respondents to a 2023 citizen survey (62 percent) support reducing the amount of CLP in the lake to avoid future population growth.

Respondents to a 2023 citizen survey indicated Half Moon Lake is a busy lake with broad recreational use. About 80 percent of respondents felt lake use was impaired by the current level of plant growth and 64 percent believed the volume of plants in the lake has increased in the last five years. When asked to rank the degree of impact that invasive species have on use or enjoyment of the lake, 36 percent indicated high impact and 31 percent indicated moderate impact. A majority (54 percent) supported removing native plants in navigation channels if they interfere with boat navigation.

The negative impact to the lake's plant community caused by the introduction of EWM clearly shows the vulnerability of the ecosystem to harmful introductions of invasive species. Half Moon Lake is a busy lake and, hence, vulnerable to the accidental introduction of additional invasive species. A large majority (84

percent) support increasing the boat inspection program to include more staffed hours at the boat landing to protect the lake from accidental introduction of additional invasive species.

Results of the citizen survey were used to select eight APM Plan goals for Half Moon Lake. The goals are shown in Figure ES-1.

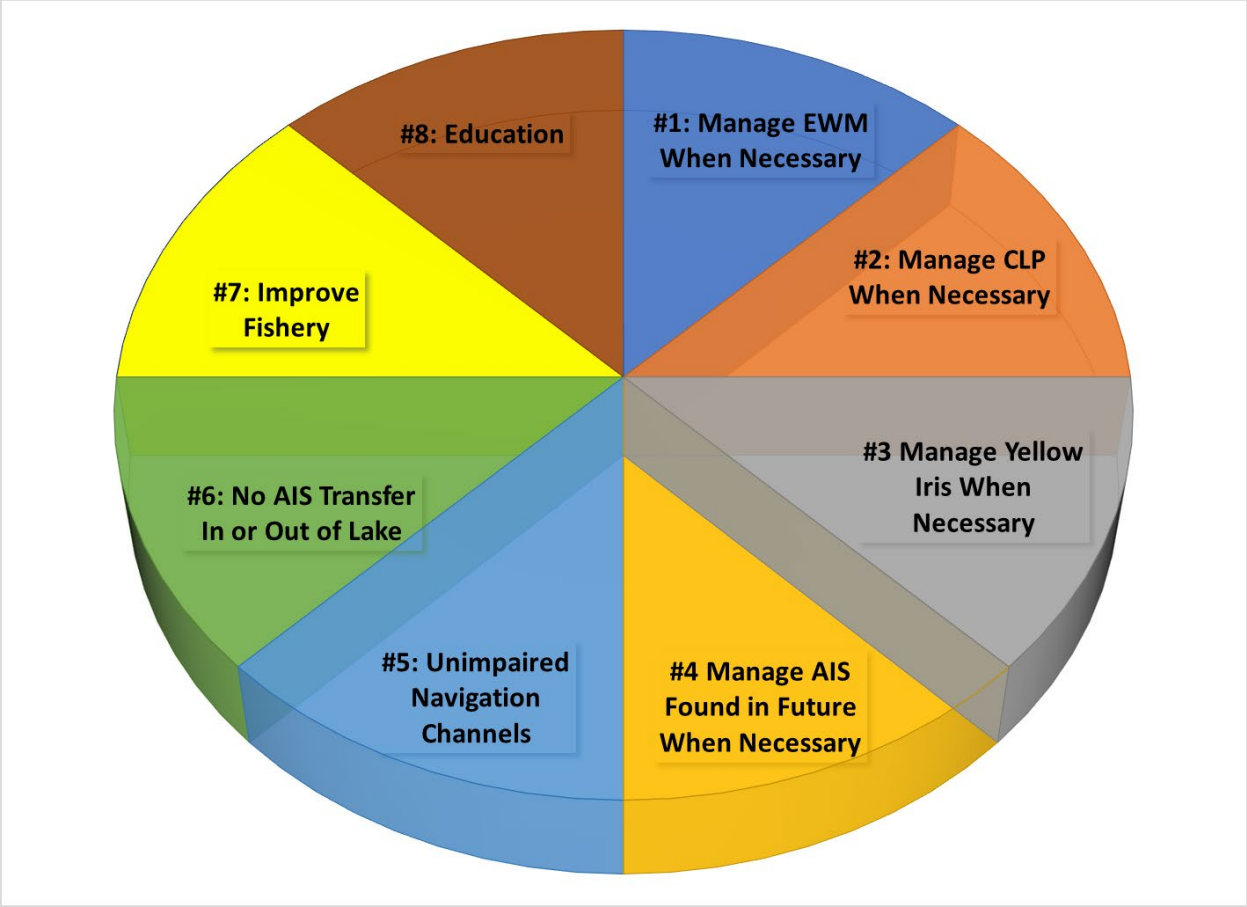

Figure ES-1 Half Moon Lake APM Plan Goals

This APM Plan details objectives and strategies to attain the eight goals as well as measurements to assess success of the strategies. Goals, objectives, strategies, and measurements of the Half Moon Lake APM Plan are summarized in Table ES-1.

Table ES-1 Half Moon Lake Goals, Objectives, Strategies, and Measurements

Goals	Objectives	Strategies	Measurements	
			Yes	No
Goal 1: EWM will be managed when necessary to prevent or minimize nuisance conditions through an integrated pest management approach.	***Objective 1:*** *Protect the lake's ability to support recreational uses such as boating, fishing, swimming, and enjoying the view.*	**Strategy 1:** Complete fall bed-mapping plant survey to determine if EWM present and, if so, locations.		
		Strategy 2: If EWM present in fall bed-mapping survey, complete EWM removal plan for subsequent year.		
		Strategy 3: If WDNR permit required for EWM removal, complete application for permit and submit to WDNR.		
	Objective 2: *Protect fisheries habitat and the overall health of the lake.*	**Strategy 4:** Complete EWM removal when WDNR permit received or as soon as possible if no permit required.		
		Strategy 5: Complete bed-mapping surveys in June, July, and/or August to determine if EWM present and, if so, EWM locations.		
	Objective 3: *Protect wild rice and other native species from displacement by EWM.*	**Strategy 6:** Complete early-July whole lake point intercept survey of all plants.		
		Strategy 7: If EWM present in June, July, and/or August surveys, develop EWM removal plan.		
		Strategy 8: If WDNR permit required for EWM removal, complete application for permit and submit to WDNR.		
	Objective 4: *Reduce EWM management cost.*	**Strategy 9:** Complete EWM removal when WDNR permit received or as soon as possible if no permit required.		
		Strategy 10: Assess early-July point intercept data to determine native plant response to EWM removal.		
Goal 2: Curly-leaf pondweed (CLP) will be managed when necessary to prevent or minimize nuisance conditions through an integrated pest management approach.	***Objective 1:*** *Prevent CLP dominance and the subsequent long-term annual control to hold the plant back from resurgence to dominance.*	**Strategy 1:** Complete annual point intercept plant survey in early-July.		
	Objective 2: *Protect the lake's water quality from degradation due to nutrient addition from senescing CLP in July following its annual late-June die-off.*	**Strategy 2:** Whenever CLP is present in the early-July point intercept plant survey, complete CLP pre-treatment plant survey in subsequent spring to identify CLP removal areas and determine an appropriate CLP removal plan.		
	Objective 3: *Protect the lake's ability to support recreational uses such as boating, fishing, swimming, and enjoying the view.*	**Strategy 3** If WDNR permit required for CLP removal, complete application for permit and submit to WDNR.		
	Objective 4: *Protect fisheries habitat and the overall health of the lake.*	**Strategy 4:** Conduct CLP removal when WDNR permit received or as soon as possible if no permit required.		
	Objective 5: *Protect wild rice and other native species from displacement by CLP.*	**Strategy 5:** Following CLP removal, complete annual point intercept plant survey in early-July and assess data to determine CLP removal effectiveness and native plant response to CLP removal.		
Goal 3: Yellow iris will be managed when necessary to prevent or minimize nuisance conditions through an integrated pest management approach.	***Objective 1:*** *Protect native species from displacement by yellow iris.*	**Strategy 1:** Conduct boat survey of shoreline areas of lake to identify/document locations where yellow iris is present.		
	Objective 2: *Protect shoreland habitat and the overall health of the lake.*	**Strategy 2:** Discuss yellow iris presence and yellow iris removal plan with property owners; identify and agree upon removal plan.		
	Objective 3: *Reduce yellow iris management cost.*	**Strategy 3:** Property owners remove yellow iris per agreed upon removal plan.		
Goal 4: Additional Aquatic Invasive Species (AIS) found in the lake in the future will be managed when necessary to prevent or minimize nuisance conditions through an integrated pest management approach.	***Objective 1:*** *Protect the lake's ability to support recreational uses such as boating, fishing, swimming, and enjoying the view.*	**Strategy 1:** Complete annual point intercept plant survey in early-July.		
	Objective 2: *Protect fisheries habitat and the overall health of the lake.*	**Strategy 2:** Whenever an AIS species not previously present in the lake is identified/documented, identify AIS removal plan.		
	Objective 3: *Protect wild rice and other native species from displacement by AIS.*	**Strategy 3:** If WDNR permit required for AIS removal, complete application for permit and submit to WDNR.		
	Objective 4: *Reduce management costs.*	**Strategy 4:** Conduct AIS removal when WDNR permit received or as soon as possible if no permit required.		

Table ES-1 Half Moon Lake Goals, Objectives, Strategies, and Measurements *(Continued)*

Goals	Objectives	Strategies	Measurements	
			Yes	No
Goal 5: Maintain navigation channels/riparian access corridors that are not impaired by native plants and invasive plant growth.	***Objective 1:*** *Protect the lake's ability to support recreational uses such as boating, pontooning, and fishing.*	**Strategy 1:** Determine and document navigation channel/riparian access corridor impairment annually during summer plant surveys completed by District representative.		
		Strategy 2: Riparian residents to report channel/riparian access corridor impairment to District and provide impairment documentation.		
		Strategy 3: Complete permit application to treat impaired navigation channels and/or impaired access corridors and submit to WDNR. Submit documentation of impairment with permit application.		
		Strategy 4: Complete permitted treatment.		
	Objective 2: *Provide riparian owners with the ability to access and navigate the lake with their boats and pontoons.*	**Strategy 5:** Complete whole lake point intercept summer survey annually and assess data to evaluate the lake's plant community, including treated areas.		
Goal 6 Prevent transfer of invasive plant and animal species both to and from Half Moon Lake.	***Objective 1:*** *Protect the lake's ability to support recreational activities.*	**Strategy 1:** Fully fund the Half Moon Lake's Clean Boats/Clean Waters boat inspection program if grant money is not available. If grant money is available to fund 75 percent of the program cost, fund the 25 percent local cost share.		
		Strategy 2: CBCW inspectors attend yearly CBCW training provided by Polk County in partnership with WDNR every spring.		
	Objective 2: *Protect the lake's fishery.*	**Strategy 3:** Provide educational material to each lake user whose boat is inspected by the Clean Boats/Clean Waters program.		
		Strategy 4: Place signage at each boat landing educating boaters to clean boats and trailers of any plant materials before entering and leaving the lake.		
	Objective 3: *Containment of EWM, CLP, yellow iris and any additional AIS found in the future to prevent the introduction of AIS to other lakes.*	**Strategy 5:** A Boat Cleaning Station was installed by the District at the public access located within the City of Milltown Park (Figure 2-1) for boaters to use to clean boats and trailers of any plant materials before entering and leaving the lake. Place signage at the Boat Cleaning Station educating boaters to use it to clean boats and trailers of any plant materials before entering and leaving the lake.		
	Objective 4: *Prevent introduction of AIS to Half Moon Lake.*	**Strategy 6:** Educate readers by including information in each newsletter on removing plants and animals from boats before entering or leaving the lake.		
Goal 7: Improve the fishery resource through proper management of aquatic plants.	***Objective 1:*** *Improve fishery habitat through removal of AIS.*	**Strategy 1:** Select and implement effective removal methods to optimize removal of EWM, CLP, yellow iris, and/or any other AIS while minimizing harm to native plants.		
	Objective 2: *Protect fishery habitat by minimizing harm to the native plants found in the lake while removing AIS.*	**Strategy 2:** Complete summer whole lake point intercept survey and assess data to determine AIS removal effectiveness and native plant response to AIS removal.		
Goal 8: Provide educational materials to educate the public about AIS and progress on goals and strategies of the Half Moon Lake Protection and Rehabilitation District.	***Objective 1:*** *Help residents protect the attributes of the lake they most enjoy.*	**Strategy 1:** Provide education materials and report progress on attaining District goals and strategies at annual meeting.		
	Objective 2: *Help residents protect fish and wildlife habitat and the overall health of the lake.*	**Strategy 2:** Provide education materials and report progress on attaining District goals and strategies in District newsletters and on the District website.		
	Objective 3: *Keep the public informed about progress on attaining District goals and strategies of the Half Moon Lake Protection and Rehabilitation District.*	**Optional Strategy 3:** Use other media to provide education materials and report about progress on attaining District goals and strategies.		

This APM Plan describes the framework for AIS control activities that include the required elements of the APM Plan. Herbicide treatment (and all attendant monitoring) is a critical element to be reviewed and will be used to plan and apply for each WDNR permit for AIS control activities per the requirements detailed in Chapter NR 107 of the Wisconsin Administrative Code. New technical developments for control of AIS will be incorporated into the AIS control activities as they become available to optimize the control of AIS.

This APM Plan intends to meet the permitting requirements of State Statute 23.24(3)(b) and Wisconsin Administrative Code NR 109.04(3) that state "The department may require that an application for an aquatic plant management permit contain a plan for the department's approval as to how the aquatic plants will be introduced, removed, or controlled." The APM Plan intends to meet the requirements in Wisconsin Administrative Code NR 198.43 (Table 1-1) as well as the requirements in Aquatic Plant Management in Wisconsin (Table 1-2).

This APM Plan fulfills the need of a long-term commitment to AIS management. The District intends to continue Aquatic Invasive Species (AIS) management in Half Moon Lake indefinitely. This APM Plan is not limited to a 5-year period. With an approved APM Plan, the District may apply for cost-share dollars from the Wisconsin Department of Natural Resources (WDNR). However, the District is firmly committed to continued implementation of this APM Plan if cost-sharing money is not available.

Half Moon Lake Aquatic Plant Management Plan

November 2023

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1.0 Introduction

Half Moon Lake in Polk County, Wisconsin is valued by lakeshore property owners, area residents, Polk County, and the Wisconsin Department of Natural Resources (WDNR) for its fisheries and for its recreational uses (see Figure 1-1). The lake has a surface area of 550 acres, a maximum depth of 60 feet, and an average depth of 25 feet.

Figure 1-1 Half Moon Lake

Eurasian watermilfoil (EWM), an invasive plant not native to Wisconsin, was first observed at its boat landing on October 6th, 2021. A bed mapping survey of the EWM on October 30th, 2021 indicated it covered about 0.59 acres (0.24% of the plant inhabitable area) (ERS, 2021). The Half Moon Lake Protection and Rehabilitation District (District) with assistance from Barr Engineering Co., applied for and was awarded a WDNR Rapid Response Grant to help fund EWM management efforts and preparation of an Aquatic Plant Management Plan (APM Plan). The District managed EWM during 2022 and 2023.

Although management of EWM is the focus of the District's aquatic invasive species (AIS) management program, a second AIS, yellow iris, poses a threat to native vegetation on or near the lake's shore. Yellow iris was first observed in the lake during an aquatic plant survey in 2018 and was managed during 2021-2023.

The District is completing this APM Plan to guide their management efforts for current and future AIS. The APM Plan intends to fulfill the permitting requirements of State Statute 23.24(3)(b) and Wisconsin Administrative Code NR 109.04(3) that state: "The department may require that an application for an aquatic plant management permit contain a plan for the department's approval as to how the aquatic plants will be introduced, removed, or controlled." The APM Plan intends to meet the requirements in Wisconsin Administrative Code NR 198.43 (Table 1-1) as well as the requirements in Aquatic Plant Management in Wisconsin (Table 1-2).

Table 1-1 Report Directory of Fulfillment of NR 198.43 Requirements for an Aquatic Plant Management Plan

NR 198.43 Requirement				Section/Appendix
NR 198.3			NR 198.43 Sponsors shall prepare a management plan and submit it to the department for approval before applying for a control project under s. NR 198.42 (1) (a)	--
	(1)		A management plan shall include all of the following:	--
		(a)	An identification of the problems or threat to the aquatic ecosystem presented by the aquatic invasive species including recreational uses and other beneficial functions up to the time of application, and how these uses and functions may have changed because of the presence of aquatic invasive species	Section 10.0
		(b)	A description of the historical control actions taken or those that are in progress	Section 7.0
		(c)	A thorough characterization of the waterbody's aquatic ecosystem's historical and current condition, including at least one year of current base line survey data quantifying the extent of the population	Sections 4.0-8.0
		(d)	An assessment of the sources of watershed pollution and a strategy for their prevention and control.	Section 3.0
		(e)	An assessment of the fishery, wildlife, and aquatic plant community	Sections 4.0, 7.0, and 8.0
		(f)	An identification of the need for the protection and enhancement of fish and wildlife habitat, endangered resources, and other local natural resource concerns.	Sections 4.0 and 10.0
		(g)	Identification of the management objectives needed to maintain or restore the beneficial uses of the aquatic ecosystem including shoreland and shallow area protection and restoration.	Section 12.0
		(h)	Identification of target levels of control needed to meet the objectives.	Section 12.0
		(i)	Identification and discussion of the alternative management actions considered and proposed for aquatic invasive species control including expected results.	Section 11.0 and Appendix H
		(j)	An analysis of the need for and a list of the proposed control actions that will be implemented to achieve the target level of control.	Section 12.0 and Appendix H
		(k)	A discussion of the potential adverse impacts the project may have on non-targeted species, drinking water or other beneficial waterbody uses.	Section 14.0
		(l)	A strategy for effectively monitoring and preventing the reintroduction of the aquatic invasive species after the initial control and to reasonably assure that new introductions of aquatic invasive species will not populate the waterbody.	Section 12
		(m)	A contingency strategy for effectively responding to the reintroduction of the aquatic invasive species after the initial control.	Section 12.0
		(n)	Sufficient information for determining the feasibility of alternative control measures, including costs; the relative permanence of the control; the potential for long-term control of the causes of infestation; and the baseline data required to measure subsequent change.	Section 11.0 and Appendix H, Sections 7.0 and 12.0

Table 1-2 Report Directory of Fulfillment of Requirements for an Aquatic Plant Management Plan in Aquatic Plant Management in Wisconsin

Chapter 2 Requirement	Section/Appendix
1. Goal Setting	Section 12.0
2. Inventory	Sections 2.0-9.0
3. Analysis	Sections 7.0-10.0
4. Alternatives	Section 11.0 and Appendix H
5. Recommendations	Section 12.0
6. Implementation	Section 12.0 and Appendix I
7. Monitor and Modify	Sections 12.0-13.0

The Half Moon Lake APM Plan includes management of non-native invasive species, such as EWM, shown in the picture immediately to the right, to prevent displacement of native species, such as water lily and wild rice, shown in the far right picture. Photo Credit: Endangered Resource Services LLC.

1.1 Public Input for the APM Plan

Public input was an important part of APM Plan development. Opportunities for public involvement in APM Plan development have included a citizen survey and an opportunity to review the APM Plan posted on the District website and submit comments to the District. The public has been informed of opportunities to provide input on the APM Plan development through the District website. Appendix A provides public input details.

2.0 Lake and Watershed Information

2.1 Lake

Half Moon Lake, located in the Town of Milltown in Central Polk County, Wisconsin, is a 550-acre stratified drainage lake (Figure 2-1). It reaches a maximum depth of 60 feet in the deep hole on the southeast end of the central basin and has an average depth of 25 feet (WDNR 2022).

Harder Creek enters Half Moon Lake on the north end of the lake and exits the lake on the west side of the lake. A two-foot high dam is present at the outlet. Tamarack Creek enters through the Tamarack Bay area at the northwest corner of the lake.

The lake has seven miles of shoreline. The lakeshore is developed with dwellings.

Two carry-in and two ramp boat landings provide access to Half Moon Lake. The ramp access on the northwest end of the lake is within a park owned by the Town of Milltown that also has a fishing pier, bathrooms, swimming beach, and a picnic shelter. The Town of Milltown owns three additional parcels that reach the waters' edge. Collectively, the public boat landings provide a total of 17 car/trailer parking spaces, which satisfy the requirement of Wisconsin Administrative Code NR 1.91 public boating access standards for WDNR decisions related to providing natural resource enhancement services.

Half Moon Lake, shown above, is located in the town of Milltown in Central Polk County, WI.

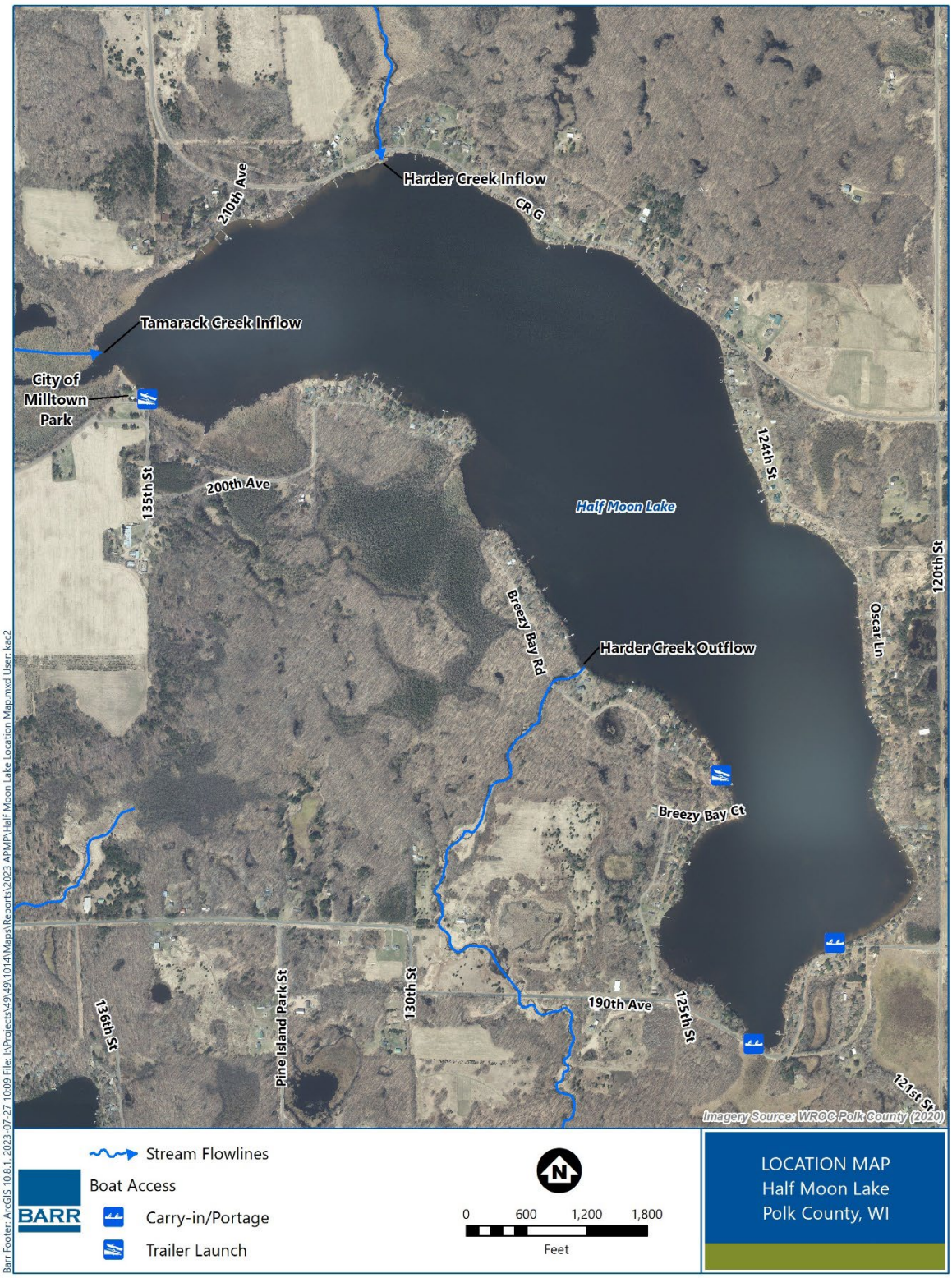

Figure 2-1 Half Moon Lake Location Map

2.2 Watershed

The Half Moon Lake watershed is the land area that drains to the lake. The lake's watershed includes about 5,100 acres and extends about 3 ½ miles north of the lake. The watershed is about 74 percent natural areas of forest, wetland, and grassland, 13 percent row crops, and 5 percent residential use. The rest of the watershed includes commercial use, farmsteads, barren land, and open water (Harmony Environmental, 2007). Table 2-1 summarizes Half Moon Lake watershed land cover.

The watershed is divided according to whether or not surface runoff flows to the lake and, if so, how directly. In some areas, large ponds and extensive wetland areas capture runoff water and overflow only in periods of very high water. These "high retention" areas capture large quantities of runoff and the sediment and nutrients found in the runoff. "Direct drainage" areas drain directly to the lake. The watershed's "direct drainage" area contributes the greatest amount of runoff to the lake. "Landlocked" areas do not contribute surface runoff to the lake (Figure 2-2).

Table 2-1 Half Moon Lake Watershed Land Cover[1]

Land Cover Type	High Retention Area (ac)	% of High Retention Acres	Direct Drainage Area (ac)	% of Direct Drainage Acres	Total Watershed Area (ac)	% of Total Watershed Acres
Commercial	33.1	1.9	0	0	33.1	0.6
Row crops	325.7	18.3	311.9	9.4	637.6	12.5
Farmstead	33.1	1.9	37.2	1.1	70.3	1.4
Forest	875.4	49.2	1,841.7	55.4	2,717.1	53.3
Grassland	79.1	4.4	348.6	10.5	427.7	8.4
Barren	41.3	2.3	141.7	4.3	183.0	3.6
Open water	143.7	8.1	0	0	143.7	2.8
Residential	33.6	1.9	229.7	6.9	263.3	5.2
Wetland	214.6	12.1	412.1	12.4	626.7	12.3
Total	1,779.6	--	3,322.3	--	5,101.6	--

[1]Table Credit: Harmony Environmental (2007)

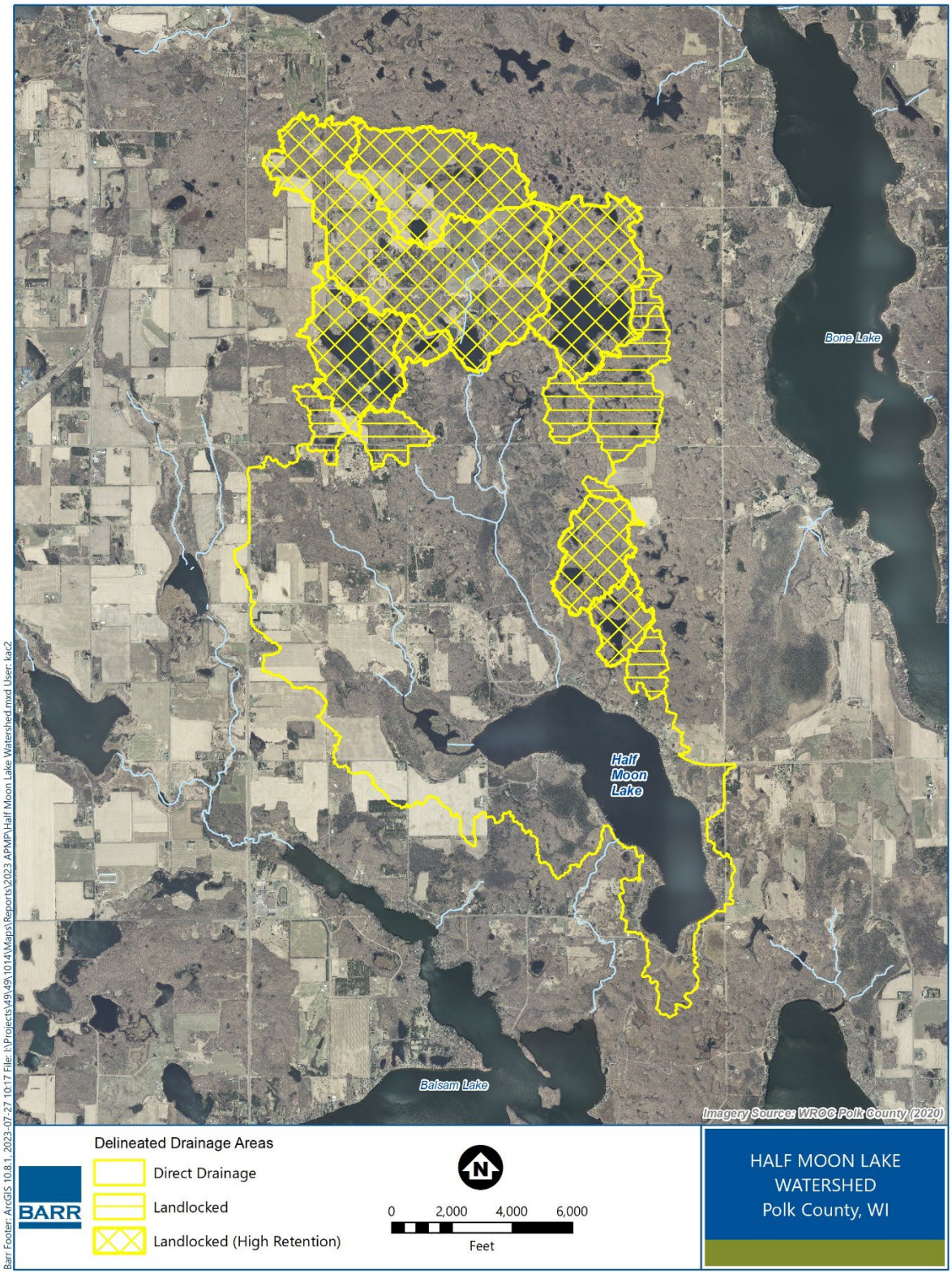

Figure 2-2 Half Moon Lake Watershed

3.0 Watershed Management

Half Moon Lake watershed management has consisted of activities by the Half Moon Lake Conservancy to preserve the water quality and natural beauty of Half Moon Lake. The Half Moon Lake Conservancy completed a strategic plan in 2007 to establish priorities and a course of action to preserve the water quality and natural beauty of Half Moon Lake. In 2022 the Half Moon Lake Conservancy completed a project to identify and prioritize critical land areas for protection in the Half Moon Lake watershed to improve the water quality entering Half Moon Lake. Because Half Moon Lake is located in Polk County, the Polk County Land and Water Resource Management Plan 2020-2029 includes the lake. Summaries of the Half Moon Lake Conservancy strategic plan and identification and prioritization of critical areas projects and the Polk County Land and Water Resource Management Plan 2020-2029 follow.

3.1 Half Moon Lake Conservancy Strategic Plan

In 2007, the Half Moon Lake Conservancy contracted with Harmony Environmental to complete the Half Moon Lake Conservancy Strategic Plan. The Half Moon Lake Conservancy, incorporated in 2003, was formed:

- To preserve, maintain, and enhance ecological integrity of the lands and waters of Half Moon Lake;
- To protect agricultural and wooded lands, environmental corridors, wildlife habitat, and open space areas surrounding Half Moon Lake;
- To acquire and hold property for the purposes stated above;
- To educate the public and elected officials to support sustainable patterns of development.

The strategic plan established priorities and a course of action to preserve the water quality and natural beauty of Half Moon Lake. The Half Moon Lake strategic plan goals, objectives, and recommended action items are summarized in Table 3-1.

Table 3-1 Half Moon Lake Strategic Plan Goals, Objectives, and Recommended Action Items[1]

Goals	Objectives	Recommended Action Items
Goal 1: Watershed characteristics protect and maintain Half Moon Lake water quality	*Objective 1: Discourage land use changes that will negatively impact Half Moon Lake water quality.*	Include representatives from the Town of Milltown, Polk County, and the lake district on the Conservancy Board.
	Objective 2: Work effectively to influence local and state decisions that impact Half Moon Lake water quality.	Designate board members to participate in Town of Milltown and Polk County planning, zoning, and other regulatory activities within the Half Moon Lake direct watershed drainage area.
	Objective 3: Protect critical parcels of land in the Half Moon Lake watershed.	Approach priority landowners to encourage land protection. Emphasize the voluntary nature of options available to them.
		Consider preservation of priority parcels to protect watershed characteristics and water quality.
		Complete fundraising campaigns to support land protection activities
Goal 2: Water quality practices reduce pollutant loading from the watershed	*Objective 1: Maximize wetland restorations in the watershed.*	Promote technical assistance provided by WDNR, Polk County Land and Water Resources Department, University of Wisconsin Extension, and other agencies.
	Objective 2: Promote the preservation and restoration of natural vegetation along the Half Moon Lake shoreline.	Identify and implement incentives to encourage restoration of buffer zones and reduction of waterfront runoff around Half Moon Lake.
Goal 3: Half Moon Lake residents understand and support lake management activities	*Objective 1: Increase lake residents' understanding of the connection between watershed activities and lake water quality.*	Develop an organizational brochure: summarize strategic plan, status of current land holdings (public access?), present land protection priorities and options available to landowners.
	Objective 2: Inform lake residents about Half Moon Lake Conservancy land protection priorities and rationale.	Update lake residents and partner agencies regularly regarding Half Moon Lake Conservancy progress and activities.
	Objective 3: Increase lake resident awareness and support of Half Moon Lake Conservancy water quality and land protection efforts.	Conduct a survey to assess resident understanding and support of Half Moon Lake Conservancy efforts
		Assess effectiveness of various educational techniques and incentives residents will respond best to through surveys and focus group sessions.
Goal 4: The Half Moon Lake Conservancy maintains a vital board to address lake and watershed management issues.	*Objective 1: Increase board knowledge of water quality and land protection tools.*	Support board training by paying the following expenses: workshop registration, travel, and lodging
	Objective 2: Develop and maintain a clear understanding of roles and responsibilities for Half Moon Lake management with partner organizations such as the Half Moon Lake Protection and Rehabilitation District.	Meet initially with the Half Moon Lake Protection and Rehabilitation District to discuss roles for lake management then on an annual basis (at least) to discuss planned activities and opportunities for cooperation.
		Invite guest speakers to provide land protection and lake and watershed management information to the board.

[1]Credit for Content of Table: Harmony Environmental (2007)

3.2 Identification and Prioritization of Critical Protection Areas in Half Moon Lake Watershed

In 2022, the Half Moon Lake Conservancy retained Barr Engineering Co. for the identification and prioritization of critical land areas for protection in the Half Moon Lake watershed to improve the water quality entering Half Moon Lake. The scope of work included data compilation and preliminary analysis, meeting/discussion to confirm the prioritization approach, and development of final mapping and a memorandum.

The prioritization mapping is shown in Figure 3-1. The map shows that the high priority drainage areas represent cultivated cropland that is mostly concentrated in the direct drainage to Tamarack Bay (directly west-northwest of Half Moon Lake). Almost all of this cultivated cropland is contained within 20 land parcels. Two of the high priority drainage areas discharge to drained wetland areas and another area drains to a restored wetland. Along with a high priority drainage area that discharges to a small network that enters Half Moon Lake about 1,000 feet west of Harder Creek, the remaining high priority drainage areas discharge directly to Tamarack Bay or the fringe wetland surrounding the bay and would represent the highest priorities for future management actions (Barr 2022a).

The memorandum provided recommendations for implementing future management actions, including prioritized land areas based on the available water quality monitoring and potential for downstream pollutant delivery (i.e., agricultural lands that would otherwise have similar amounts of phosphorus runoff could be distinguished based on their individual landscape and/or proximity to channelized flow or restorable wetlands). The recommended next steps for the Conservancy include working with Barr and/or the Polk County Land Conservation Department to determine the presence of drain tile within the cultivated cropland delineated within the high priority drainage areas. To the extent that this requires interactions with the landowners and renters, it would also be beneficial to obtain more information about existing cropland management (such as crop rotations, fertilization rates/timing, tillage, etc.). Willing landowners and/or renters would be good candidates for enrollment in government programs for land conservation or development of conservation easements. Unwilling landowners (or renters) that pose the highest risk for phosphorus discharge to Half Moon Lake (because of existing cropland management, tile drainage/erosion and/or proximity to restorable wetlands) are likely to be better candidates for land acquisition or some other financial incentives for land management (Barr 2022a).

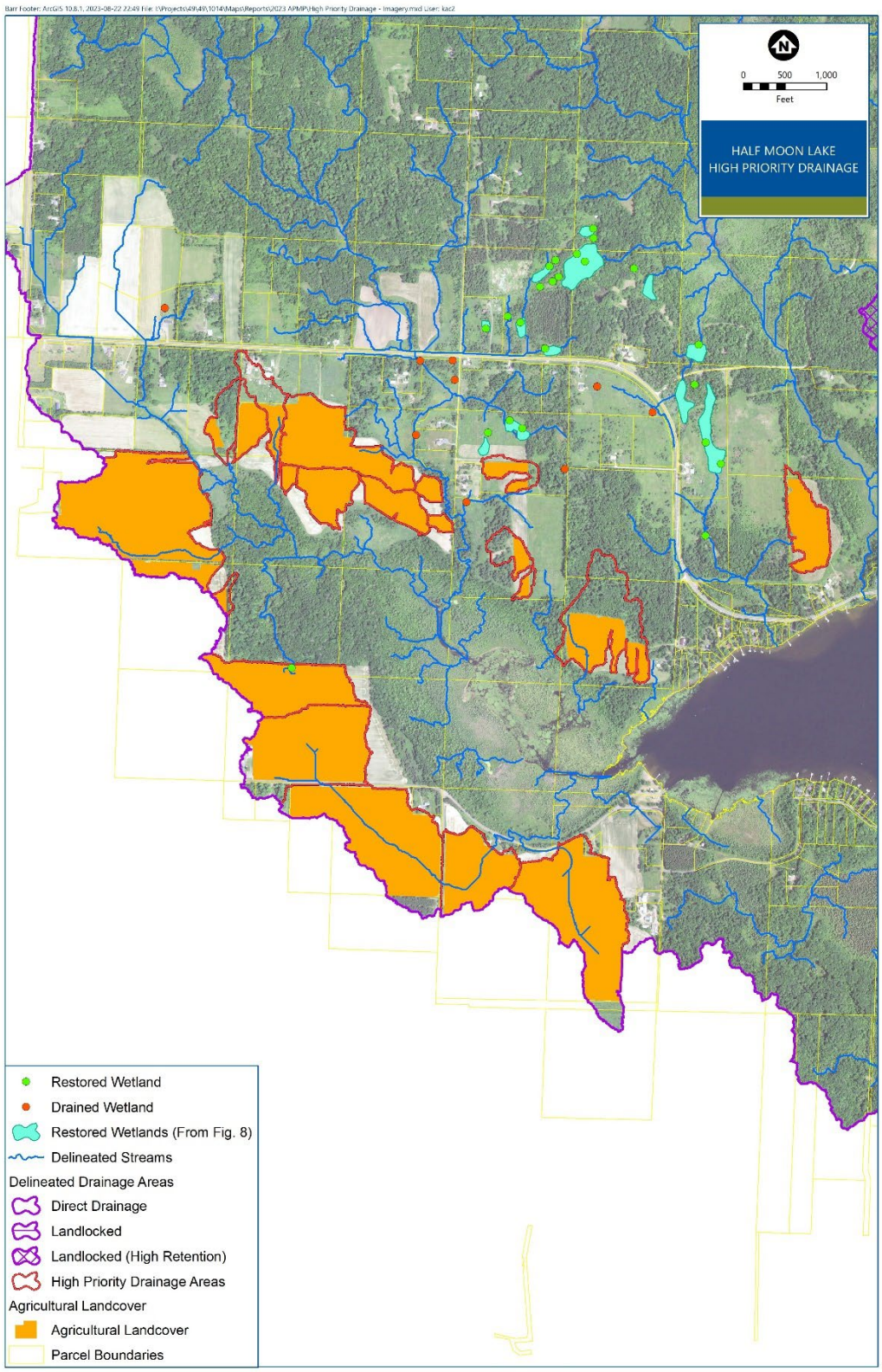

Figure 3-1 Half Moon Lake High Priority Drainage Areas[1]

[1]Figure Credit: Barr (2022a)

3.3 Polk County Land and Water Resource Management Plan 2020-2029

The Polk County Land and Water Resources Department (LWRD) prepared a Land and Water Resources Management Plan (LWRM Plan) for 2020-2029. The plan describes the strategy the Land and Water Resources Department (LWRD) will employ from 2020-2029 to preserve, protect, and enhance the surface, groundwater, land, and community resources present in the county. The LWRM plan details Polk County ordinances relevant to the LWRM Plan:

LWRD

- Manure and Water Quality Management Ordinance – promotes the proper storage and management of animal waste including prohibitions found in NR151.08
- Storm Water Management and Erosion Control Ordinance – establishes regulatory requirements for land development and land disturbing activities aimed to minimize the threats to public health, safety, welfare, and the natural resources in Polk County from construction site erosion and post-construction storm water runoff.
- Nonmetallic Mining Reclamation Ordinance – ensures the effective reclamation of nonmetallic (sand, gravel, or other nonmetallic minerals) mining sites after mining operations have ceased.
- Illegal Transport of Aquatic Plants and Invasive Animals Ordinance – prevents the spread of aquatic invasive species in Polk County and surrounding waterbodies to protect property values and the property tax base and ensure quality recreational opportunities. It requires all plants and invasive animals be removed from a boat and trailer prior to entering a public roadway. This ordinance was amended and now requires decontamination where a station is present.

Land Information-Zoning

- Comprehensive Land Use Ordinance – promotes and protects public health, safety, and other aspects of the general welfare.
- Shoreland Protection Ordinance – ensures the proper management and development of the shoreland of all navigable lakes, ponds, flowages, rivers, and streams in the unincorporated areas of Polk County. The intent of these regulations is to further the maintenance of safe and healthful conditions; prevent and control water pollution; protect spawning ground for fish and aquatic life; control building sites, placement of structures, and land uses; and preserve shore cover and natural beauty.
- Private Sewage System Ordinance – accomplishes basic goals in environment, health, and safety by proper siting, design, installation, inspection, maintenance, and management of private on-site waste treatment and non-plumbing sanitary systems.
- Subdivision Ordinance -regulates and controls subdivision development within Polk County to promote public health, safety, general welfare, water quality, and aesthetics.
- Floodplain Ordinance – regulates floodplain development in order to minimize the potential for damage, the expenditure of public funds for flood control projects, and interruptions to business or other land uses.

The goals, objectives, and recommended activities of the LWRM Plan are summarized in Table 3-2.

Table 3-2 Polk County, Wisconsin Land and Water Resource Management Plan 2020-2029 Goals, Objectives, and Recommended Action Items[1]

Goals	Objectives	Recommended Action Items
Goal 1: Protect and improve the water quality of lakes, rivers, and streams	*Objective 1A: Limit runoff and pollution from working lands.*	1. Implement best management practices regarding NR 151 Runoff Management Performance Standards and Prohibitions
		2. Continue to administer the Polk County Manure and Water Quality Ordinance
		3. Continue to support existing Farmer Led Watershed Councils and pursue the formation of new councils
		4. Provide education on proper nutrient management and erosion control practices to agricultural producers
		5. Encourage use of cover crops, cropland residue, and soil health principles to agricultural producers
		6. Continue to administer the Working Lands Initiative and the Farmland Preservation Program
		7. Collaborate with multi-state efforts to achieve the 20% reduction in total phosphorus loading to the St. Croix Basin
		8. Apply for surface water grants to obtain money for installation of conservation practices
	Objective 1B: Limit runoff and pollution from developed landscapes	1. Continue to administer the Polk County Storm Water Management and Erosion Control Ordinance
		2. Provide technical assistance for urban runoff planning and upgrading storm water infrastructure
		3. Partner with riparian groups and lake organizations to encourage native plantings, diversions, rock infiltration, rain gardens, rain barrels, and other practices to manage runoff
		4. Complete site visits with riparian landowners to provide technical assistance for managing runoff through the WDNR Healthy Lakes grant program
		5. Assist with local planning efforts to encourage conservation and resource protection
		6. Continue to advise WDNR with NR 115 and Polk County Land Information Department with the Polk County Shoreland Protection Zoning Ordinance
		7. Collaboration with multi-state efforts to achieve the 20% reduction in total phosphorus loading to the St. Croix River Basin
	Objective 1C: Monitor surface water to ascertain condition and address problems before they impact the resource or human health	1. Perform water quality studies of chemical, physical, and biological features to ascertain condition of local surface waters as possible
		2. Assess the condition of each watershed on a 10-year rotational basis
		3. Work with lake and river groups to apply for grants to monitor surface water
		4. Assess historic changes at the waterbody and landscape level using sediment cores as possible
		5. Quantify runoff and pollution reductions and track practice location and effectiveness using tracking software
		6. Utilize and expand the use of new technologies and sampling tools for measuring water quality
		7. Expand tributary monitoring for waterbodies as possible
		8. Prioritize monitoring of waterbodies known to have blue-green algae blooms
		9. Engage volunteers in surface water monitoring programs

Goals	Objectives	Recommended Action Items
		10. Analyze landscape features using digital data and computer models to accurately identify drainage patterns
	Objective 1D; Prevent and control aquatic invasive species (AIS)	1. Implement Polk County-wide AIS Strategic Plan (below, italics) *a. Prevent the introduction, establishment, and spread of AIS in Polk County waterbodies* *b. Control populations of AIS* *c. Monitor Polk County waterbodies for AIS and document results* *d. Provide AIS information and education in Polk County and surrounding areas* e. *Sustain the implementation of the plan*
		2. Update the Polk County-wide AIS Strategic Plan every five years
		3. Engage volunteers and partners in AIS monitoring and education whenever possible
		4. Continue to administer the Polk County Illegal Transport of Aquatic Plants and Invasive Animals Ordinance
		5. Pursue decontamination opportunities
		6. Determine which waterbodies are most susceptible to aquatic invasive species to target efforts
Goal 2: Protect and improve groundwater quality and quantity	*Objective 2A: Obtain pertinent groundwater data to determine current groundwater conditions.*	1. Reexamine, repeat, and expand previous groundwater inventories including testing for nitrogen, pesticides, and contaminants of concern in drinking water
		2. Obtain and utilize data collected by partner groups to expand groundwater datasets from previous inventories
		3. Determine the relationship between surface water and groundwater quality and quantity
	Objective 2B: Evaluate landscape susceptibility to groundwater impairment	1. Identify Wellhead Protection, recharge areas, and potential sources of groundwater contamination
		2. Promote Wellhead Protection through other agencies to preserve quality of drinking water
		3. Obtain and utilize data collected by partner groups to evaluate risk susceptibility
	Objective 2C: Administer programs that protect groundwater	1. Facilitate proper abandonment of wells by assisting landowners with locating, properly filling, and sealing unused wells
		2. Assist landowners with closing abandoned manure storage facilities
		3. Develop and implement measures to protect areas identified in Objective 2B, Action 1
Goal 3: Sustain and enhance landscape resources	*Objective 3A: Preserve working lands and improve soil health and productivity*	1. Continue to administer the Polk County Manure and Water Quality Ordinance
		2. Continue to administer the Working Lands Initiative and the Farmland Preservation Program
		3. Continue to support existing Farmer Led Watershed Councils and pursue the formation of new councils
		4. Continue to provide technical assistance and funding for the installation of best management practices to meet NR 151 agricultural performance standards and prohibitions
		5. Assess the condition of agricultural land in priority watersheds by completing a cover crop inventory, tillage inventory, and soil phosphorus indexing on a rotational basis
		6. Encourage use of cover crops, cropland residue, and soil health principles to agricultural producers through education and collaboration with federal or state programs

Goals	Objectives	Recommended Action Items
		7. Utilize computer models to assess erosion vulnerability, nutrient runoff reductions, and crop residue to prioritize best management practice implementation
		8. Continue to collect countywide cropland data through the Transect Survey
		9. Provide technical assistance and resources as needed to agriculture producers, graziers' networks, and other agriculture related conservation organizations
		10. Provide education on proper nutrient management, cover crops, soil health principles, erosion control, and nutrient management to agricultural producers
		11. Encourage implementation of soil health principles and regenerative agriculture to improve agricultural productivity
	Objective 3B: Prevent, control, and eradicate terrestrial invasive species	1. Promote and participate in the mission and goals (below, italics) of the St. Croix-Red Cedar Cooperative Weed Management Area a. *Raise public awareness about invasive species through education and outreach efforts* b. *Develop an early detection and management framework* c. *Maintain and build organizational capacity*
		2. Work with Towns, Highway Departments, contractors, and utility companies to deliver education and develop best management practices for mowing, seeding, and control strategies
		3. Provide education to make the public aware of invasive species, their impact, and their means of spread
		4. Support and encourage removal of terrestrial invasive species and restoration of habitat whenever possible
		5. Employ strategies to keep native ecosystems intact
		6. Work with partner agencies and volunteers to coordinate programs and provide information
	Objective 3C: Protect and restore native aquatic and terrestrial habitat	1. Partner with riparian groups and lake organizations to promote native riparian and near-shore habitat
		2. Promote native habitat on mine reclamation sites when administering NR135 and the Polk County Nonmetallic Mining Reclamation Ordinance
		3. Promote re-establishment of native vegetation following invasive species control efforts
		4. Promote wetland and shoreland restoration
		5. Work with Polk County Forestry, Parks, and Trails Department to maintain or improve native habitats on county land
		6. Assist with conservation easements when opportunities arise
		7. Continue to administer the County tree sale
	Objective 3D: Preserve and protect existing landscape diversity	1. Develop a FIS database documenting land use/land cover changes, cover crops and tillage
		2. Assist with conservation easements when opportunities arise

Goal 4: Support and develop community stewardship and partnerships to improve our natural resources	*Objective 4A: Educate the public and elected officials to instill a conservation ethic*	1. Provide information and promote events using a variety of communication tools, workshops, and demonstrations
		2. Expand natural resource education through innovative approaches and offer incentives whenever possible
		3. Foster advocacy for the Land and Water Resources Department (LWRD) by sharing positive outcomes of the department
		4. Provide education using the Information and Education Strategies section of this plan
	Objective 4B: Encourage natural resource management through civic engagement	1. Provide support for volunteers and residents who are properly managing natural resources by both technical and financial means whenever possible
		2. Continue to support existing Farmer Led Watershed Councils and pursue the formation of new councils
		3. Continue to support existing lake and river organizations and the formation of new organizations
		4. Support the formation of riparian watershed councils
		5. Encourage and assist citizen peer-to-peer education strategies
	Objective 4C: Maintain and expand partnerships to promote natural resource programs to accomplish the goals of this plan	1. Join forces with other agencies and volunteers on projects whenever possible and practical
		2. Apply for grants with partners whenever feasible
		3. Facilitate meetings and idea exchange between citizens and agencies
		4. Expand relationships with local universities to continue an LWRD intern program
		5. Continue technical assistance to Polk County Zoning Department regarding NR115 and Polk County Shoreland Protection Zoning Ordinance
		6. Explore all means to accomplish the goals of this plan, such as updating and creating ordinances, laws, policies, and incentive programs
	Objective 4 D: Support staff needs for professional development	1. Encourage LWRD staff to attend conferences, seminars, and other educational opportunities to maintain and enhance knowledge of specific subjects as it relates to their job duties whenever possible
		2. Achieve and maintain appropriate staff certifications as it relates to their job duties

[1]Credit for Content of Table: Polk County (2019)

4.0 Fishery and Wildlife Management

4.1 Fisheries

Half Moon Lake was sampled during 2012 with early-spring fyke netting, early-spring and late-spring night electrofishing, fall night electrofishing following the DNR comprehensive Treaty assessment protocol. A low-density adult walleye population was observed in Half Moon Lake during 2012 (adults/ac = 0.5) and survival of stocked large fingerlings to age-1 was average compared to other stocked fisheries in Barron and Polk counties. The current walleye fishery likely remains stocking-dependent with stocking necessary to maintain the fishery. Half Moon Lake is stocked by the DNR with large fingerling walleyes on alternate years at a density of 10 fish/ac. The northern pike catch-per-unit-effort was below the 50th percentile for similar complex-warm-clear Wisconsin lakes and indicative of a low-density population. Size structure of the northern pike population was low-moderate with an average length of 20.7 in. The spring electrofishing survey was conducted to assess vital rate metrics of largemouth bass and panfish populations. The largemouth bass catch-per-unit-effort was near the 75th percentile for similar complex-warm-clear Wisconsin lakes and indicative of a moderate-density population. Largemouth bass size structure was average and within the generally accepted range of values for a balanced largemouth bass population. Half Moon Lake has a diverse panfish assemblage with moderate overall abundance and average size structure. The bluegill catch-per-unit-effort was below the 25th percentile for similar complex-warm-clear Wisconsin lakes and indicative of a low-density population. Bluegill size structure was average. The bluegill population size structure indices were average and within the generally accepted range for a balanced bluegill population (PSD-6 = 20-60). Other panfish species present included black crappie, yellow perch, pumpkinseed sunfish and rock bass. The next comprehensive fisheries survey on Half Moon Lake is anticipated to occur during spring 2025. (Broadway, 2023)

4.2 Wildlife

The WDNR and Polk County do not have lake specific wildlife information for Half Moon Lake (Carlisle 2023 and Anderson 2023). The Half Moon Lake Protection and Rehabilitation District completed a plant and wildlife survey within the Half Moon Lake watershed in 1996 and 1997 (Bursik 1998). Following is a wildlife discussion based upon the report *Half Moon Lake* (Bursik 1998).

A survey along the lower 0.3 mile of Harder Creek was completed in October 1996 and July 1997 from Dau Road (in the north) to the outlet in Half Moon Lake. Beaver and muskrat were observed as were other water dependent species such as kingfishers. Woodpecker activity was observed due the abundance of standing snags (dead trees), which provide foraging and nesting habitat. The woody shrubs and trees dominating the landscape were browse for the white tail deer and the creek provided access to water. Harder Creek provided a corridor for wildlife to move between the relatively wild upper regions of Harder Creek, which are covered by broad wetland complexes and adjacent forests, and the relatively developed regions around Half Moon Lake. Beaver were active along the lower stretch of the creek. A large beaver dam was observed approximately 200 yards upstream from the mouth on Half Moon Lake. Remnants of another dam were observed farther north.

A survey was completed in Tamarack Bay in early July, 1997. Muskrat, beaver, bald eagle, great blue heron, painted and snapping turtles were observed while surveying Tamarack Bay. The adjacent forested and shrub-dominated swamp provide heavy browse for white tail deer. Deer sign was abundant throughout the wetland, particularly in the swampy margins with more stable substrate. A variety of song birds were also noted.

The Nelson Bay wetland complex, located on the southwest end of Half Moon Lake, just to the east of the public beach and boat launch in the extreme southern portion of the southeast ¼ section 23, T35N, R17W, consists of peatland communities from rich fen to sphagnum-dominated, extremely rich nutrient bog. Peatlands provide a home for many animal species which are uniquely adapted to these habitats. Shrews and voles are common rodents of peatlands (Tester 1995). Sandhill cranes often nest in peatlands due to the isolation of these habitats from human development and activities. Two native warblers prefer peatlands for nesting – the Connecticut and palm warblers. Both build nests of fine sedge stems at the top of sphagnum hummocks in tamarack and spruce forests. Other bird species, including the great gray owl, yellow rail, LeConte's sparrow, Lincoln's sparrow, savannah sparrow, ruby-crowned kinglets, gray jay, Swainson's thrush, and the Tennessee, Nashville, yellow-rumped, and Cape May warblers are common in open to forested peatland habitats (Tester 1995). Geese are also known to settle into open bogs with large stands of cranberries and graze heavily on the nutritious berries. Many insects, including the bog fritillary butterfly, are restricted to peatland habitats throughout their range of occurrence.

The Baldwin Bay wetland, located in the northwest ¼ of section 25, T35, R17W, just to the east of Nelson Bay on the southwestern end of Half Moon Lake, occurs immediately adjacent to Half Moon Lake and is very similar to the Nelson Bay wetland. Wildlife within the Baldwin Bay wetland are similar to the wildlife within the Nelson Bay wetland complex.

4.3 Need for Protection and Enhancement of Fish and Wildlife Habitat

Fish and wildlife habitat in Half Moon Lake is in need of protection to insure the current diverse and valuable fish and wildlife community are fully supported in the future. Fish and wildlife habitat protection includes protection of woody debris, native shoreland and lake vegetation, and lake water quality. The Half Moon Lake Conservancy strives to protect the lake's water quality and natural beauty through implementation of their strategic plan and the recommendations provided in the identification and prioritization of critical areas in the Half Moon Lake watershed. Polk County strives to protect the lake's water quality and native vegetation community through implementation of the Polk County Land and Water Resources Management Plan (LWRM Plan) for 2020-2029. The Half Moon Lake Protection and Rehabilitation District strives to protect the lake's water quality and native shoreland and lake vegetation through completion of annual water quality monitoring (Citizen Lake Monitoring Network) and management of aquatic invasive species (Eurasian watermilfoil and yellow iris).

The focus of this APM Plan is management of the lake's plant community to protect, and whenever possible, improve the native plant community. Protection and improvement of the native plant community will protect and improve fish and wildlife habitat. Threats to fish and wildlife habitat from adverse changes to the lake's native plant community include rapid expansion of invasive species

currently residing in the lake and a concurrent reduction of native species that currently provide important habitat for the lake's fish and wildlife community. Introduction of additional invasive species to the lake, such as zebra mussel or starry stonewort, could adversely impact the lake's fish and wildlife community through habitat alteration. This aquatic plant management plan addresses the need for protection, and whenever feasible, enhancement of fish and wildlife habitat in the lake by managing invasive species and protecting native species.

5.0 Water Quality

Volunteers participating in the WDNR Citizen Monitoring Network have collected water quality data from Half Moon Lake since 1993. Data were collected from the deepest portion of the lake. Total phosphorus concentrations were measured during 1993-2009 (Figure 5-1). Chlorophyll concentrations were measured during 1993-2008 and during 2022 (Figure 5-2). Secchi disc transparency was measured during 1993-2023 (Figure 5-3). The data are posted on the WDNR website at the following link (WDNR 2023):

Wisconsin Lakes

Total phosphorus measurements indicate the water quality of Half Moon Lake during 1993-2009 ranged from oligotrophic (low nutrients) to eutrophic (high nutrients), but was generally within the mesotrophic category (moderate nutrients, good water quality) (Figure 5-1). Chlorophyll *a* measurements during 1993-2008 ranged from oligotrophic (low nutrients) to eutrophic (high nutrients), but were generally within the mesotrophic category (moderate nutrients, good water quality) (Figure 5-2). Chlorophyll *a* measurements in 2022 were in the mesotrophic category (moderate nutrients and good water quality) (Figure 5-2). Secchi disc measurements during 1993-2023 ranged from oligotrophic (low nutrients, crystal clear) to mesotrophic (moderate nutrients, good water quality) (Figure 5-3). The 2023 Secchi disc measurements were in the oligotrophic category (low nutrients, crystal clear) (Figure 5-3).

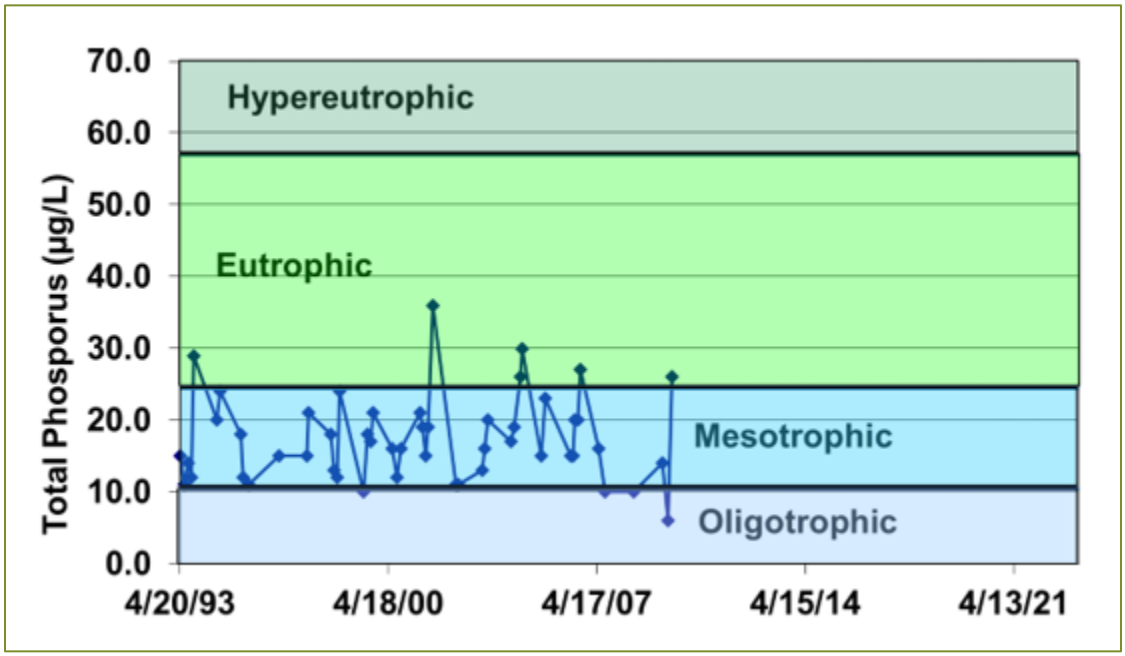

Figure 5-1 1993-2009 Half Moon Lake Total Phosphorus Concentrations: Deep Hole

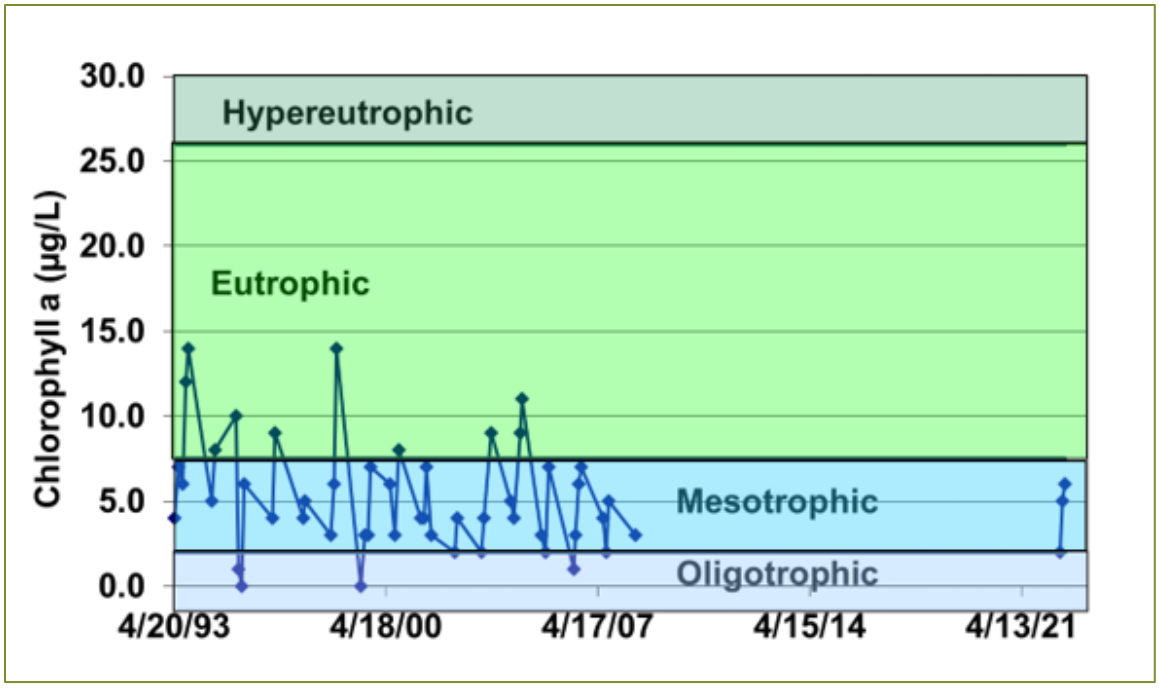

Figure 5-2 1993-2022 Half Moon Lake Chlorophyll *a* Concentrations: Deep Hole

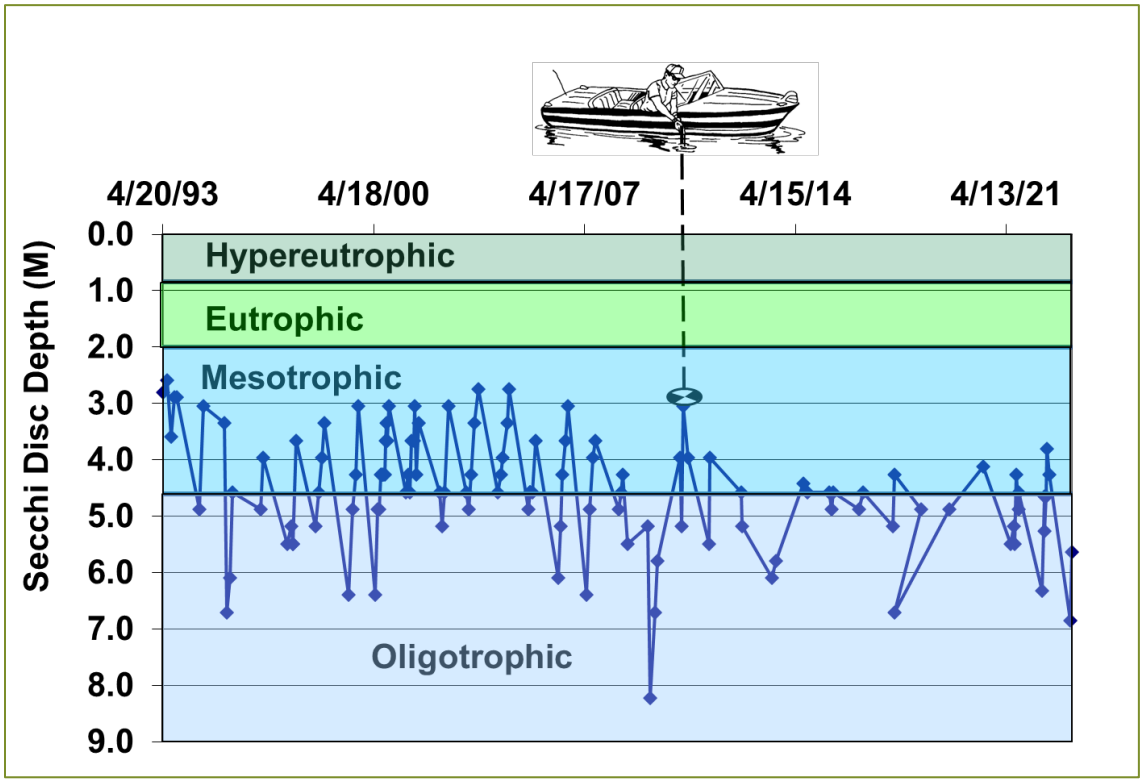

Figure 5-3 1993-2023 Half Moon Lake Observed Secchi Disc Transparency: Deep Hole

6.0 Clean Boats/Clean Waters

During 2010-2023, the Half Moon Lake Protection and Rehabilitation District has fully funded a Clean Boats/Clean Waters inspection program except for 2017 when boat inspections did not occur. The District has hired 2 boat monitors and the boat monitors have inspected boats entering the lake at the landing located within the City of Milltown Park (Figure 2-1). Boats entering and leaving the lake during 7 AM through 3 PM seven days per week from Memorial Day weekend through Labor Day weekend were inspected during 2013-2016, 2018-2020, and 2022-2023. Fewer hours were devoted to inspections during 2010-2012 and during 2021. The results of the inspection were recorded on forms provided by the WDNR and the information was then electronically entered on the DNR on-line database known as Surface Water Integrated Monitoring System.

During the 2010-2023 period, the number of boats inspected annually has ranged from 460 to 1,275 (Figure 6-1). The number of people counted at the boat landing during the 2010-2023 boat inspections has ranged from 626 to 2,826 (Figure 6-2). The number of hours spent inspecting boats (Figure 6-3).

- ranged from 154 to 301 during 2010-2012;
- ranged from 699 to 941 during 2013-2020;
- was 350 in 2021, 836 in 2022, and 581 in 2023.

Results of the boat inspections at the Half Moon Lake boat landing within the City of Milltown Park (Figure 2-1) are shown in Figure 6-1, Figure 6-2, and Figure 6-3 and found on the DNR website: Wisconsin Lakes.

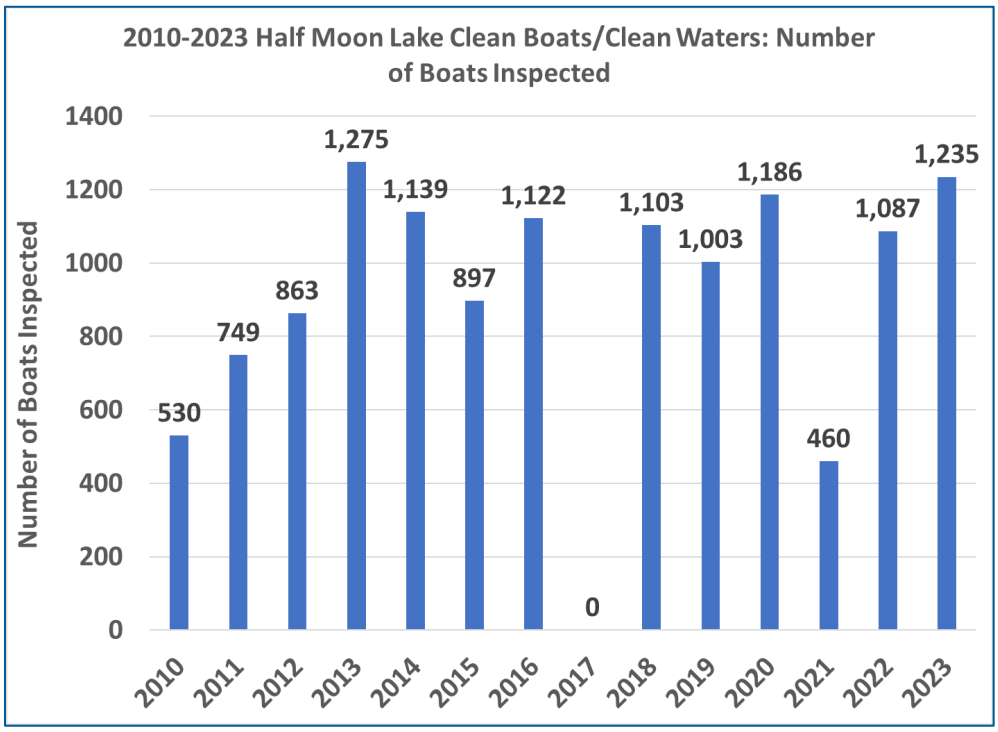

Figure 6-1 2010-2023 Half Moon Lake Clean Boats/Clean Waters: Number of Boats Inspected

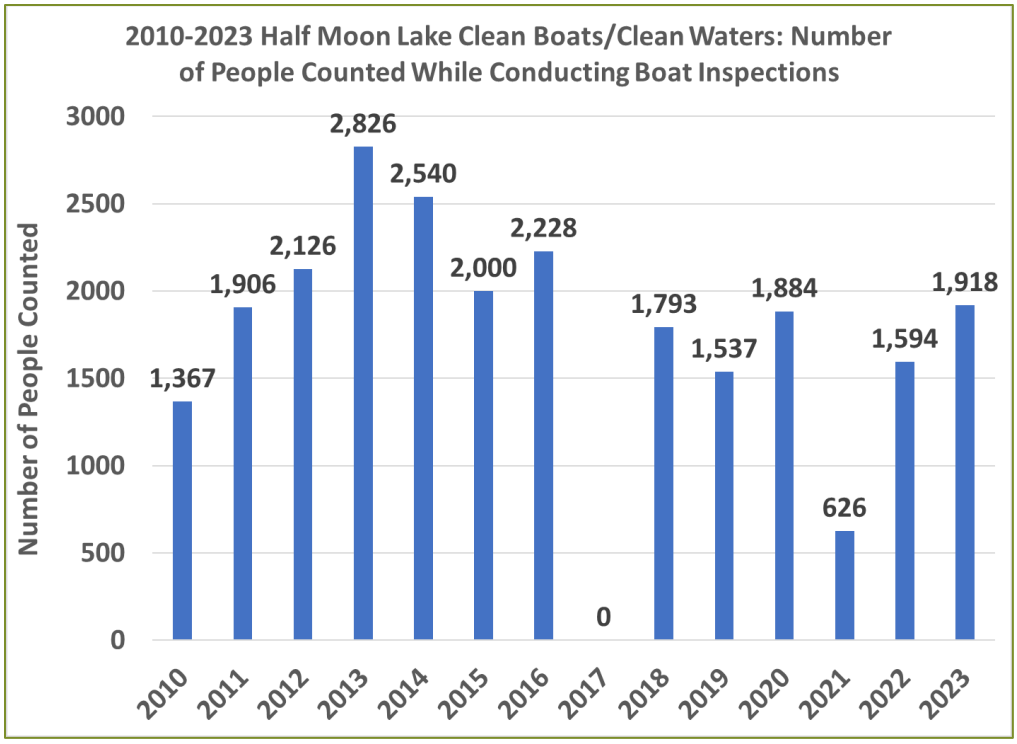

Figure 6-2 **2010-2023 Half Moon Lake Clean Boats/Clean Waters: Number of People Counted While Conducting Boat Inspections**

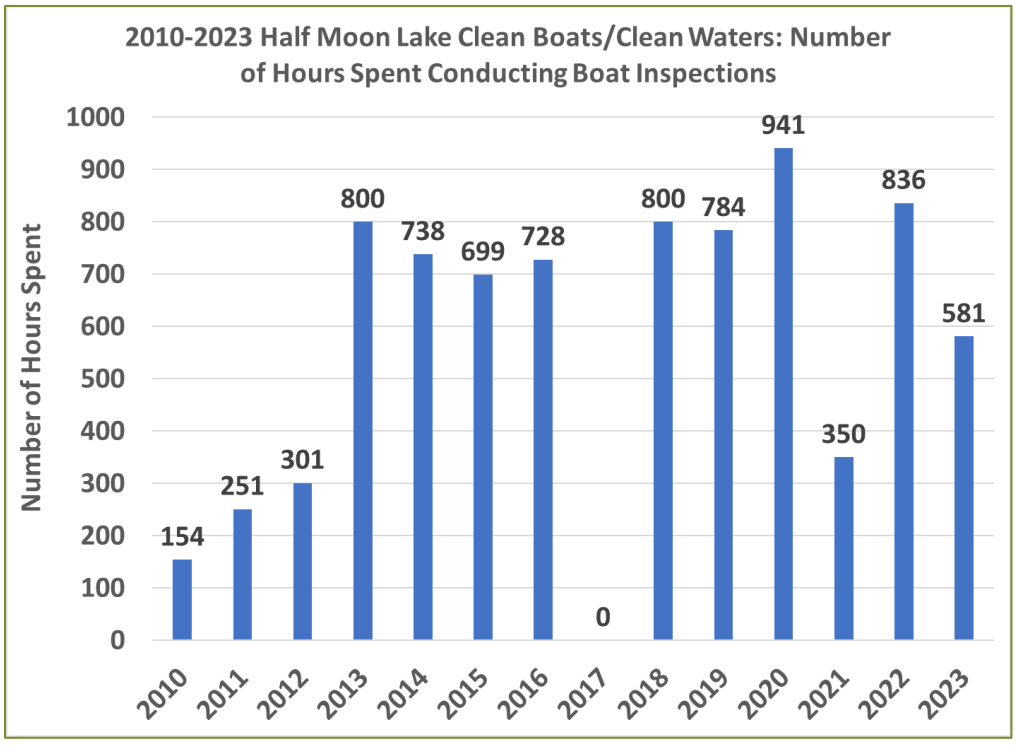

Figure 6-3 **2010-2023 Half Moon Lake Clean Boats, Clean Waters: Number of Hours Spent Conducting Boat Inspections**

7.0 Half Moon Lake Invasive Species

Five invasive plant species are currently present in Half Moon Lake: Eurasian watermilfoil, yellow iris, curly-leaf pondweed, hybrid cattail, and reed canary grass.

7.1 Eurasian watermilfoil (EWM)

EWM is a submersed aquatic plant native to Europe, Asia, and northern Africa (U.S. Forest Service, 2012). EWM was first introduced to the United States in the 1880s, being first observed in the Chesapeake Bay (Nichol's et al., 1986). EWM moved westward and was first introduced in southern Wisconsin in the 1960s (WDNR, 2012a). EWM was first observed in Half Moon Lake during 2021 (Barr 2022b).

Unlike many other plants, EWM generally does not rely on seeds for reproduction. Its seeds usually germinate poorly under natural conditions and it generally reproduces by fragmentation—each fragment can grow into a new plant. The plant produces fragments after fruiting at least once or twice during the summer. These fragments can be carried downstream by water currents or spread by waves or boaters throughout a waterbody (WDNR, 2012a).

Once established in an aquatic community, EWM generally reproduces from fragments and stolons (runners that creep along the lake bed) rather than seeds. Stolons, lower stems, and roots persist over winter and store the carbohydrates that help EWM claim the water column early in spring, photosynthesize, divide, and form a dense leaf canopy that shades out native aquatic plants. EWM's fast growth rate, up to 2 inches per day in spring and summer, its ability to spread rapidly by fragmentation, and its ability to effectively block out sunlight needed for native plant growth often result 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. EWM spreads rapidly and can grow to dominance in as little as two years (WDNR, 2012a).

Dense stands of EWM also inhibit recreational uses like swimming, boating, and fishing. Cycling of nutrients from sediments to the water column by EWM may lead to deteriorating water quality and algae blooms of infested lakes (WDNR, 2012a).

Eurasian watermilfoil (EWM) was first observed in Half Moon Lake at its boat landing on October 6th, 2021 (Figure 7-1). A bed mapping survey of the EWM on October 30th, 2021 indicated it covered about 0.59 acres (0.24% of the plant inhabitable area) (ERS 2021). EWM extent from the October 30th survey is shown in Figure 7-2. The Half Moon Lake Protection and Rehabilitation District, with assistance from Barr Engineering Co., applied for and was awarded a WDNR Rapid Response Grant to help fund EWM management efforts.

Figure 7-1 EWM in Half Moon Lake Photo Credit: Endangered Resource Services, LLC

A June 8, 2022 sub point intercept (PI) plant survey and EWM bed-mapping survey documented 22.03 acres of EWM in Half Moon Lake (Figure 7-3) (Barr 2022b). The plant surveyor commented, "Floating EWM fragments common throughout – plant appears to be spreading rapidly."

The Half Moon Lake Protection and Rehabilitation District contracted with Aquatic Plant Management, LLC (APM) to obtain WDNR permits and manage the EWM in the lake. After receiving WDNR permits on July 28, 2022, APM completed ProcellaCOR treatment of 13.7 acres of EWM on August 1, 2022 (Figure 7-4) and DASH removal of 158 cubic feet of EWM from 8.3 acres during August 8-12, 2022 (Figure 7-5) (Barr 2022b).

The effectiveness of the ProcellaCOR and DASH EWM removal was documented by post-treatment plant surveys on September 18 and October 15, 2022. In fall 2022, EWM was visually observed at only 1 sample location within the 2022 EWM managed areas (Figure 7-6). However, spread of EWM to areas not managed in 2022 resulted in EWM beds with an extent of 1.0 acre and single EWM plants at two locations during fall 2022 (Figure 7-6) (Barr 2022b).

The Half Moon Lake Protection and Rehabilitation District contracted with APM to obtain a WDNR permit to manage EWM in 2023. On June 21, 2023, the WDNR issued a DASH removal permit for areas with EWM that were documented by the fall 2022 plant surveys. DASH removal of 162 acre-feet of EWM from 3.5 acres in DASH areas 1, 2, 11, 12, 13, 14, and 15, shown in Figure 7-7, occurred during July 17-21, 2023. An August 2, 2023 bed-mapping survey documented the continuing presence of EWM in all 7 DASH removal areas (Figure 7-7). Because DASH removal of EWM was ineffective, no further DASH removal of EWM occurred in 2023.

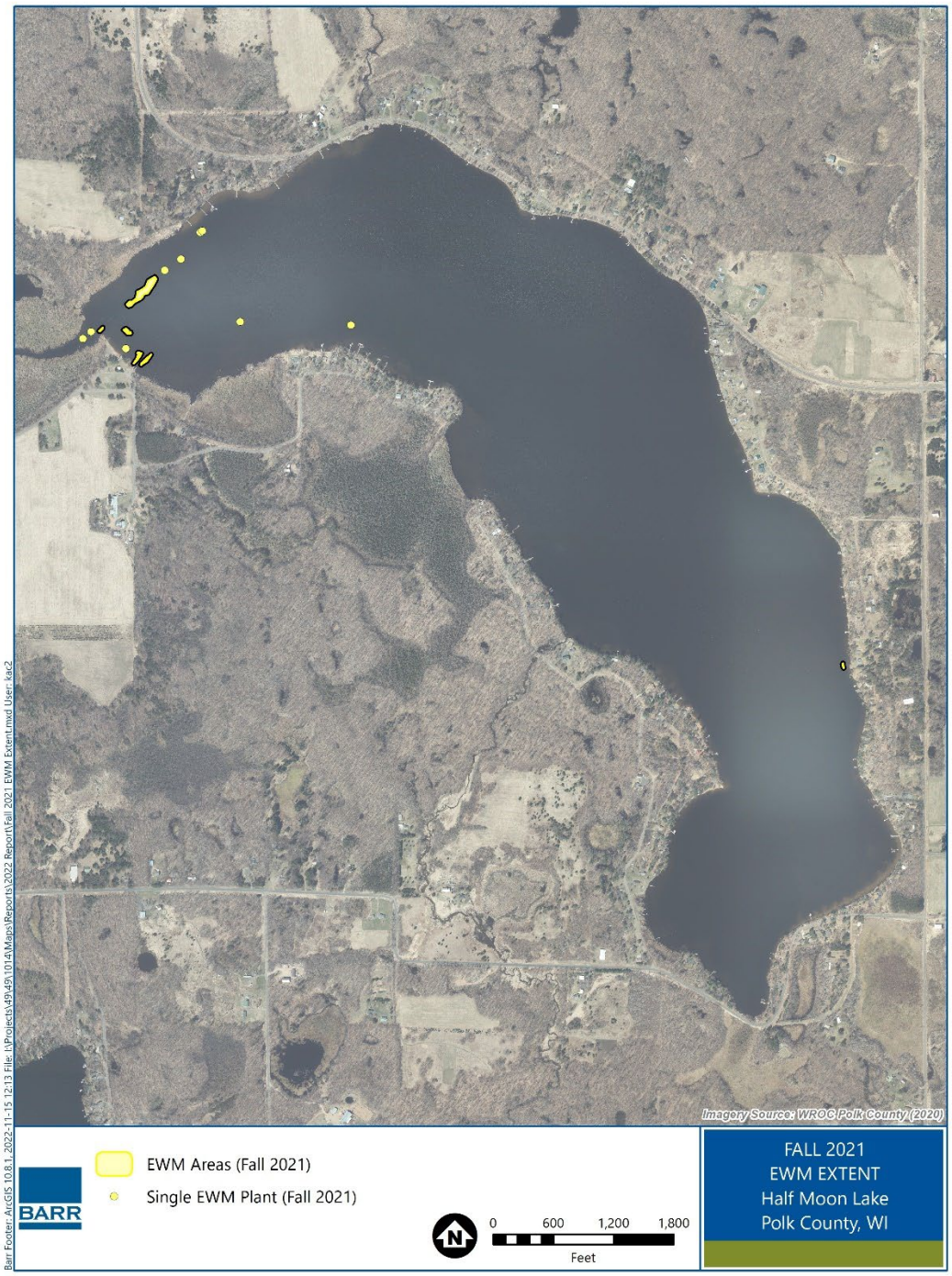

Figure 7-2 Fall 2021 EWM Extent in Half Moon Lake

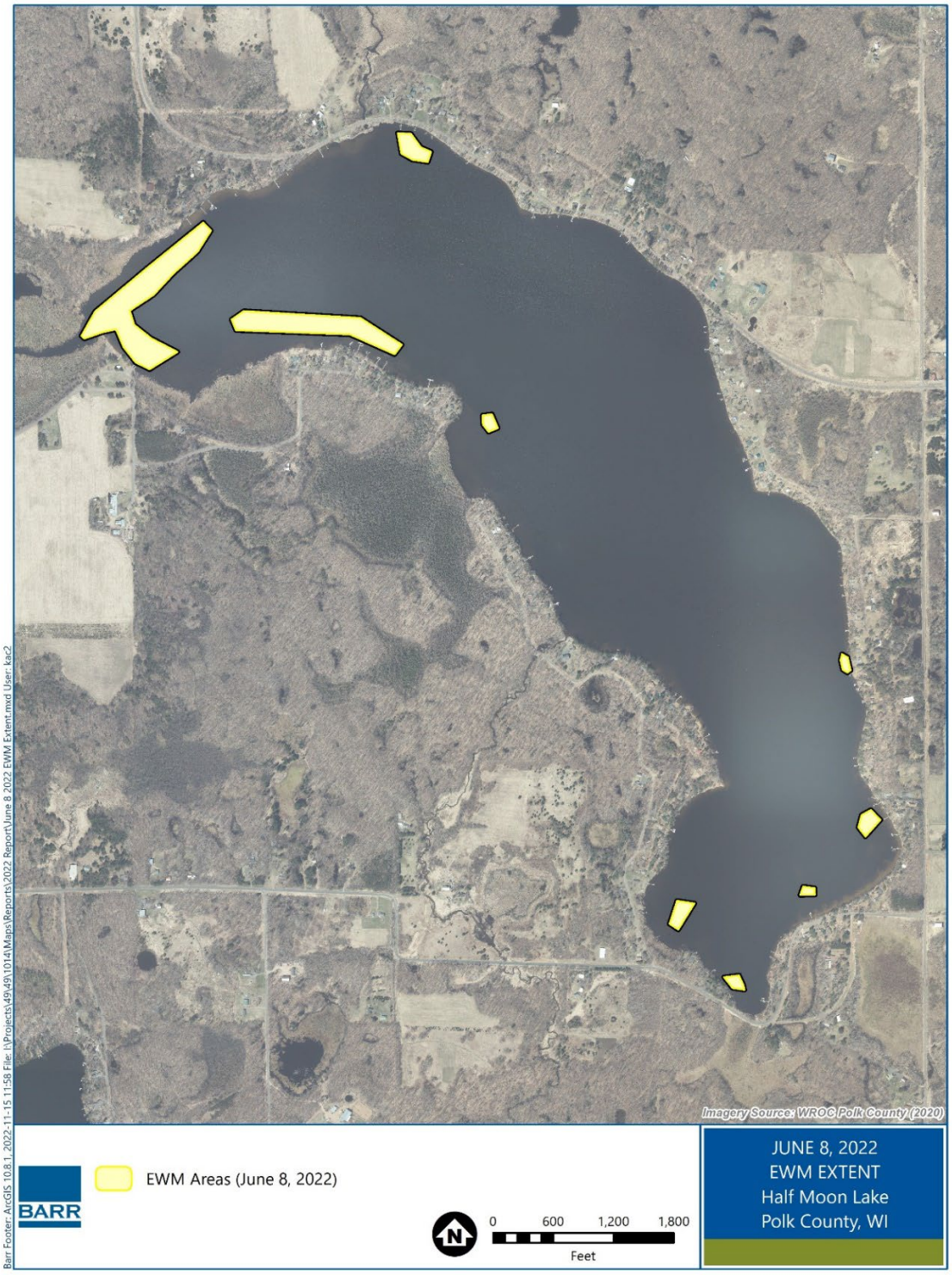

Figure 7-3 EWM Extent in Half Moon Lake on June 8, 2022

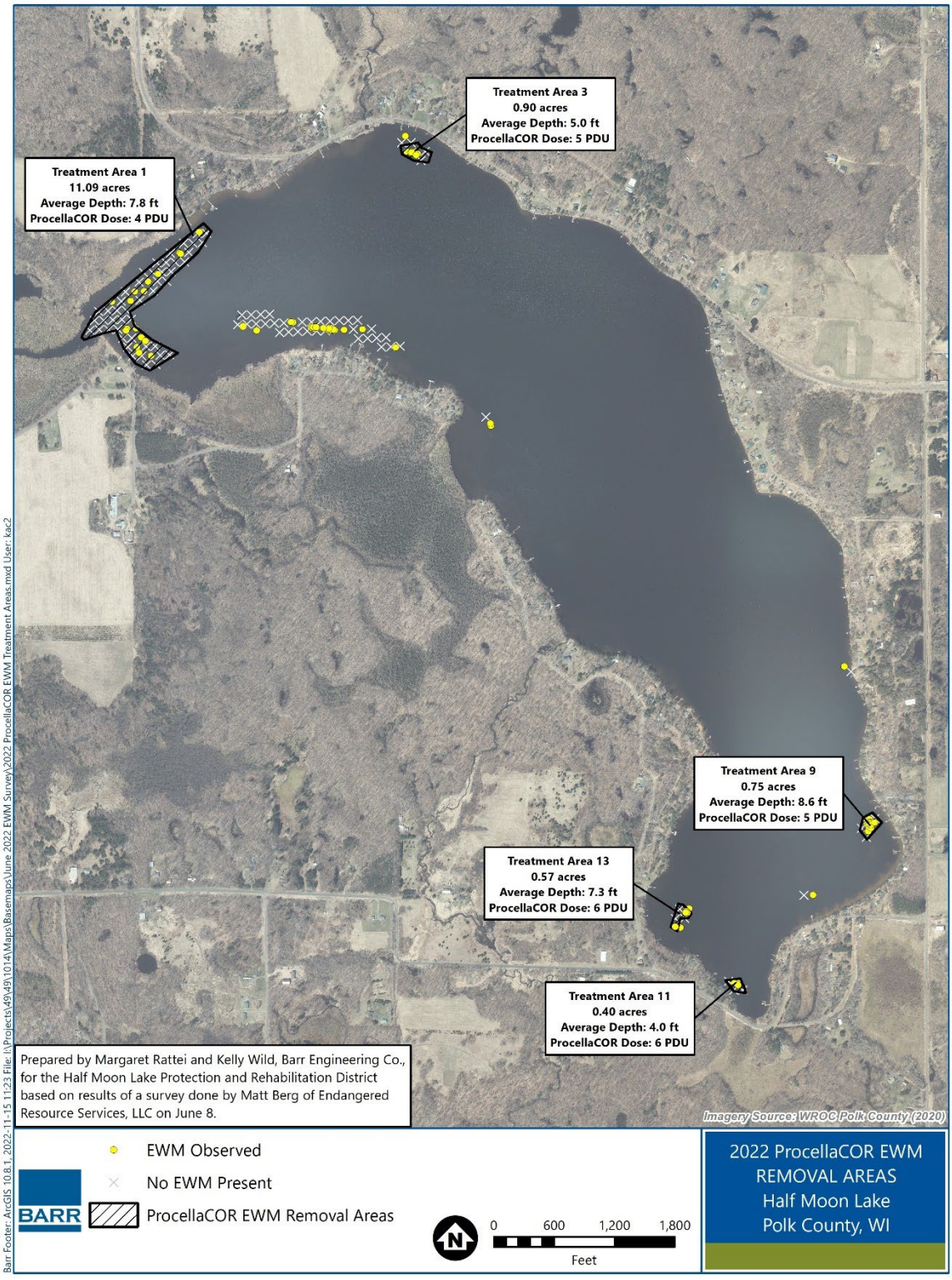

Figure 7-4 August 1, 2022 ProcellaCOR Treatment Areas in Half Moon Lake

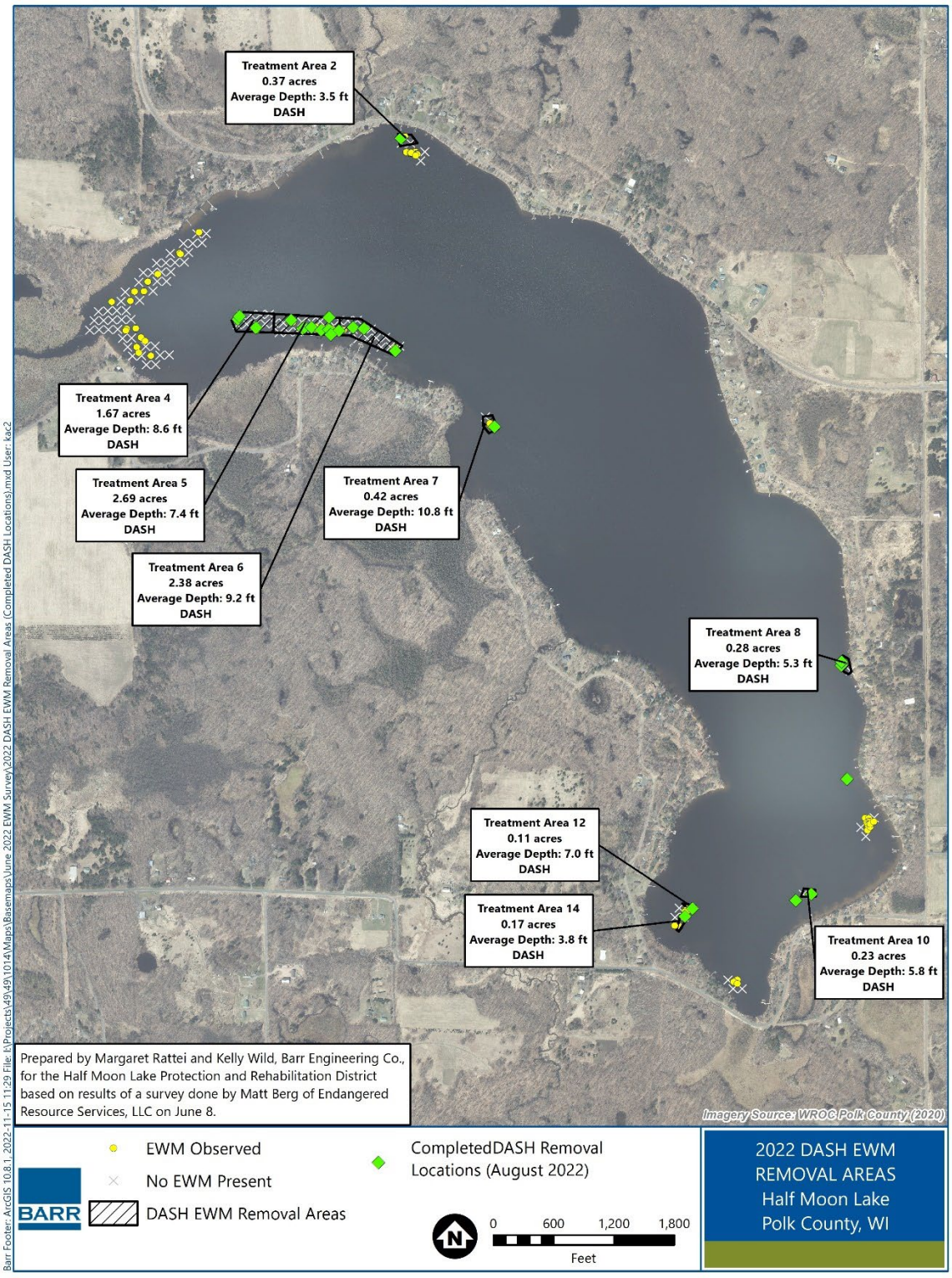

Figure 7-5 August 8-12, 2022 DASH EWM Removal Areas in Half Moon Lake

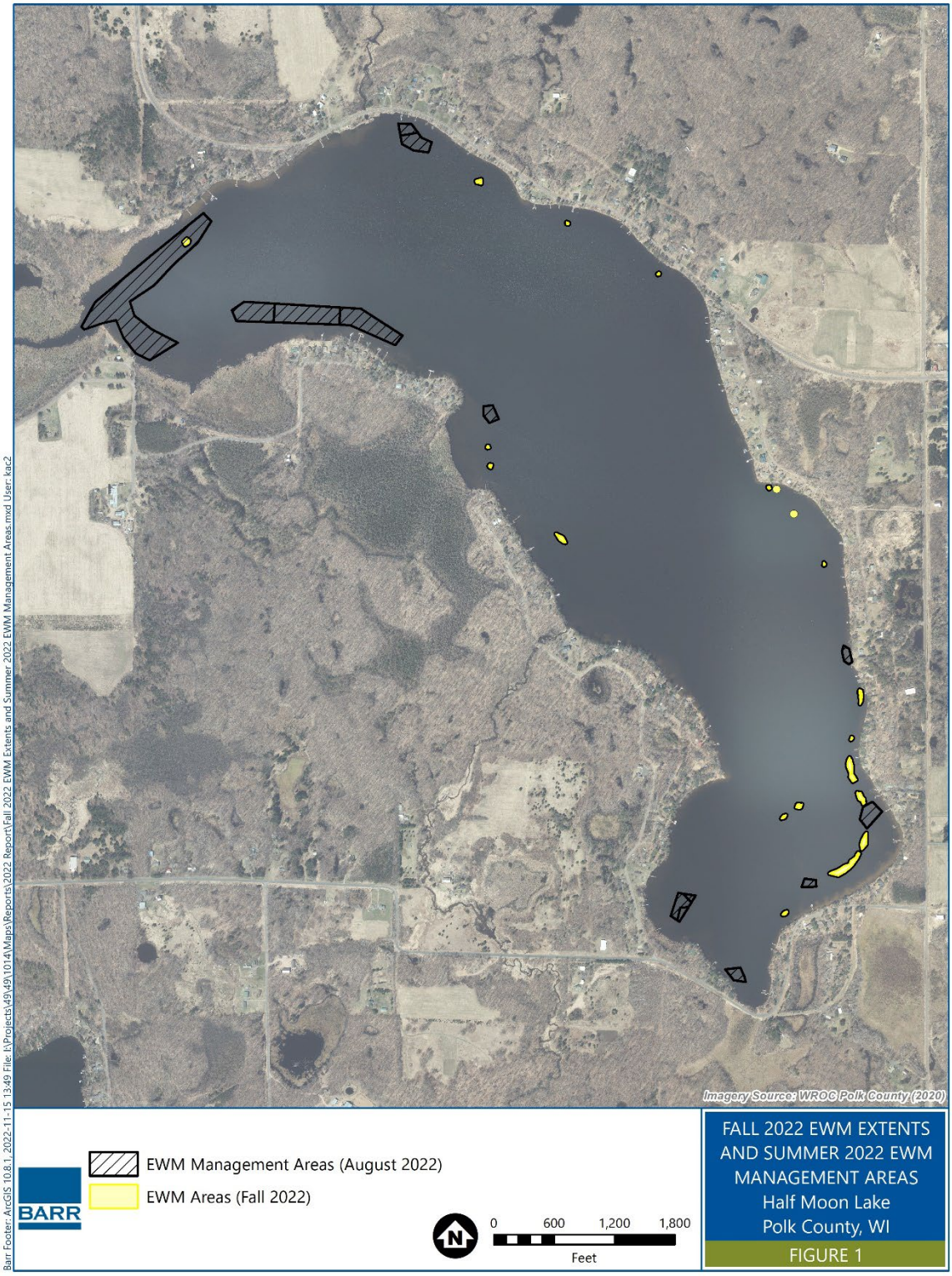

Figure 7-6 Comparison of Fall 2022 EWM Extents with Summer 2022 EWM Management Areas

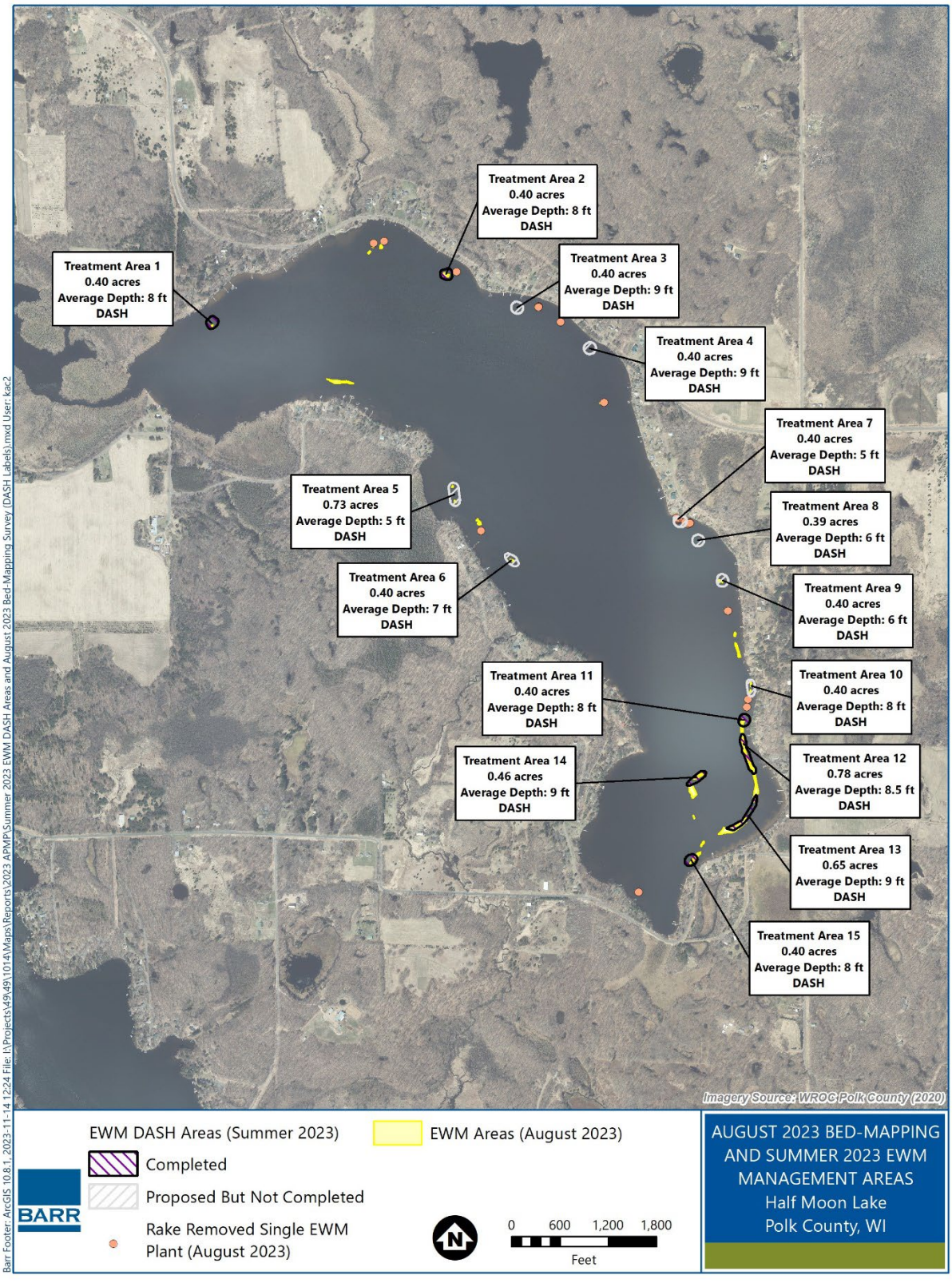

Figure 7-7 **August 2, 2023 Bed-Mapping Results Compared with Summer 2023 EWM Management Areas**

EWM bed-mapping surveys were completed on June 5, 2023 (Figure 7-8), August 2, 2023 (Figure 7-9), and October 8, 2023 (Figure 7-10). All single EWM plants observed during June 5 and August 2 surveys were rake removed (Figure 7-8 and Figure 7-9). DASH removal of some EWM during July 17-21 resulted in a decline of EWM extent from 2.57 acres on June 5, 2023 to 1.86 acres on August 2, 2023. Rapid spread of EWM caused its extent to more than double between August 2 (1.86 acres) and October 8 (5.76 acres).

The 2023 data document the rapid spread of EWM in Half Moon Lake despite EWM removal efforts (Figure 7-11, Figure 7-12, and Figure 7-13). Factors contributing towards the spread of EWM in the lake in 2022-2023 include:

- **2022 EWM spread during the lengthy WDNR permitting process** – additional EWM growth and spread occurred during the time period between the plant survey and permit issuance, resulting in EWM that was not removed in 2022. The plant survey to determine EWM removal areas was completed on June 8 and the 2022 EWM removal permit was issued July 28. EWM removal occurred on August 1 (ProcellaCOR treatment of 13.71 acres) and August 8-12 (DASH removal of 8.32 acres). Fall bed-mapping surveys found approximately one acre of EWM in the lake. The surveys found EWM was only present at 1 location within the 2022 EWM removal areas, but was present at 19 other locations within the lake (Figure 7-6).

- **2023 WDNR restriction of EWM removal to DASH only, which was ineffective** – WDNR did not permit the use of ProcellaCOR to remove EWM from the lake in 2023. A DASH permit was issued on June 21 for removal of the EWM documented by plant surveys completed during the fall of 2022. EWM removal occurred on July 17-21, the earliest available DASH removal dates when the permit was issued. Removal of EWM in mid-summer was challenging because the EWM was mixed with densely growing native plants in the southern and eastern areas of the lake where most of the DASH removal occurred. In addition, EWM was growing more densely in 2023 than 2022. EWM removal in 2022 averaged 19 cubic feet per acre compared with 46 cubic feet per acre in 2023. The challenges slowed DASH removal and made it difficult to effectively remove the EWM. Consequently, EWM removal only occurred in 7 of the 15 areas intended for DASH removal during the scheduled one week period. An August 2 bed-mapping survey found a continued presence of EWM in all 7 of the DASH removal areas (Areas 1-2 and 11-15 on Figure 7-7). The EWM extent on August 2, 2023 (1.86 acres) was less than the EWM extent on June 5, 2023 (2.57 acres), but nearly double the EWM extent in fall of 2022 (1 acre) (Figure 7-13). Because DASH removal was ineffective, no further DASH removal occurred in 2023. The rapid spread of the EWM remaining after DASH removal was documented by plant surveys in late August and October. A post-treatment plant survey documented a significant increase in EWM frequency in the lake during the June 5 through August 24 period (Appendix E and Appendix F). A fall 2023 EWM bed-mapping survey (Figure 7-10) documented an EWM extent more than double the August 2, 2023 EWM extent (Figure 7-9) and 6 times greater than the fall 2022 EWM extent (Figure 7-14).

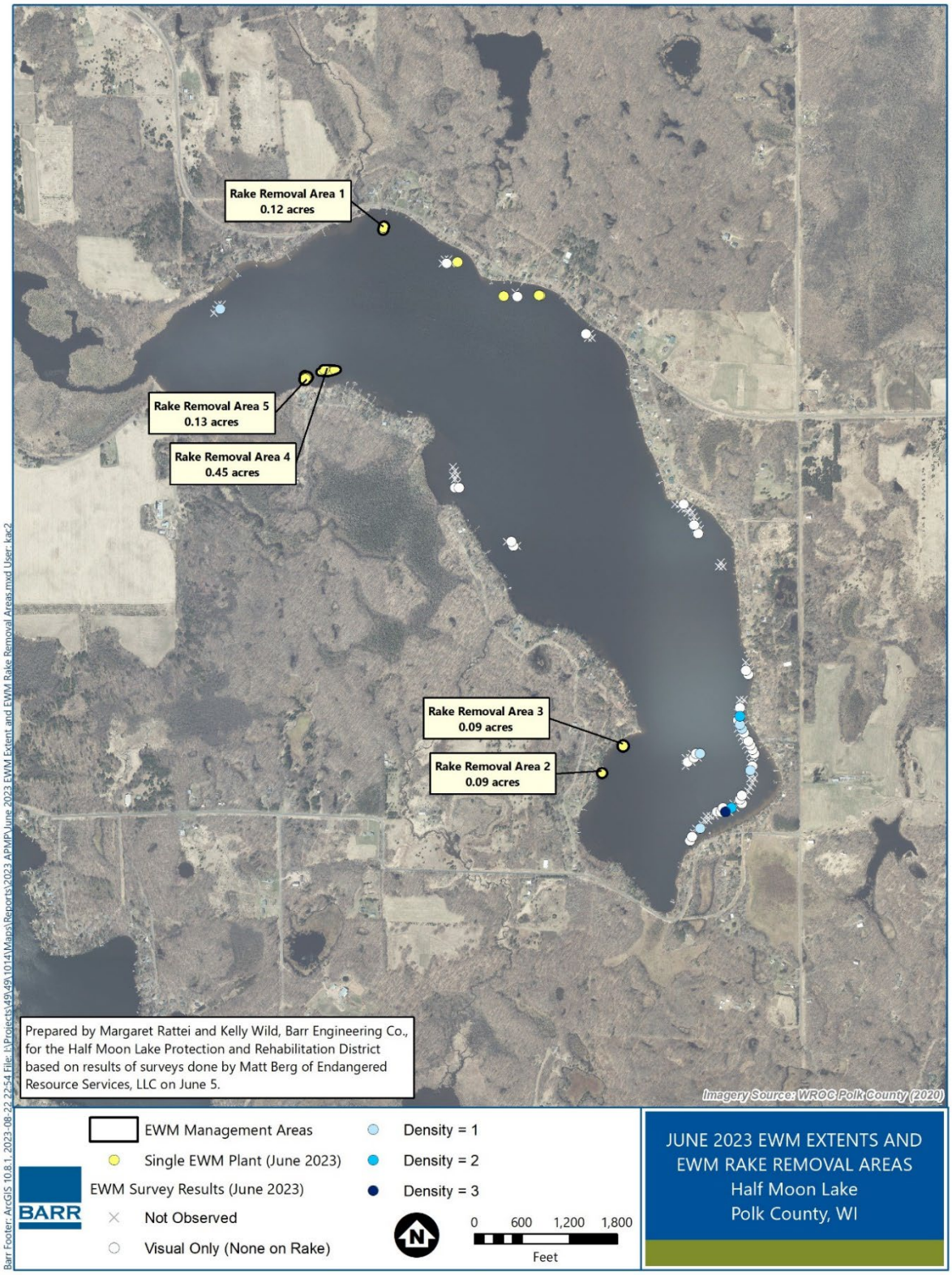

Figure 7-8 June 5, 2023 EWM Extent and Locations of Rake Removed Single EWM Plants

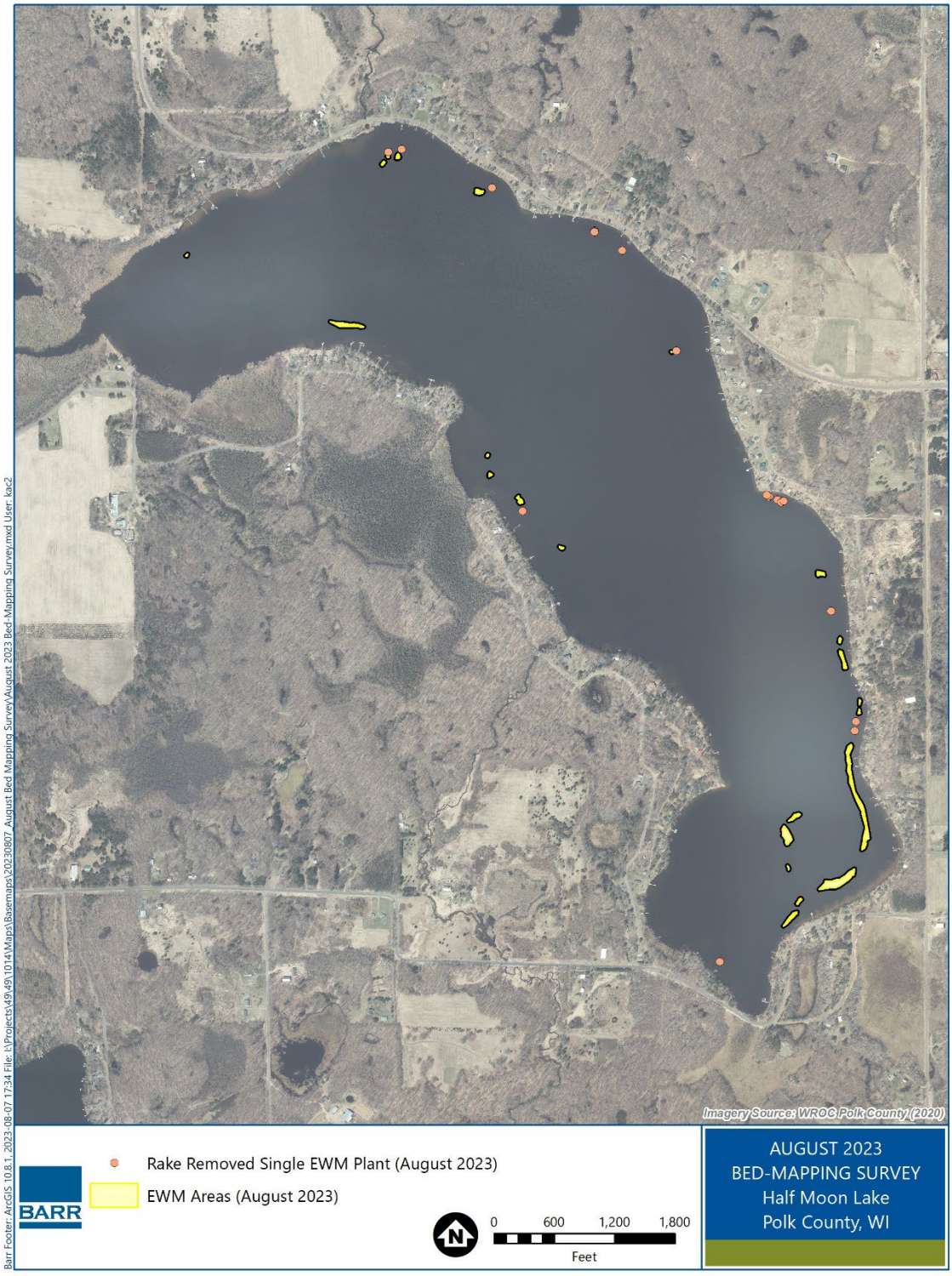

Figure 7-9 August 2, 2023 EWM Extent and Locations of Rake Removed Single EWM Plants

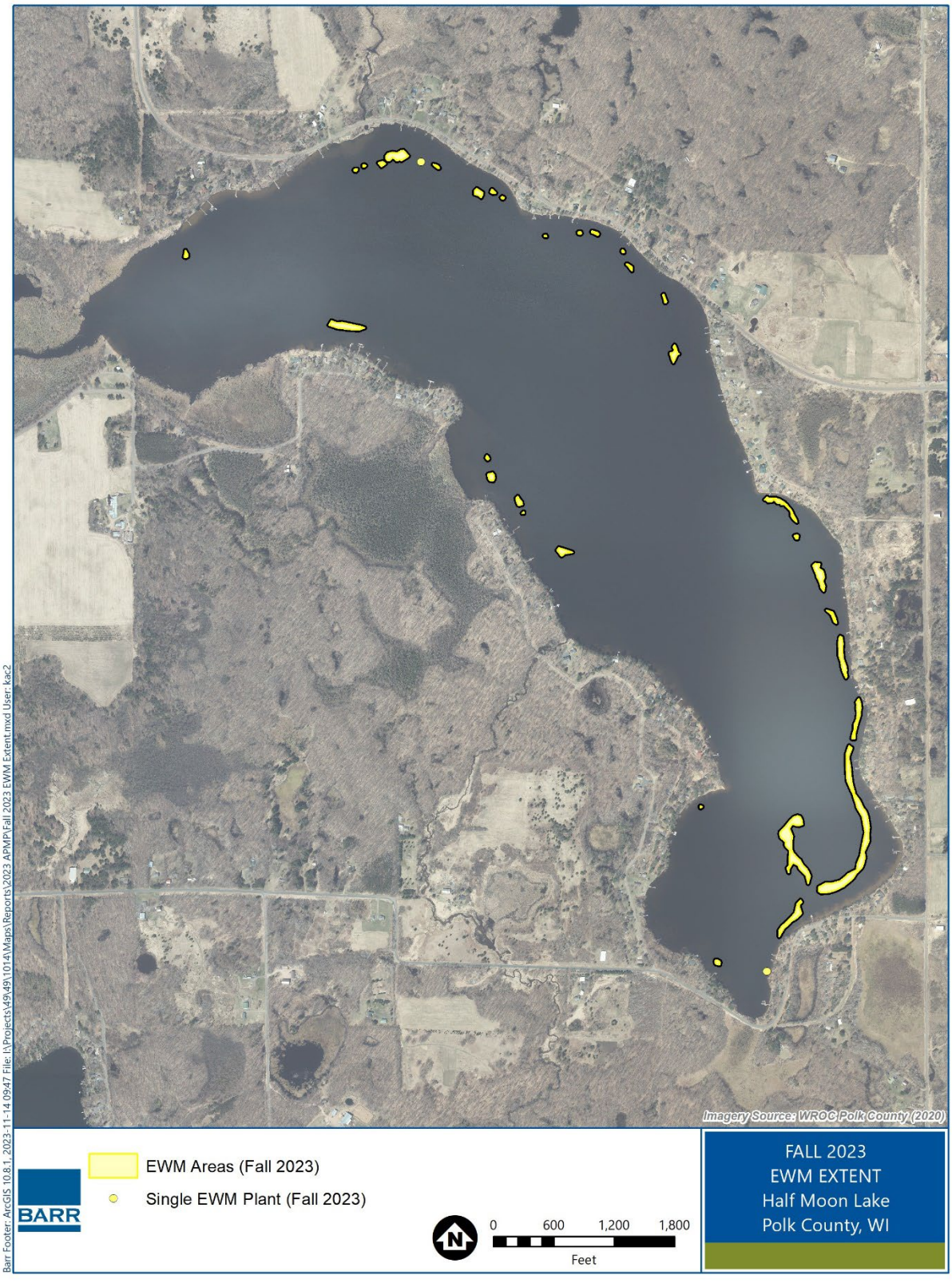

Figure 7-10 October 8, 2023 EWM Extent

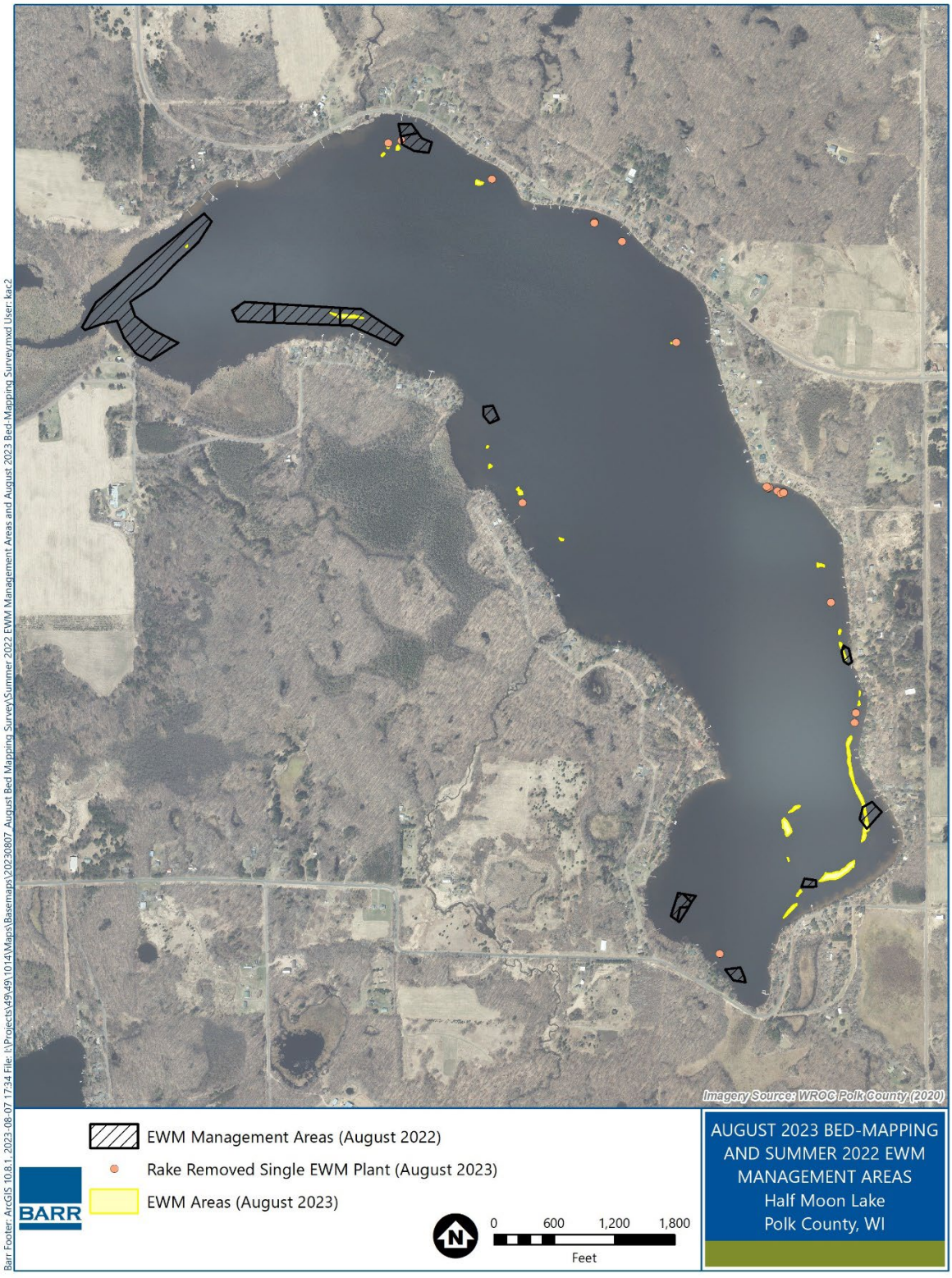

Figure 7-11 Comparison of August 2, 2023 EWM Extent with Summer 2022 EWM Management Areas

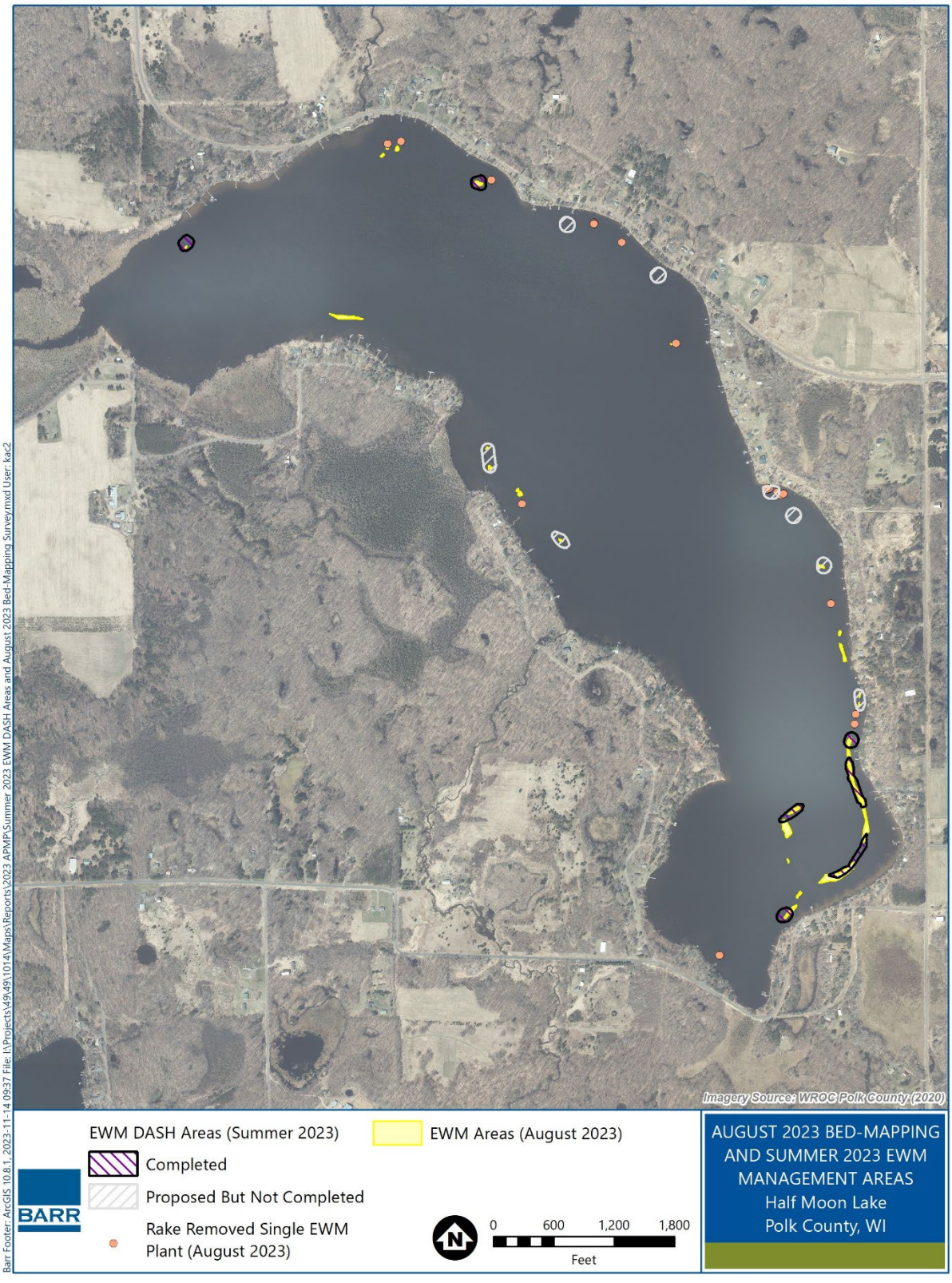

Figure 7-12 Comparison of August 2, 2023 EWM Extent with Summer 2023 DASH Removal Areas

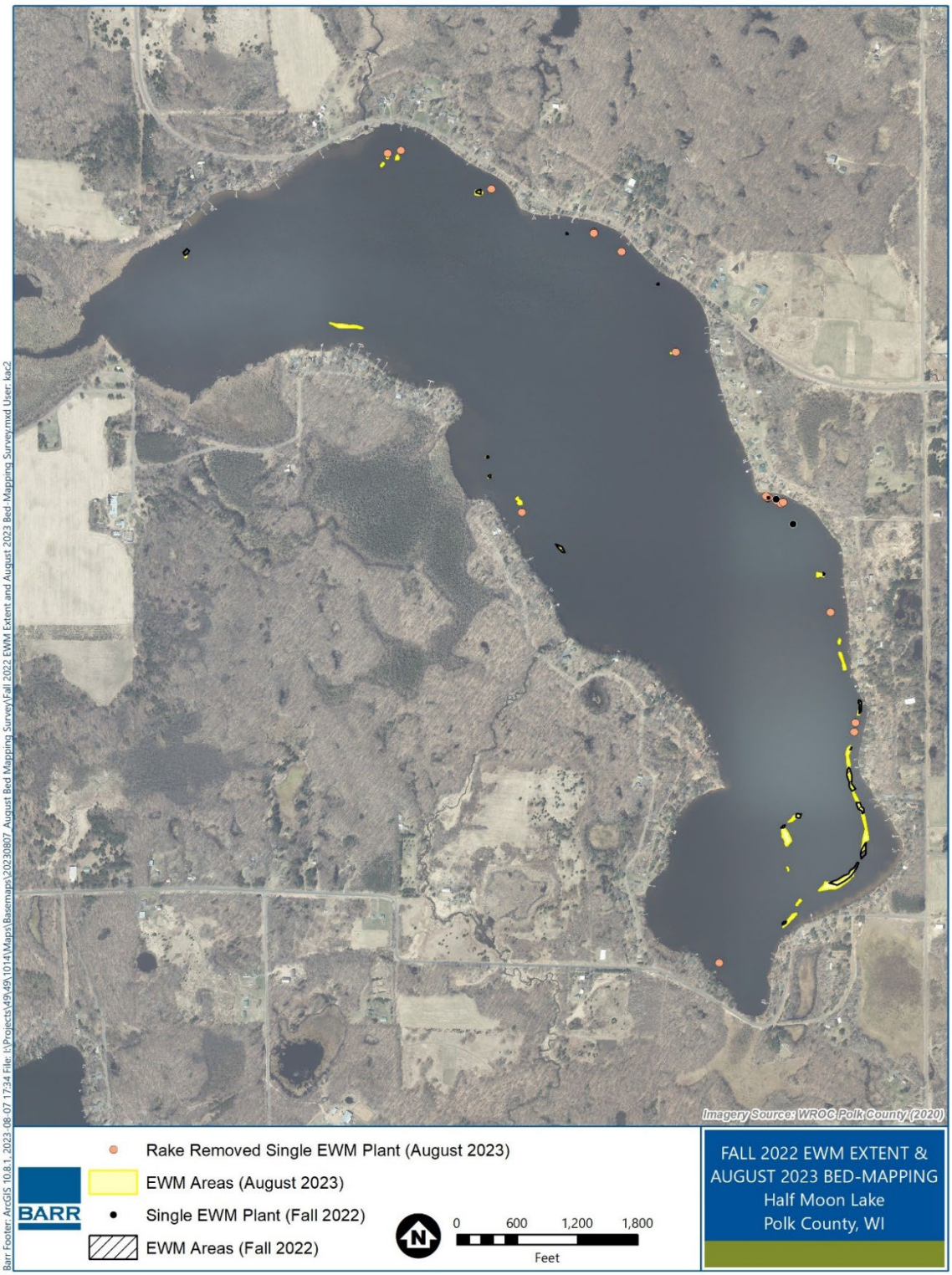

Figure 7-13 Comparison of August 2, 2023 EWM Extent with Fall 2022 EWM Extent

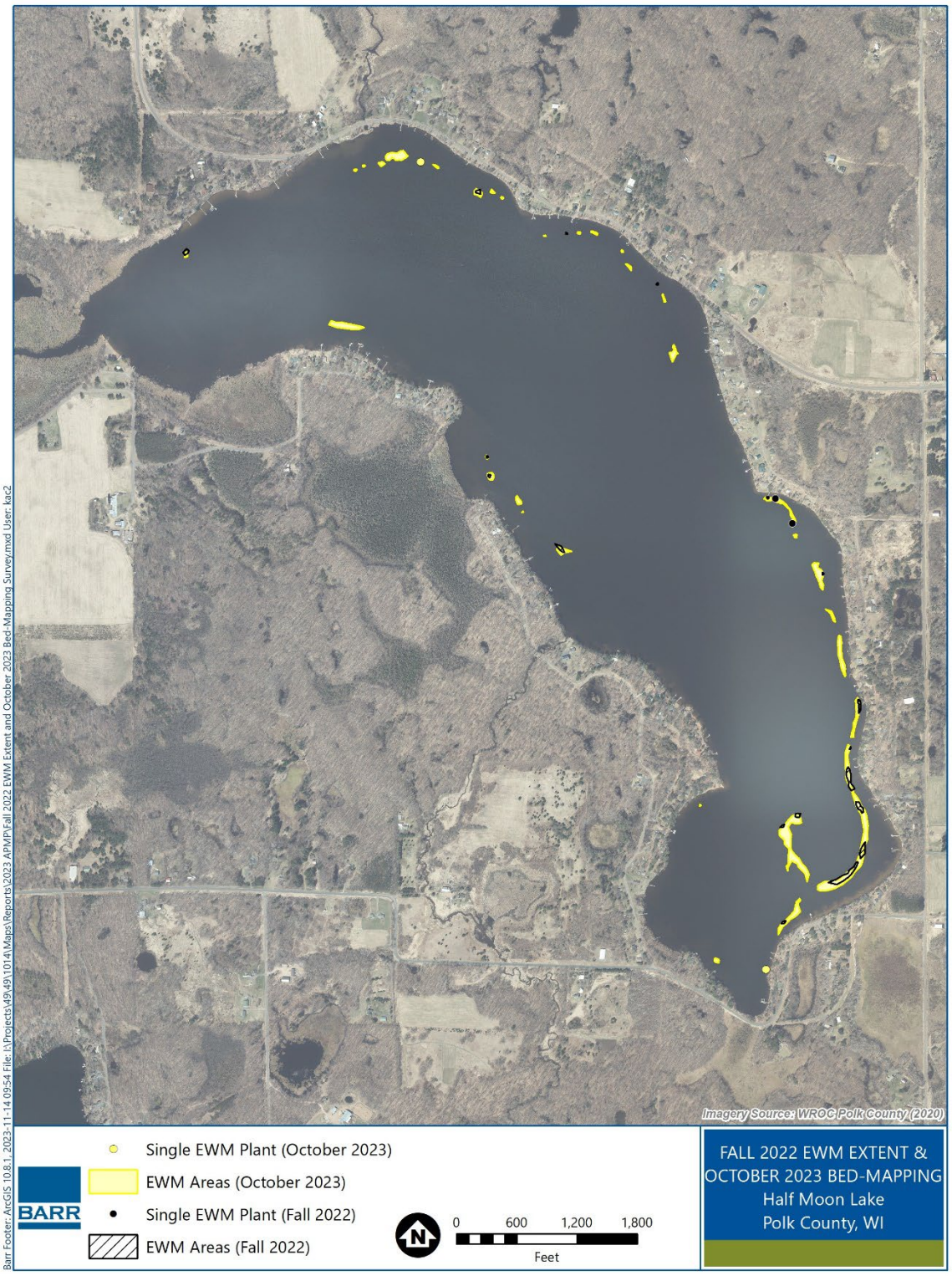

Figure 7-14 Comparison of October 8, 2023 EWM Extent with Fall 2022 EWM Extent

7.2 Yellow Iris

Yellow iris (*Iris pseudacorus*) 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 spreads quickly, by both rhizome and water-dispersed seed. 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 food sources in areas where it dominates. Dense areas of this plant may alter hydrology by trapping sediment. In Wisconsin, it can be an invasive garden escapee found along lake shorelines (WDNR 2023b). It was first observed in Wisconsin in 2005 (Wikipedia 2023) and at Half Moon Lake in 2018 (Figure 7-15) (Barr 2018).

Figure 7-15 Yellow iris at the southern end of Half Moon Lake in June 2018 (Photo Credit: Endangered Resource Services, LLC)

In 2021, the Half Moon Lake Protection and Rehabilitation District contracted with an applicator to chemically treat the yellow iris observed along the shoreline of Half Moon Lake. In 2022-2023, the Half Moon Lake Protection and Rehabilitation District completed a boat survey in June to look for yellow iris along the lake's shoreline. Whenever yellow iris was seen, the boat was parked and the homeowner informed of the presence of yellow iris and how to get rid of it (chemical treatment or hand digging). After becoming aware of the presence of yellow iris and how to remove it, homeowners have removed the yellow iris. This management approach has been successful and yellow iris was not observed in Half Moon Lake during the July 1, 2022 and July 1, 2023 plant surveys.

7.3 Curly-leaf Pondweed (CLP)

CLP, a plant native to Europe, Asia, northern Africa, and Australia (US Forest Service, 2012), was first introduced to the United States in 1859 (Nichols et al., 1986). CLP spread from Wilmington, Delaware, where it was first found, throughout the United States and was first reported in Wisconsin in 1905 (Bolduan et al., 1994, WDNR, 2012b). CLP was first observed in Half Moon Lake during 2007.

CLP differs from native plants that generally begin their growth cycle in spring and end their growing season by fall. CLP begins its growing cycle in late summer, continues to grow through the fall and winter, grows very rapidly in spring after ice-out, and finishes its growing cycle in early summer (Figure 7-16). CLP generally reproduces from turions, overwintering buds, which perform a similar role as seeds in native species. Studies show that each CLP plant can produce up to 900 turions (Catling et al., 1985) and turions can remain viable for several years (Newman 2009). CLP's ability to produce large numbers of turions and its unique growing cycle give this species a competitive advantage over native species. CLP begins its growth cycle when native species have ended their growth cycle and are no longer competing for space on the lake bottom. CLP is actively growing when natives begin their growth cycle. Hence, natives are restricted to areas not occupied by CLP.

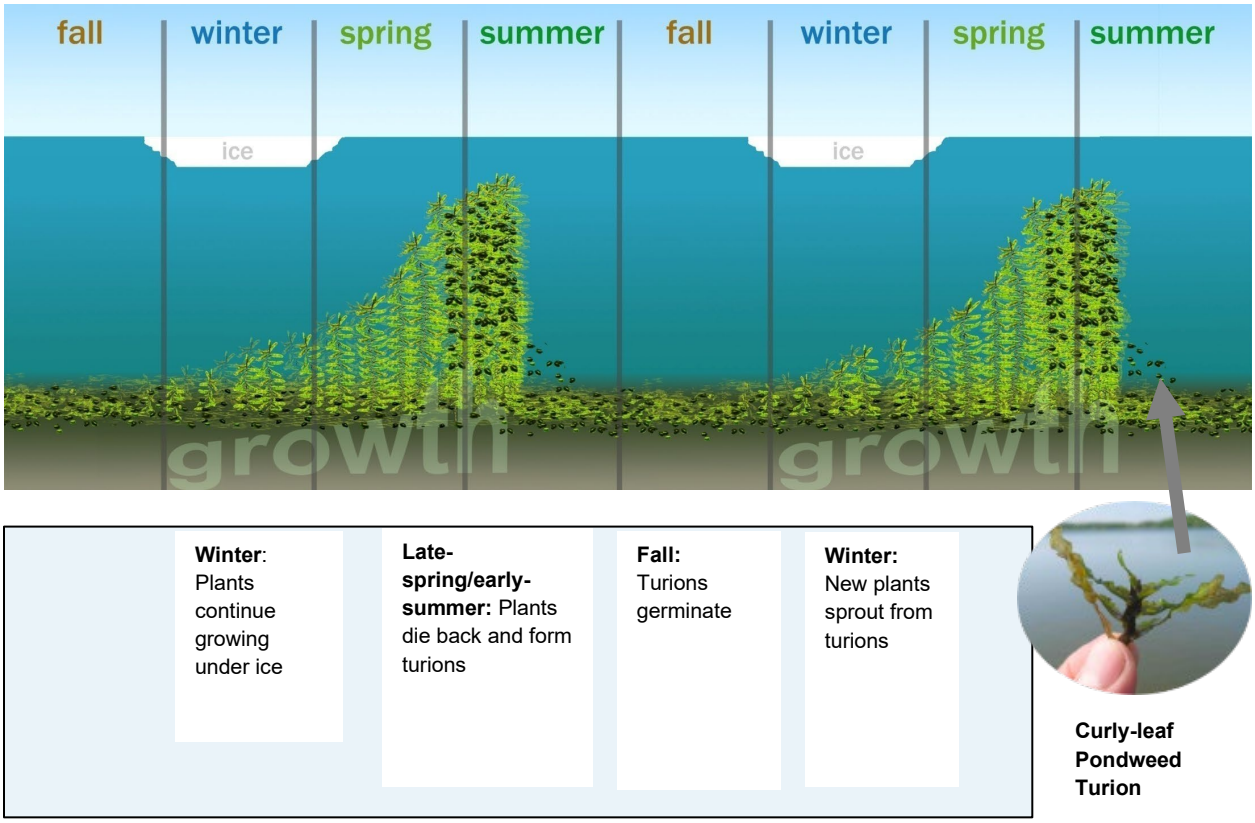

Figure 7-16 Curly-leaf Pondweed Growth Cycle

Plant surveys have documented the presence of curly-leaf pondweed (*Potamogeton crispus*) in Half Moon Lake since 2007. In 2007, curly-leaf pondweed (*Potamogeton crispus*) was collected on the rake at three sample locations in the northern end of the lake (Barr, 2018). In 2018, curly-leaf pondweed was collected on

the rake at four sample locations and observed near two additional locations in the northern end of the lake (Barr, 2018). In 2022, curly-leaf pondweed was found at fewer locations than 2007 and 2018. It was collected on the rake at one location in the northwestern corner of the lake and visually observed at one location near the east side of the lake (Barr 2022b). In 2023, curly-leaf pondweed was visually observed at one location on the northwestern side of the lake and collected on the rake at one location on the northeastern side of the lake. In 2018, 2022, and 2023 the plant surveyor commented that most curly-leaf pondweed plants were observed in 5 to 10 feet of water over organic muck and there was very little of this type of habitat in the lake. During 2007-2023, CLP was not problematic and management did not occur.

Although CLP has not been problematic to date, problematic conditions could occur in the future. While CLP has been found to grow best in 1 to 3 meters of water, it has been found at depths up to 7 meters (Bolduan 1994) and could expand from the 5 to 10 foot depth to deeper depths in Half Moon Lake. CLP appears to utilize a variety of sediments for growth (Bolduan 1994) and could expand from organic muck to other types of sediment in Half Moon Lake. CLP currently seems to be a latent problem, but annually produces turions which are winter buds that act like seeds. Yeo (1966) found that CLP plants in 5.9 m^2 produced 23,520 turions during a growing season. Kunii (1989) found that CLP plants produced 7,000 to 9,000 turions per square meter during a growing season. Turions can remain viable for several years. CLP may languish at a low level in Half Moon Lake until a favorable environmental circumstance happens that allows it to expand rapidly into a problematic condition. Removal of CLP from Half Moon Lake now will minimize the risk of rapid expansion to problematic conditions in the future.

7.4 Hybrid Cattail

Hybrid cattail was found at the same location in the northwestern corner of the lake during 2018 (Barr, 2018), 2022 (Barr, 2022b) and 2023. Because it was only found at one location and has not spread, it is not considered problematic. Hence, hybrid cattail management was not needed during this period.

7.5 Reed Canary Grass

Reed canary grass was observed in Half Moon Lake at one location in the northwest corner of the lake in 2018 and at one location in the southeast corner of the lake in 2023. It was not observed in 2007 and 2022. Because it has only been intermittently observed at a single location, it is not considered problematic and has not been managed.

8.0 Half Moon Lake Native Plant Community

8.1 Whole Lake Point Intercept Plant Surveys

Summer whole lake point intercept plant surveys during 2007, 2018, 2022, and 2023 indicate the plant community within Half Moon Lake is very healthy and of very high quality. The number of species (including visuals and boat surveys) in Half Moon Lake during this period has ranged from 37 in 2007 to 61 in 2023 (Table 8-1). In 2023, the number of species in Half Moon Lake was more than 4 times greater than the median value for lakes in the same eco-region (median value of North Central Hardwood Forests is 14) (Nichols, 1999). The quality of the plant community, measured by Floristic Quality Index (FQI), has ranged from 33 in 2007, to 45 in 2023 (Table 8-1). In 2023, the FQI was more than double the median value for lakes in the same eco-region (i.e., 20.9) (Nichols, 1999).

Half Moon Lake, pictured above, has a very healthy and high quality plant community.

In 2023, plant diversity as represented by Simpson's Diversity Index was within the range of previous years—0.94 in 2023 compared with 0.93 to 0.95 during 2007-2022 (Table 8-1). The values indicate the probability that two individual plants randomly selected from Half Moon Lake will belong to different species—94 percent in 2023 compared with 93 to 95 percent during 2007-2022.

In 2023, the maximum depth of plant growth was slightly lower than the range observed in previous years. The maximum depth at which plants were found was 17.5 feet in 2023 compared with a range of18 feet to 25.0 feet in 2007-2022 (Table 8-1). The mean depth of plant growth in 2023 was slightly lower than the range observed in previous years—5.5 feet in 2023 compared with a range of 5.6 feet to 7.0 feet in 2007-2022 (Table 8-1).

Plant frequency and the average number of native plant species per sample location were higher in 2023 than previous years. The plant frequency of occurrence at sites shallower than the maximum depth of plants was 89 percent in 2023 compared with 64 percent to 87 percent in 2007-2022 (Table 8-1). On average, more than 2 native plant species have been found at Half Moon Lake sample locations during the period of measurement. The average number of native plant species at each sample location was 3.4 in 2023 compared with 2.7 to 3.0 in 2007- 2022 (Table 8-1).

Table 8-1 2007-2023 Half Moon Lake Summary Statistics

SUMMARY STATS:	7/16-7/18/2007	6/21/2018	7/1/2022	7/1/2023
Total number of points sampled	372	734	734	734
Total number of sites with vegetation	197	213	205	202
Total number of sites shallower than maximum depth of plants	285	335	235	228
Frequency of occurrence of all species at sites shallower than maximum depth of plants	69.1	63.6	87.2	88.6
Simpson Diversity Index	0.93	0.95	0.95	0.94
Maximum depth of plants (ft)	25.0	25.0	18.0	17.5
Average number of all species per site (shallower than max depth)	2.8	2.7	3.0	3.4
Average number of all species per site (veg. sites only)	4.0	4.3	3.5	3.8
Average number of native species per site (shallower than max depth)	2.8	2.7	3.0	3.4
Average number of native species per site (veg. sites only)	4.0	4.2	3.5	3.8
Species Richness	32	44	46	49
Species Richness (including visuals)	35	50	48	54
Species Richness (including visuals and boat survey)	37	58	55	61
Mean depth of plants (ft)	7.0	6.1	5.6	5.5
Median depth of plants (ft)	4.5	4.5	4.0	4.0
Mean rake fullness (veg. sites only)	1.8	1.8	2.1	2.0
Mean C	6.0	6.3	6.6	6.5
FQI	32.5	41.5	43.0	45.3

During 2007-2023, plant species abundance was balanced between many different types and no single plant species dominated the plant community. From 70 to 76 percent of the lake's plant species had a frequency of less than 10 percent during 2007-2023 (Table 8-2, Figure 8-1 and Figure 8-2). The most prevalent native species in Half Moon Lake in 2023, ranging in frequency from 11 to 43 percent, were muskgrasses (*Chara sp.*), variable pondweed (*Potamogeton gramineus*), fern pondweed (*Potamogeton robbinsii*), wild celery (*Vallisneria americana*), filamentous algae, small pondweed (*Potamogeton pusillus*), coontail (*Ceratophyllum demersum*), common waterweed (*Elodea canadensis*), dwarf watermilfoil (*Myriophyllum tenellum*), flat-stem pondweed (*Potamogeton zosteriformis*), and slender naiad (*Najas flexilis*).

Significant frequency changes of native species in 2023 documented by a Chi-squared analysis of 2022 and 2023 data included 4 significant frequency increases—small pondweed (*Potamogeton pusillus*), clasping-leaf pondweed (*Potamogeton richardsonii*), wild celery (*Vallisneria americana*), and common watermeal (*Wolffia columbiana*)—and 1 significant decrease—(large-leaf pondweed (*Potamogeton amplifolius*) (Table 8-2).

Significant frequency changes have occurred in nearly half of the lake's native species since 2007, but the majority of changes were significant increases in year-over-year plant frequency (Table 8-2).

- 24 of the lake's 52 native species collected on the sampling rake have significantly changed in year-over-year frequency on at least one occasion since 2007.
- 5 native species have both significantly declined and significantly increased in a year-over-year frequency since 2007.
- 14 native species have significantly increased in a year-over-year frequency since 2007.
- 5 native species have significantly decreased in a year-over-year frequency since 2007.

Table 8-2 2007-2023 Half Moon Lake Frequency of Occurrence at Sites Shallower than Maximum Depth of Plants and Significant Change Between Years

Scientific Name	Common Name	Frequency of occurrence at sites shallower than maximum depth of plants				2007-2023 Significant Changes			Increase/Decrease
		7/16-7/18/2007	06/21/18	7/1/2022	7/1/2023	2007-2018	2018-2022	2022-2023	
Bidens beckii	Water marigold	3.86	2.39	1.28	0.44				
Brasenia schreberi	Watershield	0.70	2.09	6.81	6.58		**		Increase
Ceratophyllum demersum	Coontail	29.47	13.13	18.72	17.11	***			Decrease
Chara sp.	Muskgrass	15.44	27.76	39.15	42.54	***	**		Increase
Eleocharis acicularis	Needle spikerush	4.91	10.15	12.34	11.84	*			Increase
Eleocharis erythropoda	Bald spikerush	0.00	0.00	0.00	0.44				
Eleocharis palustris	Creeping spikerush	P	0.30	P	0.88				
Elodea canadensis	Common waterweed	22.81	14.63	14.47	14.47	**			Decrease
Filamentous algae	Filamentous algae	15.44	8.66	19.15	24.12	**	***		[1]Not Included with natives
Freshwater sponge	Freshwater sponge	0.00	0.00	0.43	2.19				[1]Not Included with natives
Heteranthera dubia	Water star-grass	5.96	12.84	9.79	9.65	**			Increase
Isoetes echinospora	Spiny spored-quillwort	0.00	2.99	2.13	2.19	**			Increase
Lemna minor	Small duckweed	5.61	2.69	3.83	3.51				
Lemna trisulca	Forked duckweed	5.61	8.36	5.11	8.77				
Myriophyllum sibiricum	Northern watermilfoil	10.53	11.94	14.04	8.77				
Myriophyllum spicatum	Eurasian watermilfoil	0.00	0.00	0.85	P				Non-native invasive species
Myriophyllum tenellum	Dwarf watermilfoil	4.56	10.45	11.49	14.47	**			Increase
Myriophyllum verticillatum	Whorled watermilfoil	0.00	0.60	0.43	0.44				
Najas flexilis	Slender naiad	5.61	11.94	7.23	10.96	**			Increase
Nitella sp.	Nitella	1.40	0.60	1.70	1.75				
Nuphar variegata	Spatterdock	3.86	4.18	8.09	6.14		*		Increase
Nymphaea odorata	White water lily	3.86	5.07	6.38	8.77				
Pontederia cordata	Pickerelweed	0.35	2.69	5.53	4.39	**			Increase
Potamogeton amplifolius	Large-leaf pondweed	8.42	2.99	11.06	5.70	**	***	*	Both
Potamogeton crispus	Curly-leaf pondweed	1.05	1.19	0.43	0.44				Non-native invasive species
Potamogeton friesii	Fries' pondweed	0.00	9.85	4.26	3.07	***	*		Both
Potamogeton gramineus	Variable pondweed	15.44	20.00	27.23	33.33		*		Increase
Potamogeton illinoensis	Illinois pondweed	0.35	2.99	0.85	2.63	*			Increase
Potamogeton natans	Floating-leaf pondweed	0.35	0.90	1.28	1.32				
Potamogeton praelongus	White-stem pondweed	0.00	0.90	0.43	0.44				
Potamogeton pusillus	Small pondweed	23.16	15.82	12.34	20.18	*		*	Both
Potamogeton richardsonii	Clasping-leaf pondweed	9.82	4.48	2.55	7.02	**		*	Both
Potamogeton robbinsii	Fern pondweed	25.61	24.48	24.68	27.19				
Potamogeton sp.	Narrow-leaved pondweed	2.46	0.00	0.00	0.00	**			Decrease
Potamogeton strictifolius	Stiff pondweed	0.00	0.00	0.00	0.44				
Potamogeton zosteriformis	Flat-stem pondweed	29.47	21.19	14.04	13.16	*	*		Decrease
Ranunculus aquatilis	White water crowfoot	7.02	2.09	3.40	1.75	**			Decrease

Table 8-2 2007-2023 Half Moon Lake Frequency of Occurrence at Sites Shallower than Maximum Depth of Plants and Significant Change Between Years *(Continued)*

Scientific Name	Common Name	Frequency of occurrence at sites shallower than maximum depth of plants				2007-2023 Significant Changes			Increase/Decrease
		7/16-7/18/2007	06/21/18	7/1/2022	7/1/2023	2007-2018	2018-2022	2022-2023	
Sagittaria cristata	Crested arrowhead	0.00	1.49	2.55	2.19	*			Increase
Sagittaria graminea	Grass-leaved arrowhead	0.00	0.30	0.00	0.44				
Sagittaria sp.	Arrowhead	0.35	0.00	0.00	0.00				
Schoenoplectus acutus	Hardstem bulrush	0.00	0.30	1.28	0.88				
Schoenoplectus pungens	Three-square bulrush	0.00	0.30	0.85	0.88				
Schoenoplectus subterminalis	Water bulrush	0.00	P	0.43	0.44				
Sparganium emersum	Short-stemmed bur-reed	0.00	P	0.85	0.44				
Sparganium eurycarpum	Common bur-reed	P	0.30	0.43	0.00				
Spirodela polyrhiza	Large duckweed	0.70	2.39	3.83	3.51				
Stuckenia pectinata	Sago pondweed	0.70	0.90	0.43	0.44				
Typha glauca	Hybrid Cattail	0.00	P	0.43	P				Non-native invasive species
Typha latifolia	Broad-leaved cattail	0.00	0.30	P	0.44				
Typha sp.	Cattail	P	0.00	0.00	0.00				
Utricularia gibba	Creeping bladderwort	0.00	0.30	5.11	5.26		***		Increase
Utricularia intermedia	Flat-leaf bladderwort	0.00	P	0.85	0.44				
Utricularia minor	Small bladderwort	0.00	0.00	0.00	1.32				
Utricularia vulgaris	Common bladderwort	0.00	0.30	1.28	1.32				
Vallisneria americana	Wild celery	27.37	11.64	12.34	27.19	***		***	Both
Wolffia columbiana	Common watermeal	0.35	0.30	0.43	3.95			**	Increase
Zizania palustris	Northern wild rice	0.00	0.60	0.43	0.44				
	Both Significant Increase and Decrease in Frequency During 2007-2023 = 5				# of native species significantly changing in frequency = 24				
	Significant Increase in Frequency = 14				# of native species = 52				
	Significant Decrease in Frequency = 5				% of native species significantly changing in frequency during 2007-2023 = 46%				
[1]Not Included with natives - only vascular plants or macroalgae included with natives;									
* means p≤0.05; ** means p≤0.01; ***means p≤0.001									

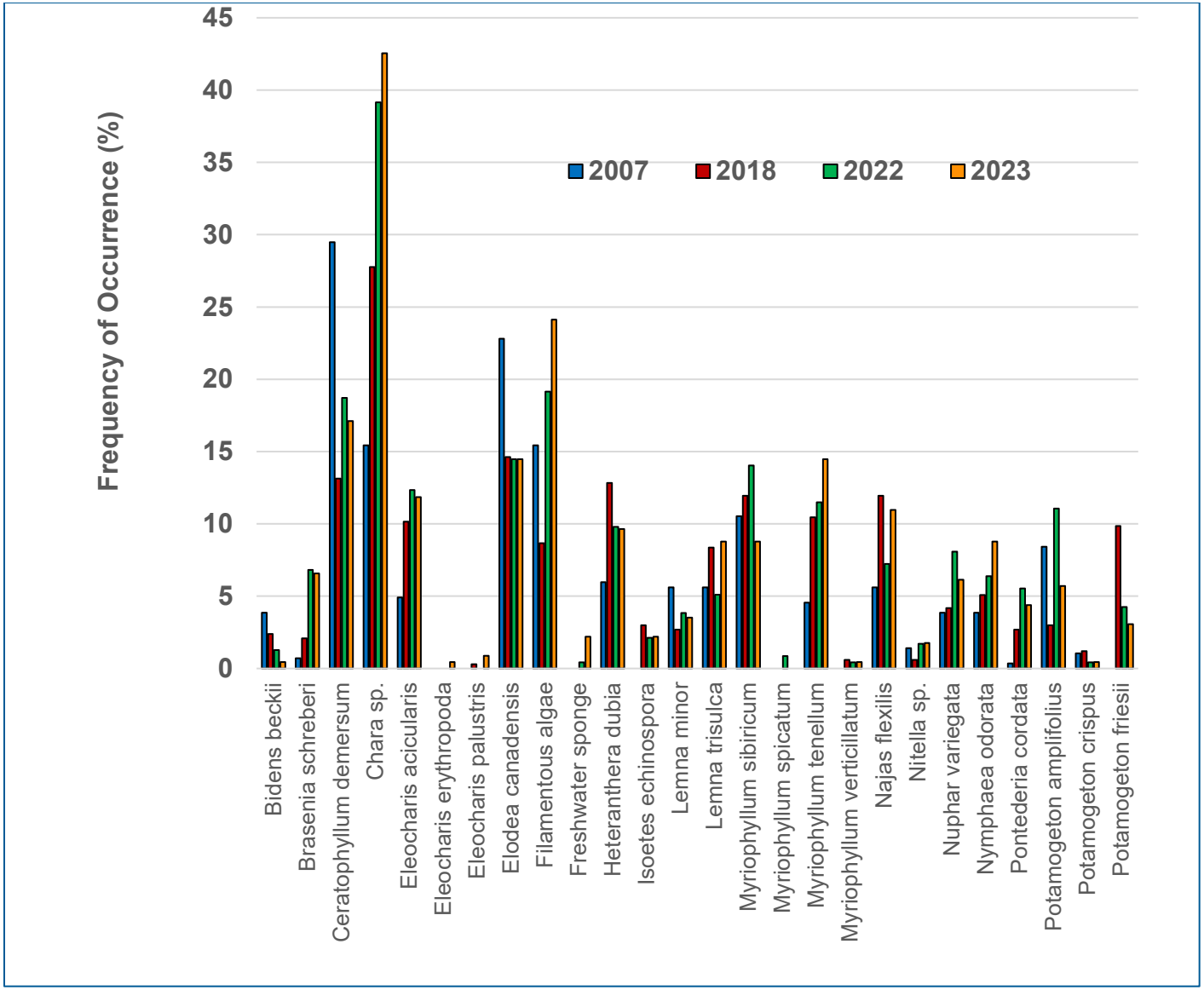

Figure 8-1 2007-2023 Half Moon Lake Frequency of Occurrence (% of Sites Shallower Than Maximum Depth of Plants)

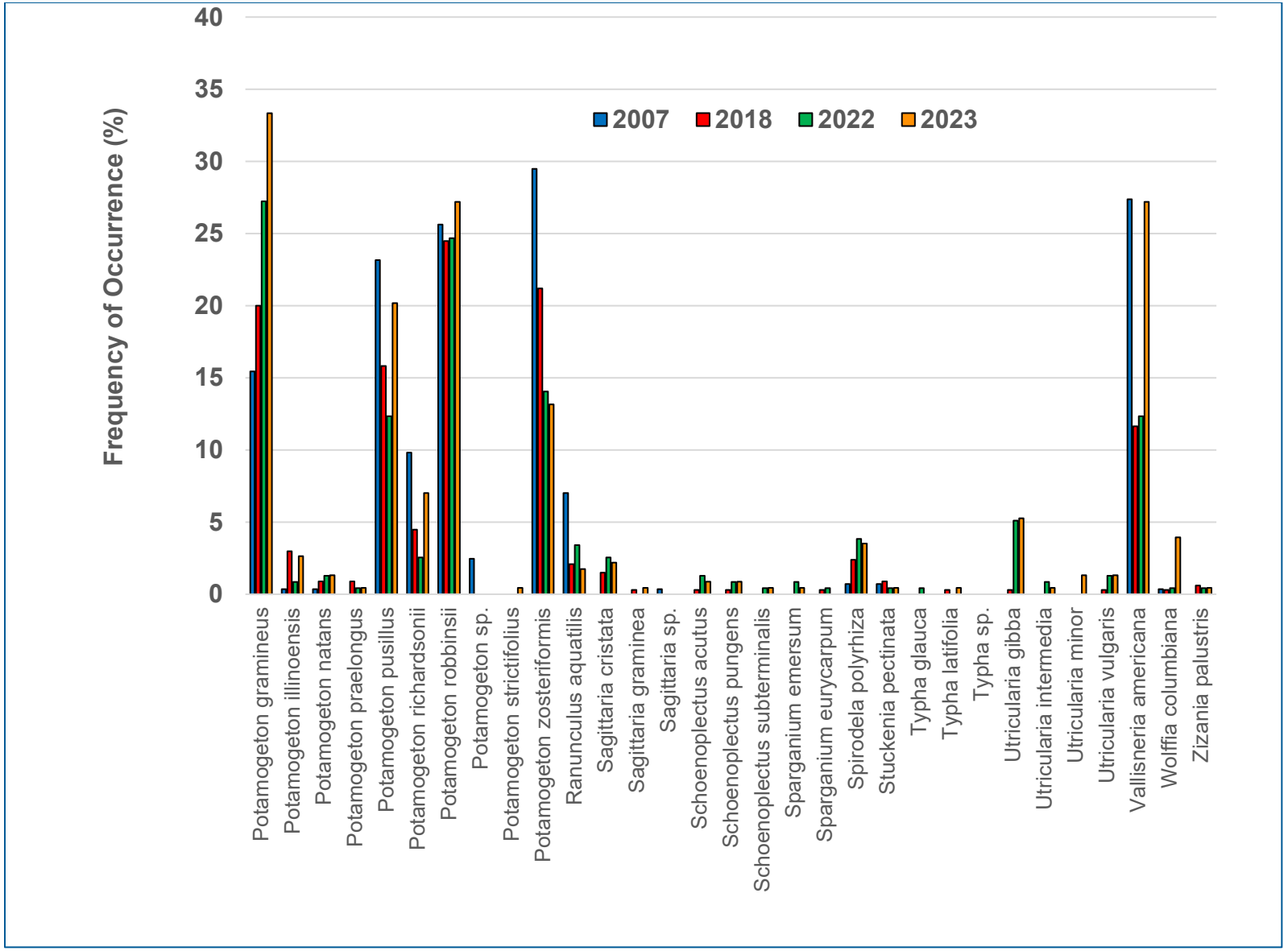

Figure 8-2 2007-2023 Half Moon Lake Frequency of Occurrence (% of Sites Shallower Than Maximum Depth of Plants)

8.2 Sub Point Intercept Plant Surveys

In 2022, pre-management and post-management sub PI plant surveys were completed on June 8 and September 18 to assess the plant community within EWM managed areas. Sample points are shown in Figure 7-4. The survey results are summarized in Table 8-3, Table 8-4, Figure 8-3, Appendix C, and Appendix D.

In 2022, post-management data document increases in the number of plant species (from 26 to 30), average number of native species per sites shallower than the maximum depth of plant growth (from 2.6 to 3.4), plant diversity as measured by the Simpson Diversity Index (from 0.89 to 0.92), the quality of the plant community as measured by the Floristic Quality Index (FQI) (from 32 to 35), plant frequency (from 92 percent to 97 percent), and plant density as measured by mean rake fullness (from 2.1 to 2.2) (Table 8-3). The increases are favorable changes for the lake's plant community. Factors likely causing the increases include seasonal changes in the plant community between June and September and removal of EWM from the monitored areas.

In 2022, significant frequency changes of species before and after EWM removal from the managed areas were documented by a Chi-squared analysis of June 8 and September 18 data. A significant post-management frequency decrease for EWM documents the success of the EWM removal efforts (Figure 8-3 and Table 8-4). Significant post-treatment frequency increases occurred for filamentous algae and seven native plant species—small duckweed (*Lemna minor*), slender naiad (*Najas flexilis*), nitella (*Nitella sp.*), variable pondweed (*Potamogeton gramineus*), floating-leaf pondweed (*Potamogeton natans*), wild celery (*Vallisneria americana*), and common watermeal (*Wolffia columbiana*) (Figure 8-3 and Table 8-4). Factors likely causing the increases include seasonal changes in the plant community between June and September and removal of EWM from the monitored area. The increased frequency of the native species is a positive change for the lake.

In 2023, pre-management and post-management sub PI plant surveys were completed on June 5 and August 24 to assess the plant community within EWM managed areas. Sample points are shown in Figure 8-4. The survey results are summarized in Table 8-5, Table 8-6, Figure 8-5, Appendix E and Appendix F.

In 2023, post-treatment data document increases in the number of plant species (from 19 to 21), average number of native species per sites shallower than the maximum depth of plant growth (from 2.5 to 3.7), plant diversity as measured by the Simpson Diversity Index (from 0.90 to 0.91), the quality of the plant community as measured by the Floristic Quality Index (FQI) (from 27 to 29), plant frequency (from 95 percent to 98 percent), and plant density as measured by mean rake fullness (from 1.6 to 2.3) (Table 8-3). The increases are favorable changes for the lake's plant community. The increases are likely due to seasonal changes in the plant community between June and August.

In 2023, significant frequency changes of species before and after EWM removal from some of the managed areas were documented by a Chi-squared analysis of June 5 and August 24 data. A significant post-management frequency increase for EWM documents the ineffectiveness of the efforts to remove EWM using DASH (Figure 8-5 and Table 8-6). Significant post-management frequency decreases occurred

for filamentous algae and for two native plant species—Fries' pondweed (*Potamogeton friesii*) and forked duckweed (*Lemna trisulca*) (Figure 8-5 and Table 8-6). Significant post-management frequency increases occurred for six native plant species—small pondweed (*Potamogeton pusillus*), variable pondweed (*Potamogeton gramineus*), northern watermilfoil (*Myriophyllum sibericum*), clasping-leaf pondweed (*Potamogeton richardsonii*), wild celery (*Vallisneria americana*), and slender naiad (*Najas flexilis*) (Figure 8-5 and Table 8-6). Frequency increases are likely due to seasonal changes in the plant community between June and August. The increased frequency of the native species is a positive change for the lake.

Table 8-3 2022 Half Moon Lake Sub PI Summary Statistics

SUMMARY STATS:	6/8/2022	9/18/2022
Total number of points sampled	119	119
Total number of sites with vegetation	109	112
Total number of sites shallower than maximum depth of plants	118	115
Frequency of occurrence of all species at sites shallower than maximum depth of plants	92.4	97.4
Simpson Diversity Index	0.89	0.92
Maximum depth of plants (ft)	17.5	16.5
Average number of all species per site (shallower than max depth)	2.7	3.4
Average number of all species per site (veg. sites only)	2.9	3.5
Average number of native species per site (shallower than max depth)	2.6	3.4
Average number of native species per site (veg. sites only)	2.8	3.5
Species Richness	26	29
Species Richness (including visuals)	26	30
Species Richness (including visuals and boat survey)	26	30
Mean depth of plants (ft)	6.8	6.9
Median depth of plants (ft)	6.0	6.0
Mean rake fullness (veg. sites only)	2.1	2.2
Mean C	6.5	6.4
FQI	31.8	34.7

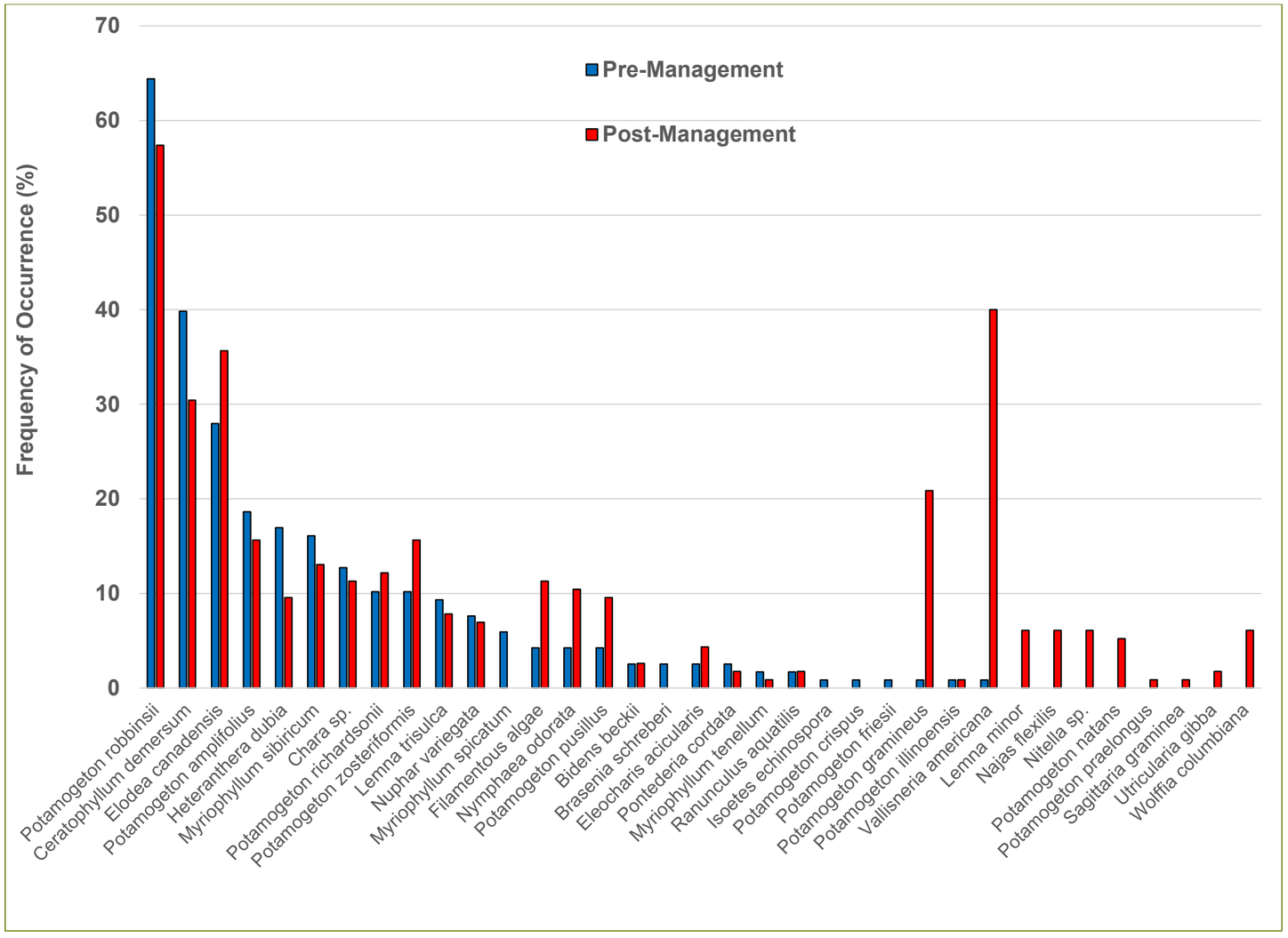

Figure 8-3 Comparison of 2022 Half Moon Lake Pre-management (June 8) and Post-management (September 18) Frequency of Occurrence (% of Sites Shallower than Maximum Depth of Plants)

Table 8-4 2022 Half Moon Lake Sub PI Survey Results: Frequency of Occurrence at Sites Shallower Than Maximum Depth of Plant and Significant Change Between June 8 (Pre-management) and September 18 (Post-management)

Scientific Name	Common Name	Frequency of occurrence at sites shallower than maximum depth of plants		Significant Changes 6/8/2022 to 9/18/2022	Significant Increase/ Decrease
		06/08/22	09/18/22		
Bidens beckii	Water marigold	2.54	2.61	--	--
Brasenia schreberi	Watershield	2.54	0.00	--	--
Ceratophyllum demersum	Coontail	39.83	30.43	--	--
Chara sp.	Muskgrass	12.71	11.30	--	--
Eleocharis acicularis	Needle spikerush	2.54	4.35	--	--
Elodea canadensis	Common waterweed	27.97	35.65	--	--
Filamentous algae	Filamentous algae	4.24	11.30	*	Increase
Heteranthera dubia	Water star-grass	16.95	9.57	--	--
Isoetes echinospora	Spiny-spored quillwort	0.85	0.00	--	--
Lemna minor	Small duckweed	0.00	6.09	**	Increase
Lemna trisulca	Forked duckweed	9.32	7.83	--	--
Myriophyllum sibiricum	Northern watermilfoil	16.10	13.04	--	--
Myriophyllum spicatum	Eurasian watermilfoil	5.93	0.00	**	Decrease
Myriophyllum tenellum	Dwarf watermilfoil	1.69	0.87	--	--
Najas flexilis	Slender naiad	0.00	6.09	**	Increase
Nitella sp.	Nitella	0.00	6.09	**	Increase
Nuphar variegata	Spatterdock	7.63	6.96	--	--
Nymphaea odorata	White water lily	4.24	10.43	--	--
Pontederia cordata	Pickerelweed	2.54	1.74	--	--
Potamogeton amplifolius	Large-leaf pondweed	18.64	15.65	--	--
Potamogeton crispus	Curly-leaf pondweed	0.85	0.00	--	--
Potamogeton friesii	Fries' pondweed	0.85	0.00	--	--
Potamogeton gramineus	Variable pondweed	0.85	20.87	***	Increase

Table 8 4 2022 Half Moon Lake Sub PI Survey Results: Frequency of Occurrence at Sites Shallower Than Maximum Depth of Plant and Significant Change Between June 8 (Pre-Management) and September 18 (Post-Management) *(Continued)*

Scientific Name	Common Name	Frequency of occurrence at sites shallower than maximum depth of plants		Significant Changes	Significant Increase/ Decrease
		06/08/22	6/8/2022 to 9/18/2022		
Potamogeton illinoensis	Illinois pondweed	0.85	0.87	--	--
Potamogeton natans	Floating-leaf pondweed	0.00	5.22	*	Increase
Potamogeton praelongus	White-stem pondweed	0.00	0.87	--	--
Potamogeton pusillus	Small pondweed	4.24	9.57	--	--
Potamogeton richardsonii	Clasping-leaf pondweed	10.17	12.17	--	--
Potamogeton robbinsii	Fern pondweed	64.41	57.39	--	--
Potamogeton zosteriformis	Flat-stem pondweed	10.17	15.65	--	--
Ranunculus aquatilis	White water crowfoot	1.69	1.74	--	--
Sagittaria graminea	Grass-leaved arrowhead	0.00	0.87	--	--
Utricularia gibba	Creeping bladderwort	0.00	1.74	--	--
Vallisneria americana	Wild celery	0.85	40.00	***	Increase
Wolffia columbiana	Common watermeal	0.00	6.09	**	Increase

A p value, or probability value, describes how likely it is that the differences are due to random chance and, hence, are not statistically significant differences.

* means $p \leq 0.05$ and there is less than a 5% probability;

** means $p \leq 0.01$ and indicates there is less than a 1 percent probability;

***means $p \leq 0.001$ and indicates there is less than a 0.1 percent probability

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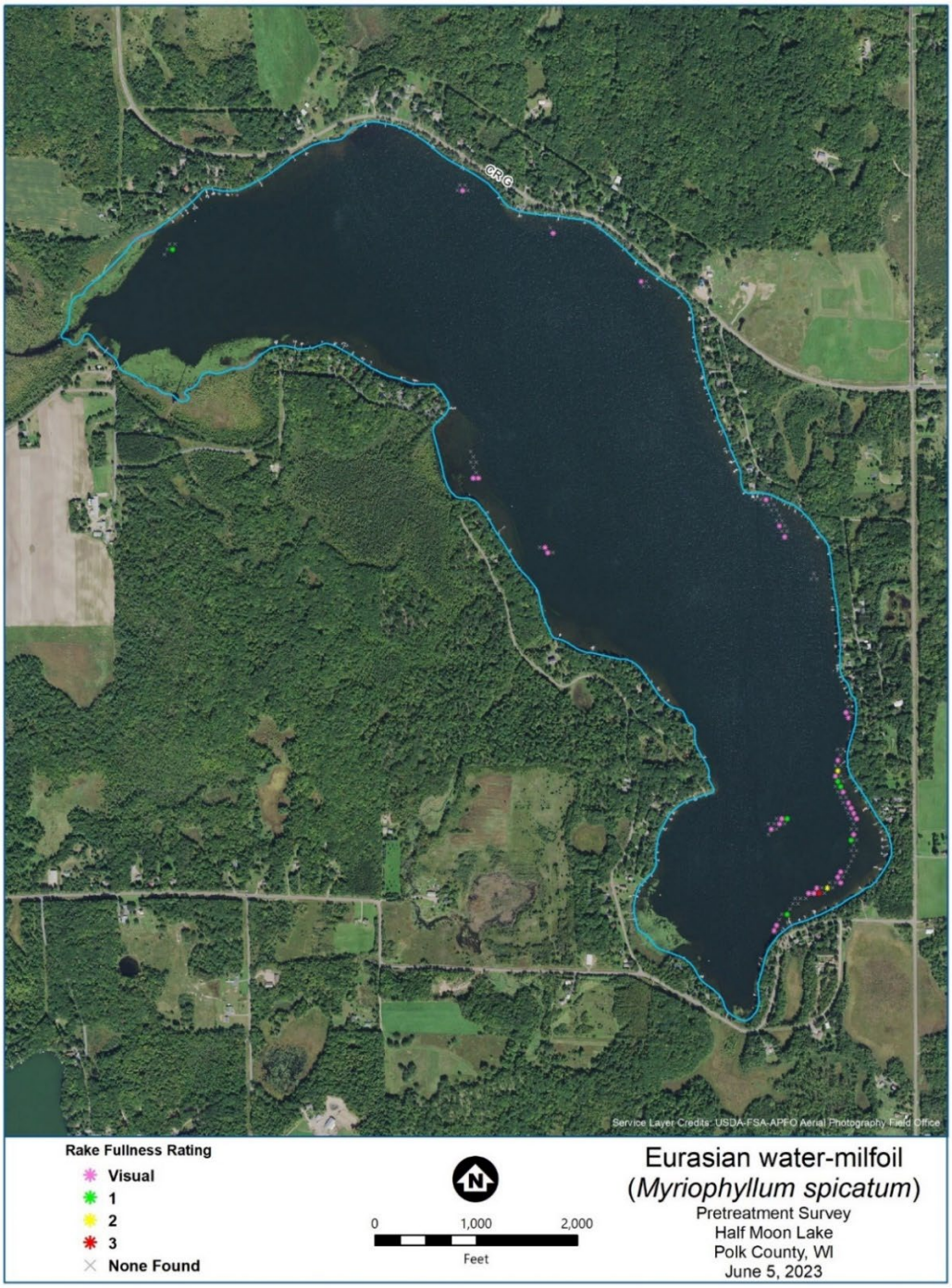

Figure 8-4 **2023 Sampling Locations for Pre-management and Post-management Sub PI Plant Surveys and Pre-management Locations of EWM (Map Credit: Endangered Resource Services LLC)**

Table 8-5 2023 Half Moon Lake Sub PI Summary Statistics

SUMMARY STATS:	6/5/2023	8/24/2023
Total number of points sampled	125	125
Total number of sites with vegetation	117	120
Total number of sites shallower than maximum depth of plants	123	122
Frequency of occurrence of all species at sites shallower than maximum depth of plants	95.12	98.36
Simpson Diversity Index	0.90	0.91
Maximum depth of plants (ft)	15.5	15.0
Average number of all species per site (shallower than max depth)	2.56	3.89
Average number of all species per site (veg. sites only)	2.69	3.96
Average number of native species per site (shallower than max depth)	2.49	3.72
Average number of native species per site (veg. sites only)	2.62	3.78
Species Richness	19	21
Species Richness (including visuals)	19	21
Species Richness (including visuals and boat survey)	19	21
Mean depth of plants (ft)	7.74	8.02
Median depth of plants (ft)	7.50	7.50
Mean rake fullness (veg. sites only)	1.57	2.26
Mean C	6.4	6.5
Floristic Quality Index (FQI)	27.3	28.8

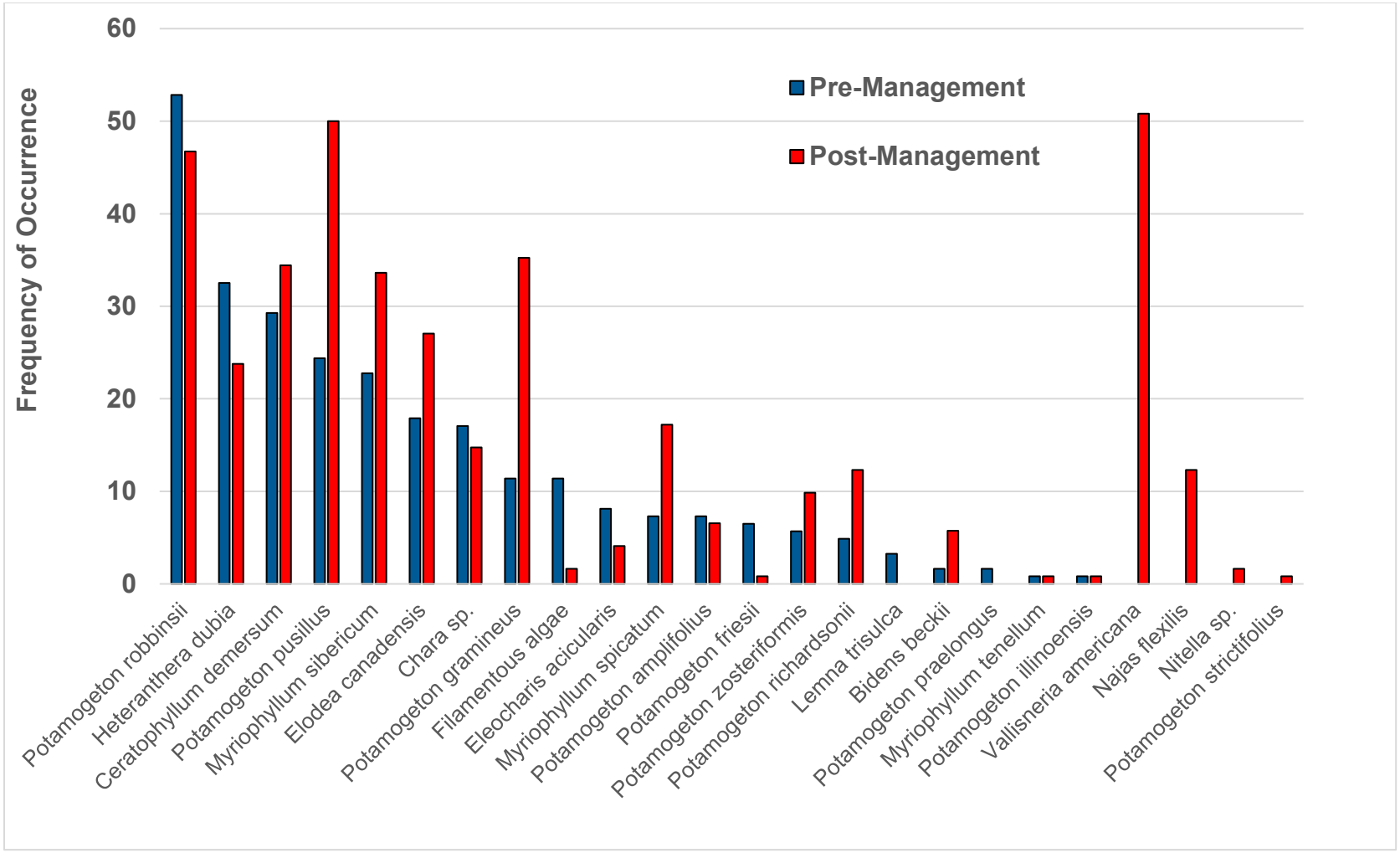

Figure 8-5 **Comparison of 2023 Half Moon Lake Pre-management (June 5) and Post-management (August 24) Frequency of Occurrence (% of Sites Shallower than Maximum Depth of Plants)**

Table 8-6 2023 Half Moon Lake Sub PI Survey Results: Frequency of Occurrence at Sites Shallower Than Maximum Depth of Plant and Significant Change Between June 5 (Pre-management) and August 24 (Post-management)

Scientific Name	Common Name	Frequency of occurrence at sites shallower than maximum depth of plants		Significant Changes 6/5/2023 to 8/24/2023	Significant Increase/ Decrease
		6/5/2023	8/24/2023		
Bidens beckii	Water marigold	1.63	5.74		
Ceratophyllum demersum	Coontail	29.27	34.43		
Chara sp.	Muskgrass	17.07	14.75		
Eleocharis acicularis	Needle spikerush	8.13	4.10		
Elodea canadensis	Common waterweed	17.89	27.05		
--	Filamentous algae	11.38	1.64	**	Decrease
Heteranthera dubia	Water star-grass	32.52	23.77		
Lemna trisulca	Forked duckweed	3.25	0	*	Decrease
Myriophyllum sibericum	Northern watermilfoil	22.76	33.61		
Myriophyllum spicatum	Eurasian watermilfoil	7.32	17.21	*	Increase
Myriophyllum tenellum	Dwarf watermilfoil	0.81	0.82		
Najas flexilis	Slender naiad	0	12.30	***	Increase
Nitella sp.	Nitella	0	1.64		
Potamogeton amplifolius	Large-leaf pondweed	7.32	6.56		
Potamogeton friesii	Fries' pondweed	6.50	0.82	*	Decrease
Potamogeton gramineus	Variable pondweed	11.38	35.25	***	Increase
Potamogeton illinoensis	Illinois pondweed	0.81	0.82		
Potamogeton praelongus	White-stem pondweed	1.63	0		
Potamogeton pusillus	Small pondweed	24.39	50.00	***	Increase
Potamogeton richardsonii	Clasping-leaf pondweed	4.88	12.30	*	Increase
Potamogeton robbinsii	Fern pondweed	52.85	46.72		

Table 8-6 2023 Half Moon Lake Sub PI Survey Results: Frequency of Occurrence at Sites Shallower Than Maximum Depth of Plant and Significant Change Between June 5 (Pre-management) and August 24 (Post-management) (*Continued*)

Scientific Name	Common Name	Frequency of occurrence at sites shallower than maximum depth of plants		Significant Changes 6/5/2023 to 8/24/2023	Significant Increase/ Decrease
		6/5/2023	6/5/2023 to 8/24/2023		
Potamogeton strictifolius	Stiff pondweed	0	0.82		
Potamogeton zosteriformis	Flat-stem pondweed	5.69	9.84		
Vallisneria americana	Wild celery	0	50.82	***	Increase

A p value, or probability value, describes how likely it is that the differences are due to random chance and, hence, are not statistically significant differences.

* means $p \leq 0.05$ and there is less than a 5% probability;

** means $p \leq 0.01$ and indicates there is less than a 1 percent probability;

***means $p \leq 0.001$ and indicates there is less than a 0.1 percent probability.

9.0 Citizen Survey and Results

A citizen survey was prepared by the Half Moon Lake Protection and Rehabilitation District, with assistance from the WDNR, and sent to the 220 property owners on Half Moon Lake during August of 2023. The survey provided an opportunity for citizen input to the Aquatic Plant Management Plan. The survey included questions about lake use, the impact of aquatic plants on lake use, and citizen opinions on management of aquatic plants in Half Moon Lake. The District received 89 completed surveys which is a 40 percent return rate. The survey questions and a tabulation of the responses are found in Appendix G and discussed in the following paragraphs.

As shown in Figure 9-1, 64 percent of survey respondents were citizens who reported at least a 20-year lake residency.

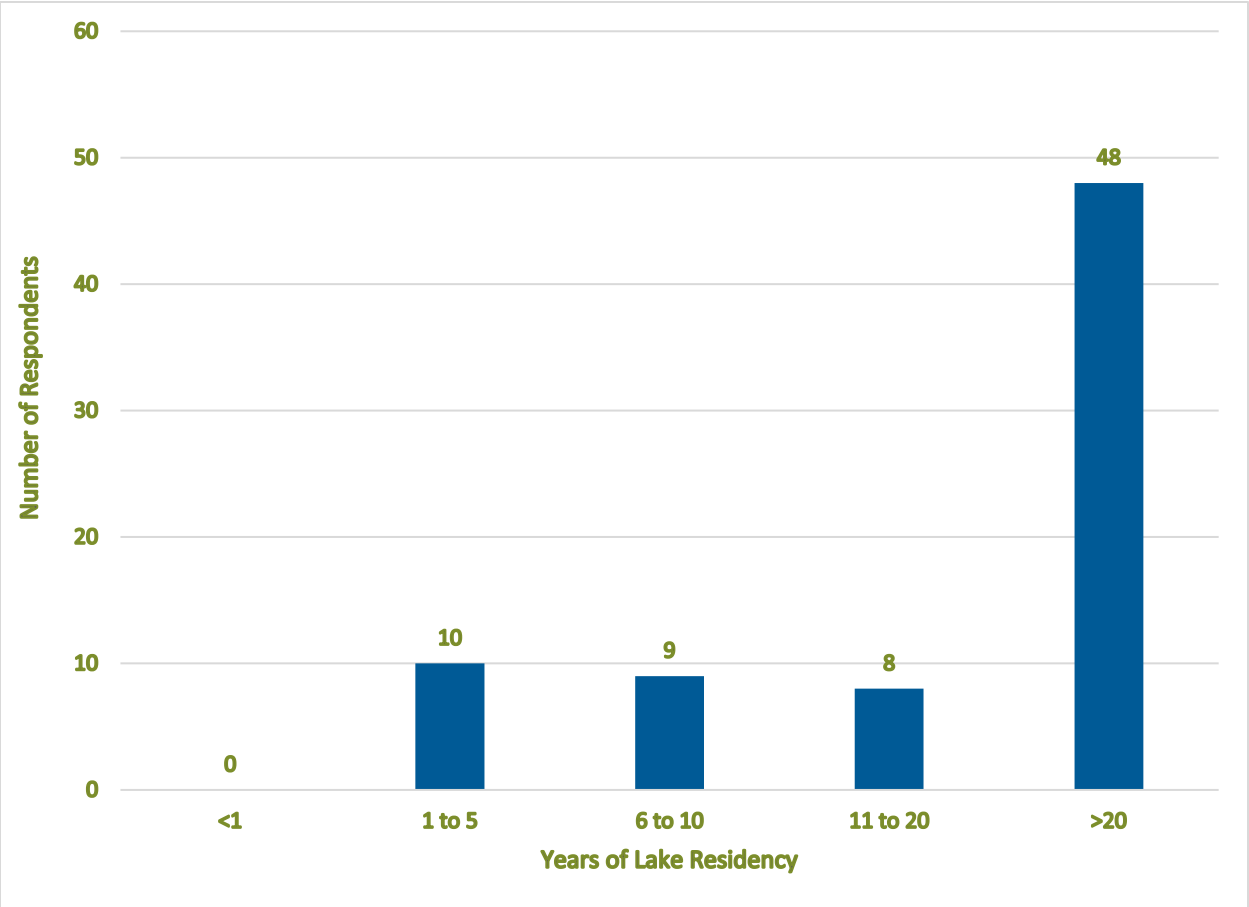

Figure 9-1 Years of Lake Residency Reported by Survey Respondents

Respondents indicated Half Moon Lake is a busy lake with broad recreational use. The highest uses of the lake are swimming, enjoying the view, fishing and pontoon boating (Figure 9-2).

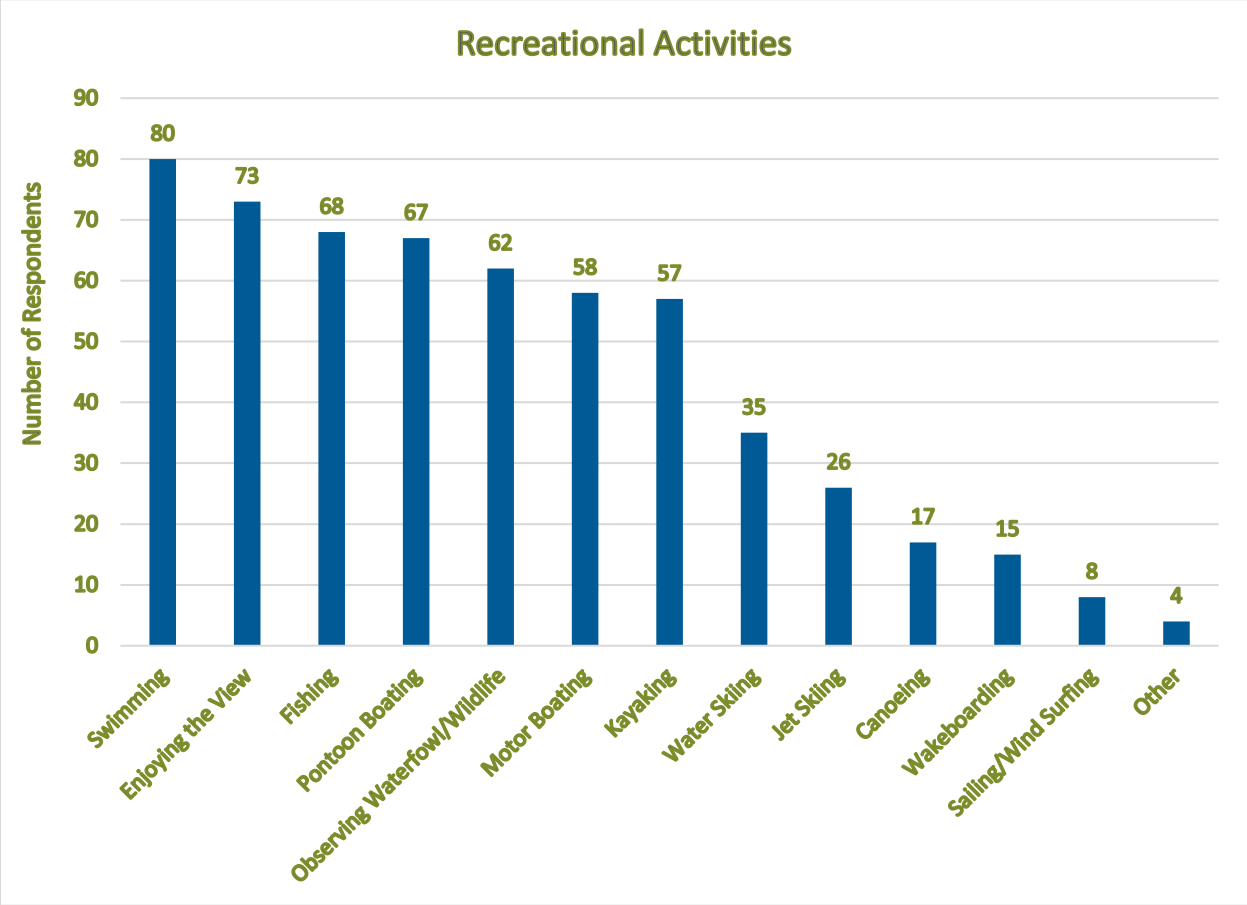

Figure 9-2 Recreational Activities Reported by Survey Respondents

Only 20 percent of respondents feel the lake is never impaired by the current levels of plant growth (Figure 9-3). The majority believed current levels of plant growth either rarely or occasionally caused impairment (Figure 9-3). Respondents indicated nearly all recreational activities were impaired by plant growth and believed the most impaired activities were swimming, fishing, pontoon boating, and motor boating (Figure 9-4).

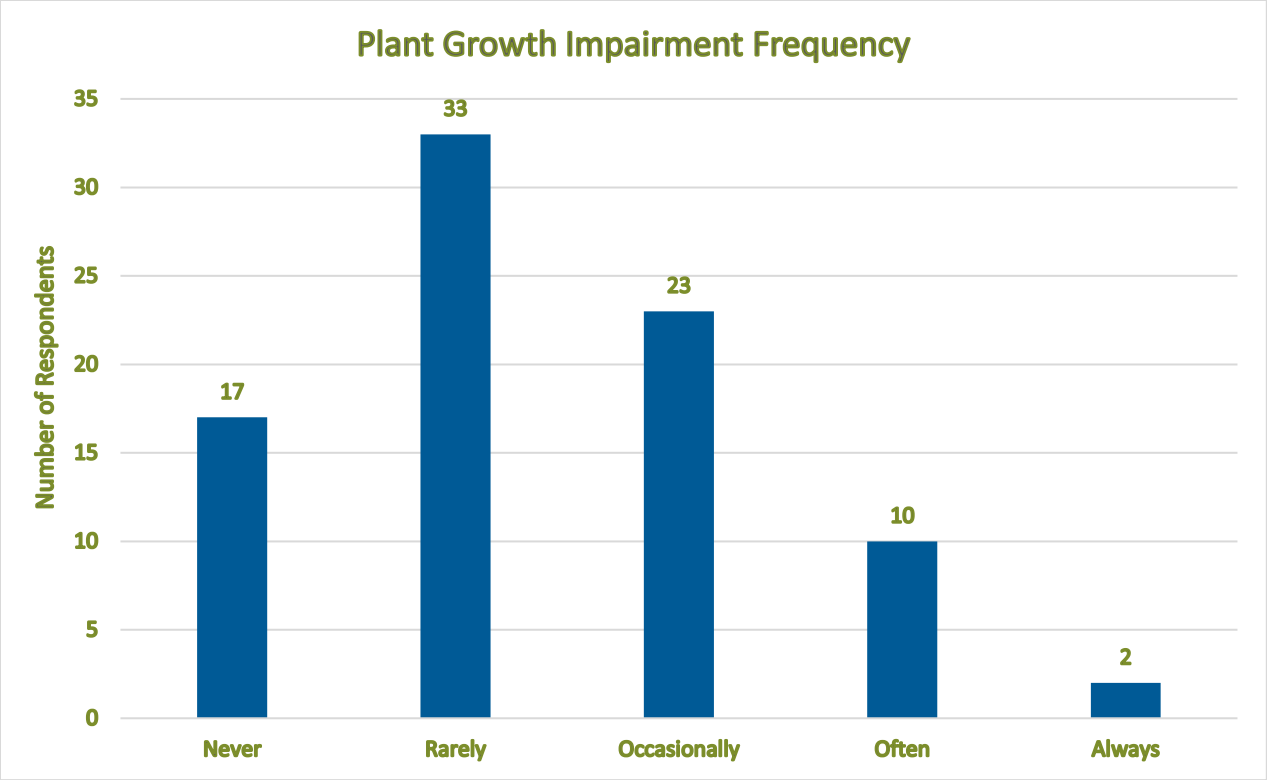

Figure 9-3 Plant Growth Impairment Frequency

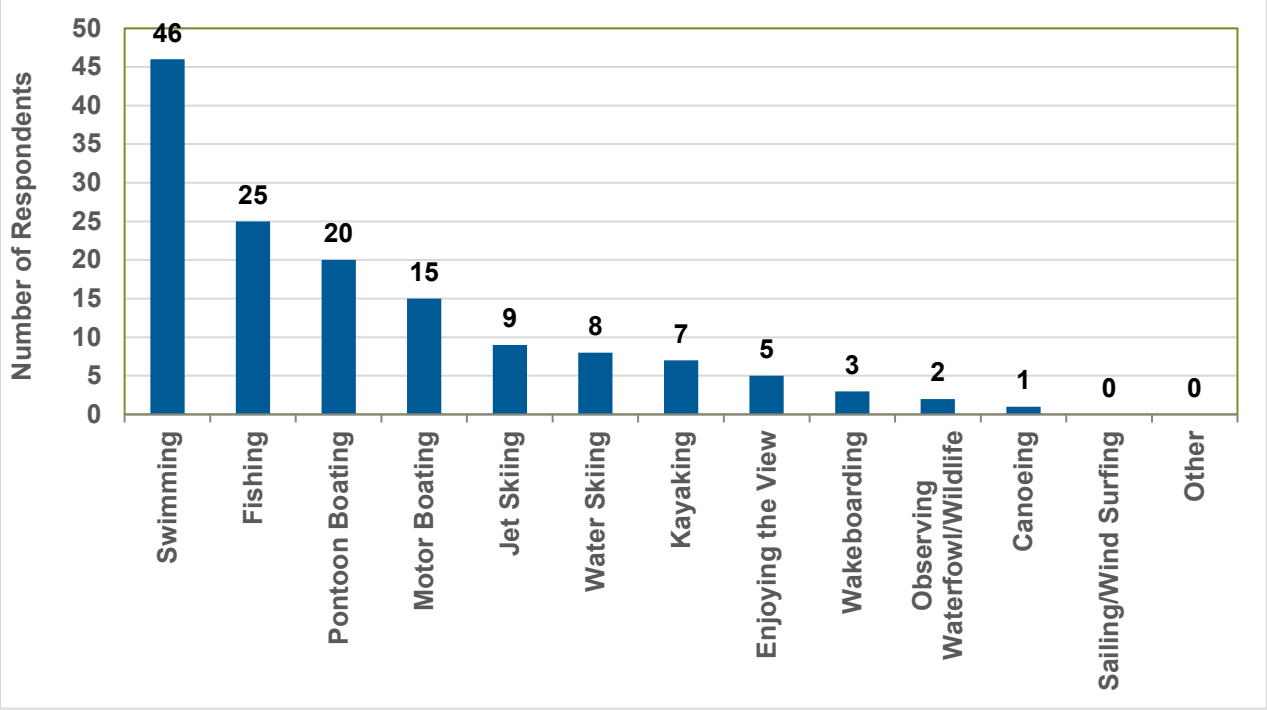

Figure 9-4 Lake Uses Impaired by Plant Growth

More than 60 percent of respondents believed the volume of vegetation in the lake had increased in the last five years (Figure 9-5). Nearly half believed there was an increase in the types of plants in the lake in the last five years while nearly half did not know if plant types had increased in the last five years (Figure 9-6). When asked to rank the degree of negative impact that invasive plant species have on use or enjoyment of the lake, 36 percent of the respondents selected high impact and 31 percent selected moderate impact (Figure 9-7).

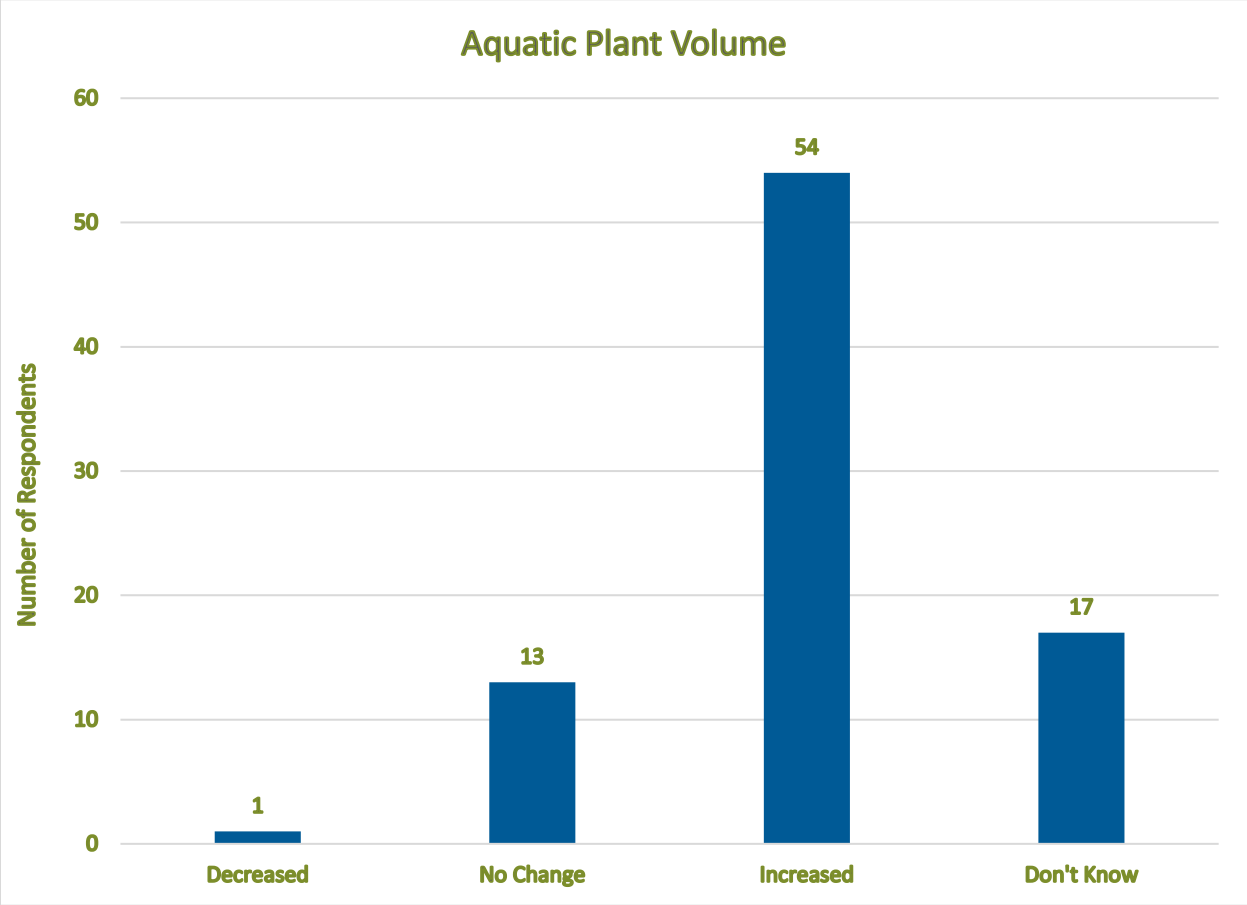

Figure 9-5 Changes in Aquatic Plant Volume in Last Five Years

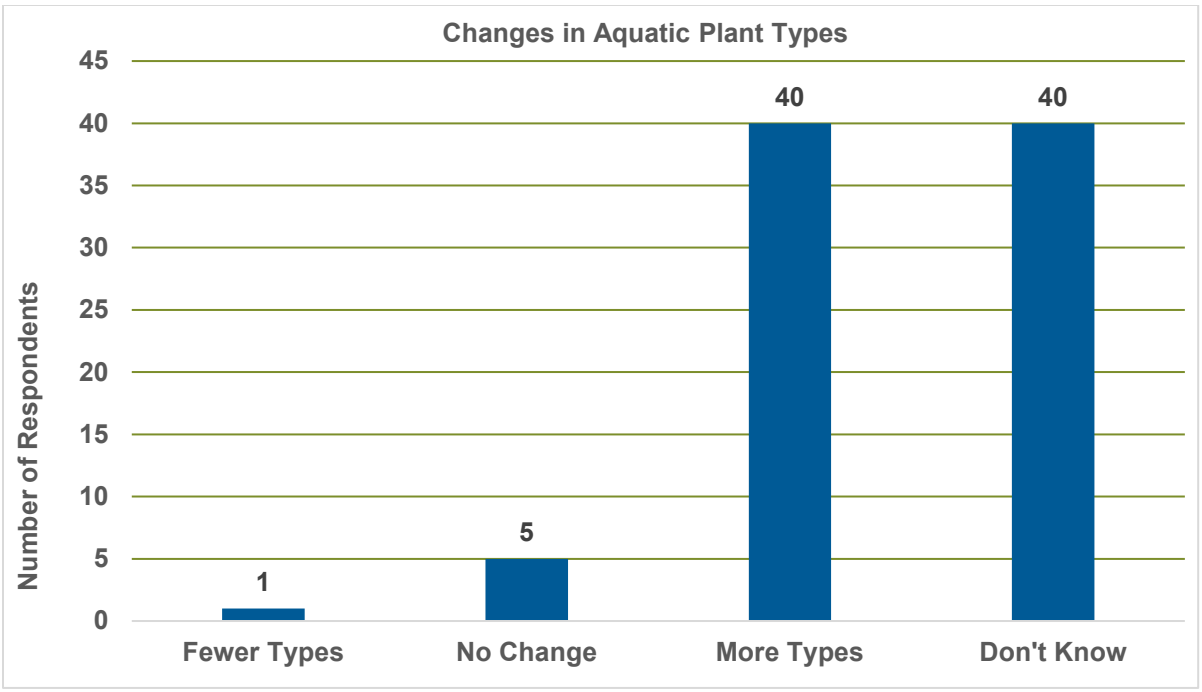

Figure 9-6 **Changes in Aquatic Plant Types in Last Five Years**

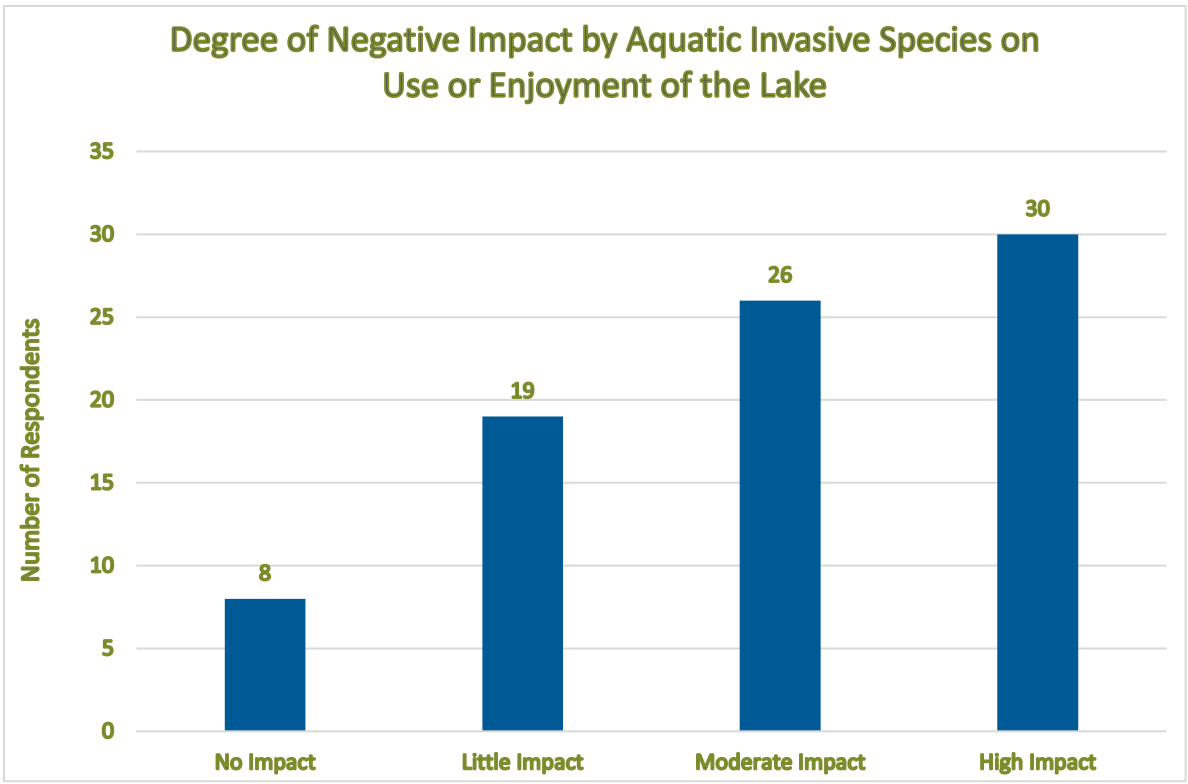

Figure 9-7 **Degree of Negative Impact by Invasive Plant Species on Use or Enjoyment of the Lake**

86 percent of respondents support reducing invasive plants as much as possible to avoid future problems (Figure 9-8).

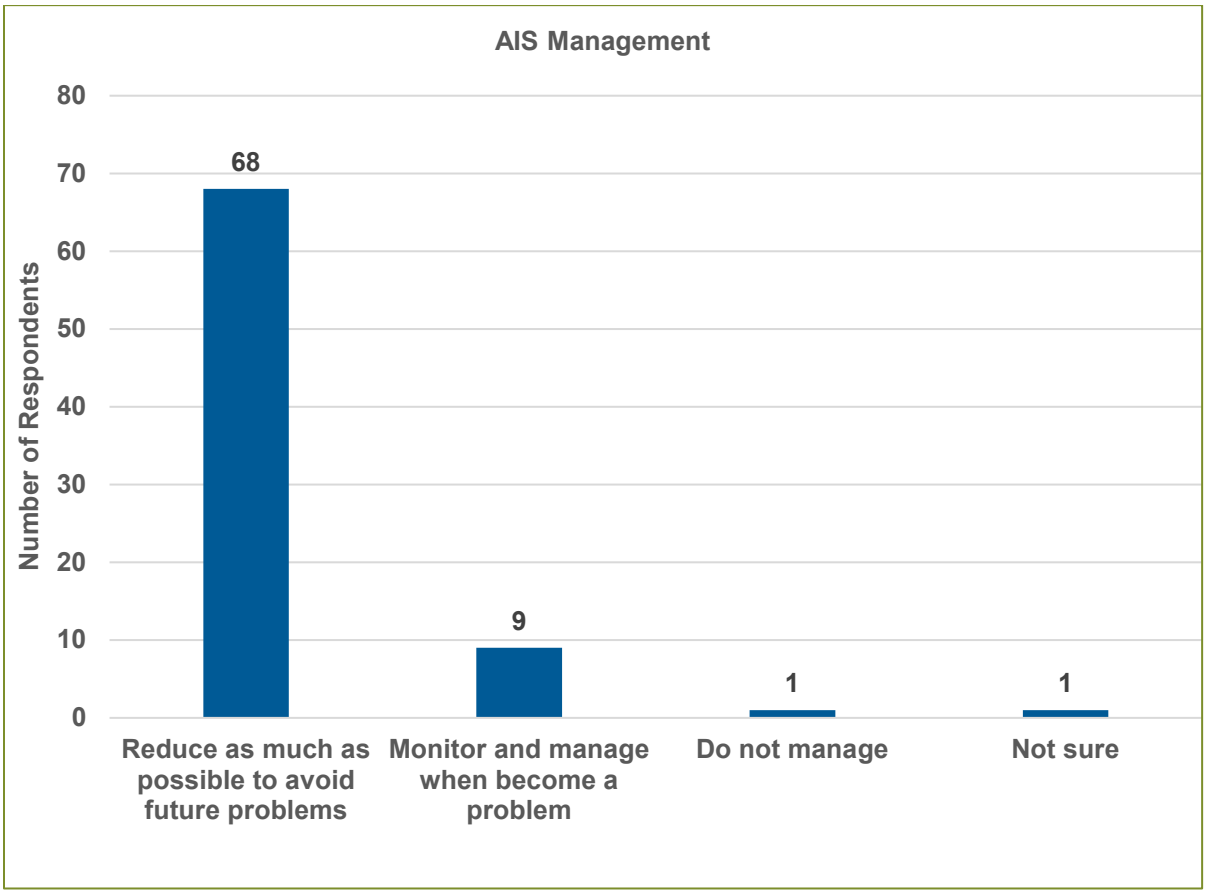

Figure 9-8 Management of Invasive Species in the Lake

EWM was first observed in the lake during 2021 and has been managed by herbicide treatment and hand pulling during 2022 and 2023. A huge majority either strongly support or support the use of herbicides (Figure 9-9) or hand pulling (Figure 9-10) to remove EWM from Half Moon Lake. Eighty three percent either strongly oppose or oppose no active management of the EWM in Half Moon Lake Figure 9-11.

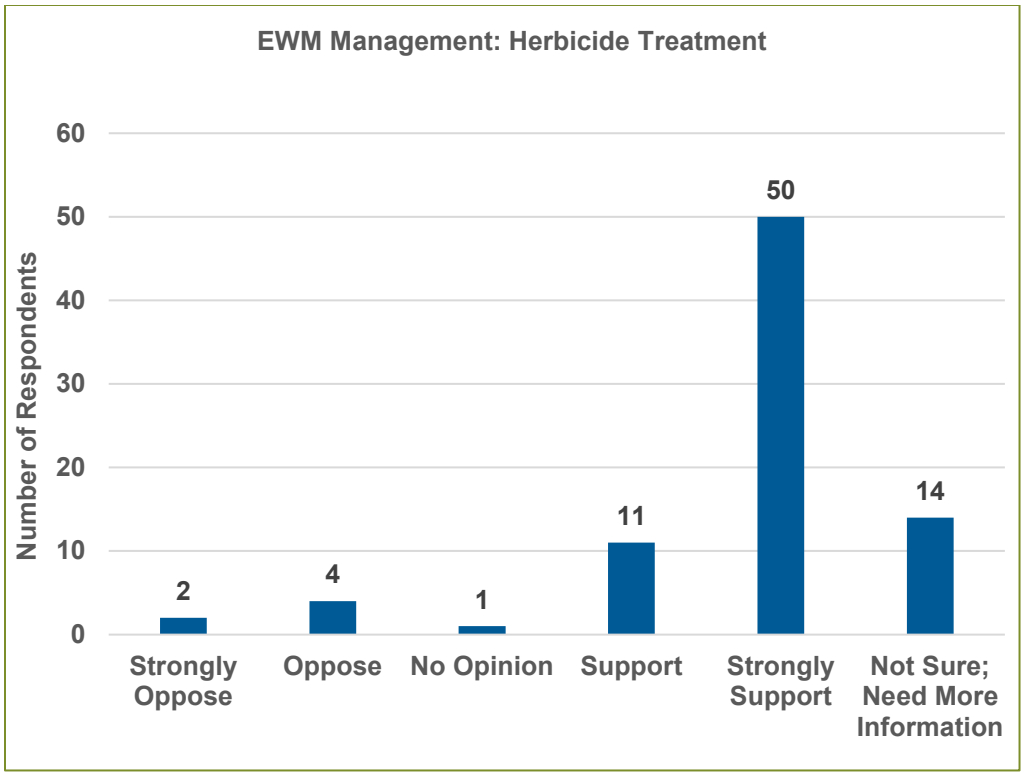

Figure 9-9 **Level of Support for Use of Herbicides to Manage Eurasian Watermilfoil in the Lake**

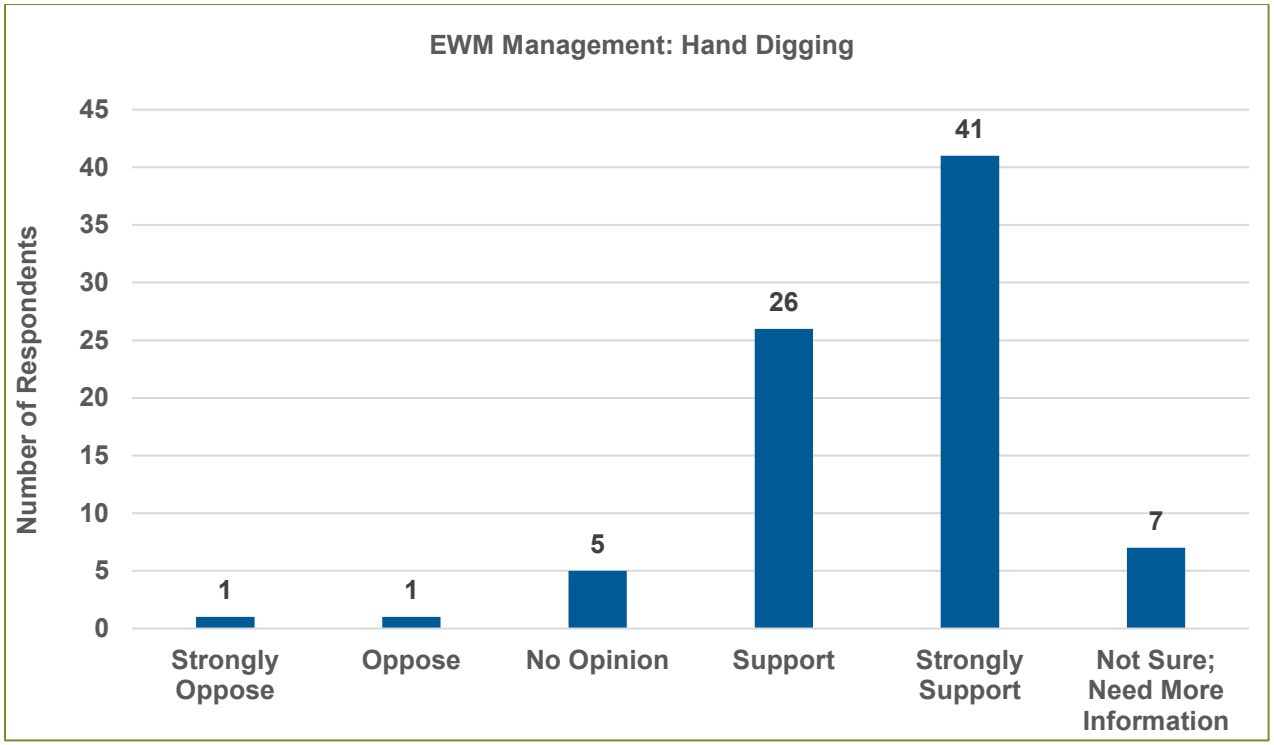

Figure 9-10 **Level of Support for Use of Hand Digging to Manage Eurasian Watermilfoil in the Lake**

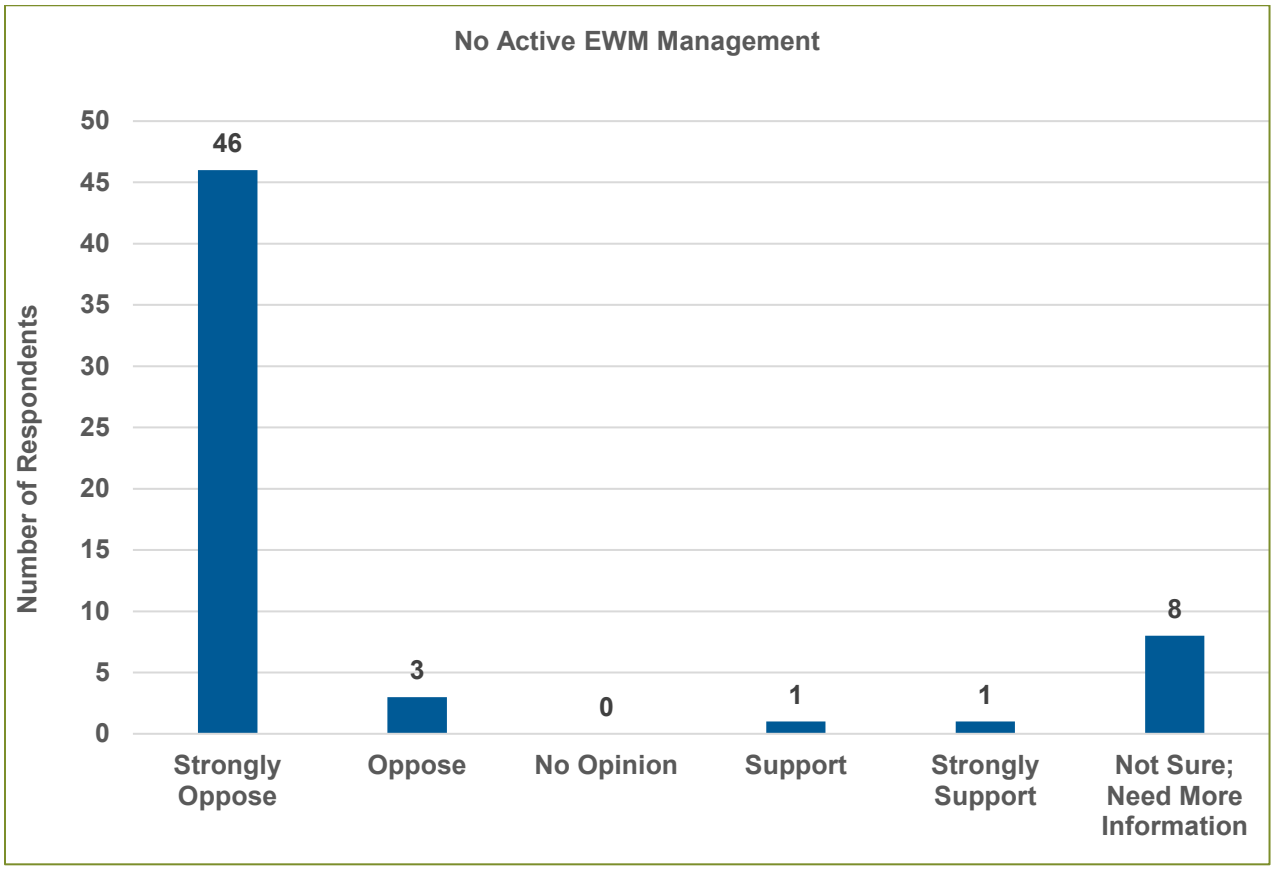

Figure 9-11 Level of Support for No Active Management of the EWM in Half Moon Lake

Yellow iris was first observed in the lake during 2018 and was managed using chemical treatment or hand digging during 2021 through 2023. A huge majority either strongly support or support the use of herbicides (Figure 9-12) or hand digging (Figure 9-13) to remove yellow iris from Half Moon Lake. 83 percent either strongly oppose or oppose no active management of the yellow iris in Half Moon Lake (Figure 9-14).

CLP has been observed in Half Moon Lake since 2007, but has not yet been managed. Nearly two thirds support reducing CLP as much as possible now to avoid future population growth (Figure 9-15).

A huge majority (84 percent) support increasing the boat inspection program to include more staffed hours at the boat landing (Figure 9-16).

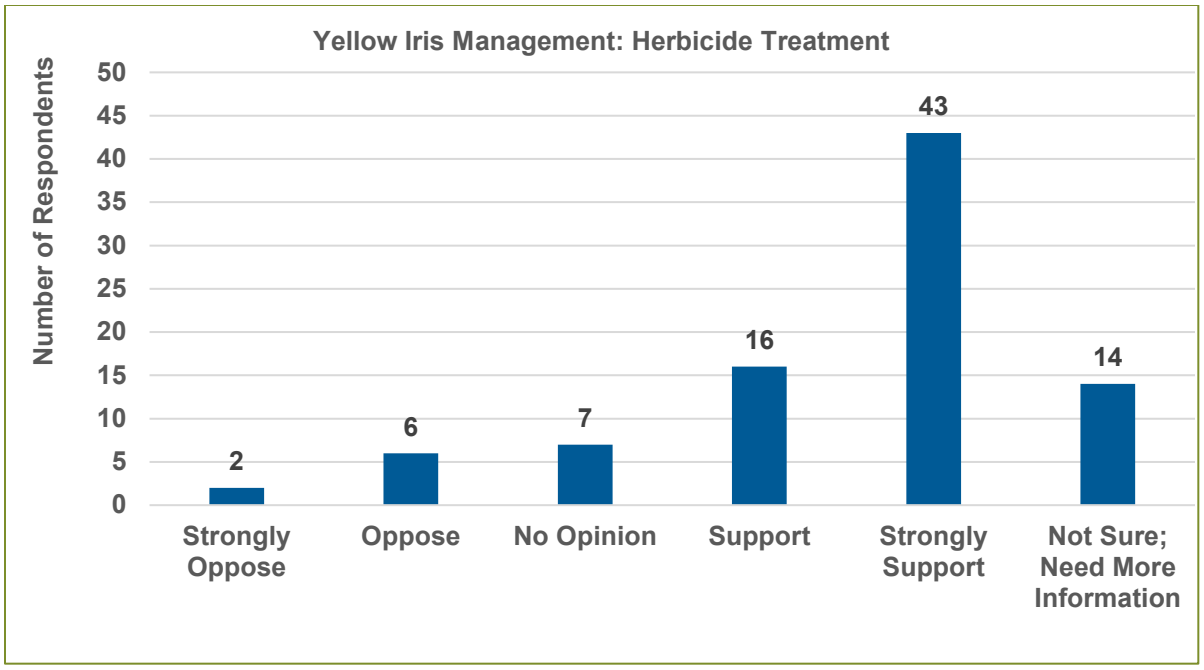

Figure 9-12 Level of Support for Use of Herbicides to Manage Yellow Iris in the Lake

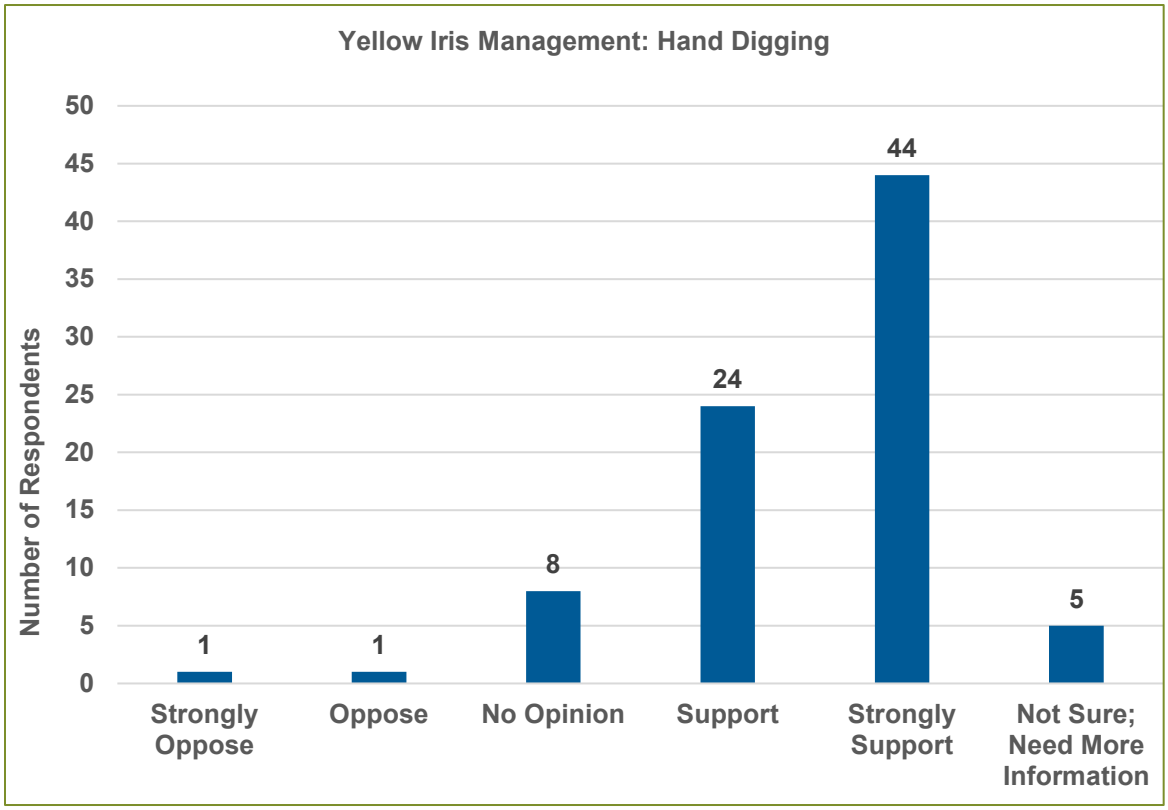

Figure 9-13 Level of Support for Use of Hand Digging to Manage Yellow Iris in the Lake

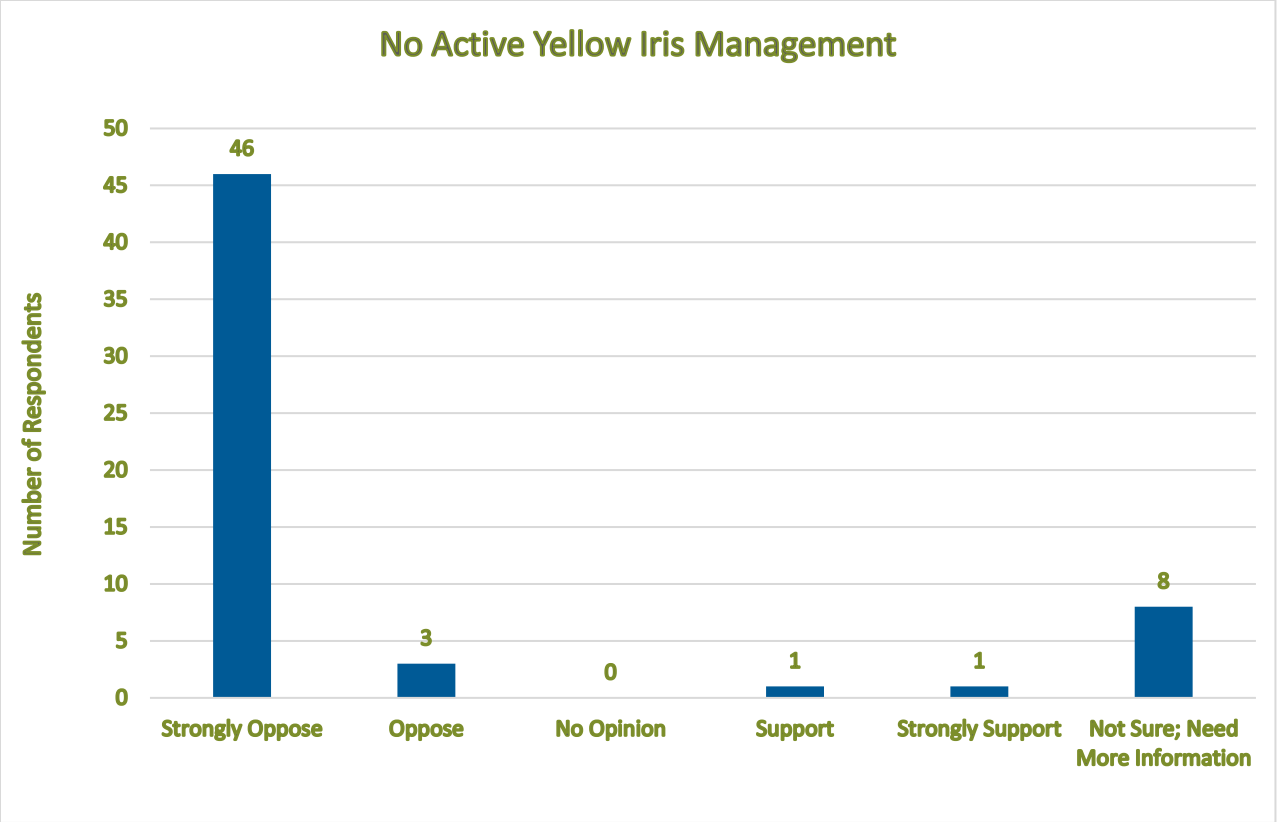

Figure 9-14 Level of Support for No Active Management of the Yellow Iris in Half Moon Lake

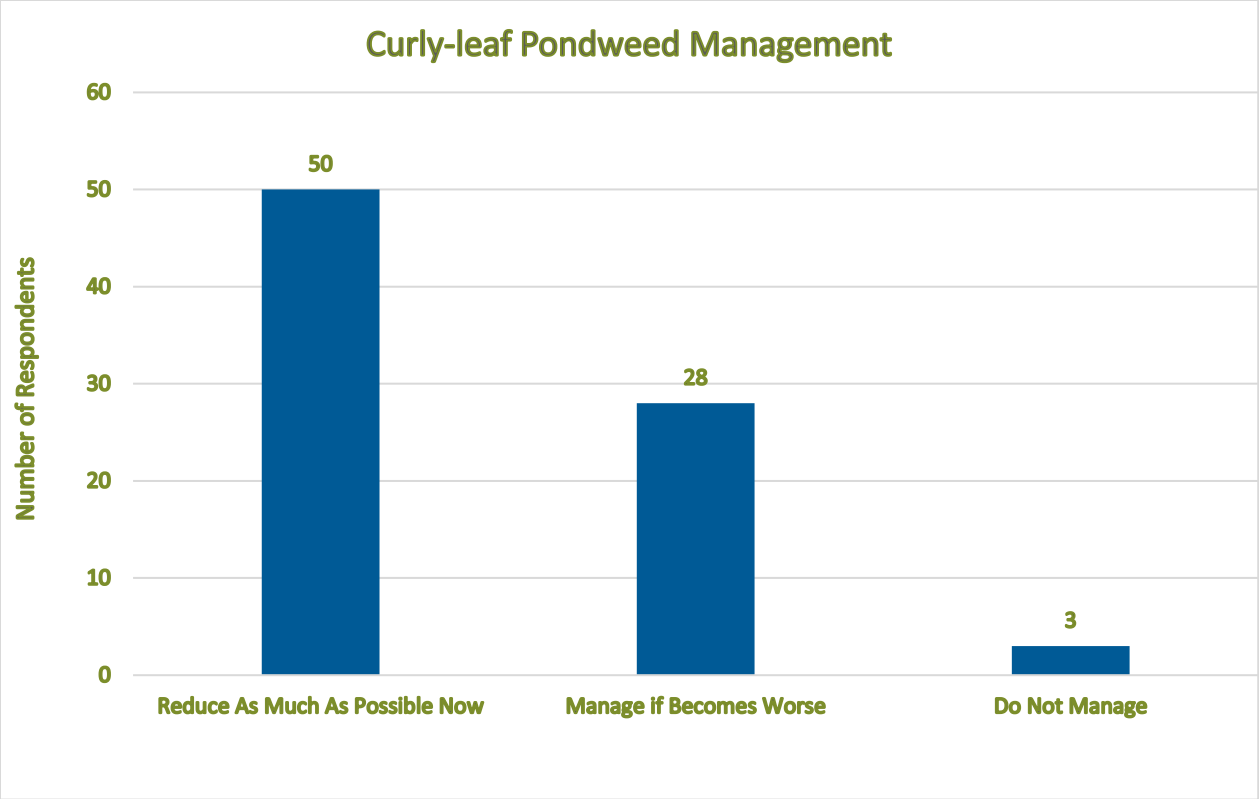

Figure 9-15 Management of Curly-Leaf Pondweed in the Lake

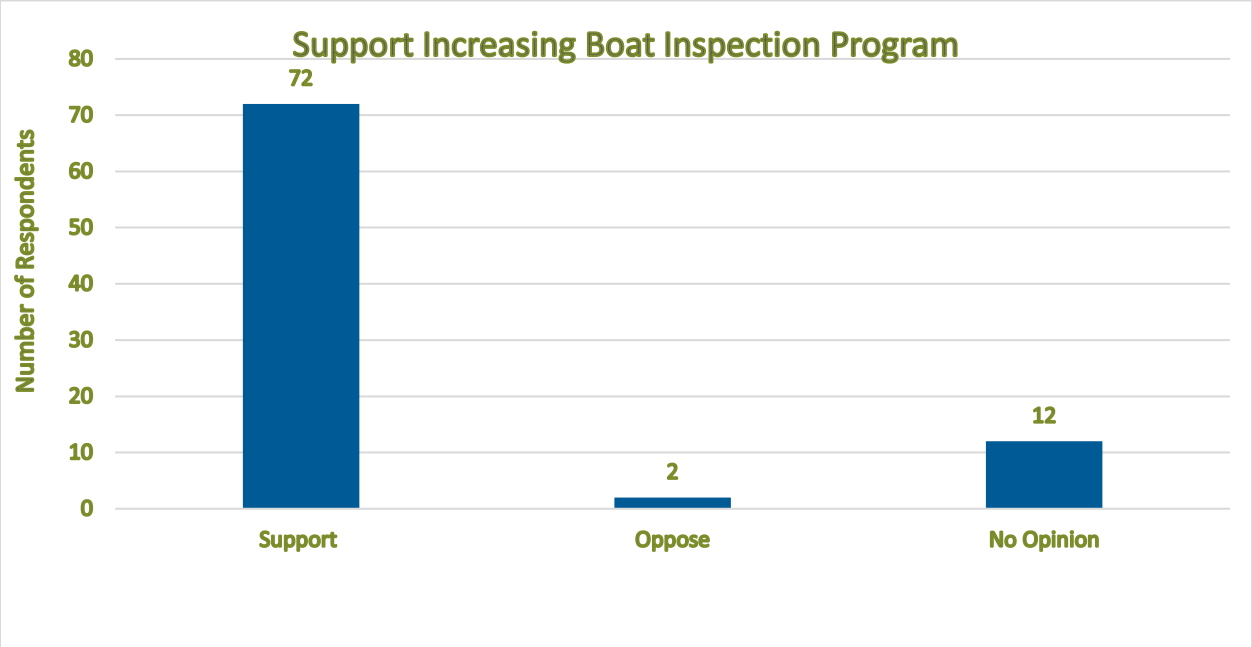

Figure 9-16 Support Increasing the Boat Inspection Program

As shown in Figure 9-17, the property location of survey respondents included all four areas of the lake shown on the map in Figure 9-18. As shown in Figure 9-19, respondents recreate in all four areas of the lake shown on the map in Figure 9-18. As shown in Figure 9-20, respondents believed all four areas of the lake had excessive plant growth, but a greater number believed excessive plant growth was present in the northern and southern areas than the eastern and western areas shown on Figure 9-18.

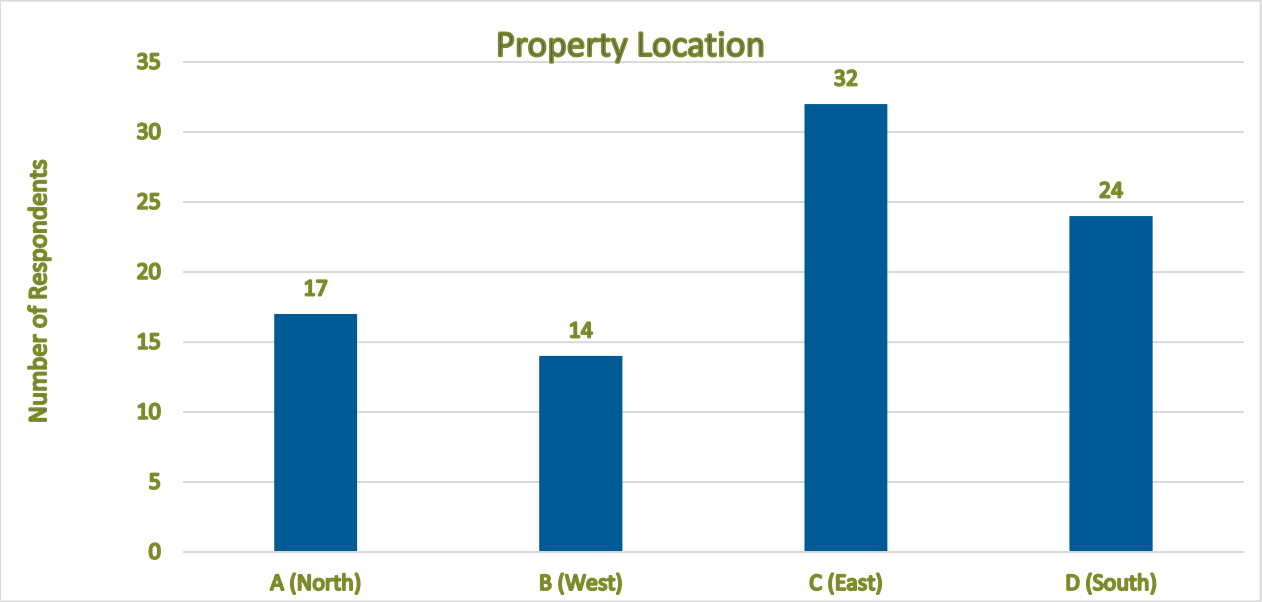

Figure 9-17 Property Location of Respondents

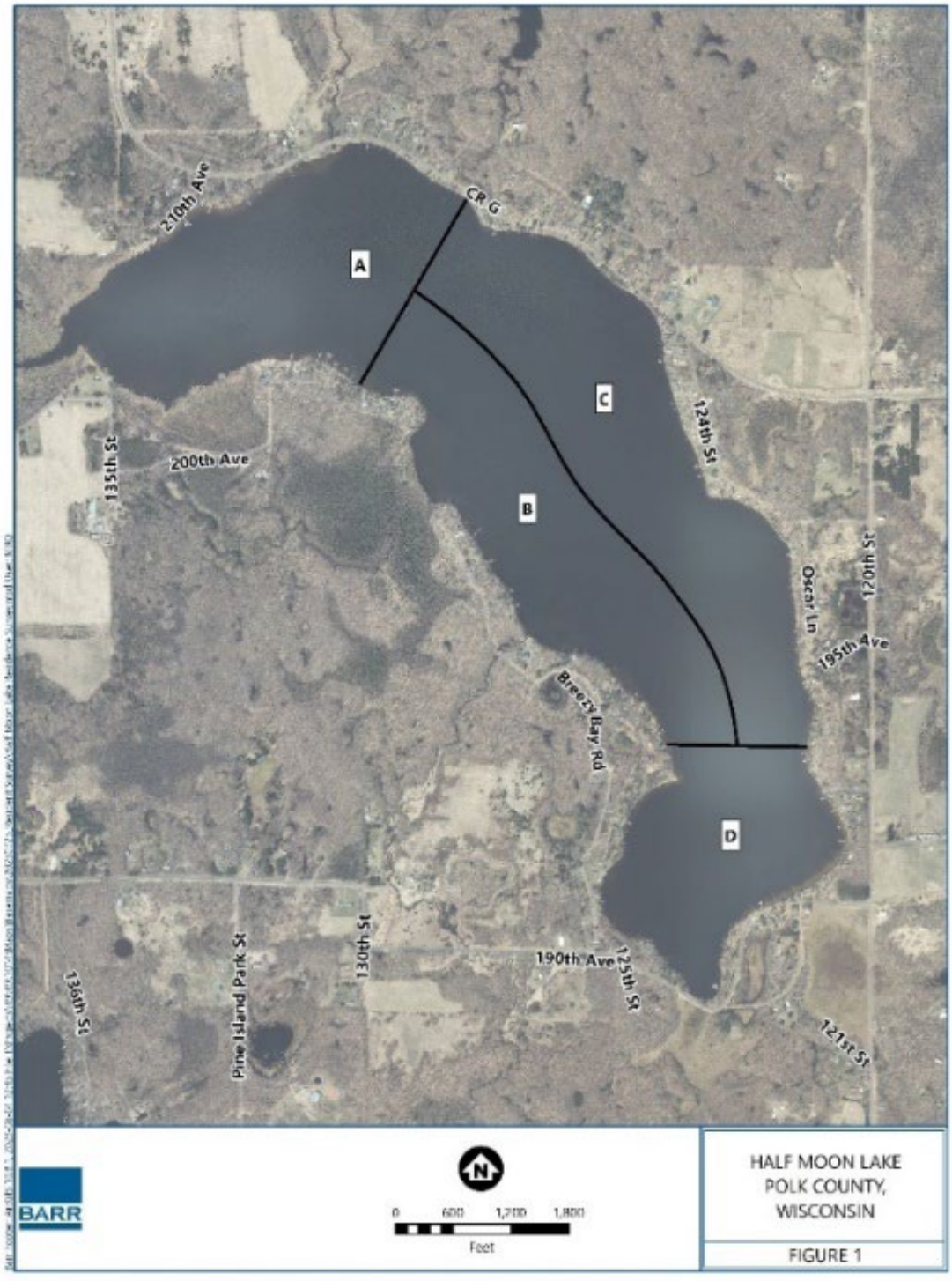

Figure 9-18 Half Moon Lake Areas

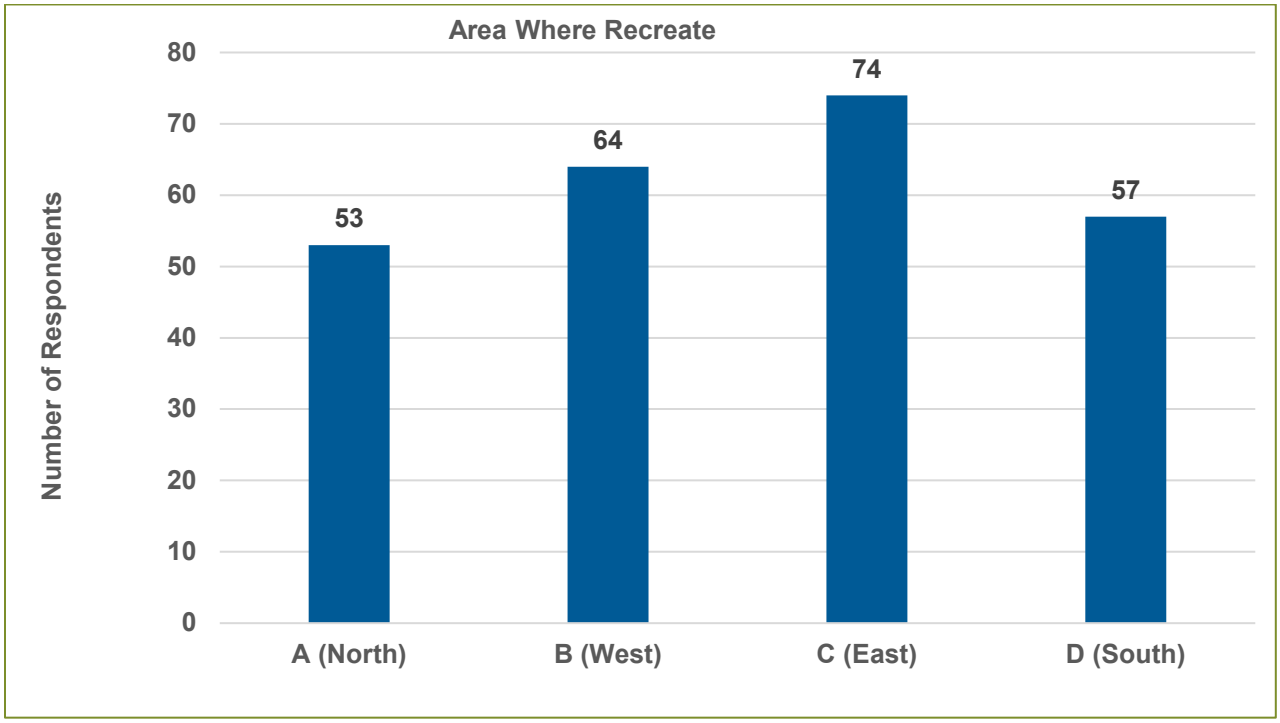

Figure 9-19 Areas Where Respondents Recreate

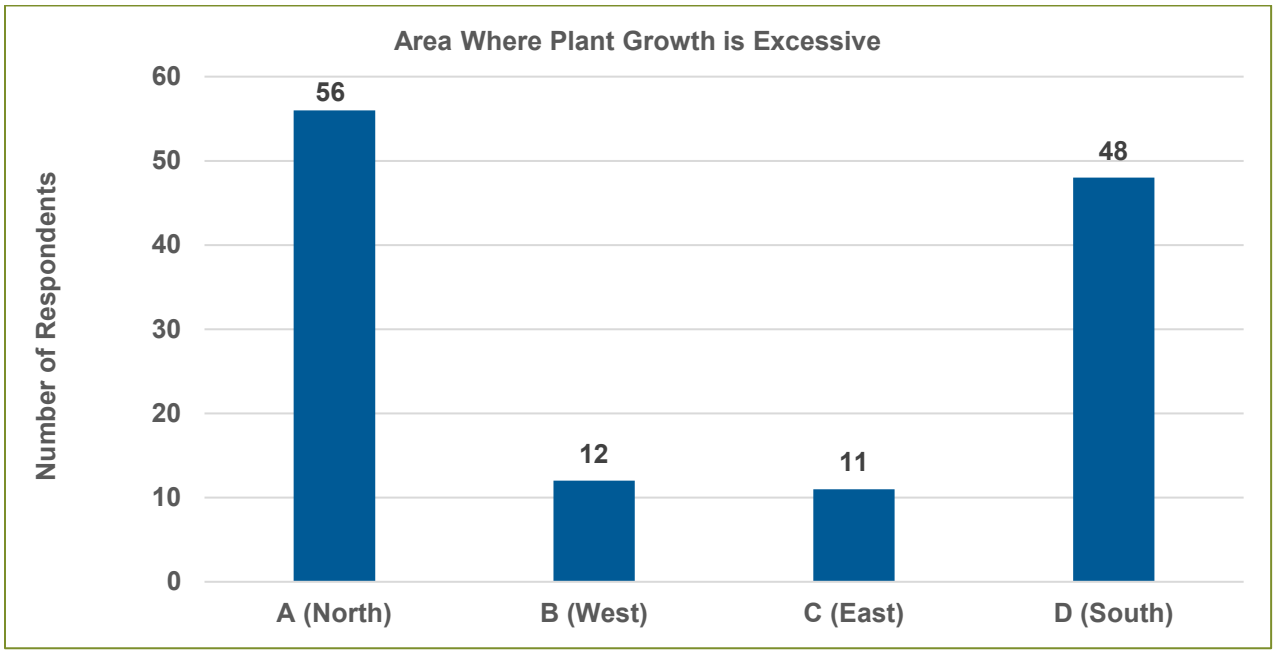

Figure 9-20 Areas Where Plant Growth is Excessive

When asked to rank the degree of negative impact that native plant species have on use or enjoyment of the lake, 35 percent of the respondents selected little impact and 27 percent selected moderate impact (Figure 9-21). A majority (54 percent) support the removal of native plants in navigation channels if they interfere with boat navigation (Figure 9-17).

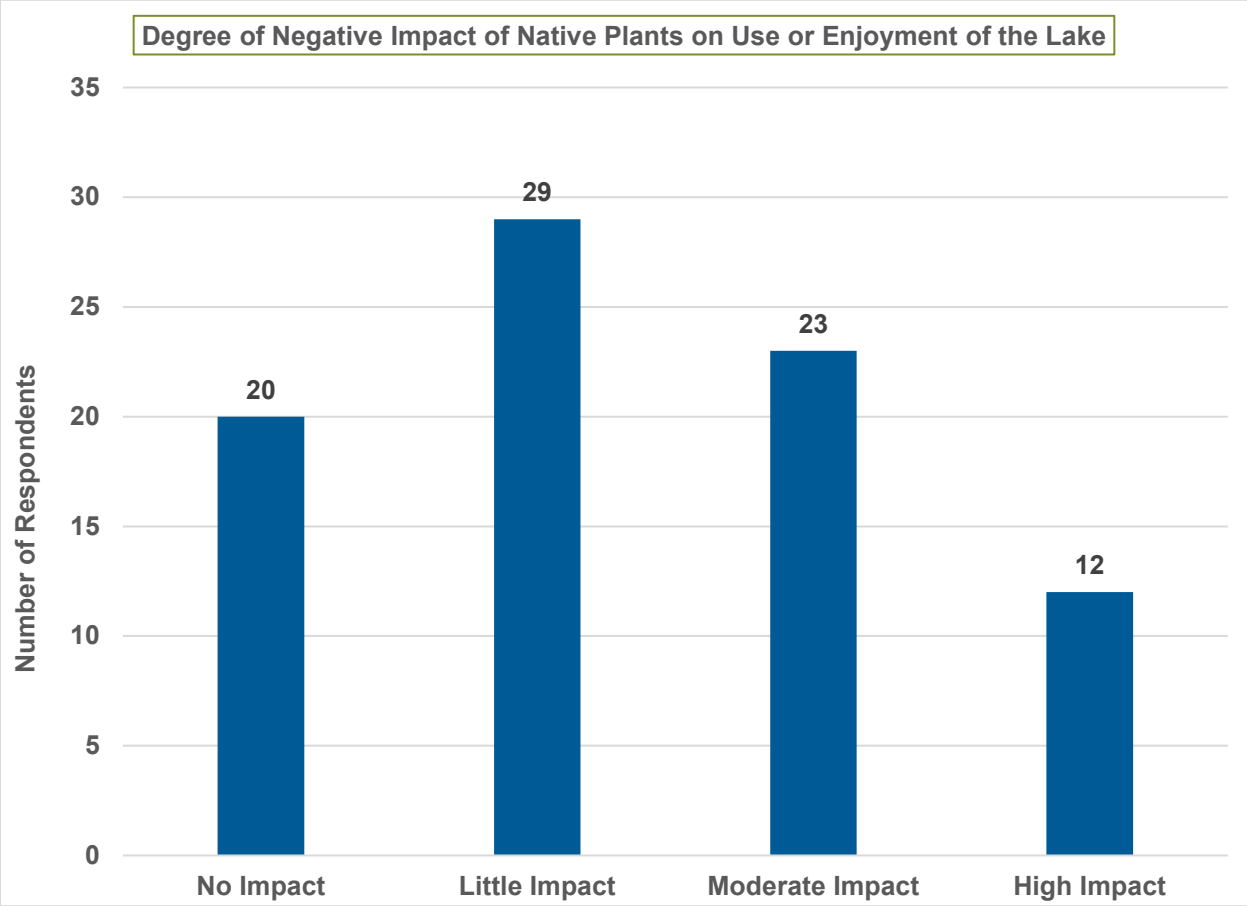

Figure 9-21 Degree of Negative Impact of Native Plants on Use or Enjoyment of the Lake

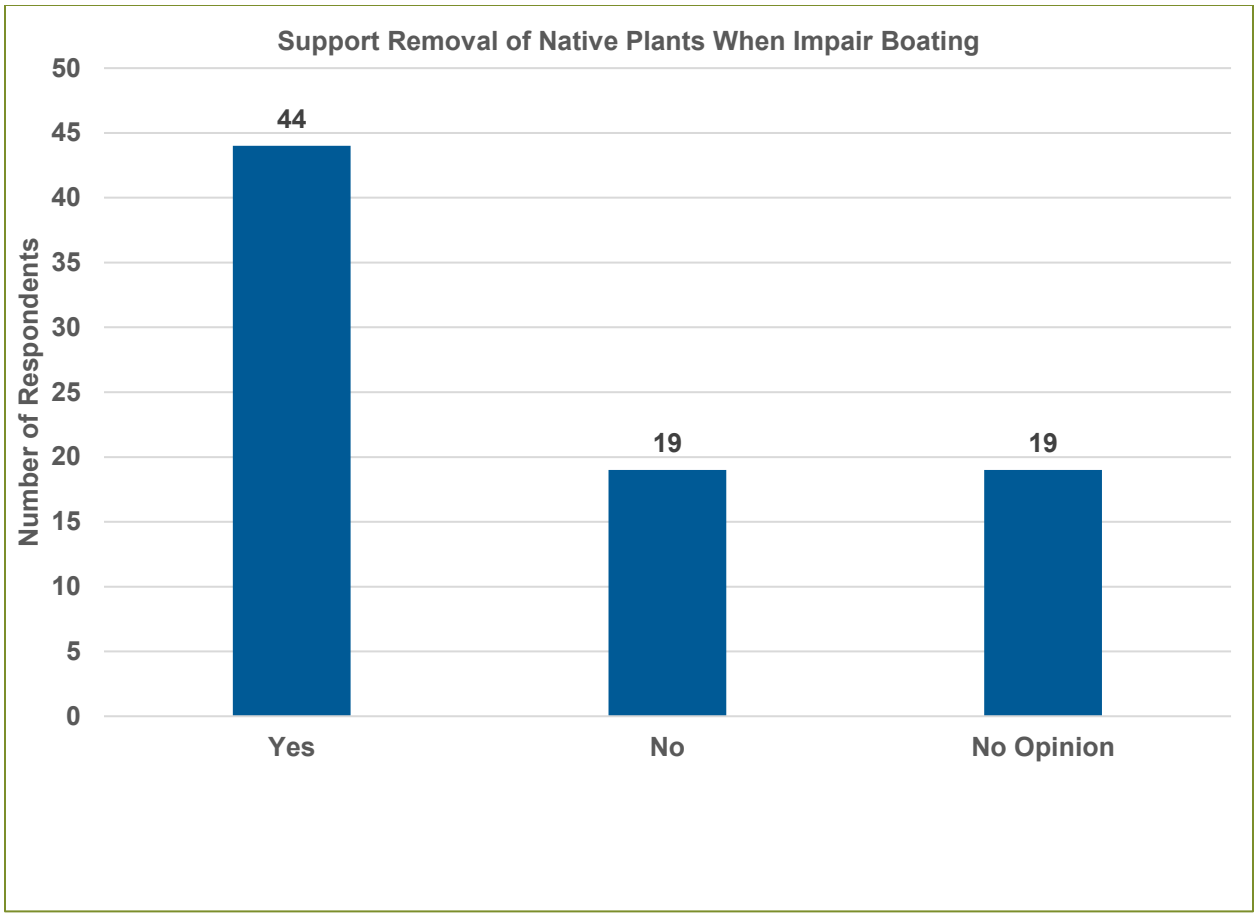

Figure 9-22 Support Removal of Native Plants When Impair Boating

More than half of respondents have not removed aquatic plants from their lakeshore (Figure 9-23) and 97 percent have not had an approved private treatment of aquatic plants (Figure 9-24). When asked whether or not an approved private treatment of aquatic plants would be considered, 40 percent of respondents would consider the treatment next year, 17 percent in the next 2 years, and 19 percent in the next 5 years (Figure 9-25).

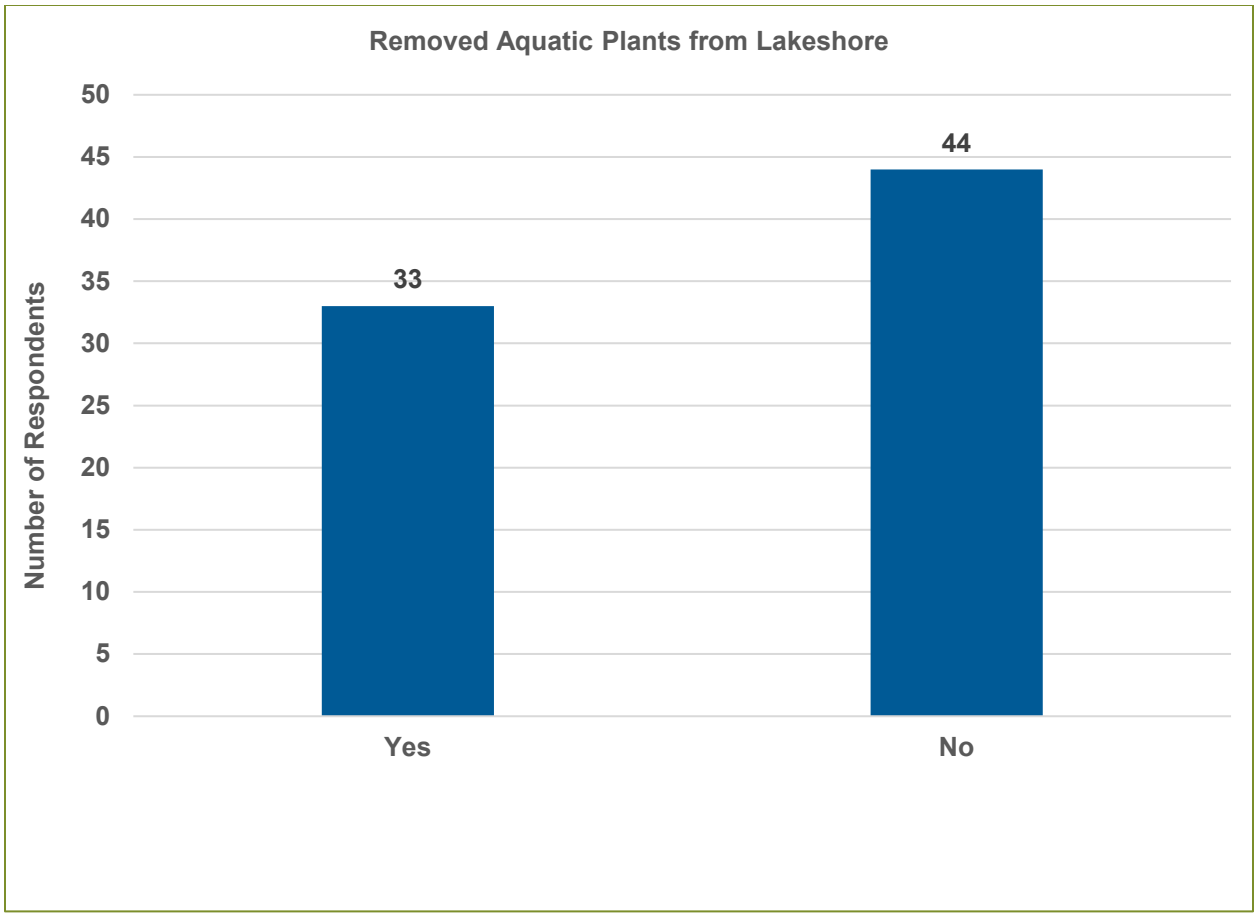

Figure 9-23 Removed Aquatic Plants from Lakeshore

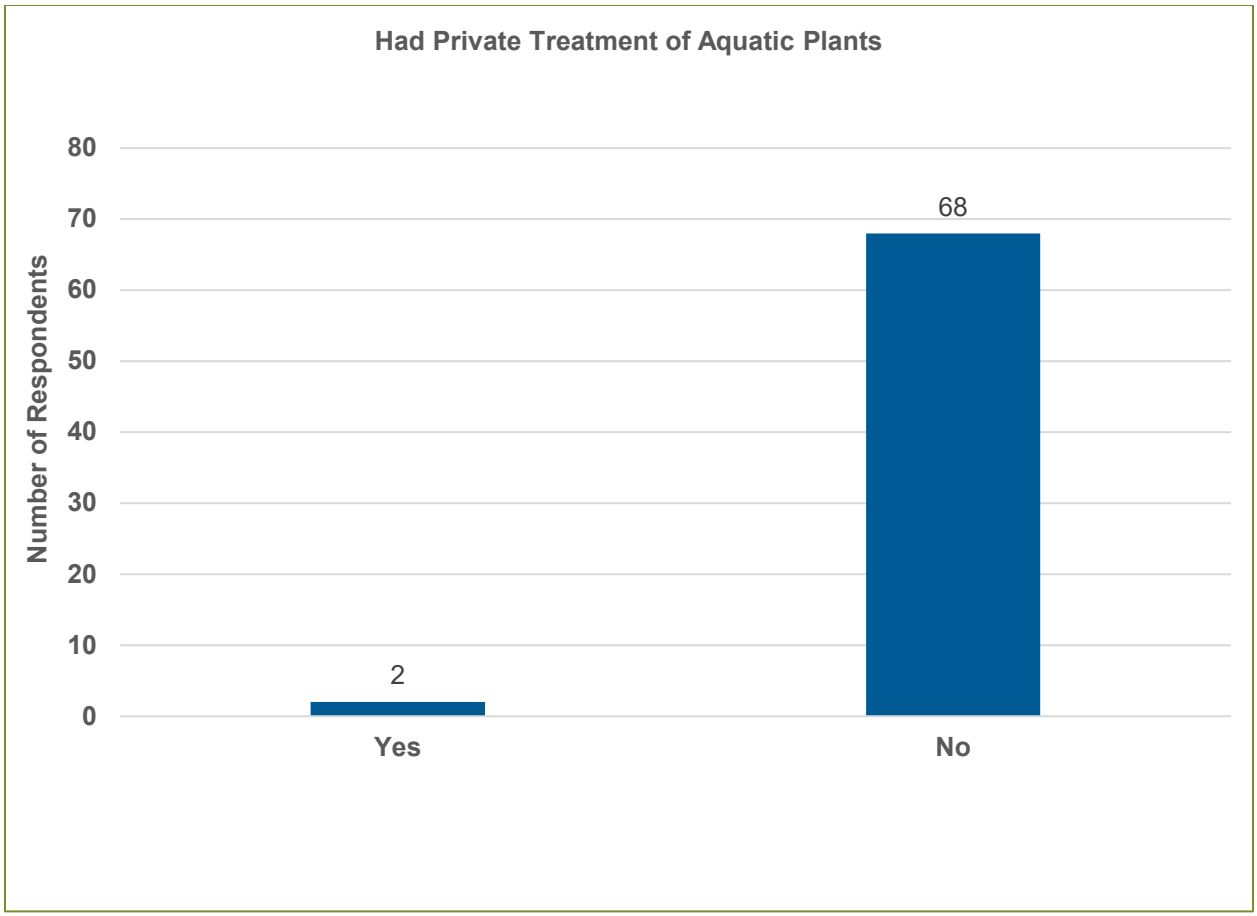

Figure 9-24 Had a Private Treatment of Aquatic Plants

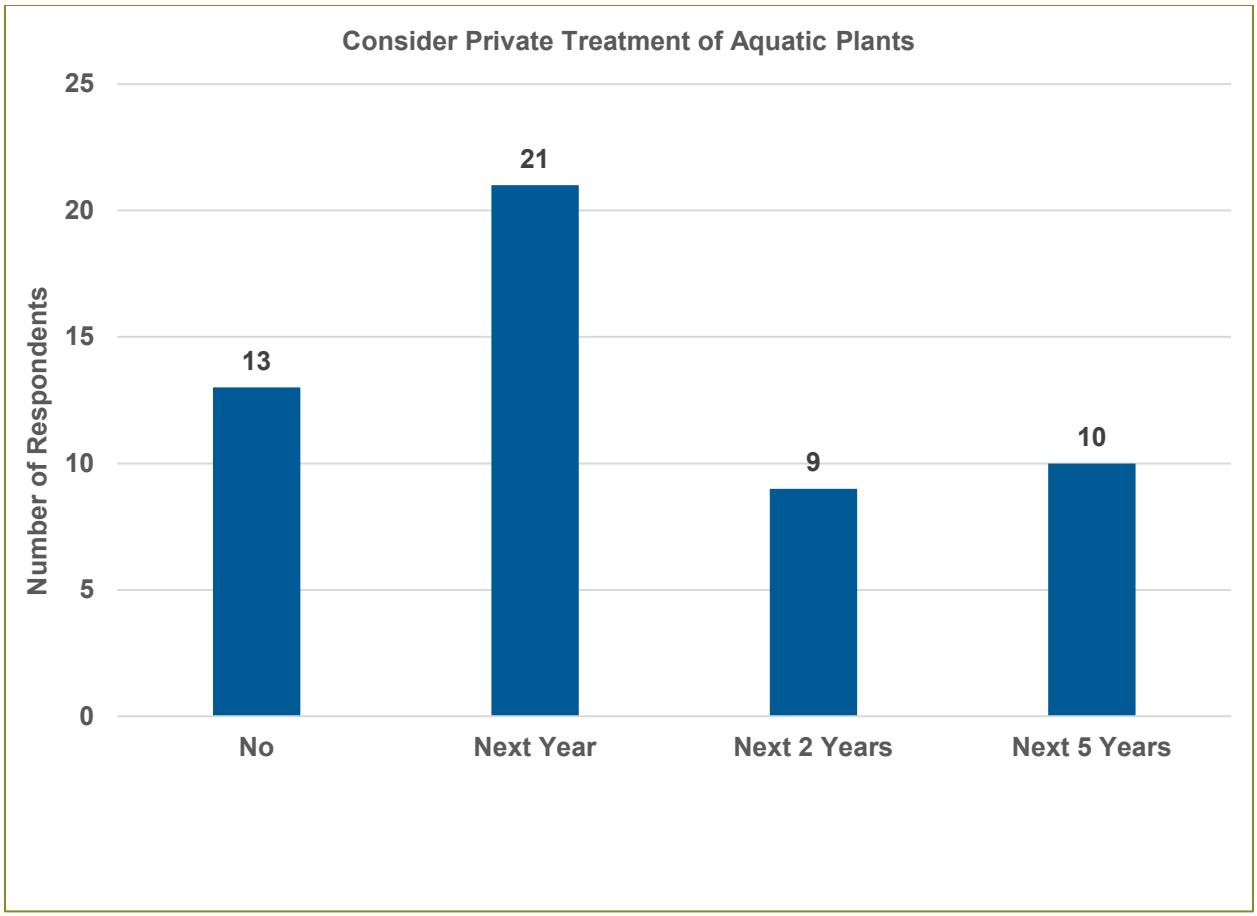

Figure 9-25 Consider Private Treatment of Aquatic Plants

10.0 Problem

Half Moon Lake has a diverse and high quality aquatic plant community. However, EWM poses a threat to the lake's native community and the lake's support of recreational uses such as motor boating, swimming, and fishing. EWM was first observed in the lake in 2021. EWM management is necessary to remove the EWM from the lake. Data collected during 2021 through 2023 show that EWM in Half Moon Lake expands rapidly. EWM expanded from 0.59 acres in fall of 2021 to 22 acres by June of 2022. A combination of herbicide treatment and manual removal by Diver Assisted Suction Harvesting (DASH) in August 2022 was effective. However, EWM spread rapidly during the time period between application and permit issuance for a WDNR EWM removal permit. The additional EWM growth during this timeframe was not removed from the lake resulting in continued EWM infestation in the lake.

EWM, pictured above, was introduced to Half Moon Lake in 2021 and rapidly spread throughout the lake. Photo Credit: Endangered Resource Services, LLC.

WDNR did not permit the use of ProcellaCOR to remove EWM from the lake in 2023, but permitted removal of EWM using DASH. EWM removal occurred on July 17-21, the earliest available DASH removal dates when the permit was issued. Removal of EWM in mid-summer was challenging because the EWM was mixed with densely growing native plants in the southern and eastern areas of the lake where most of the DASH removal occurred. In addition, EWM was growing more densely in 2023 than 2022. EWM removal in 2022 averaged 19 cubic feet per acre compared with 46 cubic feet per acre in 2023. The challenges slowed DASH removal and made it difficult to effectively remove the EWM. Consequently, EWM removal only occurred in 7 of the 15 areas intended for DASH removal during the scheduled one week period. An August 2 bed-mapping survey found a continued presence of EWM in all 7 of the DASH removal areas. DASH removal of some EWM resulted in a decline of EWM extent from 2.57 acres on June 5, 2023 to 1.86 acres on August 2, 2023. Rapid spread of EWM caused its extent to more than double between August 2 (1.86 acres) and October 8 (5.76 acres). An August 24 plant survey documented a significant increase in EWM frequency in the lake between June 5 and August 24 despite DASH removal efforts.

The Half Moon Lake Protection and Rehabilitation District will manage EWM to prevent or minimize nuisance conditions from the rapidly spreading EWM in the lake. Additionally, EWM management will prevent or minimize the risk of Half Moon Lake being a source of infestation for Balsam Lake, a lake receiving flow from Harder Creek which outflows from Half Moon Lake. Because Half Moon Lake receives significant use by boaters, removal of EWM from Half Moon Lake will help protect neighboring lakes not yet infested with EWM.

Removal of EWM from Half Moon Lake will eliminate current problematic growths of EWM that prevent the lake from fully supporting recreational activities. Respondents to a citizen survey indicated invasive plant species currently have a high negative impact (36 percent) or moderate negative impact (31 percent)

on their use or enjoyment of the lake (Figure 9-7). Removal of EWM from the lake will prevent future problematic growth of EWM. Removal of EWM is necessary to prevent displacement of native plants, including wild rice, and protect the lake's high quality native plant community.

Fishery surveys have documented the high quality fishery in the lake, including walleye, northern pike, largemouth bass and a diverse panfish assemblage. Because EWM can aggressively displace native species that provide necessary habitat for the lake's fishery, removal of EWM is necessary to protect the lake's high quality fishery.

While EWM is the primary invasive species of concern, the presence of yellow iris poses a threat to the lake's native plant community along its shoreline. Yellow iris was first observed in Half Moon Lake in 2018. In 2021, the Half Moon Lake Protection and Rehabilitation District contracted with an applicator to chemically treat the yellow iris observed along the shoreline of Half Moon Lake. In 2021-2022, the Half Moon Lake Protection and Rehabilitation District completed a boat survey in June to look for yellow iris along the lake's shoreline. Whenever yellow iris was seen, the boat was parked and the homeowner informed of the presence of yellow iris, how to get rid of it, and asked if they would like assistance to get rid of the yellow iris. This management approach has been successful and yellow iris was not observed on July 1, 2022 and July 1, 2023 plant surveys. Continued management of yellow iris will prevent or minimize nuisance conditions and protect native plant species from displacement by yellow iris.

The presence of yellow iris, pictured above, in Half Moon Lake is a threat to the lake's native plant community along its shoreline. Photo credit: Endangered Resource Services, LLC

The presence of CLP in the lake also poses a threat to the lake's native plant community. CLP was first observed in Half Moon Lake in 2007. However, because CLP was not problematic during 2007-2023, CLP management did not occur. During 2018, 2022, and 2023 plant surveys, most curly-leaf pondweed plants were observed in 5 to 10 feet of water over organic muck and there was very little of this type of habitat in the lake.

Although CLP has not been problematic to date, problematic conditions could occur in the future. While CLP has been found to grow best in 1 to 3 meters of water, it has been found at depths up to 7 meters (Bolduan 1994) and could expand from the 5 to 10 foot depth to deeper depths in Half Moon Lake. CLP appears to utilize a variety of sediments for growth (Bolduan 1994) and could expand from organic muck to other types of sediment in Half Moon Lake. CLP currently seems to be a latent problem, but annually produces turions which are winter buds that act like seeds. Yeo (1966) found that CLP plants in 5.9 m^2 produced 23,520 turions during a growing season. Kunii (1989) found that CLP plants produced 7,000 to 9,000 turions per square meter during a growing season. Turions can remain viable for several years. CLP may languish at a low level in Half Moon Lake until a favorable environmental circumstance happens that allows it to expand rapidly into a problematic condition. Removal of CLP from Half Moon Lake now will minimize the risk of rapid expansion to problematic conditions in the future. Nearly two-thirds of

respondents to a citizen survey support reducing CLP as much as possible now to avoid a future population growth (Figure 9-15).

Half Moon Lake is a busy lake and, hence, vulnerable to the accidental introduction of additional invasive species. A preventative program to protect the lake from the introduction of additional invasive species is crucial to the protection of the lake. Annual boat inspections at the landing located within the City of Milltown park are important to prevent the introduction of additional aquatic invasive species to the lake. Should an additional aquatic invasive species be introduced to Half Moon Lake, swift and effective management measures to remove it from the lake will be important to protect the lake's native species and fishery and to enable the lake to fully support recreational uses. A huge majority (84 percent) support increasing the boat inspection program to include more staffed hours at the boat landing Figure 9-16).

11.0 Integrated Pest Management

Integrated Pest Management (IPM) is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. IPM programs use current, comprehensive information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, is used to manage pests and prevent damage by the most effective means with the least harm to the environment (EPA, 2023). Using IPM, a management plan was identified for managing AIS in Half Moon Lake. A detailed discussion of management alternatives considered for control of AIS in Half Moon Lake is found in Appendix H.

12.0 Goals, Objectives, Strategies, and Measurements for the Half Moon Lake Aquatic Plant Management Plan

The Half Moon Lake Protection and Rehabilitation District have selected eight goals for management of aquatic plants in Half Moon Lake. The eight goals selected for the APM Plan are shown on Figure 12-1.

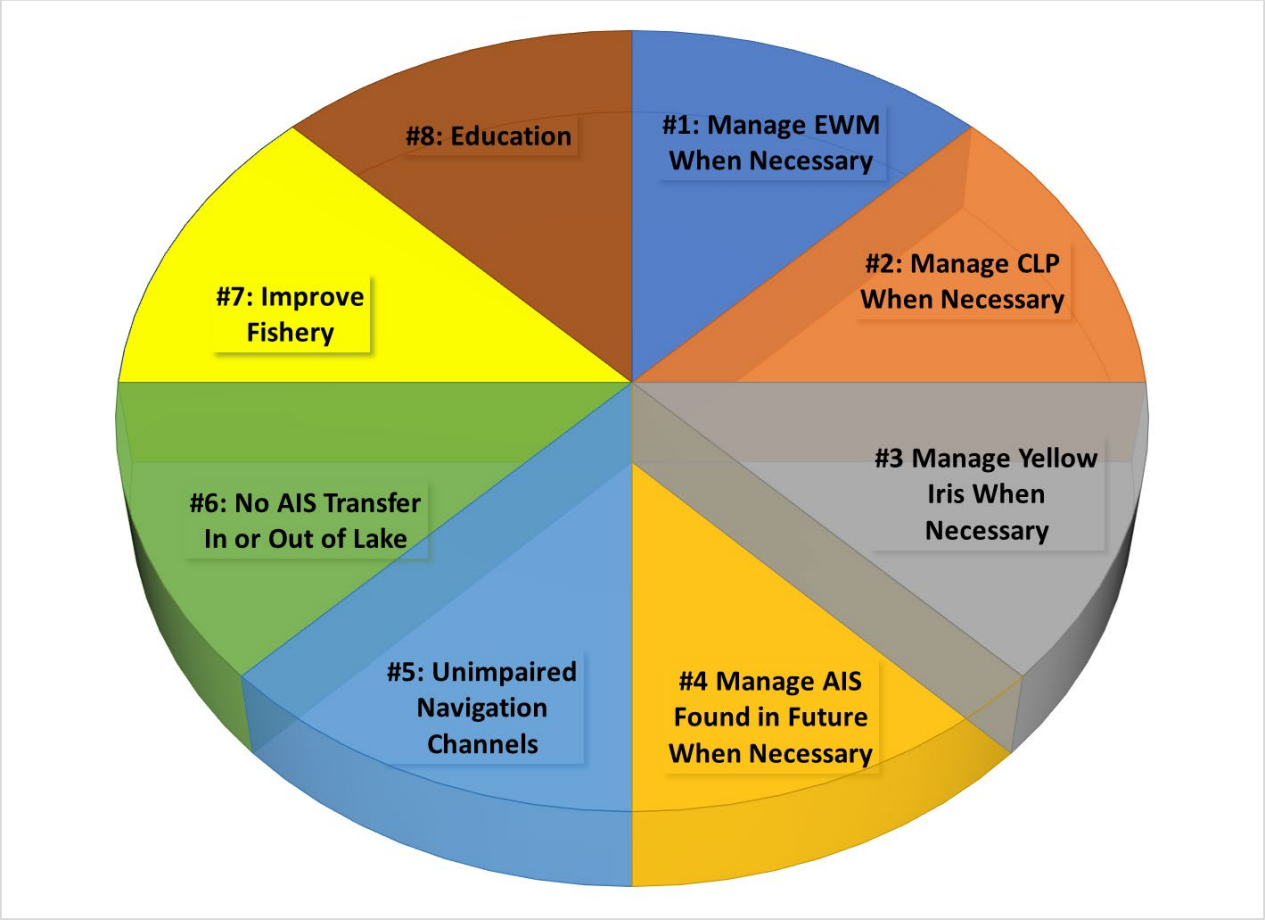

Figure 12-1 Half Moon Lake APM Plan Goals

This section of the report discusses the APM Plan goals, objectives, strategies, and measurements. Goals are broad statements of what the District intends to accomplish. Objectives are supporting statements and clarifications of the goals that provide reasons why the goals are important. Strategies are action steps to attain the goals. Measurements show how we know whether the strategy was successful. The goals, objectives, strategies, and measurements for the Half Moon Lake APM Plan are shown in Table 12-1 through Table 12-8 and are discussed in the following paragraphs.

12.1 Goal 1: Manage EWM When Necessary to Prevent or Minimize Nuisance Conditions

Goal 1: ***EWM will be managed when necessary to prevent or minimize nuisance conditions through an integrated pest management approach.***

Objectives: *(1) Protect the lake's ability to support recreational uses such as boating, fishing, swimming, and enjoying the view; (2) Protect fisheries habitat and the overall health of the lake; (3) Prevent wild rice and other native plant displacement by EWM; (4) Reduce EWM management cost.*

The strategies to manage EWM in Half Moon Lake are shown in Table 12-5 and discussed in the paragraphs below.

Table 12-1 Goal 1 Strategies and Measurements

Strategies	Measurements	
	Yes	No
Strategy 1: Complete fall bed-mapping plant survey to determine if EWM present and, if so, locations.		
Strategy 2: If EWM present in fall bed-mapping survey, complete EWM removal plan for subsequent year.		
Strategy 3: If WDNR permit required for EWM removal, complete application for permit and submit to WDNR.		
Strategy 4: Complete EWM removal when WDNR permit received or as soon as possible if no permit required.		
Strategy 5: Complete bed-mapping surveys in June, July, and/or August to determine if EWM present and, if so, EWM locations.		
Strategy 6: Complete-early July whole lake point intercept survey of all plants		
Strategy 7: If EWM present in June through August surveys, develop EWM removal plan.		
Strategy 8: If WDNR permit required for EWM removal, complete application for permit and submit to WDNR.		
Strategy 9: Complete EWM removal when WDNR permit received or as soon as possible if no permit required.		
Strategy 10: Assess early-July point intercept data to determine native plant response to EWM removal.		

The EWM removal plans for Half Moon Lake will generally use herbicide to effectively remove EWM because data collected during 2021 through 2023 show:

1. EWM spread very rapidly in Half Moon Lake, increasing from 0.59 acres in October 2021 to 22 acres in June 2022. 2022 management efforts reduced EWM extent to 1 acre by fall 2022, but EWM increased to 6 acres by fall 2023 despite DASH removal efforts in July 2023.

2. EWM rapidly increased in density as shown by Dash removal rates of 19 cubic feet per acre in 2022 compared with 46 cubic feet per acre in 2023.

3. Manual removal was ineffective and failed to attain EWM eradication in removal areas in 2023 when all seven DASH removal areas contained EWM two weeks after removal. A post-treatment plant survey documented a significant increase in EWM frequency during June 5 through August 24, 2023 despite DASH removal of EWM during July. Challenges for manual removal of EWM include inability of divers to see EWM plants hidden among native vegetation and EWM root crowns left in the sediment to grow new plants when EWM plants break off during removal.

Use of herbicide to effectively remove EWM from Half Moon Lake will prevent the rapid increase of EWM to dominance that occurred in Long Lake (Mahtomedi and Pine Springs, MN) and Lake Jane (Lake Elmo, MN). EWM was first observed in Long Lake during May 2007. Unmanaged, EWM extent had increased to 52 acres by June 2010 which was 97 percent of the littoral area of Long Lake (Barr 2022c). The first siting of EWM in Lake Jane occurred in June 2012 when a few scattered plants were observed at a single location. By May 2015, EWM extent had increased to 44 acres (35 percent of the lake's littoral area) immediately prior to a herbicide treatment of 7.9 acres that temporarily reduced EWM extent to 31 acres. No management occurred in 2016 and EWM extent increased to 69 acres (52 percent of the lake's littoral area) by June 2016 (Barr 2022c).

When herbicide treatment is used, herbicide, dose, and application methods within each treatment area will be selected to attain EWM control based upon past experience with EWM herbicide treatments and the latest research studies. Herbicides likely to be used for large scale treatments are 2,4-D and fluridone. Herbicides likely to be used for small scale treatment are ProcellaCOR, diquat, and Aquastrike.

DASH or SCUBA removal of EWM could be considered in the future for small areas of EWM if plant density of both EWM and native plants were low and it was feasible to remove root crowns by digging them out should plants break off during the removal process.

12.1.1 Implementation of EWM Management Strategies

Implementation of the EWM management strategies is illustrated in the 2022 through 2023 EWM management plans found in Appendix I.

EWM management will occur when necessary to prevent or minimize nuisance conditions in Half Moon Lake. Although the geographic locations of the EWM management areas and the method of EWM management used on the areas will vary, the future management plans will follow the format of the 2022 through 2023 EWM management plans found in Appendix I. Each management plan will be based upon the results of the most recent plant survey documenting the presence of EWM in the lake and determining EWM locations requiring management. Each plan will show specifics of EWM management within each management area. When herbicide treatment is used, the type of herbicide and dose applied to each treatment polygon to control EWM will be shown on the treatment map. When the treated area is large enough to attain a lake-wide impact, the expected "whole lake" concentration will be shown on the treatment map. When EWM is not observed during a plant survey, no management will occur.

12.2 Goal 2: Manage CLP When Necessary to Prevent or Minimize Nuisance Conditions

Goal 2: ***CLP will be managed when necessary to prevent or minimize nuisance conditions through an integrated pest management approach.***

Objectives: *(1) Prevent CLP dominance and the subsequent long-term annual control to hold the plant back from resurgence to dominance; (2) Protect the lake's water quality from degradation due to nutrient addition from senescing CLP in July following its annual June die-off; (3) Protect the lake's ability to support recreational uses such as boating, fishing, swimming, and enjoying the view; (4) Protect fisheries habitat and the overall health of the lake; (4) Protect wild rice and other native species from displacement by CLP.*

The strategies to manage CLP are shown in Table 12-5 and discussed in the paragraphs below.

Table 12-2 Goal 2 Strategies and Measurements

Strategies	Measurements	
	Yes	No
Strategy 1: Annual point intercept survey completed in early-July.		
Strategy 2: Whenever CLP is present in the early-July point intercept plant survey, complete CLP pre-treatment plant survey in subsequent spring to identify CLP removal areas and determine an appropriate CLP removal plan.		
Strategy 3: If WDNR permit required for CLP removal, complete application for permit and submit to WDNR.		
Strategy 4: Conduct CLP removal when WDNR permit received or as soon as possible if no permit required		
Strategy 5: Following CLP removal, complete annual point intercept plant survey in early-July and assess data to determine CLP removal effectiveness and native plant response to CLP removal.		

CLP in Half Moon Lake has a frequency of occurrence of less than 0.5 percent and seems to be a latent problem. The management goal for CLP is to manage CLP when necessary to prevent or minimize nuisance conditions. CLP management to prevent the accumulation of turions which can grow into CLP plants and potentially cause nuisance conditions is an important component of goal attainment. Turions are CLP winter buds that act like seeds. Yeo (1966) found that CLP plants in 5.9 m^2 produced 23,520 turions during a growing season. Kunii (1989) found that CLP plants produced 7,000 to 9,000 turions per square meter during a growing season. Turions can remain viable for several years. Removing CLP with early spring herbicide treatment not only removes CLP plants from the lake, but also prevents the plants from producing turions. This approach prevents CLP dominance and the subsequent required long-term annual control to hold the plant back from a resurgence to dominance. It appears that many aquatic invasive species, including CLP, may languish at a low level until a favorable environmental circumstance happens that allows it to expand rapidly. This seems to fit the theoretical concept that an organism can

make itself established and then only needs the right trigger to expand into a problem. Removal of CLP from the lake will prevent its rapid expansion to problematic conditions.

The management of CLP in Half Moon Lake is intended to avoid the CLP expansion that occurred in Kohlman Lake, located in Maplewood, Minnesota. A whole lake point intercept survey in June of 2001 indicated CLP was present at 1.5 percent of sample locations (Barr, 2008b). Unmanaged, CLP rapidly expanded during 2002 through 2006 and was found at 73 percent of sample locations during June of 2006 (Barr, 2008b). Large scale treatment to control CLP during 2008 through 2011 reduced CLP to 3 percent of sample locations (Barr, 2012b). Although no treatment occurred in 2012, a spot treatment occurred in 2013 and CLP was not observed in 2013 after the treatment. The large number of turions deposited during the years in which CLP was unmanaged and allowed to expand annually replenished CLP in Kohlman Lake and, hence, caused the presence of CLP in the lake during the 2008 through 2013 treatment period. However, the 2008 through 2013 treatments prevented the addition of turions as the turion supply in the sediment was exhausted. The Half Moon Lake Protection and Rehabilitation District recognizes that the small investment to remove CLP while it is at low levels will avoid the larger investment required to control a large-scale infestation resulting from a rapid expansion of CLP. Hence, the District strategy for CLP management is to remove CLP when necessary to prevent or minimize nuisance conditions.

12.2.1 Implementation of CLP Management Strategies

Implementation of the CLP management strategies are illustrated in the 2022 through 2023 EWM management plans found in Appendix I.

CLP management will occur only when CLP is found in the lake and may not occur every year. Whenever management is needed, herbicide treatment will be used for CLP management. Although CLP management plans will vary, the future plans will follow the format of the 2022 and 2023 Half Moon Lake EWM management plans (Appendix I). Each treatment plan will be based upon the results of a spring pre-treatment survey. Each plan will show the treatment polygons within each treatment area, the herbicide and dose applied to each treatment polygon. When the treated area is large enough to attain a lake-wide impact, the expected whole lake herbicide concentration following treatment will be shown in the plan.

When CLP is not observed during a plant survey, no management will occur.

12.3 Goal 3: Manage Yellow Iris When Necessary to Prevent or Minimize Nuisance Conditions

Goal 3: ***Yellow iris will be managed when necessary to prevent or minimize nuisance conditions through an integrated pest management approach.***

Objectives: *(1) Protect native species from displacement by yellow iris; (2) Protect shoreland habitat and the overall health of the lake; and (3) Reduce yellow iris management cost.*

The strategies to manage yellow iris are shown in Table 12-5 and discussed in the paragraphs below.

Table 12-3 Goal 3 Strategies and Measurements

Strategies	Measurements	
	Yes	No
Strategy 1: Conduct boat survey of shoreline areas of lake to identify/document locations where yellow iris is present.		
Strategy 2: Discuss yellow iris presence and yellow iris removal plan with property owners; identify and agree upon removal plan.		
Strategy 3: Property owners remove yellow iris per agreed upon removal plan.		

Volunteers from the Half Moon Lake Protection and Rehabilitation District will annually complete a boat survey in June to look for yellow iris along the lake's shoreline. Whenever yellow iris is seen, the boat will park at the yellow iris location and the homeowner adjacent to the yellow iris location will be informed of the presence of yellow iris and how to get rid of it. A yellow iris removal plan involving chemical treatment with glyphosate or manual removal (hand digging) will be discussed and agreed upon. The homeowner will then remove the yellow iris per the agreed upon removal plan.

12.4 Goal 4: Manage AIS Found in the Future When Necessary to Prevent or Minimize Nuisance Conditions

Goal 4: ***AIS found in the future will be managed when necessary to prevent or minimize nuisance conditions through an integrated pest management approach.***

Objectives: *(1) Protect the lake's ability to support recreational uses such as boating, fishing, swimming, and enjoying the view; (2) Protect fisheries habitat and the overall health of the lake; (3) Protect wild rice and other native species from displacement by AIS; (4) Reduce AIS management cost.*

The strategies to manage AIS found in Half Moon Lake in the future are shown in Table 12-5 and discussed in the paragraphs below.

Table 12-4 Goal 4 Strategies and Measurements

Strategies	Measurements	
	Yes	No
Strategy 1: Complete annual point intercept plant survey in early-July.		
Strategy 2: Whenever an AIS species not previously present in the lake is identified/documented, identify AIS removal plan.		
Strategy 3: If WDNR permit required for AIS removal, complete application for permit and submit to WDNR.		
Strategy 4: Conduct AIS removal when WDNR permit received or as soon as possible if no permit required.		

The AIS management plans for Half Moon Lake will generally use herbicide to effectively remove the AIS because 2023 Half Moon Lake data document the ineffectiveness of manual removal of EWM from the lake. Challenges of manual removal of AIS include the inability of divers to see AIS plants hidden among native plants and, when applicable, the inability to remove root crowns due to plants breaking off and leaving the root crowns in the sediment. Use of herbicide to effectively remove AIS from Half Moon Lake will prevent the rapid increase of AIS to dominance.

When herbicide treatment is used, herbicide, dose, and application methods within each treatment area will be selected to attain AIS control based upon past experience with AIS herbicide treatments and the latest research studies.

12.4.1 Implementation of AIS Management Strategies

AIS management is expected to occur when necessary to prevent or minimize nuisance conditions in Half Moon Lake. Although the geographic locations of the AIS management areas and the method of the AIS management used on the areas will vary, the management plans will follow the format of the 2022 through 2023 EWM management plans. Each management plan is based upon the results of the most recent plant survey documenting the presence of the AIS in the lake and determining the AIS locations requiring management. Each plan shows specifics of the AIS management within each management area. When herbicide treatment is used, the type of herbicide and dose applied to each treatment polygon to control the AIS is shown on the treatment map. When the treated area is large enough to attain a lake-wide impact, the expected "whole lake" concentration will be shown on the treatment map. When the AIS is not observed during a plant survey, no management will occur.

12.5 Goal 5: Unimpaired Navigation Channels

Goal 5: ***Maintain navigation channels/riparian access corridors that are not impaired by native plants and invasive plant growth.***

Objectives: *(1) Protect the lake's ability to support recreational uses such as boating, pontooning, and fishing; (2) Provide riparian owners with the ability to access and navigate the lake with their boats and pontoons.*

The strategies to maintain navigation channels and riparian access corridors that are not impaired by native plants and invasive plant growth are shown in Table 12-5 and discussed in the paragraphs below.

Table 12-5 Goal 5 Strategies and Measurements

Strategies	Measurements	
	Yes	No
Strategy 1: Determine and document navigation channel/riparian access corridor impairment annually during summer plant surveys completed by District representative.		
Strategy 2: Riparian residents to report navigation channel/riparian access corridor impairment to District and provide impairment documentation.		
Strategy 3: Complete permit application to treat impaired navigation channels by selected herbicide applicator and submit to WDNR. Submit documentation of impairment with permit application.		
Strategy 4: Complete permitted treatment.		
Strategy 5: Complete whole lake point intercept summer survey annually and assess data to evaluate the lake's plant community, including treated areas.		

The District understands the risk of AIS spread to navigation channels and riparian access corridors cleared by herbicide treatment. However, treatment of navigation channels and riparian access corridors is sometimes necessary when plant growth prevents navigation in common navigation channels or prevents homeowners from accessing the lake. Treatment of navigation channels and riparian access corridors in this APM Plan follows WDNR policy detailed in *Aquatic Plant Management Strategy Northern Region WDNR* (WDNR, 2007). When navigation channels or riparian access corridors impaired by plants are identified, the impairment will be documented as required by WDNR policy. Documentation of impairment of navigation will include:

a. Specific locations of navigation routes (preferably with GPS coordinates)

b. Specific dimensions in length, width, and depth

c. Specific times when plants cause problems and how long the problem persists

d. Adaptations or alternatives that have been considered by the lake shore user to avoid or lessen the problem.

e. The species of plant or plants creating the nuisance (documented with samples or from a Site inspection) (WDNR, 2007).

Documentation of nuisance conditions will include:

a. Specific periods of time when plants cause the problem (e.g., when does the problem start and when does it go away).

b. Photos of the nuisance are encouraged to help show what uses are limited and to show the severity of the problem.

c. Examples of specific activities that would normally be done when native plants occur naturally on a site but cannot occur because native plants have become a nuisance (WDNR, 2007).

The Half Moon Lake Protection and Rehabilitation District will work with WDNR as needed to obtain treatment permits to attain Goal 5, unimpaired navigation channels and riparian access corridors. Each navigation channel and riparian corridor treatment area will be mapped annually and tracked for need of treatment in subsequent years. After a couple of years of documentation, these areas could be considered as planned annual treatments and may not need documentation.

12.6 Goal 6: No AIS In or Out of Lake

Goal 6: Prevent transfer of invasive plant and animal species both to and from Half Moon Lake

Objectives: *(1) Protect the lake's ability to support recreational activities (2) Protect the lake's fishery (3) Containment of EWM, CLP, yellow iris, and any additional AIS found in the future to prevent the introduction of AIS to other lakes and (4) prevent introduction of AIS to Half Moon Lake.*

The strategies to prevent the transfer of invasive plant and animal species both to and from Half Moon Lake are shown in Table 12-6 and discussed in the paragraphs below.

Table 12-6 Goal 6 Strategies and Measurements

Strategies	Measurements	
	Yes	No
Strategy 1: Fully fund the Half Moon Lake Protection and Rehabilitation District's Clean Boats/Clean Waters boat inspection program if grant money is not available. If grant money is available to fund 75 percent of program cost, fund the 25 percent local cost share.		
Strategy 2: Clean Boats Clean Waters (CBCW) inspectors attend CBCW training provided by Polk County in partnership with WDNR every spring.		
Strategy 3: Provide educational material to each lake user whose boat is inspected by the Clean Boats/Clean Waters program.		
Strategy 4: Place signage at each boat landing educating boaters to clean boats and trailers of any plant materials before entering and leaving the lake.		
Strategy 5: A Boat Cleaning Station was installed by the District at the public access located within the City of Milltown Park (Figure 2-1) for boaters to use to clean boats and trailers of any plant materials before entering and leaving the lake. Place signage at the Boat Cleaning Station educating boaters to use it to clean boats and trailers of any plant materials before entering and leaving the lake.		
Strategy 6: Educate readers by including information in each newsletter on removing plants and animals from boats before entering or leaving the lake.		

The Half Moon Lake Protection and Rehabilitation District will annually hire two boat monitors to inspect boats entering and leaving the lake at the landing located within the City of Milltown Park (Figure 2-1). This Clean Boats/Clean Waters program will inspect all boats entering and leaving the lake at this landing during 7 AM through 3 PM seven days per week from Memorial Day weekend through Labor Day. The results of the inspections will be recorded on forms provided by the WDNR and the information will then electronically be entered on the DNR on-line data base known as Surface Water Integrated Monitoring System.

A boat cleaning station has been placed at the landing located within the City of Milltown Park (Figure 2-1) for boaters to use to clean boats and trailers of any plant materials before entering or leaving the lake.

Educational materials will be distributed to each lake user whose boat was inspected by the Clean Boats/Clean Waters program. The District newsletter will consistently contain information to educate readers to remove plants and animals from boats before entering or leaving the lake.

Signs at each boat landing educate lake users to clean boats and trailers of any plant materials before entering or leaving the lake.

12.7 Goal 7: Improve Fishery

Goal 7: Improve the fishery resource through proper management of aquatic plants

***Objectives**: (1) Improve fishery habitat through removal of AIS; (2) Protect fishery habitat by minimizing harm to the native plants found in the lake while removing AIS.*

The strategies to improve the lake's fishery through proper management of aquatic plants are shown in Table 12-7.

Table 12-7 Goal 7 Strategies and Measurements

Strategies	Measurements	
	Yes	No
Strategy 1: Select and implement effective removal methods to optimize removal of EWM, CLP, yellow iris, and/or any other AIS while minimizing harm to native plants.		
Strategy 2: Complete summer whole lake point intercept survey and assess data to determine AIS removal effectiveness and native plant response to AIS removal.		

12.8 Goal 8: Education

Goal 8: ***Provide educational materials to educate the public about AIS and progress on goals and strategies of the Half Moon Lake Protection and Rehabilitation District.***

Objectives: *(1) Help residents protect the attributes of the lake they most enjoy; (2) Help residents protect fish and wildlife habitat and the overall health of the lake; (3) Keep the public informed about progress on attaining District goals and strategies of the Half Moon Lake Protection and Rehabilitation District.*

The education strategies are shown in Table 12-8.

Table 12-8 Goal 8 Strategies and Measurements

Strategies	Measurements	
	Yes	No
Strategy 1: Provide education materials and report progress on attaining District goals and strategies at annual meeting.		
Strategy 2: Provide education materials and report progress on attaining District goals and strategies in District newsletters and on the District website.		
Strategy 3: Use other media to provide education materials and report progress on attaining District goals and strategies.		

13.0 Potential Adverse Impacts on Non-Targeted Species

The aquatic plant management detailed in this APM Plan involves herbicide treatment of aquatic invasive species (EWM and yellow iris), possible future herbicide treatment of CLP and any other AIS found in the lake in the future, as well as herbicide treatment of navigation channels and/or resident access corridors to support boating use of the lake whenever needed. The AIS management program is a continuation of a management program begun in 2021 (yellow iris) and 2022 (EWM). It is acknowledged that non-target species may be unintentionally harmed during the herbicide treatment of invasive species. However, data collection of the 2022 invasive species treatment program has documented that the herbicide treatment program resulted in excellent removal of invasive species. The 2022 plant data indicate the treatment benefited the ecosystem by reducing frequency and extent of invasive species while improving the native plant community.

Annual monitoring of the plant community would detect adverse impacts caused by implementation of the APM Plan. Should adverse impacts be detected, the APM Plan has the flexibility to be changed to address the issue and prevent additional adverse impacts from occurring.

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Appendices

Appendix A

Public Input

The APM Plan was posted on the Half Moon Lake Protection and Rehabilitation District website during October 13 through November 15 for review and comment by the public. During this period, the Half Moon Lake Protection and Rehabilitation District received comments from a staff member from Polk County and a staff member from the WDNR. Following are the comments received and the changes made to the APM Plan to address these comments.

Polk County Comments – A staff member from Polk County provided the following two comments:

(1) "You could add a goal to the plan that CBCW inspectors attend yearly CBCW training—our department offers these every spring in partnership with WDNR"

Change Made to APMP Plan to address comment – added strategy 2 to Goal 6: Clean Boats Clean Waters (CBCW) inspectors attend CBCW training provided by Polk County in partnership with WDNR every spring.

(2) "Section 3.3 could add that the illegal transport ordinance was amended and now requires decontamination where a station is present.

Change Made to APM Plan to address comment – Added to Section 3.3, Illegal Transport of Aquatic Plants and Invasive Animals Ordinance, "This ordinance was amended and now requires decontamination where a station is present."

WDNR Comment – A staff member from WDNR provided the following comment:

"After briefly reviewing the draft APM plan, we have come to a conclusion that the overall goals and objectives specified within the plan are not suitable and realistic for the overall management of Half Moon Lake. Expectations of eradication should not be encouraged as it is highly unlikely that eradication will occur for any of the AIS currently present on Half Moon Lake. The plan, as is, is not approvable/eligible for future surface water grant funding. We recommend rewriting the draft plan, goals, and objectives to set realistic expectations for any aquatic plant management that may occur in the future on Half Moon Lake."

Changes made to APM Plan to address comment – changed goals one through four to replace "eradicate" with "will be managed to prevent or minimize nuisance conditions through an integrated pest management approach". Following are the changed goals:

Goal 1: EWM will be managed when necessary to prevent or minimize nuisance conditions through an integrated pest management approach.

Goal 2: CLP will be managed when necessary to prevent or minimize nuisance conditions through an integrated pest management approach.

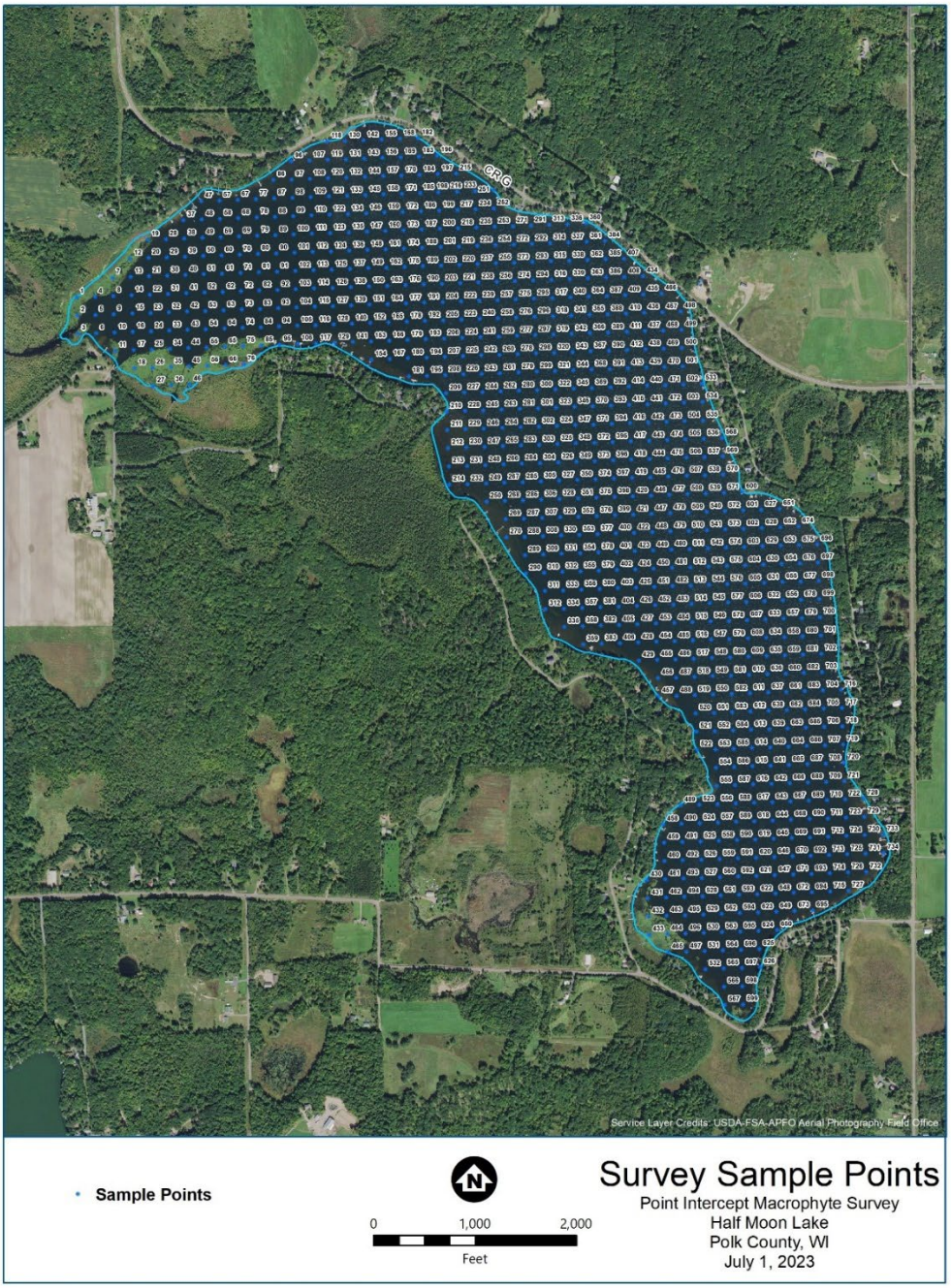
Goal 3: Yellow iris will be managed when necessary to prevent or minimize nuisance conditions through an integrated pest management approach.

Goal 4: ***AIS found in the future will be managed when necessary to prevent or minimize nuisance conditions through an integrated pest management approach.***

Additional changes were made in the APM plan to replace eradicate with "will be managed when necessary to prevent or minimize nuisance conditions."

Appendix B

Whole Lake Point Intercept Sample Points



Half Moon Lake Whole Lake Point Intercept Sample Points (Map Credit: Endangered Resource Services, LLC)

Appendix C

Half Moon Lake Pre-management Plant Survey Data Summary

June 8, 2022

Half Moon Lake Pre-management Data Summary: June 8, 2022

Scientific name	Common name	Number of sites where species found	Relative Frequency (%)	Frequency of occurrence within vegetated areas (%)	Frequency of occurrence at sites shallower than maximum depth of plants	Average rake fullness	#Visual sightings
Potamogeton robbinsii	Fern pondweed	76	24.13	69.72	64.41	1.99	0
Ceratophyllum demersum	Coontail	47	14.92	43.12	39.83	1.13	0
Elodea canadensis	Common waterweed	33	10.48	30.28	27.97	1.55	0
Potamogeton amplifolius	Large-leaf pondweed	22	6.98	20.18	18.64	1.23	0
Heteranthera dubia	Water star-grass	20	6.35	18.35	16.95	1.15	0
Myriophyllum sibiricum	Northern watermilfoil	19	6.03	17.43	16.10	1.68	0
Chara sp.	Muskgrass	15	4.76	13.76	12.71	1.40	0
Potamogeton richardsonii	Clasping-leaf pondweed	12	3.81	11.01	10.17	1.08	0
Potamogeton zosteriformis	Flat-stem pondweed	12	3.81	11.01	10.17	1.08	0
Lemna trisulca	Forked duckweed	11	3.49	10.09	9.32	1.09	0
Nuphar variegata	Spatterdock	9	2.86	8.26	7.63	1.33	0
Myriophyllum spicatum	Eurasian watermilfoil	7	2.22	6.42	5.93	2.14	18
Nymphaea odorata	White water lily	5	1.59	4.59	4.24	1.00	0
Potamogeton pusillus	Small pondweed	5	1.59	4.59	4.24	1.00	0
--	Filamentous algae	5	*	4.59	4.24	1.80	0
Bidens beckii	Water marigold	3	0.95	2.75	2.54	1.00	0
Brasenia schreberi	Watershield	3	0.95	2.75	2.54	1.00	0
Eleocharis acicularis	Needle spikerush	3	0.95	2.75	2.54	1.33	0
Pontederia cordata	Pickerelweed	3	0.95	2.75	2.54	1.33	0
Myriophyllum tenellum	Dwarf watermilfoil	2	0.63	1.83	1.69	1.00	0
Ranunculus aquatilis	White water crowfoot	2	0.63	1.83	1.69	1.00	0

Half Moon Lake Pre-management Data Summary: June 8, 2022 (Continued)

Scientific Name	Common Name	Number of sites where species found	Relative Frequency (%)	Frequency of occurrence within vegetated areas (%)	Frequency of occurrence at sites shallower than maximum depth of plants	Average rake fullness	# Visual sightings
Isoetes echinospora	Spiny-spored quillwort	1	0.32	0.92	0.85	1.00	0
Potamogeton crispus	Curly-leaf pondweed	1	0.32	0.92	0.85	2.00	0
Potamogeton friesii	Fries' pondweed	1	0.32	0.92	0.85	1.00	0
Potamogeton gramineus	Variable pondweed	1	0.32	0.92	0.85	1.00	0
Potamogeton illinoensis	Illinois pondweed	1	0.32	0.92	0.85	1.00	0
Vallisneria americana	Wild celery	1	0.32	0.92	0.85	1.00	0

*Excluded from relative frequency analysis

Appendix D

Half Moon Lake Post-management Plant Survey Data Summary

September 18, 2022

2022

Half Moon Lake Post-management Data Summary: September 18, 2022

Scientific name	Common name	Number of sites where species found	Relative Frequency (%)	Frequency of occurrence within vegetated areas (%)	Frequency of occurrence at sites shallower than maximum depth of plants	Average rake fullness	# Visual sightings
Potamogeton robbinsii	Fern pondweed	66	16.79	58.93	57.39	1.83	0
Vallisneria americana	Wild celery	46	11.70	41.07	40.00	1.22	0
Elodea canadensis	Common waterweed	41	10.43	36.61	35.65	1.59	0
Ceratophyllum demersum	Coontail	35	8.91	31.25	30.43	1.34	0
Potamogeton gramineus	Variable pondweed	24	6.11	21.43	20.87	1.46	0
Potamogeton amplifolius	Large-leaf pondweed	18	4.58	16.07	15.65	1.17	0
Potamogeton zosteriformis	Flat-stem pondweed	18	4.58	16.07	15.65	1.17	0
Myriophyllum sibiricum	Northern watermilfoil	15	3.82	13.39	13.04	1.20	0
Potamogeton richardsonii	Clasping-leaf pondweed	14	3.56	12.50	12.17	1.57	0
Chara sp.	Muskgrass	13	3.31	11.61	11.30	1.54	0
--	Filamentous algae	13	*	11.61	11.30	1.31	0
Nymphaea odorata	White water lily	12	3.05	10.71	10.43	1.75	0
Heteranthera dubia	Water star-grass	11	2.80	9.82	9.57	1.64	0
Potamogeton pusillus	Small pondweed	11	2.80	9.82	9.57	1.18	0
Lemna trisulca	Forked duckweed	9	2.29	8.04	7.83	1.00	0
Nuphar variegata	Spatterdock	8	2.04	7.14	6.96	1.88	0
Lemna minor	Small duckweed	7	1.78	6.25	6.09	1.00	0
Najas flexilis	Slender naiad	7	1.78	6.25	6.09	1.29	0
Nitella sp.	Nitella	7	1.78	6.25	6.09	1.86	0
Wolffia columbiana	Common watermeal	7	1.78	6.25	6.09	1.00	0

Half Moon Lake Post-management Data Summary: September 18, 2022 (Continued)

Scientific name	Common name	Number of sites where species found	Relative Frequency (%)	Frequency of occurrence within vegetated areas (%)	Frequency of occurrence at sites shallower than maximum depth of plants	Average rake fullness	# Visual sightings
Potamogeton natans	Floating-leaf pondweed	6	1.53	5.36	5.22	1.50	0
Eleocharis acicularis	Needle spikerush	5	1.27	4.46	4.35	1.80	0
Bidens beckii	Water marigold	3	0.76	2.68	2.61	1.00	0
Pontederia cordata	Pickerelweed	2	0.51	1.79	1.74	2.00	0
Ranunculus aquatilis	White water crowfoot	2	0.51	1.79	1.74	1.00	0
Utricularia gibba	Creeping bladderwort	2	0.51	1.79	1.74	1.00	0
Myriophyllum tenellum	Dwarf watermilfoil	1	0.25	0.89	0.87	1.00	0
Potamogeton illinoensis	Illinois pondweed	1	0.25	0.89	0.87	1.00	0
Potamogeton praelongus	White-stem pondweed	1	0.25	0.89	0.87	1.00	0
Sagittaria graminea	Grass-leaved arrowhead	1	0.25	0.89	0.87	1.00	0
Myriophyllum spicatum	Eurasian watermilfoil	*	*	*	*	*	2

*Excluded from relative frequency analysis

Appendix E

Half Moon Lake Pre-management Plant Survey Data Summary

June 5, 2023

Half Moon Lake Pre-management Data Summary: June 5, 2023

Scientific name	Common name	Number of sites where species found	Relative Frequency (%)	Frequency of occurrence within vegetated areas (%)	Frequency of occurrence at sites shallower than maximum depth of plants	Average rake fullness	# Visual sightings
Potamogeton robbinsii	Fern pondweed	65	20.63	55.56	52.85	1.45	0
Heteranthera dubia	Water star-grass	40	12.70	34.19	32.52	1.30	0
Ceratophyllum demersum	Coontail	36	11.43	30.77	29.27	1.25	0
Potamogeton pusillus	Small pondweed	30	9.52	25.64	24.39	1.07	0
Myriophyllum sibiricum	Northern watermilfoil	28	8.89	23.93	22.76	1.36	0
Elodea canadensis	Common waterweed	22	6.98	18.80	17.89	1.14	0
Chara sp.	Muskgrass	21	6.67	17.95	17.07	1.38	0
Potamogeton gramineus	Variable pondweed	14	4.44	11.97	11.38	1.00	0
--	Filamentous algae	14	*	11.97	11.38	1.07	0
Eleocharis acicularis	Needle spikerush	10	3.17	8.55	8.13	1.20	0
Myriophyllum spicatum	Eurasian watermilfoil	9	2.86	7.69	7.32	1.44	31
Potamogeton amplifolius	Large-leaf pondweed	9	2.86	7.69	7.32	1.22	0
Potamogeton friesii	Fries' pondweed	8	2.54	6.84	6.50	1.00	0
Potamogeton zosteriformis	Flat-stem pondweed	7	2.22	5.98	5.69	1.00	0
Potamogeton richardsonii	Clasping-leaf pondweed	6	1.90	5.13	4.88	1.17	0
Lemna trisulca	Forked duckweed	4	1.27	3.42	3.25	1.00	0
Bidens beckii	Water marigold	2	0.63	1.71	1.63	1.00	0
Potamogeton praelongus	White-stem pondweed	2	0.63	1.71	1.63	1.00	0
Myriophyllum tenellum	Dwarf water-milfoil	1	0.32	0.85	0.81	1.00	0
Potamogeton illinoensis	Illinois pondweed	1	0.32	0.85	0.81	1.00	0

*Excluded from relative frequency analysis

Half Moon Lake Pre-management Data Summary: June 5, 2023 (Continued)

Scientific name	Common name	Number of sites where species found	Relative Frequency (%)	Frequency of occurrence within vegetated areas (%)	Frequency of occurrence at sites shallower than maximum depth of plants	Average rake fullness	# Visual sightings
Eleocharis acicularis	Needle spikerush	10	3.17	8.55	8.13	1.20	0
Bidens beckii	Water marigold	2	0.63	1.71	1.63	1.00	0
Potamogeton illinoensis	Illinois pondweed	1	0.32	0.85	0.81	1.00	0
Potamogeton praelongus	White-stem pondweed	2	0.63	1.71	1.63	1.00	0
Myriophyllum spicatum	Eurasian watermilfoil	9	2.86	7.69	7.32	1.44	31

*Excluded from relative frequency analysis

Appendix F

Half Moon Lake Post-management Plant Survey Data Summary

August 24, 2023

Half Moon Lake Post-management Data Summary: August 24, 2023

Scientific name	Common name	Number of sites where species found	Relative Frequency (%)	Frequency of occurrence within vegetated areas (%)	Frequency of occurrence at sites shallower than maximum depth of plants	Average rake fullness	# Visual sightings
Vallisneria americana	Wild celery	62	13.05	51.67	50.82	1.18	0
Potamogeton pusillus	Small pondweed	61	12.84	50.83	50.00	1.89	0
Potamogeton robbinsii	Fern pondweed	57	12.00	47.50	46.72	1.33	0
Potamogeton gramineus	Variable pondweed	43	9.05	35.83	35.25	1.42	0
Ceratophyllum demersum	Coontail	42	8.84	35.00	34.43	1.26	0
Myriophyllum sibericum	Northern watermilfoil	41	8.63	34.17	33.61	1.78	0
Elodea canadensis	Common waterweed	33	6.95	27.50	27.05	1.36	0
Heteranthera dubia	Water star-grass	29	6.11	24.17	23.77	1.31	0
Myriophyllum spicatum	Eurasian watermilfoil	21	4.42	17.50	17.21	1.71	26
Chara sp.	Muskgrass	18	3.79	15.00	14.75	1.33	0
Najas flexilis	Slender naiad	15	3.16	12.50	12.30	1.13	0
Potamogeton richardsonii	Clasping-leaf pondweed	15	3.16	12.50	12.30	1.33	0
Potamogeton zosteriformis	Flat-stem pondweed	12	2.53	10.00	9.84	1.08	0
Potamogeton amplifolius	Large-leaf pondweed	8	1.68	6.67	6.56	1.13	0
Bidens beckii	Water marigold	7	1.47	5.83	5.74	1.43	0
Eleocharis acicularis	Needle spikerush	5	1.05	4.17	4.10	1.00	0
Nitella sp.	Nitella	2	0.42	1.67	1.64	1.00	0
--	Filamentous algae	2	*	1.67	1.64	1.50	0
Myriophyllum tenellum	Dwarf watermilfoil	1	0.21	0.83	0.82	1.00	0
Potamogeton friesii	Fries' pondweed	1	0.21	0.83	0.82	1.00	0

Half Moon Lake Post-management Data Summary: August 24, 2023 (Continued)

Scientific name	Common name	Number of sites where species found	Relative Frequency (%)	Frequency of occurrence within vegetated areas (%)	Frequency of occurrence at sites shallower than maximum depth of plants	Average rake fullness	# Visual sightings
Potamogeton illinoensis	Illinois pondweed	1	0.21	0.83	0.82	1.00	0
Potamogeton strictifolius	Stiff pondweed	1	0.21	0.83	0.82	2.00	0

*Excluded from relative frequency analysis

Appendix G

Citizen Survey Results

Half Moon Lake Citizen Survey

The Half Moon Lake Protection and Rehabilitation District needs citizen help to complete an Aquatic Plant Management Plan required by the Wisconsin Department of Natural Resources (WDNR). The plan is drafted every five years and is necessary to obtain permission to manage the lake. Please complete the citizen survey below by **August 31, 2023** and mail it to Jim Benike, Half Moon Lake Protection and Rehabilitation District, 1971 Oscar Lane, Balsam Lake, WI 54810 or you may email your completed survey to jimb@benike.com .

Based on what you tell us we will establish goals for the Half Moon Lake Aquatic Management Plan. There will be an opportunity for you to provide comments on the draft plan in a few months.

Thank you on behalf of the Half Moon Lake Protection and Rehabilitation District.

Ellen Butler, Chairperson.

Surveys were mailed to 220 residents and 89 responses were received (40 percent return)

HALF MOON LAKE RECREATION

1. What recreational activities do you enjoy at the lake? *(Check all that apply)*

58 Motor Boating	26 Jet Skiing	35 Water Skiing	67 Pontoon Boating
17 Canoeing	57 Kayaking	8 Sailing/Wind Surfing	15 Wakeboarding
80 Swimming	62 Observing Waterfowl/Wildlife	73 Enjoying the view	68 Fishing
___ Other (Please describe)			

2. How often is your lake recreation impaired by current levels of plant growth?

17 Never 33 Rarely 23 Occasionally 10 Often 2 Always

3. Which of your recreational activities, if any, are impaired by plant growth?

15 Motor Boating	9 Jet Skiing	8 Water Skiing	20 Pontoon Boating
1 Canoeing	7 Kayaking	0 Sailing/Wind Surfing	3 Wakeboarding
46 Swimming	2 Observing Waterfowl/Wildlife	5 Enjoying the view	25 Fishing
___ Other (please describe)		24 None; my recreation is not impaired	

PLANT GROWTH and CHANGES IN THE LAKE

4. In your opinion, how has the volume of aquatic plants in Half Moon Lake changed in the past 5 years?

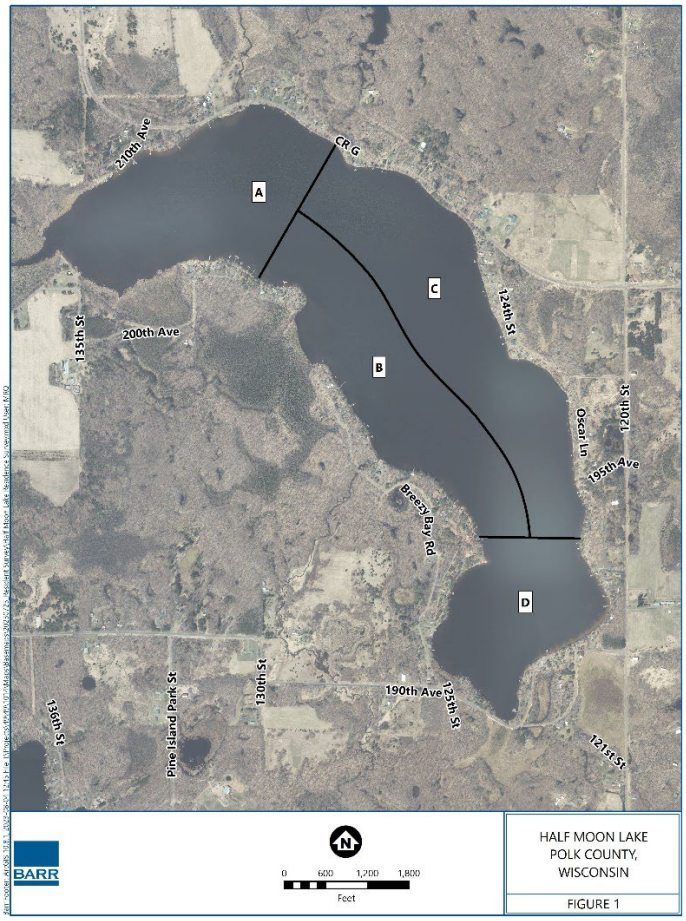
1 Decreased **13** No Change **54** Increased **17** Don't know

5. In your opinion, how have the types of aquatic plants changed in the past 5 years?

1 Fewer types **5** No Change **40** More types **40** Don't know

6. How much of a negative impact, if any, do each of the following have on your use or enjoyment of the lake. ***Circle one option per row.***

	No impact	*Little impact*	*Moderate impact*	*High impact*
Lake Level Too High	*1* **(43)**	*2* ***(13)***	*3*	*4*
Lake Level Too Low	*1* ***(15)***	*2* ***(15)***	*3* **(29)**	*4* **(26)**
Loss of Wildlife Habitat	*1* **(26)**	*2* **(23)**	*3* **(23)**	*4* **(11)**
Boat traffic	*1* **(13)**	*2* **(22)**	*3* **(32)**	*4* **(14)**
Noise	*1* **(21)**	*2* **(28)**	*3* **(14)**	*4* **(18)**
Loss of Natural Scenery	*1* **(30)**	*2* **(19)**	*3* **(16)**	*4* **(10)**
Small Fish	*1* **(30)**	*2* **(26)**	*3* **(21)**	*4* **(7)**
Not Enough Fish	*1* **(23)**	*2* **(21)**	*3* **(19)**	*4* **(16)**
Algae Growth	*1* **(18)**	*2* **(17)**	*3* **(27)**	*4* **(17)**
Native Plant Growth	*1* **(20)**	*2* **(29)**	*3* **(23)**	*4* **(12)**
Invasive Plant Species	*1* **(8)**	*2* **(19)**	*3* **(26)**	*4* **(30)**



The next three questions all reference the map above and will help us understand the areas of the lake you spend time in.

7. In which area of the lake on the map above is your property located? Choose one.

17 A **13** B **32** C **24** D

8. In which area(s) of the lake on the map above do you typically recreate? Check all that apply.

53 A **64** B **74** C **57** D

9. In which area(s) of the lake on the map above do you feel plant growth is excessive? Check all that apply.

56 A **12** B **11** C **48** D

LAKE MANAGEMENT OPTIONS

Aquatic invasive species (AIS) are non-native plants and animals that are introduced into our lakes and streams and can potentially upset the natural balance of a lake ecosystem while decreasing recreational opportunities. Examples of AIS include animals such as carp, zebra mussels, rusty crayfish, round goby, and spiny waterflea; and plants such as Eurasian watermilfoil (EWM), purple loosestrife, and curly-leaf pondweed.

10. Prior to receiving this survey, had you heard of AIS?

84 Yes **2** No _____ Not sure

11. Which of the following best describes your opinion on management of invasive plants in Half Moon Lake?

68 Reduce them as much as possible to avoid future problems

9 Monitor and manage if and when they become a problem

1 Do not manage

1 Not sure

12. Eurasian watermilfoil (EWM), a plant not native to Wisconsin, was first observed in Half Moon Lake in October 2021. Removal of EWM occurred in 2022 and 2023. We are assessing future techniques for managing EWM. ***What is your level of support for each of the below options?***

	Strongly oppose	**Oppose**	**No opinion**	**Support**	**Strongly support**	**Not sure; need more information**
Herbicide Treatment	1 **(2)**	2 **(4)**	3 **(1)**	4 **(11)**	5 (**50)**	6 **(14)**
Hand Pulling	1 **(1)**	2 **(1)**	3 **(5)**	4 **(26)**	5 **(41)**	6 **(7**
No active management	1 **(62)**	2 **(7)**	3 **(1)**	4	5	6 **(3)**

13. Yellow iris, a plant not native to Wisconsin, was first observed in Half Moon Lake during 2018. Removal of yellow iris occurred in 2021, 2022, and 2023. We are assessing future techniques for managing yellow iris. ***What is your level of support for each of the below options?***

	Strongly oppose	**Oppose**	**No opinion**	**Support**	**Strongly support**	**Not sure; need more information**
Herbicide Treatment	1 **(2)**	2 **(6)**	3 **(7)**	4 **(16)**	5 **(43)**	6 **(14)**
Hand Digging	1 **(1)**	2 **(1)**	3 **(8)**	4 **(24)**	5 **(44)**	6 **(5)**
No active management	1 **(46)**	2 **(3)**	3	4 **(1)**	5 **(1)**	6 **(8)**

14. Curly-leaf Pondweed (CLP), a plant not native to Wisconsin, was first observed in the lake in 2007. It has not yet been managed and currently has a small population area. ***What is your preference for managing CLP?***

50 Reduce it as much as possible now to avoid future population growth

28 Only manage if it becomes worse

3 Do not manage

15. What type(s) of watercraft, if any, do you currently use on Half Moon lake? *Check all that apply.*

6 Sailboat

63 Canoe/Kayak/Paddleboard

24 Jet Ski (personal watercraft)

55 Motorboat

59 Pontoon

8 Wake boat

2 Do not use watercraft

16. Do you support the removal of native plants in navigation channels if they interfere with boat navigation?

44 Yes **19** No **19** No opinion

17. The Half Moon Lake Protection and Rehabilitation District operates a boat inspection program at the boat landing to prevent introduction of invasive species to the lake. Would you support or oppose increasing this program to include more staffed hours at the boat landing?

2 Oppose **12** No opinion **72** Support

LAKE RESIDENTS

18. How long have you lived on the Lake?

10 Less than 1 year **10** 1-5 years **9** 6-10 years **8** 11-20 years **48** More than 20

19. Have you ever removed aquatic plants from your lakeshore? **33** Yes **44** No

20. Have you had approved private treatment of aquatic plants? **2** Yes **68** No
21. Would you consider approved private treatment of aquatic plants on your lakeshore?

13 No **21** Next year **9** Next 2 years **10** Next 5 years

Thank you on behalf of the Half Moon Lake Protection and Rehabilitation District for helping us with the Plant Management Survey. It will help us with the task of managing plant growth in the lake.

What other comments or suggestions do you have for the Half Moon Lake Protection and Rehabilitation District?

_____

_____

_____

_____

Thank you for completing this survey. We appreciate your input and participation.

Please return your completed survey by **August 31, 2023.**

Please either email your completed survey to jimb@benike.com
or mail to:

Jim Benike
Half Moon Lake Protection and Rehabilitation District
1971 Oscar Lane
Balsam Lake, WI 54810

Appendix H

Assessment of IPM Techniques

1.0 Assessment of IPM Techniques

Following a consideration of IPM management alternatives, an aquatic plant management plan was selected for Half Moon Lake. The following discussion focuses on the assessment of four types of aquatic plant management techniques currently used for aquatic plant control. They include:

1. Physical
2. Mechanical
3. Chemical
4. Biological

1.1 Physical

Physical tactics typically used to manage aquatic plants are light manipulation and habitat manipulation. Habitat manipulation includes such techniques as overwinter lake drawdown, dredging, sand blanketing, the use of dyes, and nutrient limitation and inactivation (Barr, 1997).

Although light manipulation has been used in lakes with some success, its greatest utility has been found in managing dense vegetation in streams through streamside shading. Shading by use of different densities of shading cloth has resulted in decreased plant biomass. Natural shade from streamside vegetation has also reduced plant biomass along the stream course (Barr, 1997). Dark colored dyes are sometimes used in small ponds and lakes to reduce aquatic plant growth. The dyes are added to the lake or pond. The resultant change in water color reduces the amount of light reaching the submersed plants, thereby limiting plant growth. Use of dyes is limited to shallow waterbodies with no outflow. Because Half Moon Lake is a large lake with an outflow, dyes cannot be used in the lake for plant management.

Lake level drawdown, particularly over winter, is commonly used to control nuisance aquatic plants in northern North America. Biomass studies before and after drawdown have demonstrated that drawdown was effective in controlling plants down to the depth of drawdown, but had no effect at greater depths. While drawdown is an extremely effective technique for some species, it may actually stimulate the growth of other species (Madsen and Bloomfield, 1992). A study of Trego Flowage (Washburn County, Wisconsin) indicated the benefits of drawdown were temporary, and the same species of plants returned in about their former abundance within a few years (Barr 1994). Consequently, drawdown as a plant management technique is not a feasible option for Half Moon Lake.

Another commonly used group of physical control techniques uses benthic barriers, weed rollers, or sediment alteration to inhibit the growth of aquatic plants at the sediment surface. Barrier material is applied over the lake bottom to prevent plants from growing, leaving the water clear of rooted plants. Benthic barriers are generally applied to small areas (Barr, 1997). Negatively buoyant (i.e., sink in water) screens are available in rolls 7 feet wide and 100 feet long. The screens can be laid on the lake bottom in the spring and removed in the fall. These screens can be reused for about 10 years. Burlap has been found to provide up to 2 to 3 years of relief from problematic growth before eventually decomposing (Truelson 1985 and Truelson 1989). Bottom barriers would be appropriate for controlling aquatic plant nuisances for

small applications such as adjacent to a boat dock or from small swimming areas. The barriers are safe, effective, non-chemical control using a simple technology. Bottom barriers do not result in significant production of plant fragments (critical for milfoil treatment). Bottom barriers may cause harm to fisheries and invertebrate habitat and are too expensive to use over widespread areas. Bottom barriers are not feasible for Half Moon Lake because the area requiring management is large.

Weed rollers or 'Automated Unintended Aquatic Plant Control Devices' are motor-drive rollers (round bars) placed on the lake bottom and roll over and uproot plants. The rollers are 25-to-30 feet long and are centered on the end post of a dock. The rollers roll in a circular pattern, normally covering 270^0 or using a 25-foot roller over a full circular area. Weed rollers would be appropriate for controlling aquatic plant nuisances in small areas such as adjacent to a boat dock or for small swimming areas. The rollers are an effective non-chemical control using a simple technology. However, weed rollers cause harm to fisheries and invertebrate habitat. Consequently, use of rollers in Wisconsin lakes is not allowed.

1.2 Mechanical/Manual Removal

Mechanical control and manual removal involve aquatic plant removal via harvesting, hand pulling, SCUBA removal (hand pulling while SCUBA diving), hand-digging, rotovation/cultivation, and diver assisted suction harvesting (DASH). Small scale harvesting may involve the use of the hand or hand-operated equipment such as rakes, cutting blades, or motorized trimmers. Individual residents frequently clear swimming areas via small scale harvesting or hand pulling or hand digging. Hand pulling is feasible for private landowners who wish to remove small areas of EWM or curly-leaf pondweed growth. SCUBA removal is feasible for small areas of EWM or curly-leaf pondweed growth when plant density is low. However, hand pulling and SCUBA removal are not feasible options for the large scale management required for Half Moon Lake because the area requiring management is too large and the density of the EWM is too high for management by small scale methods.

Large-scale mechanical control often uses floating, motorized harvesting machines that cut the plants and remove them from the water onto land, where they can be disposed. Harvesting has not proven to be an effective means of sustaining long-term reductions in plants such as coontail and Eurasian watermilfoil (EWM) that grow from fragments. Fragments from harvesting may cause coontail or EWM to regrow to preharvest levels or to spread to new areas and increase coverage of these species within a lake. Harvesting is not a feasible option for Half Moon Lake because it has the potential to spread EWM via the spreading of EWM fragments.

Rotovation/cultivation (underwater rototilling) are bottom tillage methods that remove aquatic plant root systems. This results in reduced stem development and seriously impairs growth of rooted aquatic plants. Derooting methods were developed by aquatic plant experts with the British Columbia Ministry of Environment as a more effective EWM control alternative to harvesting. Essentially two types of tillage machinery have been developed. Deep water tillage is performed in water depths of 1.5 to 11.5 feet using a barge-mounted rototiller equipped with a 6-10 foot wide rotating head. Cultivation in shallow water depths up to a few meters is accomplished by means of an amphibious tractor or modified WWII "DUCW" vehicle towing a cultivator. Both methods involve tilling the sediment to a depth of 4 to 6 inches, which dislodges plants including roots. Certain plants like EWM have roots that are buoyant and float on the

surface where they can be collected. Treatments are made in an overlapping swath pattern. Bottom tillage is usually performed in the cold "off-season" months of winter and spring to reduce plant growth potential.

Bottom tillage has been used effectively for long-term control of EWM where populations are well-established and prevention of stem fragments is not critical. Single treatments using a crisscross pattern have resulted in EWM stem density reductions of 80-97 percent in bottom tillage treatments (Gibbons et al. 1987 and Maxnuk 1979). Depending on plant density, carryover effectiveness of rototilling can persist for up to 2 to 3 years without retreatment. Following treatment, rotovated areas in Washington and British Columbia have shown increases in species diversity of native plants, of potential benefit to fisheries (Gibbons 1994). Rototilling is not advised where bottom sediments have excessive nutrient and/or metals concentrations, because of potential release of contaminants into the overlying water. The method does result in production of plant fragments, and is not recommended for use in waterbodies with new or sparse EWM infestations or where release of fragments is a concern. Bottom tillage is not a feasible option for Half Moon Lake because this method results in the production of plant fragments that would result in the spread of EWM.

DASH utilizes a small barge or boat carrying portable suction heads that are operated by scuba divers to remove individual rooted plants (including roots) from the sediment. Divers physically dislodge plants. The plant/sediment slurry is then suctioned up and carried back to the barge through hoses operated by the diver. On the barge, plant parts are sieved out and retained for later off-site disposal. The water sediment slurry can be discharged back to the water or piped off-site for upland disposal. DASH can be highly effective under appropriate conditions (Gibbons 1994). Efficiency of removal is dependent on sediment conditions, density of aquatic plants and underwater visibility (Cooke et al. 1993). As it is best used for localized infestations of low plant density where fragmentation must be minimized, the technique has great potential control of small localized infestations. Depending on local conditions, EWM removal efficiencies of 85-97 percent can be achieved by diver dredging (Maxnuk 1979). DASH was used for removal of EWM in Half Moon Lake during 2022 and 2023. DASH removal was effective in 2022 and EWM was not observed in the DASH removal areas during post-treatment bed-mapping and plant surveys. However, DASH removal was not effective in 2023. A post-treatment bed-mapping survey found EWM in all DASH removal areas. Removal of EWM in mid-summer was challenging because the EWM was mixed with densely growing native plants in the southern and eastern areas of the lake where most of the DASH removal occurred. In addition, EWM was growing more densely in 2023 than 2022. EWM removal in 2022 averaged 19 cubic feet per acre compared with 46 cubic feet per acre in 2023. The challenges slowed DASH removal and made it difficult to effectively remove the EWM. Consequently, EWM removal only occurred in 7 of the 15 areas intended for DASH removal during the scheduled one week period. An August 2 bed-mapping survey found a continued presence of EWM in all 7 of the DASH removal areas. An August 24 plant survey documented a statistically significant increase in EWM frequency during June 5 through August 24, 2023 despite DASH removal of EWM in July. DASH removal of EWM is not feasible for Half Lake because the area of EWM infestation is too large and plant density is too great. The 2023 data document its ineffectiveness. DASH or SCUBA removal of EWM could be considered in the future for small areas of EWM if plant density of both EWM and native plants were low and it was feasible to remove root crowns by digging them out should plants break off during the removal process.

1.3 Chemical

Chemical control involves the use of a herbicide (i.e., a plant-killing chemical) that is applied in liquid, granular, or pellet form. Herbicides are of two types, systemic herbicides and contact herbicides. Systemic herbicides, such as 2, 4-D, fluridone, Triclopyr, and ProcellaCOR are absorbed by and translocated throughout the plant, capable of killing the entire plant (roots and shoots). In contrast, contact herbicides, such as diquat and endothall, kill the plant surface with which it comes in contact, leaving roots alive and capable of regrowth. The aquatic plants (sometimes only stems and leaves) die and decompose in the lake. To reduce human exposure to the chemicals, temporary water-use restrictions may be imposed in treatment areas when herbicides are used. Only herbicides for aquatic use are allowed.

EWM has been effectively managed with herbicide treatments. Five large-scale 2,4-D treatments during 2011 through 2016 reduced EWM extent in Long Lake (Mahtomedi and Pine Springs, MN) from 52 acres in June 2010 to 0.3 acres in June 2016 (Barr 2022c). A large-scale Triclopyr treatment in spring of 2008 reduced EWM in Kohlman Lake (Maplewood, MN) from a pre-treatment 47 percent frequency of occurrence in April 2008 to not observed in the lake during the post-treatment June and August 2008 plant surveys (Barr 2009). A Half Moon Lake ProcellaCOR treatment of 13.71 acres on August 1, 2022 reduced EWM to a single location of about 0.4 acres within the treated areas per a post-treatment plant survey and bed-mapping survey completed on September 18, 2022 (Barr 2022b).

Curly-leaf pondweed (CLP) has been effectively managed with herbicide treatments. After a partial drawdown followed by herbicide treatment in the areas not included in the drawdown CLP was not observed in Northwest Anderson Lake (Eden Prairie, MN) and Southwest Anderson Lake (Eden Prairie, MN). Southwest Anderson Lake was treated with endothall during 2010 to 2011 (Barr 2011a and Barr 2011b). CLP was not observed in Southwest Anderson Lake during April, June, and August 2012 point intercept plant surveys (Barr 2011a and Barr 2011b). Northwest Anderson Lake was treated with endothall during 2009 to 2013 (Barr 2014). CLP was not observed in Northwest Anderson Lake during an April 2014 point intercept plant survey (Barr 2014).

Use of the herbicides 2,4-D and Triclopyr are feasible for large-scale EWM treatments and use of the herbicides ProcellaCOR, Diquat (Reward), and diquat plus endothall (Aquastrike) are feasible for small-scale EWM treatments in Half Moon Lake. Use of systemic herbicides (2,4-D, Triclopyr, and ProcellaCOR) are preferable because systemic herbicides kill the entire plant (roots and shoots). Use of endothall is feasible for large-scale curly-leaf pondweed treatments and use of either diquat or diquat plus endothall (Aquastrike) is feasible for small scale curly-leaf pondweed treatments. Use of glyphosate is feasible for yellow iris treatments.

1.4 Biological

Biological control involves the use of a biological control agent to control aquatic plant growth. Biological controls include predation by herbivorous fish, mammals, waterfowl, insects and other invertebrates, diseases caused by microorganisms and competition from other aquatic plants (Little, 1968). The most widely used biological control agent is herbivorous fish, particularly grass carp. Use of grass carp as a biological control agent is not allowed in Wisconsin. Weevils have been used experimentally to control EWM (Creed, et al., 1995; Newman, et al., 1995; Newman 1999).

During 1997, the WDNR completed a milfoil weevil project in Beaver Dam Lake (Cumberland, WI). During late June and early July 1997, weevil eggs and larvae were stocked in three plots in Library Lake. Stocking was done by tying small bundles of EWM containing the eggs and larvae onto existing milfoil plants in the plots. Approximately 5 weeks post-stocking, weevil density was measured again among the plots. Weevil densities were also measured a full year post stocking in June and August 1998. A survey completed just prior to stocking in June of 1997 indicated milfoil weevils in Beaver Dam Lake occurred at an average density of 1.3 weevils per plant. Stocking occurred to increase weevil density to 2 weevils per plant. August 1997 survey results indicated weevil density had declined to 0.1 weevils per plant. Densities observed in 1998 were 0.4 weevils per plant in June and 0.5 weevils per plant in August. Despite the reductions in density noted during the project, surveys of Eurasian watermilfoil during the study indicated considerable weevil damage occurred in the top few inches of the plants. The damage did not allow the plants to flower. However, weevil damage was usually confined to the upper portions of the plant and did not cause the milfoil to "crash" in the water column and sink out of site. In fact, the lower portions of the plants often appeared healthy. Study results indicated a significant increase in percent of Eurasian watermilfoil plants noting broken tips occurred following milfoil weevil stocking (Jester et al. 1999).

During 1999, a survey was completed to determine portions of Beaver Dam Lake containing the milfoil weevil or exhibiting weevil damage to Eurasian watermilfoil plants. A total of 11 sites were surveyed in the western basin and 3 sites were surveyed in the eastern basin. Survey results indicated the milfoil weevil was present in 7 of 11 western basin sites (64 percent) and 1 of 3 eastern basin sites (33 percent). The survey confirmed the milfoil weevil was present throughout Beaver Dam Lake and was causing damage to Eurasian watermilfoil plants throughout the lake. Both the milfoil weevil and Eurasian watermilfoil were more prevalent in the western basin than the eastern basin of the lake (Barr 2000).

During 2005, a survey was completed to determine whether the milfoil weevil was present in Beaver Dam Lake. A total of 15 sites were surveyed and a total of 86 EWM stems were examined (Barr 2006). The results indicated none of the stems contained weevils (i.e., adult, larvae, or eggs). A total of 6 stems (7 percent) noted meristem damage (i.e., damage to the tips of EWM plants which is the location of damage inflicted by weevils). All of the damaged meristems were collected from the western basin. Hence, none of the stems collected from the eastern basin were damaged. The plants were also evaluated to determine whether any of them contained Lepidoptera caterpillar because it also damages EWM stems. None of the plants contained Lepidoptera caterpillar. A total of 80 stems (93 percent) were undamaged and did not contain either weevils or Lepidoptera (Barr, 2006). The data indicate very little biological control of EWM was occurring within the western basin and no biological control was occurring within the eastern basin.

The results of the Beaver Dam Lake weevil study indicate weevils are an ineffective method of managing EWM. For this reason, introduction of weevils to Half Moon Lake is not a feasible EWM management alternative.

2.0 Cost Summary

Mechanical/manual removal, physical, and chemical aquatic plant control techniques and estimated costs are summarized in Table I-1. The costs are dated (i.e., based upon 1997 dollars), but provide a relative cost comparison between the various techniques.

Table 1 Control Techniques for Aquatic Plants: Procedure, Cost, Advantages and Disadvantages (Modified from a Summary Prepared by the Vermont DNR in 1997)

Control Technique	Procedure	Cost	Advantages	Disadvantages
Mechanical and Physical Removal			+Immediate plant removal and creation of open water +No interference with water supplies or water-use	-– Creates plant fragments – Usually disturbs sediments, affecting biota and causing short-term turbidity – Plant disposal necessary
Harvesting	Plant stems and leaves cut up to 8 ft below water surface, collected and removed from lake	Cut from 1 to 2 ac/day @ $1,200/day New machine: $80,000-100,000+	+Relatively low operational cost	– Can get regrowth within 4 weeks – Removes small fish, turtles, etc. – Plant fragments may cause spread of Eurasian watermilfoil
Hydro-raking	Mechanical rake removes plants up to 14 ft below water surface and deposits them on shore	Rake up to 1 ac/day @ $1,500–$2,000/ac	+Longer lasting control than harvesting because of root removal	– Regrowth by end of growing season
Rotovating	Sediment is "tilled" to a depth of 4"-6" to dislodge plant roots and stems Can work in depths up to 17 ft	Can do up to 2-3 ac/day @$700–$1,200/ac Cost of new machine is $100,000+	+Immediate 85% – 95% decrease in stem density +Up to 2 years control +Frequently done in fall when plant fragments not viable	
Hydraulic Dredging	Steel cutter blade dislodges sediment and plants; removed by a suction pump	$2,500/ac and up Cost of new machine is $100,000+	+90% effective at root removal, with plant regrowth probable within 1 year	– Expensive

Table 1 Control Techniques for Aquatic Plants: Procedure, Cost, Advantages and Disadvantages (Modified from a Summary Prepared by the Vermont DNR in 1997)

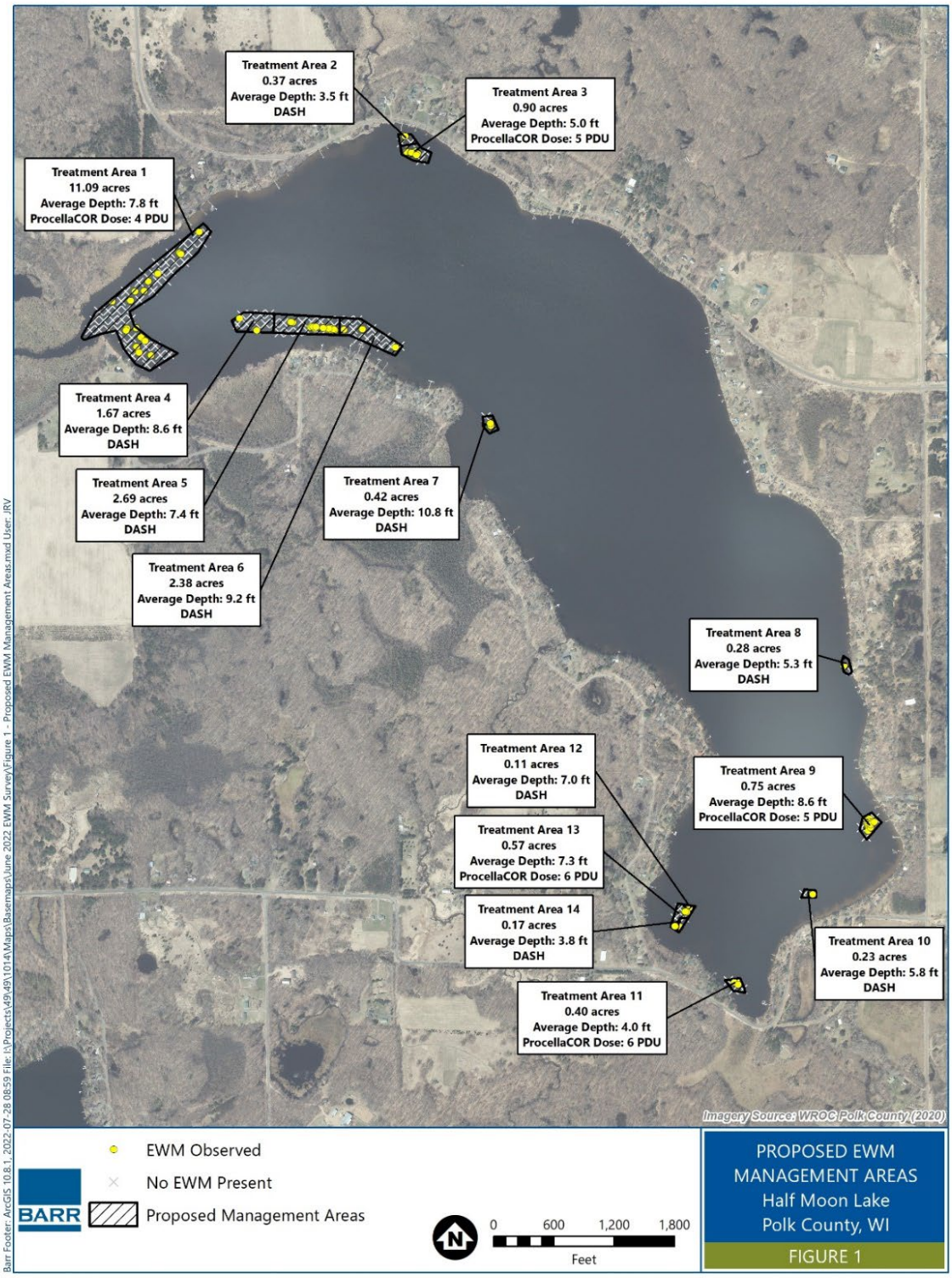
Control Technique	Procedure	Cost	Advantages	Disadvantages
Diver-operated Suction Harvesting	Scuba divers use 4" suction hose to selectively remove plants from lake bottom Plants disposed of on shore	Cost is $800–$10,000/ac depending on cost of divers, type of sediments, travel time, etc. Cost of new machine $20,000+	+Up to 97% effective at removing plant roots and stems +1–2 years of control +Can work in areas with underwater obstruction	– Effectiveness varies greatly with type of sediment – Slow and labor intensive – Expensive – Potentially hazardous because of scuba
Handpulling	Plants and roots are removed by hand using snorkeling and wading Plants disposed of on shore	Variable, depending on volunteers; divers cost $15-$60/hr	+Most effective on newly established populations of EWM that are scattered in density +Volunteers can keep cost down +Long term control if roots removed	– Too slow and labor intensive to use on large scale – Short-term turbidity makes it difficult to see remaining plants
Chemical Treatment			+ Doesn't interfere with underwater obstructions	– Affects water-use; can be toxic to biota – Plants remain in lake and decompose, which can cause oxygen depletion late in the season
2,4-D (Aquakleen, Aquacide, Navigate)	Systemic herbicide available in liquid and pellet form that kills plants by interfering with cell growth and division Can be applied at surface or subsurface in early spring as soon as plants start to grow, or later in the season	$350–$700/ac depending on plant density and water depth; cost does not include collection or analysis of water samples, which may be required	+Under favorable conditions can see up to 100% decrease +Kills roots and root crowns +Fairly selective for EWM	– Plants decompose over 2-3 weeks

Table 1 Control Techniques for Aquatic Plants: Procedure, Cost, Advantages and Disadvantages (Modified from a Summary Prepared by the Vermont DNR in 1997)

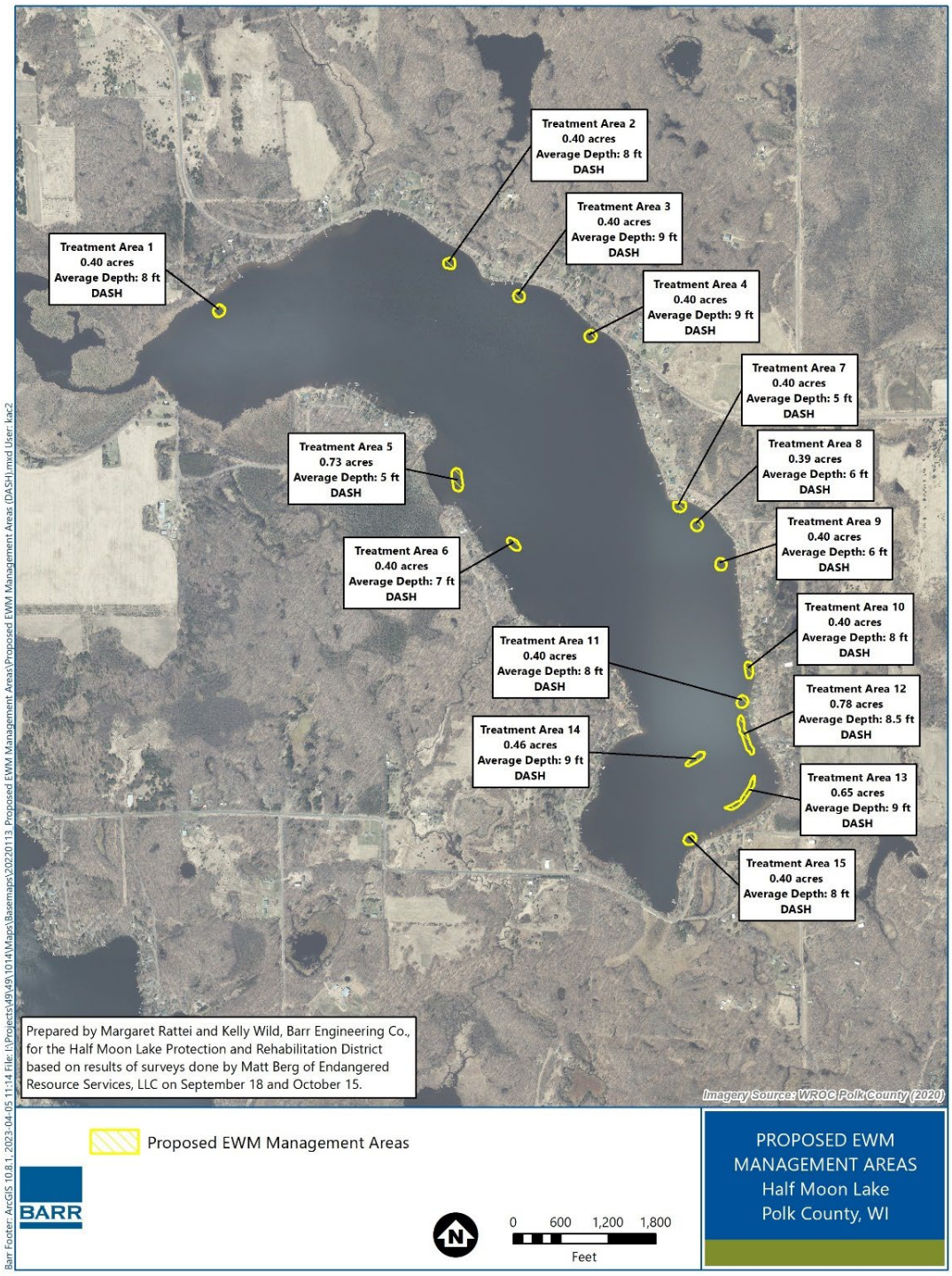
Control Technique	Procedure	Cost	Advantages	Disadvantages
Tripclopyr (Garlon 3A)	Liquid systemic herbicide that kills plants by interfering with hormones that regulate normal plant growth	$75/gal or $1200-$1700/ac, depending on water depth, concentration of chemical, etc.	+Effectively removes up to 99% of EWM biomass 4 weeks after treatment +Fast-acting herbicide +Kills roots and root crowns +Fairly selective for EWM	– No domestic-use of water within 1 mile of treated area for 21 days after treatment – No fishing in treated area for 30 days after treatment – Expensive
Fluridone (Sonar)	Systemic herbicide available in liquid and pellet form that inhibits a susceptible plant's ability to make food Can be applied to surface or subsurface in early spring as soon as plants start to grow	$500-$1500/ac depending on water depth and formulation	+Can be applied near water intakes if concentration is less than 20 ppb +Under favorable conditions susceptible species may decrease 100% after 6-10 weeks +Control lasts 1-2 years depending supplemental hand removal +Because slow-acting, low oxygen generally not a problem	– Long contact time required; may take up to 3 months to work – Potential risk to human health remains controversial – Not selective for milfoil – Spot treatments generally not effective
Endothal (Aquathol and Aquathol K)	Granular (Aquathol) and liquid (Aquathol K) kills plants on contact by interfering with protein synthesis Can be applied to surface or subsurface when water temperature is at least 65°F	$300-$700/ac depending on treatment area and use of adjuvants	+Under favorable conditions can see up to 100% decrease +Fast-acting herbicide	– Regrowth within 30 days – Not selective for milfoil – Does not kill roots; only leaves and stems that it contacts – No swimming for 24 h, no fishing for 3 days
Diquat (Reward)	Liquid kills plants on contact by interfering with photosynthesis Can be applied to surface or subsurface when water temperature is at least 65°F	$200-$500/ac	+Fast-acting herbicide +Relatively cheap per acre	– Retreatment within same season may be necessary – Not selective for milfoil – Does not kill roots; only leaves and stems that it contacts – No swimming for 24 h, no drinking for 14 days – Toxic to wildlife

Appendix I

2022-2023 Half Moon Lake EWM Management Plans



2022 EWM Management Plan: ProcellaCOR Treatment and DASH Removal



2023 EWM Management Plan: DASH Removal

Note: Although DASH removal was intended for all areas shown on the map, DASH removal only occurred in Treatment Areas 1-2 and 11-15 in 2023. Because DASH removal in these areas was ineffective, no further DASH removal occurred in 2023.