GEI Consultants

Comprehensive Planning – Phase 1

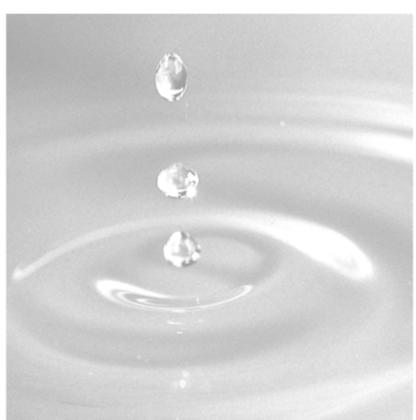
2025 Little Lake Butte des Morts Aquatic Plant Management Strategy - DRAFT

Little Lake Butte des Morts, Winnebago County, Wisconsin

Submitted to:
City of Neenah
211 Walnut Street
Neenah, WI 54956

Submitted by:
GEI Consultants, Inc.
3159 Voyager Drive
Green Bay, WI 54311
920.455.8200

February 10, 2025
Project No. 2403578



Korin M Doering, CLM
Project Manager – Aquatic Ecology

Brian Majka
Senior Restoration Ecologist

Table of Contents

List of Figures:

List of Tables:

Appendices

KD/BM:amp B:\Working\NEENAH, CITY OF\2403578 LLBDM Management\06_In_Progress\4a_Aquatic Plant Management Plan\LLBDM_APM Strategy_DRAFT_FOR PUBLIC REVIEW_v2.docx

Record of Approvals and Revisions

Record of approvals and revisions are listed in the table below. Approval letter(s) from the Wisconsin Department of Natural Resources will be added as Appendix E once the plan is approved and finalized.

Name	**Title**	**Agency / Org**	**Date**	**Approval or Revision**	**Attachment** *(if applicable)*
Korin Doering	Project Manager	GEI Consultants	02/07/2025	Final draft for public review	

Acronyms and Abbreviations

ADA	Americans with Disabilities Act
AIS	Aquatic Invasive Species
AOI	Areas of Influence
APM	Aquatic Plant Management
ARTS	Agricultural Runoff Treatment Systems
BMP	Best Management Practices
cfs	Cubic Feet Per Second
Chl-a	Chlorophyll a
CBCW	Clean Boats, Clean Waters
CLM	Certified Lake Management
CLMN	Citizen Lake Monitoring Network
CLP	Curly-leaf pondweed
CWA	Clean Water Act
DATCP	Department of Agriculture, Trade and Consumer Protection
DASH	Diver Assisted Suction Harvesting
DO	Dissolved Oxygen
eDNA	Environmental DNA
EDRR	Early Detection and Rapid Response
EPA	Environmental Protection Agency
EWM	Eurasian Water Milfoil
FOO	Frequency of Occurrence
FQI	Floristic Quality Index
FWWA	Fox-Wolf Watershed Alliance
FRNSA	Fox River Navigational System Authority
GEI	GEI Consultants, Inc.
GP	General Public
HAB	Harmful Algal Bloom
IPM	Integrated Pest Management
LFR	Lower Fox River
LLBDM	Little Lake Butte des Morts Leadership Team
LME	Lead Management Entity
LMPN	Lake Monitoring & Protection Network
LWCD	Land & Water Conservation Department
MSL	Mean Sea Level
NEWLT	Northeast Wisconsin Land Trust
PCALR	Polk County Association of Lakes
PFD	Personal Floatation Device
pH	Potential of Hydrogen
PI	Point Intercept
PL	Purple Loosestrife

QAQC	Quality Assurance and Quality Control
RBF	Recreational Boating Facilities
SCUBA	Self-Contained Underwater Breathing Apparatus
SDI	Simpson Diversity Index
SPO	Shoreline Property Owners
SWGP	Surface Water Grant Program
SWIMS	Surface Water Information Management System
SWTP	Southeastern Wisconsin Till Planes
TP	Total Phosphorus
TSI	Trophic State Index
USACE	United States Army Corps of Engineers
UWGB	University Wisconsin Green Bay
WisCALM	Wisconsin Consolidated Assessment and Listing Methodology
WDNR	Wisconsin Department of Natural Resources

Funding & Support

This project was made possible thanks to the vision of the Little Lake Butte des Morts Leadership Team, guidance from the Support Team, and funding from multiple organizations.

The Little Lake (LLBDM) Leadership Team includes representatives from the City of Neenah, Village of Fox Crossing, and City of Menasha. The Leadership Team was advised by the Support Team which includes representatives from Winnebago County Land & Water Conservation Department (LWCD), Fox-Wolf Watershed Alliance (FWWA), GEI Consultants (GEI) and the Wisconsin Department of Natural Resources (WDNR).

Funding was provided through the WDNR Surface Water Grant Program, Fund for Lake Michigan, City of Neenah Parks Department, City of Menasha, Village of Fox Crossing, Future Neenah, and the Community Foundation of the Fox Cities. In-kind donations were provided by all representatives of the LLBDM Leadership Team as well as Winnebago County LWCD, FWWA, GEI, and WDNR.

Executive Summary

This project was initiated to address the overgrowth of aquatic plants in Little Lake Butte des Morts (LLBDM), a 1,234-acre body of water bordered by the Village of Fox Crossing, City of Menasha and City of Neenah in Winnebago County, Wisconsin. The leadership and funding for this initiative were provided by a coalition of local governments and organizations, including the City of Neenah, Village of Fox Crossing, City of Menasha, Winnebago County Land & Water Conservation Department (LWCD), Fox-Wolf Watershed Alliance (FWWA), GEI Consultants (GEI), and the Wisconsin Department of Natural Resources (WDNR).

In 2023, the City of Neenah's Parks and Recreation Department recognized the need to improve recreational access in parts of the lake hindered by aquatic plant overgrowth, particularly near Arrowhead Park and Herb and Dolly Smith Park. Initial plans to use mechanical harvesting for managing aquatic plants required a study of the lake to obtain necessary permits from the WDNR. This realization led to a collaborative effort with neighboring municipalities and various support teams to develop an aquatic plant management (APM) strategy.

The purpose of the APM strategy is to provide a collaborative framework for informing stakeholders on options to address aquatic plant issues in LLBDM, enhance navigation and recreation, and protect the lake ecosystem, benefiting all three communities. This strategy includes:

- Review of baseline conditions
- Stakeholder engagement and feedback
- Evaluation of potential management approaches
- Potential funding sources for future work
- Recommended actions for next steps

The development of this strategy was made possible through grant funding, financial contributions from involved municipalities, and in-kind support from multiple partners. The process involved defining the problem, identifying its causes, and characterizing the lake's conditions.

Key recommendations include:

1. Form a lake organization to lead aquatic plant management efforts for LLBDM including implementation of this strategy.
2. Implement the City of Neenah's Harvesting Pilot Project (Appendix A) for LLBDM to evaluate feasibility and efficacy of harvesting while improving public access and recreation and protecting important habitat.
3. Develop a whole-lake APM plan by building upon this document to meet stakeholder needs and satisfy WDNR requirements.
4. Implement the APM plan to manage nuisance aquatic plant growth in targeted areas to improve navigation and recreation while protecting important habitat and water quality.
5. Prevent new introductions of aquatic invasive species and detect and report new introductions early.

6. Develop and implement an education strategy to increase understanding of lake ecology, invasive species prevention and identification, and aquatic plant management among lake residents and lake users.
7. Develop and implement monitoring programs for aquatic plants, aquatic invasive species, and water quality to track ecosystem health and identify new issues early.
8. Adopt an adaptive management approach.
9. Develop and implement a pilot project for the City of Menasha.

1. INTRODUCTION

1.1. Purpose of the Strategy

The purpose of this aquatic plant management (APM) strategy is to provide a framework for stakeholders to take a collaborative approach to addressing aquatic plant issues in Little Lake Butte des Morts (LLBDM). LLBDM is a 1,234-acre body of water bordered by the Village of Fox Crossing, City of Neenah, and City of Menasha in Winnebago County, Wisconsin (Figure 1-1).

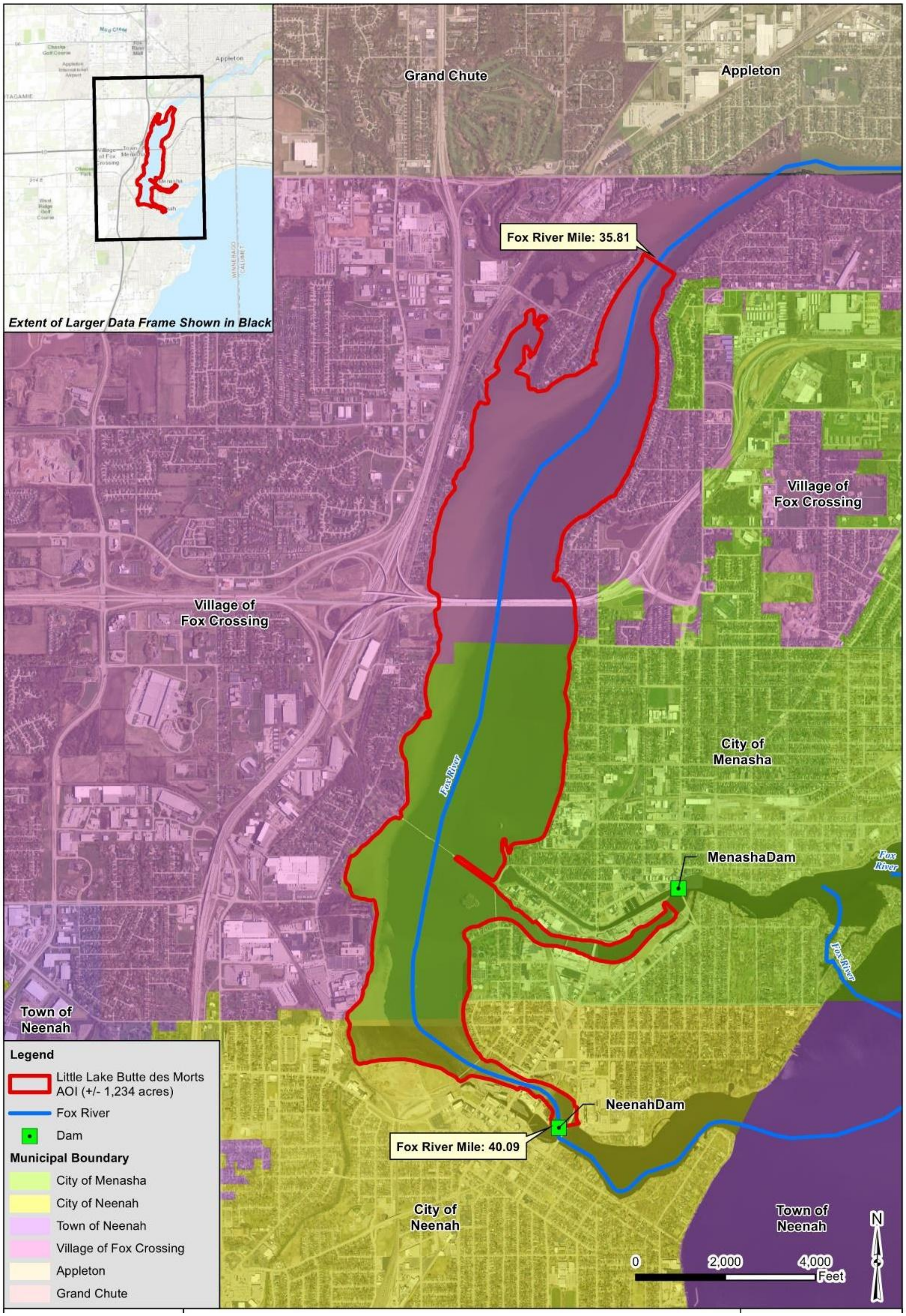
In 2023, the City of Neenah Parks and Recreation Department identified the need to improve recreational access in the area of the lake near Arrowhead Park and Herb and Dolly Smith Park. An overgrowth of aquatic plants had been preventing kayakers, boaters, and swimmers from using the lake near those public spaces and lake access points. Their initial idea was to periodically use a mechanical harvester to cut lanes through the vegetation during the summer months. However, this type of management requires a Wisconsin Department of Natural Resources (WDNR) permit and to obtain a permit the whole lake needed to be studied to inform a harvesting plan. Studying a lake the size of LLBDM is a significant undertaking.

Aquatic plant overgrowth has been impairing lake recreation, well beyond the City of Neenah's municipal boundary. The City of Neenah, motivated to improve public access and use near their parks, recognized an opportunity and extended an invitation to their neighboring municipalities, the Village of Fox Crossing and City of Menasha, to collaborate on a project that would benefit all three communities. With the help of Fox-Wolf Watershed Alliance (FWWA) and GEI Consultants, Inc. (GEI), the municipalities came together to develop this APM strategy that explores options for managing nuisance aquatic plant growth to improve navigation and recreation while protecting the lake ecosystem. In 2024, grant funding combined with financial contributions from each municipality, other community groups, and in-kind support from multiple partners helped make this strategy a reality.

This strategy includes a review of baseline conditions, stakeholder engagement and feedback, an evaluation of potential management approaches, potential funding sources for future work, and recommended actions for next steps. The process for developing this strategy included the following steps:

1. Defining the problem
2. Identifying the sources or causes of the problem
3. Studying and characterizing the lake
4. Engaging stakeholders to inform goals and objectives
5. Evaluating potential management approaches (alternatives)
6. Assessing lake management leadership and capacity
7. Identifying potential funding sources for future work
8. Developing recommendations for next steps (implementation strategy)

Figure 1-1. Map of Little Lake Butte des Morts



To evolve this strategy into an APM plan and administer management efforts, a lead management entity (LME) will need to be identified or formed. This need could be met through the formation of a lake organization such as an association or district. An APM plan, approved by the WDNR, will be required to implement lake-wide integrated pest management, obtain certain aquatic plant management permits, and meet eligibility requirements of key grant funding programs.

1.2. Summary of Key Issues and Challenges

LLBDM faces several issues because of the lake's location, the shape and size of the lake, and the land use in the watersheds that drain to the lake.

Themes that emerged from stakeholder input include:

- **Water Quality Concerns**: Many stakeholders expressed concerns about the declining water quality, citing increased algae, weeds (aquatic plants), and garbage, which have diminished the enjoyment of the lake.
- **Weed Infestation**: Residents noted a significant increase in aquatic plant growth, making it difficult for boating and other recreational activities.
- **Impact on Property Values**: Concerns were raised that the decline in water quality and the closure of the Menasha lock have negatively impacted property values and the overall enjoyment of their properties.
- **Lock System and Access**: Several stakeholders have expressed frustration over the closure of the Menasha locks, which prevents boats from navigating from LLBDM to Lake Winnebago and affects the overall use of the lake.
- **High Water Levels**: High water levels are a recurring concern, with suggestions for implementing no-wake zones during such periods to prevent shoreline erosion and property damage.
- **Aquatic Invasive Species (AIS)**: Respondents are worried about the presence of aquatic invasive species like zebra mussels and carp, which affect water quality, recreational activities, and the overall ecosystem of the lake.

The top three issues of concern as identified by stakeholders are:

1. Algae blooms
2. Excessive aquatic plant growth
3. Poor water quality

Nuisance level aquatic plant growth negatively impacts recreational activities such as boating, swimming, wildlife viewing, fishing, and use of the trails. When plant growth is excessive, these activities may not be possible. Overgrowth of aquatic plants chokes out boat motors and wraps around propellors, making boating impossible in some high use areas.

There are several factors that make aquatic plant management (APM) in LLBDM challenging, such as:

- A lead management entity does not currently exist, so there is no central organization to coordinate or fund lake improvement efforts.

- There are multiple sources of nutrient and sediment pollution that enter the lake from a large area of land (large drainage basin) which feeds aquatic plant and algal growth.
- There are many different stakeholder groups with varied interests to consider.
- Contentious topics such as management of water levels and the closure of the Menasha Lock can also make it challenging for stakeholders to reach a consensus on action items.

If short-term relief from nuisance level growth of aquatic plants is achieved, long-term ongoing management will still be needed to maintain improvements and protect the lake against future threats such as new introductions of invasive species, new sources of or increases in pollution, and a changing climate. Warmer temperatures, shorter periods of ice cover, and increases in the severity and frequency of storm events will likely provide conditions favorable to invasive species and further fuel aquatic plant overgrowth.

1.3. Recommended Goals and Actions

Shoreline property owners and the general public have expressed support for efforts to address priority concerns. There is a strong desire among residents for regular maintenance, including aquatic plant management, to improve the lake's condition. The goals, objectives, and recommended actions included in Chapter 8 of this strategy were informed by stakeholder input collected during public meetings, surveys, one-on-one meetings, and a public comment period. Key recommendations include:

1. Form a lake organization to lead aquatic plant management efforts for LLBDM including implementation of this strategy.
2. Implement the City of Neenah's Harvesting Pilot Project (Appendix A) for LLBDM to evaluate feasibility and efficacy of harvesting while improving public access and recreation and protecting important habitat.
3. Develop a whole-lake APM plan by building upon this document to meet stakeholder needs and satisfy WDNR requirements.
4. Implement the APM plan to manage nuisance aquatic plant growth in targeted areas to improve navigation and recreation while protecting important habitat and water quality.
5. Prevent new introductions of aquatic invasive species and detect and report new introductions early.
6. Develop and implement an education strategy to increase understanding of lake ecology, invasive species prevention and identification, and aquatic plant management among lake residents and lake users.
7. Develop and implement monitoring programs for aquatic plants, aquatic invasive species, and water quality to track ecosystem health and identify new issues early.
8. Adopt an adaptive management approach.
9. Develop and implement a pilot project for the City of Menasha.

This 2025 LLBDM APM Strategy is focused on addressing excessive aquatic plant growth while protecting habitat quality. It provides core elements for stakeholders to build from for the future development of a whole-lake APM plan for LLBDM. To address the full scope of issues and challenges facing LLBDM, a comprehensive lake management plan would be needed [1].

2. PUBLIC INPUT

Providing valuable insights and diverse perspectives, stakeholder input is critical when developing an APM strategy. For LLBDM, stakeholders include shoreline property owners, conservation groups, recreational users, industry, government agencies, and members of the broader community. Incorporating stakeholder feedback results in a balanced approach for addressing the needs and concerns of the community while promoting the ecological health of the lake and supporting recreational and economic interests.

Development of this strategy was driven by the LLBDM Leadership Team, which includes representatives from the Village of Fox Crossing, City of Neenah, and City of Menasha. The Leadership Team was advised by the Support Team which includes representatives from the Winnebago County LWCD, FWWA, GEI[1] and WDNR. LLBDM leadership team meetings were held monthly beginning in May 2024.

Input gathered from stakeholders is included throughout this strategy. Detailed reports of each engagement effort are provided in **Appendix C**.

PUBLIC MEETING #1 – JULY 2024

The LLBDM Leadership Team held their first public meeting on July 18, 2024, at the Neenah Public Library. Approximately 150 people were in attendance. During the meeting, the LLBDM Leadership Team provided attendees with background information on the project and what to expect moving forward. The meeting also included a public input session and stakeholder mapping exercise. During the mapping exercise, attendees were provided a paper map, colored pencils, and a list of questions. They were then asked to answer the questions by drawing on the map and writing in comments using specific colors. The majority of attendees supported moving forward with the development of an APM strategy for LLBDM. Input gathered from the map exercise and public input session were used to inform the development of this strategy. A complete summary of the public meeting is provided in **Appendix C.2**.

Figure 2-1. Public Meeting #1 held on July 18, 2024.

[1] GEI and FWWA were hired to facilitate stakeholder engagement, complete field investigations, develop the APM strategy, and create the City of Neenah's Harvesting Plan.

STAKEHOLDER SURVEYS

In July 2024, following the first public meeting, two stakeholder surveys were conducted as part of the LLBDM planning process. The survey was designed to measure stakeholders' awareness of lake-related issues, enhance understanding of their perceptions and usage of the lake, and gather feedback on possible support for various management strategies. The surveys addressed several topics such as invasive species, aquatic plant management, lake use and recreation, shoreline property management, and leadership in lake management. The surveys also aimed to identify potential topics for future outreach and education efforts.

The surveys were directed at two different stakeholder groups. The primary group was shoreline property owners (SPO) and the secondary group, intended to capture a broader audience of lake users, was the general public (GP). Following the first public meeting, two online stakeholder surveys were made available. The surveys were advertised through social media, direct mailing to shoreline property owners, and during the first public meeting. The surveys opened on July 18th, 2024, and closed on August 21, 2024. Physical surveys were available upon request.

For the GP survey, 298 submissions were initially received. After QAQC review, 291 survey submissions were included in the data analysis with a 59% completion rate. For the SPO survey, 366 properties were mailed survey invitations. In response, 160 survey submissions were received. After QAQC review, 150 survey submissions were included in the data analysis, resulting in a 41% response rate with a 93% completion rate[2]. Highlights from survey responses include:

- **Visitation and Usage**: Most respondents have been visiting the lake for over 26 years, with frequent visits for recreational activities like boating, fishing, and birdwatching.
- **Property Ownership and Use**: The majority of shoreline properties are used as year-round residential properties.
- **Water Quality Concerns**: Respondents highlighted declining water quality due to algae blooms, which negatively impact recreational activities and property values.
- **Lock Closure Impact**: Respondents reported that the closure of the Menasha lock has restricted access to Lake Winnebago, affecting property values and the overall enjoyment of the lake.
- **Weed Management**: Recreational activities such as fishing, boating, and walking the trail system are popular and have been negatively affected by aquatic plant overgrowth. There is strong support for various methods to manage aquatic plants, including mechanical harvesting and biological controls.
- **Support for Lake Management**: Residents are concerned with aquatic weeds, geese, and invasive plants, and expressed a need for more guidance on better management practices. There is significant support for forming a lake association and for more formal collaboration among local municipalities to manage the lake effectively.

[2] *Completion rate is the percentage of people that started and completed the entire survey.*

Additional results from the surveys are included throughout this strategy. A detailed report of the stakeholder surveys is provided as **Appendix C.1**.

PUBLIC MEETING #2

The LLBDM Leadership Team held a second public meeting on February XX, 2025, at XX. The public meeting included stakeholder survey results overview, aquatic plant management plan overview, and a public input session. A copy of the public comments is provided as ***Appendix C.3****.*

This section will be completed after the public meeting is held in 2025.

PUBLIC NOTICE AND COMMENT

The final opportunity for stakeholders to provide their input on the plan took place in early 2025. The draft aquatic plant management plan was made available online for public review and comment. Comments and questions could be submitted through an online form, by email, or through the mail. The public comment period lasted XX weeks, closing on XX, 2025. Comments received were documented and considered for revisions to the plan. A copy of the public comments is provided as ***Appendix C.4****.*

This section will be completed after the public notice period closes in 2025.

3. LAKE CHARACTERIZATION

LLBDM[3] is approximately 1,234 acres in size and has a shoreline of 12.83 miles. The lake is part of the Lower Fox River (LFR)[4]. It begins at the outfall of Lake Winnebago at the Neenah and Menasha dams and extends downstream to the north end of Stroebe Island[5] [3].

3.1. Lake Classification

LLBDM is classified as a **shallow lowland, drainage lake** according to Wisconsin's Natural Community Determination [1]. A shallow lowland natural community is defined as being a lake of 10 acres or greater, mixed stratification, and lowland drainage.

Lake depth is an important physical characteristic that influences water clarity, temperature, chemistry, and more. LLBDM is **shallow** compared to its surface area. According to the WDNR, LLBDM has a maximum depth of 18 feet. However, water depths frequently fluctuate due to weather and changes in the outflows of the Neenah and Menasha Dams (Figure 1-1). For example, during the 2024 aquatic plant surveys, LLBDM had a maximum measured depth of 23.0 feet which is five feet deeper than what is listed on the WDNR website. The average water depth measured during the surveys was 7.23 feet. Water level fluctuations (timing and severity) affect a lake's water quality by impacting nutrient cycling, light availability, erosion, and water temperature.

The Menasha Dam is regulated by the United States Army Corps of Engineers (USACE). The Neenah Dam is owned by Neenah Paper and is regulated by the WDNR. Neenah Paper adjusts the gates on their dam in coordination with the USACE.

Water levels in Lake Winnebago[6], which drains to LLBDM, are regulated by the USACE under Federal Marshall Order 1886. The USACE regulates outflow of the dams for flood risk mitigation and, in the summer, recreational navigation on Lake Winnebago. Each of the dams receives approximately 50% of the discharge capacity from Lake Winnebago into LLBDM. Flow through LLBDM is generally restricted by USACE to 12,000 cubic feet per second (cfs) due to the shoreline erosion and flooding impacts that high water flow can have at the ThedaCare Hospital and where LLBDM narrows near Stroebe Island [4]. However, during extreme events, this discharge rate may be exceeded to prevent Lake Winnebago from flooding[7]. During most of the year, water level changes due to dam operations are subtle and may range between 0.01- and 0.03-foot fluctuations [4]. Water level fluctuations within LLBDM have and continue to impact riparian landowners, indicating that the lake may benefit from a LLBDM specific water level management plan developed in collaboration with the USACE [5].

---

[3] WDNR WBIC: 129800

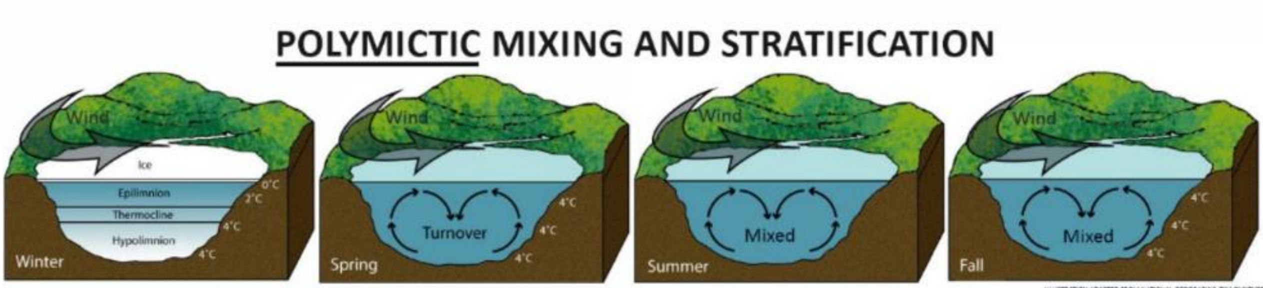
[4] Because LLBDM overlaps geographically with a portion of the Lower Fox River, the same stretch of water is identified and documented under two different waterbody names and sets of identification codes within WDNR databases. This is important to note for documenting and communicating impairments, monitoring data, and prescribing management actions.

[5] The southern boundary of LLBDM starts at Fox River mile 40.09 and ends approximately at Fox River mile 35.81 [2].

[6] Water level management of the Winnebago Waterways is further described in the 2019 Water Level Management Report as a part of the Winnebago Waterways Lake Management Plan [4].

[7] Utilization of 100% gate capacity of the dams is rare.

Figure 3-1. Stratification and Mixing in Polymictic Lakes



The layers that develop when a lake stratifies are called the epilimnion, metalimnion, and hypolimnion. LLBDM is a polymictic lake that follows the stratification pattern shown along the bottom of the figure. The lake only stratifies and forms layers during the winter when ice forms on the surface.
Source: Fox-Wolf Watershed Alliance. Illustration adapted originally from National Geographic.

LLBDM is a **polymictic** lake. In most lakes, differences in water temperature creates layers, a process called thermal stratification. As water temperature varies by depth it affects water density and mixing action. Shallow lakes that are less than 20 to 30 feet in depth with large surface areas, such as LLBDM, can remain completely mixed throughout the entire open water season [6]. Temperatures within the water column remain relatively constant from surface to bottom except for the winter when the surface freezes. The rest of the year, the lake does not stratify – it stays mixed due to the river flow, wind and waves. Mixed lakes may become oxygen depleted during the winter when ice and snow cover the lake surface, inhibiting photosynthesis [7]. When dissolved oxygen is too low, it can lead to a significant loss of aquatic life such as a fish kill [18]. This can also happen as water warms and decomposition in the lake exceeds production during calm periods where there is little wind or wave action.

LLBDM is a **lowland, drainage lake**. **Drainage** refers to a lake's hydrology. Water enters the lake primarily from streams and rivers [8]. Additional sources of water to LLBDM include surface water runoff, precipitation, and groundwater. Water leaves the lake by flowing through the river and evaporation. The source of a lake's water supply has significant influence on the condition of the lake.

Lowland refers to a lake's position in the landscape [6]. LLBDM sits low in the landscape and receives water from water from the surrounding watersheds and larger drainage basin. Water quality can be greatly impacted by nutrient and sediment pollution from the land [21].

3.2. Water Level Fluctuations

Depth is an important consideration for APM, especially when defining lanes for mechanical harvesting. A minimum of 3.0 feet of water depth is needed to operate without disturbing the lakebed. Depending on the size and specifications of the harvesting equipment used, the actual depth required to operate effectively may be deeper than 3.0 feet.

According to the WDNR website, LLBDM has a maximum depth of 18 feet [9]. However, water depths fluctuate daily, seasonally, and annually due to weather and outflows of the Neenah and Menasha Dams[8]. During the 2024 aquatic plant survey, LLBDM had a maximum measured depth of 23.0 feet and

[8] USACE regulates the outflows of the Menasha Dam and influences decisions for outflows of the Neenah Dam.

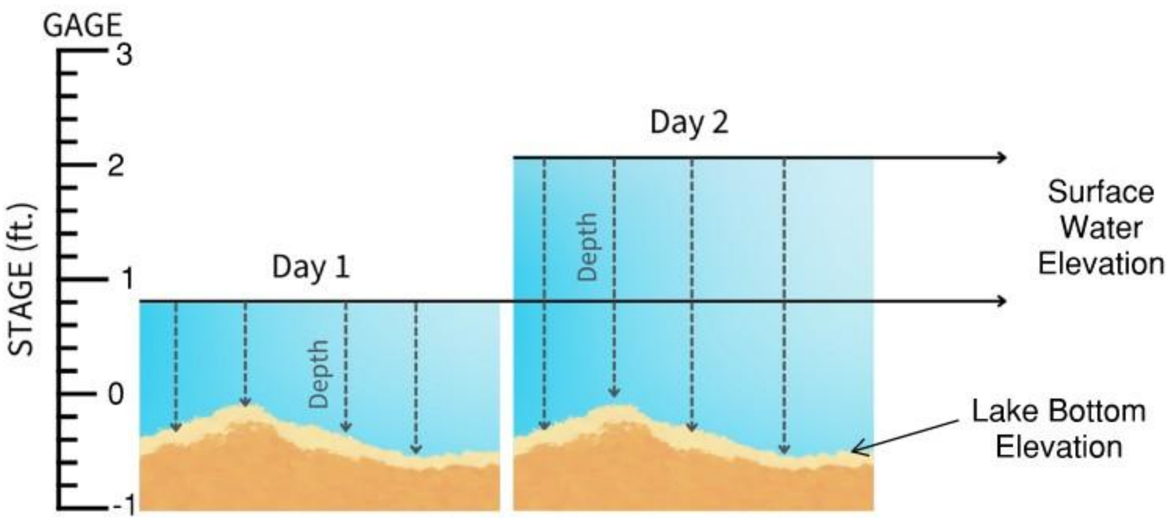
an average water depth of 7.23 feet[9]. The maximum depth measured during that survey was deeper than the WDNR's listing of 18 feet. This is an example of how much water depths can fluctuate in LLBDM. To better understand the degree to which water levels fluctuate, stage data from the Fritse Park gage were reviewed.

Water level or stage refers to the vertical distance (height) from an established point of reference (elevation plane). Terms often used interchangeably include stage, gage height and water level. For the gage at Fritse park, the established point of reference is equal to the elevation of the 0-foot stage level (736.21 NAVD88 USACE). Stage readings from a water level gage can be tied to surface water elevations using the known elevation of the established point of reference.

Water depth is the difference between surface water elevation and the elevation of the lake bottom. Water depth is not the same as stage or water level (Figure 3-2)**Figure 3-2. Example of Stage versus Water Depth.**

. Depth varies throughout a lake depending on the contours and variability of the lake bottom. There is a relationship between water depth, surface water elevation, and stage.

Figure 3-2. Example of Stage versus Water Depth.



Note: 0-foot stage is not equivalent to the bottom of the lake, therefore, a stage of 2.0 feet does not mean that the lake is 2.0 feet deep.

The United States Army Corps of Engineers (USACE) collects water stage data hourly at their Fritse Park gage station[10]. Monthly (June to September) and annual (2012 – 2024) average stage calculated from Fritse Park gage readings are included in Table 3-1. The results in the table show that stage can vary quite a bit annually and monthly with August typically having the lowest water stage.

Water depths measured throughout the lake can be tied to stage readings at the gage if measurements are taken during the same time period. When the Fritse Park gage reads 0-feet, the surface water elevation is 736.21 feet (NAVD88). If the gage reads 1-foot, the surface water elevation of the lake is

[9] *These water depths were measured at an average surface water elevation across survey dates of 738.45 feet above mean sea level (NAVD88).*

[10] *USACE Fritse Park Gage metadata: https://hads.ncep.noaa.gov/cgi-bin/hads/interactiveDisplays/displayMetaData.pl?table=dcp&nesdis_id=CE26C6EC*

737.21 feet (NAVD88). This assumes that the surface of the lake is level. The elevation of the lake bottom can be calculated by subtracting measured water depth from the surface water elevation obtained from stage readings. Combining the above information, the stage reading on a specific day can be used to estimate what the water depth would be at certain locations within LLBDM.

To provide an example, average water depths in were estimated using the relationships that were established between Fritse Park Gage readings and water depths measured in the field at sampling locations during the 2024 aquatic plant survey. The average stage reading from that same time was converted to surface water elevation of 738.454 feet above mean sea level (MSL) – NAVD88. The surface water elevation was then used to estimate the elevation of the lake bottom for each aquatic plant survey point by subtracting the water depth in feet from the surface water elevation. Table 3-2 includes estimated average water depths of the lake at the gage using this method.

Table 3-1. Monthly and Annual Average Stage at the Fritse Park Gage[1]- Little Lake Butte des Morts

		Water Stage (feet) by Year													MONTHLY AVERAGES
		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	
Month[2]	Jun.	0.81	1.88	2.34	2.14	1.71	2.32	1.95	2.46	2.99	1.04	1.75	1.08	2.64	1.93
	Jul.	0.52	1.11	1.05	0.91	1.15	1.83	1.22	2.05	1.96	2.63	1.15	0.85	3.29	1.52
	Aug.	0.61	0.70	0.98	0.79	0.97	1.06	1.15	1.33	1.19	1.93	1.32	0.96	1.68	1.13
	Sep.	0.48	0.68	1.42	1.44	1.67	1.27	3.21	2.45	1.23	1.67	1.43	0.79	1.14	1.45
ANNUAL AVERAGES		0.60	1.09	1.44	1.31	1.37	1.61	1.87	2.07	1.84	1.84	1.41	0.92	2.19	

Table Notes:

1. Stage level readings measured in feet at the Fritse Park Gage. Stage levels do not equal lake water depth.
2. For the purposes of the harvesting plan, water levels were analyzed seasonally (June - September). Analyzed months are when harvesting may occur within LLBDM. WDNR guidance does not allow harvesting within Wisconsin Lakes until June 1.

Table 3-2. Monthly and Annual Average Water Depths at the Fritse Park Gage - LLBDM

		Lake Water Depth (feet) at the Fritse Park by Year													MONTHLY AVERAGES
		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	
Month[1]	Jun.	3.26	4.33	4.79	4.59	4.16	4.77	4.40	4.91	5.44	3.49	4.20	3.53	5.09	4.38
	Jul.	2.97	3.56	3.50	3.36	3.60	4.28	3.67	4.50	4.41	5.08	3.60	3.30	5.74	3.97
	Aug.	3.06	3.15	3.43	3.24	3.42	3.51	3.60	3.78	3.64	4.38	3.77	3.41	4.13	3.58
	Sep.	2.93	3.13	3.87	3.89	4.12	3.72	5.66	4.90	3.68	4.12	3.88	3.24	3.59	3.90
ANNUAL AVERAGES		3.05	3.54	3.90	3.77	3.82	4.07	4.33	4.52	4.29	4.27	3.87	3.37	4.64	

Table Notes:

1. For the purposes of the harvesting plan, water levels were analyzed seasonally (June - September). Analyzed months are when harvesting may occur within LLBDM.

3.3. Watershed

When evaluating issues and recommending management actions, it is important to consider the influences on the lake from the surrounding watersheds and larger drainage area. The areas of influence (AOI)[11] for the purposes of this strategy have been defined as the Watershed AOI and Drainage Basin AOI. The lake is nested within the Watershed AOI which are both nested within the Drainage Basin AOI.

The term “watershed” can be used generally to describe an area of land that channels surface water runoff (such as rainfall and snowmelt) to creeks, streams, and rivers, eventually reaching outflow points such as lakes. The size of a watershed can vary depending on the area of land that is of interest. Large areas of land that drain to lakes are often referred to as drainage basins which consist of several different watersheds.

The LLBDM watershed and Mud Creek watershed form the Watershed AOI for this strategy. The LLBDM watershed covers approximately 44 square miles [3,10] and contains approximately 100 waterway features. The eight main tributaries that drain directly into LLBDM are listed in Table 3-3. The northern extent of LLBDM is directly adjacent to the Mud Creek watershed [3]. Although the Mud Creek Watershed does not drain to LLBDM, the geographic proximity and habitat connectivity makes Mud Creek an important consideration for protecting and restoring the lake.

LLBDM and the Watershed AOI are located within the Fox Basin (Drainage Basin AOI). The Fox Basin is divided into four subbasins:

- Wolf Subbasin
- Upper Fox Subbasin
- Lake Winnebago Subbasin
- Lower Fox Subbasin

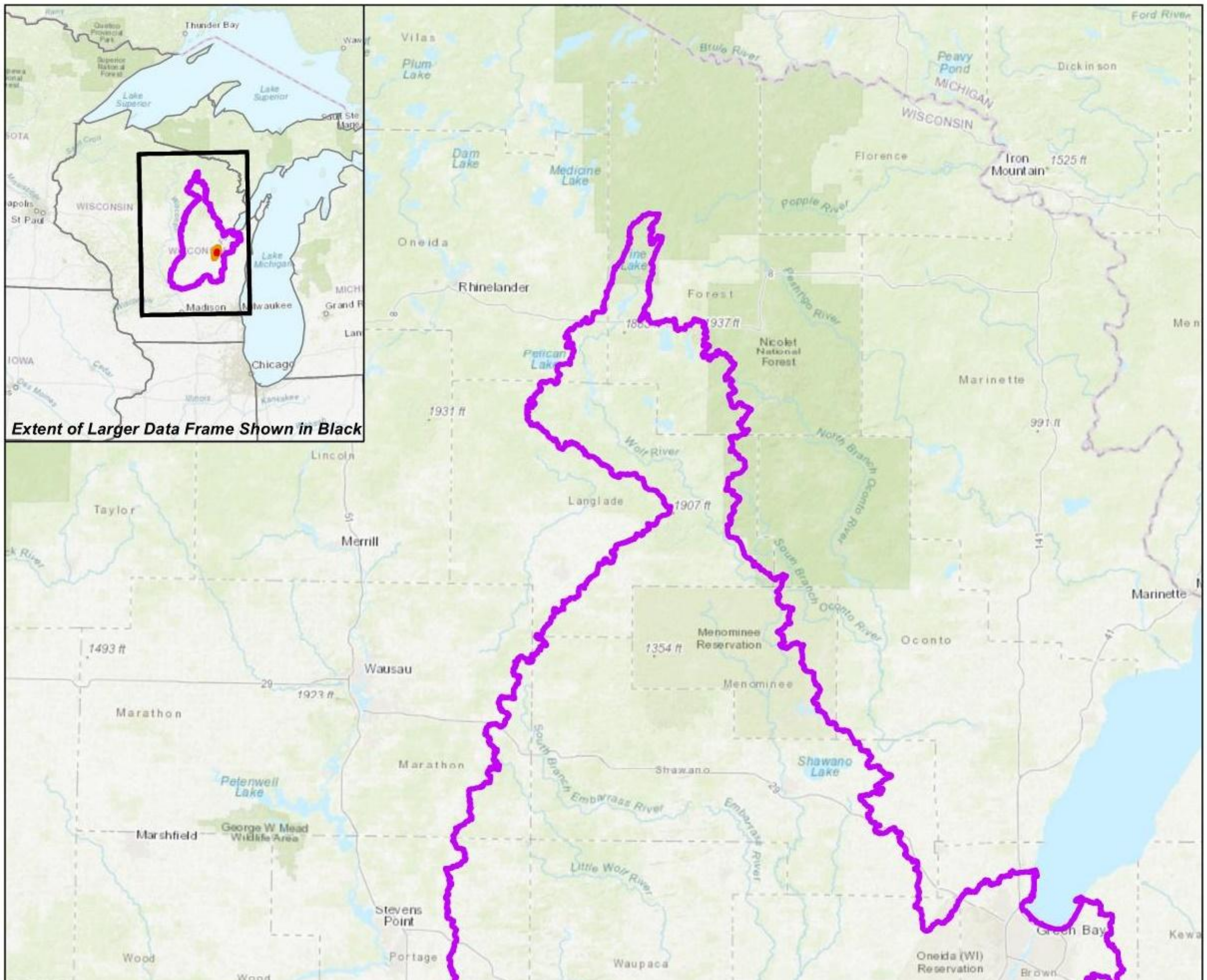
Water from the Wolf drains south into the Upper Fox Subbasin. The Upper Fox drains northeast into the Lake Winnebago Subbasin. The Lake Winnebago Subbasin drains into LLBDM within the Lower Fox Subbasin. Water then flows through LLBDM into the Lower Fox River (LFR). The LFR flows north, eventually draining into Green Bay in Lake Michigan. The Wolf, Upper Fox, and Lake Winnebago Subbasins combined cover approximately 5,900 square miles of land. This represents just under 10% of Wisconsin and it all drains into LLBDM.

Table 3-3. Tributaries in the LLBDM Watershed that drain to the lake

Map No.	**Waterbody Name**	**WBIC**	**Length** (miles)	**Condition**
1	Neenah Slough	130800	4.5	Poor / impaired
2	Little Lake Butte des Morts Tributary	130500	3.75	Suspected Poor
3	Unnamed	130200	Unknown	Unknown
4	Unnamed	129900	Unknown	Unknown
5	Unnamed	130000	Unknown	Unknown
7	Unnamed	5022094	Unknown	Unknown
8	Fox River	117900	199.45	Poor / impaired

[11] A detailed summary of the AOIs is provided as Appendix D.

Figure 3-3. Map of the Areas of Influence for LLBDM.



3.4. Water Quality

A lake's water source, shape, depth, and position in the landscape influences its water quality. Water quality is commonly assessed by measuring water clarity, total phosphorus (TP), temperature, chlorophyll a (Chl-a), and dissolved oxygen (DO). Aquatic plant and algae growth can also be used as a biological indicators of water quality and lake health.

Because of its position in the landscape, LLBDM would be expected to naturally contain higher levels of nutrients and is classified as eutrophic. Eutrophic lakes have high rates of primary production in the form of plant and algae growth. This allows lakes like LLBDM to support a wide variety and abundance of fish and wildlife. In a healthy state, we would expect to see high density of aquatic plants including submergent, emergent, and floating leaf plants with some algae.

Unfortunately, the lake receives an excessive amount of nutrient and sediment pollution from internal and external sources. External sources include agricultural, urban, and shoreline surface water runoff as well as point-sources such as wastewater treatment plants. Those external sources contribute to internal sources. Some of the pollution that enters the lake builds up in the sediments along the lake bottom over time. When disturbed by wind or waves, these legacy pollutants are resuspended which is commonly referred to as internal loading. The amount of pollution entering the system has pushed the lake from a natural eutrophic state to an unnatural, hypereutrophic state.

Stakeholder survey results provided valuable insights into perceptions of current water quality conditions and changes over time. Many survey respondents reported that algae cause "very negative" or "somewhat negative" impacts on overall enjoyment, aesthetics, property values, habitat, recreation and water quality. Shoreline property owners noted water quality has deteriorated, often making the lake unsuitable for swimming and other recreational activities due to algae growth. When it came to purchasing a lakefront property, they considered proximity to the water, views of the water, and beauty of the location as extremely important.

Figure 3-4. Blue-green algae bloom mixed with filamentous algae on LLBDM.

Photo captured by GEI staff on July 25, 2024

Recreational and aesthetic enjoyment, the reasons many people purchase homes on the water, are diminished when the lake is impaired. Property owners who have children or pets worry about exposure to toxins from blue-green algae. Low water clarity, frequent blue-green algae blooms[12], and nuisance growth of filamentous algae decrease the value of lakefront property.

General public respondents expressed concerns about algae, weeds, and overall water quality, describing the lake as “gross and smelly”, particularly in the summer. The highest concerns for both stakeholder groups are visibly apparent issues which directly impact water usage and recreational enjoyment. Most respondents reported that algae blooms have gotten much worse since they first visited LLBDM which indicates a potential decline in water quality over time.

In Wisconsin, lakes should be fishable, drinkable, swimmable, and aesthetically enjoyable. Wisconsin has numeric and narrative water quality criteria that are used to assess whether a body of water can support those uses and meet state standards[13]. Every two years, the WDNR compiles and reviews water quality data for lakes and rivers[14]. If the appropriate data are available, the WDNR conducts a water quality assessment. If a lake does not meet water quality criteria because of chemical, physical or biological conditions, it is considered impaired, and the lake is added to the U.S. Environmental Protection Agency (EPA) and WDNR Impaired Waters List.

Although LLBDM is known for having water quality issues, it is currently listed by the WDNR as being in good condition and attaining standards [11][15]. This is because the only usable data the WDNR had available at the time of their assessment of LLBDM in 2022 were results from 2016 water clarity readings obtained using satellite imagery. However, nuisance level growth of plants, harmful algal blooms, and low water clarity are signs that LLBDM receives too much phosphorus and should be re-assessed.

In addition to having a limited water quality monitoring history, LLBDM has not yet been thoroughly studied to fully quantify sources of nutrient and sediment pollution. Likely sources can be inferred from studies that have been done on the Lower Fox River (LFR), Lake Winnebago, surrounding watersheds, and larger drainage basin. LLBDM shares a footprint with a portion of the LFR. The LFR is listed as impaired due to low DO and contaminated fish tissue caused by phosphorus and PCB pollution [12]. LLBDM also receives water from other impaired waterbodies including Lake Winnebago and the Neenah Slough. There were two different WDNR watershed studies that estimated the amount of phosphorus and sediment pollution entering Lake Winnebago and the LFR (among other waterbodies), identified pollutant sources, and estimated the pollution reductions needed to delist those bodies of water. Those studies have been summarized in the following reports:

1. Lower Fox River Basin Total Maximum Daily Load (TMDL)[16]
   https://dnr.wisconsin.gov/topic/TMDLs/LowerFox/index.html
2. Upper Fox and Wolf Rivers TMDL
   https://dnr.wisconsin.gov/topic/TMDLs/FoxWolf/index.html

[12] Blue-green algae are also known as cyanobacteria.
[13] The federal Clean Water Act requires states to adopt water quality standards. The state of Wisconsin established total phosphorus criteria in 2010 for lakes.
[14] Learn more about Wisconsin’s assessment process: https://dnr.wisconsin.gov/topic/SurfaceWater/Assessments.html
[15] Based on information provided in email correspondence from Ashley Beranek, WDNR, on October 23, 2024.
[16] LLBDM was not identified in the LFR TMDL report, so reduction targets have not yet been assigned

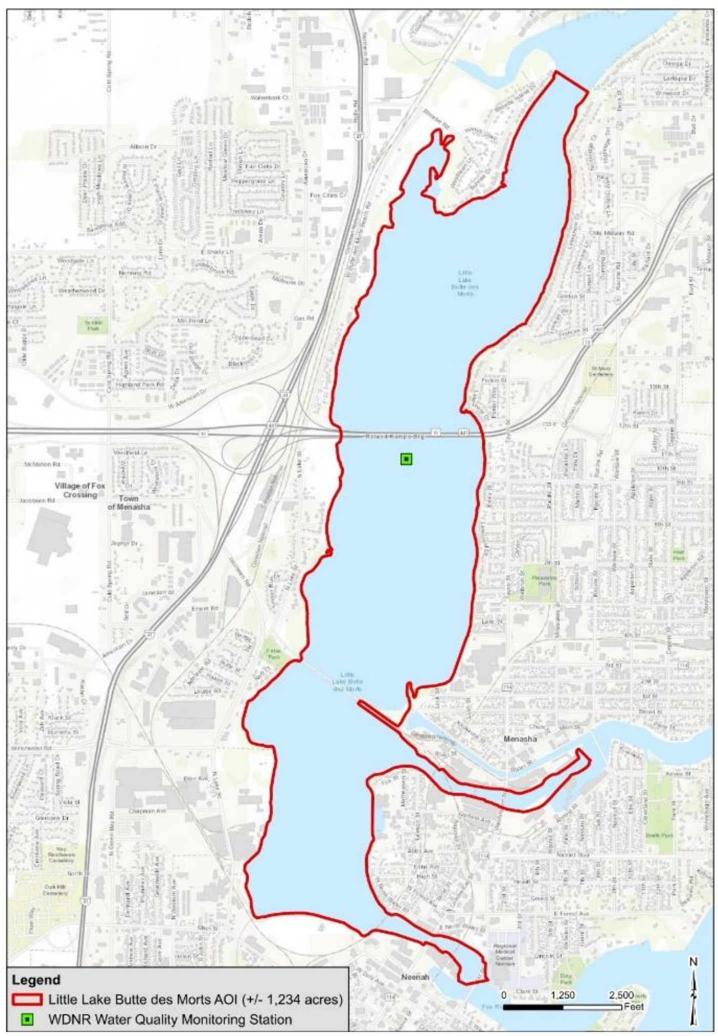
Even though LLBDM has not yet been the focus of a watershed study, the lake benefits from efforts to reduce pollution that enters Lake Winnebago and other tributaries. There are many organizations, including the municipalities, counties, agencies, businesses, farmer groups, and nonprofits, that have been working to reduce nutrient and sediment pollution. Many individuals, such as shoreline property owners, have also made changes to reduce the amount of runoff that leaves their property. While this is great news, there is collectively a long way to go to reach the point of good water quality for the lake.

WDNR Monitoring results from 2024, observations of lake conditions, data from contributing waterbodies, and results from the studies listed above point to LLBDM as likely being impaired. Knowing that more data are needed to fully assess the lake, the WDNR has committed to monitoring the lake again in 2025. If they conduct monitoring in 2025, there would be enough data for the WDNR to re-assess LLBDM for impairments during the 2028 listing cycle. Additional monitoring could be conducted by volunteers which would help support an impairment assessment and give more insight into water quality issues to inform management decisions.

3.4.1. 2024 Water Quality Baseline

To support the development of this APM strategy and establish a water quality baseline, the WDNR conducted water quality monitoring for LLBDM once per month in July, August, and September 2024. Monitoring[17] took place at the long-term trend, deep hole sampling site near the HWY 10 bridge (Station 713305 shown in Figure 3-5). Parameters measured included TP, chl-a, water temperature, DO, and Secchi depth. Additional Secchi depth data were collected in 2000 and 2013-2015 by a volunteer and included in this assessment.

Figure 3-5. Location of Monitoring Station 713305.



Data were downloaded from the WDNR's Surface Water Information Management System (SWIMS) database in October 2024 and analyzed by GEI including calculation of trophic state index (TSI). Analysis and summary of results were based on the WDNR classification that LLBDM is a lake and not a river (although LLBDM is part of the LFR). Overall, results are consistent with stakeholder reports of poor water quality. Table 3-4 provides

[17] *Water quality monitoring methods on the WDNR website: https://dnr.wisconsin.gov/topic/SurfaceWater/Monitoring.html*

a summary of water quality results for Secchi depth, chl-a, TP, and TSI for each parameter. Table 3-5 summarizes results for depth profiles of DO, water temperatures, and pH. Each parameter is described in more detail in subsequent sections below.

Table 3-4. 2024 Results for Secchi Depth, Chl-a, and TP measurements and calculated TSI.

Date	Secchi Depth			Chlorophyll a (Chl-a)		Total Phosphorus (TP)	
	feet	*meters*	*TSI*	*µg/L*	*TSI*	*µg/L*	*TSI*
7/30/24	2.5	0.76	63.9	53.4	69.6	132.0	74.6
8/13/24	2.0	0.61	67.1	50.2	69.0	135.0	74.9
9/17/24	2.0	0.61	67.1	32.8	64.8	91.7	69.3
Annual Average	2.17	0.66	66.0	45.47	68.0	119.6	73.1

Table 3-5. 2024 Depth Profiles for DO, Water Temperature, and pH for LLBDM.

Depth		Dissolved Oxygen (mg/L)			Water Temperature (°F)			pH		
Meters	*Feet*	7/30	8/13	9/17	7/30	8/13	9/17	7/30	8/13	9/17
1.0	3.3	10.3	9.8	8.19	78.6	72.9	74.1	8.8	9	9
2.0	6.6	9.9	9.5	8.76	77.9	72.1	73.4	8.8	9	9
3.0	9.8	9.8	9.1	6.78	77.7	72.0	72.9	8.8	9	8.9

Note – the results summarized below were compared to Wisconsin water quality criteria for informational and discussion purposes. Data available at the time of this analysis did not meet the minimum data requirements under WI NR 102 for an impairment assessment under Section 303(d) of the CWA for any parameter. At least one more year of monitoring following the methods outlined in the Wisconsin Consolidated Assessment and Listing Methodology (WisCALM) guidance is needed to meet the minimum number of samples for most parameters. Sampling frequency and timing requirements for impairment assessments vary depending on the parameter of interest.

3.4.1.1. Dissolved Oxygen (DO)

Oxygen is necessary for aquatic life. The type of oxygen available for aquatic organisms is in the form of dissolved oxygen (DO). Healthy lakes should generally have DO concentrations above 6.5 mg/L (Table 3-6). For LLBDM, DO concentrations need to be at or above 5.0 mg/L to meet water quality standards[18]. DO levels below 5.0 are considered stressful for fish and levels below 3.0 mg/L are too low to support most fish species [13]. Below 1 mg/L, conditions are hypoxic and typically devoid of live. If there is no oxygen (less than 0.2 mg/L), water is considered anoxic.

DO concentrations in water are affected by water temperature, rates of decomposition and respiration, photosynthesis, aeration, and salinity. Warmer water holds less DO than cold water. In many lakes, DO is often highest in winter and early spring and lowest in summer and fall.

[18] NR 102.04(4)(a)2.

Table 3-6. DO concentrations needed to support aquatic life.

DO (mg/L)	DO Conditions
6.5 to 8.0	Good
≥ 5.0	Minimum
< 5.0	Stressful
< 3.0	Unable to support most fish
< 1.0	Hypoxic
< 0.2	Anoxic

Sources of oxygen include the atmosphere, groundwater, and photosynthesis. Oxygen from the atmosphere enters the water when it comes into contact at the lake's surface (diffusion). The surface water is then mixed into the water column by wind-wave action. Wind-wave action can also increase DO through aeration. Groundwater is cold in temperature, and it increases the capacity of the lake to hold dissolved oxygen when mixed with the warmer, oxygenated waters. Photosynthesis also contributes as plants use sunlight to convert carbon dioxide and water to sugar and oxygen.

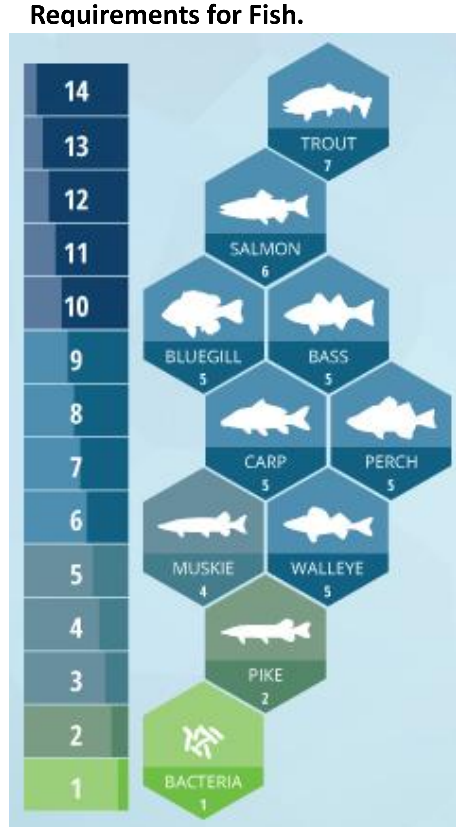
Sinks of oxygen in aquatic systems include respiration and decomposition. Respiration is when aquatic animals and plants use oxygen to break down sugars to obtain energy. This process produces carbon dioxide. Decomposition removes oxygen through the action of microorganisms such as bacteria that break down organic matter such as dead plants, algae, and animals.

Photosynthesis is an important source of oxygen in the lakes. Water clarity can impact the amount of oxygen available. This is because low water clarity can prevent plants from receiving the amount of sunlight that they need for photosynthesis. If DO demand from respiration exceeds the amount produced by photosynthesis, it can result in fish kill or dead zones. Dead zones can be temporary during certain times of year or under the right conditions. Some fish are more sensitive to low DO than others and DO concentrations can influence growth rates, reproduction, and other life processes. As an example, minimum DO requirements for various fish species are shown in Figure 3-6**Figure 3-6. Examples of DO Requirements for Fish.**

[19].

Because DO is important for aquatic life, it is used as one of the measures of lake health. When oxygen gets so low that conditions become anoxic (absent of oxygen), phosphorus stored in the sediment is released at higher rates through a process called diffusion. Excessive amounts of phosphorus fuels blue-green algae blooms. To prevent higher amounts of phosphorus from being released through diffusion, it is important that DO concentrations remain above anoxic conditions [14].

Figure 3-6. Examples of DO Requirements for Fish.



Source: fondriest.com

[19] *Figure source: https://www.fondriest.com/environmental-measurements/parameters/water-quality/dissolved-oxygen/*

Dissolved oxygen is measured along a depth profile in lakes. This means that readings are collected using a sensor at specific depth intervals. For LLBDM, readings were collected at depths of 1.0, 2.0, and 3.0 meters in 2024 once per month in July, August, and September (3.3, 6.6, and 9.8 feet, respectively). Results are listed in Table 3-5. DO remained well above the required 5.0 mg/L for Wisconsin water quality standards during all sampling events at all depths.

3.4.1.2. Water Temperature

Water temperature affects several factors in a lake. Dissolved oxygen levels vary with temperature as cooler water can hold more oxygen. Chemical processes such as reaction rates and solubility of chemicals are mediated by temperature; the rate of chemical reactions generally increases as temperatures increase. Water density and stratification is dependent upon temperature; water is most dense at 39°F and differences in water temperature in a lake leads to stratification. Biological processes such as growth, reproduction, and metabolism of animals and plants are temperature dependent. Species composition most aquatic species have a limited temperature range which varies by species. Temperature also acts as an important environmental cue or signal for various species life histories such as fish spawning or insect emergence.

In Wisconsin, water quality standards for temperature[20] were established to protect fish and other aquatic life from "mortality, immobilization, loss of equilibrium, impaired growth, adverse reproductive effects, and other sub-lethal effects" [15]. Sub-lethal effects are those that result in inadequate reproductive development, spawning or growth. There are three different temperature categories for inland lakes with ambient, sub-lethal, and acute temperature thresholds set for each month of the calendar year. The deep hole sampling site used for this water quality baseline only has temperature data from July, August and September. The temperature criteria for those months are listed in Table 3-7.

Table 3-7. Water Quality Criteria for Temperature in Southern Wisconsin Inland Lakes

Month	**Ambient** (°F)	**Sub-lethal** (°F)	**Acute** (°F)
July	77	80	87
August	76	80	87
September	67	73	85

Table Notes:
1. Ambient: the temperature that would exist without any significant external heating or cooling factors.
2. The ambient temperature, sub-lethal water quality criterion, and acute water quality criterion specified for any calendar month are applied simultaneously to establish the protection needed for aquatic life use. Sub-lethal water quality criteria are applied as maximum weekly average temperatures. Acute water quality criteria are applied as daily maximum temperatures.
3. Criteria are available in WI NR 102.25(4). Minimum data requirements of 20 discrete values collected within a given calendar month were not met. Minimum exceedance frequency of Greater than 10% of daily maximum or any weekly average temperature values in a calendar month was not met.

Water temperatures are measured along a depth profile just like DO. Results from 2024 show similar temperatures were measured along the depth profile, which is expected for a mixed, polymictic lake (Table 3-5). Comparing the 2024 results to the water quality temperature thresholds in Table 3-7, LLBDM exceeded ambient water quality criteria at all three depths at the deep hole sampling site in on July 30, 2024. On August 13, 2024, temperatures were under the established maximum. On September 17, 2024, temperatures exceeded ambient criteria at all depths and sub-lethal criteria at 3.3 feet and 6.6 feet.

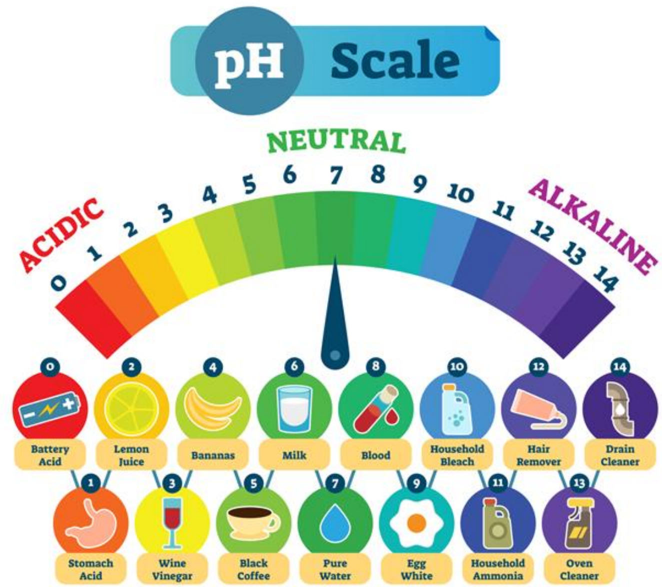
[20] NR 102.25

3.4.1.3. pH Values

Potential of Hydrogen or ‘pH’ is a measure of the amount of hydrogen ions (H+) present in a substance. The pH scale ranges from 0.0 (most acidic) to 14.0 (most basic), with the value of 7.0 representing neutral solutions. Each unit of pH on the scale represents a tenfold difference in how much hydrogen is present. For example, bananas with a pH of 4.0 are 10 times more acidic than coffee with a pH of 5.0 Figure 3-7. The pH level of lakes is important to aquatic life and plays a role in the solubility and biologic availability of nutrients and heavy metals.

Most natural waters in the United States have pH values between 6.5 and 8.5. In Wisconsin, lakes are impaired if pH is outside of the range of 6.0 to 9.0; this is the pH water quality criteria for aquatic life. Optimal pH for many species is between 7.0 and 9.0 with most fish bring able adapt to the pH level of their environment (6.0-9. 0) if there are no dramatic fluctuations. As pH levels move away from this range (up or down) it can stress animals, reducing hatching and survival rates. The further outside of the optimal range, mortality rates increase. Fish are unable to survive when pH exceeds 10.0 or drops below 4.0.

Figure 3-7. Common substances and their typical pH.



Source: https://www.snexplores.org/article/explainer-what-the-ph-scale-tells-us

Most aquatic animals cannot survive if the water is too acidic (< 5.0) or too basic (> 9.0). Some species are more tolerant to changes in pH than others. Some frogs and other amphibians can tolerate pH levels as low as 4.0. The pH levels of natural water bodies can be used as an indicator for the types of animals likely to be found in a particular lake or river. For example, bass and bluegill might be found at pH 8.5, but trout and mayflies would not be found in the same area. If pH were around 7.0, bass, bluegill, trout, and mayflies might be found in the same habitat.

Changes in pH can increase the solubility of nutrients, such as phosphorus, which can make them more accessible for plant and algae growth. As aquatic plants and algae thrive with an abundance of nutrients, there is an increase in the demand for DO. This can result in the lake being rich in nutrients and plant life, but low in dissolved oxygen concentrations.

Algae blooms have an optimum pH between 8.2 and 8.7. When algae grow, pH levels increase. Extreme pH levels (up or down) increase the solubility of some chemicals and metals, making toxic chemicals more “mobile” and increasing the risk of absorption by aquatic life. Lower pH levels increase the risk of toxic metals being mobilized and absorbed, even by humans. pH levels outside of 6.5-9.5 can damage and corrode pipes and other systems, further increasing heavy metal toxicity. Humans can also be directly affected by pH. Very high or low pH levels (>11.0 or <4.0) can cause skin and eye irritation.

In lakes, pH is measured along a depth profile just like DO and water temperature. Results from 2024 show that pH stayed relatively consistent along the depth profile and sampling events ranging from 8.8

to 9.0 (Table 3-5). A pH of 9.0 is at the top end of the acceptable limit for water quality standards in Wisconsin.

3.4.1.4. Secchi Depth – Water Clarity

Water clarity affects how far sunlight can reach through the water column and is used as a measure of water quality. Low water clarity is due to increased turbidity caused by sediment (soil particles) and other materials, such as blue-green algae (cyanobacteria) and filamentous algae, that are suspended in the water column. These materials block sunlight and, at high densities, can prevent sunlight from reaching aquatic plants along the lake bottom, even in shallow areas.

Water clarity can vary daily, seasonally, and from year to year. It can also be different depending on the location within the same lake at the same time. Poor water clarity can impact the ability of predators that rely on sight to locate and capture prey. Low water clarity also reduces the area in the lake where rooted aquatic plants can grow and are often associated with higher concentrations of blue-green algae.

A common way to measure water clarity is with a Secchi disk (Figure 3-8).**Figure 3-8. Secchi disks are visible at greater depths in clearer water.**

An 8-inch black and white disk (attached to a rope) is lowered into the water column until it is no longer visible to the naked eye. The disk is then raised and the depth at which the disk is once again visible is recorded as the Secchi depth. The Secchi depth results can then be used to evaluate whether water clarity is good or poor (Table 3-8).

Figure 3-8. Secchi disks are visible at greater depths in clearer water.

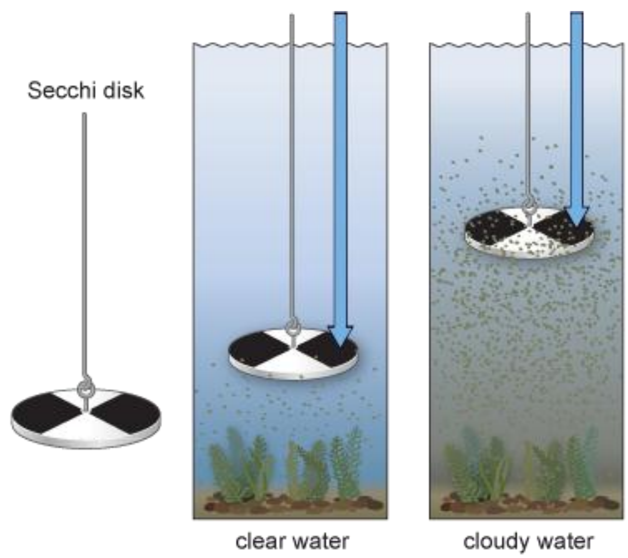


Image Source: http://www.themanyfacesofwater.eu/index.php/2017/05/19/measuring-water-clarity-with-secchi/

Table 3-8. Water clarity index [6].

Secchi depth		Water Clarity
(feet)	*(meters)*	
3.0	0.9	Very poor
5.0	1.5	Poor
7.0	2.1	Fair
10.0	3.1	Good
20.0	6.1	Very good
32.0	9.8	Excellent

Secchi disk depth measurements for LLBDM in 2024 ranged from 2.0 feet to 2.5 feet (Table 3-4). Comparing the 2024 results to the index in Table 3-8, LLBDM had very poor water clarity on all three sampling dates.

Additional Secchi depth data collected in 2000 and 2013-2015 by a volunteer provide insight into past years (Table 3-9). On July 15, 2000, and June 12, 2014, Secchi disk depth results showed LLBDM had poor water clarity. On all other sampling dates, LLBDM had very poor water clarity.

Looking at the results by month across all years, LLBDM generally has slightly better water clarity in June and July versus August or September. This may be an indication that algae blooms are typically worse later in the summer.

Table 3-9. Secchi Depth Results for Station 713305 from 2000, 2013-2015, and 2024.

Date	Secchi Depth (feet)	Secchi Depth (meters)
6/26/2000	3.0	0.91
7/1/2000	2.5	0.76
7/15/2000	3.25	0.99
7/24/2000	1.5	0.46
7/29/2000	2.0	0.61
8/7/2000	1.25	0.38
8/12/2000	1.75	0.53
8/19/2000	1.75	0.53
8/26/2000	1.75	0.53
9/9/2000	1.5	0.46
9/16/2000	2.0	0.61
9/23/2000	1.75	0.53
9/30/2000	1.75	0.53

Date	Secchi Depth (feet)	Secchi Depth (meters)
8/22/2013	1.75	0.53
9/6/2013	1.25	0.38
9/22/2013	1.5	0.46
6/12/2014	3.5	1.07
8/8/2014	0.75	0.23
9/25/2014	1.5	0.46
5/9/2015	1.25	0.38
7/19/2015	1.75	0.53
7/28/2015	1.25	0.38
8/9/2015	1.25	0.38
7/30/2024	2.5	0.76
8/13/2024	2.0	0.61
9/17/2024	2.0	0.61

Secchi depth can also be used to estimate the maximum potential depth of plant growth. Sunlight can typically penetrate the water column up to 2.5 times the Secchi depth. For example, if Secchi depth is 2.0 feet, then plants would be able to receive enough sunlight for photosynthesis at a depth of 5.0 feet, depending on average conditions. This is called the photic zone. Outside of the photic zone, there is not enough light for rooted plants to grow.

3.4.1.5. Chlorophyll *a* (Chl-a)

Chlorophyll *a* (chl-a) is a type of chlorophyll used by plants and algae for photosynthesis. It is what makes plants and algae green. Algae, including blue-green algae (Figure 3-9), are naturally occurring and an important part of a healthy, balanced freshwater ecosystem in low concentrations. For water quality, chl-a is used to estimate the amount (biomass) of algae, including blue-green algae, growing in a body of water. High levels of chlorophyll a typically indicate high algal biomass, which can be a sign of nutrient enrichment or eutrophication. This can lead to various water quality issues, such as decreased oxygen levels, harmful algal blooms, and reduced water clarity.

Figure 3-9. The image shows a harmful algal bloom (blue-green algae which is also known as cyanobacteria).

Image Source: GEI Consultants, 2024.

Algae tend to grow well in warm, shallow, calm water high in nutrients. During intense blooms, algae can form large floating mats blocking sunlight. As the algae die in large numbers, the decomposition process causes DO to decline. Algae can also cause odor and aesthetic problems.

Blue-green algae can produce toxins that are released as they die. The toxins are harmful to humans, pets, livestock, and wildlife. Higher concentrations of algae mean the higher the likelihood of toxins being present. This is why high concentrations of blue-green algae are referred to as a Harmful Algal bloom (HAB). While chl-a is not a direct measure of blue-green algae, it can be used as an indicator for the likely presence of harmful algal blooms and the associated potential for human health risks.

For LLBDM, the chl-a water quality threshold for aquatic life use assessments is 27 µg/L and for recreational use it is 20 µg/L[21]. Chl-a exceeded both thresholds for all three sampling events in 2024 with the highest concentration occurring on July 30 (Table 3-4).

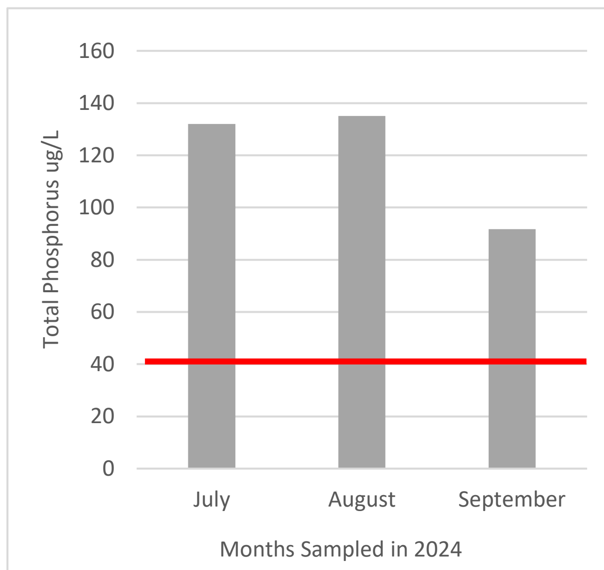
3.4.1.6. Total Phosphorus (TP)

Pollution is defined as a substance introduced into the natural environment beyond impairment limits that has an undesired effect. An excessive amount of phosphorus is a type of pollution that negatively impacts water quality in lakes, including LLBDM.

Phosphorus is a nutrient that naturally comes from weathered rocks that have worn down over long periods of time. This is a slow process, and, in nature, phosphorus is typically more scarce than other types of nutrients such as nitrogen. This is why phosphorus is referred to as a "limiting nutrient" in aquatic ecosystems: it is the scarcest resource necessary for primary production. Humans have significantly increased the availability of phosphorus well beyond natural, background concentrations. As a result, plants and algae grow to high densities creating nuisance situations for humans and degrading habitat.

Wisconsin's water quality criterion for total phosphorus is 40 µg/L during the summer months[22]. TP greatly exceeded the state threshold for all three months in 2024 as shown in Figure 3-10.

Figure 3-10. TP results from samples collected in LLBDM in 2024 compared to the water quality impairment threshold of 40 µg/L.



---

[21] NR 102.56(1)(a)2. *In Wisconsin, a lake or reservoir other than a stratified two-story fishery lake is not attaining its aquatic life use if its arithmetic mean suspended chlorophyll a concentration exceeds 27 µg/L. For recreational use assessments, chl-a should not exceed 20 µg/L for more than 30% of days during the summer (July 15 to September 15).*

[22] NR 102.07(1)(a) *TP criteria specified in WI s. NR 102.06 (4) apply to samples taken near a lake or reservoir's deepest point, within 2 meters of the surface. For assessment purposes samples are taken at least once per month for 3 months during the sampling period of June 1 to September 15. The WDNR calculates a lake's arithmetic mean total phosphorus concentration using at least 2 years of data from the sampling period.*

3.4.1.7. Trophic State Index (TSI)

Eutrophication is the process of increased availability of one or more factors needed for photosynthesis such as nutrients, sediment, and sunlight. This is a natural aging process that occurs in lakes over long periods of time (thousands to millions of years) [16]. Eventually, eutrophication causes lakes to completely fill in with sediment and plant material. Impacts from human activities, such as nutrient pollution from runoff, can significantly speed up the eutrophication process [16].

The extent to which eutrophication has occurred in a lake is described as a lake's trophic state. There are four trophic states found in Wisconsin Lakes: oligotrophic, mesotrophic, eutrophic, and hypereutrophic (Figure 3-11). Over the natural aging process, lakes generally transition from oligotrophic to eutrophic.

Oligotrophic lakes have low amounts of nutrients, high oxygen levels, low primary production, few aquatic plants and animals, and high water clarity [16]. As an intermediate state, **mesotrophic** lakes have moderate nutrient and oxygen levels, moderate primary production, and some sediment accumulation on the lake bottom. **Eutrophic** lakes tend to have high amounts of nutrients, lower oxygen levels, high levels of sediment accumulation (mucky sediments), low water clarity, and large and diverse populations of aquatic plants, algae, and animals [16].

A **hypereutrophic** lake is in an unnatural state marked by extremely high amounts of nutrients. These lakes tend to experience frequent and severe algae blooms and very low water clarity. Fish communities within hypertrophic lakes are typically dominated by species tolerant of low oxygen and warm water conditions, such as the invasive common carp. This level of eutrophication is a result of human-caused nutrient enrichment.

A healthy lake that is desirable for recreation and people often associate lake-front property with the clear waters of an oligotrophic lake. While Wisconsin has many clear-water, low nutrient lakes that fit this description, LLBDM is a shallow, lowland drainage lake, is classified as naturally eutrophic and based on 2024 water quality data, may be reaching an unhealthy hypereutrophic state.

Figure 3-11. Four tropic states found in Wisconsin Lakes.

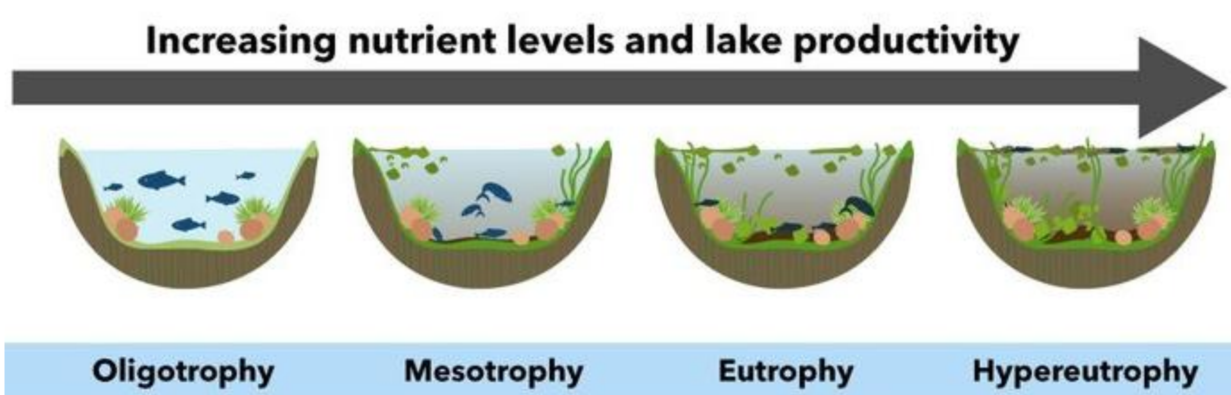


Image Source: https://www.researchgate.net/figure/Trophic-status-of-lakes-4_fig1_353480610

Naturally shallow and eutrophic lakes are fundamentally different from deep, clear, low nutrient oligotrophic lakes. The abundance of nutrients in a eutrophic lake supports high levels of aquatic plant and algae growth. Due to LLBDM's position in the landscape and water depth, it will never be oligotrophic. This should be taken into consideration when developing expectations for what ideal conditions within LLBDM could be. Criteria to evaluate the trophic state are discussed below and should be referenced to identify feasible and realistic trophic state goals for LLBDM.

Carlson's Trophic State Index (TSI) is commonly used to assess productivity, algal biomass (amount of algae), and biological condition of a lake, as well as overall lake health [17]. According to the WDNR, algal production is highly correlated with nutrient levels (especially phosphorus). High levels of nutrients can lead to eutrophication and blue-green algae blooms [18]. This limits the amount of light available to aquatic plants and has negative impacts on other aquatic organisms. The relationships between chl-a, Secchi depth, and TP can be used to better understand a lake's condition and what may be influencing algae blooms. Any of the following three variables can be used to calculate the TSI of a waterbody:

1. Chlorophyll a concentrations
2. Secchi disk depth
3. Total phosphorus (TP) concentration [17].

Figure 3-12. Formulas to calculate TSI.

Secchi Disk: $TSI(SD) = 60 - 14.41 \ln(SD)$

Chlorophyll-a: $TSI(CHL) = 9.81 \ln(CHL) + 30.6$

Total Phosphorus: $TSI(TP) = 14.42 \ln(TP) + 4.15$

Where: TSI = Trophic Status Index; Ln = natural log; SD = Secchi depth (meters); CHL = Chlorophyll-a concentration

Chl-a is typically the preferred variable in Wisconsin because it is the most direct measure of trophic state. Formulas for calculating TSI are shown in Figure 3-12.

According to the WDNR, algal production is highly correlated with nutrient levels (especially phosphorus). High levels of nutrients can lead to eutrophication and blue-green algae blooms [18]. This limits the amount of light available to aquatic plants and has negative impacts on other aquatic organisms. The relationships between chl-a, Secchi depth, and TP can be used to better understand a lake's condition and what may be influencing algae blooms. For each year of data, an annual average for each parameter is calculated. All available Annual Averages are then averaged together, to produce a multi-year average. This is done separately for each TSI parameter. The resulting value can then be used to categorize a lake by trophic state.

Chl-a, Secchi depth, and TP results from July, August, and September 2024 were used to calculate the annual average TSI for each parameter (Table 3-10). The results were then compared to the index ranges in Table 3-12. Based on the 2024 water quality monitoring data, LLBDM is borderline hypereutrophic (Figure 3-13).

Calculating TSI using the additional Secchi depth data available from 2000, 2013, 2014, 2015, and 2024 shows that LLBDM was in a hypereutrophic state in 2013, 2014, and 2015 (Table 3-11). A multi-year average was then calculated indicating that LLBDM is likely, on average, hypereutrophic during the summer months.

Table 3-10. 2024 LLBDM TSI values and associated Chl-a, Secchi, and TP values.

Sample Date	Chl-a (µg/L)	Chl-a TSI	Secchi (meters)	Secchi TSI	TP (µg/L)	TP TSI
7/30/2024	53.4		0.76		132.0	
8/13/2024	50.2		0.61		135.0	
9/17/2024	32.8		0.61		91.7	
Annual Average	45.5	**68.0**	0.66	**66.0**	119.6	**73.1**
Trophic State	**Eutrophic**		**Eutrophic**		**Hypereutrophic**	

Figure 3-13. Calculated TSI values for July, August, and September, and annual average in 2024

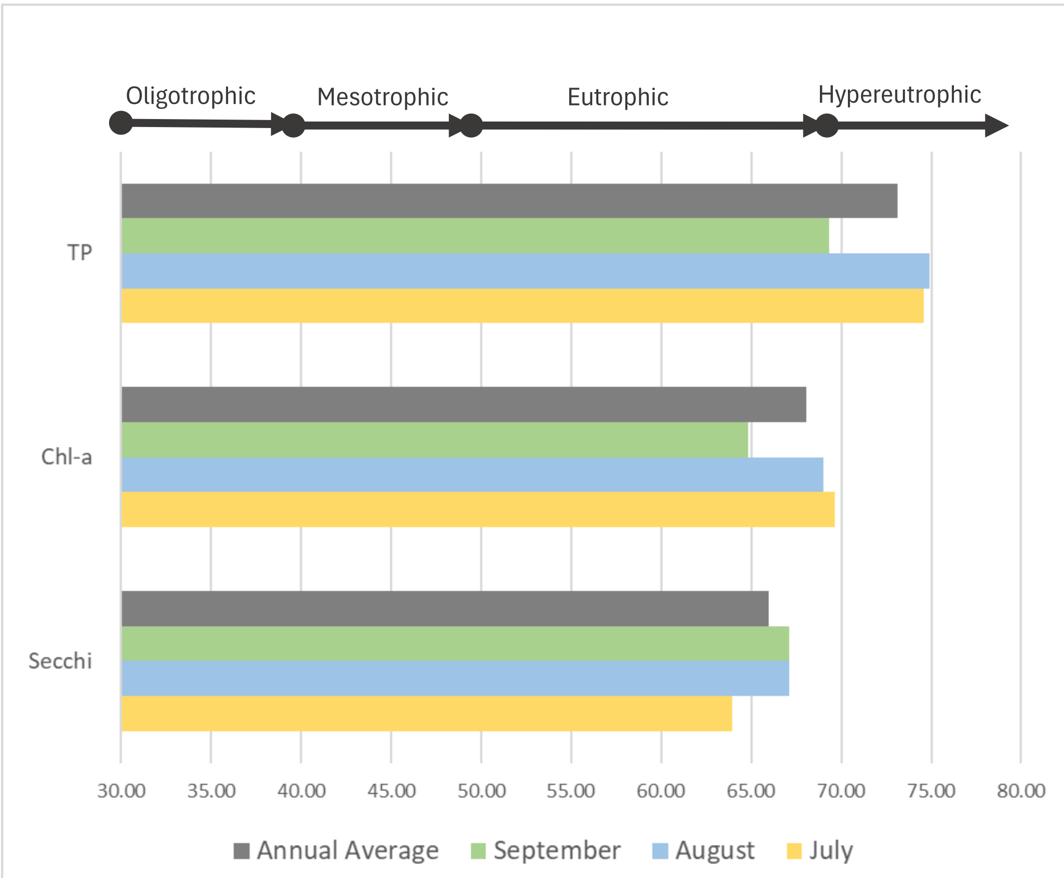


Table 3-11. Average Annual TSI from Secchi depth (m) in LLBDM for years with available data.

Year	Average Secchi (meters)	TSI	Trophic State
2000	0.58	67.9	Eutrophic
2013	0.46	71.3	Hypereutrophic
2014	0.34	75.4	Hypereutrophic
2015	0.43	72.1	Hypereutrophic
2024	0.66	66.0	Eutrophic
Multi-year Average	**0.53**	**70.5**	Hypereutrophic

Table Notes:

1. Only data collected in the months of July, August, and September were used to calculate TSI.

Table 3-12. Trophic State Categories with TSI values and associated Chl-a, Secchi, and TP values.

Trophic State	TSI	Chl-a (µg/L)	Secchi (meters)	TP (µg/L)	Attributes	Fisheries & Recreation
Oligotrophic	< 30	< 0.95	> 8	< 6	Clear water, high DO throughout the year.	Salmonid fisheries dominate.
	30 – 40	0.95 – 2.6	8 – 4	6 – 12	In shallower lakes, areas near the lake bottom may become anoxic.	Salmonid fisheries in deep lakes only.
Mesotrophic	40 – 50	2.6 – 7.3	4 – 2	12 – 24	Water moderately clear; increasing probability of anoxia during summer.	Hypolimnetic anoxia results in loss of salmonids. Walleye may predominate.
Eutrophic	50 – 60	7.3 – 20	2 – 1	24 – 48	Aquatic plant problems possible.	Warm-water fisheries only. Bass may dominate.
	60 – 70	20 – 56	0.5 – 1	48 – 96	Blue-green algae dominate, algal scums and nuisance aquatic plant problems.	Nuisance plants, algal scums, and low clarity may discourage swimming and boating.
Hyper-eutrophic	70 – 80	56 – 155	0.25 – 0.5	96 – 192	Light limited productivity. Dense algae and plants.	Boating may not be possible in area and HABs may prevent swimming due to safety concerns.
	> 80	> 155	< 0.25	192 – 384	Lake is algae dominated, covered in scum, with very few aquatic plants.	Rough fish dominate; summer fish kills possible.

Table Notes:
1. Table was adapted from "*A Coordinator's Guide to Volunteer Lake Monitoring Methods*", North American Lake Management Society.
2. Anoxic: little to no dissolved oxygen.

In Wisconsin, thresholds have been established for chl-a and Secchi depth TSI values[23] to help assess the general condition of lakes based on their natural community [19]. These thresholds are shown for various lake community types in Table 3-13. LLBDM is a shallow, lowland lake. The TSI values calculated using the average chl-a and Secchi depth data from 2024 indicate that LLBDM is in fair condition. The multi-year average for Secchi depth pushes LLBDM closer to the threshold for poor condition.

Wisconsin does not use TSI values calculated from total phosphorus concentrations in their water quality 303(d) assessments. Instead, Wisconsin uses TP concentrations because TP is a pollutant. However, TSI for TP can still be helpful when evaluating general conditions of a lake for planning and management.

Table 3-13. WI TSI Thresholds (Chl-a and Secchi) for General Assessment of Lake Communities [18].

	Shallow Lakes			Deep Lakes			
Condition	**Headwater**	**Lowland**	**Seepage**	**Headwater**	**Lowland**	**Seepage**	**Two-story**
Excellent	< 53	< 53	< 45	< 48	< 47	< 43	< 43
Good	53 - 61	53 - 61	45 - 57	48 - 55	47 - 54	43 - 52	43 - 47
Fair	62 - 70	62 - 70	58 - 70	56 - 62	55 - 62	53 - 62	48 - 52
Poor	≥ 71	≥ 71	≥ 71	≥ 63	≥ 63	≥ 63	≥ 53

[23] *According to WisCALM, for chlorophyll-a and Secchi data, TSI requires 2 samples per year in 3 different years. Samples should be collected between July 15 – September 15. For satellite clarity data, at least one satellite inferred clarity reading in 3 different years (3 values minimum) are needed and samples should be collected between July 1 – September 30: https://apps.dnr.wi.gov/swims/Documents/DownloadDocument?id=343906539*

3.5. Dominant Sediment Types

Sediment type can influence where aquatic plants will grow in a lake. Nutrient availability and root anchoring are ways that sediment influences the growth of aquatic plants. Organic, nutrient rich sediments, such as muck, create ideal conditions for many aquatic plant species. Coarse, sandy sediments have lower nutrient availability, which creates less than ideal conditions for aquatic plant growth. Clay sediments have the capability to retain and provide nutrients to aquatic plants; however, highly compact clay sediments can limit the ability of the plant's roots to grow.

During the 2024 aquatic plant survey, the pole rake was used to feel for and categorize the dominant sediment type at each sample point. Six sediment types were observed across the lake (Table 3-14). Muck was the most prevalent sediment type (60.7% of sites). Clay and rock mix was the least prevalent sediment type (0.3% of sites). Additional sediment data, summary statistics, and figures are included within the *LLBDM Aquatic Plant Survey Tech Memo* (Appendix B).

Table 3-14. Dominant Sediment Type Summary Statistics.

Dominant Sediment Type	Number of Sample Points	Percentage of Sample Points
Clay	22	3.4%
Muck	389	60.7%
Rock	173	27.0%
Sand	46	7.2%
Clay/Rock Mix	2	0.3%
Muck/ Rock Mix	9	1.4%

3.6. Land Use

3.6.1. Watershed Land Use

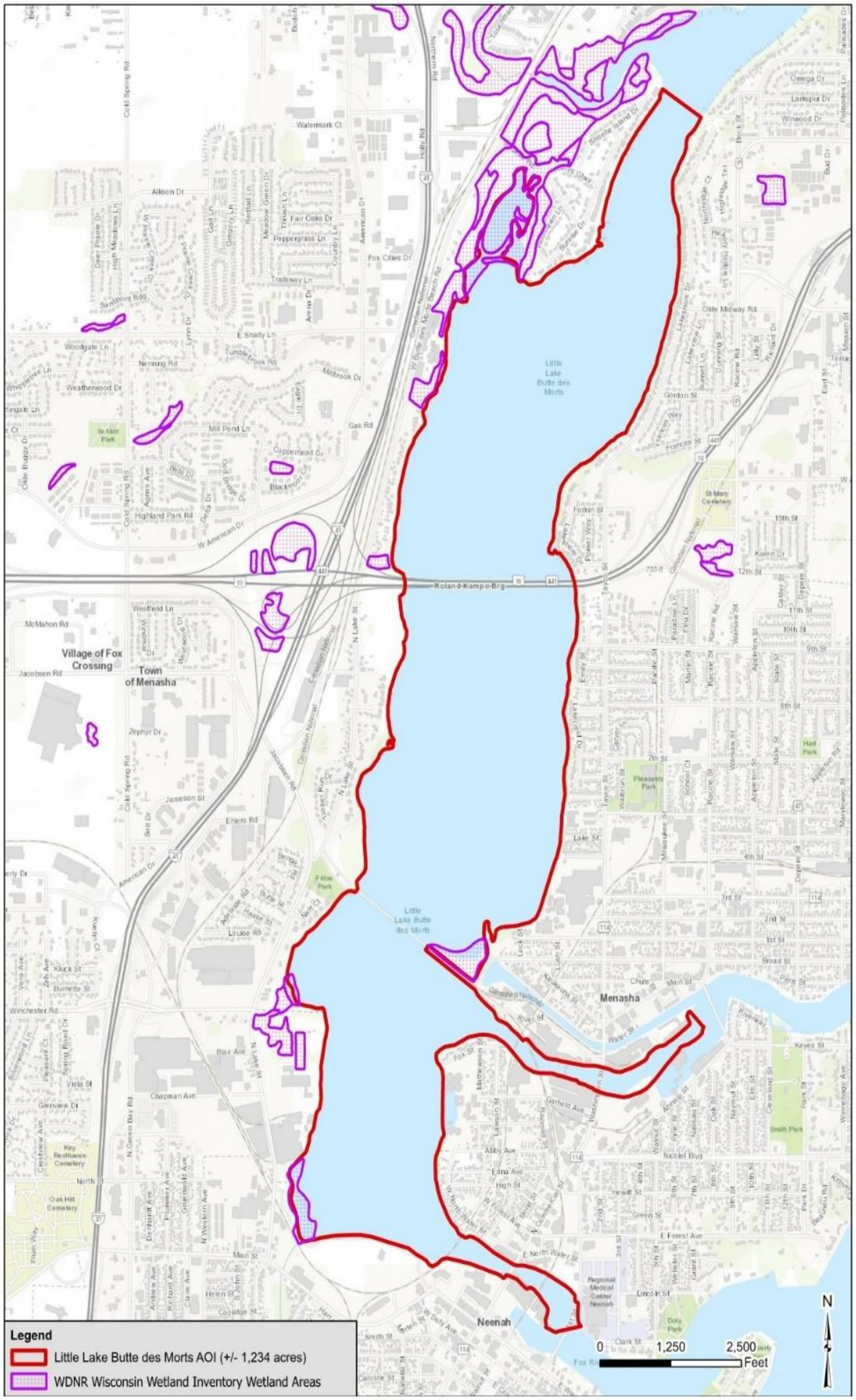
Historical land cover within the LLBDM watershed was likely a mix of prairie, oak forests and savannah, and maple-basswood forests. Wetlands, including wet-mesic prairies, southern sedge meadows, emergent marshes, and calcareous fens were found in the lower portions of the landscape [10].

Maple-basswood forests and oak openings were the dominant original land cover of this region, with swamp conifer forests, prairie, lowland hardwood forest, and marsh/ sedge meadow mixed throughout. Following European settlement, land use drastically changed and shifted towards an agriculture dominated landscape. Land use was dominated by agriculture prior to 1938 [20].

Current land use within the LLBDM watershed is a mix of suburban ([ex. residential development] 32.90%), agricultural (23.00%), urban ([ex. municipal, industrial, and commercial development] 22.50%), grassland (8.61%, open land (5.41%), and other uses (7.51%). The watershed contains approximately 60.88 miles of rivers and streams, 74.47 acres of lakes, and 848.70 acres of wetlands [1].

The original land cover of LLBDM was influenced by the Fox River and its floodplain dynamics. The dominant feature of this landscape would have been an extensive wetland complex. A review of the WDNR Wisconsin Wetland Inventory (WWI) indicates mapped wetlands along the shoreline of LLBDM near the mouth of Mud Creek/ Stroebe Island, the I-41 on/ off ramp, the intersection of County Road II and North Lake Street, the mouth of the Neenah Slough, and the eastern extent of the Friendship Trail [21]. This includes the 48-acre Guckenberg-Sturm Preserve, also known as the Stroebe Island Marsh. WDNR wetland indicators are present throughout the majority of the land adjacent to and nearby LLBDM. WDNR WWI wetlands are shown in Figure 3-14.

Figure 3-14. Wisconsin Wetland Inventory mapped wetlands surrounding LLBDM.



3.6.2. Shoreline Development

Prior to 1938 land use surrounding LLBDM consisted of mainly agricultural development [20]. High density residential development was present along the LLBDM shoreline near the Neenah Channel and the Fox River Lock Channel – Menasha [20]. By 1957, residential development had extended up the eastern and southwestern shorelines of LLBDM, industrial development had expanded near the Fox River Lock Channel – Menasha, the I-41 highway corridor had been developed to the west of LLBDM, and STH 10 had been developed with a bridge crossing over LLBDM [22]. By 1976, residential development had further expanded around the southern shoreline and to the east of LLBDM [22]. By 1994, industrial and residential development had expanded along the northwestern shoreline of LLBDM and agriculture development near LLBDM decreased [22]. The shorelines of LLBDM continue to remain in high density residential development, industrial development, transportation development, with small amounts of public, undeveloped land mixed in.

Figure 3-15. Wetland (top) and forb (bottom) vegetation buffer areas mapped during the shoreline erosion inventory.

Source: Winnebago County LWCD.

Managing the lake and shoreline properties to prevent erosion is a challenge. To further understand existing shoreline conditions, a shoreline inventory of LLBDM was conducted by Winnebago County LWCD on May 30 and 31, 2024. The inventory consisted of capturing drone photography of the shoreline and conducting GPS collection of erosion and vegetative buffers along the LLBDM.

A total of 13 vegetative buffer points were recorded including two buffers less than 10 feet wide, five buffers between 10 – 35 feet wide, and six buffers greater than 35 feet wide. Dominant vegetation within the buffers included forbs, grasses, wetlands, and trees/ shrubs (Figure 3-15).

A total of seven shoreline erosion lines were mapped including four areas with low/ slight erosion, two areas with moderate erosion, and one area with high/ severe erosion (Figure 3-16).

At the time of the surveys, water levels in the lake were high because of recent precipitation, which may have limited the ability to identify all possible areas of erosion. Stakeholders reported on steepness, erosion, and landscape features of shoreline property. Most property was considered “not too steep” or “somewhat flat". 30% of the SPO group reported their property has a "somewhat steep" or "very steep" slope. In contrast to the results of the shoreline erosion inventory conducted in 2024, shoreline erosion was reported by 34% of the SPO group at their property. The presence of a steep slope and erosion were mostly reported by SPOs on the northeastern shoreline.

Figure 3-16. Moderate (top) and severe (bottom) erosion areas mapped during the Winnebago County LWCD shoreline erosion inventory.

Source: Winnebago County LWCD.

3.7. Native Wildlife & Habitat

Eutrophic lakes, such as LLBDM, support an abundant variety of species. In Wisconsin, 80% of endangered or threatened species spend all or part of their lives using shoreland habitat [23]. Some species, such as certain types of waterfowl, require upland habitat for breeding/nesting and an aquatic or semi-aquatic habitat for feeding. Others, like fish, live in a true aquatic habitat, but might rely on insects that require habitat near the shore.

The habitat present in LLBDM supports activities which are highly valued by the public including enjoyment of the water and viewing of wildlife. Results from the stakeholder surveys indicate a wide variety of recreational uses of the lake related to fish and wildlife on LLBDM. When asked about important factors in purchasing or owning property on LLBDM, approximately 75% of shoreline property owners ranked wildlife viewing/ bird watching and approximately 55% of shoreline property owners ranked fishing as “extremely important” or “moderately important”. On the other hand, 28% of general public respondents ranked wildlife viewing/ bird watching and 25% of general public respondents ranked fishing as one of their top three most important reasons for visiting LLBDM. Additionally, 72% of shoreline property owner respondents and 51% of general public respondents reported they have fished in LLBDM previously, with over 34% of both survey groups reporting they have fished in LLBDM for over 16 years.

To understand the connection that stakeholders make between aquatic plants and wildlife habitat, stakeholders were asked to select how important they feel it is to protect habitat within LLBDM. A total of 67% of the shoreline property owners group and 69% of the general public group reported that it is “extremely important”. This suggests a desire for balanced management approaches that address both recreational access and ecological preservation.

During a stakeholder mapping exercise, participants were asked to illustrate areas where they would like to see habitat preserved. Data and notes from the worksheets were merged and digitized onto a map. Results indicated that areas to the west of Stroebe Island, along the west shore under US-10, along the trestle trail, and the southern portion of LLBDM were noted to be areas that stakeholders want to see preserved for fish and wildlife habitat. Comments left by stakeholders indicate a desire to see the habitat preserved for fish. Stakeholders recognize the importance of aquatic vegetation communities to healthy fish populations and recreational opportunities, such as fishing and wildlife viewing. Aquatic plant management should be carefully conducted in these areas to enhance public access for recreational activities, such as fishing, while protecting the integrity of the habitat. Habitats of significance identified by stakeholders are illustrated in Figure 3-17.

The towns of Neenah and Menasha are considered one of the best places for gulls in the state, with at least thirteen species recorded [24]. LLDBM is also a popular fishing destination for panfish, bass and walleye. A comprehensive habitat field assessment has not been performed for LLBDM. Field observations, desktop reviews, and consultations with the WDNR were completed to understand what habitat currently exist as well as the fish and wildlife species present within or near LLBDM. Results of that desktop activity are described in the sections below.

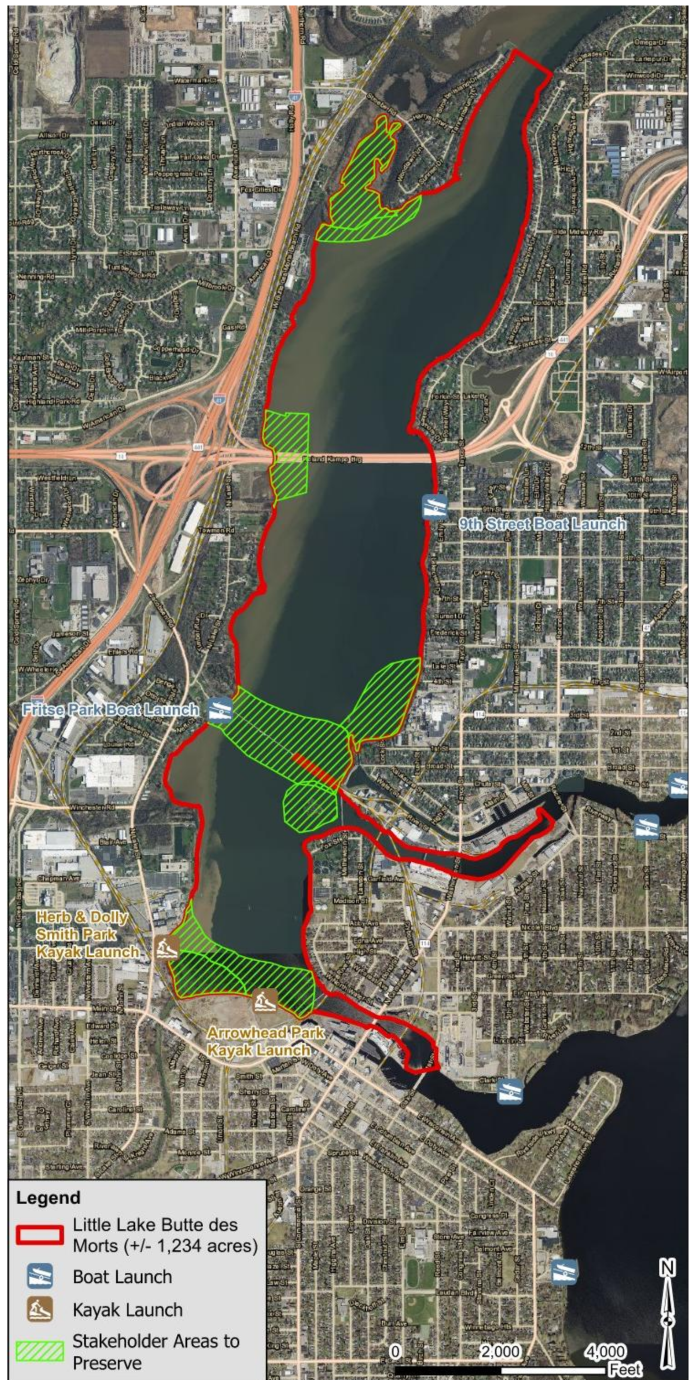
3.7.1. Fish

Fish have an important role in aquatic ecosystems, as they drive food chain dynamics through predation, and mediate nutrient fluxes. Fish species generate ecosystem services through ecological function and meeting human demands for harvest [25]. Habitat for fish species is dependent on physical structure and water quality. Physical structure for fish habitat includes riparian structures, aquatic vegetation, woody habitat, and substrate.

Shoreline buffers provide many benefits including filtering nutrients, pesticides, and animal waste from agricultural land runoff [26]. They also stabilize eroding banks; filter sediment from runoff; provide shade, shelter, spawning habitat, and food for fish and other aquatic organisms, as well as providing wildlife habitat and corridors for terrestrial organisms. Of surveyed shoreline property owners only 14% indicated a native vegetated shoreline buffer. Nearly all shoreline property owners (99%) reported that they have a conventional lawn on their property, and most (88%) remove leaves. The vast majority of SPOs also have impervious structures such as a dock (84%) and boatlift (62%).

Aquatic vegetation is a vital component of aquatic ecosystems and provides habitat for many aquatic organisms. Structure created by aquatic vegetation provides food for small fish, zooplankton, and other aquatic animals. As shelter it shades and protects fish from predators and cannibalism. For spawning and rearing aquatic vegetation provides areas for fish to lay eggs and raise their young [27].

Figure 3-17. Potential fish or wildlife habitat preservation areas selected by stakeholders.

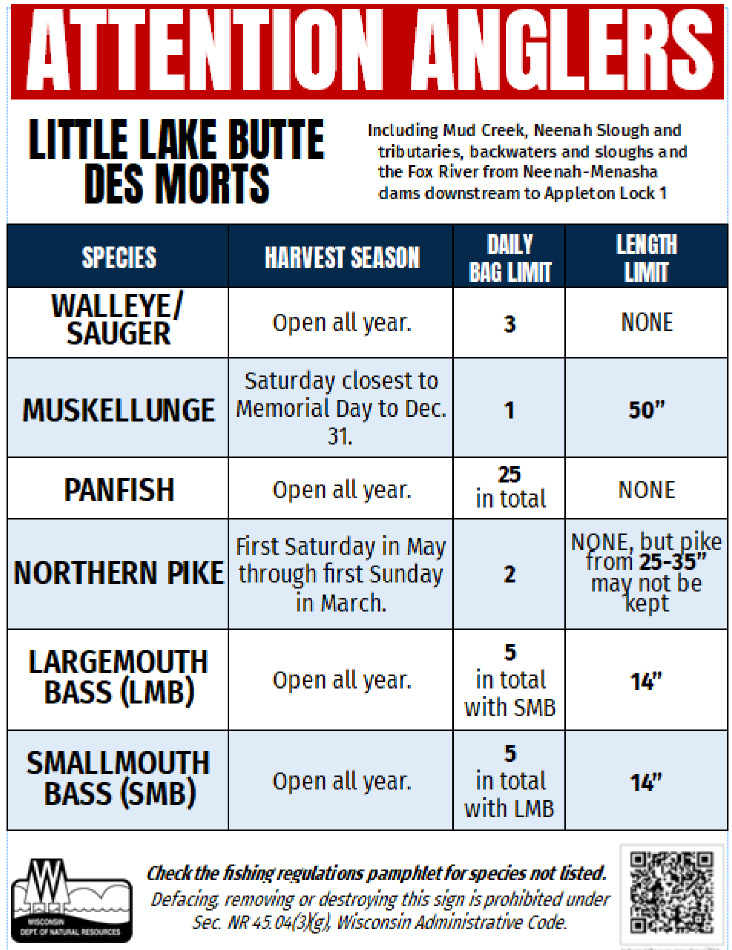


Note: The Green Areas were identified by stakeholders during the first public meeting's mapping exercise for habitat preservation in July 2024. Source: GEI Consultants.

Aquatic vegetation can increase water quality by removing nutrients from the water; it also protects sediments as it slows down water velocity, protecting spawning sites from silt accumulation.

Shoreline woody habitat provides food and protection for smaller fish from predators, currents and sunlight. Fallen trees provide shelter and feeding areas for a diversity of fish species and may also provide nesting and sunning areas for birds, turtles and other terrestrial animals. Nearly all fish species use woody habitats for at least a portion of their life cycle [28]. Providing a surface for algal growth, wood debris traps organic material, a food source for invertebrates and fish. Large woody structures that are anchored to the shore and partially or fully submerged can improve fish habitat by providing hard surfaces to lay eggs and creating pools of water for spawning. Woody debris reduces wave action and sediment suspension increasing clarity, prevents erosion and increases overall habitat diversity [29].

Figure 3-18. WDNR fishing regulations for LLBDM.



ATTENTION ANGLERS

LITTLE LAKE BUTTE DES MORTS

Including Mud Creek, Neenah Slough and tributaries, backwaters and sloughs and the Fox River from Neenah-Menasha dams downstream to Appleton Lock 1

SPECIES	HARVEST SEASON	DAILY BAG LIMIT	LENGTH LIMIT
WALLEYE/ SAUGER	Open all year.	3	NONE
MUSKELLUNGE	Saturday closest to Memorial Day to Dec. 31.	1	50"
PANFISH	Open all year.	25 in total	NONE
NORTHERN PIKE	First Saturday in May through first Sunday in March.	2	NONE, but pike from 25-35" may not be kept
LARGEMOUTH BASS (LMB)	Open all year.	5 in total with SMB	14"
SMALLMOUTH BASS (SMB)	Open all year.	5 in total with LMB	14"

Check the fishing regulations pamphlet for species not listed.
Defacing, removing or destroying this sign is prohibited under Sec. NR 45.04(3)(g), Wisconsin Administrative Code.

Source: WDNR, 2024.

The LLBDM shoreline erosion survey located little erosion or vegetative buffers. A total of 13 vegetative buffer points were located, and seven erosion line locations were recorded. Water levels in the lake were high because of recent rainfall which may have limited the ability to identify all possible areas of erosion. A typical Lake Butte des Morts property has less than 100 feet of frontage, a low bank, and rock rip rap. The invasive round goby prefers rocky habitat. Rip-rap additions increase round goby abundance and invasion success, while vegetated banks increase the abundance and diversity of native species [30].

Substrate is a vital component of fish habitats which provides shelter, food, and a place to spawn. The type of substrate, its grain size, and its surface roughness can all impact fish growth, survival, and reproduction. Substrate in aquatic habitats consists of surface and subsurface materials in the streambed, riverbed, or ocean bottom with different fish preferring different types of substrates. In freshwater ecosystems, substrate is classified by particle size [31]. In LLBDM the majority of substate is muck, fine sediment rich in organic matter. Shoreline rip rap additions add large rocky substrate and there is some (< 20%) sand, with shallow rocky substrate found near James Island. Ledges and channels within a waterbody are used by fish as structures to rest, ambush, and access deep water and favorable flows.

Fish passage in tributaries that are connected to LLBDM are another important habitat element for many fish species. WDNR fisheries staff conducted fish passage assessments on Mud Creek and the Neenah Slough in 2020. Findings from the study indicate that both of these LLBDM tributaries are highly utilized by multiple fish species. These tributary habitats can serve as important spawning grounds for both game and forage species as well as nursery areas for young fish.

Several different data sources from the WDNR were used to determine which fish species are present in LLBDM including the WDNR lakes page, the Fisheries Management Information System (FMIS), and communications with WDNR fisheries staff. The WDNR has stocked northern pike and muskellunge in the past. Northern pike were stocked in LLBDM in 1974, 1988, 1990, and 2007 [32]. LLBDM currently hosts a healthy northern pike population that is sustained solely through natural reproduction. Muskellunge were stocked in LLBDM in 1979, 1988, 2003, 2004, 2005, 2006, 2021, and 2024 [32]. Stocking of 600 yearling muskellunge every other year is proposed by the WDNR for LLBDM in future years. Fishing regulations for commonly targeted species on LLBDM are shown in Figure 3-18.

The WDNR conducts a comprehensive fisheries survey on LLBDM every 5 years with additional surveys completed for special projects. WDNR fisheries completed surveys on LLBDM in 2015, 2020, and 2021, including electrofishing and fyke net surveys, captured a total of 9,028 individual fish representing 29 different species (Table 3-15).

Table 3-15. Number of fish captured per species in all fyke net and electrofishing surveys in 2015, 2020, and 2021 on LLBDM.

Fish Species	Number of Fish	Fish Species	Number of Fish
Bigmouth buffalo	8	Longnose gar	26
Black bullhead	16	Northern pike	490
Black crappie	439	Pumpkinseed	226
Bluegill	862	Pumpkinseed x bluegill	1
Bowfin	43	Quillback	2
Brown bullhead	16	Rock bass	329
Bullheads	12	Sauger	1
Burbot	122	Shortnose gar	13
Channel catfish	69	Smallmouth bass	56
Common carp	145	Walleye	502
Freshwater drum	162	White bass	44
Gizzard shad	3	White sucker	145
Golden shiner	19	Yellow bullhead	113
Largemouth bass	302	Yellow perch	4859
Logperch	3	**Total fish captured:**	**9,028**

Table notes: Data were provided by WDNR Fisheries Biologist, Angelo Cozzola, on June 6, 2024, and January 15, 2025.

3.7.2. Birds

Birds play a crucial role in maintaining healthy ecosystems through pollination, seed dispersal, and pest control. Habitat requirements vary per species, but general requirements are food availability and structures for cover and nesting. Diverse bird populations indicate a balanced ecosystem, their presence and health can signal environmental changes. Complex vegetation structure increases available foraging and breeding resources, therefore increasing the number and diversity of species an area can support [33]. The bird habitat in LLBDM consists of open water, emergent marsh, patches of bottomland hardwoods, and urban development.

In open water habitat, mats of floating vegetation provide diverse food resources including many invertebrates, and nesting substrates. Lake shorelines with intact native plant communities and coarse woody debris provide nest sites, food sources and cover for protection. Isolated islands in lakes and rivers such as James Island in LLBDM support colonial waterbirds [34]. Open water habitats support large hatches of midges and other aerial insects, as well as fly larvae and amphipods which are especially important prey. The winter buds and rootstocks of submergent macrophytes provide food for a variety of waterfowl. Inland lakes such as LLBDM provide important migratory staging and feeding areas. Small herons, some shorebirds, and flocks of blackbirds sometimes forage on their floating-leaved aquatic beds. Lakes with a large surface area and high pH may support high abundances of fish and thus piscivorous birds, other waterbirds may occupy these open waters as long as food remains accessible [35].

Figure 3-19. Birds loafing on course woody habitat that had fallen into the lake.

Source: Jon Gumtow

Emergent marshes are among the most productive of all habitats for waterfowl and other waterbirds. Large marshes or marshes within a wetland complex often support a diverse breeding bird community because of the variety of habitat conditions and nesting substrates. Emergent marshes provide abundant food sources in the form of seeds and invertebrates as well as optimum brood habitat for many of Wisconsin's locally breeding waterfowl [36]. Mudflats associated with edges of emergent marshes support plants used by wetland-associated species and numerous migrant waterfowl species. Considering the diverse habitat requirements of emergent marsh birds, it is important to maintain a mosaic of conditions across the landscape [37].

Bottomland hardwoods are dynamic component of a larger ecosystem interspersed between developed shoreline on LLBDM. The bottomland hardwood bird community supports fish-eating birds, including herons, egrets, Bald Eagle, Osprey. Dead or dying trees killed by flooding or disease support cavity nesters, bark gleaners, and wood drillers. Their location along major river corridors also make bottomland hardwoods critical habitat for migrating birds, particularly landbirds, in both fall and spring [38].

Many bird species have adapted to utilize urban development as habitat. Various types of urban landscapes such as naturally vegetated spaces, lawns, parks, and street trees play important roles as bird habitat. Green spaces in urban landscapes can serve as bridges between protected areas and natural habitat [39]. Landscaped lawn spaces are used to forage for insects, gardens support nectar-feeding birds. Man made structures such as docks, building ledges and bridges are used as roosts, and rooftops can mimic cliff nesting sites. In LLBDM stakeholder surveys there were concerns about the size of Canadian geese populations and the majority of SPOs felt geese waste was contributing to poor water quality. Incidental bird observations throughout the Project Area were recorded during the 2024 aquatic plant survey in July 2024. Identification was completed by a GEI environmental scientist. A total of 20 different bird species, including one state endangered species and one state species of concern, were observed. The incidental bird observations are listed in Table 3-16.

Table 3-16. Bird Observations on LLBDM by GEI in 2024.

Species Name	Scientific Name
American robin	*Turdus migratorius*
American white pelican	*Pelecanus erythrorhynchos*
Bald eagle	*Haliaeetus leucocephalus*
Barn swallow	*Hirundo rustica*
Belted kingfisher	*Megaceryle alcyon*
Black-crowned night-heron[1]	*Nycticorax nycticorax*
Canada goose	*Branta canadensis*
Caspian tern[2]	*Hydroprogne caspia*
Double-crested cormorant	*Phalacrocorax auritus*
European starling	*Sturnus vulgaris*
Great blue heron	*Ardea herodias*
Great egret	*Ardea alba*
Herring gull	*Larus argentatus*
Mallard	*Anas platyhryhnchos*
Mourning dove	*Zenaida macroura*
Osprey	*Pandion haliaetus*
Red-winged blackbird	*Agelaius phoeniceus*
Ring-billed gull	*Larus delawarensis*
Rock pigeon	*Columba livia*
Tree swallow	*Tachycineta bicolor*

Table Notes:

1. Wisconsin state species of concern
2. Wisconsin state endangered species
3. All observations took place on 7/22/24 and 7/24/24

4. LAKE ACCESS, USE & NAVIGATION

4.1. Lake Access and Recreation Amenities

Little Lake Butte des Morts offers a variety of recreational opportunities and is heavily used for by shoreline property owners and residents of the broader region. Recreational features and public access on LLBDM include Loop the Little Lake, Fox Wisconsin Heritage Water Trail, Fritse Park and Rydell Conservancy, Ninth Street Boat Launch, Grant Park, Butte des Morts Park, Herb and Dolly Smith Park, Arrowhead Park, Guckenberg-Sturm Preserve, Menasha Lock, and the Neenah Slough (Figure 4-1). A description of each of these features is described below.

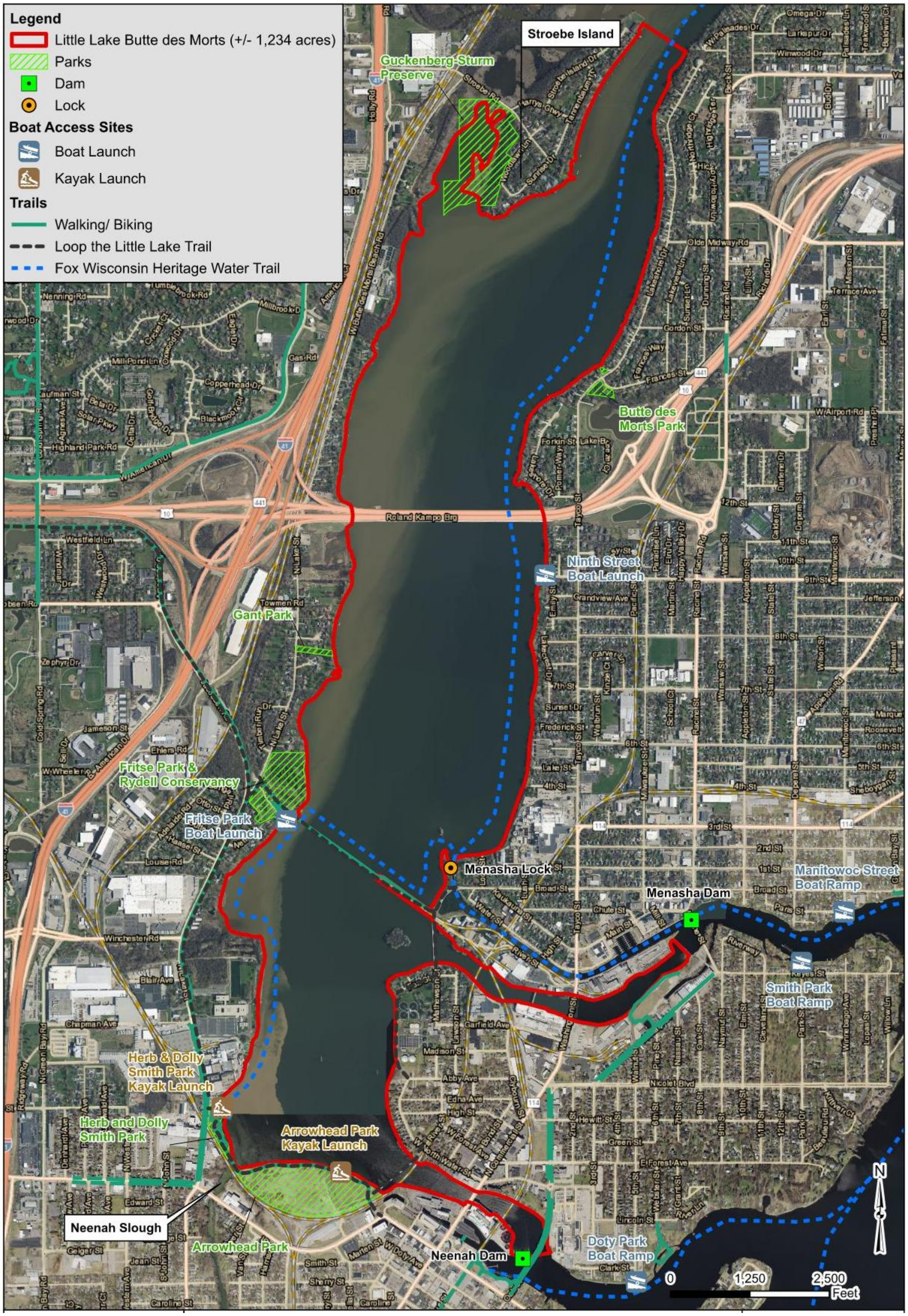
Loop the Little Lake

According to the City of Neenah website, Loop the Little Lake, often referred to as the "Loop" is a 3.5-mile route that consists of off-road and pedestrian trails and links the communities of the Village of Fox Crossing, City of Menasha, and City of Neenah [40]. The Loop provides access to LLBDM with four unique trestle crossings: Fox Cities Trestle, Slough Trestle, Neenah Trestle, and Menasha Trestle [40]. Details about each of the four unique trestle crossings:

1. Fox Cities Trestle:
    a. Approximately 1,600 feet long
    b. Provides views of the entire lake including the 441 bridge, paper mills, open space, and residential development along the shores.
2. Slough Trestle:
    a. Approximately 150 feet long
    b. Crosses the Neenah Slough connecting Herb and Dolly Smith Park and Arrowhead Park in the City of Neenah.
3. Neenah Trestle:
    a. Approximately 740 feet long
    b. Connects Arrowhead Park to North Water Street near Cook Park in the City of Neenah near the border of the City of Menasha.
4. Menasha Trestle:
    a. Approximately 725 feet long
    b. Connects the Menasha Locks and Trestle Trail with Fox Street near Shepard Park in the City of Menasha.

The Loop also connects to other trails that extend beyond LLBDM to other communities and waterbodies, including Lake Winnebago. These trails include the Paper Trail, the Friendship Trail, and many others.

Figure 4-1. LLBDM Recreational Access, Parks, and Trails.



Fox-Wisconsin Heritage Water Trail

The Fox-Wisconsin Heritage Water Trail is a paddle friendly water trail designated as a National Recreational Trail designed for non-motorized watercraft that connects the Upper Fox River, Winnebago Lakes, LLBDM, Lower Fox River, and Lower Green Bay.

Fritse Park and Rydell Conservancy

Fritse Park is a 15.26-acre park located along the southwest shoreline of LLBDM near the Friendship Trail bridge in the Village of Fox Crossing. Approximately 10.5 acres of the park was acquired from the Natural Resource Damage Assessment and Restoration (NRDA) Fox River PCB Clean-up Settlement in 2003 and is referred to as Rydell Conservancy.

Figure 4-2. Aquatic vegetation washed up near the Fritse Park Boat Launch.

Source: GEI Consultants, 2024.

The park has a boat launch with a boarding dock and kayak launch that are Americans with Disabilities Act (ADA) accessible. Kayak rentals are available onsite. The daily launch fee is $5.00, which can be paid by card or cash at the kiosk. A high-pressure wash station, ADA accessible kayak launch, and personal floatation device (PFD) station are also available [41]. The boat wash station and kayak rental station have usage and rental fees. The boat wash station requires quarters to start; however, there is no change machine available on-site. The kayak rental requires scanning a QR code and paying rental fees online. A year-round two-tiered comfort station with restrooms and an indoor pavilion exists in the park.

The 2024 aquatic plant survey results indicate that dense aquatic vegetation growing and washing up at the boat launch may inhibit or make launching more difficult (Figure 4-2).

Ninth Street Boat Launch

The Ninth Street Boat Launch is located along the east-central shoreline of LLBDM just south of the Roland Kampo Memorial Bridge. The boat launch is managed by the City of Menasha. The boarding docks are not ADA accessible, and no boat wash station is available [42]. The 2024 aquatic plant survey results indicate that dense aquatic vegetation growing around, and washing up around, the boat launches may inhibit launching or make it more difficult.

Herb and Dolly Smith Park

Herb and Dolly Smith Park is located on the southwest corner of LLBDM within the City of Neenah. The kayak and canoe launch provide non-motorized access to LLBDM within the pilot project area. There is also a fishing deck that provide shoreline fishing opportunities, and the park is connected to the Loop.

Arrowhead Park

Arrowhead Park is located along the southern extent of LLBDM within the City of Neenah. This was the former location of the Arrowhead Park Landfill. Ongoing efforts to restore and enhance connections to the site are being conducted by the Neenah Parks and Recreation Commission. Arrowhead has a new kayak launch that is located along the southern shoreline of LLBDM.

Guckenberg-Sturm Preserve

The Guckenberg-Sturm Preserve is also located along the west shore of LLBDM near Mud Creek [43]. This preserve is approximately 48-acres and is protected by the Northeast Wisconsin Land Trust (NEWLT). The preserve is adjacent to and includes Strobe Island.

Grant Park

Gant Park, a 1.13-acre park located on the west shore of LLBDM in the Village of Fox Crossing, was acquired through NRDA grant funds as a part of the Fox River PCB Clean-up Settlement.

Butte des Morts Park

Butte des Morts Park is a 1.6-acre park located on the east shore of Little Lake Buttes des Morts in the Village of Fox Crossing. Facilities include a natural area and trail along with playground equipment.

Neenah Slough (Neenah Creek)

The Neenah Slough, also called Neenah Creek, is a unique system because it can be characterized as a stream, lake and marsh[24]. According to the WDNR, the slough is one of the major northern pike spawning areas connected to LLBDM. Migrating waterfowl utilize the wetlands located along the slough as resting and feeding areas. The slough ends where it enters LLBDM and is a popular route for kayaking and other paddle sports. Access to the slough for these activities is a valuable recreational asset to the community.

Menasha Lock

The Menasha Lock is owned by the Fox River Navigational System Authority (FRNSA). The lock was heavily utilized by commercial traffic until the late 1950s. By 1987, the USACE closed all but three of the locks in the Lower Fox River, which resulted in the Menasha lock being utilized by recreational boaters because of the connection to Lake Winnebago. In 2015, due to the presence and identification of an invasive fish (round goby) caught below the Neenah Dam in LLBDM, the Menasha locks was closed to prevent the goby from entering the Winnebago System. The lock has remained closed since 2015. More information on the closure is provided in Section 7.

4.2. Stakeholder Lake Usage

Stakeholders provided insight into their recreational usage through stakeholder surveys and a public meeting held in July 2024. LLBDM serves as a multifaceted recreational resource, with stakeholders reporting active participation in boating, kayaking, trail activities, wildlife viewing, fishing, and swimming. Most of the general public respondents reported visiting LLBDM multiple times per year, with 95% visiting at least twice and 43% more than 20 times per year. The high frequency of visits underscores the lake's importance as a local recreational and community resource.

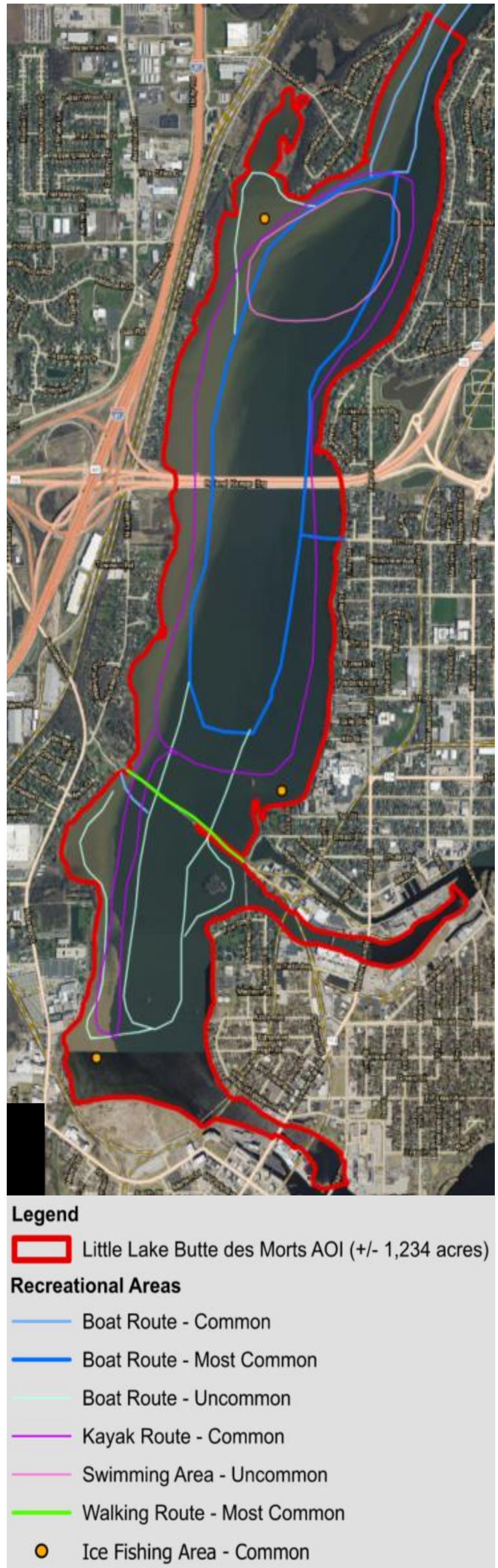
The most popular recreational activities reported by both the shoreline property owner and general public survey groups was walking or biking the trails. The biggest difference in lake use across the stakeholder groups was related to watercraft usage patterns, which reveal distinct preferences and behaviors amongst the two groups.

[24] https://apps.dnr.wi.gov/water/waterDetail.aspx?WBIC=130800

Although shoreline property owners conduct motorized boating on a more frequent basis (43% daily or weekly), not all shoreline property owners partake in motorized boating. A large portion of general public respondents (41%) have participated in motorized boating on LLBDM at some point in time, highlighting watercraft use may be an activity drawing lake users to LLBDM. The Ninth Street Boat Launch was the most common access point to the lake reported.

The most frequently reported boat navigation route indicated by stakeholder mapping activity participants is a loop around the north central portion of LLBDM, ranging from approximately 400-900 feet offshore (Figure 4-3). A route from the northern portion of LLBDM to the LFR was also commonly noted. A loop along the northcentral shoreline of LLBDM was highlighted as a common kayaking route, with a few responses also noting the southwest shoreline as a kayaking route. A loop within the northern portion of LLBDM was noted as a swimming route by a few participants. Three ice fishing areas were commonly noted on the maps and are located near the northwest, southwest, and east-central shoreline of LLBDM.

Figure 4-3. Stakeholder mapped recreation.



5. AQUATIC PLANTS

5.1. Understanding Where Plants Grow

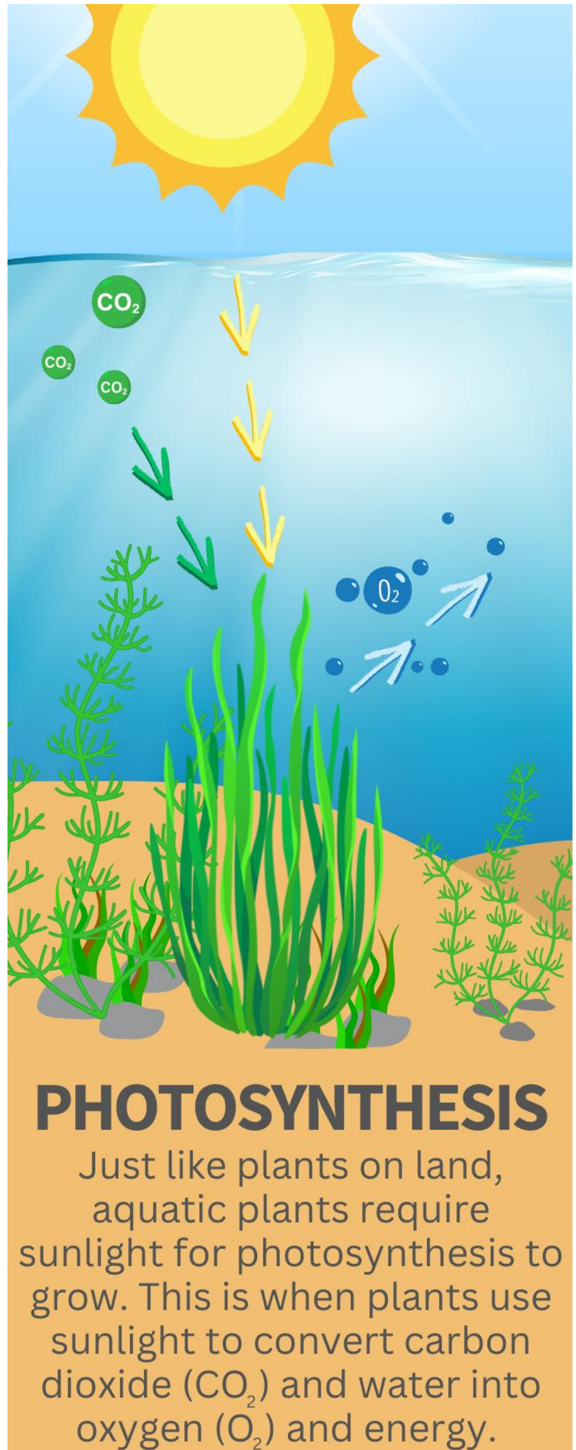
Plants and algae are primary producers. This means that they take sunlight and carbon dioxide in the water and convert them into energy to grow (a process called photosynthesis shown in Figure 5-1). As part of this process, plants release oxygen into the water which is important for fish and other underwater animals.

To understand where plants are likely to grow, we can divide the lake into different zones based on physical, chemical and biological features. The zones of a lake are interconnected, creating a complex freshwater ecosystem. The primary lake zones are euphotic, aphotic, and benthic. The euphotic zone is further divided into the littoral zone and the limnetic zone. Each zone is shown and described in Figure 5-2.

These zones influence where different types of plants can be found within a waterbody. For example, plants need sunlight, water, nutrients, and proper temperature to photosynthesize. Emergent, floating leaf, and submerged plants also need stable soil or lakebed sediment for their roots [44]. The amount of sunlight that gets through the water, how deep sunlight reaches, the temperature of the water, the sediment type, and the amount of nutrients available all play a role in where aquatic plants can grow. This is why plants are typically found in the shallow; warmer areas of the lake called the littoral zone.

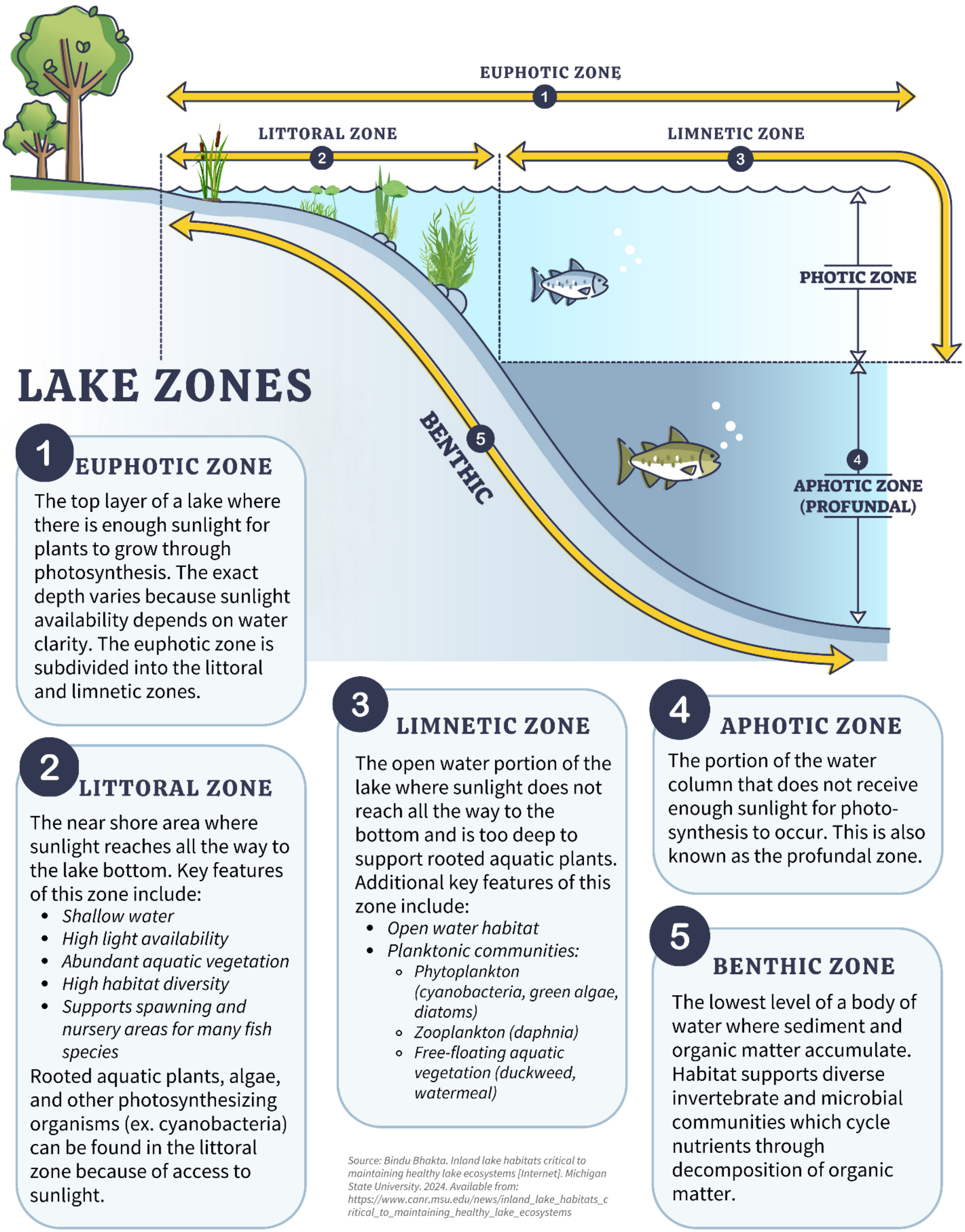
Understanding lake zones, including the interactions among zones, is crucial when making decisions for lake and aquatic plant management. The littoral zone will be the focus of this plan because this is where the majority of aquatic plants are found.

Figure 5-1. Illustration of photosynthesis.



Source: GEI Consultants

Figure 5-2. Illustration of lake zones.



5.2. Benefits and Types of Aquatic Plants

Native aquatic plants, including algae, are important for supporting healthy lakes [45]. Plants form the foundation of the lake ecosystem and provide many benefits to both animals and humans, including:

- Providing food, shelter and spawning or nesting habitat for fish, birds, frogs, turtles and other wildlife [44] [46].
- Producing and releasing oxygen into the water that aquatic organisms need to survive.
- Preserving water quality by using nutrients—like phosphorus and nitrogen—that would otherwise be available for algae growth [47].
- Stabilizing lake sediments with their roots, further protecting water quality and clarity.
- Protecting and stabilizing the shoreline, reducing shoreline erosion by buffering wind and wave energy [47].
- Sustaining healthy populations of fish and wildlife species, which directly supports human recreational opportunities, such as fishing, hunting, and wildlife viewing.
- Competing with invasive plant species helping to keep populations in check.

In LLBDM, a healthy aquatic plant community includes a mix of different types of aquatic plants and algae growing in abundance. This is because LLBDM is a naturally eutrophic lake. True aquatic plants come in four types: emergent, submerged, floating leaf, and free-floating (Figure 5-3). Algae, although not true plants because they lack roots, stems and leaves, are often lumped in with aquatic plants because algae need sunlight to grow. Algae come in numerous forms and most algae in freshwater lakes fall into one of the following three categories: planktonic, filamentous, or plant-like.

EMERGENT PLANTS

Emergent plants are rooted in the lake bottom with their leaves and stems extending out of the water. These types of plants grow along the shoreline and in wetlands. Examples of emergent plants include bulrushes, cattails, arrowhead, wild rice, and native phragmites (common reed).

Emergent plants help to filter runoff from the land to protect water quality. Their network of complex roots stabilize lakebed near the shore and protect the shoreline from erosion by reducing wave energy. These plants also provide cover and nesting habitat for waterfowl and songbirds and spawning habitat for fish such as northern pike and yellow perch [48].

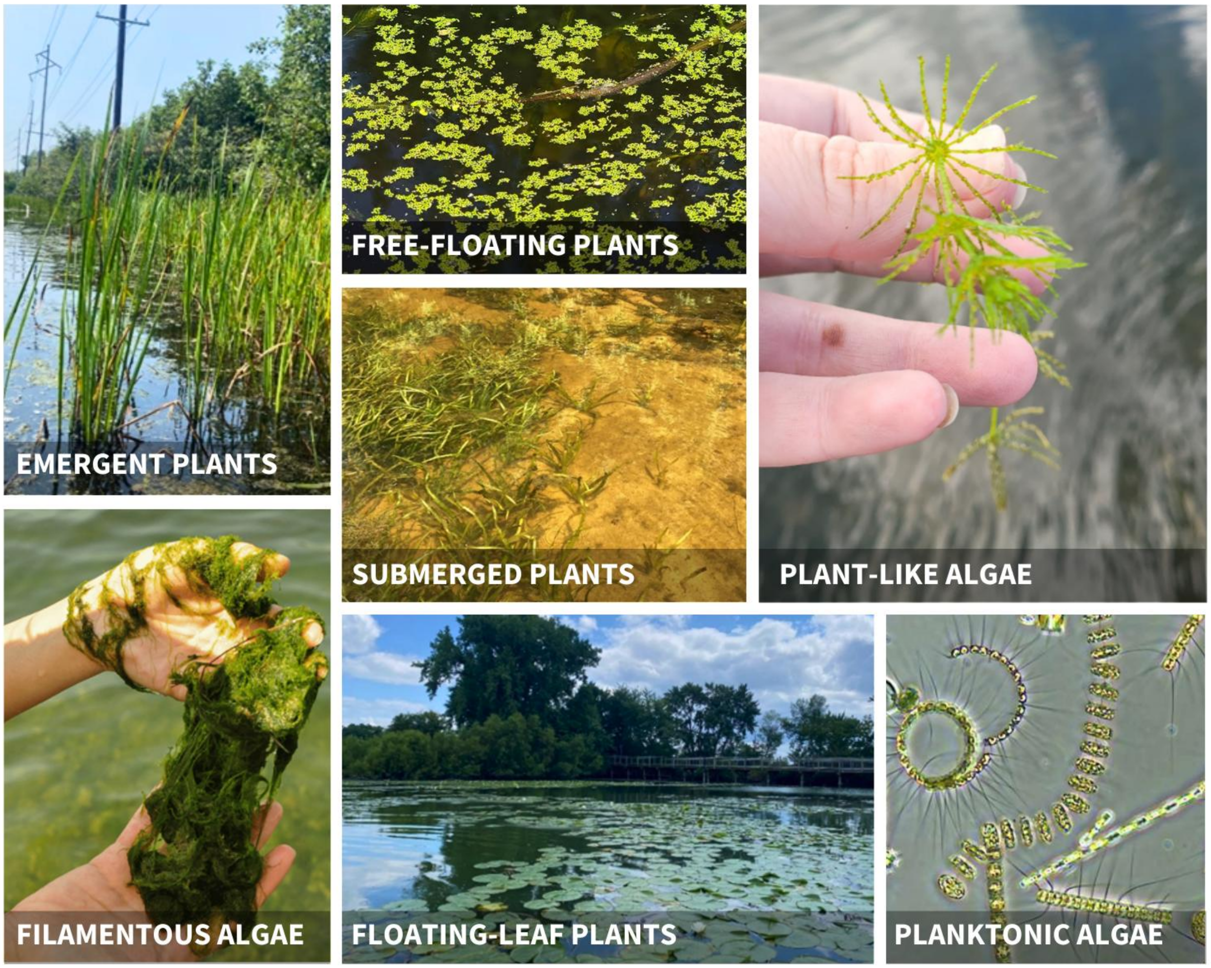
FLOATING-LEAF PLANTS

Floating-leaf plants are rooted in the lake bottom with leaves and flowers that float on the surface of the water. Examples of floating-leaf plants include white water lily, watershield, American lotus, and spatterdock. Floating-leaf plants provide shade and refuge for invertebrates and fish. They also serve as hunting grounds for predatory fish [48].

FREE-FLOATING PLANTS

Free-floating plants float along the surface and are not anchored to the lake bottom by roots. Examples include duckweed and watermeal. Free-floating plants, like duckweed, are important food for waterfowl and songbirds [49].

Figure 5-3. Examples of plants and algae



Sources: Planktonic algae photo : https://phys.org/news/2023-08-plankton-central-life-earth-climate.html; Filamentous algae photo: https://healthyponds.com/filamentous-algae-explained/; all other photos provided by GEI Consultants.

SUBMERGED PLANTS

The vast majority of submerged aquatic plant growth occurs under water, although flowers and seeds on short stems that extend above the water may be present. Submerged plants grow in the littoral zone of the lake (near shore where light reaches the lake bottom). Examples of submerged plants include coontail, common waterweed, wild celery, pondweeds, naiads, and watermilfoils.

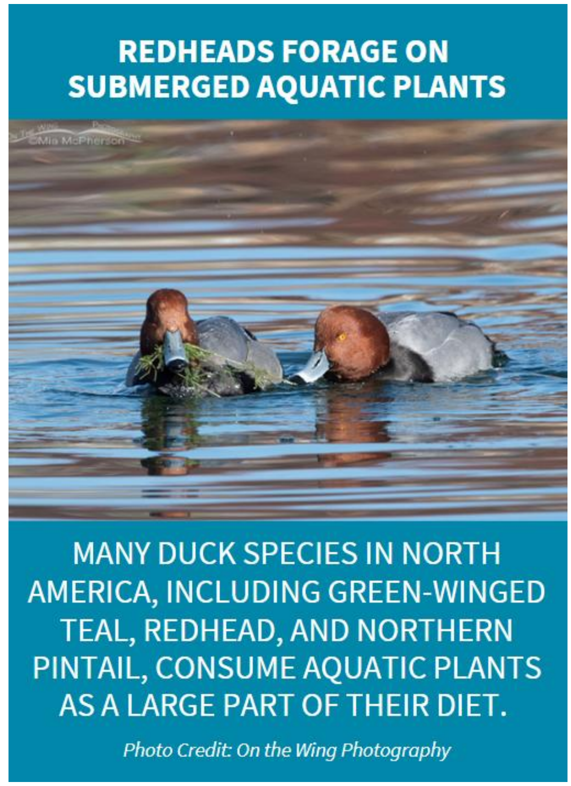
Submerged plants absorb phosphorus and nitrogen through their roots and over the surface of their leaves. Their roots stabilize the sediment and improve water clarity by keeping the sediment from being re-suspended due to wave action. They are also an important food source and provide shelter for fish from predators and create oxygen that helps to sustain life of underwater organisms.

PLANT-LIKE ALGAE

Plant-like algae is a type of macro-algae (large algae) that look very similar to submerged aquatic plants. The difference is that these algae do not have true roots and stems. Examples of plant-like algae include chara, stonewort, and nitella.

FILAMENTOUS ALGAE

Filamentous algae are single-celled organisms that grow together forming long, green hair-like strands. As the filaments entangle with each other, mats can form. This alga is an important part of a healthy aquatic ecosystem in small quantities [50]. It is important to note that filamentous algae are not the same as blue-green algae. There are three common forms of filamentous algae that can be distinguished by texture: Spirogyra (bright green and slimy), Cladophora (cotton-like feel), and Pithophora (coarse texture like horse hair) [51].



PLANKTONIC ALGAE

Planktonic algae, or phytoplankton, are free-floating photosynthesizing microscopic organisms found in the water column [52]. Examples of phytoplankton include diatoms and cyanobacteria (blue-green algae). Algae are important and healthy for a lake in small amounts. Planktonic algae are fed on by zooplankton making it the base of the food chain in lakes. Zooplankton are small animals or immature stages of larger animals such as insect larvae.

When a lake has too little aquatic vegetation, there is a loss of the ecosystem services described above. Inadequate quantity or quality of aquatic plants may reduce the number of fish, wildlife, and invertebrate species capable of surviving and reproducing within the lake. Without suitable habitat being present, recreational opportunities for humans to fish and view wildlife within the lake become limited.

LLBDM hosts well known northern pike and yellow perch fisheries. Aquatic plant communities serve several functions for these species and many others including habitat structure, shelter from predators, foraging area, spawning habitat, and nursery habitat for young fish. The success of these fisheries in LLBDM is likely related to the abundant aquatic plant life.

Small, sparse or fragmented aquatic plant communities create conditions in which nutrients and space are available for the establishment of invasive species and overgrowth of algae. If shorelines lack an aquatic plant buffer, there is an increased risk of shoreline erosion, leading to land loss and expensive repairs to address existing and future erosion. Erosion and algal blooms contribute to decreased water quality and clarity due to increased sediment and algae in the water column.

Algae blooms and invasive species can negatively impact fish and wildlife habitat by reducing water circulation and dissolved oxygen, and increasing water temperatures [53]. Certain species of algae, such as cyanobacteria (also known as blue-green algae), may release toxins as algal blooms die off, which can be harmful to people, fish, and wildlife.

Harmful algal blooms (HABs) occur when colonies of microscopic algae that grow out of control. HABs can grow quickly and form floating mats when conditions are warm, water is calm, and the water has an excessive amount of nutrients such as phosphorus and nitrogen [54]. In Wisconsin, HABs are typically caused by blue-green algae (cyanobacteria). Blue-green algae blooms are considered harmful due to the impact they can have. Dense blooms reduced light penetration in the water column. When algae die and decompose in large numbers, it can deplete dissolved oxygen and cause odor problems [54]. The toxins produced by HABs can sicken humans, pets, cattle, and wildlife [54]. LLBDM routinely experiences large-scale HABs, especially during the late summer months. Ultimately, poor water quality can limit human activities such as boating, kayaking, or swimming in the lake.

HAB observed near the northern end of LLBDM in July 2024. A blue-green algae die-off is present at the center of the photograph (light blue coloration).

Source: GEI Consultants, 2024.

5.3. 2024 Aquatic Plants Conditions in LLBDM

An aquatic plant point intercept (PI) survey was conducted by GEI Consultants with assistance from FWWA on July 22, 24, and 25 in 2024. The goal of the survey was to establish a baseline of aquatic plant presence, abundance, and diversity to inform aquatic plant management for LLBDM. This section provides a summary of the results. A detailed report is available as Appendix B.

The WDNR standardized aquatic plant protocol was followed which included using a double headed rake on a pole or a rope to sample vegetation at predetermined locations [55]. This protocol provides consistency in sampling over time and space, so the survey can be repeated in the future to assess changes. Data collected included: depth, rake fullness, species present, visual sitings, and inaccessible sites. Results from the field survey were used to calculate summary statistics that describe the quality, diversity, and density of aquatic plants in LLBDM (Table 5-1).

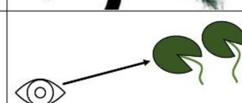
Field technicians sampled 641 out of the 658 pre-determined sampling locations. Sampling points were spaced 88 meters apart (~288 feet). Seventeen locations were not sampled due to shallow water conditions that prevented access. Vegetation was found on the rake at 347 (54.13%) out of 641 locations sampled (Figure 5-6).

During the survey, species found on the sampling rake, through visual observations within six feet of the boat at sample sites, and observations made in other parts of the lake were recorded. A total of 24 species were observed during the survey with 17 different aquatic plant species being found on the sampling rake. A list of species observed is provided in Table 5-2.

Figure 5-4. Double-headed rake utilized during aquatic plant surveys.

Source: GEI Consultants, 2024.

Figure 5-5. Examples of rake fullness ratings.

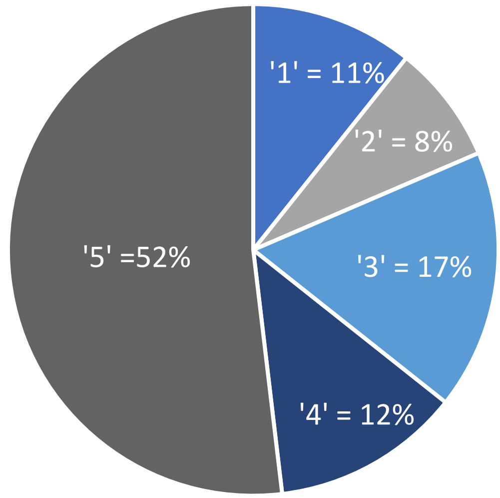
Fullness Rating	Coverage	Description
1		Only few plants. There are not enough plants to entirely cover the length of the rake head in a single layer.
2		There are enough plants to cover the length of the rake head in a single layer, but not enough to fully cover the tines.
3		The rake is completely covered and tines are not visible.
Visual		Any observed species within 6 feet (2m) of the sample site, but not collected on the rake.

Source: Modified from WDNR protocols.

Rake fullness is used as an indicator for plant density and abundance and values are assigned using the fullness ratings shown in Figure 5-4. After pulling the rake from the water at each sampling location, total rake fullness was recorded. A separate rake fullness score was also assigned to each species present on the rake. Average total rake fullness across vegetated sites was 2.05. Distribution of total rake fullness in LLBDM is shown in Figure 5-7.

Growth form is used as an indicator plant height and nuisance potential. At each sampling site, a ranking is assigned for the maximum height of rooted aquatic plants relative to the water depth at each site. A ranking of "1" means plant height was 0-25% of water depth; "2" was 26-50% of water depth means; "3" was 51-75% of water depth means; "4" was 76-99% of water depth; and "5" means that rooted aquatic vegetation was growing at or sprawling across the water surface. This metric can be paired with rake fullness to understand the approximate volume and potential recreational impact of aquatic vegetation throughout the lake. The average growth form across all vegetated sites was 3.87 with 52% of vegetated sites being assigned a growth rating of 5 (Figure 5-6). This indicates that large number of locations likely had aquatic plants growing at nuisance levels that would impede navigation. Figure 5-8 shows the distribution of growth form ratings across the lake.

Figure 5-6. Percentage of growth form rating results across vegetated sites in LLBM – 2024.



The **maximum depth of plants** is the deepest site where plants were found on the sample rake. Water depth was recorded at sample points to the nearest 0.25-foot. The shallowest site sampled was +/- 1.0 feet. The deepest site was +/- 23.0 feet. The average water depth observed across all sampled points was 7.23 feet The maximum depth where plants were observed was 18.0 feet at site 657 which had a rake fullness of 3. Plant species observed at that site include: coontail, common waterweed, sago pondweed (*Stuckenia pectinata*), and wild celery/eel grass (*Vallisneria ameriacana*). Site 657 was likely vegetated due to the proximity of the site to a dense plant community northwest of the site, near Strobe Island, and the flow of water which may provide better water clarity than other areas. Although this site had vegetation 5.25 feet deeper than the original second deepest depth of plants, it was included in the calculations because of the complexity of the lake and river system. Most plants were found at depths less than 11 feet.

Frequency of occurrence (FOO) is expressed as a percentage and describes how often plants were found. There are a few different ways to calculate FOO with each value providing a slightly different perspective. The FOO at sites shallower than the maximum depth of plants was 58.82%.

FOO at sampled sites by species indicates how often a plant species was found at sites sampled. This is an indicator for how widespread a particular plant species is within the lake across all sample sites (the number of sites a plant was sampled divided by the total number of sites visited). The greater the value, the more common and widespread (Table 5-3). **FOO at vegetated sites** is the percentage of sites sampled where a plant species was found out of the total number of vegetated sites. Coontail (*Ceratophyllum demersum* [81%]) and common waterweed (*Elodea canadensis* [76%]) were the most frequently observed species at vegetated sample sites (Table 5-3).

Relative frequency measures how often a plant species appears compared to other species. This statistic for each species is independent of the number of sample points. To calculate it, the number of occurrences of all species are added up then divided by an individual species' number of occurrences. This gives a truer measure of the dominant plant species present in a lake. A higher relative frequency indicates a more dominant plant. Coontail (44.4%) and common waterweed (41.5%) had the highest relative frequencies (Table 5-3).

Table 5-1. Summary Statistics from 2024 Aquatic Plant Survey of LLBDM

Summary Statistics	Value
Total number of sites proposed	658
Total number of sites visited	641
Vegetated sites[1]	347
Percent of visited sites that were vegetated	54.13%
Maximum depth of plants	18.00 feet
Sites shallower than maximum depth of plants	633
Average Rake Fullness	2.05
Average Growth Form	3.87
Average number of *all* species per site at all sites shallower than maximum depth	1.68
Average number of *all* species per site at vegetated sites only	3.07
Average number of *native* species per site at all sites shallower than maximum depth	1.41
Average number of *native* species per site at vegetated sites only	2.60
Frequency of occurrence (FOO) at sites shallower than maximum depth of plants	54.82%
Species richness (sampled on rake)	17
Native species richness (sampled on rake)	15
Species richness (including visuals)	18
Total species richness (including visuals and boat survey)	24
Simpson Diversity Index (SDI)	0.83
Mean C-value	5.4
Floristic Quality Index (FQI)	20.91

Table 5-2. Species Observation List

Common Name	Species	Number of Sites		Boat Survey[2]
		Rake Findings	Visuals[1]	
Coontail	*Ceratophyllum demersum*	281	14	
Common watermeal	*Wolffia columbiana*	25	3	
Common waterweed	*Elodea canadensis*	263	5	
Curly-leaf pondweed	*Potamogeton crispus*	40	4	
Eurasian water milfoil	*Myriophyllum spicatum*	135	22	
Flat-stem pondweed	*Potamogeton zosteriformis*	14	1	
Fries' pondweed	*Potamogeton friesii*	12	1	
Large duckweed	*Spirodela polyrhiza*	19	31	
Leafy pondweed	*Potamogeton foliosus*	3	1	
Northern watermilfoil	*Myriophyllum sibiricum*	2	0	
Sago pondweed	*Stuckenia pectinata*	19	5	
Slender naiad	*Najas flexilis*	7	1	
Small duckweed	*Lemna minor*	33	28	
Water star-grass	*Zosterella dubia*[3]	129	17	
Watershield	*Brasenia schreberi*	0	1	
White water lily	*Nymphaea odorata*	3	17	
White-stem pondweed	*Potamogeton praelongus*	2	1	
Wild celery	*Vallisneria americana*	78	13	
Aquatic moss	--	1	0	
Filamentous algae	--	116	2	
Hybrid cattail	*Typha x glauca*	--	--	X
Phragmites	*Phragmites australis*	--	--	X
Purple loosestrife	*Lythrum salicaria*	--	--	X
Nuttall's waterweed	*Elodea nuttalli*	--	--	X

Table Notes:
1. Observed within six feet of the boat at sample locations.
2. Only includes species observed during the boat survey that were not found on the rake or near the boat at sample sites.
3. Formerly known as *Heteranthera dubia* (Jacq.) MacM.

Table 5-3. Frequency, C-value, and Average Rake Fullness for Species Sampled on the Rake – 2024.

Common Name	Scientific Name	C-value	FOO by species across:			Relative Frequency (%)	Average Species Rake Fullness
			Sampled Sites	Vegetated Sites	Littoral Sites[3]		
Coontail	*Ceratophyllum demersum*	3	43.8%	81.0%	44.4%	26.4%	2.05
Common waterweed	*Elodea canadensis*	3	41.0%	75.8%	41.5%	24.7%	1.75
Eurasian water milfoil	*Myriophyllum spicatum*	0	21.1%	38.9%	21.3%	12.7%	1.34
Water star-grass	*Zosterella dubia*[2]	6	20.1%	37.2%	20.4%	12.1%	1.24
Wild celery/eel grass	*Vallisneria americana*	6	12.2%	22.5%	12.3%	7.3%	1.36
Curly-leaf pondweed	*Potamogeton crispus*	0	6.2%	11.5%	6.3%	3.8%	1.03
Small duckweed	*Lemna minor*	4	5.1%	9.5%	5.2%	3.1%	1.06
Common watermeal	*Wolffia columbiana*	5	3.9%	7.2%	3.9%	2.3%	1.00
Large duckweed	*Spirodela polyrhiza*	5	3.0%	5.5%	3.0%	1.8%	1.11
Sago pondweed	*Stuckenia pectinata*	3	3.0%	5.5%	3.0%	1.8%	1.26
Flat-stem pondweed	*Potamogeton zosteriformis*	6	2.2%	4.0%	2.2%	1.3%	1.07
Fries' pondweed	*Potamogeton friesii*	8	1.9%	3.5%	1.9%	1.1%	1.25
Slender naiad	*Najas flexilis*	6	1.1%	2.0%	1.1%	0.7%	1.00
Leafy pondweed	*Potamogeton foliosus*	6	0.5%	0.9%	0.5%	0.3%	1.33
Northern watermilfoil	*Myriophyllum sibiricum*	6	0.5%	0.9%	0.5%	0.3%	1.00
White water lily	*Nymphaea odorata*	6	0.3%	0.6%	0.3%	0.2%	1.00
White-stem pondweed	*Potamogeton praelongus*	8	0.3%	0.6%	0.3%	0.2%	1.00
Aquatic moss[1]	--	--	--	--	--	--	1.00
Filamentous algae[1]	--	--	--	--	--	--	2.03

Table Notes:

1. Aquatic moss and filamentous algae were found on the rake but are not counted as aquatic plants, so they were excluded from total rake fullness, and, as a result, are not given a species FOO or assigned a c-value.
2. Formerly known as *Heteranthera dubia* (Jacq.) MacM.
3. Frequency of occurrence (FOO) at sites shallower than the maximum depth of plants.

Figure 5-7. Map showing total rake fullness results for sites sampled in 2024.

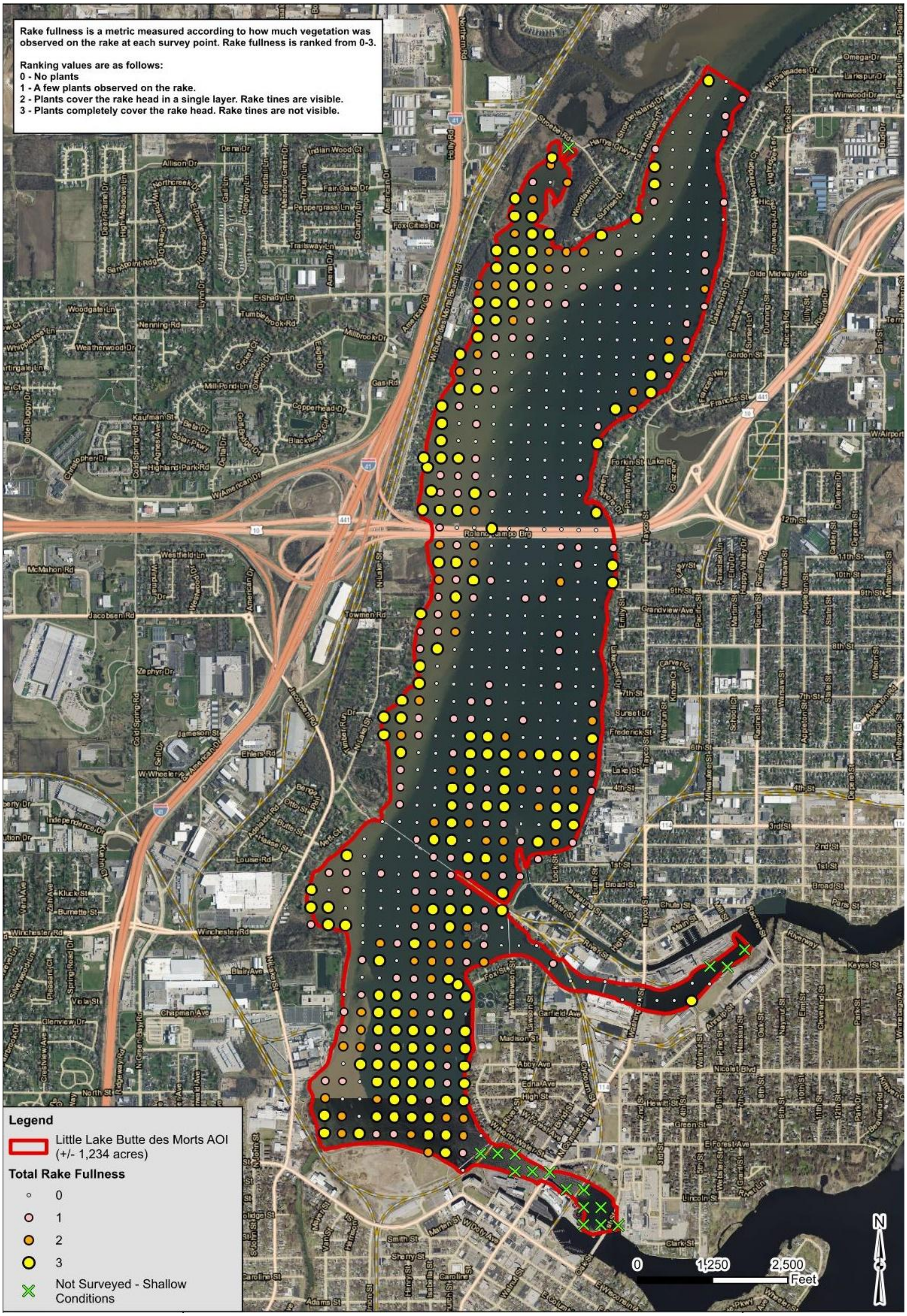
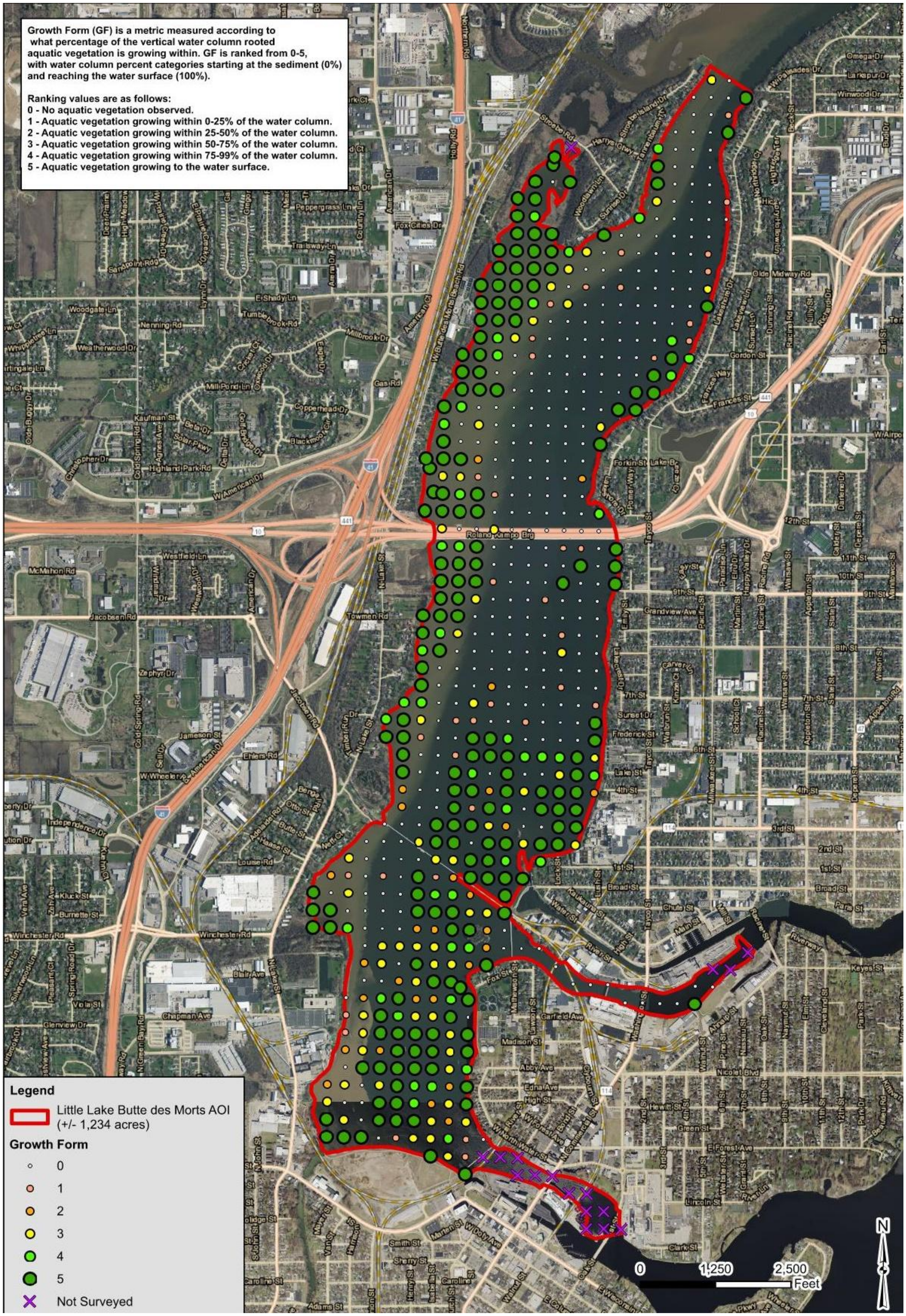


Figure 5-8. Map showing growth form results for sites sampled in 2024.



Results from the 2024 aquatic plant survey were compared to the Wisconsin Lakes Statewide averages and Wisconsin Level III Ecoregion averages to assess LLBDM conditions against other waterbodies in Wisconsin. LLBDM is located within the Southeastern Wisconsin Till Planes (SWTP) Ecoregion (Figure 5-9). This information is useful for understanding ecosystem quality and informing aquatic plant management goals. Results from this comparison are provided in Table 5-4**.**

Figure 5-9. Wisconsin Level III Ecoregions

Source: GEI Consultants, data obtained from: https://www.epa.gov/eco-research/ecoregion-download-files-state-region-5#pane-47

Total species richness for LLBDM was 17, which is higher than both the SWTP ecoregion average and the statewide average. The **Simpson Diversity Index** (SDI) quantifies biodiversity based on a formula that uses the number of species surveyed and the number of individuals per site. The SDI uses a decimal scale, with values closer to one representing high amounts of biodiversity. The SDI for LLBM was 0.83, which is higher than the SWTP ecoregion average but lower than the statewide average.

Coefficient of conservatism (C-value) represents an estimated probability that a species is likely to occur on the landscape relative to disturbance levels [56]. C-values are assigned to each species and range from 0 (highly tolerant of disturbance, little fidelity to any natural community) to 10 (highly intolerant of disturbance, restricted to pre-settlement remnants) [56]. A C-value of 0 is also assigned to all non-native species. Within LLBDM, the C-value ranged from 0 to 8 with an average C-value of 5.4. Two non-native, invasive species were observed (Curly-leaf pondweed (CLP) and Eurasian water milfoil (EWM)), which have a C-value of 0. Two of the 17 plant species observed on the rake, Fries' and white-stem pondweed, have a C-value of 8. Within vegetated areas, Fries' pondweed occurred at 3% of sampled sites and white-stem pondweed occurred at 1% of sites. The species with the highest frequency of occurrence (FOO) across vegetated sample sites was coontail, which has a C-value of 3. The mean C-value for LLBDM is lower than both the SWTP ecoregion average and the statewide average. Given that the species richness was higher in LLBDM than the statewide and SWTP average, a lower C-value indicates that the plant species present within LLBDM are relatively tolerant of impaired or disturbed conditions.

Floristic Quality Index (FQI) adds a weighted measure of species richness by multiplying the mean C-value by the square root of the total number of native species. A higher FQI indicates higher floristic integrity, and a lower level of disturbance impacts to the site. The mean FQI for LLBDM was 20.91, which is slightly above the SWTP ecoregion average but lower than the statewide average.

Table 5-4. Statewide and SWTP Ecoregion Summary Statistics Comparison [57].

Summary Statistics	Wisconsin Lakes (Statewide) Average	SWTP Ecoregion Average	LLBDM 2024
Species richness	13	14	17
Mean C-value	6.0	5.60	5.4
Mean floristic quality index (FQI)	22.2	20.90	20.91
Simpson's Diversity Index (SDI)	0.85	0.81	0.83

5.4. Nuisance-level Growth of Aquatic Plants

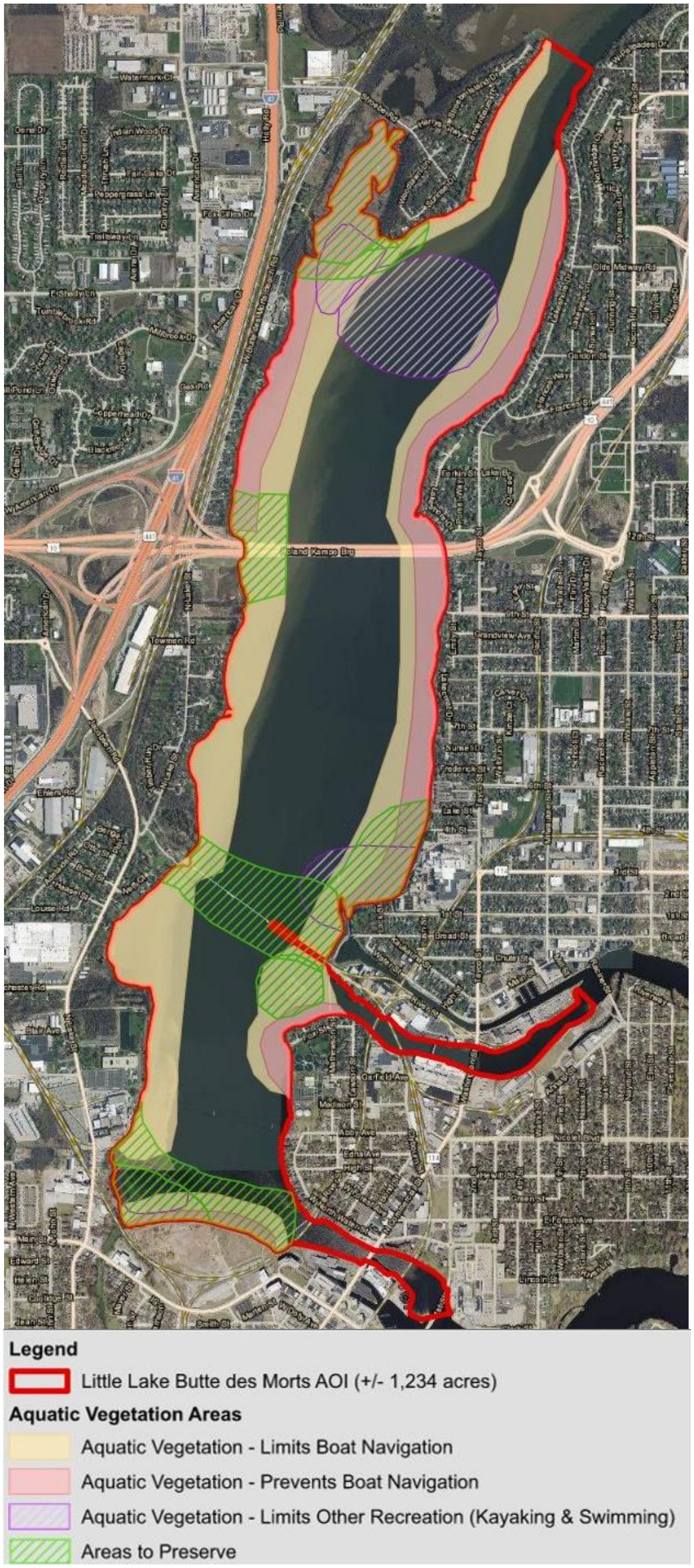
Aquatic plants are a natural and important part of aquatic ecosystems, especially eutrophic lakes like LLBDM. However, overly dense plant growth can be a nuisance to lakefront property owners and other lake users by interfering with or impeding recreation such as boating, swimming and kayaking. Fragments of plants pile up on the shorelines and at boat launches creating additional maintenance challenges.

Before aquatic plants are managed or controlled, conditions should be assessed to determine whether plants are growing at nuisance levels. This will help to prevent spending money on unnecessary management actions and protect the integrity of the lake ecosystem. Questions that can help assess whether plants are at nuisance levels are provided in Table 5-5. If the answer is yes to most of the questions, then the lake likely has nuisance level growth and development of an aquatic plant management plan may be warranted.

Table 5-5. Questions to assess whether a lake has nuisance level aquatic plant growth [48].

Assessment Questions		2024 Nuisance Plant Growth Assessment Results
1	Are the plants native species?	**Yes.** There are several native plant species present in LLBDM. See Section 5.3.
2	Are the plants invasive species?	**Yes.** There are invasive plant species present. See Sections 5.3 and 6.1.
3	Do most users and user groups agree that there are too many plants that are impeding recreation? If no, is there an opportunity to find compromise?	**Yes.** Based on stakeholder survey results and public input received during a public meeting, most stakeholders are in agreement that nuisance level growth is impeding recreation in parts of the lake.
4	Are plants changing the lake's ecosystem in a negative way?	**No**. There is no evidence that plant growth is negatively impacting the lake ecosystem.
5	Are the plants limiting people's ability to use the lake for boating, fishing, swimming, etc.?	**Yes.** Stakeholders identified areas where recreation is impaired or impeded. This is especially true in certain areas of the lake.
6	Has plant growth been increasing in abundance or density each year?	**Unknown.** The first aquatic plant survey to be completed was in 2024. The survey will need to be repeated in the future to assess for change.
7	Is the plant growth a weather-related anomaly?	**Not likely.** Stakeholders have reported observations of excessive plant growth for a number of years.
8	Is this plant growth a seasonal (annual) observation?	**Yes.** Based on stakeholder reports, this is an annual issue.
9	Are the plants of one or more than one species?	**Yes.** The plant community consists of more than 17 species.
10	Are the plants located in an important habitat area?	**Some.** There are areas of the lake that have been identified by stakeholders as being important to protect for habitat.

Figure 5-10. Results from the stakeholder mapping exercise.



In the stakeholder surveys, shoreline property owners (SPO) and the general public (GP) were asked how aquatic plants impact various factors within LLBDM including water quality, recreation, habitat, property values, aesthetics, and overall enjoyment. Over half of the SPO group reported that aquatic plants have a “very negative impact” or “somewhat negative impact” on all factors. The SPO group generally reported greater negative impacts resulting from aquatic plants and a greater need for APM compared to the GP group. Over half of SPOs reported that the amount of aquatic vegetation has gotten “much worse” since they visited LLBDM.

Participants were also asked about aquatic plants. Survey responses revealed significant concerns about their impact on lake usage, as 64% of all survey participants reported APM is necessary in LLBDM. Opened ended responses further indicated many respondents are concerned about the excessive growth of aquatic plants, which affects boating, kayaking, and swimming.

During a public meeting held on July 18, 2024, attendees were asked to take part in a mapping exercise to gather information on how meeting participants use the lake and issues they encounter or observe. Prompts included categories such as recreation use areas and areas where recreation is impacted by aquatic plant growth. Data from the worksheets were merged and used to create a digital map (Figure 5-10).

Results indicate that the northwest, eastern, and southern nearshore areas of LLBDM have aquatic vegetation growth that prevents boat navigation. In addition, the remainder of the nearshore and offshore areas of LLBDM were reported to have aquatic vegetation growth that limits boat navigation. The northwestern/ northcentral portions of LLBDM, an area near the Menasha Lock, and the southwest portion of LLBDM were noted to have aquatic vegetation growth that limits other types of recreation (such as kayaking or swimming).

The outcome of the assessment (Table 5-5), taking stakeholder input and aquatic plant survey results into consideration, indicates that LLBDM does have a nuisance aquatic plant growth issue. The overgrowth of aquatic plants has been identified as a significant problem, impacting various recreational activities such as boating, swimming, and kayaking. For example, when conditions are at their worst, these activities may not be possible due to the dense growth of aquatic plants, which can choke out boat motors and wrap around propellers, making boating impossible in some high-use locations.

Figure 5-11. Aquatic plants and debris observed at the Fritse Park public boat launch on July 22, 2024.

Source: GEI Consultants, 2024.

Figure 5-12. Aquatic plants and algae observed in LLBDM on July 22, 2024.

Source: GEI Consultants, 2024.

6. AQUATIC INVASIVE SPECIES

Aquatic invasive species are non-native plants, animals or pathogens found in water or wetlands that are likely to cause economic, environmental, or human harm. The best way to address invasive species is to prevent new introductions—this includes limiting the introduction of new invasive species to LLBDM as well as reducing the spread AIS from LLBDM to other water bodies.

Wis. Admin. Code NR 40 defines AIS prevention regulations, identifies species considered to be invasive in Wisconsin, and classifies AIS as prohibited or restricted[25] [58]. The Wisconsin invasive species rule makes it illegal to possess, transport, transfer or introduce certain invasive species in Wisconsin without a permit. NR 40 also outlines control methods, prevention measures, and enforcement.

WISCONSIN

CHAPTER NR 40

INVASIVE SPECIES RULE

Wis. Admin. Code NR 40 makes it illegal to possess, transport, transfer or introduce certain invasive species in Wisconsin without a permit.

Non-native plants, animals or pathogens are considered to be "invasive" if they have potential to rapidly take over a new location and alter the ecosystem.

The law requires that all attached aquatic plants and animals be removed from any vehicle, boat, boat trailer, and equipment and that all water must be drained from the motor, livewell, ballasts or other containers before leaving the boat launch.

TERMINOLOGY

PROHIBITED

Invasive species not currently found in WI* that, if introduced, are likely to survive and spread, potentially causing significant harm to the environment, economy, or human health.

**except for small, isolated populations*

RESTRICTED

Invasive species that are already established in the state and cause or could cause significant harm to the environment, economy, or human health.

This includes established nonnative fish and crayfish, fish in the aquaculture trade, fish in the aquarium trade and non-viable fish species.

NON-RESTRICTED

Species that may have negative impacts on the environment but are already integrated into Wisconsin's ecosystems so control or eradication is not practical or feasible. Not proposed to be regulated at this time.

https://dnr.wisconsin.gov/topic/Invasives/terminology

[25] *Two additional categories, caution list species and non-restricted AIS, are used for educational and communication purposes, but those categories are not regulated under NR 40.*

Most public boat launches have a sign posted in a visible location reminding boaters to follow the law under NR 40 like the one shown in Figure 6-1.

According to NR 40, people are required to[26]:

- Remove all attached aquatic plants and aquatic animals and drain all water from vehicles, boats, trailers, equipment and gear of any type in the following circumstances:
  - Immediately upon their removal from the water.
  - Before traveling into the state over land for use on any water of the state or its bank or shore.
  - From a seaplane before entering any water of the state, and before taking off in a seaplane.
  - Before transporting a vehicle, boat, boat trailer, equipment or gear of any type on a public highway.
- Notify the department of escaping restricted invasive fish species from a safe facility.
- Do not use a prohibited invasive fish or crayfish species as bait.
- Do not introduce a nonnative aquatic plant, algae or cyanobacteria species into any state water.

While WDNR NR 40 is the primary invasive species regulation in Wisconsin, there are a few others worth noting. Regulated activities include wild bait harvest (NR 20.14), fish and bait production and importation (s. 29.735, Wis. Stats.), private fish stocking (s. 29.736, Wis. Stats.) and fishing tournaments (NR 20.40) [59].

Frequent monitoring and reporting of new findings can help identify new introductions early and allow for rapid response to increase the likelihood of early eradication or control. Controlling established AIS populations may help to minimize harmful impacts, but this should be used as a last resort because it is costly and rarely leads to eradication.

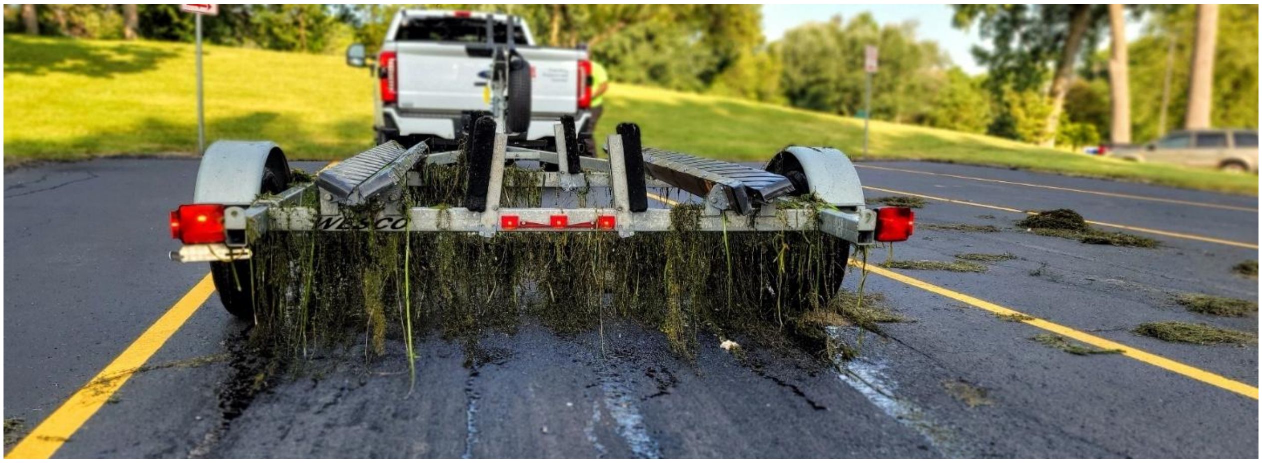
Once established, invasive species can reduce diversity and disrupt natural processes of native plants and animals. AIS outcompete native species for food and habitat, displacing or reducing native species populations and changing food webs. Invasive species can also alter habitat and degrade water quality. Some AIS spread new diseases, pathogens and parasites that can affect wildlife and sometimes humans [59].

Figure 6-1. WDNR Boat Launch AIS Outreach Sign

Source: Wisconsin AIS Partnership.

[26] https://dnr.wisconsin.gov/topic/Invasives/prevention

Figure 6-2. Aquatic vegetation, including EWM, attached to a boat trailer after launching a boat.



The damage from AIS can negatively affect the recreation and tourism industries by altering sportfishing opportunities, degrading shorelines and beaches, and impeding navigation while reducing aesthetic appeal and impacting swimming opportunities. Excessive growth of invasive aquatic plants can make boating, swimming, and other recreational activities difficult or impossible. For example, plants like Eurasian watermilfoil (EWM) and Curly leaf pondweed (CLP) can spread rapidly, forming dense mats, wrapping around boat propellers, and making it too difficult to kayak. Economic impacts can decrease property values and increase costs to utilities such as water treatment plants.

Even though natural dispersal of AIS and range expansion have been documented, most invasions have at least initially been from human activity. Transport pathways (also known as vectors) describe the different ways human activity introduces AIS to and then spread throughout Wisconsin [59]. These pathways include:

- **Canals, dams, diversions and locks**: These structures are human-made and connect waterways that were previously separate. Dams can also be used as barriers to limit spread of AIS.
- **Maritime Commerce**: This includes ships, such as lakers and trans-oceanic ships that can unintentionally move species from port to port. Ships carry invasive species in their ballast water (water taken on to stabilize the vessel) which is then released in a new port, potentially introducing invasive species to that area. Some species may also attach to the vessel to hitch a ride.
- **Recreational Activities:** Boating, angling, waterfowl hunting, and diving, can spread aquatic invasive species. These species can attach to boats, propellers, anchor lines, or boat trailers, and survive in bilge water, ballast tanks, and motors.
- **Service providers:** Marinas, boat rental companies, and bait shops can inadvertently contribute to the spread of AIS. These businesses often handle boats, trailers, and equipment that move between different water bodies, creating opportunities for AIS to be transported. Bait should be purchased from reputable supplies to avoid selling restricted species.
- **Non-Recreational Fishing and Aquaculture Industry**: These industries often use equipment like nets or lines on multiple waterbodies in a short period of time, which allows AIS to reach new

lakes and rivers. Additionally, live bait born and raised in different lakes can be contaminated with AIS when brought to local bait shops.

- **Transportation and Utility Corridors:** Roads, railways, and pipelines, can serve as pathways for the spread of AIS). These corridors often intersect with water bodies, creating opportunities for AIS to be transported from one location to another. For example, construction and maintenance activities along these corridors can disturb soil and vegetation, allowing invasive species to establish and spread. Examples of this are phragmites and purple loosestrife along highway I-41.
- **Organisms in Trade:** Organisms used for aquariums, water gardens, landscaping, and the pet trade, can lead to the introduction of new animals and plants into aquatic ecosystems. These organisms can be sold through traditional methods at stores or increasingly through the internet. Sometimes pet owners dump their aquarium or water gardeners relocate plants from their garden to the nearby lake or stream.

Figure 6-3. AIS Transport Pathways

Source: Wisconsin Aquatic Invasive Species Management Plan

6.1. AIS in Little Lake Butte des Morts

Several different invasive species have been observed in Little Lake Butte des Morts by volunteers, researchers, consultants, and WDNR staff, with Eurasian watermilfoil (EWM) being the first verified finding in 1998. Findings reported to the WDNR are made available to the public online through the WDNR SWIMS[27] database, the WDNR Lakes and AIS Mapping Tool[28], and on the LLBDM lake page[29] [60,61]. The AIS listed by the WDNR as having been observed or verified in LLBDM are included in Table 6-1.

The 2024 aquatic plant survey provided insight into the density and distribution of invasive plants in LLBDM. During that survey, EWM and CLP were observed. EWM was found on the sample rake at 135 of the 641 sampled sites and visually observed at an additional 22 sites. CLP was found on the rake at 39 of the 641 sampled sites and visually observed at an additional 4 sites.

Although CLP was found during the survey in late July, CLP likely grows in higher numbers and densities earlier in the year. CLP typically begins growing in late fall when water temperatures cool down, overwinters as small plants up to 12" tall, and then begins rapidly growing soon after ice-out while many native species are still dormant. This allows CLP to get a head start, outcompete native species, and reach maximum density by mid-spring. Beginning in summer, typically late June to early July, CLP begins to naturally die-back, which is why CLP was likely under sampled. To better understand CLP distribution, early-season AIS mapping could be performed in future years.

Additional AIS found along the shoreline during the 2024 survey include purple loosestrife (*Lythrum salicaria*), non-native phragmites/common reed (*Phragmites australis*), and a large stand of hybrid cattail (*Typha x glauca*).

Descriptions and photos of each AIS found in LLBDM are included in the AIS species profiles pages below. Additional details such as life history, habitat information, and ecological, recreational, economic, and health impacts are available on the WDNR's Invasive Species webpage: [30] [62].

Table 6-1. Aquatic Invasive Species – Little Lake Butte des Morts [60] [63]

Common Name	Scientific Name	Type	WDNR Verification Year
Eurasian watermilfoil (EWM)	*Myriophyllum spicatum*	Submerged plant	Verified in 1998
Curly-leaf pondweed (CLP)	*Potamogeton crispus*	Submerged plant	Verified in 2013
Purple loosestrife (PL)	*Lythrum salicaria*	Wetland plant	Observed in 2024
Common reed (Phragmites)	*Phragmites australis*	Wetland plant	Verified in 2011
Hybrid cattail	*Typha x glauca*	Wetland plant	Observed in 2024
Round goby	*Neogobius melanostomus*	Fish	Verified in 2015 and 2021
Chinese mystery snail	*Cipangopaludina chinensis*	Invertebrate	Verified in 2015
Rusty crayfish	*Faxonius rusticus*	Invertebrate	Verified in 2016
Zebra mussel	*Dreissena polymorpha*	Invertebrate	Verified in 1999

Sources: [60] [63]

[27] *WDNR Surface Water Integrated Monitoring System (SWIMS):* https://dnr.wisconsin.gov/topic/SurfaceWater/SWIMS
[28] *WDNR AIS Mapping Tool:* https://dnr.wisconsin.gov/topic/Lakes/Viewer
[29] *LLBDM Invasive Species webpage:* https://apps.dnr.wi.gov/lakes/lakepages/LakeDetail.aspx?wbic=129800
[30] https://dnr.wisconsin.gov/topic/Invasives

VERIFIED IN LITTLE LAKE BUTTE DES MORTS

AQUATIC INVASIVE SPECIES

EURASIAN WATER-MILFOIL

(Myriophyllum spicatum)

Originally from Europe, Asia, and northern Africa, Eurasian watermilfoil (EWM) is a submerged, rooted plant reached the United States in the 1880s and Wisconsin in the 1960s.

Northern watermilfoil is a native species that looks similar to EWM but has less than 10 pairs of leaflets per leaf. EWM can hybridize with native milfoil, becoming resistant to herbicides. Growing in dense mats on water surfaces, it obstructs boating and recreational activities.

Effective control methods include hand harvesting, mechanical harvesting, Diver Assisted Suction Harvesting (DASH), and chemical herbicides.

RESTRICTED IN WISCONSIN

IDENTIFICATION

- Four feather-like leaves arranged in a whorl around the stem
- Each leaf has 12-21 thin leaflets
- Small, yellow, and four-parted flowers arranged on a short stem above the water surface
- Stem can appear brown, green, red, or white in color

POTENTIAL IMPACTS

- Blocks sunlight for native aquatic plants
- Can limit boating and swimming when it grows in dense patches
- Provides low-quality habitat for fish and invertebrates

PATHWAYS

This species is spread by:

- Fragments floating through waterways
- Attached to boats, docks, and other equipment moving between water bodies

This plant reproduces via fragmentation - a single stem fragment introduced to a lake could take root and establish a new population.

VERIFIED IN LITTLE LAKE BUTTE DES MORTS

AQUATIC INVASIVE SPECIES

CURLY-LEAF PONDWEED

(Potamogeton crispus)

Native to Eurasia, Africa, and Australia Curly-leaf pondweed (CLP) is a submerged aquatic plant that was likely introduced in the 1800s as an aquarium release.

CLP reproduces by turions that form in late spring and early summer. After turion formation, the plant dies back. The turions stay dormant in the sediment for the rest of the summer and fall. When temperatures cool, some of the turions start growing with the majority germinating the following spring when water temperatures reach 50 F. Turions are viable for multiple years.

CLP can be managed by mechanical harvesting and herbicides in early spring when plant biomass is low.

RESTRICTED IN WISCONSIN

IDENTIFICATION

- Alternate leaves that are 0.5" to 3.5" long and about 0.5" wide
- Leaves are serrated with a wavy, lasagna noodles like shape
- Tiny flowers with four petal-like lobes
- Turions are short and hard

POTENTIAL IMPACTS

- Can form extensive mats that impede recreational activities
- Grows early and can shade out native plants
- Midsummer die off releases phosphorus into the water resulting in algal blooms and low dissolved oxygen
- Overtakes habitat and outcompetes native aquatic plants

PATHWAYS

This species is spread by:

- Transfer of plant fragments from trailered boats

Curley-leaf pondweed can commonly be mistaken for narrow-leaf pondweeds, white-stem, clasping-leaf and broad-leaf pondweeds

OBSERVED IN LITTLE LAKE BUTTE DES MORTS


AQUATIC INVASIVE SPECIES

PURPLE LOOSESTRIFE

(Lythrum salicaria)

Native to Europe and Asia, purple loosestrife (PL) was brought to the U.S. unintentionally by contaminated solid cargo ship ballast and intentionally through the importation of seeds. PL quickly invaded Wisconsin in the 1990s.

The plant is sold in nurseries as a sterile variety, but they can still produce viable wild-type seeds.

Control methods for purple loosestrife include:

- Herbicides (imazapr or glyphosate)
- Digging and pulling small plants
- Biological control by releasing Galerucella beetles.

Mowing is NOT recommended because pieces of the plant can resprout.

RESTRICTED IN WISCONSIN

IDENTIFICATION

- Grows 3 to 7 feet tall
- Leaves are lance-shaped, usually opposite
- Flowers are closely attached to the stem with five to six pink/purple petals
- Stems are green, stiff and usually four-sided

POTENTIAL IMPACTS

- Outcompetes native wetland and shoreland plants
- Can easily adjust to varying light conditions and water levels
- Dense stands can make it difficult for people to access open water
- Dense root systems change hydrology

PATHWAYS

This species is spread by:

- Selling and distribution for decoration
- Dense production of seeds

A single stem can produce 100,000-300,000 seeds per year and mature plants with multiple stems can produce up to two million seeds that are viable for up to seven years.

VERIFIED IN LITTLE LAKE BUTTE DES MORTS

AQUATIC INVASIVE SPECIES

COMMON REED

(NON-NATIVE PHRAGMITES)

(Phragmites australis)

Common reed (aka non-native phragmites) is native to Europe and Asia. It was unintentionally brought into the Great Lakes area through contaminated soil in the ballast of cargo ships and with packing material from shipping operations.

There is a native phragmites that looks similar to the invasive type. Native phragmites has narrower and longer leaves and a smooth, flexible stem that is often shiny, round, and has black dots (a fungus).

Herbicides, cutting underwater to drown the plants, grazing by goats or cattle are common methods for control. Control needs to be done annually and native species planted to protect disturbed ground.

RESTRICTED AREAS

PROHIBITED AREAS

IDENTIFICATION

- Grows 3 to 20 feet tall
- Smooth, linear leaves 6-24 in. long
- Leaves are blueish green in color
- Stems are dull tan to green with a center ridge
- Flowers are bushy, light brown to purple plumes, blooming July-September

POTENTIAL IMPACTS

- Invades moist habitats like lakeshores and wetlands
- Common in disturbed areas such as roadside ditches
- Alters hydrology and wildlife habitat
- Increases fire potential
- Outcompetes and shades native species forming dense stands

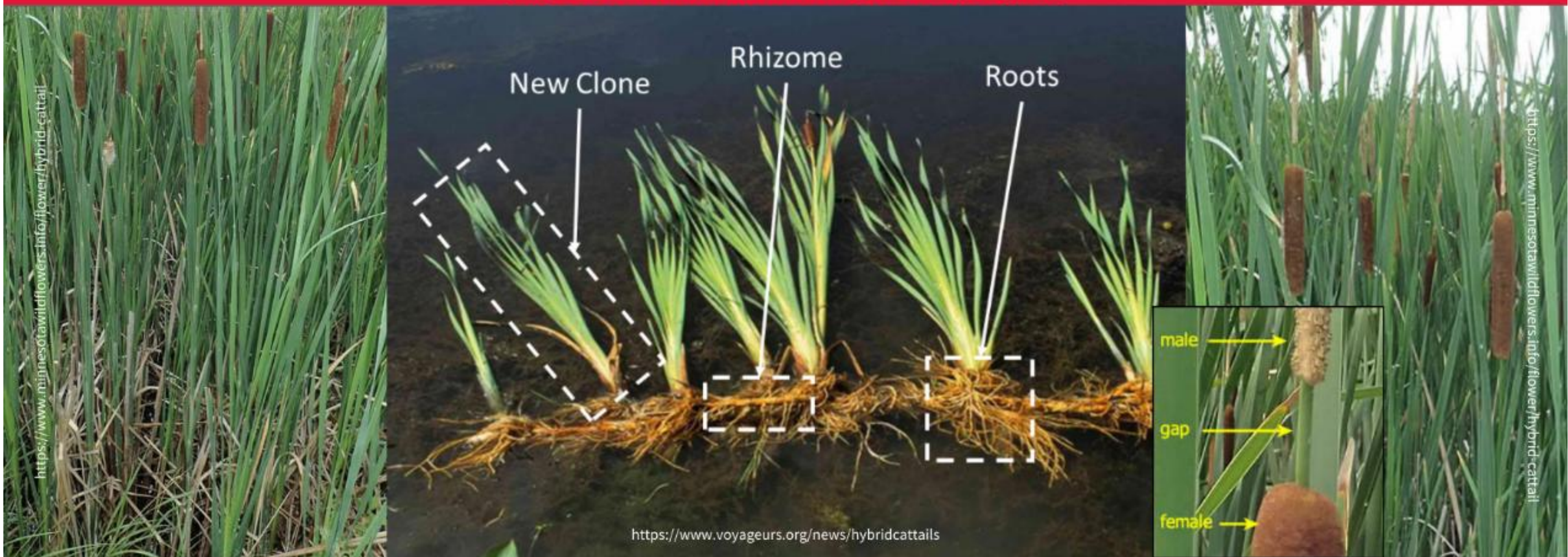
PATHWAYS

This species is spread by:

- Root fragmentation
- Wind-blown seeds
- Cut stem fragments
- Rhizomes

Phragmites has a high tolerance for pollution and disturbance, growing along wet shoreline, riverbanks, and roadways.

OBSERVED IN LITTLE LAKE BUTTE DES MORTS



AQUATIC INVASIVE SPECIES

HYBRID CATTAIL

(Typha X glauca)

This cattail is a hybrid between the native broad-leaf cattail (*T. latifolia) and* and the non-native narrow-leaved cattail (*T. angustifolia).*

The hybrid cattail outcompetes native species, including culturally significant plants like wild rice. This cattail transforms wetlands from a diverse mix of emergent, submergent, and floating-leaf vegetation to expansive stands of cattail monocultures. This degrades fish and wildlife habitat, reduces biodiversity, and can alter hydrology.

This species can be mechanical controlled by removal or treated with herbicide (foliar spray with imazapyr).

RESTRICTED IN WISCONSIN

IDENTIFICATION

- Linear, flat-leaf blades that are 0.3-0.8 inches wide
- About 15 leaves per shoot
- Cylindrical spike at the end of the stem that is divided into the upper yellow male flowers and a lower brown sausage-shaped female flowers.

POTENTIAL IMPACTS

- Invades lakeshores, streams, roadsides, wetlands, and ditches
- Outcompetes most other plants
- Reduces habitat for many wildlife
- Alters hydrology
- Can form floating mats that break away, float downstream, causing habitat loss

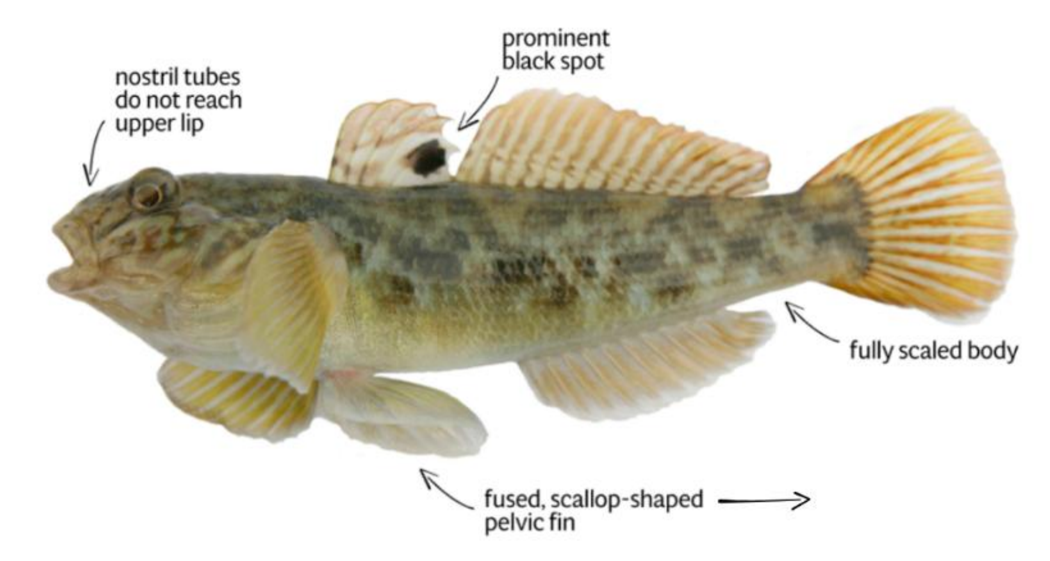
PATHWAYS

This species is spread by:

- Rhizomes - often up to 4 per year
- Root fragments

In some areas, cutting and drowning can be effective. The plant should be cut at least 3" below the water for the entire growing season.

VERIFIED IN LITTLE LAKE BUTTE DES MORTS



Invasive Species Center (left) and John Lyons, WDNR (right)

AQUATIC INVASIVE SPECIES

ROUND GOBY

(Neogobius melanostomus)

Round gobies are small fish native to the Black and Caspian Seas in Europe and Asia. The goby, invasive in North America, was first discovered in the St. Clair River in 1990. The river provides passage for cargo vessels between the upper and lower Great Lakes and was introduced through through ballast water from oceangoing ships.

Since its discovery, this bottom-dwelling species spread rapidly across the Great Lakes. The goby has also been found in a few inland waters in Wisconsin, including Little Lake Butte des Morts (LLBDM, 2015).

Once established, there are no effective control methods. The Menasha Lock between LLBDM and Lake Winnebago was closed in 2015 to prevent the goby from spreading to hundreds of miles of waters in the Winnebago System.

PROHIBITED IN WISCONSIN

IDENTIFICATION

- Mottled, gray appearance with a black spot in the first dorsal fin
- Single, scallop-shaped fused pelvic fin on its belly*
- Frog-like raised eyes and thick lips
- Typically 2.5 to 6 inches long
- Often confused with native fish such as mottled sculpin and log perch

POTENTIAL IMPACTS

Displaces native fish by taking over optimal habitat because of several competitive advantages:

- Can spawn six times per year reaching densities greater than 20 fish in 1 m^2
- Tolerates poor water quality
- Aggressive predators of fish eggs, such as smallmouth bass
- Highly territorial for food, shelter and optimal spawning sites

Contributes to fish and bird die-offs by spreading Botulism:

- Gobies can be infected with Botulism when they eat toxin carrying zebra mussels and then pass the fatal disease on to other fish or birds that eat the infected goby.

PATHWAYS

- Boat hulls and bait bucket dumps
- Ballast water releases
- Movement through tributaries

VERIFIED IN LITTLE LAKE BUTTE DES MORTS

AQUATIC INVASIVE SPECIES

CHINESE MYSTERY SNAIL

(Cipangopaludina chinensis)

Native to southeast Asia and eastern Russia, these invasive snails are in the Viviparidae family, which means they give birth to live young.

These snails prefer areas with silt, sand and mud in lakes and slow-moving rivers or streams.

They can live for more than 4 weeks out of water thanks to their operculum which is like a trap door that can close to seal the shell.

There is currently no known effective control method for this species in natural water bodies.

RESTRICTED IN WISCONSIN

IDENTIFICATION

- Grows up to 3 inches long
- Brownish to olive green in color
- Spiral shell with 6 to 7 whorls
- Operculum covering (“trap door”)
- May camouflage itself with a dark green covering

POTENTIAL IMPACTS

- Leads to a decline in native snail abundance
- Compete with native snails for food and harms food webs
- May transmit diseases and parasites to fish and other wildlife
- Can die-off in large numbers, fouling beaches and shoreland

PATHWAYS

This species is spread by:

- Unintentional transport by recreational boaters
- Illegal release of aquarium pets

Young Chinese mystery snails can be as small as a grain of rice. Snails can be hidden in mud and debris and stick to anchors, ropes, scuba, fishing, and hunting gear.

VERIFIED IN LITTLE LAKE BUTTE DES MORTS

AQUATIC INVASIVE SPECIES

RUSTY CRAYFISH

(Orconectes rusticus)

Native to the United States' Ohio River Basin, these crayfish are used as bait for anglers, which is suspected to be their original point of invasion.

They reproduce quickly, with females capable of laying between 80 and 575 eggs. They inhabit lakes, streams, and ponds, preferring areas with rocks, logs, or other debris for shelter, and substrates such as clay, silt, sand, gravel, and rock.

Currently, there is no known effective control method for this species in natural water bodies.

RESTRICTED IN WISCONSIN

IDENTIFICATION

- Grows to 2.5 inches long (not including claws)
- Claws are large with black bands on the tips
- Body color ranges from green to gray to brown
- Dark, rusty spots on body, however, these spots may be missing on young crayfish

POTENTIAL IMPACTS

- Displaces native crayfish
- Reduces aquatic plant abundance and diversity
- Damages underwater habitats and spawning areas
- Eats fish eggs

PATHWAYS

This species is spread by:

- Bait Buckets from transient anglers
- Illegal release of aquarium pets

Rusty Crayfish are an aggressive species that actively defend themselves against predators. These predators are often not used to their prey exhibiting such resistance.

VERIFIED IN LITTLE LAKE BUTTE DES MORTS

AQUATIC INVASIVE SPECIES

ZEBRA MUSSEL

(Dreissena polymorpha)

These small mollusks are native to the Caspian Sea, Black Sea, and the Sea of Azov. They were accidentally introduced into the Great Lakes through commercial cargo ship ballast water and then spread to inland lakes by hitching a ride on boats and other recreational equipment.

Zebra mussels are very effective filter feeders. They can temporarily increase water clarity but they avoid consuming blue-green algae. This can increase harmful algal blooms and deplete the food supply for native fish.

Mechanical and chemical methods for controlling zebra mussels are expensive and can harm native species.

RESTRICTED IN WISCONSIN

IDENTIFICATION

- “D” shaped shell
- 1/8 inch to 2-inches long
- Alternating dark and light colored zigzag stripes
- Typically attached to hard surfaces

POTENTIAL IMPACTS

- Deplete the food supply for fish
- Potentially increase the likelihood of harmful algal blooms because they avoid consuming blue-green algae
- Attach to the shells of native mussels and smother them
- Clog pipes, damage equipment, and cut bare feet

PATHWAYS

This species is spread by:

- Unintentional transport by recreational boaters
- Transport of residual water left in equipment and boats.

Adults can survive outside of water for several days in moist conditions. Larvae, aka veligers, are microscopic and easily transported by accident.

https://dnr.wisconsin.gov/topic/Invasives/fact/Zebra

6.2. AIS Threats

LLBDM is connected directly to other waterbodies, is heavily used for recreation, and is near the Great Lakes. The Winnebago Pool Lakes drain to LLBDM through the Neenah and Menasha Dams and LLBDM is part of the Lower Fox River (Figure 6-4). Both systems have several invasive species that have not yet been found in LLBDM and LLBDM has species that need to be contained to prevent invasion upstream to Lake Winnebago. A list of which species have been found in each water body is provided in Table 6-2.

Species that have not yet been found in LLBDM that have been observed or verified in the Winnebago Pool Lakes should be considered high-risk for spreading to LLBDM. These species include Asiatic clam, banded mystery snail, Chinese mystery snail, faucet snail, brittle naiad, hybrid watermilfoil, flowering rush, Japanese knotweed, reed mana grass, and possibly spiny waterflea. Species found in the LFR that have not yet been observed in LLBDM are also a risk to the lake. These species include water hyacinth, Asiatic clam, and spiny waterflea.

Sea lamprey has been verified in the LFR and poses a risk to LLBDM, but the risk is much lower. This is because the Rapide Croche lock was closed in the late 1980s to prevent the sea lamprey and other AIS from spreading from Green Bay up the river into Lake Winnebago. A sea lamprey barrier was also installed, and FRNSA is required to maintain the barrier under WI Statute Chapter 237.10(1). According to WI Statute Chapter 237.10(2)., “If the authority decides to construct a means to transport watercraft around the Rapide Croche lock, the authority shall develop a plan for the construction that includes steps to be taken to control sea lampreys and other aquatic nuisance species. The authority shall submit the plan to the department of natural resources and may not implement the plan unless it has been approved by the department.”

The Great Lakes have more than 60 invasive species and 180 nonnative species, so barriers like Rapide Croche are the last line of defense against increasing AIS threats. Additional threats to LLBDM include starry stonewort, hydrilla, yellow floating heart, red swamp crayfish, quagga mussel, grass carp, black carp, bighead carp, and silver carp. These species are also listed in Table 6-2.

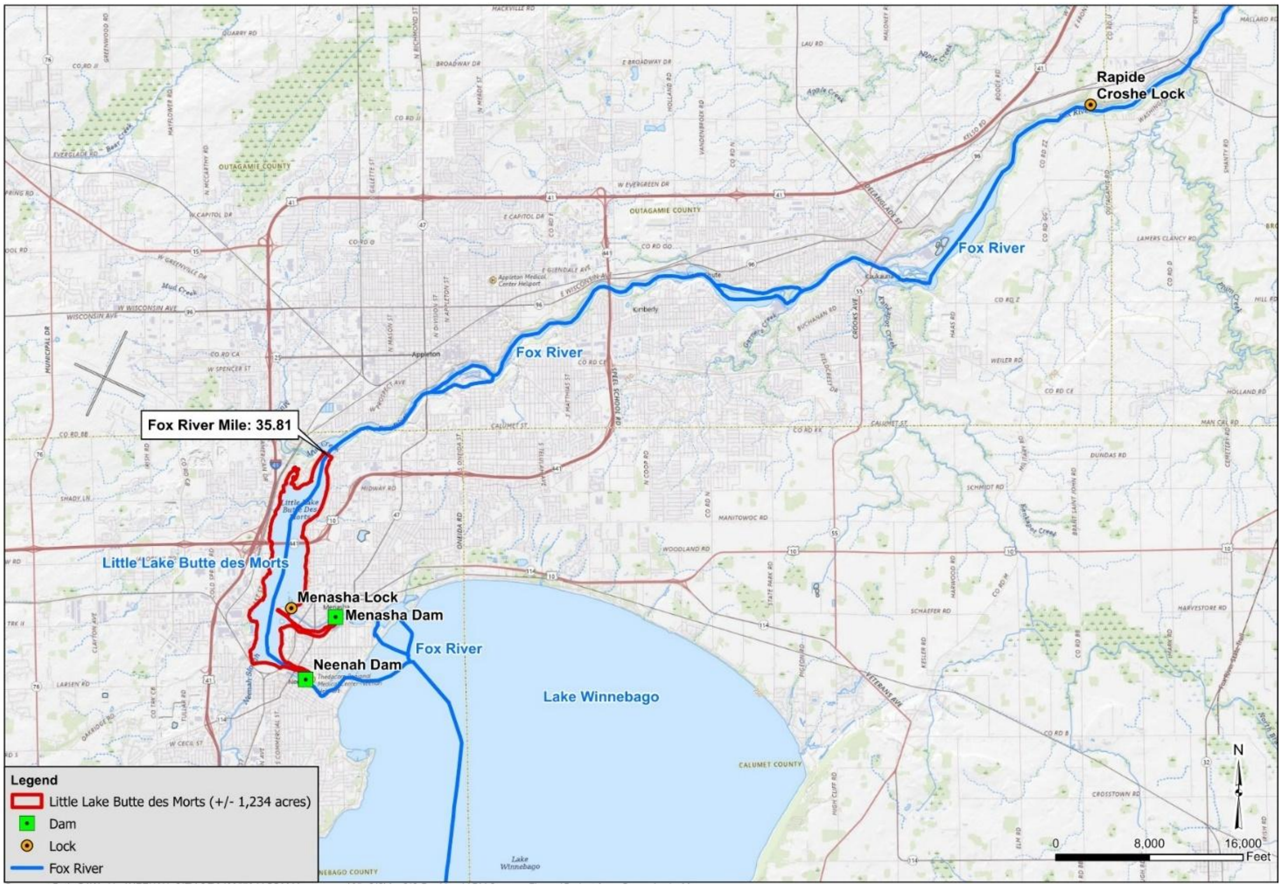
When stakeholder understanding and familiarity with aquatic invasive species (AIS) was evaluated most respondents, 69% of the SPO group and 89% of the GP group, indicated AIS are present within LLBDM. Across both stakeholder groups, the most selected AIS believed to be present included Eurasian watermilfoil, zebra mussels, carp, and round goby. Some respondents indicated AIS currently not present in LLBDM (faucet snail, starry stonewort, and spiny waterflea). These responses identified knowledge gaps across both stakeholder groups and highlight the need for public education regarding the identification and impacts of AIS. 66% of SPO respondents only use their boat on LLBDM. The majority (78%) of the GP group, trailer their watercraft to lakes or rivers other than LLBDM, indicating high risk for future introductions of AIS. Regarding AIS prevention most respondents, 86% of SPO and 90% of GP, who use watercraft on waters other than LLBDM reported that they “remove all visible aquatic hitchhikers”.

Table 6-2. AIS Comparison Table – LLBDM, Winnebago Pool Lakes, LFR, and new threats

				Winnebago Pool Lakes				
Common Name	**Scientific Name**	**Type**	**LLBDM[3]**	**WN[4]**	**BDM[5]**	**WC[6]**	**POY[7]**	**LFR[8]**
Sea lamprey	*Petromyzon marinus*	Fish						2019[1]
Round goby	*Neogobius melanostomus*	Fish	2015					2016
Water hyacinth	*Eichhornia crassipes/asurea*	Floating plant				2015[1]		2019
Asiatic clam	*Corbicula fluminea*	Invertebrate		2012				1999
Banded mystery snail	*Viviparus georgianus*	Invertebrate		2014				
Chinese mystery snail	*Cipangopaludina chinensis*	Invertebrate	2015	2015			2010	2015
Faucet snail	*Bithynia tentaculata*	Invertebrate		2014	2011	2011	2011	
Rusty crayfish	*Faxonius rusticus*	Invertebrate	2015	2014	Verified	2014	2014	
Zebra mussel	*Dreissena polymorpha*	Invertebrate	1999	1999	1999	1999	2000	1999
Brittle Waternymph (naiad)	*Najas minor*	Submerged plant			2022			
Curly-leaf pondweed	*Potamogenton crispus*	Submerged plant	2013	2006	2006	2011	2012	2017
Eurasian watermilfoil	*Myriophyllum spicatum*	Submerged plant	1998	1992	1969	2011	1994	2014
Hybrid watermilfoil	*Myriophyllum spicatum x Myriophyllum sibiricum*	Submerged plant		2017				
Viral Hemorrhagic Septicemia (VHS)	*Piscine novirhabdovirus*	Virus	2007	2007				
Common reed *(non-native phragmites)*	*Phragmites australis*	Wetland plant	2011	2018	2014			2020
Flowering rush	*Butomus umbellatus*	Wetland plant		2010	2016	2015	2012	
Hybrid cattail	*Typha x glauca*	Wetland plant	2021					
Japanese knotweed	*Fallopia japonica*	Wetland plant		2016				
Purple loosestrife	*Lythrum salicaria*	Wetland plant	2024	2017	2017	2018	2018	2015
Reed manna grass	*Glyceria maxima*	Wetland plant		Observed				
Spiny waterflea	*Bythotrephes longimanus*	Zooplankton		2022				2016
Spiny waterflea	*Bythotrephes longimanus*	Zooplankton		2022				2016
Starry stonewort	*Nitellopsis obtusa*	Plant-like algae						
Hydrilla	*Hydrilla verticillata*	Submerged plant						
Yellow floating heart	*Nymphoides peltata*	Floating leaf plant						
Red swamp crayfish	*Procambarus clarkii*	Invertebrate						
Quagga mussel	*Dreissena bugensis*	Invertebrate						
Grass carp	*Ctenopharyngodon idella*	Fish						
Black carp	*Mylopharyngodon piceus*	Fish						
Bighead carp	*Hypophthalmichthys nobilis*	Fish						
Silver carp	*Hypophthalmichthys molitrix*	Fish						

Notes:
1. Water hyacinth is no longer observed in Lake Winneconne. It has been eradicated.
2. Sea lamprey was observed by the WDNR north of Wrightstown in 2019 [64].
3. LLBDM = Little Lake Butte des Morts [60] [63]
4. WN = Lake Winnebago [65]
5. BDM = Lake Butte des Morts [66]
6. WC = Lake Winneconne [67]
7. POY = Lake Poygan [68]
8. LFR = Lower Fox River

Figure 6-4. Dams and locks located near LLBDM.



6.3. AIS Prevention Efforts & Monitoring Efforts

Various measures have been implemented by different organizations, agencies, and volunteers to prevent new AIS introductions to LLBDM, some of which are still ongoing. Additionally, there have been efforts to contain AIS within LLBDM to prevent their spread to other waterbodies.

The Aquatic Invasive Species Prevention Program at FWWA is dedicated to preventing the spread of AIS through outreach, monitoring, and region-wide coordination in Northeast Wisconsin [69]. LLBDM is located within FWWA's AIS Prevention Program's five-county area of coverage, and the lake is eligible for education, outreach, and monitoring services.

FWWA provides education about AIS impacts through presentations, exhibiting at local events, training volunteers to monitor for AIS, and offering technical assistance. As a designated agent, FWWA's AIS programming is funding by the WDNR's Lake Monitoring & Protection Network (LMPN). According to the WDNR, "the LMPN provides annual support to counties, tribes, and designated agents to perform services and activities to assist in AIS prevention and lake monitoring activities" [70].

To educate the public and reduce the spread of AIS, signs have been installed by FWWA at the two public boat launches on LLBDM, Fritse Park and Ninth Street Boat Launch. Signs have also been installed by FWWA and WDNR along the Neenah Channel and Fox River Lock Channel – Menasha [61].

FWWA's Adopt a Launch Program works to engage community members to take action and ownership of their lakes. Volunteers encourage the community to help search for aquatic invasive species and they improve boat launches. The volunteers are trained and monitor for AIS and remove them from the launch area to prevent spread, along with removing litter around their chosen or adopted boat launch. There are 18 boat launches have been adopted as of 2024 throughout the Fox-Wolf Watershed, including the Fritse Park Public Boat launch which had been adopted by volunteers from 2020-2024

6.3.1. Clean Boats, Clean Waters (CBCW)

According to the University of Wisconsin Extension Lakes website, "The Clean Boats, Clean Waters watercraft inspection program is an opportunity to take a front-line defense against the spread of aquatic invasive species. Through the Clean Boats, Clean Waters (CBCW) program, inspectors are trained to organize and conduct a boater education program in their community. Adults and youth teams educate boaters on how and where invasive species are most likely to hitch a ride into waterbodies. Inspectors perform boat and trailer checks for invasive species, distribute informational brochures, and collect and report any new AIS presence in waterbodies"[31].

FWWA is a local coordinator for CBCW, and they have had volunteers over the past few years that have helped with CBCW events like Drain Campaign and Great Lakes Landing Blitz.

Prior to that, the launches on LLBDM were staffed by paid watercraft inspectors through the University of Wisconsin – Oshkosh who conducted inspections [61]. There were additional inspection locations within the Neenah Channel and Fox River Lock Channel – Menasha as well. The Winnebago CBCW Intern team conducted regular CBCW efforts throughout the summer. Their team of 6-8 interns would be scheduled around the entire Winnebago Lakes system which included several boat launches on LLBDM. This team of CBCW interns was originally housed at the UW-Oshkosh campus before moving to the Fox-Wolf Watershed Alliance's AIS Program. These inspection and public education efforts are critical to continue to prevent the spread of other AIS to and from the lake.

6.3.2. Boat Wash Station

Fritse Park has a boat wash station to remove AIS that is available to use for a fee (Figure 6-5). The station also has educational signage.

Figure 6-5. High pressure wash station available at the Fritse Park Boat Launch.

Source: GEI Consultants, 2024.

[31] *https://www3.uwsp.edu/cnr-ap/UWEXLakes/Pages/programs/cbcw/default.aspx*

6.4. AIS Monitoring - Past and Current

The Fox River Navigational System Authority (FRNSA) initiated LFR AIS monitoring efforts in 2006 with the goal of tracking the abundance and distribution of spiny waterflea and round goby in the LFR. Sampling for AIS in this system was conducted by Lawrence University from 2006-2017, and by University of Wisconsin-Green Bay (UWGB) from 2018-2024.

This adaptive survey effort has confirmed the presence of the round goby, rusty crayfish, and zebra mussels. Spiny waterflea has not been detected in LLBDM; although this species is established (2015) in Lake Michigan, confirmed upstream (2017) in the Fox River, and detected downstream (2022) in Lake Winnebago. Round goby presence in LLBDM was confirmed by the WDNR in 2015, and by 2018 reproduction was considered evident. UWGB survey efforts verify a continued reproducing round goby population in LLBDM, as round goby of all age classes were collected (29 in 2022 and 55 in 2023). Populations remain established in Little Lake Butte de Morts below the closed Menasha Dam, however there are no confirmed round goby detections in Lake Winnebago. The FRNSA is committed to continued AIS monitoring efforts focused solely on sampling for round goby within the closed lock and outflow of the Menasha navigation channel in northern Lake Winnebago.

The Citizen Lake Monitoring Network (CLMN) is a statewide program through the Wisconsin Lakes Partnership. Citizen volunteers conduct water quality and aquatic invasive species monitoring. FWWA is a local coordinator for CLMN. They have volunteers who are monitoring for invasive species at the Ninth Street boat launch on LLBDM once per month.

6.5. AIS Containment – Menasha Lock Closure

In 2015, the Fox River Navigational System Authority (FRNSA) closed the Menasha Lock after the round goby was discovered in LLBDM. The decision to close the lock was based on a recommendation by the WDNR to contain the round goby and prevent the fish from spreading to the Winnebago System [71]. The round goby is an invasive fish species.

From 2015 to 2024, FRNSA had been working with fish researchers, engineers, and consulting firms to research potential invasive species barriers that would allow the lock to be reopened while keeping the goby from entering Lake Winnebago. FRNSA had invested $1 million in research, planning, and development of a 60% design for an electronic barrier system [71]. In June 2024, FRNSA board of directors voted to suspend work on plans to re-open the lock because all solutions that had been identified and evaluated proved to be too expensive to install and operate. According to FRNSA, the electric barrier would cost upwards of $7 million, operating costs were estimated at $400,000 per year, and annual monitoring for invasive species would cost close to $20,000 per year [71].

7. AQUATIC PLANT & AIS CONTROL HISTORY

Management actions using pesticides have been taken to control nuisance and invasive species in LLBDM in the past. Many aquatic plant management and nuisance control activities require a permit issued by the DNR to protect diverse and stable communities of native aquatic plants and prevent the spread of invasive aquatic plants. The WDNR permitted treatment record indicates management actions have been taken in LLBDM for invasive fish and plants (Table 7-1). Prenfish has been applied for round goby management. It is a specially formulated product containing rotenone to be used in fisheries management for the eradication of fish from lakes, ponds, reservoirs. The aquatic herbicide "Habitat", which targets emergent foliage located above the water's surface has been used to manage Phragmites populations. To facilitate lake navigation by reducing plant biomass, multiple different broad-spectrum herbicides (used to target a wide variety of submerged weed types) have been applied such as: Reward, Aquathol, Hyrothol, and Tribune. Cutrine has been utilized for treating surface growth of planktonic algae and floating mats of filamentous algae.

Table 7-1. WDNR Permitted Treatment Record (2014 – 2023) [72].

Permit Type	Year	Pesticides used	Amount used	Acreage Treated
Phragmites	2014	Habitat	0.15 gal	0.25
Phragmites	2015	Habitat	0.45 gal	0.25
AIS treatment (goby)	2017	Prenfish		0.15
AIS treatment (goby)	2018	Prenfish		0.15
AIS treatment (goby)	2019	Prenfish		0.15
Navigation	2019	Reward	0.45 gal	0.45
Navigation	2019	Aquathol	0.45 gal	0.45
Navigation	2019	Cutrine	0.45 gal	0.45
AIS treatment (goby)	2020	Prenfish		0.15
Navigation	2020	Hydrothol granular	43 lbs	0.08
Navigation	2020	Cutrine	0.34 gal	0.34
Navigation	2020	Reward	0.68 gal	0.34
Navigation	2020	Reward	0.68 gal	0.34
Navigation	2020	Cutrine	0.34 gal	0.34
Navigation	2020	Reward	0.3 gal	0.15
Navigation	2020	Cutrine Plus	0.15 gal	0.15
Navigation	2020	Hydrothol granular	30 lbs	0.15
Navigation	2020	Reward	2.4 gal	0.62
Navigation	2020	Cutrine Plus	1.2 gal	0.62
Navigation	2020	Reward	0.4 gal	0.41
Navigation	2020	Cutrine Plus	0.4 gal	0.41
Navigation	2020	Aquathol K	0.4 gal	0.41
Navigation	2020	Hydrothol granular	23 lbs	0.28
AIS treatment (goby)	2021	Prenfish		
Navigation	2022	permit issued no treatment		
Navigation	2022	permit issued no treatment		
Navigation	2022	permit issued no treatment		
AIS treatment (goby)	2022	Prenfish		
Navigation	2022	permit issued no treatment		
Navigation	2023	permit issued no treatment		
Navigation	2023	permit issued no treatment		
AIS treatment (goby)	2023	Prenfish		
Navigation	2023	Tribune	0.68 gal	
Navigation	2023	Aquathol K	1 gal	
Navigation	2023	Cutrine	0.68 gal	

8. EVALUATION OF POTENTIAL APM METHODS

In Wisconsin, there are a variety of options for managing aquatic plants. Each method presents a unique set of benefits, challenges, and risks. The sections below describe and evaluate several different methods. The evaluation considers the applicability, pros and cons, and stakeholder support of each management option, as well as how effectively each option may provide relief from existing nuisance species, prevent new AIS introductions, and protect valuable habitat within LLBDM.

The methods described in this strategy include:

1. **No Management**: Not taking any action to address nuisance aquatic plants.

2. **Direct Management Methods:** Techniques that specifically target aquatic plant either causing plant death or resulting in plant cutting and removal. These include physical and mechanical methods such as hand pulling and harvesting, herbicide applications, biological control, and water level manipulation.

3. **Indirect Management Methods:** Techniques or practices that address the primary drivers of nuisance aquatic plant growth. These include education, AIS prevention, monitoring, reducing nutrient and sediment pollution, and habitat protection and enhancement.

4. **Integrated Pest Management:** Combination of more than one management technique into an ecosystem-based strategy.

Figure 8-1. Nuisance level aquatic plant growth on LLBDM in July 2024.

Source: GEI Consultants, 2024.

8.1. No Management

Figure 8-2. Aquatic plant conditions in LLBDM, 2024

Source: GEI Consultants, 2024

A "no management" approach means not taking any action to manage or control aquatic plants, reduce nutrient pollution, prevent invasive species introductions, or protect habitat. This method relies on the natural ecosystem to balance itself over time. However, this approach is typically not effective in lakes that have high nutrient concentrations entering the system or challenges with invasive plant species. The initial cost of this method is minimal since no intervention is needed, but if it fails, future expenses could be much higher than if other methods were implemented earlier on. This method is simple to implement and does not require any permits.

For LLBDM, this approach is risky due to the presence of known invasive species and current negative impacts to recreation of nuisance level growth of aquatic plants. Stakeholders have expressed that they want to see something done to improve conditions. Stakeholder surveys reported significant negative impacts from aquatic plants and algae on lake usage, aesthetics, and property values. Most respondents supported aquatic plant management. The combined results of both stakeholder groups indicate that 64% of all survey participants reported APM is necessary in LLBDM. The majority (60%) of the SPO group reported "definitely yes", followed by 20% reporting "probably yes". The highest percentage of the GP group (34%) reported "unsure", followed by 29% "probably yes". As such, this option is not recommended for LLBDM at this time.

8.2. Direct Management Methods

Related to aquatic plant management techniques, mechanical harvesting was the most supported option by shoreline property owners (SPO) who participated in the stakeholder survey. Manual removal by hand or rake by the property owner was the most supported method by general public (GP) survey participants. Both groups indicated a need for more information on control techniques such as diver assisted suction harvesting (DASH) and biological controls. Doing nothing was the most opposed option by the SPO group and chemical control (herbicides) was the most opposed option by the GP group.

To evaluate potential management approaches, direct methods were assessed for applicability, reliability[32], duration of benefits, frequency of application, regulatory requirements, costs, and likelihood of stakeholder support.

[32] *This evaluation method was adapted from the book, Lake Management Best Practices: Managing Algae Problems, as written by Dick Osgood and Harry Gibbons, 2017.*

Applicability – how likely is the method to produce desired results and address the identified problems? How well is the method understood, what are the risks, and what is the potential for non-target impacts? Applicability for each method was assigned as high, medium, or low. High applicability, for example, means that the method is appropriate for the issue being addressed, is well understood, risks are minimal and known, and non-target impacts are likely to be low.

Reliability – has this method been demonstrated to produce positive outcomes with proper application? Reliability for each method was assigned as high, medium, or low. High reliability means that the method is likely to produce the desired result (efficacy) and has a track record in Wisconsin for demonstrating positive outcomes with proper application.

Duration - how long can the benefits of a particular method be expected to last? Duration for each method was categorized as long, medium, or short. Long duration means that a treatment will last multiple seasons or years. Medium is about one season or year and short is less than one month.

Frequency – how frequently will each method need to be applied? Is it continuous, frequent (more than once per season), seasonal (once per season), occasional (less than once per year), or rare (applications last more than one year)?

Permits – what regulatory requirements need to be considered? Permits are required for many management methods and can influence the feasibility, timing, or practicality of a management method. Aquatic plants are regulated in Wisconsin by the WDNR under NR 107 and 109. Potential permit requirements were considered during evaluation of management methods.

According to the WDNR, "WI Chapter NR 107 establishes the procedures and requirements for permitting the use of chemicals for APM. Chapter NR 109 establishes procedures and requirements for issuing non-chemical APM permits and allows the DNR to request an aquatic plant management plan prior to permit issuance." [73]. Other WDNR permits, local permits, and U.S. Army Corps of Engineers regulations may also apply. For more information on permit requirements, please contact the WDNR Regional Water Management Specialist or Aquatic Plant Management and Protection Specialist.

Costs – how expensive is the method? Cost can vary greatly depending on conditions even within one proposed management method. Each method is assigned low, medium, or high to describe the relative expectations for cost. Additionally, cost is assessed for some methods as a cost benefit analysis. For example, is there a large upfront cost that will pay off in the long term or a small cost up front that will end up costing more in the long term?

Support – how likely are shoreline property owners, lake users, and other stakeholders to approve of each method? Selecting management methods that are supported by stakeholders improves the decision-making process, increases likelihood for collaboration, saves time and money, and helps to reduce conflict. Support plays a pivotal role in the successful implementation of invasive aquatic management practices. Potential support was evaluated based on stakeholder survey feedback.

A table with an associated recommendation based on the outcomes of the evaluation is included at the end of each section describing a direct management method.

8.2.1. Physical and Mechanical Aquatic Plant Management Options

There are numerous ways to physically and mechanically manage native aquatic plants that grow to nuisance levels and aquatic invasive plants in Wisconsin. For this APM Strategy, hand removal, suction harvesting, diver assisted suction harvesting, and mechanical harvesting are discussed below[33].

8.2.1.1. Manual Removal – by hand

Hand removal, also known as manual removal, involves the physical extraction of invasive or nuisance aquatic plants by hand. This might include removing floating aquatic plant debris and algae that accumulate on shore or pulling rooted aquatic plants. Roots, runners, and even fragments of some species can grow into new plants, so all of plant must be removed from the water and disposed of properly when using this technique.

Manual removal by hand does not rely on machinery or chemicals, making it potentially less harmful to the lake ecosystem. This method can be effective at removing problem plants, particularly following early detection of an invasive species. It can also be highly selective, minimizing negative impacts to beneficial plant species. However, it is labor-intensive and may need to be repeated multiple times throughout the growing season to maintain control.

For evaluation, this method was subdivided into the following two categories:

1. Hand Pulling and Removal by Landowners along their Shoreline
2. Hand Pulling by Paid Contractors or Volunteers

Most stakeholders (>50% of both SPO and GP groups) indicated they support manual removal of aquatic plants, however there is difference in the preferred method. Almost 60% of shoreline property owners seemed to prefer removal by contractors or volunteers, while the 58% general public indicated more support for removal by property owners. For both methods of plant removal, a permit may be required in certain circumstances. It is recommended to contact the local WDNR aquatic plant management coordinator for questions or guidance.

8.2.1.2. Hand Pulling and Removal by Shoreline Property Owners

Lakeshore property owners can manually remove detached, floating aquatic plant debris and algae that accumulate on shore[34]. They can also hand pull rooted aquatic plants within a single 30-foot wide area (measured along the shore) extending from a use area (such as a dock) without the need for a permit [74]. This 30-foot-wide area is inclusive of any piers, boatlifts, swim rafts, and other recreational and water use equipment. This area cannot be in addition to an area where plants are controlled by another method.

---

[33] *Additional methods described on the WDNR website: https://dnr.wisconsin.gov/topic/Waterways/construction/mechanizedAPM.html*
[34] *WDNR NR 109.04*

Exceptions to this are wild rice and WDNR designated Sensitive Areas. Any removal of wild rice requires a permit[35] and aquatic plant removal may not be allowed in a Sensitive Area as defined by the department under NR 107, or in an area known to contain threatened or endangered resources or floating bogs.

Hand pulling along the shoreline can be a good option for small scale control around docks and to provide an opening for swimming in front of private properties. When removing plants by hand, it is critical that the entire plant be removed. Even in situations where a permit is not needed, all cut or pulled plant material needs to be removed from the lake and disposed of properly, including plant fragments.

DID YOU KNOW?

Eurasian Watermilfoil (EWM) and Curly Leaf Pondweed (CLP) are invasives that can spread by re-growing from small plant fragments. It can be difficult to remove the entire plant and root system of these species.

COOPERATION

Some lake associations or districts will provide a service with designated times to collect and compost plants removed by property owners. The plant material is typically piled at the end of their piers on pick up days.

Aquatic plants, when removed from the water, are heavy. This method is labor-intensive and may not be suitable for people with limited mobility or strength. Hand pulling and removal may need to be repeated multiple times a season for multiple seasons. It is also important for people to be familiar with aquatic plant identification to avoid removing protected species.

Disposal is another consideration. Aquatic plants can be composted onsite to supplement gardens. Other disposal options will vary by municipality. Some lake associations or districts provide a service, funded by dues, with designated times to collect and compost plants removed by property owners. The plant material is typically piled at the end of their piers on pick up days and then transported to a central composting site[36].

Table 8-1. Hand Pulling by Lakeshore Property Owners – Evaluation Summary

Hand Pulling by Lakeshore Property Owners	
RECOMMENDED (for small scale applications)	
APPLICABILITY	**MEDIUM.** This approach would be most appropriate for small areas along the shoreline. It would not be appropriate for addressing issues on a lake-wide scale.
RELIABILITY	**HIGH.** This method has been shown to be effective in small, isolated areas such as along the shoreline of private properties to allow for recreational access.
DURATION	**SHORT.** Results will typically last up to one month.
FREQUENCY	**FREQUENT.** Will likely be needed multiple times per season.
PERMITTING	**NONE.** No permits would be required in most cases if NR 107 and NR 109 are followed, and control takes place within a single 30-foot wide area (measured along the shore).
COST	**LOW.** Costs would be low.
SUPPORT	**MODERATE.** Over half of surveyed stakeholders support this method, the general public more strongly than the property owners.

[35] *If wild rice is involved, the procedures of s. NR 19.09 (1) should be followed.*

[36] *Example of pick-up program: https://www.cleanlakesalliance.org/aquatic-plant-management/*

8.2.1.3. Hand Pulling by Paid Contractors or Volunteers

Lakeshore property owners, a lake association, or lake district may decide to pay a contractor to manually remove aquatic vegetation by hand or utilize a highly trained group of volunteers. It is critical for those performing hand removal to have strong plant identification skills. For this method, contractors or volunteers use snorkeling equipment, surface supplied air systems or SCUBA dive to identify, and hand pull aquatic plants [75]. Roots, runners, and even fragments of some species can grow into new plants, so the entire plant is removed. The removed plant material is then placed in a designated collection location either on shore or a boat. From there, the material is properly disposed.

With the right training and equipment, hand pulling can be a highly selective technique, provided the target species can be easily identified which may depend on water clarity. This technique is often used to target new infestations of invasive plants with low plant density (generally less than 500 stems per acre). Hand pulling can be used to remove more dense plant growth in small areas, but there may be more effective approaches in those situations. This technique can also be used as a follow-up strategy to an herbicide treatment program to extend the duration of plant control. Hand pulling disturbs the lake bottom which kicks up sediment and reduces visibility in the water. As a result, multiple passes over the same area may be required. Larger hand pulling efforts typically use multiple divers. Manual removal that extends beyond a 30-foot area along the shoreline requires a permit. Hand removal by contractors can be expensive because it is labor-intensive, requires appropriate training, and takes time. Having people in boats that can collect dive bags full of removed plants helps improve efficiency. Hand removal works better for certain species that do not spread through fragmentation. When using this method to remove EWM and CLP, extra care should be taken so that the entire plant can be collected and removed to prevent vegetative regrowth.

Because of the risk for fragmentation, potential high costs, and labor intensity, this method is not recommended for large scale control on LLBDM. However, it could be appropriate on a small scale around docks, launches, or high public use areas if those performing the removal are properly trained in identification of target species and acknowledge the importance of removing the entirety of an individual plant.

Table 8-2. Hand Pulling by Paid Contractors or Volunteers – Evaluation Summary

Hand Pulling by Paid Contractors or Volunteers	
RECOMMENDED (for small scale applications)	
APPLICABILITY	**MEDIUM.** This approach would be most appropriate for small areas of targeted plant species control. It would not be appropriate for addressing issues on a lake-wide scale.
RELIABILITY	**HIGH.** This method has been shown to be effective when targeting new infestations of invasive plants with low plant density (generally less than 500 stems per acre).
DURATION	**SHORT.** Results will typically last up to one month.
FREQUENCY	**FREQUENT.** Will likely be needed multiple times per season.
PERMITTING	**LIKELY REQUIRED.** Manual removal that extends beyond a 30-foot area along the shoreline requires a permit under NR 109.
COST	**HIGH.** Costs would likely be high if hiring a paid contractor to complete the work.
SUPPORT	**MODERATE.** Over half of surveyed stakeholders support this method, the property owners more strongly than the general public.

8.2.1.4. Suction Harvesting

Suction harvesting involves suctioning the lakebed to remove sediment and uproot aquatic vegetation [76]. The material is pumped through tubing to either a boat or on shore storage and then disposed. Because this process disturbs and removes lakebed materials, it is classified as dredging in Wisconsin and requires a dredging permit[37]. This method also requires a mechanical aquatic plant management permit to prevent harmful effects on the native aquatic plant community[38].

Figure 8-3. Suction harvester example.

Source: https://weedersdigest.com/

Removing lakebed material can pose risks to water quality, habitat, and aquatic organisms. Suction harvesting can also be logistically challenging, expensive, and it can be difficult to target specific species. Permits may require contaminated sediment sampling, in-water sediment control practices, and dredge spoil disposal techniques. Due to the high costs and low applicability, this method is not recommended for LLBDM.

Table 8-3. Suction Harvesting – Evaluation Summary

SUCTION HARVESTING	
NOT RECOMMENDED	
APPLICABILITY	**LOW.** Although this method is well understood, and risks are known, non-target impacts are high and cannot feasibly be scaled to address the size of the issue.
RELIABILITY	**LOW.** Positive outcomes have been documented in other lakes in limited areas and applications.
DURATION	**MEDIUM.** Could potentially provide relief in select areas for one season.
FREQUENCY	**SEASONAL.** Would need to be repeated annually.
PERMITTING	**REQUIRED.** Dredging and mechanical harvesting permits would be needed at a minimum. Additional permits may be required.
COST	**HIGH.** Requires contractor with specialized equipment and training.
SUPPORT	**MODERATE.** Many stakeholders supported this method or wanted more information.

[37] *Applicable state statutes and code include ss. 30.19 and. 30.20, Wis. Stats., chs. NR 341, NR 345, NR 346, and NR 347, Wis Adm. Code. Practice may also require local or federal permits.*
[38] *Applicable state statues and code include ss. 35.93, Wis. Stats., chs NR 109, Wis Adm Code*.

8.2.1.5. Diver Assisted Suction Harvesting (DASH)

Diver Assisted Suction Harvesting (DASH) offers a localized approach for controlling aquatic plants and is typically used to target invasive plant species. DASH uses a similar device as suction harvesting, but the difference is that a trained underwater diver hand-picks target species in a defined area and feeds the plant material into the suction device. DASH does not require a dredging permit because plants are removed by hand and the lakebed is not intentionally targeted for removal (although a small amount of sediment attached to plant roots may be incidentally captured and removed).

Figure 8-4. DASH diver feeding plants into suction device.

Source: [Chuck Drucker, WI Lakes Convention Presentation, 2016]

The underwater diver needs to be SCUBA certified and proficient with aquatic plant identification to be selective. DASH can be useful for controlling invasive aquatic plants like EWM in confined areas where plants can be specifically targeted. However, extra caution needs to be taken with species like EWM that can grow new plants through fragmentation. While this method can be effective, it is costly due to specialized diver training, safety considerations, and operation of equipment. This method can also reduce water clarity during application when the sediment is disturbed as plants are pulled from the lake bottom. Annual monitoring should occur pre- and post-implementation and follow-up treatments may be needed.

DASH is not recommended for the entirety of LLBDM due to its high cost. The lake's size makes it impractical and too expensive for widespread use. However, it is a management method that could be used in smaller areas where high densities of AIS have been found or around high public use areas. DASH requires a WDNR mechanical aquatic plant management permit[39] to avoid negative impacts on the native aquatic plant community. As per the WDNR website, should DASH be explored it is recommended that the local WDNR aquatic plant management coordinator be contacted for further guidance [76].

---

[39] *Applicable state statues and code include ss. 35.93, Wis. Stats., chs NR 109, Wis Adm Code*.

Table 8-4. DASH – Evaluation Summary

DIVER ASSISTED SUCTION HARVESTING (DASH)	
NOT RECOMMENDED	
APPLICABILITY	**LOW.** Although this method is well understood, risks are known, and non-target impacts could be low in select areas, it cannot feasibly be scaled for widespread use in LLBDM.
RELIABILITY	**MEDIUM.** Positive outcomes have been documented in other lakes.
DURATION	**MEDIUM.** Could potentially provide relief in select areas for one season.
FREQUENCY	**SEASONAL.** Would need to be repeated annually.
PERMITTING	**REQUIRED.** Mechanical harvesting permit (NR 109) would be needed. Additional permits may also be required.
COST	**HIGH.** Specialized equipment and training are required.
SUPPORT	**MODERATE.** Over half of surveyed stakeholders support this method, many also requested more information on this approach.

8.2.1.6. Mechanical Harvesting

Mechanical harvesting uses equipment to cut areas of aquatic plants below the waters' surface and removes the collects the cut material, removing plant fragments from the lake. This technique is similar to mowing the lawn. Plants are typically cut to depths of 2-6 feet and collected via a conveyor belt. Plant materials is then off-loaded onto a designated site on shore such as a dumpster or dump truck and disposed of properly.

Figure 8-5. Mechanical harvester on a lake shore following operation efforts

Harvesters range in size, speed and price, and can generally cut plants in strips up to 10 feet wide (exact specifications depend on the model of harvester). Aquatic plants may be mechanically harvested down to five feet below the water surface or one half the depth of the water column.

Mechanical harvesting can be used for nuisance plants as well as AIS control. If harvesting is being used to control CLP or EWM, it should take place early in the season before EWM grows advantageous roots and CLP develops turions.

There are numerous advantages of mechanical harvesting, including:

1. Permits can be multi-year, renewable on a 3 to 5-year cycle.
2. Trimming the plants generally leaves a portion of the plant including roots in place. This provides shelter for fish and stabilizes lake sediments protecting water clarity.
3. Removal of plant cuttings prevents large plant die-offs that lead significant release of nutrients (fueling blue-green algae blooms or additional plant growth), and cause DO to drop (as plant material decays).
4. Mechanical harvesting permits generally allow harvesting to begin on June 1st (to protect spawning centrarchids and their fry in spring) and can take place anytime thereafter typically to October without additional permits or permit revisions.
5. Navigation lanes maintained by harvesting can allow predator fish, such as bass or pike, better ambush opportunities leading to a more balanced fishery.
6. Harvesting can also be used as a means to facilitate native aquatic plant growth by "top cutting" AIS growth that has canopied out. Use of a top cut in areas of dense AIS growth, can provide additional sunlight for native plant growth, increasing diversity and habitat quality.
7. Free floating plants or algae uprooted by wave and boating action may be surface skimmed without the use of the cutting head. Skimming can occur outside of the designated harvest areas with care to avoid non-target vegetation. This includes removal of dense mats of filamentous algae.

While there are many advantages to harvesting, there are disadvantages to consider, including:

1. Potential for plant fragmentation which can facilitate the spread of EWM.
2. Turbidity due to equipment disturbing sediment in shallow water.
3. Limited by depths that they can effectively operate. Permits typically require depths greater than 3 feet of water, but some harvesters may require deeper water depending on equipment design.
4. Difficult to navigate around docks and piers.
5. Requires significant infrastructure. If being conducted by a lake group, the purchase of a harvester and other necessary equipment can range from $20,000 to over $200,000
6. Harvester storage, maintenance, and operator costs need to be considered in addition to insurance and cost of plant disposal.
7. Hiring a contractor to complete the work can also be expensive, especially if contractors travel a long distance to the project site. Cost estimates range from $200 – $1,000 per acre for contracted services.

Mechanical harvesting is highly recommended for small-scale or large-scale aquatic plant management within LLBDM due to its effective and efficient outcomes and high public support (Table 8-5). Stakeholder feedback indicated that there was strong support for mechanical harvesting within the SPO and GP groups. Survey results indicated that 76% of SPO respondents and 54% of GP respondents reported that they "completely support" or "moderately support" the potential future use of mechanical harvesting within LLBDM.

Table 8-5. Mechanical Harvesting – Evaluation Summary

MECHANICAL HARVESTING	
RECOMMENDED	
APPLICABILITY	**HIGH.** Effective method for immediate removal of nuisance vegetation.
RELIABILITY	**HIGH.** Positive outcomes have been documented in other lakes.
DURATION	**LOW.** Would need to be repeated annually multiple times per season.
FREQUENCY	**HIGH.** Would need to be repeated annually multiple times per season.
PERMITTING	**REQUIRED.** Mechanical harvesting permit (NR 109) would be needed.
COST	**HIGH.** Contractors and specialized equipment are required.
SUPPORT	**HIGH.** The majority of shoreline property owners and most of the general public support this method.

8.2.2. Herbicide Treatments for Aquatic Plants

Aquatic vegetation can be treated chemically through the application of herbicides, a type of pesticide designed to target plant populations. In lakes, herbicides are typically applied at or below the water's surface using spreaders, sprayers, or underwater hoses. Herbicide treatments may have potential non-target effects. Although this is a common method for managing aquatic plants in Wisconsin, careful planning and application is important to ensure effectiveness and protect non-target species and water quality.

In Wisconsin, an Aquatic Plant Management (APM) permit is required for the application of herbicides. It is also necessary to hire a certified applicator for treatments, which adds to the financial cost. Individual active ingredients of aquatic herbicides can vary on their cost per unit of measurement such as gallon versus pound. This can alter the overall cost of an herbicide management program, as the cost for herbicide is very dependent on the active ingredient selected as well as the determined application area. For example, applying herbicides to the entire littoral zone of a waterbody would be high cost and likely to be viewed negatively by the public. Alternatively, it is lower cost to treat a specified area dense with AIS or to improve recreation. In terms of cost per effort, herbicides are on the low side compared to other aquatic plant management techniques. However, in some waterbodies poor management designing herbicide treatment programs require annual or semiannual herbicide applications.

The cost to treat small areas (50 feet by 150 feet) ranges from $200 to $400, depending on the number of treatments and chemicals used. Large-scale treatments usually range from $400 to $1,400 per acre, depending on the chemical used. Nearly all aquatic herbicides are classified as restricted use products by the Department of Agriculture, Trade, and Consumer Protection (DATCP), and pesticide certification is required. These types of pesticides carry a risk of potentially harming the environment and/or affecting human health. It is recommended to consult with a professional lake management firm if using chemicals to control aquatic plants.

There are different types of herbicides based on their actions: direct contact and systemic. Direct herbicides are contact based and degrade plant structures; systemic herbicides are absorbed, interfering with a plant's chemistry and biological processes. Contact herbicides generally begin working faster than systemic herbicide treatments but may not result in the complete death of the plant. Systemic herbicides take longer to work because the herbicide needs to travel throughout the plant but generally are more likely to result in complete death of the plant.

When selecting an herbicide for use on a target species there are many factors to consider such as selectivity, toxicity, and cost of the active ingredient. By using the most appropriate herbicide under the right conditions, a higher level of control can be reached.

Chemical control of aquatic plants has advantages such as broad control over large areas, and applications in shallows and around docks. Herbicide application is less physically demanding than manual removal and can be applied throughout the growing season, depending on types of chemicals used and their dosage.

Drawbacks to herbicide-based plant control includes negative perceptions about chemicals in natural lakes, as well as possible water use restrictions after application. Herbicides can also potentially affect non-target plant species and other aquatic organisms such as fish. (if the wrong herbicide is used, not applied at an appropriate application rate, under the right conditions, and/or time of year).

Another negative of this method is that plants are killed but not removed which results in plant die-offs. As plants die and decay, they release nutrients into the water. Those nutrients can fuel blue-green and filamentous algae blooms. Plant die-offs can also cause dissolved oxygen levels in the water to drop as the decay process of the plants consumes oxygen. This may inadvertently trigger hypoxic conditions and, in extreme situations, fish kills. This is prevalent in small waterbodies with restricted hydrology, and much less likely to occur in a flowage style lake such as LLBDM. Aquatic plant death can also lead to reduced sediment stabilization and habitat fragmentation.

After repeated treatments plants can become resistant to herbicides, and openings created increase the potential for encroachment and takeover of invasive species. Repeated use of herbicides that use the same mode of action to kill the plants increases the risk of herbicide resistance developing in aquatic plant communities. To reduce the risk of developing resistant communities, using the same type of herbicides year after year should be avoided.

Aquatic herbicide applications must be completed by a state certified applicator with proper training. Well-qualified and reputable contractors should apply herbicides at specific rates using techniques under appropriate conditions that minimize collateral damage to native plants and/or non-target species. Aquatic herbicides are generally applied at a rate that does not affect other aquatic life (i.e., fish and macroinvertebrates) but depending on time of year and temperature of the water, some losses may occur. To manage nuisance growth of invasive plants, herbicide applications are usually done early in the season, after the invasive plants have started to grow and before the native plants have emerged. This helps minimize impacts to native plants and allows for a more effective herbicide application.

If conducted, an herbicide application plan and schedule should be designed to effectively eliminate target species with a goal of not having to apply herbicides on an annual or semiannual basis. If liquid herbicides are applied at LLBDM a surfactant should be utilized to ensure that the applied product has sufficient contact time with target species to be effective. Additionally, applications near areas with known populations of rare or desirable species should be avoided or applied with extreme caution to protect these communities.

Table 8-6. Aquatic Herbicides Approved for Use in Wisconsin, WDNR

Active Ingredients[1]	Selectivity	Mode of Action	Concentration and Exposure Times (CET)	Benefits	Limitations	Potential Non-target Impacts[2]
2,4-D[3]	Selective for broadleaf plants	Systemic	Acts rapidly but kills plants in 1-2 weeks	Selectivity	Drinking and irrigation restrictions apply.	Variable toxicity to aquatic fauna
Bispyribac-Sodium	Selective	Systemic	60-90 days	Selectivity	Irrigation restrictions	Likely to leach into groundwater
Carfentrazone-Ethyl	Selective	Contact	Acts rapidly	Selectivity	Cannot be applied within ¼ mile of potable water intake	Moderately toxic to fish and invertebrates
Copper Compounds	Selective, typically used for algae	Contact	Short exposure (~3 hours, depending on product)	Selective, long track record	Builds up in sediment, resistance over time, invertebrate toxicity	Highly toxic to certain fish species
Diquat Dibromide[4]	Non-selective	Contact	Acts rapidly kills plants in 1-3 days	Fast acting	May not work as well in turbid water, water use restrictions	Toxic to freshwater fauna
Endothall Acid[5]	Non-selective	Contact	Acts rapidly but kills plants in 10-14 days	Many formulations	Fish consumption, drinking, and irrigation restrictions.	Potential reproductive impacts on fish
Florpyrauxifen-Benzyl[6]	Selective	Systemic	12-24 hours	Track record of success with milfoils	Costly, irrigation restrictions, potential for slight impacts on native species	Potential to harm desirable milfoil species
Flumioxazin	Non-selective	Contact	Rapid with signs quickly appearing	Ability to control floating or submersed plants	Cannot be used at high pH levels, irrigation restrictions	Moderately toxic to freshwater invertebrates
Fluridone	Selective based on dosage	Systemic	Long exposure (45+ days)	Selectivity	High exposure time, need to maintain target concentrations	May persist in sediments for a period
Glyphosate	Non-selective	Systemic	Acts rapidly but kills plants in 1 to 4 weeks	Strips out of water column quickly	Potable water intake restrictions. Requires the use of a surfactant to ensure uptake by plants.	Inert ingredients may have toxic properties to fauna
Imazamox	Selective	Systemic	Short exposure, plant decomposition over weeks	Selectivity	Potable water intake and irrigation restrictions	May persist in sediments of deeper waters
Imazapyr	Non-selective	Systemic	Short exposure, plant decomposition over weeks	Low toxicity to animals	More effective on emergent species	Can be active in soil, likely to leach into groundwater
Penoxsalum	Selective	Systemic	60+ days	Selectivity	Irrigation restrictions, high exposure time, need to maintain target concentrations	Likely to leach into groundwater
Triclopyr	Selective	Systemic	Acts rapidly	Selectivity	Irrigation restrictions	May leach into soil but not likely groundwater

Table Notes:

1. Product names are provided solely for your reference and should not be considered exhaustive nor endorsements.
2. Listed potential non-target impacts can be minimized with proper use and application by adhering to product labels.
3. Example trade names: Aquakleen, Aquacide, Navigate®, Weedtrine
4. Example trade names: Reward®, Diquat
5. Example trade names: Aquathol®, Hydrothol®
6. Example trade name: ProcellaCOR®
7. Example trade name: Rodeo®
8. Example trade name: Sonar®
9. Chemical fact sheets are available on the WDNR website: https://dnr.wisconsin.gov/topic/lakes/plants/factsheets

When the WDNR evaluates a chemical herbicide permit, they consider the suitability of the chosen herbicide, its impact on non-target organisms, potential environmental effects, and human safety. They may issue a conditional permit to ensure responsible herbicide use and adherence to best management practices. There are several different types of herbicides used in Wisconsin. These products, sold under a variety of trade names, are listed in Table 8-6. A few helpful definitions for interpreting the table include:

> **Selectivity:** a selective herbicide can kill or slow the growth of some types of plants while leaving other types of plants unharmed. Non-selective herbicides are broad-spectrum and likely to kill or damage most types of plant species.
>
> **Contact herbicide**: an herbicide that kills plants through direct contact with the green parts of the plant such as the leaves. The chemical penetrates the cell membrane of the plant, breaking it down and killing the cell. These types of herbicides are typically faster acting.
>
> **Systemic herbicide**: an herbicide that is absorbed by the plant's leaves or roots and moves through the plant's vascular system to cause plant death. This typically results in the death of the entire plant rather than just the portion that came into contact with the herbicide.
>
> **Water use restrictions:** Water use restrictions vary by herbicide and are listed on the herbicide label. Potential water use restriction examples include fishing and irrigation. Water use restriction signs must be posted at public access points to the waterbody for at least one day near an herbicide treatment and sent to shoreline landowners in advance of the treatment. The signs list the herbicides used and water use restrictions, if applicable. The EPA has determined that minimal exposure would result for adults or children swimming in waters treated with herbicides approved for use in Wisconsin. To minimize the risk of direct exposure, people and pets can keep a safe distance away from the herbicide control area during application and for the duration of the posted water use restriction.
>
> **Concentration and Exposure Time (CET):** For aquatic herbicides, “concentration" refers to the amount of active ingredient present in the water or solution. "Exposure time" is how long a plant needs to be in contact with the herbicide at a certain concentration for the herbicide to be effective. Concentration and exposure time significantly impact the effectiveness of an herbicide and its potential environmental impacts. CET can vary significantly depending on the herbicide being used and site conditions such as weather, water volume, plant density, water flow, and more.

Table 8-7 provides a comparison of active ingredients that have demonstrated herbicidal activity on the five most abundant aquatic plants found during the LLBDM aquatic plant survey: coontail, Canadian waterweed, E, CLP, and water stargrass.

A Best Management Practice (BMP) for herbicide application includes treatment in segments or sections. Herbicide choice as well as application rates or treated areas are dependent upon chemical limits of each product, ecology of the waterbody, site conditions, and the applicator in consultation with LLBDM stakeholders.

Table 8-7. Herbicides labeled for aquatic use to control the five most abundant species encountered in LLBDM during 2024 survey efforts.

Active Ingredient	Coontail[1]	Canadian Waterweed[1]	Eurasian Watermilfoil	Curly Leaf Pondweed	Water Stargrass[1]
2,4D	X	X	X	X	X
Bispyribac-Sodium			X		
Carfentrazone-Ethyl			X		
Copper-Based Products	X	X	X	X	
Diquat Dibromide	X	X	X	X	
Endothall[3]	X	X	X	X	X
Florpyrauxifen-Benzyl	X		X		
Flumioxazin[4]	X		X	X	
Fluridone	X	X	X	X	
Glyphosate					
Imazamox	X		X	X	X
Imazapyr					
Penoxsulam			X	X	
Sodium Percarbonate					
Triclopyr			X		

Table Notes:
1. Coontail, Canadian waterweed, and water stargrass are native aquatic plant species.
2. Product names are provided solely for your reference and should not be considered exhaustive nor endorsements.
3. Endothall has been shown to be highly effective for treating curly leaf pondweed.
4. Florpyrauxifen-Benzyl has been shown to be highly effective for treating Eurasian watermilfoil in many Wisconsin lakes.

Stakeholder feedback in the 2024 surveys indicates support for chemical treatment within the shoreline property owner (SPO) group. The general public (GP) did express some support for this method, however, there also was a significant negative response expressed by the GP not found in the SPO group. For LLBDM, small-scale treatments in targeted areas are recommended as a potential APM tool as part of an integrated pest management approach. Large-scale treatments are not recommended (Table 8-8).

Table 8-8. Herbicide Application - Evaluation Summary

HERBICIDE APPLICATION	
SMALL SCALE RECOMMENDED; LARGE SCALE NOT RECOMMENDED	
APPLICABILITY	**MODERATE.** Small problem areas can be treated but large areas would be high cost with low benefit.
RELIABILITY	**MODERATE**. Most effective in targeted small-scale efforts for certain species or problem areas.
DURATION	**LOW**. This method acts quickly usually under a few weeks, but effects may not last.
FREQUENCY	**HIGH.** Treatments can be required annually as effects are temporary.
PERMITTING	**REQUIRED.**
COST	**MODERATE-HIGH**. Depends on the amount and type of active ingredient.
SUPPORT	**LOW.** Some shoreline owners support this method however there is stronger opposition from the general public.

8.2.3. Biological Control of Aquatic Plants

Biocontrol is biological control using natural predators or competitors to reduce plant growth. The types of living organisms used are usually insects or fungi that eat or infect the plants [77]. This method is used to target invasive plant species and can take several years to show results. A successful biocontrol program typically reduces the number of plants in a given area to a tolerable level, but does not eliminate the invasive species [78]. Reducing the growth of invasive plants allows for native plants to better compete for resources such as light and space. Biocontrol is self-sustaining, organisms often over-winter and then resume eating its host the next year. Control response may be slow, and effectiveness of these methods will vary as the control agent's population fluctuates. There are two biological control programs relevant to LLBDM: purple loosestrife biocontrol and Eurasian watermilfoil biocontrol.

8.2.3.1. Purple Loosestrife Biocontrol

Purple loosestrife (PL) Biocontrol is a proven effective and environmentally sound alternative to herbicides that has been used in Wisconsin since 1994 [79]. In Wisconsin, there are four types of beetles that have been shown to be effective. Two of those beetle species, *Galerucella calmariensis and G. pusilla,* are most commonly used because they are the easiest to intentionally rear and place where needed and they are regarded as the most effective biocontrol agents for purple loosestrife due to their high selectivity and minimal risk to native or ornamental plants. These beetles cannot complete their lifecycle on any plant other than purple loosestrife.

Figure 8-6. Galerucella beetle on purple loosestrife.

Source: https://extension.umn.edu/yard-and-garden-news/backyard-biocontrol-combating-purple-loosestrife

Galerucella sp. beetles are raised and then released by volunteers to control purple loosestrife. To rear the beetles, volunteers capture live specimens in the field. Purple loosestrife plants are then excavated from the field and transplanted into pots. The beetles are introduced to the potted purple loosestrife, and a net is placed around each plant. Once the beetles have produced a second generation, thereby increasing their population, and the purple loosestrife in the area has reached peak growth, the beetles are released.

Purple loosestrife biocontrol is a relatively affordable option to LLBDM because it can be done by volunteers instead of a paid subcontractor. Training, supplies, and equipment may be available at no-cost depending on funding capacity in the area. FWWA is locally implementing a Purple Loosestrife Biocontrol Program where eight volunteers across the watershed help raise the beetles. They have also aided in the capture and raise of beetles for control for the Oneida Nation and the Mosquito Hill Nature Center. There are a few disadvantages of this method to be aware of. Timing of plant collection, beetle rearing, and beetle release may not be convenient for everyone. Rearing requires dedicated outdoor space with access to water for watering the plants. For LLBDM, implementation and ongoing maintenance of a purple loosestrife biocontrol program is recommended because of the low cost, high applicability, and need to keep purple loosestrife populations in check (Table 8-9).

More information on this method is available here: https://dnr.wisconsin.gov/topic/Invasives/loosestrife

Table 8-9. Purple Loosestrife Biocontrol - Evaluation Summary

PURPLE LOOSESTRIFE BIOCONTROL	
RECOMMENDED	
APPLICABILITY	**HIGH.** This method is currently implemented by local groups and large populations of this plant are present for treatment.
RELIABILITY	**MODERATE**. Success of this method depends on scale and amount of community involvement.
DURATION	**LOW.** Annual efforts for beetle rearing and release.
FREQUENCY	**LOW**. Beetles are raised and released annually.
PERMITTING	**REQUIRED.** Transport of WI restricted species.
COST	**LOW.** This method is volunteer based with funding source opportunities.
SUPPORT	**LOW.** Although there was some stakeholder support most requested more information on this method.

8.2.3.2. Eurasian watermilfoil Biocontrol

Extensive research has gone into the potential for the milfoil weevil (*Eurychiopsis lecontei*) to control populations of Eurasian watermilfoil (*Myriophyllum spicatum*). The weevils are native to Wisconsin and can provide selective control of EWM [77]. However, this method requires that the weevil be stocked in large numbers, even in lakes where the weevil is already present. The weevils also require quality habitat for overwintering on undeveloped shorelines with leaf litter present. Bluegill feed on the weevil which lowers the weevil's population density. This method is not recommended in conjunction with herbicide application as herbicide has a negative effect on the weevils lowering their effectiveness [80].

Although some success has been shown in Wisconsin from stocking EWM weevils, it has proven to be challenging to keep up with and sustain the populations to effectively control EWM through biocontrol alone [81]. As EWM biocontrol has high maintenance with potential for minimal control, this is not a recommended option for LLBDM (Table 8-10).

Table 8-10. Eurasian watermilfoil Biocontrol– Evaluation Summary

EURASIAN WATERMILFOIL BIOCONTROL	
NOT RECOMMENDED	
APPLICABILITY	**LOW**. Minimal control results as weevils may reduce but do not eliminate EWM and methods such as herbicides and mechanical harvest reduce weevil populations.
RELIABILITY	**LOW**. Size of weevil populations required can take years to establish or never reach sizes for effective control.
DURATION	**HIGH**. Requires ecological factors which support weevil life cycle success for significant feeding activity on plant biomass.
FREQUENCY	**LOW.** Factors which limit weevil density and abundance such as predation, overwintering habitat of undeveloped shorelines limit the amount of herbivory for control.
PERMITTING	**REQUIRED.**
COST	**MODERATE**. Efforts to promote current populations would be low cost however stocking or shoreline habitat alteration could be high cost.
SUPPORT	**LOW.** This method is not predictable or reliable for the reduction of EWF.

8.2.4. Water Level Manipulation

Altering the physical habitat, such as adjusting water levels or sediment composition, can reduce plant growth but careful attention needs to be paid to potential unintended consequences. LLBDM is a candidate for water level manipulation by the means of flooding and drawdowns as it is part of the Lower Fox Fiver and has dams upstream and downstream. These two types of water level manipulation are likely not feasible due to water rights, industry, and USACE management.

8.2.4.1. Flooding

Flooding is a low-cost control technique where lake levels are raised for a given period of time to drown wetland and terrestrial plant species. The duration and level of the flooding needed to successfully drown and kill target plants varies by species. This method may subject lake-front home and business owners to property flooding, so careful planning is required. For plants that fragment, such as EWM and CLP, flooding may exasperate their spread.

Flooding is not a recommended method for LLBDM because submergent plants are the primary type of plants causing impairments to lake use and flooding is typically used for emergent plants [82].

Table 8-11. Water Level Manipulation – Flooding – Evaluation Summary

Water Level Manipulation – Flooding	
NOT RECOMMENDED	
APPLICABILITY	LOW. Water levels are controlled by USACE.
RELIABILITY	LOW. This method is not effective for submerged plants.
DURATION	LOW. Targeted timing to submerge target species during growing season.
FREQUENCY	LOW. Annual to biannual.
PERMITTING	REQUIRED.
COST	LOW. Inexpensive if means to conduct drawdown are present.
SUPPORT	LOW. Little option to manipulate water levels, due to water rights, industry and USACE control; potential negative impact to shoreline property owners.

8.2.4.2. Drawdowns

For lakes that have a water level control structure, such as a dam, drawdowns are a potential option for managing aquatic plants. During a drawdown, water level in the lake is lowered to expose aquatic plants to the air. Dewatering dries and freezes the vegetation during winter. This method can help encourage the growth of native vegetation and help to the restore emergent plant communities such as sedges and rushes.

The success of this control method depends on the duration, timing, and level of the drawdowns. Control during the winter months has shown the most success in controlling aquatic plants [83]. During the period of the drawdown homeowners and lake-front businesses could do shoreline clean up and perform maintenance of docks and seawalls, with the proper permits. This can be a cost-effective method of control.

However, lake drawdown may result in the increase of invasive species populations. To sustain recreational activities in the lake, the drawdown may be restricted to over the winter season limiting the amount of time plants have to die and dry out. Once the lake level has been restored, the decaying plant matter left behind may release nutrients into the water which can result in harmful algal blooms.

Table 8-12. Water Level Manipulation – Drawdown – Evaluation Summary

WATER LEVEL MANIPULATION – DRAWDOWN	
NOT RECOMMENDED	
APPLICABILITY	**LOW.** Water levels are controlled by the USACE.
RELIABILITY	**MODERATE.** This method can reduce plant populations but increase opportunity for HABs and invasive species.
DURATION	**LOW.** Targeted timing such as winter drawdowns.
FREQUENCY	**LOW.** Annual manipulation.
PERMITTING	**REQUIRED.**
COST	**LOW**. Inexpensive if means to conduct drawdown are present.
SUPPORT	**LOW.** Little option to manipulate water levels due to water rights, industry and USACE control.

8.3. Integrated Pest Management

Integrated pest management (IPM) is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a diversity of treatment options, monitoring, and adaptive management strategies [84]. The ultimate goals of IPM are to achieve effective long-term pest management while reducing impacts to native species and the ecosystem [84]. To do so, all available treatments options and best management practices are considered during the planning process.

Science-based data are used to inform which treatment option is the most effective strategy to control the target species while limiting impacts to the non-target species, human health, and the environment [85] . As target species can become resistant to repetitive management, a combination of management approaches may be necessary to most effectively manage the species long-term [85]. This may include a combination of techniques such as biological control, mechanical treatment, chemical treatment, habitat manipulation, and modification of land use practices [23].

The benefits of IPM include [86]**:**

- Ecosystem based approach
- Focus placed on pest impacts
- Reduces harm to non-target species and the environment
- Variety of treatment options are considered
- Reduced likelihood of target species developing treatment resistance

The challenges of IPM include [86]**:**

- Management recommendations may be complex
- Requires stakeholder support and organizational capacity
- Does not fix root causes leading to pest establishment
- Management techniques are adjusted over time

Recommended treatment options for a target species may vary based on annual conditions, waterbody characteristics, and ecosystem functions. To improve long-term effectiveness, IPM must include an adaptive management strategy to re-evaluate and adjust management techniques over time. Adaptive management is a structured approach where decision-making is continuously adjusted based on new information gathered through monitoring, such as annual post-treatment monitoring. This method allows for flexibility and improvement in managing the ecosystem over time, even when there is uncertainty about the best course of action.

IPM, with an emphasis on adaptive management, is highly recommended for LLBDM due to the complexity of the lake ecosystem and variety of human and wildlife uses. Within LLBDM, IPM should consist of informed decision making based on collected data and stakeholder needs. Strategies should be adjusted over time to allow for dynamic management responses to changing conditions of the system.

8.4. Indirect Management Methods

An effective aquatic plant management program includes preventing the spread of aquatic invasive species, reducing nutrient and sediment pollution, and habitat protection as a primary action. These are indirect ways to reduce the amount of direct management needed to control aquatic plants.

Management strategies solely focused on aquatic plant extermination is a temporary measure that reduces the symptoms of the issue. Preventing new invasive plants from entering the lake eliminates the need to manage those plants in the future. Reducing nutrient and sediment pollution that enters the lake means there would be less food to fuel plant growth. Protecting areas of habitat helps to maintain the biological integrity of the plant communities, making them more resilient against encroachment of invasive species and maintains healthy competition among different plant species.

8.4.1. AIS Education, Prevention, Monitoring and Rapid Response

Efforts to protect Wisconsin's lakes from new AIS introductions focus on raising awareness through education and engagement. Working closely with the Wisconsin Lakes Partnership, the WDNR, and UW-Extension, organizations like FWWA and lake groups as well as citizen volunteers teach boaters, anglers, and other lake users how to:

1. Prevent the spread of AIS
2. Comply with state regulations
3. Identify AIS
4. Monitoring for AIS
5. Report new AIS findings

Examples of potential outreach and education efforts include CBCW, CLMN, Fox-Wolf's Adopt-A-Launch, and local implementation of statewide initiatives such as the Drain Campaign and Landing Blitz. Volunteer work and public involvement are essential for successful implementation of education initiatives. There are many educational resources and tools available from the WDNR and UW-Extension Lakes such as brochures, publications and other online resources.

Preventing the introduction of new AIS is essential to protect the lake. It is the most effective method to mitigate AIS impacts. AIS can significantly disrupt local ecosystems by preying on native species, competing for resources, and introducing diseases. This disruption can lead to a decline in biodiversity and the collapse of local ecosystems. Additionally, preventing new introductions of AIS helps in maintaining the improvements achieved through management efforts and protects the lake against future threats such a changing climate.

Monitoring provides the data needed to understand the presence, distribution, and impacts of AIS. While prevention is critical, monitoring serves several key functions such as:

- **Early Detection**: AIS can be difficult to detect because they may not immediately show noticeable signs of damage or may blend in with native species. Monitoring allows for early detection, which is crucial for managing and containing a newly introduced species before it spreads widely, becomes established, or causes extensive harm.

- **Assessing Effectiveness of Management**: Even with prevention efforts, some AIS may still infest the lake. Monitoring helps assess how well control or management measures are working, allowing for adjustments and improvements in strategies over time.

- **Tracking Spread**: Invasive species often spread rapidly and unpredictably. Ongoing monitoring helps track their movement and expansion across different areas, enabling proactive measures to prevent further spread to new water bodies or regions.

- **Understanding Ecological Impacts**: Monitoring provides critical information on how AIS are affecting the ecosystem. By studying the interactions between invasive and native species, scientists and resource managers can predict and mitigate ecological damage.

- **Raising Awareness**: Consistent monitoring efforts can help raise public awareness about the threats of AIS. When communities are aware of local monitoring programs, they can be more engaged in reporting sightings and taking precautions to prevent the introduction or spread of invasive species.

Rapid response to findings of newly introduced AIS discovered through monitoring is another crucial component of AIS management. Early detection and quick intervention can stop AIS before they disrupt ecosystems, harm native species, or cause economic losses.

Evaluation of potential methods for implementing education, prevention, monitoring and rapid response programs and projects is described below.

8.4.1.1. Clean Boats Clean Waters (CBCW)

The Clean Boat Clean Waters (CBCW) program, sponsored by the Wisconsin Lakes Partnership, is an AIS prevention program where volunteers or staff inspect boats and trailers and educate boaters to prevent AIS spread at landings. The program and local coordinators conduct training workshops across the state each spring and summer for volunteers as well as paid inspectors. During these sessions, professionals provide an overview of AIS such as EWM and zebra mussels and offer guidance on organizing effective watercraft inspection programs. Participants also engage in role-playing exercises to practice conversations with boaters at landings. The workshops are free to attend, and participants can purchase the Clean Boats, Clean Waters Watercraft Inspection manual and kit. With training and the kit, volunteers and paid inspectors can begin CBCW efforts at their local boat launch.

Many lake associations and districts pay inspectors to staff boat launches during the peak recreation season. These positions are sponsored by the lake group and are often partially funded through the WDNR Surface Water Grant Program. More information about this program can be found online[40].

8.4.1.2. Drain Campaign and Landing Blitz

The Drain Campaign occurs in early June each year and is focused on sharing AIS prevention steps with anglers. Since boaters and anglers must empty their livewells at the boat launch and not take any lake water with them according to Wisconsin law, the Drain Campaign recommends ice as a legal alternative to keep fish fresh. The Landing Blitz is another statewide effort to remind boaters to take the necessary prevention steps to stop the spread of AIS. The event occurs every Fourth of July weekend when boat traffic is highest around the state. Organizations, including lake groups, can contact the WDNR AIS program to become local sponsors of these statewide campaigns. Local sponsors help to recruit and coordinate volunteers to have a presence at the local boat launches during the campaigns. Volunteers talk with boaters and anglers about the importance of preventing the spread of AIS including specific actions people can take.

8.4.1.3. Adopt-a-Launch Program

The Fox-Wolf Adopt-a-Launch Program works to clean up the lakes and rivers by engaging community members through volunteer efforts at boat launches. Through the Fox-Wolf Adopt-a-Launch program, volunteers:

1. Identify new introductions of aquatic invasive species.
2. Prevent the spread of aquatic invasive species by removing plant and debris at launch sites.
3. Improve and protect habitat and water quality by removing garbage.
4. Help ensure recreational boating facilities are maintained by reporting issues.
5. Develop a sense of pride and ownership.

[40] https://www3.uwsp.edu/cnr-ap/UWEXLakes/Pages/programs/cbcw/getinvolved.aspx

Volunteers visit their boat launch at least three times per year between April 1 and November 1. FWWA trains volunteers and provides trash bags, safety vests, materials to search for aquatic invasive species, and a sign at the boat launch that acknowledges the volunteer's efforts. There is no charge for groups to participate in the Adopt-a-Launch Program.

Figure 8-7. Adopt-A-Launch Sign

Source: FWWA Website, 2024.

8.4.1.4. Early Detection and Rapid Response

Early Detection and Rapid Response (EDRR) is a proactive approach for managing AIS before a species establishes a large population or causes significant ecological, economic, or social harm. This strategy involves two key components:

1. **Early detection:** monitoring for and identifying the presence of AIS soon after being introduced into a new ecosystem before a species spreads widely. The sooner AIS are detected, the easier and more cost-effective it is to control their spread. Early identification and reporting are crucial to prevent them from becoming widespread, which can make eradication much more difficult and expensive.

   Examples of early detection actions:
   - Regular surveys and monitoring by environmental agencies, consulting firms, trained volunteers or researchers.
   - Annual volunteer monitoring events such as AIS Snapshot Day in Wisconsin.
   - Use of environmental DNA (eDNA) sampling to detect genetic traces of species in water.
   - Public reporting systems where recreational users, boaters, and anglers can alert authorities about potential sightings. This can be more effective when lake users are educated on AIS identification.

2. **Rapid Response:** if an invasive species is detected, immediate action is taken to report the finding to the WDNR and then to contain, control, or remove the species before it becomes established. The goal is to prevent or minimize its spread and impact. Invasive species can spread quickly, and many have exponential growth rates. Without quick intervention, the cost and difficulty of control increase significantly. Rapid response helps prevent an AIS from becoming a widespread and permanent problem.

   Examples of rapid response actions:
   - Physical removal or eradication efforts, such as hand pulling invasive plants.
   - Chemical or biological control measures.
   - Public education campaigns to reduce the spread by human activities (e.g., transporting AIS on boats or fishing gear).

EDRR has many benefits. Early detection and quick intervention can prevent long-term damage by stopping a species before it disrupts the lake ecosystem, harms native species, or causes economic losses. The sooner AIS are managed after being newly introduced, the lower the cost of eradication and control. Once a species becomes widespread, it can be resource intensive and expensive to manage.

Examples of monitoring approaches:

Volunteers can join programs like the Citizen Lake Monitoring Network (CLMN) to monitor for and identify invasive species. CLMN, part of the Wisconsin Lakes Partnership, relies on citizen volunteers for water quality and invasive species monitoring. Volunteers monitor boat launches or shorelines. Early AIS detection through CLMN helps reduce AIS impact. CLMN provides equipment and training via staff or regional coordinators such as FWWA. For more details, contact FWWA.

Another option is to hire professionals who are experts in surveying and identifying AIS such as a Certified Lake Manager (CLM) or qualified consulting firm. Although this option is more costly than using volunteers, professionals have experience and training so the result of monitoring efforts can be more accurate.

Environmental DNA (eDNA) is a new technique for monitoring invasive species. By testing water samples from a lake, eDNA can detect the presence of specific invasive species with less effort than whole lake surveys. Collected samples are sent to accredited labs to identify DNA markers. Positive results prompt detailed surveys by natural resource managers. eDNA also helps confirm eradication after management efforts if field surveys show no presence of the species. However, eDNA cannot pinpoint exact locations of the species and might detect DNA from connected systems. The method relies on accredited labs and genetic markers for the targeted species.

8.4.2. Reduce Nutrient and Sediment Pollution

Reducing nutrient and sediment pollution in the water that drains to a lake from the surrounding land is important for restoring the delicate balance of its ecosystem. Excessive nutrients, particularly phosphorus and nitrogen, drive eutrophication in LLBDM, a process where the lake has become overly enriched with soil and nutrients. This enrichment promotes excessive growth of algae and aquatic plants, which has hindered recreation in the lake. Algae blooms deplete oxygen levels in the water, harming fish and other aquatic life. Sediment pollution can also smother habitats, disrupt spawning grounds, and introduce contaminants that further degrade water quality.

LLBDM stakeholders drew strong negative connections between water quality and industrial, agricultural, and natural factors while the relationship between property management or recreational activities was less understood. Many survey respondents felt shoreline alterations had no impact, and attributed decreases in water quality to septic systems. However, there are no known septic systems located on property adjacent to LLBDM. Public education on how various property management or recreation activities may influence water quality is necessary to form a more consistent and accurate understanding of these connections amongst stakeholder groups. Any strategy for nutrient reduction should include increased access to education about best management practices. Potential options for reducing nutrient and sediment loads are described below.

8.4.2.1. Nutrient Inactivation

Nutrient inactivation involves using substances such as aluminum sulfate, iron salts, lime, or rare-earth metals to remove phosphorus from water and trap it in sediment. This method prevents algal blooms but may not significantly limit the growth of rooted vascular plants. Nutrient inactivation is primarily used for improving water quality and controlling algae. Reducing nutrients and algae in the water column can lead to increased growth of aquatic plants due to enhanced water clarity and light penetration, which allows plants to grow in deeper areas.

8.4.2.2. Agricultural BMPs

Agricultural Best Management Practices (BMPs) are practical actions that agricultural producers can implement to reduce the amount of nutrients (fertilizers and animal waste) and other pollutants including sediment from entering lakes and tributaries. These practices were developed by conservation professionals to benefit water quality while maintaining or even enhancing agricultural production. Agricultural BMPs fall into two categories: cropping and structural practices.

Cropping Best Management Practices (BMPs)
Cropping practices are implemented annually by the farmer and focus on how cropland is managed. Cropping practices work to improve soil structure, ultimately leading to increased soil health while reducing phosphorus and sediment loading to the lakes. These practices include:

- Nutrient Management
- Reduced Tillage (Strip/Zone till, No till, Mulch till)
- Cover Crops
- Low Disturbance Manure Injection

Structural Best Management Practices (BMPs)

Structural practices are considered permanent. Usually, they require engineering design, surveying and contracting with a vendor to install. Structural Practices fall into two categories:

1. Interception and diversion: practices that capture and redirect surface runoff to stable outlets, such as terraces and grassed waterways.
2. Practices that filter surface runoff and process contaminated water through soil infiltration:
    a. Vegetated Buffers
    b. Field Borders
    c. Wetland Restorations
    d. Streambank Restoration
    e. Agricultural Runoff Treatment Systems (ARTS) enhance with phosphorus filters

Conservation professionals work with farmers or landowners to determine what type of conservation practices will work best on their individual land and business.

8.4.2.3. Stormwater

Managing stormwater runoff from urban, shoreline, and rural areas helps prevent nutrient and sediment load into the lake. Techniques include:

- Constructing rain gardens and bioswales to absorb runoff
- Installing permeable pavements
- Maintaining healthy vegetation along shorelines to stabilize soil

Implementing BMPs along the shoreline helps manage stormwater and reduce pollution. This includes:

- Planting native vegetation along shorelines
- Minimizing impervious surfaces to reduce runoff
- Using rain barrels and other water collection systems
- Practice lake friendly lawn care BMPs
- Test your soils & apply fertilizers correctly
- Leave your leaves on land
- Keep grass clippings out of the lake
- Compost yard waste
- Clean up pet waste
- Locate fire pits away from the lake
- Let your grass grow

For more information about the nutrient and sediment reduction practices, visit Fox-Wolf Watershed Alliance at www.fwwa.org.

The Healthy Lakes and Rivers program in Wisconsin encourages property owners and organizations to engage in cost-effective projects that protect and restore water quality and habitats. The program provides guidance on the following (Figure 8-8):

- Creating fish and wildlife habitats (fish sticks)
- Planting native vegetation
- Preventing runoff by diverting water away from houses
- Installing runoff capture systems
- Planting rain gardens.

For more information about the Healthy Lakes and Rivers program, visit: https://healthylakeswi.com/

.

Figure 8-8. Wisconsin Healthy Lakes and Rivers Program BMPs [87].

8.4.3. Habitat Protection and Enhancement

Approximately 80% of state-listed threatened and endangered species spend all or part of their life cycle nearshore making it critical to protect these vulnerable areas which contribute to the lake's overall health [88]. Aquatic plant communities help protect water quality through stabilizing the sediments, slowing or preventing erosion, using nutrients, producing oxygen, and providing habitat and food for fish and other wildlife. There are areas in lakes that have healthy plant communities that become vulnerable to human activity. Keeping a good balance of protecting native vegetation and managing invasive and problematic species is important. Putting protections in place can help keep these areas healthy therefore keeping the lake healthy.

There are several ways habitat can be protected and restored in LLBDM:

- Reduce human disturbances in designated areas
- Advocate for appropriate water level fluctuations
- Enhance habitat through coarse woody projects
- Shoreline restoration
- Breakwall maintenance and installation
- Critical Habitat designation
- Land preservation
- Wetland Restoration

Lake habitat restoration projects come in many forms. Examples include fish passage restoration, riparian restoration, fish habitat enhancements like adding tree piles or rock reefs, shoreline stabilization, wetland restoration, invasive species removal, dredging to remove sediment and various water quality improvement projects.

Cost for habitat restoration projects varies widely based on the activity and scale. Installation of coarse woody structures can cost $1,000 to $3,000 per bundle while a large-scale installation such as a break wall may cost $100,000 or more. By working with local agencies and lake management resources, options for habitat restoration projects that best fit the needs of LLBDM, and its stakeholders can be identified and discussed. Grant funding is an option that can help to cover costs for habitat restoration projects.

Lake habitat restoration may involve complex issues like managing watershed-wide pollution sources, addressing deep-seated sediment problems, and coordinating with multiple stakeholders, requiring significant planning, time, and financial investment, even when tackling relatively minor degradation. However, some restoration techniques can be relatively straightforward to implement, especially if focused on managing external nutrient inputs or removing invasive species. The scale of any restoration project is related to the difficulty of implementation, small scale efforts can be valuable to management and implemented with ease.

Permits are very often, if not almost always required for work on the shoreline or in and near the water. Depending on the project type and location, you may need local, state, and/or federal permits. Actions taken even to improve habitat will likely need some type of permit, or at least formal permission from a regulatory authority, before you do any restoration activity. The WDNR permits for lake restoration projects that involve dredging, withdrawing water, or other activities. Permits can be applied for online using the DNR Water ePermitting System [89].

Lake groups and shoreline property owners can work with the WDNR to designate areas of a lake as critical habitat. A Critical Habitat Designation is a program that recognizes and maps important habitat in a lake to communicate areas most vulnerable to impacts from human activity. Areas can be designated as Critical Habitat if they have Public Rights Features, Sensitive Areas or both. Public rights features (defined in NR 1.06, Wis. Adm. Code) include the following:

1. Fish and wildlife habitat
2. Physical features of lakes and streams that ensure protection of water quality
3. Reaches of bank, shore or bed that are predominantly natural in appearance
4. Navigation areas

Critical Habitat Designations provide information to shoreline property owners that clarifies which regulations apply when construction or other activity is planned along the shoreline. If a project is proposed in a designated Critical Habitat area, the WDNR is able to evaluate the proposed activities during the permit process to ensure that projects will not harm the sensitive habitat resources. Critical habitat designations in LLBDM can be used to communicate with stakeholders about how lake use, and restoration efforts correspond with valuable habitat.

There are numerous opportunities in LLBDM for habitat restoration and protection. Efforts to protect valuable habitat are supported by stakeholders, both the general public and shoreline property owners indicated areas they would like to see preserved for wildlife. The public valued habitat preservation and restoration more highly than shoreline property owners, indicating an opportunity to engage a broad audience in efforts to improve habitat conditions in LLBDM.

8.4.4. Lake Ecology Education and Communication

The LLBDM lake management education strategy should raise awareness about lake ecosystems, provide targeted educational programs, and facilitate community engagement to promote responsible lake use. Education should include proactive conservation efforts, ultimately aiming to improve lake health through informed decision-making by the public and relevant authorities.

Planning lake management education initiatives requires assessments of stakeholder education needs, development of educational content, and delivering educational opportunities to the public while creating opportunities for community engagement.

The educational needs of stakeholders should be assessed through surveys, focus groups, and interviews to understand current knowledge levels, concerns, and priorities regarding the lake among residents, lake users, and local businesses. Educational and communication efforts should explain the key components of a lake ecosystem, including water quality parameters, aquatic plant and animal life, nutrient cycles, and the impact of human activities.

Programs should educate on best management practices for shoreline management, boat maintenance, septic system management, and responsible waste disposal. Local lake issues should be addressed, highlighting specific concerns related to the LLBDM, such as invasive species, algal blooms, and water quality degradation. Lake education programs should also share resources and policies with stakeholders about relevant local, state, and federal regulations governing lake use and management.

There are many ways to engage stakeholders in educational opportunities, some strategies include:

- Public workshops and presentations are a valuable tool to provide informative sessions for various stakeholder groups, including homeowners' associations, community groups, and school groups.
- Online platforms can also be utilized, developing a dedicated website or online portal provides accessible information, educational materials, and updates.
- Social media campaigns and platforms can be used to spread awareness, share educational content, and encourage community engagement.
- Field trips and demonstrations are an opportunity to organize hands-on experiences to observe lake conditions and management practices firsthand.

Community engagement and participation can also be increased by establishing volunteer programs and opportunities for lake monitoring, invasive species removal, or shoreline restoration projects. Residents should be encouraged and empowered to collect data on lake health through citizen science programs. Create a stakeholder advisory committee to provide input on lake management decisions and education strategies. Regularly assess the effectiveness of educational programs by monitoring changes in knowledge, attitudes, and behaviors of lake users; adjusting the educational content and delivery methods to better address identified needs. The LLBDM lake management education program should have content and materials tailored to the specific knowledge level and interests of different stakeholder groups. By creating partnerships and collaboration with local government agencies, conservation organizations, and lake management professionals the reach and impact of education efforts can be enhanced. The goal is to promote long-term sustainability by building a culture of responsible lake stewardship and proactive conservation practices among residents.

Costs incurred in education programs generally depend on the scope and goals of the initiative. The cost of a lake public education outreach program can vary significantly depending on location, activities, and target audience. Generally, education programs range from several thousand to tens of thousands of dollars per year. Factors impacting the cost include program size and duration, staff involvement, as well as materials and supplies. Depending on the program's focus, costs could include educational materials, brochures, signage, presentation equipment, or even specialized kits for hands-on activities. If the program involves public events, renting a space like a community center or park could add significant cost. Advertising the program through various channels like social media, local publications, or mailers can increase the overall budget. A large-scale program with multiple events and a wide reach will naturally be more expensive than a smaller, focused initiatives. Many public education outreach programs can be funded through grants, sponsorships, or allocations from community organization budgets.

The stakeholder surveys indicated a want for increased education about best lake management practices such as rain gardens, erosion control practices, and shoreland buffers. Most of the shoreline property owners maintain lawns and there are limited native shoreline buffer zones. Increased access to materials about lake ecology and education programs could lead to better shoreline management practices and improved lake health. In LLDBM education initiatives can be easily implemented. There are multiple management and special interest groups which could enact strategies listed above.

Further specific lake management education resources can be found at: https://lakewisconsinalliance.org/education-outreach/

9. PERMITS AND CONTRACTOR SELECTION

9.1. APM Permit Considerations

The WDNR is responsible for regulating the management of aquatic plants in Wisconsin and their authority, as defined in Wisconsin State Statute, is implemented under two sets of rules [73]:

1. **NR 107**: established procedures and requirements for permitting the use of chemicals for aquatic plant management (APM).
2. **NR 109**: establishes procedures and requirements for issuing non-chemical APM permits. This rule also allows the WDNR to require an APM plan prior to issuing a permit.

Almost all aquatic plant management activities in Wisconsin require a permit.

- Mechanical harvesting requires a WDNR mechanical aquatic plant management permit[41].
- Herbicide applications (also known as chemical control) also require a permit

However, there are several exemptions for manual removal, including:

1. Removal of vegetation from a 30-foot area that extends from a use area such as a dock[42].
2. Removal of aquatic invasive species from the shoreline by a riparian owner when the removal of these plants does not harm native species.
3. Removal of aquatic plants that accumulate onshore (unless located in a sensitive area or wild rice is involved).
4. APM conducted by the WDNR.
5. Removal for research.
6. Manual or mechanical removal on an exposed lakebed.
7. Incidental removal resulting from beneficial water use activities[43].
8. If the body of water is 10 acres or less and is entirely confined on the property of one person with the permission of that property owner.

It is recommended that property owners or other APM sponsors consult with the WDNR before initiating management activities to confirm whether a permit is needed. Under certain conditions, the WDNR has the authority to deny issuance of APM permits and limit or stop chemical applications. Consulting with the WDNR and being prepared in advance of applying for a permit helps to prevent delays in permit issuance or permit denial.

---

[41] *https://docs.legis.wisconsin.gov/code/admin_code/nr/100/109*
[42] *(s. NR 109.06 (2) (a) 1.)*
[43] *(s. NR109.06)*

The WDNR provides a checklist to help permit applicants avoid common application issues [90]. There is also a WDNR e-permitting guidebook and other online, informative resources [47,73,91].

9.2. Selecting a Contractor

Many lake groups hire a contractor to help with grant writing, applying for permits, monitoring, conducting surveys, plan writing, and conducting management activities such as harvesting or applying herbicides. Qualifications and expertise vary among firms – taking the time to carefully select a contractor may be the difference between success and failure of your project.

Prior to hiring a consultant, make sure the contactor will not be duplicating work that has already been completed. This APM Strategy provides baseline information on aquatic plant communities, water quality, past management activities, and more. It is also helpful to check with the WDNR and area organizations to see if any additional information already exists for your project. This can help prevent paying for work that has already been done.

The following checklist was adapted from a guide developed by the Polk County Association of Lakes (PCALR) to assist with evaluating, selecting, and working with a qualified contractor [92]:

1. Develop a specific list of tasks for contractor bids (detailed work plan).
2. Consider having several contractors offer proposals for the project.
3. Request training, background, certifications, memberships, affiliations, and committees from those you plan to interview for the project. Look for aquatic plant identification training, herbicide applicator certificate (if applicable), etc.
4. Interview at least three contractors.
5. Check with the Wisconsin Circuit Court[44], Better Business Bureau[45], and Department of Agriculture, Trade & Consumer Protection[46] for complaints or violations.
6. Contact the contractor's references and get a credit report before signing any contract.
7. Request proof of insurance.
8. Sign a contract with the contractor you have selected. Make sure the contract includes a detailed list of project deliverables as well as their AIS decontamination procedures for equipment.
9. Communicate regularly with the contractor and WDNR during the project.
10. Choose different firms for planning/monitoring and implementation. This helps to avoid bias of pre- and post-treatment monitoring.

[44] http://wcca.wicourts.gov
[45] www.bbb.org
[46] www.datcp.state.wi.us

10. LAKE MANAGEMENT LEADERSHIP & CAPACITY

Many lakes have benefited from successful and effective aquatic plant management administered by a group that provides central leadership to guide and facilitate lake management activities. The central leadership group to have the capacity to effectively plan, organize, and implement those activities. This capacity may include factors such as time, resources, volunteers, staff, and public support.

Many lakes have benefited from successful and effective aquatic plant management, administered by a central leadership group that guides and facilitates lake management activities. The central leadership group must possess the capacity to effectively plan, organize, and implement these activities. Essential capacity elements include time, resources, volunteers, staff, and public support.

Central leadership can take the form of a lake organization. Lake organizations are important for cohesive and collaborative management of our lakes. These organizations work together towards common goals for protecting, preserving, and enhancing a lake [93]. The goals of lake organizations are developed based on lake specific characteristics, ecosystems, and functions.

General activities conducted by lake organizations may include, but are not limited to[93]:

- Facilitating public outreach, engagement, and educational activities
- Hold and facilitate group meetings and discussions
- Conducting research, monitoring, and identification of lake issues
- Communicating with state and local governments
- Development of lake management, aquatic plant management, and water recreation plans
- Applying for state grants to fund lake management activities
- Obtaining necessary state and local permits to conduct lake management activities
- Implementing lake management activities (ex. fish stocking, habitat restoration, aquatic plant management, or invasive species management activities)

10.1. Types of Lake Organizations

Different types of lake organizations have different roles, authority, structure, and funding sources. One of the biggest differences between organization types is whether it is a voluntary organization or government body. The type of lake organization that is best suited for a lake is dependent on the community's long-term goals, number of shoreline property owners and lake users, lake characteristics, and severity of lake issues [93].

When determining which types of lake organization is most suitable, the following factors should be considered [93]:

- **Formation:** Requirements required by the town, county, village, or state to establish the organization.
- **Power:** Authoritative power over leadership, membership, budgeting, or lake users.

- **Geographical Scope**: Area that the organization incorporates and targets for management actions and recruiting membership.
- **Boundaries:** Requirements by the state to define strict organization boundaries for management actions and membership.
- **Financial Fairness**: Sources of funding and how costs are shared across lake users.
- **Public Accountability**: Requirements by the state regarding public access to records, meetings, and decision making.
- **Availability of Funding:** Eligibility to receive matching funds from the state.

The most common types of lake organizations, and each of the factors above, are discussed below. Additional resources on the development of a lake organization are included in the Wisconsin Lake Partnership's *People of the Lakes – A Guide for Wisconsin Lake Organizations* [93].

10.1.1. Lake Association

Lake associations are a type of voluntary organization made up of private citizens. They can be formed for any purpose including social interactions, public engagement, or management implementation. This type of organization can form opinions and recommendations for what should be done at and around the lake but does not have any regulatory power over land or lake use [93].

As lake associations are voluntary organizations, there are no regulations governing their structure, operation, geographic scope, or boundaries. Voluntary organizations are not required to hold public meetings. Funding for lake associations requires membership dues and fundraising to support initiatives and action items [93]. This means that the majority of funding will be contributed by members, although the lake's resources will be utilized by members and non-members. To be eligible for state lake grants, a lake association must meet state requirements to designate it as a 'qualified lake association'.

Lake associations have the ability to [93]**:**

- Require dues/ raise funds and borrow money (loans)
- Make contracts
- Acquire and sell property
- Sue and be sued
- Have educational programs
- Communicate with unties of government and others
- Conduct lake management activities

Lake management activities often include:

- Monitoring water quality
- Inventorying/ monitoring aquatic plants
- Managing invasive/ nuisance aquatic plants
- Purchasing lands to protect sensitive areas

- Restoring wetlands
- Developing erosion control programs
- Developing long-range lake management plans
- Working in the watershed to implement practices that reduce pollution to the lake
- Being eligible for state lane grants -Q*ualified lake associations only*

Examples of lake associations in Wisconsin include:

- **Green Lake Association Inc. –** Green Lake (Green Lake County) [94]
- **Kettle Moraine Lake Association –** Kettle Moraine Lake (Fon du Lac County) [95]

10.1.2. Lake District

Lake districts are a specialized unit of government with the ability to tax property within the district boundaries [93]. Typically, a formal petition is required to form and establish the lake district through the town, city, or county board/ council. This type of organization can form opinions and recommendations for what should be done at and around the lake. However, unlike lake organizations, the governmental power of lake districts are set by law with legal responsibilities and consequences to protect the rights and interests of the public [93].

As lake districts are government units, they are required by the state to establish strict boundaries and meet state laws protecting public access to records, meetings, and decision making. They are also required to advertise and hold public meetings [93]. The structure of a lake district typically consists of daily operations conducted by an elected board of commissioners and financial operations determined by district members during an annual meeting [93]. Funding for the lake district comes from taxes placed on properties located within the district boundaries. This means that funding will be contributed equitably across lake users. All lake districts are eligible for state lake grants.

Lake districts have the ability to [93]**:**

- Levy taxes and impose special assessments and special charges
- Operate water safety patrols
- Enact boating regulations
- Exercise sanitary district powers
- Borrow money (loans)
- Make contracts
- Acquire and sell property
- Sue and be sued
- Have educational programs
- Communicate with unties of government and others
- Be eligible for state lane grants

- Conduct lake management activities

Lake management activities often include:

- Monitoring water quality
- Inventorying/ monitoring aquatic plants
- Managing invasive/ nuisance aquatic plants
- Purchasing lands to protect sensitive areas
- Restoring wetlands
- Developing erosion control programs
- Developing long-range lake management plans
- Working in the watershed to implement practices that reduce pollution to the lake
- Being eligible for state lake grants

Examples of lake associations in Wisconsin include:

- **Lake Puckaway P&R District –** Lake Puckaway (Green Lake County) [96]
- **Little Green Lake P&R District –** Little Green Lake (Green Lake County) [97]

10.2. Organizational Capacity

Despite the type of lake organization that is developed, the success of a lake organization is dependent on its level of organizational capacity (the potential of an organization to be productive and effective). Organizational capacity consists of membership support, internal functions, external relationships, and organization programs [98].

Membership is the foundation for a lake's organizational capacity. To be successful, a lake organization must be built upon members who are able and willing to contribute financial and volunteer support to facilitate goals and objectives [98]. Strong membership capacity requires community members to have a well-established appreciation and value for their lake. It also requires community members and stakeholders to understand the connection between the organization's actions and the health of their lake. When developing a lake organization, the first step should be to focus on building a solid foundation of motivated members.

Figure 10-1. Organizational capacity hierarchy.

Source: UW Stevens Point – Extension Lakes website: https://www3.uwsp.edu/cnrp/UWEXLakes/Pages/resources

Internal functions within an organization build off membership capacity to work together and accomplish goals. Practices that improve the internal functions of an organization include [98]:

- Group policies and procedures for how the organization will conduct its business
- Defined roles and expectations for staff and volunteers
- Conflict management and mitigation measures to resolve disputes or conflicts of interest
- Social media and outreach plan to communicate with members and the community
- Access to technical advisors that can provide guidance and expertise on lake management issues

External relationships are important for expanding the capabilities of the organization through collaboration with other lake organizations, stakeholder groups, or local, state, or federal governments [98]. It is important to identify and form relationships with other groups who may mutually benefit from improving lake conditions and resources. Forming strong partnerships creates opportunities for each to leverage their own strengths, share resources, and meet common goals. These relationships may also provide technical guidance that individual members within the organization may not have. External, as well as internal, relationships bridge the gap between organization members and implementation of management activities. Key stakeholder groups to gain support from and collaborate with are included in the section below.

The success of a lake organization is demonstrated by meeting goals and objectives [98]. This is typically done through the implementation of programs, such as aquatic vegetation harvesting, to protect, enhance, or preserve lake conditions [98]. Planning and completing successful projects depend on the strength and capacity of the three areas described above (membership, internal functions, and external relationships). Without strong membership support, internal communication and organization, and external collaboration, programs may not have the resources (technical expertise, funding, staff, volunteers, community support, government approval, etc.) required to be successful.

10.3. Key Stakeholder Groups

Collaboration with and support from stakeholder groups is critical for the successful implementation of an aquatic plant management plan and development of a central leadership organization. The key stakeholders for LLBDM management include a diverse group of individuals and organizations, generally falling within one or more of the following categories:

- **Shoreline property owners**: These are individuals who own property along the shoreline of LLBDM and have a direct interest in the management of aquatic plants in the lake.
- **Conservation groups**: Organizations dedicated to preserving and protecting the natural environment, which have a vested interest in the ecological health of the lake.
- **Recreational users**: People who use the lake for recreational activities such as boating, fishing, and swimming.
- **Industry**: Businesses that may be affected by or have an interest in the management of the lake.
- **Government agencies**: Local, state, and federal agencies involved in environmental regulation and management as well as those the local government units that border the lake.
- **Broader community members**: Individuals from the surrounding community who have an interest in the lake's health and management.

Organizations and government agencies that have already been involved or provided input include:

- City of Neenah
- City of Menasha
- Fox Wolf Watershed Alliance
- Village of Fox Crossing
- United States Army Corps of Engineers
- University of Wisconsin Green Bay
- Winnebago County Land and Water Conservation Department
- Outagamie County Land Conservation Department
- Wisconsin Department of Natural Resources
- Northeast Wisconsin Land Trust
- Fox River Navigational System Authority
- Wild Ones
- Community Foundation
- Future Neenah

11. POTENTIAL GRANT FUNDING

There are costs associated with most methods for planning and managing nuisance growth of aquatic plants. This strategy benefited from grant funding, financial contributions from local municipalities, and in-kind support from various partners. Moving forward, exploring additional funding opportunities will help support completion of an aquatic plant management plan and implementation of management solutions. Many lake groups seek funding from more than one source including grants, donations, membership dues (or tax revenue for districts), and fees for services. Examples of possible grant opportunities are listed below. Depending on the management action, there may be other applicable grant programs available.

11.1. Recreational Boating Facilities Grants

The WDNR Recreational Boating Facilities (RBF) grants can be used by counties, towns, cities, villages, tribes, sanitary districts, public inland lake protection and rehabilitation districts and qualified lake associations for recreational boating facility projects. This includes purchase of aquatic plant harvesting equipment, navigational aids and dredging waterway channels associated with boat launch facilities.

More information: https://dnr.wisconsin.gov/aid/RBF.html

11.2. WDNR Surface Water Grant Program[47]

The WDNR Surface Water Grant Program (SWGP) supports a range of projects including outreach, data collection, planning, AIS prevention, project design or implementation, and more. Information about this grant program can be found here: https://dnr.wisconsin.gov/aid/SurfaceWater.html

EDUCATION AND PLANNING

These types of projects help communities understand surface water conditions, determine management goals, and develop strategic management plans. Education projects inform people about the function, importance, and protection of surface waters. Grants under this category include:

- Surface water education grants
- Surface water planning grants
- Comprehensive management planning for lakes & watersheds
- County lake grants (counties and tribes)

Eligible projects may address aquatic ecosystem quality, uses, ecological condition, and associated threats or challenges.

Surface water planning grants support projects that assess water quality or develop management plans to benefit surface water. Projects should aim to protect or improve surface water, prevent pollution, control invasive species, or enhance aquatic ecosystems and habitats.

[47] *Information gathered from this website in November 2024: https://dnr.wisconsin.gov/aid/SurfaceWater.html#tabx6*

Grants that can help fund these types of efforts include:

- AIS Prevention grants
- Lake Monitoring and Protection Network funding to counties and tribes
- AIS Control – Large or Small-Scale Population Management[48]
- AIS Control – Early Detection & Response
- AIS Research & Demonstration

CLEAN BOATS, CLEAN WATERS GRANTS

CBCW provides grants for volunteers or staff to inspect boats and trailers and educate boaters on preventing AIS spread at landings. Eligible sponsors can apply for funding through a streamlined WDNR application process [99].

AIS PREVENTION AND MANAGEMENT GRANTS

AIS Prevention grants aim to further reduce the spread or risk of introduction of AIS beyond the CBCW Grant program. Despite prevention efforts, invasive species may still be introduced. When this occurs, it is beneficial to gather information about the population and begin planning. If an established population of aquatic invasive species negatively impacts a waterbody or wetland, funding is available for control activities [100].

11.3. WDNR Healthy Lakes and Rivers Grants

WDNR Healthy Lakes & Rivers grants offer funding to eligible organizations to support the implementation of five different practices on public or private property aimed at enhancing habitat and water quality. These practices include fish sticks, native plantings, diversions, rock infiltrations, and rain gardens. All practices must adhere to department guidelines as outlined in the Healthy Lakes and Rivers Action Plan and supporting technical guidance [100]. All practices must adhere to department guidelines as outlined in the Healthy Lakes and Rivers Action Plan and supporting technical guidance [100].

More information available here: https://healthylakeswi.com/

[48] *Participation in the large- or small-scale control program requires an approved recommendation in an aquatic plant or aquatic invasive species management plan.*

12. IMPLEMENTATION STRATEGY

The City of Neenah, City of Menasha, and Village of Fox Crossing identified a potential need to manage nuisance aquatic plant growth to improve navigation and recreation while protecting the lake ecosystem in LLBDM. This strategy was developed to evaluate the need, assess and summarize baseline conditions, collect stakeholder input, and outline potential next steps.

The goals and actions listed below, if implemented, will result in a whole-lake aquatic plant management plan. An approved aquatic plant management plan is required for obtaining certain permits and to meet eligibility requirements of key grant funding programs.

Goal 1 describes the need for a lake organization. Implementation of Goals 3 through 8 will be led by the lake organization developed under Goal 1. Implementation of Goal 2 will be led by the City of Neenah and Goal 9 will be led by the City of Menasha.

GOAL 1: ESTABLISH A LAKE ORGANIZATION for LLBDM

Form a lake organization to lead APM efforts for LLBDM including implementation of this strategy.

Objective 1.1: By the end of 2025, establish a stakeholder led lake organization.

Action: *In early 2024, two to three shoreline property owners and/or lake users will step forward as lake leaders to form an ad hoc committee and champion the development of a lake organization.*

Action: *The ad hoc committee will develop and implement a plan for forming a lake organization.*

Objective 1.2: Confirm existing commitments from local units of government to aid in the formation, ongoing administration and participation in a new lake organization.

Action: *The Cities of Neenah and Menasha have pledged to support a newly established eligible lake organization in initiating lake management efforts. They will provide a limited amount of matching funds and staff involvement for the first one to two years. The lake organization will collaborate with the City of Neenah and City of Menasha to access this assistance.*

Objective 1.3: Solicit additional support to aid in the administration of a lake organization and implementation of management efforts.

Action: *Request that the Village of Fox Crossing match or exceed the contributions from the Cities of Neenah and Menasha.*

Action: *Solicit additional financial, volunteer, and technical support from shoreline property owners, lake users, area non-profit organizations, and Winnebago County.*

Action: *Investigate and apply for grant funds to support APM efforts.*

GOAL 2: IMPLEMENT THE LLBDM HARVESTING PILOT PROJECT

Implement the City of Neenah's Harvesting Pilot Project (Appendix A) for LLBDM to evaluate feasibility and efficacy of harvesting while improving public access and recreation and protecting important habitat.

Objective 2.1: In 2025, initiate implementation of the pilot harvesting project on the southern end of the lake near Arrowhead Park and Herb and Dolly Smith Park as outlined in Appendix A.

Action: Obtain WDNR approval of the pilot harvesting plan.

Action: Solicit bids from and select a qualified contractors to conduct the work.

Action: Apply for a multi-year WDNR APM mechanical harvesting permit in April 2026.

Action: Implement informed adaptive decision making as defined in the plan.

Action: Apply for WDNR APM chemical control permits, as needed, for herbicide applications.

Action: Begin harvesting in June 2026.

Action: Implement education strategy as outlined in Appendix A.

Objective 2.2: Conduct annual post-management monitoring within the pilot project area to evaluate the effectiveness of treatments.

Action: Conduct post-management monitoring based on treatment type, location, and nuisance aquatic plant species treated.

Action: Solicit for volunteer or financial support from local universities, non-profit organizations, lake users, or shoreline property owners to conduct monitoring or support hiring a qualified consultant to conduct monitoring.

Action: Document monitoring efforts including methods used and data collected which will be used to evaluate metrics as described in Appendix A.

Action: Complete annual post- management monitoring report summarizing methods, results, and future management recommendations.

Objective 2.2: Conduct post-management monitoring within the pilot project area for potential non-targets impacts.

Action: Conduct non-target impact monitoring as described in Appendix A to assess water quality (annual), the aquatic plant community (every 3 to 5 years), and fishery.

Action: Solicit for volunteer or financial support from local universities, non-profit organizations, lake users, WDNR, or shoreline property owners to conduct monitoring or support hiring a qualified consultant to conduct monitoring.

Action: Document monitoring efforts including methods used and data collected which will be used to evaluate metrics as described in Appendix A.

Action: Complete post-management monitoring report summarizing methods, results, and future management recommendations.

Objective 2.3: Report out on APM pilot project successes and lessons learned on an annual basis.

Action: Compile, analyze, and summarize management operations, public education efforts, and other pertinent data into a summary memo.

Action: *Distribute or make the summary memo available to adjacent communities, lake users, shoreline property owners, lake organization, and other stakeholders.*

GOAL 3: DEVELOP A WHOLE LAKE APM PLAN for LLBDM

Build upon the 2025 LLBDM APM Strategy to develop a whole-lake APM plan that meets stakeholder needs and WDNR requirements. The APM plan should utilize an integrated pest management approach.

Objective 3.1: **Identify remaining elements needed to complete an APM plan that meets stakeholder needs, is consistent with lake organization APM goals, and satisfies WDNR requirements.**

Action: *Create a work plan with funding strategy and target timeframe to transform the 2025 LLBDM APM Strategy into a whole-lake APM plan.*

Action: *Seek assistance for planning facilitation and coordination from area organizations, agencies, local government units, and volunteers.*

Action: *Solicit for bids and hire a consulting firm to assist with APM planning.*

Action: *Investigate and apply for grant funds to support APM planning efforts.*

Objective 3.2: **Define APM programming and assess lake organizational capacity.**

Action: *Identify potential services to offer based on stakeholder support and interest.*
This could include a harvesting program, herbicide treatments around docks, etc. For example, some lake associations have designated times to collect and compost aquatic plants removed by property owners. Property owners pile the plant material at the end of their piers on pick up days. The material is picked up by a paid contractor and transported to a central composting site.

Action: *Determine which APM methods the lake organization will support including services that will be offered.*

Action: *Develop a map illustrating each management unit as well as locations of treatment areas.*

Objective 3.3: **Identify aquatic plant disposal location for shoreline property owners and lake users.**

Action: *Coordinate with representatives from the City of Neenah, Village of Fox Crossings, and City of Menasha to post informative guidelines on municipality and LLBDM websites for public access.*

Action: *Coordinate with representatives from the City of Neenah, Village of Fox Crossings, and City of Menasha to identify aquatic plant disposal guidelines and disposal locations for residents and lake users within each municipality.*

Objective 3.4: **Develop monitoring plans to evaluate treatment efficacy, assess non-target impacts, and inform adaptive management.**

Action: *Define post-treatment metrics and create a monitoring plan to quantify treatment success (Ex. total species diversity, rake fullness of nuisance plant species, stakeholder feedback, etc.)*

Action: *Define post-treatment metrics and create a monitoring plan to quantify potential non-target impacts.*

Objective 3.5: **Define habitat protection areas to preserve a desirable, thriving and diverse native plant community.**

Action: *Finalize habitat protections areas within LLBDM to preserve existing aquatic plant communities (habitat preservation areas). Reference aquatic plant survey data and stakeholder feedback to finalize habitat preservation areas.*

Action: *Identify implementable and feasible actions to prevent degradation of protection areas.*

Action: *Develop a map illustrating the location and purpose of each habitat preservation area (Ex. fish habitat, aesthetics, wildlife habitat, etc.)*

Action: *Define metrics and monitoring plan to quantify preservation success (Ex. total species diversity, rake fullness of nuisance plant species, etc.)*

Objective 3.6: By early 2027, complete a whole-lake APM plan supported by stakeholders and approved by WDNR.

Action: *Incorporate additional data collected, stakeholder feedback, or actions taken since the completion of the 2025 LLBDM APM Strategy.*

Action: *Seek WDNR approval of the plan.*

GOAL 4: IMPLEMENT THE WDNR-APPROVED APM PLAN

Manage nuisance aquatic plant growth in targeted areas of LLBDM to improve navigation and recreation while protecting important habitat and water quality.

Objective 4.1: Implement the WDNR-approved APM plan to improve public access and recreation throughout LLBDM.

Action: *Apply for WDNR APM permits for selected management areas and technique(s).*

Action: *Implement post-treatment monitoring efforts to evaluate treatment success and potential non-target impacts.*

Action: *Conduct permitted aquatic plant management actions.*

GOAL 5: PREVENT THE SPREAD OF AQUATIC INVASIVE SPECIES

Prevent new introductions of aquatic invasive species. Detect and report new introductions early.

Objective 5.1: Organize and facilitate a Clean Boats, Clean Waters program (CBCW) for LLBDM.

Action: *Station stewards at the Fritse Park Boat Launch and Ninth Street Boat Launch.*

Action: *Solicit volunteer support from local universities, non-profit organizations, lake users, or shoreline property owners to coordinate and conduct coverage.*

Objective 5.2: Provide accessible tools at boat and kayak launches to aid in the removal of plants, debris, and sediment from watercraft and equipment.

Action: *Improve accessibility and increase likelihood of use of the Fritse Park Boat Launch boat washing station.*

Action: *Solicit for financial support from local units of government, non-profit organizations, universities, lake users, or shoreline property owners to cover the operation costs (currently requires quarters) of the boat washing station and improve advertising of the boat washing station on the LLBDM website, WDNR website, and/or social media outlets.*

Action: *Install invasive species disposal stations at public boat launches on LLBDM.*

Objective 5.3: Starting in 2026, develop and implement an AIS monitoring program for LLBDM.

Action: *Monitor for AIS annually by coordinating volunteer programs such as the Citizen Lakes Monitoring Network AIS monitoring program.*

Action: *Work with Fox-Wolf Watershed Alliance to implement Adopt-a-Launch programming at the Fritse and Ninth Street Launches.*

Action: *Complete annual AIS monitoring report summarizing methods, results, and future management considerations.*

Action: *Complete any additional goals, objectives, or AIS related tasks described in the aquatic plant management plan.*

Objective 5.4: Rapidly report and respond to new AIS findings.

Action: *Record and report new AIS introductions observed during monitoring efforts.*

Action: Complete and submit a WDNR Aquatic Invasive Species Incident Report to the WDNR Aquatic Invasive Species Regional Coordinator within 48 hours of observation.

Action: *Report any new AIS introductions or suspected AIS introductions to the lake organization.*

Objective 5.5: Implement AIS prevention and identification education programming.

Action: *See Goal 6.*

Objective 5.6: Keep boat launches and access points clear from aquatic plant debris.

GOAL 6: IMPLEMENT AN EDUCATION STRATEGY

Implement an education strategy to increase understanding of lake ecology, invasive species prevention and identification, and aquatic plant management among lake residents and lake users.

Objective 6.1: Hold at least one public training workshop for lake residents and users, annually.

Action: *Distribute public educational materials on the importance of aquatic plants to the lake ecosystem.*

Action: *Increase understanding of AIS prevention measures, pathways, identification, and reporting opportunities.*

Action: *Improve stakeholder identification and awareness of the nuisance plant species in LLBDM.*

Objective 6.2: Hold at least one public presentation to increase knowledge of lake related topics, annually.

Action: *Improve stakeholder understanding of the locks and how they impact LLBDM.*

Action: *Improve stakeholder understanding of water level management on LLBDM.*

Action: *Identify additional topics.*

Objective 6.3: Make information about LLBDM available and easily accessible online.

Action: *Create and maintain a website dedicated to LLBDM.*

Action: *Create and maintain social media pages dedicated to LLBDM.*

Action: *Share summary of public training workshop and upload public education materials to the LLBDM website and social media.*

Action: *Share summary and results of annual AIS monitoring efforts on the LLBDM website and social media.*

Action: *Share summary and results of annual aquatic plant management efforts and post-treatment monitoring on the LLBDM website and social media.*

Action: *Upload relevant project information, stakeholder engagement efforts, monitoring, and management efforts.*

GOAL 7: IMPLEMENT A LAKE MONITORING PROGRAM

Develop and implement monitoring programs for aquatic plants, aquatic invasive species, and water quality to track ecosystem health and identify new issues early.

Objective 7.1: Coordinate and facilitate annual whole lake AIS monitoring.

Action: *See Goal 5.*

Objective 7.2: Coordinate and facilitate annual post-management monitoring within each management area to evaluate the effectiveness of treatments and potential non-target impacts.

Action: *Identify adequate time-periods to conduct post-management monitoring based on treatment type, location, and nuisance aquatic plant species treated.*

Action: *Solicit for volunteer or financial support from local universities, non-profit organizations, lake users, WDNR, or shoreline property owners to conduct monitoring or support hiring a qualified consultant to conduct monitoring.*

Action: *Document monitoring efforts including methods used and data collected which will be used to evaluate metrics defined in the APM Plan.*

Action: *Complete annual post- management monitoring report summarizing methods, results, and future management recommendations.*

Objective 7.3: After 5 years, coordinate the repeat of a whole lake point-intercept aquatic plant survey to document changes to the plant community and adjust the Aquatic Plant Management Plan as needed.

Action: *Apply for WDNR Surface Water Grant, or a similar funding opportunity, to aid in funding the survey.*

Action: *Hire a qualified consultant to conduct the survey.*

Action: *Partner with or train local universities, non-profit organizations, lake users, or shoreline property owners to aid in conducting surveys to reduce survey costs.*

Action: *Document monitoring efforts and results.*

Action: *Share annual research, monitoring, and reports on the LLBDM website for public access.*

GOAL 8: ADOPT AN ADAPTIVE MANAGEMENT STRATEGY

Objective 8.1: Complete annual LLBDM aquatic plant management memo.

Action: *Compile, analyze, and summarize management operations, public education efforts, monitoring results, and other pertinent data into a summary memo.*

Action: *Upload memo to the LLBDM website for public access.*

Objective 8.2: **At the end of each year, evaluate progress towards meeting project goals and objectives and identify necessary changes to the aquatic plant management strategy.**

Action: *Review annual reports, stakeholder feedback, and funding, volunteer, and staff availability to inform and/ or modify management recommendations for the following year.*

Objective 8.3: **At the end of the 5-year period (5 years from the date of APM plan approval), complete a final aquatic plant management report.**

Action: *Summarize all management efforts, and related activities, into a summary report.*

Action: *Upload report to the LLBDM website for public access.*

Objective 8.4: **At the end of the 5-year period (5 years from the date of APM plan approval), revise the APM Plan.**

Action: *Apply for WDNR Surface Water Grant, or similar funding opportunity, to aid in funding the plan revisions.*

Action: *Hire a qualified consultant to complete plan revisions.*

Action: *Revise the WDNR approved Aquatic Plant Management Plan based on management implementation successes and failures, monitoring results, and stakeholder engagement conducted during the 5-year period.*

GOAL 9: DEVELOP AND IMPLEMENT A PILOT PROJECT LED BY THE CITY OF MENASHA FOR LLBDM

Objective 9.1: **Develop a pilot project led by the City of Menasha to trial aquatic plant management or lake management methods on LLBDM.**

Objective 9.2: **Implement the City of Menasha pilot project.**

13. CONCLUSION

In conclusion, the 2025 Little Lake Butte des Morts Aquatic Plant Management Strategy represents a collaborative and comprehensive approach to addressing the challenges posed by aquatic plant overgrowth. By engaging stakeholders, evaluating potential management approaches, and identifying funding sources, this strategy provides a robust framework for improving recreational access while protecting the lake ecosystem. The successful implementation of this strategy will require:

1. Identification or formation of a central lead management entity such as a lake organization.
2. Ongoing collaboration among stakeholders in the region.
3. Expansion of this strategy to develop a whole-lake APM plan that incorporates an integrated pest management approach.
4. Ongoing monitoring of water quality, aquatic plants, and invasive species.
5. Evaluation of efforts and adaptive management.

The commitment of the LLBDM Leadership Team, Support Team, and community stakeholders will be crucial in achieving the goals outlined in this strategy and fostering a sustainable future for the lake.

14. REFERENCES

1. Wisconsin Department of Natural Resources. WDNR Water Detail - Little Lake Butte Des Morts, Little Lake Butte des Morts Watershed (LF06) [Internet]. [cited 2024 May 10]. Available from: https://apps.dnr.wi.gov/water/waterDetail.aspx?key=1525284

2. WDNR. Lower Fox River (Appleton Dam To L. Winnebago Outlet), Fox River - Appleton, Plum and Kankapot Creeks, Little Lake Butte des Morts, Lake Winnebago Watershed (LF03) (117900) [Internet]. Water Detail. [cited 2024 Jul 1]. Available from: https://apps.dnr.wi.gov/water/waterDetail.aspx?key=357364

3. Wisconsin Department of Natural Resources. WDNR Surface Water Data Viewer [Internet]. [cited 2024 Jun 5]. Available from: https://dnrmaps.wi.gov/H5/?Viewer=SWDV

4. Fox Wolf Watershed Alliance. Water Level Management Report for the Winnebago Waterways [Internet]. Google Docs. 2020 [cited 2024 Jun 5]. Available from: https://drive.google.com/file/d/16sHymHjyzc_dhDeyDSn9RWDyBo-s5LCq/view?usp=embed_facebook

5. The Historical Marker Database. Menasha Lock Historical Marker [Internet]. 2016 [cited 2024 May 22]. Available from: https://www.hmdb.org/m.asp?m=77281

6. Shaw B, Mechenich C, Klessig L. Understanding Lake Data [Internet]. University of Wisconsin-Extension Publishing; 2004. Available from: https://www3.uwsp.edu/cnr-ap/weal/Documents/G3582.pdf

7. WDNR. Aquatic Communities: Wildlife Action Plan [Internet]. Wisconsin Department of Natural Resources. Available from: https://dnr.wisconsin.gov/topic/WildlifeHabitat/ActionPlanAquaticCommunities

8. Epstein EE. Chapter 7: Natural communities, aquatic features, and selected habitats of Wisconsin. In: The ecological landscapes of Wisconsin: An assessment of ecological resources and a guide to planning sustainable management [Internet]. Madison: Wisconsin Department of Natural Resources; Available from: https://widnr.widen.net/view/pdf/xlefkgoqwv/ELOW_Ch7_AquaticFeatures.pdf?t.download=true&u=kkadwx

9. Wisconsin Department of Natural Resources. Wisconsin Lakes - Little Lake Butte Des Morts [Internet]. [cited 2024 May 8]. Available from: https://apps.dnr.wi.gov/lakes/lakepages/LakeDetail.aspx?wbic=129800&page=facts

10. Wisconsin Department of Natural Resources. WDNR Watershed Detail - Little Lake Butte des Morts [Internet]. [cited 2024 May 10]. Available from: https://apps.dnr.wi.gov/water/watershedDetail.aspx?code=LF06&Name=Little%20Lake%20Butte%20des%20Morts

11. Ashley Beranek, Wisconsin Department of Natural Resources. Little Lake Butte des Morts - WBIC 129800. 2024.

12. Wisconsin Department of Natural Resources. Impaired Waters Detail - Fox River [Internet]. [cited 2024 May 28]. Available from: https://apps.dnr.wi.gov/water/impairedDetail.aspx?key=357364

13. US EPA. Indicators: Dissolved Oxygen [Internet]. United States Environmental Protection Agency. Available from: https://www.epa.gov/national-aquatic-resource-surveys/indicators-dissolved-oxygen

14. Korin Doering, Emily Henrigillis. Sunset Bay Comprehensive Management Plan. Fox-Wolf Watershed Alliance; 2021.

15. WDNR. Subchapter II — Water Quality Standards for Temperature [Internet]. 2010. Available from: https://docs.legis.wisconsin.gov/document/administrativecode/subch.%20II%20of%20ch.%20NR%20102

16. New Hampshire Department of Environmental Services. Environmental Fact Sheet: Lake Eutrophication. 2019;

17. Robert Carlson, Jonathan Simpson. A Coordinator’s Guide to Volunteer Lake Monitoring Methods. North American Lake Management Society; 1996. 96 p.

18. WI DNR. Wisconsin Consolidated Assessment and Listing Methodology (WisCALM). Waterbody Assessment Guidance for 2023 - 2024 [Internet]. Wisconsin Department of Natural Resources; 2023. Available from: https://apps.dnr.wi.gov/swims/Documents/DownloadDocument?id=343906539

19. Wisconsin State Legislature. Chapter NR 102 - Water Quality Standards for Wisconsin Surface Waters [Internet]. NR 102.03 2004. Available from: https://docs.legis.wisconsin.gov/code/admin_code/nr/100/102.pdf

20. Wisconsin State Cartographer's Office. Wisconsin Historic Aerial Image Finder (WHAIFinder) [Internet]. [cited 2024 May 22]. Available from: https://maps.sco.wisc.edu/WHAIFinder/#7/44.750/-89.750

21. Wisconsin Department of Natural Resources. WDNR Wetland Mapping - Wisconsin Wetland Inventory [Internet]. [cited 2024 Jun 5]. Available from: https://dnr.wisconsin.gov/topic/Wetlands/inventory.html

22. Winnebago County GIS. Winnebago County Historic Air Photo Comparison Viewer [Internet]. [cited 2024 May 22]. Available from: https://wcgis3.co.winnebago.wi.us/historicphotoviewer/

23. Chelsey Blanke, Meghan Williams, Mikulyuk A, Michelle Nault, Scott Provost, Carroll Schaal, Scott Van Egeren. Strategic Analysis of Aquatic Plant Management in Wisconsin. Wisconsin Department of Natural Resources; 2019.

24. Cabridge. Hotspots of the Month: Neenah-Menasha Lakes and Riverfront [Internet]. Wisconsin eBird Hotspot of the Month. 2013 [cited 2025 Jan 15]. Available from: https://ebird.org/region/US-WI/post/hotspots-of-the-month-neenah-menasha-lakes-and-riverfront

25. Cecilia Holmlund, Monica Hammer. Ecosystem services generated by fish populations. Ecological Economics. 1999 May;29(2):253–68.

26. Lorna Cole, Jenni Stockan, Rachel Helliwell. Managing riparian buffer strips to optimise ecosystem services: A review. Agriculture, Ecosystems & Environment [Internet]. 2020 Jul 1;296. Available from: https://www.sciencedirect.com/science/article/abs/pii/S0167880920300761

27. Ray Valley, Timothy Cross, Paul Radomski. The Role of Submersed Aquatic Vegetation as Habitat for Fish in Minnesota Lakes, Including the Implications of Non-native Plant Invasions and their Management. 2004.

28. Greg Sass, Stephanie Shaw. Structural Habitat in Lakes and Reservoirs: Physical and Biological Considerations for Implementation. North American Journal of Fisheries Management. 2022 Jul;43(4).

29. Matthew Helmus, Greg Sass. The rapid effects of a whole-lake reduction of coarse woody debris on fish and benthic macroinvertebrates. Freshwater Biology. 2008 Jul;53(7):1423–33.

30. Kevin Roche, Ludek Slapansky, Mirek Travnik, Michal Janac, Pavel Jurajda. The importance of rip-rap for round goby invasion success – a field habitat manipulation experiment. Journal of Vertebrate Biology. 2022 Nov;70(4).

31. James Morrow Jr., Craig Fischenich. Habitat Requirements for Freshwater Fishes [Internet]. US Army Engineer Research and Development Center; 2000 [cited 2025 Jan 14]. Available from: https://www3.epa.gov/region1/npdes/merrimackstation/pdfs/ar/AR-72.pdf

32. Wisconsin Department of Natural Resources. Fisheries Management Information System | Fishing Wisconsin | Wisconsin DNR [Internet]. [cited 2024 Jun 17]. Available from: https://dnr.wisconsin.gov/topic/Fishing/data/infosystem.html

33. Karen Stagoll, Adrian Manning, Emma Knight, Joern Fischer, David Lindenmayer. Using bird–habitat relationships to inform urban planning. Landscape and Urban Planning. 2010 Oct;98(1):13–25.

34. Noel Cutright, Bettie Harriman, Robert Howe. Atlas of Breeding Birds of Wisconsin. Wisconsin Society of Ornithology;

35. Jennifer Newbrey, Michael Bozek. Effects of Lake Characteristics and Human Disturbance on the Presence of Piscivorous Birds in Northern Wisconsin, USA. Waterbirds: The International Journal of Waterbird Biology. 2005 Dec;28(4):478–86.

36. W.K. Volkert, S.W. Matteson. Wisconsin's pilot shorebird management program. Wisconsin pilot shorebird management program. 2001;(4):253–9.

37. Eldridge J. Ecology of Northern Prairie Wetlands. In: Waterfowl Management Handbook. US Fish and WIldlife Service; 1990.

38. Daniel Twedt, Randy Wilson. Management of bottomland hardwood forests for birds. In: Proceedings of 2007 Louisiana Natural Resources Symposium. U.S. Fish and Wildlife Service; 2007. p. 49–69.

39. Lei Dong, Qian Ma, Zhenkai Sun, Jianan Wang, Yuxin Ding, Dexian Zhao. The value of residential green spaces for birds: A comparative study with urban parks of different scales. Urban Forestry & Urban Greening. 2024 Dec;102.

40. City of Neenah. Loop the Little Lake [Internet]. City of Neenah. Available from: https://www.ci.neenah.wi.us/departments/parks-recreation/loop-the-little-lake/

41. Wisconsin Department of Natural Resources. WI Public Boat Access Site - Fritse Park Boat Ramp. 2016; Available from: https://dnrmaps.wi.gov/LF_ShowDetails/boats.aspx?ID=2359

42. Wisconsin Department of Natural Resources. WI Public Boat Access Site - Ninth Street Boat Launch. 2017; Available from: https://dnrmaps.wi.gov/LF_ShowDetails/boats.aspx?ID=3772

43. Northeast Wisconsin Land Trust. Guckenberg-Sturm Preserve [Internet]. NEWLT. [cited 2024 Jun 18]. Available from: https://www.newlt.org/guckenberg-sturm-preserve

44. Wisconsin Lakes. Aquatic Plants [Internet]. Wisconsin Lakes. 2016. Available from: https://wisconsinlakes.org/aquatic-plants/#:~:text=Fluctuations%20in%20lake%20levels%E2%80%94caused,and%20which%20species%20can%20survive.

45. Aquatic Plants | | Wisconsin DNR [Internet]. [cited 2024 Nov 1]. Available from: https://dnr.wisconsin.gov/topic/lakes/plants

46. Moorman, Ph.D. TE. Understanding Waterfowl: Duck Salad [Internet]. Ducks Unlimited. 2014. Available from: https://www.ducks.org/conservation/waterfowl-research-science/understanding-waterfowl-duck-salad

47. WDNR. Aquatic Plants [Internet]. Wisconsin Department of Natural Resources. Available from: https://dnr.wisconsin.gov/topic/lakes/plants

48. Kathy Aron, Jeff Bode, Heidi Bunk, Jim Cahow, Gina Dauffenbach, Jane Dauffenbach, Mary Gansberg, Sue Graham, Jennifer Hauxwell, Laura Herman, John Jereczek, Susan Knight, Debra Konkel, Robert Korth, Frank Koshere, Amy Kowalski, Tiffany Lyden, John Madsen, Scott Provost, Carroll Schaal, Mark Sesing, Buzz Sorge, Jeff Thornton, Pamela Toshner, Jennifer Wudi. Aquatic Plant Management in Wisconsin [Internet]. University of Wisconsin Extension; 2010. Available from: https://www3.uwsp.edu/cnr-ap/UWEXLakes/Pages/ecology/aquaticplants/default.aspx

49. Rulseh T. A Lakeside Companion. University of Wisconsin Press; 2018.

50. MNDNR. Filamentous algae [Internet]. Minnesota Department of Natural Resources. Available from: https://www.dnr.state.mn.us/aquatic_plants/algae/filamentous_algae.html

51. Michael Haberland. Filamentous Algae in Waterways [Internet]. Rutgers New Jersey Agricultural Experiment Station. Available from: https://njaes.rutgers.edu/fs1231/#:~:text=Spirogyra%20is%20bright%20green%20and,%2C%20long%2C%20stringy%20hairlike%20strands.

52. Bryan Swistock. Planktonic Algae [Internet]. PennState Extension. 2022. Available from: https://extension.psu.edu/planktonic-algae

53. Biology and Control of Aquatic Plants [Internet]. Fourth Edition. Aquatic Ecosystem Restoration Foundation; 2020. Available from: https://aquatics.org/wp-content/uploads/2023/07/BMP4-Online-Use-2.pdf

54. Wisconsin Department of Natural Resources. Blue-Green Algae | | Wisconsin DNR [Internet]. [cited 2024 Jun 5]. Available from: https://dnr.wisconsin.gov/topic/lakes/bluegreenalgae

55. J. Hauxwell, S. Knight, K. Wagner, A. Mikulyuk, M. Nault, M. Porzky, S. Chase. Recommended Baseline Monitoring of Aquatic Plants in Wisconsin: Sampling Design and Laboratory Procedures, Data Entry and Analysis, and Applications [Internet]. Wisconsin Department of Natural Resources; 2010. Report No.: PUB-SS-1068 2010. Available from: http://www.uwsp.edu/cnr-ap/UWEXLakes/Documents/ecology/Aquatic%20Plants/PI-Protocol-2010.pdf

56. Bernthal TW. Development of A Floristic Quality Assessment Methodology for Wisconsin [Internet]. 2003 Jun. Available from: https://dnr.wisconsin.gov/sites/default/files/topic/Wetlands/Floristic_Quality_Assessment_Methodology_2023.pdf

57. Nichols SA. Floristic Quality Assessment of Wisconsin Lake Plant Communities with Example Applications. Lake and Reservoir Management. 1999;15(2):133–41.

58. WDNR. Wis. Admin. Code NR 40 - Invasive Species Identification, Classification, & Control [Internet]. Published under s. 35.93, Wis. Stats., by the Legislative Reference Bureau; 2024. Available from: http://docs.legis.wisconsin.gov/code/admin_code/nr/001/40.pdf

59. Wisconsin Aquatic Invasive Species Management Plan [Internet]. Wisconsin AIS Partnership; 2018. Available from: https://dnr.wisconsin.gov/sites/default/files/topic/Aid/grants/surfacewater/WI%20AIS%20Management%20Plan%20Final%20Online%206.19.19%20(1).pdf

60. WDNR. Little Lake Butte Des Morts Invasive Species [Internet]. Wisconsin Department of Natural Resources. Available from: https://apps.dnr.wi.gov/lakes/lakepages/LakeDetail.aspx?wbic=129800&page=invasive

61. Wisconsin Department of Natural Resources. WDNR Lakes and AIS Mapping Tool [Internet]. [cited 2024 Jun 5]. Available from: https://dnrmaps.wi.gov/H5/?viewer=Lakes_AIS_Viewer

62. Invasives | Wisconsin DNR [Internet]. [cited 2024 May 8]. Available from: https://dnr.wisconsin.gov/topic/Invasives

63. Doering K, Cole S. 2024 Aquatic Plant Survey Results: Little Lake Butte des Morts Comprehensive Planning – Phase 1. GEI Consultants, Inc.; 2024 Dec.

64. Fish parasite reported in Fox River. Northeast Wisconsin NBC 26 [Internet]. 2019 Jul 19; Available from: https://www.nbc26.com/news/local-news/fish-parasite-reported-in-fox-river#google_vignette

65. WDNR. Lake Winnebago Invasive Species [Internet]. Wisconsin Department of Natural Resources. Available from: https://apps.dnr.wi.gov/lakes/lakepages/LakeDetail.aspx?wbic=131100&page=invasive

66. WDNR. Lake Butte des Morts Invasive Species [Internet]. Wisconsin Department of Natural Resources. Available from: https://apps.dnr.wi.gov/lakes/lakepages/LakeDetail.aspx?wbic=139900&page=invasive

67. WDNR. Lake Winneconne Invasive Species [Internet]. Wisconsin Department of Natural Resources. Available from: https://apps.dnr.wi.gov/lakes/lakepages/LakeDetail.aspx?wbic=241600&page=invasive

68. Lake Poygan Invasive Species [Internet]. Wisconsin Department of Natural Resources. Available from: https://apps.dnr.wi.gov/lakes/lakepages/LakeDetail.aspx?wbic=242800&page=invasive

69. FWWA. Aquatic Invasive Species Prevention [Internet]. Fox-Wolf Watershed Alliance. Available from: https://fwwa.org/what-we-do/aquatic-invasive-species/

70. WDNR. Surface Water Grants: Lake Monitoring and Protection Network [Internet]. Wisconsin Department of Natural Resources. Available from: https://dnr.wisconsin.gov/aid/SurfaceWater.html

71. FRNSA. FAQ Sheet: Menasha Lock [Internet]. Fox River Navigational System Authority; 2024. Available from: https://fox11online.com/resources/pdf/0403b05f-4821-49c2-ab15-34c8c74ac521-MENASHALOCKFAQS6.25.24.pdf

72. Kolasinski C. Little Lake Butte des Morts Treatment Record. Wisconsin Department of Natural Resources Data Curator; 2024.

73. WDNR. TOPIC: Permit Processing- Amendments, Exemptions and Conditions [Internet]. Wisconsin Department of Natural Resources; Available from: https://apps.dnr.wi.gov/swims/Documents/DownloadDocument?id=252508280#:~:text=Chapter%20NR%20107%20establishes%20the,plan%20prior%20to%20permit%20issuance

74. Wisconsin State Legislature. Aquatic Plants: Introduction, Manual Removal, and Mechanical Control Regulations [Internet]. WI NR 109 Mar, 2011. Available from: https://docs.legis.wisconsin.gov/code/admin_code/nr/100/109

75. Bellaud MD. 3.4 Cultural and Physical Control of Aquatic Weeds [Internet]. p. 129–32. Available from: https://aquatics.org/bmpchapters/3.4%20Cultural%20and%20Physical%20Control%20of%20Aquatic%20Weeds.pdf

76. WDNR. Mechanized Aquatic Plant Management [Internet]. Wisconsin Department of Natural Resources. Available from: https://dnr.wisconsin.gov/topic/Waterways/construction/mechanizedAPM.html

77. WDNR. Management Options for Aquatic Plants [Internet]. 2006 Oct. Available from: https://www3.uwsp.edu/cnr-ap/UWEXLakes/Documents/ecology/Aquatic%20Plants/Appendix-E.pdf

78. WDNR. Control Methods [Internet]. Wisconsin Department of Natural Resources. Available from: https://dnr.wisconsin.gov/topic/Invasives/control

79. WDNR. Purple Loosestrife Biocontrol - And You [Internet]. Wisconsin Department of Natural Resources. Available from: https://dnr.wisconsin.gov/topic/Invasives/loosestrife

80. Havel JE, Knight SE, Miazga JR. Abundance of milfoil weevil in Wisconsin lakes: Potential effects from herbicide control of Eurasian watermilfoil. Lake and Reservoir Management. 2017 Jul 5;33(3):270–9.

81. Havel JE, Knight SE, Maxson KA. A field test on the effectiveness of milfoil weevil for controlling Eurasian watermilfoil in Wisconsin lakes. Hydrobiologia [Internet]. 2017; Available from: https://apirs.plants.ifas.ufl.edu/site/assets/files/376587/376587.pdf

82. Netherland MD, Schardt J. Appendix E: A Manager's Definition of Aquatic Plant Control [Internet]. p. 173–80. Available from: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5373509.pdf

83. Water Level Drawdowns for Sediment and Aquatic Plant Management [Internet]. Door Co.; Available from: https://www.co.door.wi.gov/DocumentCenter/View/2881/General-Information-about-Water-Level-Drawdowns-for-Sediment-and-Aquatic-Plant-Management

84. Wisconsin Department of Natural Resources. Strategic Analysis of Aquatic Plant Management in Wisconsin [Internet]. 2019 [cited 2025 Jan 27]. Available from: https://widnr.widen.net/s/pjvlt9khp8/apmsa_final_2019-06-14

85. Wisconsin Department of Natural Resources. Integrated Aquatic Plant Management -Draft Rule: Key Change 2. [Internet]. Available from: https://dnr.wisconsin.gov/sites/default/files/topic/Lakes/IAPM_KeyChange_-_IntegratedPestManagementPlans.pdf

86. Johansen M. Integrated Pest Management.

87. WDNR. Healthy Lakes and Rivers Brochure. Wisconsin Department of Natural Resources; 2024.

88. WDNR. Critical Habitat Areas [Internet]. Wisconsin Department of Natural Resources. Available from: https://dnr.wisconsin.gov/topic/lakes/criticalhabitat

89. Wisconsin Department of Natural Resources. WATERWAYS PERMITTING PROCESS [Internet]. [cited 2025 Jan 17]. Available from: https://dnr.wisconsin.gov/topic/Waterways/Permits/PermitProcess.html#:~:text=The%20applicant%20uses%20the%20DNR,only%20minimal%20adverse%20environmental%20impacts.

90. WDNR. APM NR107 Permit Application Checklist [Internet]. Available from: https://dnr.wisconsin.gov/sites/default/files/topic/Lakes/plants/Lakes%20-%20Ponds%20-%20Rivers%20Permit%20Checklist.pdf

91. WDNR. APM ePermitting Guidebook [Internet]. Available from: https://dnr.wisconsin.gov/sites/default/files/topic/Lakes/APM_ePermitting_Guidebook.pdf

92. PCALR. Selecting a Contractor for Lake Planning Grant Projects [Internet]. Polk County Association of Lakes and Rivers; 2006. Available from: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://pcalr.lakekit.net/wp-content/uploads/sites/25/2011/12/ChoseContractorGuides.pdf

93. Wisconsin Lakes Partnership. People of the Lakes - A Guide to Wisconsin Lake Organizations [Internet]. 2018 p. 1–22. Report No.: 12th Edition. Available from: https://www3.uwsp.edu/cnr-ap/UWEXLakes/Documents/organizations/Lake%20Districts/Lake_Org_Guide2018.pdf

94. Green Lake Association | Green Lake, Wisconsin [Internet]. Green Lake Association. [cited 2025 Jan 22]. Available from: https://www.greenlakeassociation.org

95. Kettle Moraine Lake [Internet]. Kettle Moraine Lake Association. [cited 2025 Jan 22]. Available from: https://kettlemorainelake.org/

96. Lake Puckaway Protection Rehabilitation District [Internet]. Lake Puckaway. [cited 2025 Jan 22]. Available from: https://www.lakepuckaway.com

97. Little Green Lake Protection and Rehabilitation District | Lake | Little Green Lake, Green Lake, WI, USA [Internet]. LGLPRD. [cited 2025 Jan 22]. Available from: https://www.littlegreenlake.com

98. UWSP | UW Extension Lakes - Resources - Capacity Corner - Extension Lakes | UWSP [Internet]. [cited 2025 Jan 21]. Available from: https://www3.uwsp.edu/cnr-ap/UWEXLakes/Pages/resources/CapacityCorner/default.aspx

99. WDNR. Clean Boats, Clean Waters (CBCW) [Internet]. Wisconsin Department of Natural Resources. Available from: https://dnr.wisconsin.gov/topic/lakes/cbcw

100. WDNR. Surface Water Grant Program Applicant Guide and Program Guidance [Internet]. Wisconsin Department of Natural Resources; 2024. Available from: https://dnr.wisconsin.gov/sites/default/files/topic/Aid/grants/surfacewater/CF0002.pdf

101. UWSP | UW Extension Lakes - Resources - Capacity Corner - Extension Lakes | UWSP [Internet]. [cited 2025 Jan 21]. Available from: https://www3.uwsp.edu/cnr-ap/UWEXLakes/Pages/resources/CapacityCorner/default.aspx