Comprehensive Lake Management Plan

Lake Michelle, Iron County, Wisconsin

Funding provided by the

Lake Michelle Lake District

2025

Water Ways – Lake Management Services

ACKNOWLEDGMENTS

Many thanks to the Lake Michelle District Board of Commissioners for all of their time and effort toward this project, for without their assistance, this plan would not have come to fruition. They work hard to improve and protect Lake Michelle which sometimes means having to make hard or unpopular decisions.

Carolyn Kolson-Janov
Cathy Lambie
Colin DiGiorgio
Don Packmayer
Katie Saber

Many people contributed their volunteer and professional time to move this project forward and we whole-heartedly appreciate them. Heather Palmquist, Conservationist of Iron County Land and Water Department for listening to the Lake Michelle issues and lending her professional opinions to solve them and for allowing her staff to spend professional time on the lake; Zach Wilson, Conservation Technician and Blake Richard, 2023 Summer Intern, both of the Iron County Land & Water Department, and Allex Zelle, WDNR AIS Coordinator for conducting the fieldwork portion of the Aquatic Plant Survey – a painstaking process, but they handled it well; Quita Sheehan who volunteered to assist the consultant during both of the Shoreland Condition surveys – most appreciated; Lynn Verage for lending assistance to the consultant in collecting water quality samples – and for steadying the boat during a most windy day; and to all the respondents of the Stakeholder Survey, for without your help the results mean nothing; and Carolyn Huza, of Water Ways Lake Management Services for her professional time and energy that went into every detail of this project.

TABLE OF CONTENTS

ACKNOWLEDGMENTS

Many thanks to the Lake Michelle District Board of Commissioners for all of their time and effort toward this project, for without their assistance, this plan would not have come to fruition. They work hard to improve and protect Lake Michelle which sometimes means having to make hard or unpopular decisions.

Carolyn Kolson-Janov
Cathy Lambie
Colin DiGiorgio
Don Packmayer
Katie Saber

Many people contributed their volunteer and professional time to move this project forward and we whole-heartedly appreciate them. Heather Palmquist, Conservationist of Iron County Land and Water Department for listening to the Lake Michelle issues and lending her professional opinions to solve them and for allowing her staff to spend professional time on the lake; Zach Wilson, Conservation Technician and Blake Richard, 2023 Summer Intern, both of the Iron County Land & Water Department, and Allex Zelle, WDNR AIS Coordinator for conducting the fieldwork portion of the Aquatic Plant Survey – a painstaking process, but they handled it well; Quita Sheehan who volunteered to assist the consultant during both of the Shoreland Condition surveys – most appreciated; Lynn Verage for lending assistance to the consultant in collecting water quality samples – and for steadying the boat during a most windy day; and to all the respondents of the Stakeholder Survey, for without your help the results mean nothing; and Carolyn Huza, of Water Ways Lake Management Services for her professional time and energy that went into every detail of this project.

LIST OF FIGURES

LIST OF TABLES

LIST OF MAPS

1.0 INTRODUCTION

Surface water like lakes, rivers, and streams are vastly important for a multitude of reasons, but research indicates that due to increasing anthropogenic (human) activity surrounding these natural resources, they are vulnerable to accelerated deterioration over time (Vasistha, et.al. 2020). For this reason alone, government entities, scientists, lake organizations, and riparian landowners need to stay vigilant and consistently assess the condition of these waters, to sustain the health and vitality of them for as long as possible. The best tools to monitor overall lake health are to evaluate physical, chemical, and biological parameters.

1.1 INITIAL CONCERNS & GOALS

Sediments: Siltation at the bottom of Lake Michelle has been noticeably increasing over time, which is a natural process in all lakes. Lake sediments are nutrient rich "soil" and result in excessive aquatic plant growth throughout the lake during the open water season. As aquatic plants die off in the fall of each year and the organic matter falls to the bottom, a nutrient-rich growth medium of sediment is created for the following year's crop. Sediment accumulations occur over time in all lakes, but they are especially noticeable in shallow systems like Lake Michelle. The lake district would like to reduce the accelerated buildup of sediment, especially near the inlet pipe.

Cattails: Riparian landowners have also noticed a dense population of non-native cattails surrounding much of the shoreline. The presence of cattail has significantly reduced access to the lake, recreational opportunities, and the overall enjoyment of lake life. Residents would like to move ahead with approved plant management techniques to significantly reduce or rid the cattail around the lake shoreline in the years to come.

Watershed Pollution: Numerous concerns were shared about the potential input of fertilizers and other pollutants entering the lake from the surrounding watershed. There are a wide variety of potential pollutant sources that become detrimental to the quality of the

receiving water, which may include any of the following: oil and sediment from parking areas, pet waste, lawn fertilizers, shoreland erosion, and/or septic system leachate. These concerns are valid because nutrients coming from the surrounding watershed will continue to "feed" biological productivity within the lake, resulting in increased aquatic plant and algae growth, and accelerated lake bottom sedimentation. Lake district leaders would like to begin working with watershed landowners to reduce or abate pollutants from entering the receiving waters within this watershed.

Fishery: Stakeholders shared that Lake Michelle has a declining fish population. They reported that preferred species of fish (such as trout) have been disappearing for several years because of the marked increase in aquatic plant growth.

Outlet Dam: Finally, there were concerns voiced regarding the update and repairs to the outlet dam. There was no doubt that updates to the aged-out metal components of the old dam were necessary. The basis of the concern instead has to do with the requirement of removing the low-lying spill valve. By removing the spill valve, the lake water can no longer be drawn down during the winter months to freeze out aquatic plants or wash sediments downstream through the outlet. Lake district leaders recognize that although they will not be able to replace the current dam, implementation of management to control the plant growth in the lake will remain a priority.

1.2 SIGNIFICANCE & PURPOSE OF THE MANAGEMENT PLAN

The ecology of aquatic ecosystems must be understood to support and protect healthy systems. The purpose of this study is to collect baseline physical, biological, chemical, and social information about Lake Michelle and the surrounding watershed so that the leaders of the lake district may begin addressing the concerns voiced by the riparian residents. To date a management plan of this type has never been completed for the lake. The baseline collections of the data listed below will provide important details about the entire ecosystem that makes up Lake Michelle. The data collections will help managers make informed decisions as to any future management actions taken, so those actions will not harm or further degrade the lake ecosystem.

- ✓ Obtain water quality data to determine the existing nutrient status within Lake Michelle
- ✓ Assess the condition of the aquatic plant community within the lake
- ✓ Collect information and feedback from lakeshore residents regarding recreational use or other lake concerns
- ✓ Assess the condition of the shoreline by collecting information about development density, presence or absence of critical habitat for fish and wildlife, including in-lake course woody structure
- ✓ Complete an analysis of the land-use and identify potential critical sites of nutrient/sediment loads within the lake's immediate watershed

Results from this study will be used to provide the Wisconsin DNR and members of the Lake Michelle Lake District with an understanding of the ecosystem and potential issues affecting the quality and enjoyment of the lake community. Based on results of project surveys, data assessments and watershed modeling, the final lake management plan report will provide the Lake Michelle District Commissioners with management suggestions and recommendations to help restore and protect the lake ecosystem. The existence of the management plan will allow the district leaders to apply for treatment permits for managing aquatic plants, and it will help direct important decision making. Lastly, the plan will likely result in applications to the State of Wisconsin Surface Water Grant program to help the lake district finance the implementation of future management actions.

1.3 THE PLANNING PROCESS

Lake Michelle is represented by the Lake Michelle District Board of Commissioners, which was formed shortly after the impoundment was created. The Board of Commissioners initiated meetings with Water Ways – Lake Management Services during the summer of 2023 where initial concerns and potential future management strategies were discussed. The consultant attended the annual meeting of the lake district membership in 2023, where an introduction to the lake management planning process was presented to the members in attendance. The consultant then attended an additional meeting with the commissioners and provided a project proposal and estimated costs for completing a comprehensive lake management plan. A written project proposal and cost breakdown was provided to the district leaders, and a contract was signed to begin the management project on August 8, 2023. Field studies started in September 2023 with completion of the shoreland habitat assessment. Following ice out in May of 2024, the consultant completed an assessment of coarse woody habitat along the entire shoreline and started taking water samples for laboratory analysis. A total of four water sampling events occurred during the 2024 open water season. During the fall of 2024, the stakeholder survey was developed by the consultant and reviewed by a commissioner representative. The voluntary survey that was sent out to all district members provided a platform for them to voice any concerns they had about Lake Michelle. Raw data collected from the aquatic plant field survey (completed by Iron County Land & Water Conservation in 2023) was provided to the consultant to be analyzed and the results incorporated into this management plan report.

1.4 INTRODUCTION TO LAKE MICHELLE

Lake Michelle is located in Northern Wisconsin on the northeastern fringe of Iron County in the city of Hurley and nestled in the Welsh Creek-Montreal River watershed. Land use within the 46 square mile watershed is primarily made up of forestland, with areas of wetlands, residential, and open space. The 33.47-acre lake is an impounded section of Kominsky Creek, which is a Class 1 Trout headwater tributary of the Montreal River. The lake inlet is located on the south side, and the dam at the outlet area is centrally located on the eastern side of the lake.

> **Impoundment** = a manmade lake usually characterized by stream inflow and a stream outlet. Because of nutrient and soil loss from upstream land use practices, impoundments ordinarily have higher nutrient concentrations and faster sedimentation rates than natural lakes.

Lake Michelle is popular in the area for seasonal residents looking to relax in northern Wisconsin during the summer or winter months. Many people enjoy recreational activities in the summer like walking and golfing, and in the winter they like sports like skiing or snowmobiling.

The physical characteristics of a lake ecosystem are very important to understand when interpreting the various data collections and when deciding on the best management avenues to consider. Table 1 below exhibits summarized information about Lake Michelle. Further discussions about this information will follow in the next chapters.

Table 1. Characteristics of Lake Michelle, Iron County.

Lake Michelle Summary Information	
Surface Area (acre)	33.5
Maximum Depth (feet)	12
Mean Depth (feet)	6.3
Volume (acre-feet)	212
Residence Time (years)	0.3
Annual Water Load (feet/year)	24.8
Ave Inflowing Phosphorus (μg/L)	42
Drainage Basin:Lake Area (ratio)	42:1
Hydrology Type	Shallow Headwater Impounded Drainage

1.5 BIOLOGY OF SHALLOW LAKES

The lake is a shallow flowing impoundment with an average depth of 6.33 feet and an approximate volume of 211.87 acre-feet. Shallow impoundments typically exhibit high density aquatic plant or algae populations, as is the case for Lake Michelle (Figure 1). Shallow lakes are different than their deeper counterparts, not only because of the obvious physical differences, but also because of a myriad of biological and chemical processes occurring within them. Lake ecosystems that are shallow allow sunlight energy to reach the bottom depths which support photosynthetic activity and aquatic plant growth throughout the entire lake area. In addition, the volume of water within the shallow system is much lower than in deep lakes which concentrate all biological activity into the smaller space. The biological components of shallow lakes (microbes, algae, zooplankton, plants, invertebrates, and fish) exert stronger influences on all the chemical response interactions because oxygen and nutrients are available throughout the lake. As a result of these close and continual interactions between the biology and chemistry of shallower lakes, only one of two balanced states may occur. Either a shallow lake is a) turbid and algae dominated, or b) clear and dominated by aquatic plant growth. Lake Michelle currently exhibits the latter state of equilibrium.

The clear water state of Lake Michelle indicates that the zooplankton and fishery communities are healthy and the numerous rooted aquatic plants are stabilizing the bottom sediments. The advantage of a shallow lake that exhibits aquatic plant–domination is that the system can assimilate very large amounts of phosphorus without becoming unsightly and algae ridden. However, there is a fine tipping point between nutrient input limits, and the lake then turning turbid and algae dominated. For this reason, cautious implementation of aquatic plant management must occur in shallow lakes.

Figure 1. Depiction of the two different balanced states of shallow lake ecosystems.

2.0 HISTORY & STAKEHOLDERS

2.1 HISTORY OF THE LAKE &THE DISTRICT

The following account was provided by Thomas Lablonde's daughter.

Thomas Lablonde envisioned the concept and development of Lake Michelle. He was an art teacher, but decided he wanted to pursue something different. He owned property on 10th Avenue in Hurley and the property was large enough to accommodate three ponds. When he purchased the property, he made it a point to enlarge the ponds and plant some fish (including trout). He then purchased the entire wetland area that was fed by Kominski Creek, the outlet area that flows into the Montreal River, and the entire area where Pat's Grocery Store currently exists. There was a farm that existed across the street from where the lake exists today that extended to where Hurley School now stands. Working with the State of Wisconsin, the area was flooded, and an outlet dam was incorporated into plan.

The Lablonde Family built a house and several other duplexes for extended family members on the north side of the flooded area. To house her father's antique collection, garages were built at the back of the property. The west side of the area was cultivated as a large garden that included corn, potatoes, and various vegetables. Mr. Lablonde (along with other investors), proceeded to build condominiums on the west shoreline which provided housing for skiers visiting the area. Over the years, the family did not retain any written records of the Lake Michelle development.

Figure 2. Historical aerial photo series of Lake Michelle and the surrounding area. Left, 1938 aerial photo prior to the lake. Center, 1950 aerial photo prior to the lake. Right, 2022 aerial photo.
Source: Wisconsin Cartographers Office - Historical Digital Aerial Photography

Conception of the Lake & the District: The original dam was constructed in 1969 and consisted of a 5.5 ft diameter metal riser pipe, 100 feet of corrugated metal culvert pipe, and 100 ft of 12-inch corrugated metal lake pipe (with 12-inch valve). The Point North Corporation invested in building four-season residential housing (condominiums) around Lake Michelle in the early 1970's. In 1992, flooding of the wetland area now known as Lake Michelle progressed, and the floodway mapping was completed in 1995, by Lakewind Engineering, Inc. from Ashland, Wisconsin.

For the first 20 years of Lake Michelle's existence, the property owners of Haven North endured the full financial load of the daily operations and maintenance of the dam and the lake. Special assessments of over $75,000 were levied from Haven North property owners, while owners of private homes and Eagle Bluff paid nothing. The financial burdens to Haven North residents could not continue, and discussions were such that they either drain the area back to its' original wetland state or all landowners started to pay their share of operation and maintenance costs. After discussions and some opposition to the creation of a lake district, the Lake Michelle Management District was officially formed by the Iron County Board of Supervisors via Resolution 2463 on April 25, 2001, to protect and maintain the lake. During the same board meeting, Resolution 2464 appoints the first lake district commissioner representatives as follows: President Donald Richards; Vice President Bernie Hibbeln; Secretary/Treasurer (& City of Hurley Rep) Char Mussati; and County Rep Lawrence Vandevoorde. Records show that the first annual budget (2001-02) totaled $2,200. This allowed financial burdens to be fairly distributed amongst all property owners for daily reservoir & dam operation and maintenance. In accordance with statute, the lake district annual membership meetings were/are held between May and September and to this day, the Lake Michelle Management District remains intact and functional.

(a) *Vote by majority a tax upon all taxable property within the district. That portion of the tax that is for the costs of operation for the coming year may not exceed a rate of 2.5 mills of equalized valuation as determined by the department of revenue and reported to the district board. The tax shall be apportioned among the municipalities having property within the district on the basis of equalized full value, and a report shall be delivered by the treasurer, by November 1, by certified statement to the clerk of each municipality having property within the district for collection.*

Wis Stat. 33.30(4)(a)

DAM Reconstruction: Dam condition inspections in 2014 and 2015 found that updates were necessary due to aging out (45+ yrs) and corrosion of the original metal dam structure that regulated the water level of the lake. If upgrades to the dam and outlet area were not completed, it was likely that hydrologic failure would have eventually occurred – leaving the lake district responsible for environmental damages. Thus, planning for dam reconstruction began in 2017 and draft plans were reviewed by a WDNR Water Management Engineer. Bids for reconstruction activity started in May of 2018, in cooperation with Cooper Engineering (of Rice Lake, WI) and the Wisconsin Department of Natural Resources. The scope of the project included the replacement of the old structures with properly sized and more durable concrete ones, as well as removal of the visibly leaky drain valve. A state loan in the amount of $75,000 and a WDNR dam reconstruction grant was secured to finance the project. Construction was completed in September 2018 by Ross Peterson Construction of Hurley.

2.2 KEY STAKEHOLDERS

The likelihood of successful lake and watershed management actions significantly increase when partnerships are established because all stakeholders are working toward commonly shared goals. Partnering with diverse public and private entities can maximize the impact of effort by opening possibilities to leverage funding and resources, access diverse expertise, and access other stakeholder groups inside and outside the lake community. While federal, state, and local governments often work together to support watershed improvements, there are a wide variety of opportunities available to develop additional partnerships with other public and private sector organizations. Key stakeholders would include all groups or people that have an interest in the well-being of Lake Michelle and the successful operation of the Lake Michelle District. In addition to governments, partnerships could be developed with 1) Lake Users (anglers, hunting groups, kayakers, etc.), 2) Non-profit Organizations & Community Service Groups (Lions, Rotary, etc.), 3) Local Businesses (restaurants, golf businesses, bait shops, boat sales, etc.), or 4) Schools and local youth organizations.

The following key stakeholders were identified for Lake Michelle and all of them would serve well for the successful planning and implementation of this management plan.

The Lake Michelle District: The lake district is the primary partner when initiating any management action(s) for Lake Michelle. The five-member Board of Commissioners conducts the business operations for the lake district. They are responsible for the day-to-day business operations, the finances, and the implementation of any management actions. They represent the interests of all riparian landowners with these actions and work hard to promote and protect the health of the lake ecosystem while concurrently addressing the concerns of their membership.

The City of Hurley: The City of Hurley appoints a representative to serve as an active member of the Lake Michelle Board of Commissioners. This person participates in all lake district board meetings and serves as a liaison between city business and lake district business. This person represents the interests of the city in matters of lake district business, and they do this in two ways. First, they communicate any pertinent city matters to the Commissioner Board that may influence the lake or the lake district, while also relaying information to city leaders regarding lake topics that may influence decisions.

Iron County: Iron County may lend their services and partnerships in many ways, however, only two are mentioned here. The county appoints a representative to serve as a liaison between county business and lake district business. The representative is a member of the district Board of Commissioners. They keep the lake district board abreast of policies or actions that may have significance for the lake or the district and may also serve in the opposite capacity if the district need action(s) from the full county board.

Iron County also employs professional staff in the Land & Water Conservation Department that can directly assist the lake district in matters of lake and watershed management. The department can provide educational and technical assistance with many topics, including lake management and planning for conservation projects. They can also provide financial assistance with certain types of best management projects, including erosion control or shoreland protection projects.

The WI Department of Natural Resources: The WDNR provides professional and financial assistance to all types of lake organizations. They are also responsible for regulating environmental management activities, for example in the treatment of aquatic plants or lake dredging. The lake district would contact the Lake Coordinator for the Iron County region and apply for permits from the WDNR for any type of lake management project prior to doing it. The WDNR also has grant money available (on a competitive basis) for lake organizations from the Surface Water Grant Program to help them finance many types of management or educational projects. The WDNR values partnerships in any type of project, so it is extremely beneficial to leverage as many partners as possible to accomplish the project actions.

The Local School: Students and teachers are always willing to create partnerships with local organizations to accomplish mutual goals. Sometimes students need extra projects to learn outside the classroom and get real life experience for school credit. Some schools require high school students to accomplish community service hours before graduation and they seek local opportunities. Supervised students are great resources for fieldwork, data collection, or even newsletter or website designing.

The Local Golf Club: Sometimes local businesses will agree to provide labor or financial assistance in partnership will community members, including lake organizations. In the case of Lake Michelle, a golf club is located within the lake's drainage basin. It is likely that the golf club business and/or staff would agree to partnering to improve stormwater drainage patterns or other types of projects that may help protect the health of the community lake. This partnership would look good for their business in the public eye while helping to improve the community. Sometimes, all it takes is a conversation to get it started.

Others: There may be other types of potential partnerships in the Hurley area that haven't been mentioned here. Local service groups, fishing clubs, or church groups may be willing to help with labor or in financing improvement projects in their community. During the planning process of a project, be sure to think about all the possibilities and build these partnerships into a grant proposal.

2.3 STAKEHOLDER SURVEY

A clear understanding of how the lake is used and perceived by the riparian residents and visitors is essential for lake (and lake district) management efforts to be efficient, effective, and meaningful. For this purpose, an unbiased stakeholder survey was incorporated into this study. Honest feedback and opinions were encouraged by keeping the identity of participants anonymous, as no names were included on the surveys returned. Eighty-one surveys were sent out to lake district members during the summer of 2024, and a total of 34 were filled out (partially or completely) and returned, for a 42% response rate.

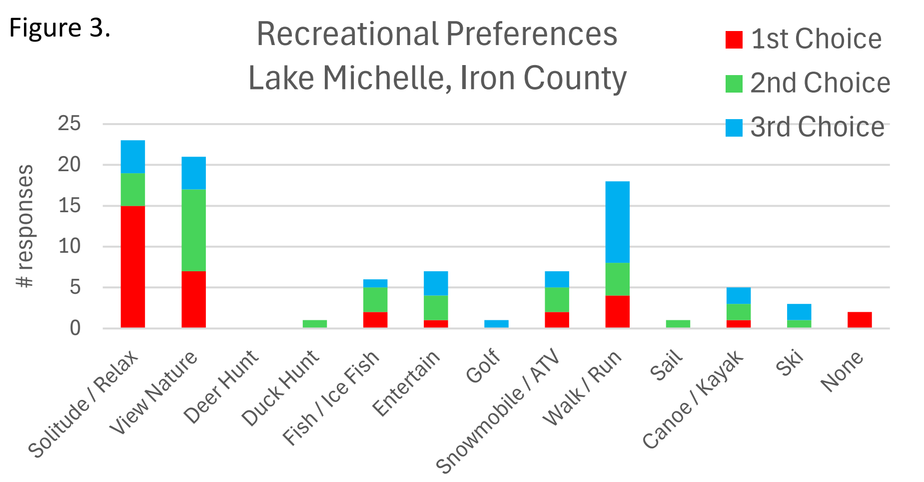
Participants were guided through the survey and answered questions that were relevant to their personal experience on Lake Michelle. The survey contained seven distinct sections as follows: 1) Familiarity with Lake Michelle; 2) Recreation; 3) Fishery; 4) Water Quality; 5) Aquatic Invasive Species; 6) General; and 7) Lake District. A summary of results for all of the questions are compiled and included in Appendix 1, while some are discussed in more detail here.

Table 2. Summary results from stakeholder survey question 1, resident status.

Q1		Total	%
Property Renter		3	8
Property Owner		31	92
TOTAL		34	100

Results show that survey participants represent mostly those who own property around the lake (Table 2). Of those respondents who own property, most utilize their property seasonally and 10 people indicated that they utilize their property as a year around, primary residence. Most interesting is that 13 of the 34 total respondents have 20 or more years of experience living around the Lake Michelle area, and 5 of them have been living around or visiting the area since the flooding of the wetland that created the existing Lake Michelle.

Figure 3.



Recreational pursuits on or around Lake Michelle take many forms. Survey participants ranked their top 3 activities from a listing of several provided and the results are shown in Figure 3. Most people picked "relaxation and solitude" or the "viewing of nature" that lake living provides because these options were not only selected most often but also ranked as first or second priority. This result indicates that keeping the lake healthy for all the wildlife that utilize it would be an important consideration in management decision making for Lake Michelle because most people enjoy this activity. Other popular picks for recreation around the lake were walking, entertaining, fishing and snowmobiling.

Eight survey respondents answered questions about fishing Lake Michelle in the last five years. They indicated that the most targeted fish species were Northern Pike and Bluegill, and the species that they caught most often were Northern Pike, Bluegill, and Yellow Perch. The respondents rated the quality of fishing in the lake as mostly poor, or they were unsure. Several respondents had indicated that fishing quality had declined when compared to the past when the lake had trout species to catch. This makes sense, because Lake Michelle is not the typical cold-water habitat where trout species thrive. Instead, the lake is more conducive to supporting warm-water fish species, such as those listed above in the lake today.

The overall water quality on Lake Michelle is perceived as good, however over half of the responses to this question on the survey were answered as "unsure" (Figure 4). Water quality can be a tricky question because many people confuse the quality of the water as the "clarity" level. In 2024, Lake Michelle was visibly clear throughout the entire open water season. The clarity level of lakes is only one of many factors that go into the overall quality ranking of the lake ecosystem. The chemistry data collected for a lake is a better indicator of the overall water quality level, as the chemistry results may reveal problems that otherwise cannot be seen on the surface of the lake. Detailed results and information about the water quality and chemistry of Lake Michelle is discussed in Chapter 4 of this document.

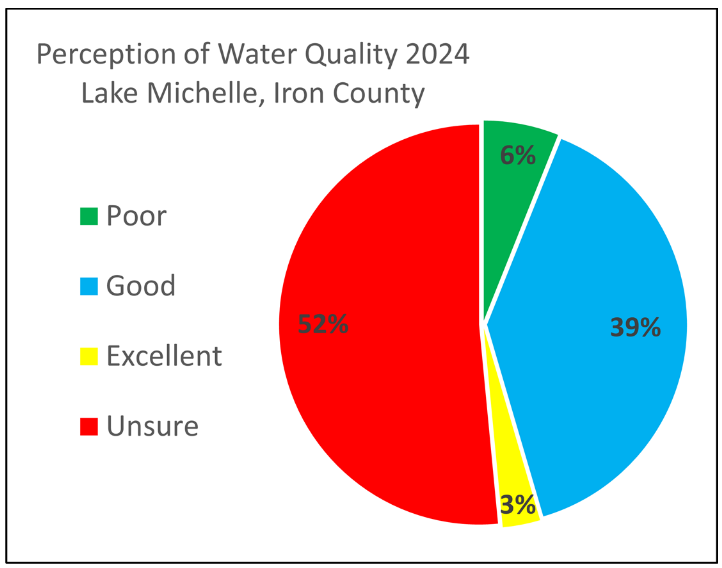


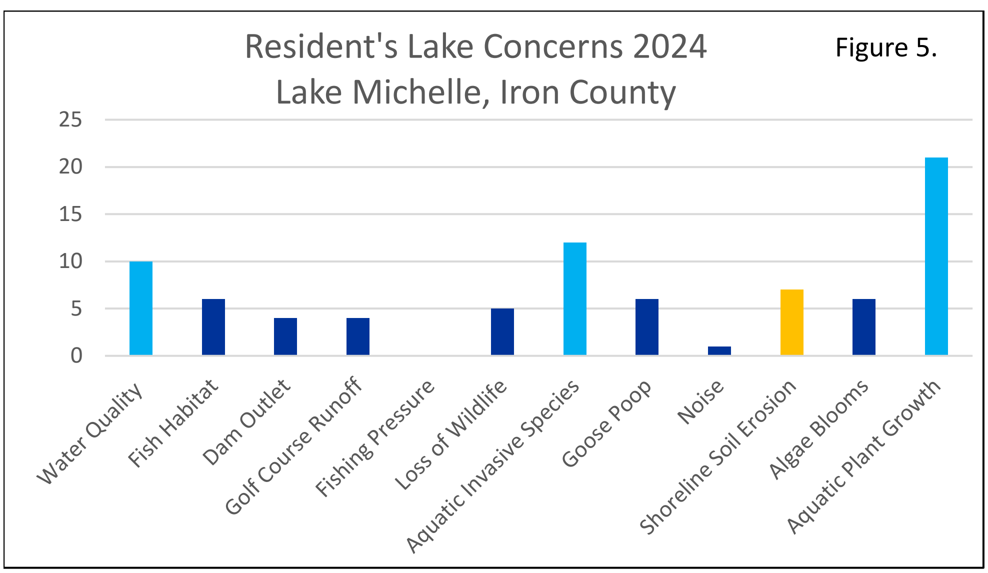
Figure 4. Perception of water quality on Lake Michelle in 2024, from question 18 of the stakeholder survey.

Prior to this survey, the majority respondents had already heard about aquatic invasive species (AIS). They are non-native species (plants or animals) that, when introduced to a new environment, may cause undesirable disruptions to an ecosystem. More specifically, when asked if they were aware of any invasive species in or around the shoreline of the Lake Michelle, the responses were split; 10 people answered "yes", 12 were "unsure", 8 responded with a definite "no", and the four remaining participants left the question blank. Those that responded with a yes or unsure were asked to further identify what invasive species they thought were present in or around Lake Michelle. Table 3 shows the results of that question. Most were aware of and mentioned non-native cattail. Interestingly, there were 2 people that indicated zebra mussels were in the lake, but survey results found no evidence of that species in Lake Michelle.

Table 3. Summarized results for invasive species thought to be present in Lake Michelle, 2024.

Q22	Total
Rusty Crayfish	
Cattail, Non-Native	8
Pale Yellow Iris	
Purple Loosestrife	4
Zebra Mussel	2
Flowering Rush	1
Eurasian Watermilfoil	
Carp	
Chinese Mystery Snail	1

A listing of the more common lake resident concerns was provided on the survey questionnaire and the top 3 that participants identified with the most are shown in light blue



in Figure 5. The growth of aquatic plants and aquatic invasive species are the top nuisances affecting residents' enjoyment of the lake, followed closely by water quality and shoreline soil erosion. It was not surprising to find that most people believe aquatic plant management is necessary, and they are opposed to a "do nothing" approach. Table 4 reveals what lake district members preferences are for various methods of aquatic plant management. The survey results indicate that many people are opposed to or unsure of the chemical treatment option. Most prefer hand-pulling or a combination of options for treating the plants.

Table 4. Summarized results for residents' comfort level of various methods of aquatic plant management.

Q26	Approve	Oppose	Unsure
Chemical Treatment	11	8	9
Water Level Control	11	3	12
Hand-Pulling	18	0	8
Combination	21	1	8
Do Nothing	1	15	10

Survey participants were asked if they felt informed about the business affairs of the Lake Michelle District, and the answers are listed in Figure 6. The responses were split. It is hard to say if people don't feel as if they are being informed, or if they choose not to pay attention to lake district news. Whatever the reasoning, the lake district leaders may want to increase their communications to the membership or diversify how they communicate. For instance, a quarterly hard copy newsletter may suffice for some people, but others may pay more attention to their incoming news by other means such as by social media, email list serves, or through a website. The lake district leaders may find that through increasing their level of communication, increased member participation in lake district matters may follow.

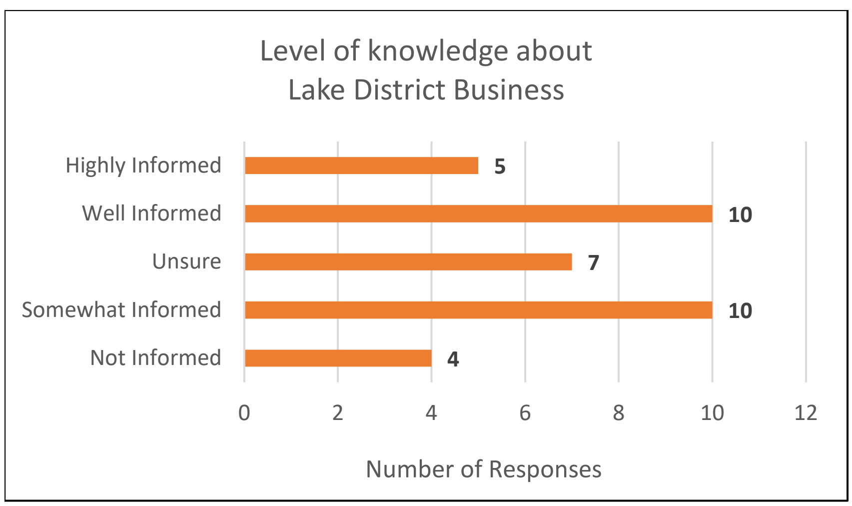


Figure 6. Responses to survey question 27, when asked how informed members feel about Lake Michelle District business.

A listing of educational lake-related topics was provided on the survey, and members were asked what they would like to learn more about. Feedback on this question was across the board, but most people indicated that any of the topics would be good to learn about. The more informed and educated people are about Lake Michelle, the more they will care about protecting it. The annual meeting of the district is a great opportunity to include a 30-minute educational presentation. There are professionals out there that are happy to share their programs and knowledge with all kinds of groups. Be sure to ask your potential speakers way ahead of time because calendars get booked, especially over the summer months. For a list of professional entities that may be available to speak, refer to Chapter 5 of this document.

3.0 THE WATERSHED

The health and quality of any waterbody is a direct reflection of the expanse of land which surrounds it – that land is its' watershed. A watershed is the total area of land that drains into a lake, stream, river, or wetland. As precipitation and snow melt flow downhill, any sediment, nutrient, or pollutant that exists on the surface of the landscape will eventually be delivered to the lower lying waters.

All geographic locations in the world exist within watersheds, and the area of land consists of unique physical and biological characteristics. No two watersheds are the same. The watershed size, soil types, topography of the land, development density, land use patterns, and annual precipitation patterns are just a few components that can influence the health of the receiving waters. Because of this, lake managers recognize that the best way to protect or restore surface and groundwater resources is to understand and manage landscapes at the watershed-scale. The following sections outline where Lake Michelle exists within various watershed sizes and how the soil and landscape features can influence the health of the lake.

All lakes are part of larger watershed areas and are identified by a series of numbers called hydrologic units. Hydrologic unit codes (HUC for short) are a digital dataset developed by the Natural Resources Conservation Service (NRCS) and the United States Geologic Survey (USGS). The HUC dataset is made up of nested regions of land, which delineate

Table 5. Hydrologic Unit Codes (HUC) classifications for Lake Michelle, Iron County, Wisconsin.

	HUC Digits	HUC Number	Unit Name	Area
Region	2	04	Great Lakes	178,300 mi²
Sub-Region	4	0401	Western Lake Superior	9,240 mi²
Basin	6	040103	SW Lake Superior	3,180 mi²
Sub-Basin	8	04010302	Bad-Montreal	1,330 mi²
Watershed	10	0401030201	Montreal River	208 mi²
Sub-Watershed	12	040103020107	Welsh Creek-Montreal R	46 mi²
Drainage Basin	Lake		Lake Michelle	2 mi²

Source https://water.usgs.gov/GIS/huc_name.html progressively into smaller watersheds – each having a unique code assigned to it. The codes are a series of two-digit groupings of numbers that describe the scale of the hydrologic unit, in addition to where it fits in the larger hydrologic framework. Numbers were assigned in an upstream to downstream fashion – starting with regions in the United States. Table 5 shows the unique number coding of the Lake Michelle area as it fits into the geography of the United States. Lake Michelle is located within a Sub-Watershed named the Welsh Creek-Montreal River system (HUC 040103020107) which includes an area of 46 square miles.

The drainage basin of a lake is the smallest unit of land that drains into the lake and the streams which surround it. The direct drainage area of Lake Michelle is a little over 2.09 square miles or 1335.04 acres in size (modeled by L-Thia). The drainage basin is illustrated in Map 1, where the blue line represents the basin outline.

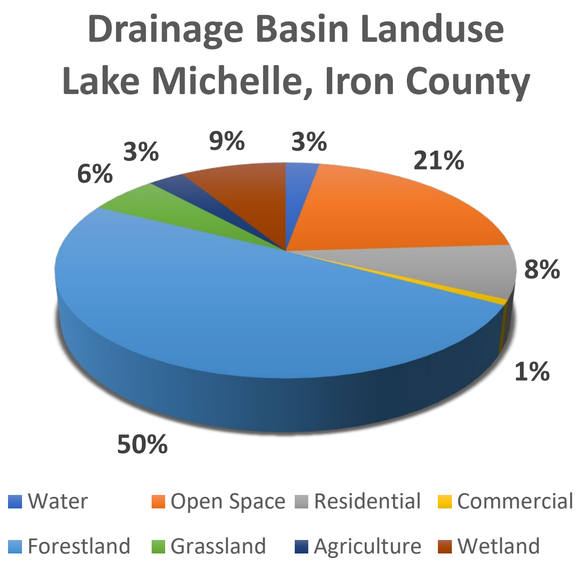
The relationship between drainage basin size and lake size is an important concept for managers to understand when trying to identify potential nutrient sources that may be contributed to a lake. A lake that is small in relation to the size of its direct drainage has greater potential to be negatively affected by sediment or nutrient inputs, whereas the opposite is true of a large lake that lies within a small drainage basin. This size relationship is defined as a ratio of drainage basin area to lake area (DB:LA). The DB:LA for Lake Michelle is 42:1 which means that for every one acre of lake size, there are 42 acres of drainage basin land that drains to it. The ratio of 42:1 is considered intermediate on the pollution "sensitivity" scale when compared to similar types of Wisconsin lakes (Understanding Lake Data).

Map 1. Lake Michelle shown here within the context of its direct drainage basin outlined in blue.

3.1 LANDUSE

The land uses within a lake drainage basin can dramatically affect the water quality and overall health of the lake. It all depends on soil types, topography of the watershed landscape, and the loads of nutrient and sediment flowing into the lake. The drainage basin of Lake Michelle was modeled using L=Thia (Purdue University). This model quickly analyses the watershed landscape and quantifies the character of the land that surrounds a lake. The modeled results are illustrated in the pie chart shown in Figure 7, and they indicate that the primary land uses within the Lake Michelle drainage basin are made up of 661.6 acres of Forestland (about 50% of the watershed), followed by Open Space (i.e. Rural Residential) that makes up 283.3 acres (about 21% of the watershed). Together these two land uses make up 71% of the total drainage area of Lake Michelle. The remaining land uses (Wet areas, Development, Grassland and Agriculture) round out the remaining 29%.

Figure 7.



Precipitation: Regional precipitation patterns (frequency, intensity, or timing) have a direct influence on lake water quality. The erosive energy produced by events of heavy rains and fast snowmelt work to displace soil particles and "wash" pollution off the landscape. In turn, sediments and pollutants are then easily transported to a lake either directly or indirectly via a stream. This concept is mentioned here because the ways in which the surrounding land is used within lake watersheds have a large influence on the amount of pollution that is transported and delivered to the surface water, especially during rainfall or snowmelt events.

Perviousness: The ways that land is used within a watershed gives a good indication of the water quality within it. For example, impervious surfaces (such as black top or concrete) allow for large volumes of water to run off very quickly (high velocity), which can physically pick up and carry more pollutants and/or sediments to any receiving surface water. The opposite is true for landscape surfaces which slow down the velocity of stormwater runoff and allow for more water infiltration into the soil. Since most of the Lake Michelle drainage basin is of a pervious nature (Forest and Open Spaces), most of the stormwater runoff or snow melt likely infiltrates into the ground, allowing less "contaminated" runoff water to be directly delivered to the receiving waters of Kaminski Creek, wetland areas, and ultimately Lake Michelle.

Stormwater Runoff = drainage of water from a land surface flowing downhill to the closest receiving waterbody.

3.2 SOIL EROSION AROUND LAKES

What is the relationship between soil and the water quality of a lake? There are several important factors at play that influence how soil could affect a lake ecosystem or the habitat within it. At the molecular level, soil particles may or may not possess high amounts of nutrients like phosphorus or nitrogen. Depending on the geographic location where the soil lies and the type of soil in the watershed, nutrient levels can vary significantly from location to location. Given an intense rain event, soil particles can saturate and begin to get carried off with stormwater runoff. The muddy runoff water runs downhill, picks up more particles and pollutants along the way and gets delivered to the nearest outlet (a wetland, a river, a pond, or a lake). If the soil contained high levels of nutrient, a significant load of non-point pollution just entered the waterbody. Once in the water, the nutrient may get flushed downstream, it may be absorbed by an actively growing aquatic plant or algae, or it may settle into the bottom sediments.

Erosion is the physical scouring of runoff water or wind. Many materials may be picked up and moved from one area to another on the landscape. Soil particles are a common pollutant picked up by rainwater or snow melt and flows downhill directly into receiving waters.

Suspended soil particles that settle into certain areas of the lake may create havoc with a prime spawning area of that waterbody. It may have been the only suitable habitat left in the waterbody for a naturally reproducing population of perch (or larger gamefish) which require clean rubble to spawn. If it wasn't the last spawning area, at the very least, the suitable spawning habitat available to the fish population in that location of the lake has been eliminated. Finally, the nutrient rich muddy deposits may settle down into the lake bottom sediment where the level of dissolved oxygen will determine if the nutrient is chemically available for aquatic plants or algae growth. The bottom line is that when added to a surface water environment, soil may be the cause of one or more detrimental effects on the ecosystem. For all of these reasons, it is best to keep soil on the land and not in the water.

3.3 KAMINSKI CREEK

Kaminiski Creek was last monitored by a WDNR biologist in 2023. It feeds Lake Michelle from a 2-mile section south of the inlet and is categorized as a Class 1 trout fishery according to the WDNR website. Under the state's Natural Community determinations, the creek is considered a Cool-Warm Headwater ecosystem. The stream is considered in good condition and meets WisCALM specifications for fish and aquatic life. More data collections would be helpful to understand the water quality, fishery, and habitat condition of the creek.

3.4 ESTIMATES OF NUTRIENT & POLLUTION LOAD

Pollutant Load Ratio Estimation Tool: PRESTO-Lite is a GIS-based modeling program that compares the average annual phosphorus loads originating from both point and non-point pollution sources within a given watershed. This tool is helpful to managers in mostly higher density populated areas or agricultural areas of the state when determining eligibility for adaptive management funding, but the model can also be utilized to determine an estimated non-point source pollutant load for landscapes that aren't necessarily urban or agriculturally

> **Nonpoint Source Pollution** (**NPS**) is the leading cause of surface water impairments in Wisconsin. Pollution comes from a variety of sources such as fertilizer, pesticide, nutrients, oil, faulty septic systems, salt, erosion sediment, timber harvests, atmospheric deposition, and bacteria from agriculture, urban, and residential areas.
>
> **Point Source Pollution** = Pollution coming from a pipe, a defined source.

dominated. The model quickly analyses upstream characteristics such as watershed size, landcover, land use, stream flows, and other natural community types for any watershed. This information is useful to lake managers when determining total phosphorus loads of a lake ecosystem and incorporating realistic landscape-based goals into the overall nutrient reduction strategy of a lake management implementation plan.

The PRESTO-Lite model indicates that the estimated average annual non-point source contribution of total phosphorus (TP) to Lake Michelle from its watershed is 95 pounds (with 80% confidence level), and there are no measurable contributions from point sources. The range of estimated non-point phosphorus is from 46 to 196 pounds each year.

Wisconsin Lake Modeling Suite: The Wisconsin Lake Modeling Suite (WiLMS), is the water quality planning tool that was used to analyze the Lake Michelle drainage area. The WiLMS tool predicts various levels of point and non-point sources of phosphorus input from streams and watershed runoff, thus allowing managers to reach reasonable conclusions regarding potential versus observed total phosphorus concentrations in a lake. Actual morphometric and hydrologic data about the lake and the watershed land use data are collected at the front end of the modeling program and in turn, the model then generates annual predictions of phosphorus loading and trophic response. Appendix 2 shows the numerical results of the WiLMS model for Lake Michelle. Estimates of the lake's "**hydraulic residence time**" are also generated during the WiLMS modeling procedure. This term relates to how much water a lake holds (volume) over a given time period. The water residence time is the total amount of time that the lake's water volume remains in the system. Lake Michelle residence time was calculated to be 0.3 years. Longer water residence times will result from larger lake volumes and smaller input/output volumes. So, it can be said that both concepts directly relate to the lake's hydrology scheme and placement within the landscape (refer to Chapter 4).

WiLMS predicted that the Lake Michelle drainage basin contributes approximately 1137 (949 from other inputs) pounds of nonpoint source phosphorus to the lake ecosystem each year, and the largest land-based contributors come from forestland (52 pounds) followed by cropland (35 pounds) (Figure 8). During the modeling procedure, the data runs through several different phosphorus prediction equations. Based on the *Dillon-Rigler-Kirchner* model of phosphorus load prediction in WiLMS, the likely mean for Lake Michelle total

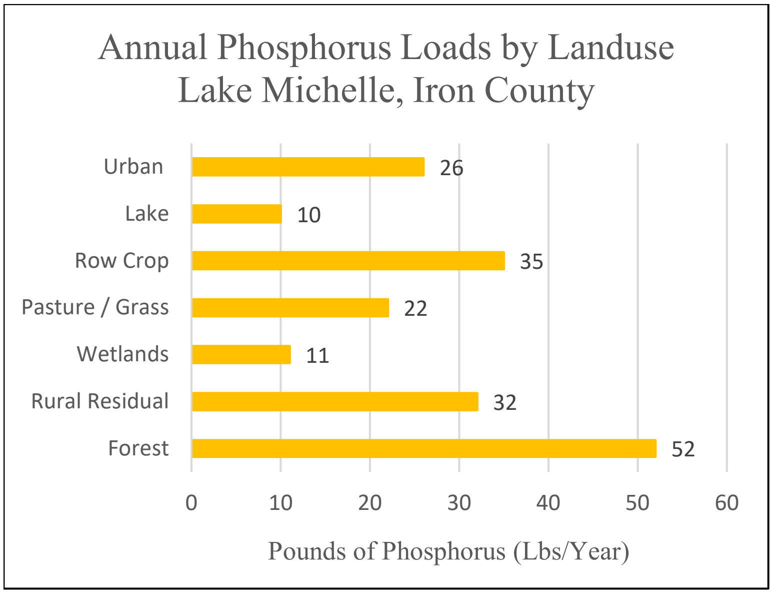


Figure 8. Estimated annual pounds of phosphorus by land use delivered to Lake Michelle. (Source WiLMS)

phosphorus concentration is near 26 µg/L during the spring overturn period. The actual observed spring overturn reading of total phosphorus during 2024 was 35 µg/L, which is slightly above the predicted value (refer to Table 7, Chapter 4). One possible reason for the higher observed value versus the predicted one might be that the springtime lake sediment conditions in Lake Michelle were prime for internal nutrient loading.

Sediment Internal Phosphorus Loading: Internal loads of phosphorus within a lake system can occur via chemical release from lake bottom sediments, or through physical disturbances of a mucky bottom. This phenomenon is called internal loading. In shallow lakes, short lived but frequent bursts of anoxic conditions (when little or no oxygen is present) may occur at the water – sediment interface during the open water period. In anoxic conditions, or if the lake pH is high (greater than 9), a chemical reaction occurs that releases the soluble form of phosphorus into the water column. Physical disturbances of the bottom sediments may also release nutrients into the water column. These disturbances may be from wind energy and vigorous mixing and stirring of the shallow areas or from human activities such as motorized boat movements. In either situation the nutrient rich bottom sediment may be stirred into the water column and those nutrients are then accessible for plant or algae growth. Further modeling can be completed that would predict the internal phosphorus load for Lake Michelle but was not included as part of this study.

4.0 THE LAKE

4.1 CLASSIFICATION OF LAKES

Lake managers often categorize ecosystems at various spatial scales to explain variability in the type, quality, or quantity of resources within a given environment. These differentiations allow for general comparisons from one ecosystem to another, but further predictions can be made about the physical and biological characteristics of a given lake by placing them into a similar class of ecosystem. Separating lakes into categories or "classes" is useful for managers because if data collections from a lake seem to be off the normal ranges for a given class, biologists are alerted early on of potential ecosystem issues. A range of variability within a category is normal and even expected, but if data waivers too far from the norm, it would set off a red flag for further investigation.

The following sections will help us see how Lake Michelle fits into various Wisconsin lake classification schemes.

Lake Type – *Hydrology-based Classification*

For years, Wisconsin lakes were simply separated into categories based on major water source inflow(s) and outflow(s), otherwise referred to as hydrology-based classification. In the lake type classification scheme, Lake Michelle is categorized simply as a *Headwater Drainage Lake (Reservoir)* because it is a dammed impoundment of Kaminski Creek. Figure 9, at left, shows water source inputs for drainage lakes that may come from groundwater, inlet stream(s), and runoff of precipitation from rain or snowmelt. Water is lost from these systems by groundwater discharge, outlet stream(s), and evaporation. Drainage lakes tend to have variable water quality and nutrient levels, depending upon the amount of land area drained by the lake's watershed. For this reason, watershed size plays a key role in the classification of drainage lakes (Emmons, et al, 1999).

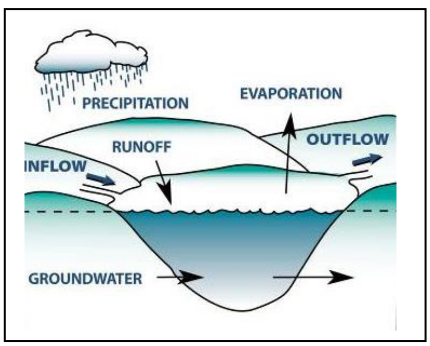


Figure 9. *Depiction of drainage lake hydrology.*

Wisconsin Lake Classification – *Stratification-based Classification*

To refine categories further, scientists have determined that in addition to hydrology, the primary influences of a lake's character are the size and depth of the system. The temperature of a lake varies by depth and this factor alone can determine whether a lake undergoes thermal stratification. To determine the stratification class of Lake Michelle, the size (33.47 acre) and maximum depth (12 feet) were placed into the following model equation developed by Lathrop and Lille which returned a value of 3.2:

Thermal Stratification = The layering of lake water due to vertical variations in temperature and water density. Stratification pattern may be mixed or fully layered.

$$\frac{\text{Maximum Depth (feet)} * 0.3048 - 0.1}{\text{Log 10 (Lake Area (acres)} * 0.40469)}$$

The model suggests that returned values of less than 3.8 predict a thermally mixed (or non-stratified) lake, which is further defined as a *Shallow Lake*. The 2024 WisCALM document describes mixed lakes "to be shallow, well-oxygenated, and may be impacted by re-suspension of the bottom sediments. Shallow lakes also have the potential to support rooted aquatic plants across the entire bottom of the lake." Confirmation of these two observations for Lake Michelle are supported in a review of both the dissolved oxygen profiles and the results of the aquatic plant survey.

Table 6. Lake and reservoir natural communities and defining characteristics - adapted from Wisconsin Lakes Classification (2024 WisCALM).

Natural Community	Stratification Status	Hydrology
Lakes / Reservoirs <10 acres - Small	Variable	Any
Lakes / Reservoirs ≥ 10 acres		
1 Shallow Seepage	Mixed	Seepage
2 Shallow Headwater	Mixed	Headwater Drainage
3 Shallow Lowland	Mixed	Lowland Drainage
4 Deep Seepage	Stratified	Seepage
5 Deep Headwater	Stratified	Headwater Drainage
6 Deep Lowland	Stratified	Lowland Drainage
Other Classification (any size)		
Spring Ponds	Variable	Spring Hydrology
Two-Story Fishery Lakes	Stratified	Any
Impounded Flowing Waters	Variable	Headwater or Lowland Drainage

Dissolved oxygen profiles taken during July of 2024 indicate that although thermal stratification was achieved during the summer, it was very weak and short-lived, not lasting over a one-month duration. Further, dissolved oxygen was always present in the lower depths of the lake, with a minimum read of 6.0 mg/L at the 11-foot depth in September. Refer to Figures 16 a-d for the dissolved oxygen profiles.

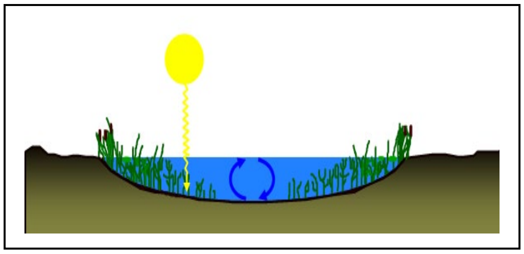


Figure 10. Illustration of a shallow, mixed lake (2024 WisCALM). This system represents that of Lake Michelle, Iron County.

The aquatic plant survey results also support the assumption that shallow lakes may support rooted plant growth throughout the entire bottom, as indeed is the case for Lake Michelle. WisCALM guidance further explains that "If the watershed draining to the lake is greater than or equal to 4 square miles, the lake is classified as a Lowland Drainage Lake". This is not the case with Lake Michelle, as the drainage basin has an area of only 2.09 square miles. Considering this criterion, Lake Michelle fits well within the category of a Class 2 - Shallow Headwater, Mixed Drainage Lake, more specifically, a shallow Impounded Flowing Water (refer to highlighted areas of Table 6). The state defines an impounded flowing water as "a waterbody impounded by a constructed outlet structure on a river or stream that is not a reservoir" (NR 102.03)(1q).

Trophic State Classification – *Age-based Classification*

Figure 11 depicts the natural aging process that all lakes undergo over hundreds and thousands of years. There is a direct correlation between the level of nutrients within a lake ecosystem and the lake's overall water quality or "trophic state". For example, lakes with high phosphorus levels (30-50 µg/L) are able to sustain consistently high levels of plant productivity, thus are categorized as eutrophic. The opposite is true of a lake with very low nutrient levels (3-10 µg/L), thus categorized as Oligotrophic. The total phosphorus levels in-between categorize a lake as *Mesotrophic* (middle-aged), because total phosphorus levels typically measure between 18-27 µg/L. Lake Michelle falls into the Mesotrophic, age classification based on the amount of phosphorus that was discovered in the water samples (average 19 µg/L). However, the productivity level exhibited in the lake is more similar to the Eutrophic class. Further detail about the trophic status of the lake is described in Chapter 6.

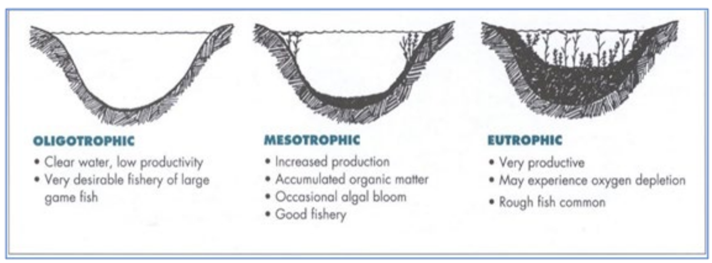
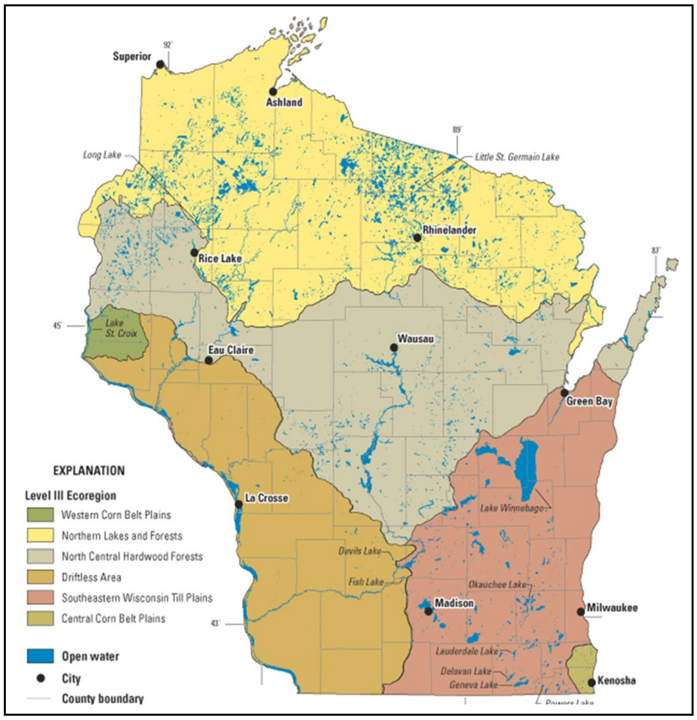


Figure 11. Three trophic states of lakes. All lakes will shift to the right in a natural aging process becoming more eutrophic (i.e. productive) over time. Source: Understanding Lake Data

Ecoregion – *Geography-based Classification*

Ecoregions are mapped geographical areas where all components of the terrestrial and aquatic ecosystem exhibit slightly different patterns or qualities in comparison to that of other areas (Omernik, 1987). At regional scales then, these defined areas can serve as the framework for ecosystem comparisons. Analysis of ecoregions allow scientists to compare and manage resources at a landscape scale and there are many applications that these defined areas can be useful. One application of ecoregion mapping that is of particular interest to lake managers is the incorporation of regional land use and the identification of potential sources of nonpoint pollution. Map 2 shows the defined ecoregions for Wisconsin and Lake Michelle is located within the Northern Lakes and Forests (NLF). This region (shown in yellow on the map) is described by Omernik as an ecoregion of relatively nutrient poor glacial soils, coniferous and northern hardwoods forests, undulating till plains, morainal hills, broad lacustrine basins, and areas of extensive sandy outwash plains. The soils are formed primarily from sandy and loamy glacial drift material. This region has lower annual temperatures and a considerably shorter frost-free period than other ecoregions in Wisconsin. The soil and colder temperatures hinder agriculture; therefore, woodlands and forests are the predominant land use/land cover. The numerous lakes that dot the landscape are clearer and typically exhibit a lower trophic state (predominantly oligotrophic to mesotrophic lakes), and less productive than those in ecoregions to the south. Historic mining of iron and copper occurred along the northern and northwestern edge of this region. At the time of writing, the trophic status of Lake Michelle had not been determined, but it tends toward a eutrophic state, as is not typical of lakes in this region when compared to similar types of waterbodies.



Map 2. Wisconsin Level III Ecoregions from Omernik, 1987.

4.2 WATER QUALITY

In this section, general water quality principles will be discussed so that the reader may understand the overall quality of the water contained within Lake Michelle. There are an abundance of physical, biological, and chemical factors all working together that influence the unique character and quality of all surface waters. Lakes are a very complicated mix of

Table 7. 2024 results of the water quality chemistry analyses for Lake Michelle, Iron County.

Sampling Parameter	May	Jul	Aug	Sep	Summer Average
NUTRIENTS					
Total Phosphorus (μg/L)	35	21	21	7	16
Soluable Reactive Phosphorus	ND	ND	ND	ND	ND
Total Kjeldahl Nitrogen *(mg/L)*	0.550	0.550	0.550	0.6	0.236
Nitrate-Nitrite N *(mg/L)*	ND	ND	ND	ND	ND
Ammonium as NH3-N *(mg/L)*	0.030	0.020	0.030	0.020	0.023
Sulfate (ICP) *(mg/L)*	3.70	2.08			2.08
WET CHEMISTRY					
Conductivity (Lab) (μS)	114	123	137	146	135
pH (Lab)	7.84	8.09			8.1
Alkalinity CaCo3 *(mg/L)*	48	50			50
Chloride *(mg/L)*	8.6	7.8	8.1	9.1	8.3
Chlorophyll *a (μg/L)*	ND	1.6	2.5	1.7	1.9
Total Hardness, Calculation *(mg/L)*	55.4	51.2			51.2
Turbidity (NTU)	0.7	0.5			0.5
METALS					
Calcium *(mg/L)*	15.23	13.52			13.52
Magnesium *(mg/L)*	4.212	4.238			4.238
Potassium *(mg/L)*	0.810	0.193			0.193
Sodium *(mg/L)*	6.39	6.394			6.394

external and internal influences that are always changing based on the inter-connectedness of all those factors. Fortunately, lakes have been studied for decades and scientists have been able to understand how lake water quality relates to these influences. Much of the information shared here is sourced and adapted from *Understanding Lake Data* and from the 2024 WisCALM guidance document. Water samples were taken from Lake Michelle on four separate occasions over the course of the open water season of 2024 and were shipped to the Water & Environmental Analysis Laboratory at UW-Stevens Point for analysis. The lake water in Lake Michelle appeared very clear during all the sampling occasions. The September occasion included a duplicate water sample to assure sampling and analysis quality, for a total of 5 samples. Summarized data for Lake Michelle water chemistry are shown in Table 7, and explanations of the data findings follow. *Note that water quality assessments reference the 2024 WisCALM Guidance document for a Shallow Headwater Drainage Lake.

Total Phosphorus: Phosphorus is an element found naturally within our environment and the level varies within a lake ecosystem over time and over a single season. Phosphorus nutrient originates from a variety of sources including (but not limited to) rock and soil erosion, wastewater runoff, runoff from fertilized lawns, failing septic systems, and runoff from barnyards or cropland. Phosphorus nutrients are also contained internally within the lake sediments, but its availability is dependent on the presence of dissolved oxygen. Phosphorus is a significant nutrient in lakes because it drives the biological productivity level within the system (i.e. the food chain). In fact, the level of plant and algae growth in the lake directly relates to the amount of chemically soluble phosphorus within the system. Even small inputs of phosphorus into surface waters can set off several undesirable events that lower the quality of a waterbody. Biological and chemical responses to a new load may include accelerated plant or algae growth, lowered oxygen levels, or even massive fishkills.

> There's an adage that states "A pound of phosphorus yields 500 pounds of algae".
>
> J.R. Vallentyne, *The Algal Bowl – Lakes and Man*, 1974.

Measures of Soluble and Total Phosphorus were included in the lab analysis. The soluble form dissolves in water and is readily available for plants or algae to grow. The immediate concentration of this form within the lake can vary widely over short periods of time as plants or algae take it up for growth, or as the plants die off and it is then released back into the water column.

Phosphorus Results: The total phosphorus reference criteria for fish & aquatic life and recreation for shallow headwater drainage lakes is ≥40 $\mu g/L$. The mean total phosphorus reading was significantly below the impairment threshold reading from the 4 sampling occasions at 19 $\mu g/L$, with a maximum reading of 35 $\mu g/L$ in May and a minimum reading of 7 $\mu g/L$ in September. Larger quantities of total phosphorus readings are expected in aquatic environments because this form includes organic forms like bacterial, plant, and animal; and inorganic particulate forms such as clays and minerals (Horne and Goldman). The soluble

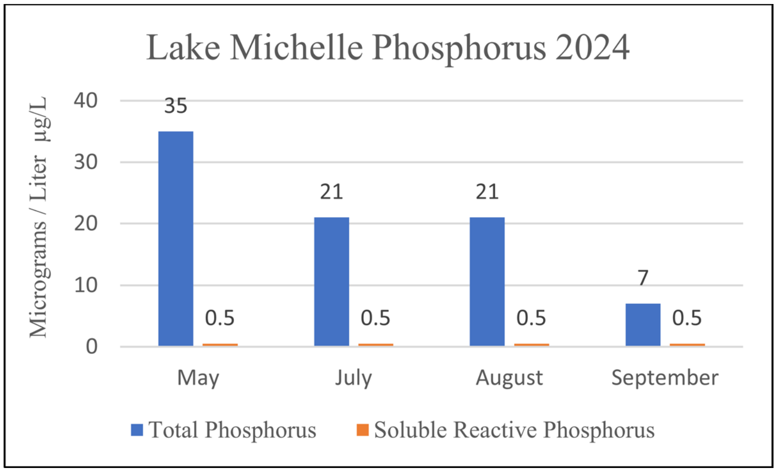


Figure 12. Raw Total Phosphorus results for Lake Michelle during the 2024 field season. Soluble Reactive Phosphorus was non-detected in the samples, but for purposes of showing up on the chart, a value of 0.5 was assigned.

form of phosphorus for each of the four sampling occurrences was ND (non-detect). *Note: For purposes of showing the Soluble Reactive P result on Figure 12 for comparison purposes, a value of 0.5 was assigned, when the actual value was closer to 0 and non-detectable. This result suggests that most of the chemically available phosphorus within the lake water column was taken up for growth of aquatic plants.

Chlorophyll-a: Chlorophyll-*a* (Chl-*a*) is a green pigment located inside plant or algae cells that is used during the process of photosynthesis. The concentration of chlorophyll-*a* in lake water samples is directly related to the amount of suspended phytoplankton (algae) in the lake's water column on any given day. Thus, if the water column has a high abundance of algae, the value of the Chl-*a* reading will be a direct reflection of that abundance and result in an increased pigment value.

Chlorophyll-a Results: The chlorophyll-a impairment threshold for Fish & Aquatic Life in the shallow headwater drainage lake category is ≥ 27 *µg/L*. The chlorophyll-a results for Lake Michelle during the 2024 field season were significantly below the WisCALM impairment threshold for Fish & Aquatic Life. The mean chlorophyll-a reading from the 3 summer sampling occasions was 1.9 *µg/L*, with a maximum reading of 2.5 *µg/L* in

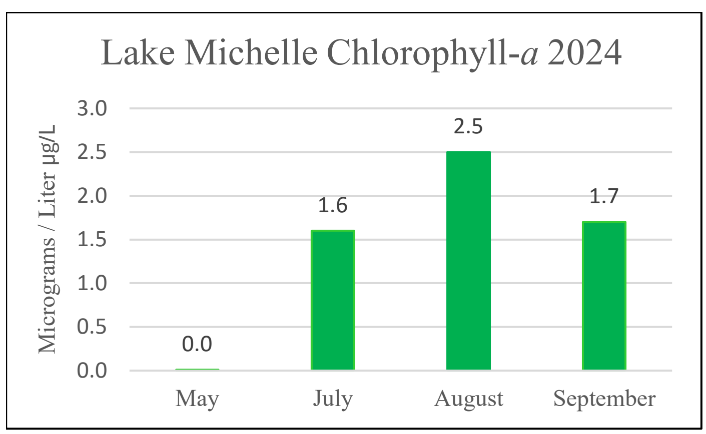


Figure 13. Chlorophyll-a results for Lake Michelle during the 2024 field season.

August and a minimum reading of 1.6 $\mu g/L$ in July. This result concurs with the observed crystal clarity of the lake on all of the sampling dates. Over the course of the open water season, the quantity of algae will fluctuate as shown in the 2024 Lake Michelle values (Figure 13). For this reason, scientists use the average of 3 summer months to indicate the normal reading of a lake for a given field season.

Water Transparency: Water transparency (clarity) is a measurement of two components of a lake system: 1) the color, which is determined by the total amount of dissolved substances in the water column; and 2) the turbidity, the amount of suspended material within the water column. Individual readings of water clarity for a lake fluctuate over a field season, so it is the average clarity that is calculated to determine a lake's overall clarity status for a given year. The clarity of lake water is measured by a simple black and white disk called a Secchi disk (Figure 14 at left) that is lowered vertically down into the water column until it disappears or hits the bottom, whichever comes first. The vertical measurement is marked and recorded as the water clarity (transparency). Over the course of time, averages of clarity readings are graphed, and trends of a given waterbody can be observed.

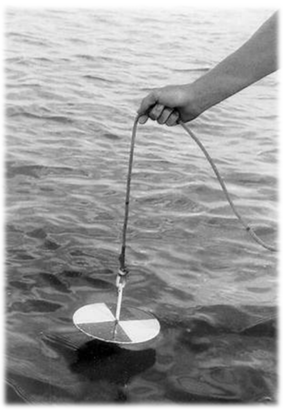


Figure 14. A Secchi disk being lowered into a lake.

There is an inverse relationship between the Secchi disk reading and chlorophyll-*a* values. For example, as more algae growth occurs throughout the water column, it follows that the transparency reading decreases. Conversely, as the transparency measurement increases, both the phosphorus and chlorophyll-*a* values understandably decrease (unless there are additional source(s) of nutrient running into the lake as explained in the previous section). Lake transparency readings taken weekly or bi-weekly by a citizen volunteer would be very useful over

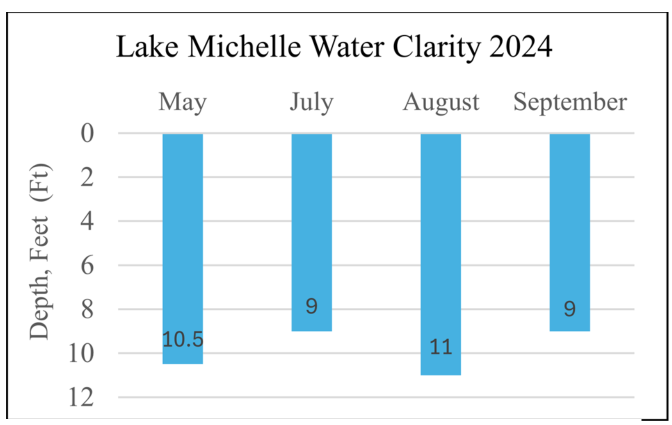


Figure 15. Secchi disk clarity measurements for Lake Michelle during the summer months of 2024.

time because the larger accumulated data collection can be used to calculate the lake's trophic state index (TSI). All lakes change over time and are in a constant state of progression, referred to as lake succession or eutrophication. This natural "aging" of a lake may take thousands of years. Scientists measure the succession process of lakes by measuring the productivity or trophic state (TSI) of a lake. Lakes will fall into predictable productivity patterns based on averaged data measurements of Secchi transparency, chlorophyll-*a* and phosphorus over the summer months. At this time, there is not enough data collected for Lake Michelle to calculate the trophic state. As of 2024, Lake Michelle was found to be visibly clear, and the 2024 transparency measures confirm this as shown in Figure 15.

Nitrogen: The presence of nitrogen within the lake ecosystem is completely normal and comes from sources such as plant decay (from respiration processes), precipitation, or from the atmosphere. Activities occurring within the lake drainage basin may also be sources of nitrogen input and include point or non-point sources such as sewage effluent, agriculture wastes, or crop fertilizers. Elevated nitrogen readings may indicate the presence of any or all of these of these activities in a lake watershed.

Nitrogen is also measured to derive an important ratio for lake biologists. The ratio of total nitrogen to total phosphorus (N:P) is indicative of whether plant growth in a lake is limited by phosphorus or nitrogen (Shaw et al. 2002). If the ratio of N:P is less than 10:1 then a lake is nitrogen-limited, but if the ratio is greater than 15:1 algal growth is controlled by phosphorus and therefore, the system is phosphorus-limited. The N:P calculation is average (Kjeldahl + inorganic N) divided by average Total Phosphorus. The summer averaged Kjeldahl nitrogen read for Lake Michelle in 2024 was .57 mg/L and the mean ammonium is .02 mg/L. The calculated N:P ratio for Lake Michelle is 37:1, thus gives a clear indication that it is a phosphorus-limited system and plant growth is controlled by the availability of soluble phosphorus nutrient within the water column.

Dissolved Oxygen / Temperature: Oxygen is a critical component in lakes for living organisms and for many ongoing molecular level chemical reactions (Horne and Goldman, 1994). Vertical measurements taken in the lake column allow us to determine what kind of suitable living habitat is available to aquatic life at all depths of the lake. Understanding the level of oxygen helps us understand the biological patterns occurring throughout the lake. Oxygen is continuously consumed in animal respiration and during decomposition processes, and conversely, it is a by-product of plant photosynthesis. The availability (solubility) of oxygen in a lake ecosystem is dependent on water temperature, so for this reason, the two data parameters are collected and analyzed together. The colder the water, the more dissolved gases the water can hold.

Dissolved Oxygen / Temperature Results: Dissolved oxygen and temperature profiles that were collected for Lake Michelle from May through September 2024 are displayed in Figures 16 a-d. The vertical graphs give a visual depiction of the numerical data that was collected, and they tell a story about the lake's thermal stratification pattern. Profiles were taken at the deepest hole, and the flow intensity of the system (or wind drift) may have interfered slightly with the integrity of the readings even though the watercraft was anchored. Shortly following ice out (May, Figure 16a), the Lake Michelle water was vertically mixed from top to bottom, which is very typical of lakes in the spring of the year. The cold lake temperatures and high dissolved oxygen levels were predictably uniform throughout the depths of the lake. As the surface temperatures rose in July (Figure 16b), the oxygen levels stayed relatively the same as in May. Plant growth was elevated at this time, so a by-product of photosynthesis (oxygen) during daylight hours was evident. Concurrently however, the solubility of oxygen was lower in the warmer surface waters. Thus, the data result for oxygen remains about equal to what it was in May at the surface depths. Shortly beyond the 6-foot depth, we begin to see the levels of both temperature and oxygen change. This is not a coincidence because what the data clearly indicates is that as the water temperature decreases, oxygen solubility increases. Plant growth was still occurring at those lower depths and oxygen was still being produced. Toward the lower depths, it is likely that respiration was occurring at a higher rate as the oxygen levels dropped. In August, both temperature and oxygen levels began to

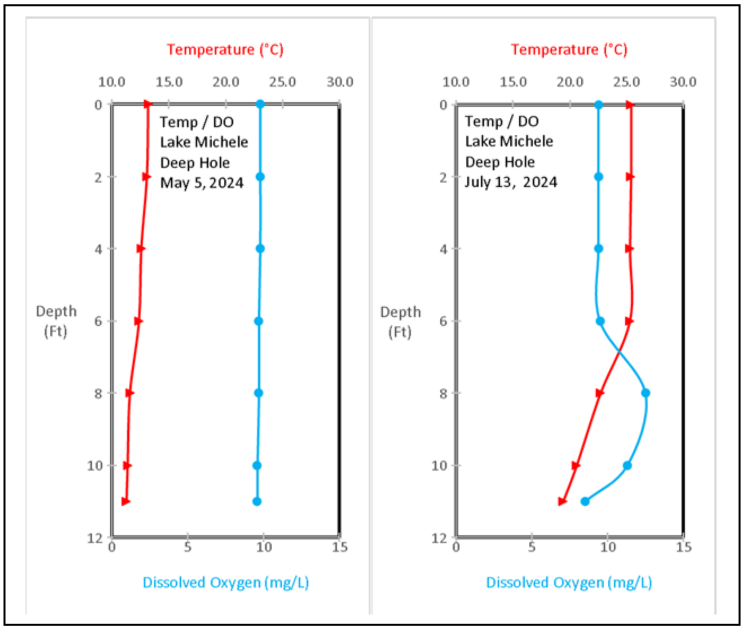


Figure 16 a-b. 2024 Lake Michelle dissolved oxygen and temperature profiles, May(a) and July(b).

slowly drop. The graph (Figure 16c) shows that levels of both were mixed throughout the water column. During late summer, plants begin to die off and photosynthesis does not occur at the same rate as earlier in the season. The profiles collected in September were similar to those taken in August. The Fish and Aquatic Life impairment threshold for dissolved oxygen is <5.0 mg/L, and the oxygen readings taken in Lake Michele never dipped below 6.0 mg/L. There was a slight increase in oxygen levels, likely due to slightly increased photosynthetic activity from algae as opposed to aquatic plant growth. This result correlates with slightly lower Secchi disk reading in September (Figure 15). And as the graph illustrates, oxygen levels dropped due to increased respiration rates that occur in lake bottom sediments.

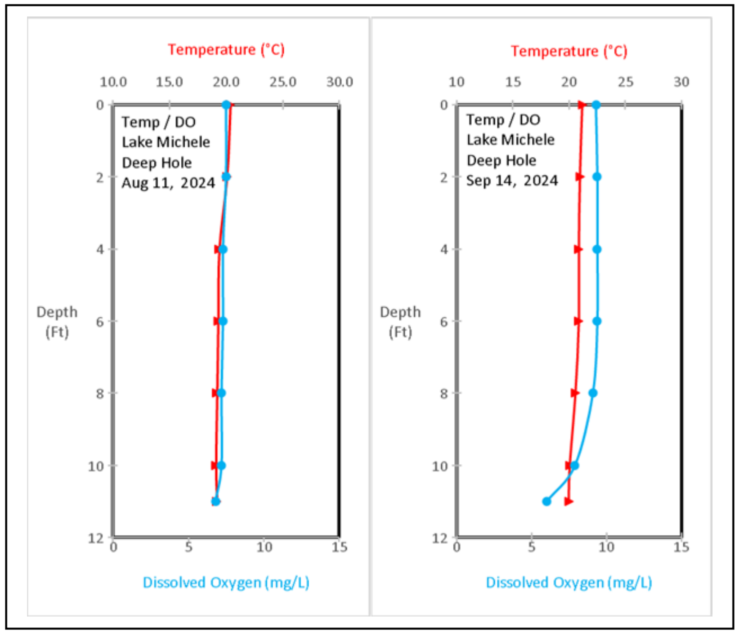


Figure 16 c-d. 2024 Lake Michelle dissolved oxygen and temperature profiles, August (c) and September (d).

Chloride: Lakes can vary in their chloride concentrations seasonally and over time, so it is best to have a baseline "normal" level for future comparison. Chloride does not affect the growth patterns of aquatic plants or algae, but its abundance in surface waters may indicate pollution caused by human activity. Potential sources of chloride include faulty septic systems, animal waste from barnyards, lawn fertilizers and road salt. In the northern part of the state, it is normal to see levels of chloride concentration greater than 10 mg/L. Chloride is a concern for Wisconsin waters in part because of road salt usage in the winter months, or because of faulty septic systems. If levels rise above certain levels within surface waters over time, its presence can be toxic to many forms of fish and aquatic life (WisCALM). Small animal species such as amphibians, fish, and invertebrates have shown life-stage sensitivity to increasing water salinization in freshwater lakes. Scientific results show that even slight elevations in chloride levels (+5mg/L) may cause significant negative impacts to aquatic communities (Lawson 2021). Impacts can range from physiological stress to decreases in reproductive success, or in worse cases, death. Studies have shown that changes in lake salinity levels have experienced a marked decrease in species richness and less biological diversity, with more tolerant (and undesirable) taxa dominating a system over time. For these reasons, it is commonly suggested that covering salt storage facilities and limiting the use of road salt throughout the watershed as much as possible by prewetting roads with a brine solution in preparation for winter storms.

Chloride Results: Levels of chloride tend to be the highest following snow melt in the spring of the year and then lower down over the course of the open water season. It is common to see levels of chloride at 10 mg/L or higher in northern parts of the state. Chloride measurements in Lake Michelle were higher in the spring 8.6 mg/L., then lowered down by July 7.8 mg/L as expected. However, over the next two summer months of August and September, chloride levels began rising from 8.1 mg/L to 9.0 mg/L. Figure 17 illustrates the variability of chloride readings in Lake Michelle over the 2024 sampling season. Chloride concentrations were rising over the summer months, which alerts lake managers that there may be pollution entering Lake Michelle from either (or both) agriculture or septic systems. Additional studies of chloride levels would be necessary to confirm where the chloride input(s) originates.

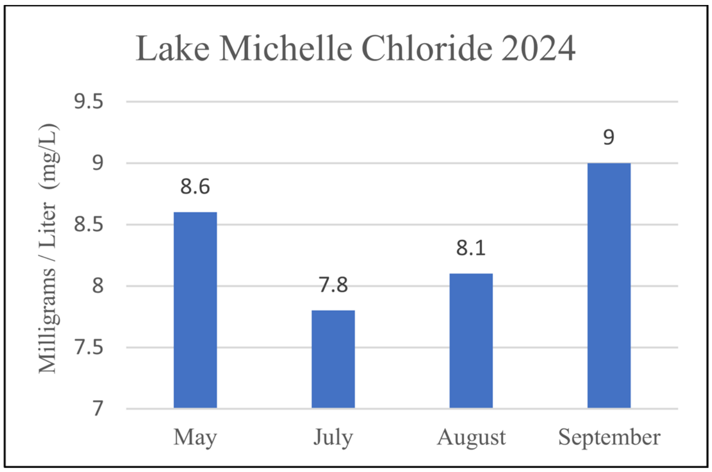


Figure 17. Results of chloride laboratory analysis during the 2024 sampling season – Lake Michelle, Iron County.

Conductivity: Conductivity is a measure of the lake's ability to conduct electric current and relates directly to the total dissolved inorganic chemicals in the water. Typical values for conductivity are two times the water hardness, unless the lake is receiving contamination inputs from human-caused sources. The average reading for Lake Michelle over the summer was 135 μS, which is over two times the hardness level. It kept increasing during the entire sampling season. This finding is indicative of potential pollutants entering the lake.

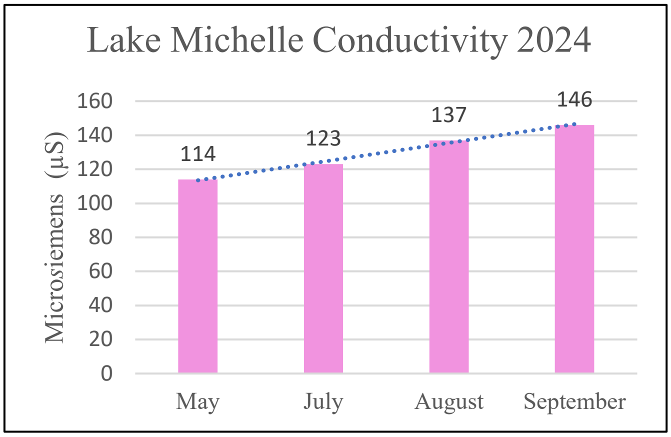


Figure 18. Results of conductivity laboratory analysis during the 2024 sampling season – Lake Michelle, Iron County.

Potassium: Potassium is a key ingredient in potash fertilizers and is also abundant in animal waste from barnyards. The presence of potassium is not toxic in and of itself but may be indicative of pollution caused by human activity from the watershed, which could become harmful to the lake ecosystem over time. The springtime value was high at 0.810 mg/L and by July the level dropped to 0.193 mg/L. This finding indicates that the spring snow melt may have been contaminated with potash fertilizer from one or more sources within the lake's watershed, and by July it was flushing downstream.

The Carbonate System: The carbonate system in lakes is a complex inter-mixing of natural molecules and ions (Ca, Mg, C, H, and O) that are in a constant state of flux based on changes in temperature, sunlight, or biological occurrences within the ecosystem. It is the carbonate system that provides acid rain buffering capacity for the lake, which is very important because natural rainfall is slightly acidic with a 5.6 pH average reading (Understanding Lake Data). The measurement of a lake's level of acidity (or the amount of $H+$ ions in water) is known as the pH, where 7 is neutral on a scale of 0 to 14. Lakes with low pH readings have more hydrogen ions and lakes with higher pH have less hydrogen ion concentrations. The pH readings for Lake Michelle were 7.8 and 8.1 which are located on the higher end of the normal range for lakes in Wisconsin.

The lake classification or "type" of lake and the primary water source that feeds it (groundwater versus precipitation) also become very important to the resulting carbonate system. A lake's hardness and alkalinity are greatly affected by the type of minerals in the soil and to the degree at which the water encounters it. For instance, if the lake is fed primarily through groundwater springs the lake water will be higher on the alkalinity scale. Lake

Michelle is classified as an impounded flowing water. These lakes are primarily fed by stream inflow and watershed runoff and secondarily by groundwater. Because the lake water is sourced mostly from stream flow and precipitation, the water that feeds Lake Michelle has very little time in contact with minerals underground which would increase the hardness level. Lake Michelle predictably measures low on the calcium carbonate scale and exhibits soft water. Lake Michelle results for the carbonate system parameters are displayed in Table 7, in the Wet Chemistry and Metals sections.

Water hardness and alkalinity are closely linked together. Hardness levels range from "soft" to "hard" based on the amount of measured alkalinity ($CaCO_3$). Calcium carbonate measurements from 0-60 mg/L are considered low (soft), 61-120 mg/L CaCO3 are considered moderately hard, and higher readings can be >150 mg/L. On this scale, Lake Michelle fits into the soft water category (48-50 mg/L), which makes it an excellent buffer against the effects of acid rain (which is typical in Northern Wisconsin).

If water is "hard" ($CaCO_3$ > 150 mg/L), phosphorus nutrient is unavailable for aquatic plant or algae growth because it gets chemically bound up (insoluble). The opposite was found to be true for Lake Michelle, at readings of 48-50 mg/L, the lake is a soft water system. These readings make sense because Lake Michelle (and Kominski Creek) is an ecosystem that is predominately fed by precipitation which is soft water, thus soluble phosphorus is readily available for the plant growth that is occurring in the lake.

4.3 AQUATIC PLANTS

Rooted aquatic plants are a natural part of all lake communities and provide important functions for a healthy and thriving lake ecosystem. Plant root systems stabilize lake bottom sediments, they help protect against bank erosion by buffering wave and wind energy near the shore, they produce life-giving oxygen for fish and other aquatic animals, and they trap nutrients and convert them into plant growth that would otherwise be available for the growth of algae.

As with any biological community, a higher diversity of plant species presence is indicative of a higher quality and healthier ecosystem. Research has shown that certain aquatic plants are sensitive to the amount of available nutrients in the lake. Aquatic plants show differences in tolerance to nutrient enrichment, and utilizing this principle, impairments to water quality can be detected by surveying a lake's plant community. As a lake becomes more enriched with nutrients, the composition of the plant community naturally shifts to tolerant adapted species. These concepts are discussed in detail below.

Native Aquatic Plants – Whole Lake Survey Results: Whole-lake statistics provide a general overview of the plant community and can be used to compare Lake Michelle to other lakes in the region or the state. Appendix 3 provides explanations of each statistic mentioned below in more detail. Of the 146 potential sampling points (see Figure 26, Chapter 6), samples were taken from 139 sites. The 7 remaining points not sampled were due to areas of densely packed emergent vegetation and difficult watercraft navigability. The maximum rooting depth of plants was found at 12 feet, which was also the maximum depth of the lake recorded, so rooted plants covered the entire lake bottom. Of the 139 sampled sites, 138 had vegetation present on the rake (Results Table 8). The average number of species found at vegetated sites was 2.81 per site and the average rake fullness rating was 2.53 on a scale of 1-3; where 1 means there are a few plant strands and 3 means that the rake head was very full (see Figure 27, Chapter 6). A total of 21 different species of aquatic plants were found, four of which were "visual sitings" (i.e., within 6 feet of the survey point but not found on the rake head).

Table 8. 2023 whole-lake point intercept survey results for Lake Michelle, Iron County.

<table>
<tr><th colspan="2">Summary Statistic</th><th>Result</th></tr>
<tr><td colspan="2">Total # sites visited</td><td>139</td></tr>
<tr><td colspan="2">Total # sites with vegetation</td><td>138</td></tr>
<tr><td colspan="2">Maximum depth of plants (feet)</td><td>12</td></tr>
<tr><td colspan="2">Total # sites shallower than max depth of plants</td><td>139</td></tr>
<tr><td colspan="2">Freq. of occurrence at sites shallower than max depth of plants</td><td>99.28</td></tr>
<tr><td rowspan="4">Average # of species / site</td><td>a) Shallower than max depth</td><td>2.79</td></tr>
<tr><td>b) Vegetated sites only</td><td>2.81</td></tr>
<tr><td>c) Native shallower than max depth</td><td>2.79</td></tr>
<tr><td>d) Native species at vegetated sites only</td><td>2.81</td></tr>
<tr><td rowspan="2">Species Richness</td><td>a) Total # species on rake at all sites</td><td>17</td></tr>
<tr><td>b) Including visual occurrences</td><td>21</td></tr>
<tr><td colspan="2">Simpson's Diversity Index</td><td>0.85</td></tr>
<tr><td colspan="2">Mean Coefficient of Conservatism</td><td>6.11</td></tr>
<tr><td colspan="2">Floristic Quality Index</td><td>25.2</td></tr>
<tr><td colspan="2">Average rake fullness</td><td>2.53</td></tr>
</table>

The Simpson Diversity Index is a calculation that measures the heterogeneity of the aquatic plant community in the lake and accounts for the number of species as well as the abundance level of each. The Lake Michelle calculated Simpson's Diversity Index was 0.85 on a scale from 0 to 1, where "0" represents no diversity and "1" represents infinite diversity. The closer to 1 on the scale, the more biodiverse the plant community is in the lake.

The Floristic Quality Index (FQI) evaluates how similar the plant community is in a lake to one that is undisturbed (Nichols, 1999). Sixteen plant species were included in the The calculated FOI for Lake Michelle is 23.5, compared to the eco-region average 24.3 and the statewide average of 22.2. The Lake Michelle FQI of 23.5 suggests that the plant community here is more similar (above average) to an undisturbed lake when compared to the state average, but more disturbed condition (below average) when compared to similar lake types in the Northern Lakes and Forests eco-region. Further, the calculated FQI only accounts for presence or absence of sensitive or tolerant species that occur in the lake, where the Coefficient of Conservatism (C value) incorporates the frequency of occurrence for plant species that are either sensitive to, or more tolerant of disturbed conditions. As more human disturbance and nutrient loading occurs in a lake, plant species with lower C values are likely to dominate the ecosystem. The C values of each species found in Lake Michelle are listed in Table 9 and rank from 0 – 10, where 0 listed species are most tolerant and a rank of 10 are most sensitive to disturbed lake conditions. The Lake Michelle average C value for sensitive species included in the FQI calculation is 5.9, which falls below both the state (6.0) and regional (6.7) averages, yet it is still greater than 5 on the 0 - 10 scale. This finding suggests that the Lake Michelle aquatic plant community is slightly compromised and tolerant of a more disturbed ecosystem than similar lakes in the Northern Lakes and Forests region.

Table 9. 2023 Floristic Quality Index results, Lake Michelle, Iron County. Mean values for state and region listed for comparison to Lake Michelle.

Common Name	Latin Name		C value
Watershield	*Brasenia schreberi*		6
Coontail	*Ceratophyllum demersum*		3
Muskgrasses	*Chara*		7
Needle spikerush	*Eleocharis acicularis*		5
Common waterweed	*Elodea canadensis*		3
Slender waterweed	*Elodea nuttallii*		7
Water horsetail	*Equisetum fluviatile*		7
Northern water-milfoil	*Myriophyllum sibiricum*		6
Slender naiad	*Najas flexilis*		6
Nitella	*Nitella*		7
Large-leaf pondweed	*Potamogeton amplifolius*		7
Leafy pondweed	*Potamogeton foliosus*		6
Small pondweed	*Potamogeton pusillus*		7
Fern pondweed	*Potamogeton robbinsii*		8
Flat-stem pondweed	*Potamogeton zosteriformis*		6
Sago pondweed	*Stuckenia pectinata*		3
N	Statewide 13	Region 13	Michelle 16
Mean C	Statewide 6.0	Region 6.7	Michelle 5.9
FQI	Statewide 22.2	Region 24.3	Michelle 23.5

Coefficient of Conservatism – A number ranking from 0-10 is assigned to each plant species based on its tolerance level of disturbances such as water level fluctuation, rooting depth, bottom substrate type, or water turbidity. A rank of "0" means high disturbance tolerance, and a "10" means very sensitive to disturbed conditions. An average score of <5 suggests that there are disburbances in the lake.

Native Aquatic Plants – Individual Species Statistics: There were 16 aquatic plant species sampled in Lake Michelle, an additional 4 species that were visual sitings only, and filamentous algae; for a total of 21 species documented Table 10. Leafy pondweed (**Potamogeton foliosus*) was the most common plant sampled with presence at 84 of the 139 sites and relative frequency of almost 22%, followed closely by Common waterweed (*Elodea canadensis*) at 81 sites and a relative frequency of 21%. The third most common species was Coontail (*Ceratophyllum demersum*) which was sampled at 73 sites and relative frequency of 19%. The total relative frequency of the top three species combined was 62%, which suggests a heterogeneous plant community. The remaining aquatic plant species in Lake Michelle were sampled at fewer sites and had much lower relative frequencies than the previous listed species, however there were some species found that are considered "high value" in Wisconsin. Overall, Lake Michelle shows a moderately high Simpson Diversity Index of 0.85 (biodiverse), but the lower FQI value (5.9) reveals that the plants that are present are tolerant of disturbed lake conditions.

High Value Aquatic Plants – Lake Michelle contains five species of high value plants: *P. foliosus*; *P. amplifolius; P. robbinsii; Eleocharis spp.*; *Brasenia schreberi*

NR 107.08(4)

The state of Wisconsin defines aquatic plant species of highest value in NR 107.08(4). The following species are known to provide important contributions to the plant community of lakes and the state carefully limits treatment of lake sites containing them as to not result in adverse long-term or permanent changes to the plant community: **Potamogeton amplifolius* (Rel. Freq. 3.4%), *Potamogeton Richardsonii, Potamogeton praelongus, Potamogeton pectinatus, Potamogeton illinoensis,* **Potamogeton robbinsii* (Rel. Freq. 1.3%), **Eleocharis spp.* (Rel. Freq 1.6%), *Scirpus spp., Valisneria spp., Zizania aquatica, Zannichellia palustris* and **Brasenia schreberi* (Rel. Freq. 0.3%). There were two non-native invasive species found during the plant survey as visual sitings only, purple loosestrife (*Lythrum salicaria*) and narrow-leaved cattail (*Typha angustifolia*).

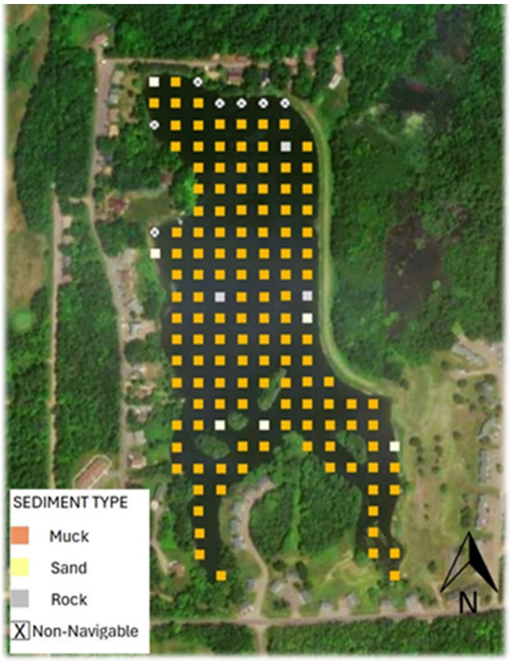
Table 10. Aquatic plants present in Lake Michelle during the 2023 season.

Common Name	Latin Name	Rel. Freq.	# Sites	# Visual	FO Veg.	FO Max Depth	Ave. Rake
Watershield	*Brasenia schreberi*	0.3	1	3	0.72	0.72	1.00
Coontail	*Ceratophyllum demersum*	18.9	73	3	52.90	52.52	1.52
Muskgrasses	*Chara*	5.9	23	0	16.67	16.55	1.22
Needle spikerush	*Eleocharis acicularis*	1.6	6	0	4.35	4.32	1.33
Common waterweed	*Elodea canadensis*	20.9	81	1	58.70	58.27	1.81
Slender waterweed	*Elodea nuttallii*	0.3	1	0	0.72	0.72	3.00
Water horsetail	*Equisetum fluviatile*	0.3	1	2	0.72	0.72	1.00
Northern water-milfoil	*Myriophyllum sibiricum*	8.3	32	24	23.19	23.02	1.28
Slender naiad	*Najas flexilis*	9.3	36	2	26.09	25.90	1.25
Nitella	*Nitella*	1.6	6	0	4.35	4.32	1.67
Large-leaf pondweed	*Potamogeton amplifolius*	3.4	13	4	9.42	9.35	1.08
Leafy pondweed	*Potamogeton foliosus*	21.7	84	3	60.87	60.43	2.12
Small pondweed	*Potamogeton pusillus*	0.8	3	0	2.17	2.16	1.00
Fern pondweed	*Potamogeton robbinsii*	1.3	5	4	3.62	3.60	1.00
Flat-stem pondweed	*Potamogeton zosteriformis*	5.2	20	11	14.49	14.39	1.00
Sago pondweed	*Stuckenia pectinata*	0.5	2	0	1.45	1.44	1.00
Filamentous Algae			4	1	2.90	2.88	1.00
Small duckweed	*Lemna minor*			3			
Purple Loosestrife	*Lythrum salicaria*			1			
Softstem bulrush	*Schoenoplectus tabernaemontani*			2			
Narrow-leaved cattail	*Typha angustifolia*			4			

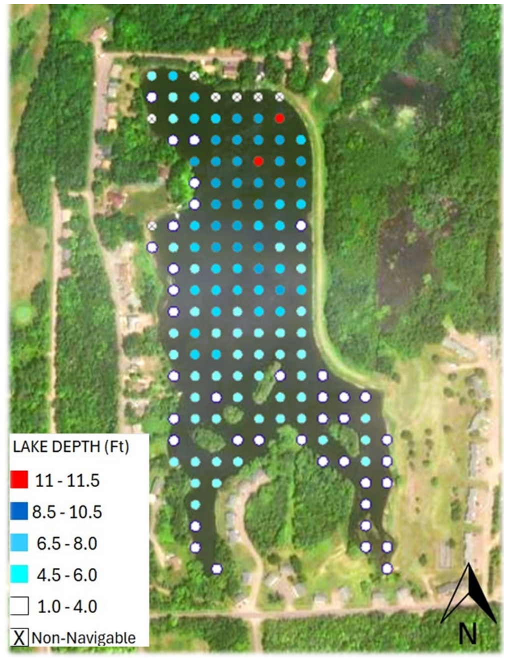
Lake Sediment: The lake bottom sediment types were noted at each sample point during the aquatic plant survey. Most of the points were classified as "muck" in Lake Michelle. There were 130 points that were identified as muck bottom, 6 sites noted as sand substrate and only 3 that were classified as rocky substrate (Map 3). It is common to find lakes (or whole bays of larger lakes) that have high accumulations of muck bottom when aquatic plant densities are also very high, such as in Lake Michelle. The nutrient rich muck layers accumulate over the years on the lake bottom from aquatic plants and other organic matter that have died off and decomposed. The amount of muck accumulation in the lake reveals an imbalance of the aquatic plant population in Lake Michelle.

Sediment = Accumulated organic and inorganic matter found on the bottom of lakes. Sediments include annual accumulations of decaying aquatic plants and algae, marl, and materials from the watershed such as fallen leaves and soil erosion.

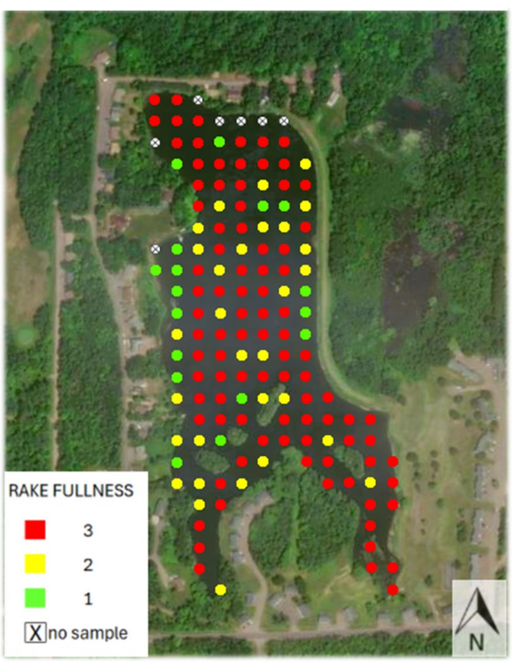
Map 3. 2023 distribution of sediment types in Lake Michelle, Iron County.



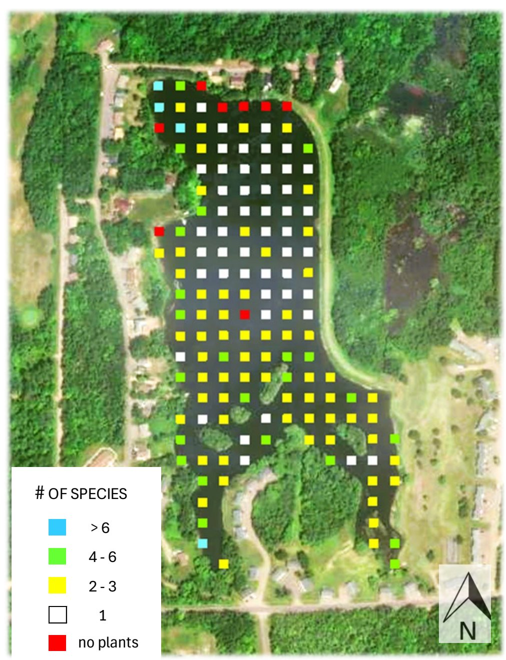
Map 4. 2023 distribution of lake depths in Lake Michelle, Iron County.



Map 5. 2023 distribution of rake fullness ratings on Lake Michelle, Iron County.



Map 6. 2023 distribution of species richness for Lake Michelle, Iron County.



Lake Depths & Plant Distribution: The morphometry of a lake is important in determining the distribution of aquatic plants. Duarte and Kalff (1986) found that the slope of the littoral zone could explain 72% of the observed variability in the growth of submerged plants. Engel found that gentle slopes support more plant growth than steep slopes. They found that gradual slopes provided a more stable substrate for purposes of rooting and plant growth. Lake Michelle fits well into this morphometric description (Map 4). Many of the lake depths fell between 4-6 feet, especially in the mid to southern portions of the lake. The deepest areas were found on the north side. The northern shoreline region of Lake Michelle was difficult to navigate to the assigned point intercept locations due to very dense beds of emergent vegetation (i.e. cattail), so there were no rake samples taken at 6 points in this location of the lake. The plant survey was physically challenging because of numerous rake fullness ratings of "very dense". Scores of "3" densities were the most common and occurred at 92 sites, followed by 30 sites with a rating of "2" and 17 sites with a "1" fullness rating (Map 5). Rake fullness ratings are mostly "scattered" throughout the lake, but it looks like ratings of only "1" or "2" occurred along the Western shoreline where there are single family residential parcels. Interestingly, the area located just Northwest of the non-sampled sites had the greatest species diversity per survey point than most other areas of the lake, except for one site at the Southwest end where there were more than 6 species identified on the rake (Map 6). In general however, it looks like the northern half of the lake is deeper but has less species diversity per sampling point overall; and the southern half is shallower but has better species diversity.

Littoral Zone = the nearshore zone of the lake where sunlight penetrates to the bottom sediments.

Aquatic Invasive Plants: Aquatic invasive plants are non-native plants that are introduced and likely to cause environmental and/or economic harm to a given ecosystem. They tend to alter biological relationships within the ecosystem which can disrupt the balance and structure of an otherwise healthy habitat. The State of Wisconsin has rules in place which regulate invasive species based on a classification system. This allows the state to

Restricted AIS Classification = Invasive species that are already established in the state and cause or have the potential to cause significant environmental or economic harm to human health. Source WDNR have consistency in rules which make concerted and coordinated management actions more likely on a statewide basis.

There were two species of invasive aquatic plants identified within Lake Michelle, Narrowleaf Cattail and Purple Loosestrife. Both AIS species are classified as "restricted" in the State of Wisconsin. More information about each is discussed in the sections below.

Narrowleaf Cattail – *(TYPHA ANGUSTIFOLIA):*

Records indicate that nuisance levels of narrowleaf cattail were evident as early as 2016 on the inlet channel and inlet bay areas on the southeast side of Lake Michelle. Since that time, the population has spread to most other areas of the lake, Map 7.

Identification: *T. angustifolia*, common name narrowleaf cattail, is a non-native perennial plant that is widely distributed throughout Wisconsin but originates from Europe. It has slender erect leaves (4-12 mm), and the main stem can grow to a height of 7 feet tall. The leaf blades are linear and flat (.15-.5 inches wide and 3 feet in length). About fifteen leaves emerge per shoot from the stem. The leaves are dark green in color and rounded on the back of the blade. The top of the leaf sheath has thin, ear-shaped lobes at the blade junction which usually disintegrate during the summer.

There are numerous tiny flowers densely packed into a cylindrical spike at the end of the stem. They are divided into the upper section of yellow male flowers, and the lower brown, sausage-shaped section of female flowers. The gap between male and female sections is about 0.5-4" in this cattail. They bloom in late spring each year. The seeds of cattail are tiny and dispersed by the wind with the aid of numerous "hairs". Each spike will develop thousands of seeds that can remain viable for up to 100 years. The roots of the species spread vegetatively by rhizomes under the sediment which develop very large colonies over time.

Habitat: Narrowleaf cattail invades freshwater marshes, wet meadows, roadside ditches, shallow streams, ponds and lakeshores. According to the wisflora herbarium website, it tends to collect near areas where road salt drainage collects. Narrowleaf cattail is an aggressive species which invades disturbed, nutrient-rich wetlands and thrives where water levels are artificially stabilized. According to this description, Lake Michelle provides the perfect habitat for this species.

Ecology: Narrowleaf cattail provides important food and shelter habitat for many species of marsh-dwelling animals, the large stands of invasive cattails out compete and exclude other less common wetland plant species. This creates monostands of the plant which decreases or eliminates the possibility for a healthy and diverse wetland plant community. This cattail may provide beneficial ecosystem services under certain conditions, including bioremediation in newly constructed wetlands or to utilize nutrient inputs from the surrounding watershed.

Map 7. 2023 estimated locations of Narrowleaf Cattail in Lake Michelle.

Lake Michelle Cattail Population: There are approximately 2-3 acres of cattails in the lake, according to an estimate completed by the Iron County Land and Water Conservation office in 2023. Most of it is located along the dike, in the south bays, and in the shallowest areas of the lake (see Map 7). Once established, the management and control of narrowleaf cattail is difficult, and often involves labor intensive removal strategies that are short-lived or ineffective (Wetlands, 2019).

Purple Loosestrife – *(LYTHRUM SALICARIA):*

Lythrum salicaria, common name Purple Loosestrife, is a non-native perennial wetland plant originally from Asia and Europe, that is now widely distributed throughout Wisconsin. Because of the beautiful flowers it exhibits, Purple Loosestrife has been utilized as a garden ornamental species where it then escapes via seed dispersal to nearby wetlands. It is sold in landscape nurseries as a sterile variety but can still produce viable seeds in the wild.

Identification: It has simple, lance-shaped leaves with opposite orientation and rotated 90 degrees from those situated below. The erect green stems are sometimes tinged with a purple color and are distinctly 4 to 6 sided. The flowers are closely attached to the stem with five or six pinkish colored petals which bloom from the bottom to the top of the spike, from June to October. A single stem can produce from 100,000 to 300,000 seeds each year, and the seeds remain viable for at least seven years. Each plant contains a large woody taproot with side roots that intertwine to form dense colonies.

Habitat: Purple loosestrife prefers moist soil and shallow waters. It often out-competes native wetland plants and over time, can grow into a large monoculture population. Wherever it grows, purple loosestrife adapts and will adjust to varying light conditions and water levels.

Ecology: Purple loosestrife can spread rapidly due to the prolific seed production and can dominate an area, excluding native wetland vegetation. This creates monotypic stands of the plant which eliminates the possibility for a healthy, balanced, and diverse wetland plant and animal community.

Lake Michelle Purple Loosestrife Population: In 2023, the Iron County Land and Water Conservation Department surveyed the aquatic plant population of Lake Michelle and found a population of invasive Purple Loosestrife near site number 10 on the southwestern leg, and on a nearby island. Purple loosestrife can be easily managed biologically by leaf-eating *Galerucella* beetles, Figure 19. These beetles feed and reproduce directly on

Figure 19. Galerucella sps. beetle on a damaged leaf.

the plants. The plant community then becomes vulnerable to various diseases or fungus and severely weakens the health of plants.

4.4 AQUATIC ANIMALS

Aquatic animals are a natural part of all lake communities and provide important functions for a healthy and thriving lake ecosystem. All animals, no matter what their size, utilize the dissolved oxygen within the water column. Aquatic animals also play important roles in a lake food chain, and each stage of the food chain is vital to sustain the health of a lake community. Microbes aid in the decomposition process of dead plant material near the lake bottom, zooplankton feed on small phytoplankton (i.e. algae), nursery fish feed on the zooplankton and invertebrates, small fish feed on the nursery fish, and adult fish populations then feed on the small fish.

Fishery of Lake Michelle (Kaminski Creek): The WDNR has no fisheries information available for Lake Michelle. Information from the state website indicates that Kaminski Creek is considered an Exceptional Resource Water (ERW), Class I trout stream. The stream flows on the western edge of Hurley northward into the East Fork of the Montreal River. There is watershed development along the stream and aerial views show pits, roadways, urban and residential development and a large impoundment pond (Lake Michelle) that includes part of the creek. Survey work conducted as part of the coastal wetland evaluation found no rare species of macroinvertebrates in the stream and overall taxa richness was low (0-4 species) (Epstein 1997). At the survey site, barnyards were considered a potential pollutant source.

Kaminski Creek (i.e. Cominski Creek) is considered a Cool-Warm Headwater under the state's Natural Community Determination, which represents modelled results based on predicted temperature and stream flow data. Cool (Warm-Transition) Headwaters are small, sometimes intermittent streams with cool to warm summer temperatures. Coldwater fish (i.e. trout, cisco, whitefish) are uncommon or absent, transitional fish species are abundant to common (northern pike), and warm water fishes are common (panfish, suckers, minnows). Headwater species are abundant to common, mainstem species are common to absent, and river species are absent.

Aquatic Invasive Animals: Like invasive plants, aquatic invasive animals are introduced to an area and are likely to cause environmental and/or economic harm to a given ecosystem. They tend to alter ecological relationships within the community food chain which can disrupt the balance and structure of an otherwise healthy habitat. Two species of invasive animals were found in Lake Michelle, the Chinese Mystery Snail and the Banded Mystery Snail.

Chinese Mystery Snail – (*CIPANGOPALUDINA CHINENSIS*):

Cipangopaludina chinensis, common name Chinese Mystery Snail, is a non-native snail that originates from southeast Asia and Russia. There is a large population of the Chinese Mystery Snail that exists in Lake Michelle. The snails can cause recreational and ecological damage to the lake ecosystem. Large die-offs can foul the shoreland area. They can begin to clog water-intake pipes in high enough numbers. These snails may serve as vectors for the transmission of parasites or disease to fish or other wildlife (Wisconsin Sea Grant website), and compete with native snails for food, which negatively affects the food web balance of the ecosystem. Once in the system, they are considered rather "benign" and there is little that may be done to manage them. Figure 20 shown at right shows a picture the invasive snail.

Figure 20. Cipangopaludina chinensis, common name Chinese Mystery Snail

Identification: The olive or brown colored snails have a coiled shell and can grow from 1-3 inches in length. The opening of the shell is on the lower right side as the top of the shell is pointed upward.

Habitat: These snails select muddy or soft bottom habitat of shallow, quiet waters.

Ecology: These snails live approximately 4 years on the bottom sediments of the lake. The snail feeds non-selectively by scraping the lake bottom for benthic algae and diatoms. The females give birth to fully developed small snails that suddenly and "mysteriously" appear.

Banded Mystery Snail – (VIVAPARUS GEORGIANUS):

Vivaparus georgianus, common name Banded Mystery Snail, originates from the southern United States and the Mississippi River. There is a population of these snails in Lake Michelle. The snails can cause recreational and ecological damage to the lake ecosystem. Large die-offs can foul the shoreland area. These snails also invade bass nests and may cause mortality of largemouth bass embryos. They may also serve as vectors for the transmission of parasites or disease to fish or other wildlife (Wisconsin Sea Grant website), and compete with native snails for food, which negatively affects the food web balance of the ecosystem.

Figure 21. Vivaparus georgianus, common name Banded Mystery Snail

Identification: These light brown snails have a small, coiled shell with visible reddish-brown bands and they grow up to 1.5 inches in length. They also have visible "hairs" with hooked ends along the lip of the shell.

Habitat: These snails prefer sandy areas of lakes, ponds and slow-moving streams.

Ecology: The banded snails can live about 4 years and may die off in large numbers. They are filter feeders that graze for dead organic matter along silty, sandy, or muddy substrates. Like the Chinese Mystery Snail, they give birth to live developed young that suddenly and "mysteriously" appear.

4.5 SHORELAND CONDITION

The shoreland area consists of the land directly above the bank (riparian buffer zone), the bank (where water meets land), and the nearshore shallow area (littoral zone). Vegetation along the shoreline is called a buffer because it protects wildlife while simultaneously protecting lake water quality from potential sediment and pollution inputs. When shorelands are developed, a full or partial denuding of vegetative cover usually follows, increasing the velocity of polluted stormwater runoff entering the lake. But that's not all. The vegetation that once existed at those developed shorelines provided deep and tangled root systems that held onto the soil at the bank area, armoring it against constant wave and wind energy that pummeled it day after day. Soil erosion is destructive to lake health for two primary reasons: nutrients and sediment. Some soils are naturally very high in dissolved phosphorus, a form of phosphorus that when delivered to a lake contributes to plant or algae growth. Refer to Chapter 3, for more information about soil erosion and water quality.

In a study comparing undeveloped versus developed shorelands in northern Wisconsin, Elias and Meyer 2003 found that undeveloped shorelands provide significantly higher species diversity and complexity than developed sites. Shoreline vegetation provides important habitat for many of the species that use the water's edge for either all or part of their lifecycle. When the three layers of shoreline vegetation are intact (grasses, shrubs, and canopy), terrestrial and aquatic wildlife species that utilize the shoreline can live comfortably. Many animals use the shoreline area to forage for food, to regulate body temperature, as a safe navigation corridor, or to nest and raise their young. It has been found that as human disturbances increase along shore areas, the frequency of preferred songbird species (Warbler, Thrush, Vireo, Ovenbird) decreases, while less preferred species increased (Grackle, Catbird, Bluejay)(Lindsay, 2002). In a study conducted by Woodford and Meyer 2002, green frog population density decreased with the increase of human development in Wisconsin lakes. The areas along altered shorelines had degraded habitat and significantly fewer frogs. And a study by Haskell concluded that highly developed lakes in northern Wisconsin have a negative effect on the diversity of the mammal community within those near-shore areas.

Research has shown that healthy nearshore physical habitats adjacent to lakes are critical to support healthy ecological processes within lakes (Kaufmann, 2014). In fact, they even suggest a higher focus be set on the restoration or protection of shoreland areas to improve the healthy biotic functions of lake ecosystems. Scientists have found that coarse woody structure that exists along undisturbed shorelands plays a vital role for lake ecosystem health. Coarse woody structure along a shoreland consists of living or dead downed trees, tree fragments, root wads, and logs that have fallen into the lake or are located in part, laying across the bank. This organic structure provides important living habitat and food resources for numerous terrestrial and aquatic organisms and it even contributes to the food web in lakes. This organic structure serves to protect the bank from wind and wave actions, while also providing refuge and food sources for small or nesting fish populations. Lawson 2011 found that less disturbed littoral zones in lakes had a positive influence on available nesting habitat and reproductive success for Largemouth Bass populations. And according to Jennings, et al., 2003 degradation of shoreland habitat and lake water quality after shoreland development is the result of a cumulation of incremental factors in the modification of the shoreland areas or within the lake's watershed. The accumulation of effects takes place over a period time (years) and the impacts wouldn't be noticed immediately.

Riparian Shoreland Habitat: A survey of the entire shoreland area of Lake Michelle was conducted on September 2, 2023 (refer to Chapter 6 for assessment method). The overall purpose of this type of survey is to assess the character of each shoreline parcel adjacent to the lake for its current ecological health status and document the condition of the riparian buffer zone, the bank zone, and the littoral zone (Figure 28, Chapter 6). During the survey, data was collected on the presence or absence of shoreland vegetation, steepness of the bank, soil erosion and other evidence of existing disturbance. The types and density of vegetation near the shoreland area of lakes can indicate potential areas where nutrients or sediment may be entering the lake from the watershed. For instance, if a parcel has more dense vegetation and is less developed (i.e. more pervious surfaces), the greater the likelihood of rainfall or snowmelt infiltrating into the land and not running off directly into a waterbody. Conversely, if there is a more open and developed space, it is likely that stormwater or snow melt will reach the adjacent lake along with any pollutants or sediment it carries.

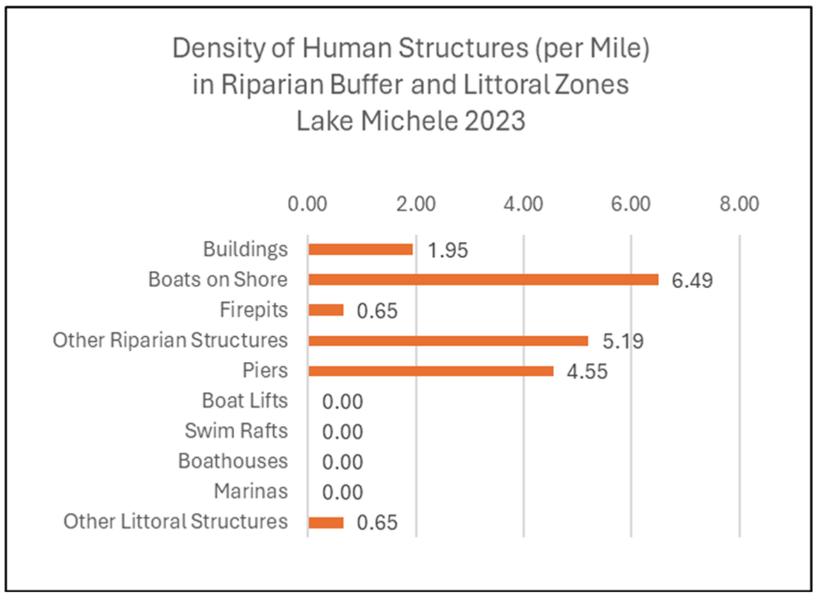


Figure 22. Density of structures per mile of shoreline within the riparian and littoral zones around Lake Michelle, 2023.

Riparian Shoreland Habitat Results: Forty sites were evaluated around the shoreline of Lake Michelle. At each of the sites, data was collected in 3 zones: Riparian Buffer Zone, Bank Zone, and Littoral Zone. The types of human structures that were found in one or more of the zones are shown in Figure 22. Boats sitting on the shore were the most common type of structure found along the shoreland. Sixteen docks per mile (16/mi) of shoreline has been shown to be a threshold of maintaining a high-quality fishery diversity in one Minnesota study (Jacobsen 2016). The Lake Michelle shoreline is 1.54 miles, and we counted 7 piers. That equates to 4.6 piers per mile of shoreline, which is well within threshold limit to maintain high-quality fishery diversity. However, there were other structures noted in the assessment that would inherently add to the density of disturbance for fisheries but were not included in the pier density calculation. Most of the riparian buffer zone around Lake Michelle had either a lawn or shrub and herbaceous cover layer. Together they make up 96% of the cover layer within the buffer zone. Open bare soil or duff (organic matter) made up 3% of the riparian cover, and the remaining was impervious surface (1%) (Figure 23). Further, only a minority of parcels contained a full 3 layers structure of shoreland vegetation. If we consider the general provisions of the Iron County Shoreland Zoning Ordinance (13.07)(1)(pg6), where the county allows lot widths of 65 feet for sewered lots and 100 feet for unsewered lots; and each lot is allowed a 35-foot viewing corridor as per 13.08(2)(pg12), the lake-wide target for shoreland vegetation buffer coverage for each riparian parcel should be 65 feet (or greater) on 100-foot parcels. If that is the case, then Lake Michelle (as a whole) meets the riparian buffer zone vegetation coverage target, but individual parcels did not meet the targeted standard for 3-tier layered vegetation.

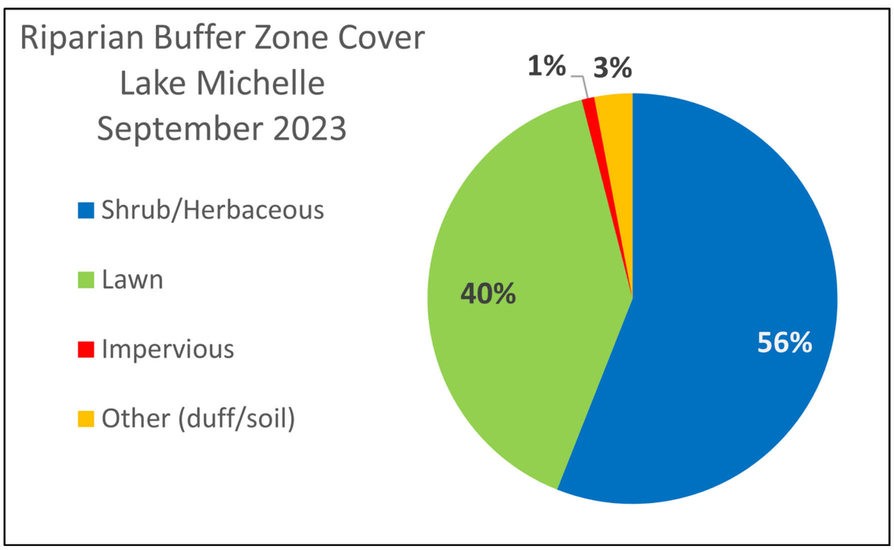


Figure 23. Types of ground cover found in the riparian buffer zone (from the bank to 35 feet inland) around Lake Michelle, 2023.

Potential areas of concern along the shoreline of Lake Michelle were also noted during the survey. Figure 24. summarizes the types of concerns we noted around the shoreline. Twelve of the 40 sites along the shoreline exhibited lawn or open soil sloping directly to the lake, and seven sites had stairways, roads or trails that may have shown signs of contributing various pollution sources to the lake, and 5 areas had obviously exposed soil that would likely run off to the lake during storm events or snowmelt. In total, 27 potential areas of erosion or runoff concerns were identified around Lake Michelle.

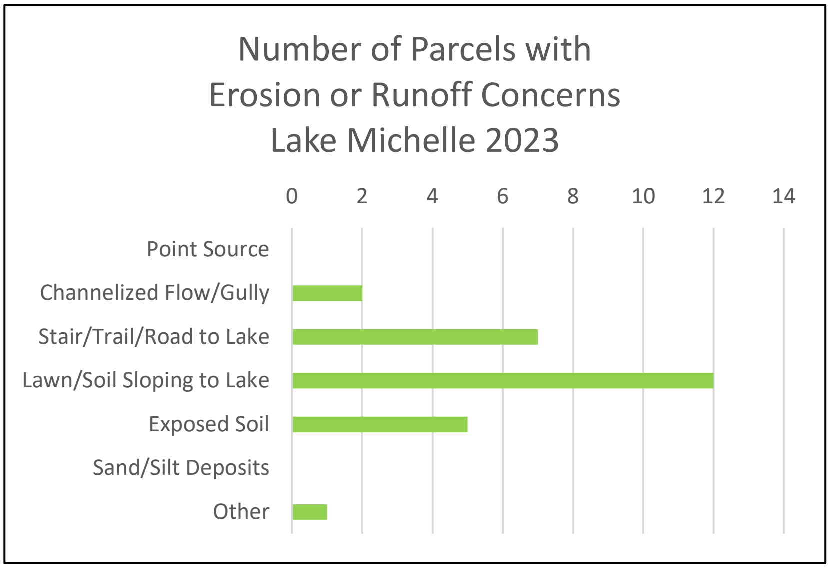


Figure 24. Types of concerns found on the riparian shoreland areas (from the bank to 35 feet inland) around Lake Michelle, 2023.

Woody Structure: The coarse woody habitat survey for Lake Michelle was conducted in early May of 2024, prior to plant growth when the water was at its clearest and it was easy to see submerged structure. The purpose of this type of survey is to assess the structural habitat in the lake and near the shoreland bank. It has been shown that as the number of wood structures increase along the bank, the more opportunities for wildlife and aquatic organisms to utilize the lake edge for living and resting habitat, for providing shade cover, or for finding food. Downed wood also provides additional benefit by preventing suspension of bottom sediments during heavy wave action. As lakeshores are developed, the clearing away of coarse woody debris follows, which allows riparian landowners to access the shoreline and the lake. But this activity has been found to degrade the ecological integrity and health of adjacent lakes and shoreland areas.

Woody Structure Results: A study of Wisconsin lakes conducted in 1996 showed that, on average, undeveloped lakes had roughly 345 pieces of coarse woody debris per mile of shoreline, while lakes with houses built adjacent to the shore revealed a reduced density of 92 logs per mile of shoreline (Christensen et al. 1996).

There was a total of 80 pieces of coarse wood recorded along the 1.54-mile shoreline of Lake Michelle, which reveals a density of approximately 52 pieces of woody structure per mile of shoreline. If we consider the research by Christensen, the opportunity exists to increase the amount of woody habitat for the terrestrial and aquatic organisms that live around the lake and to improve the ecosystem function of Lake Michelle.

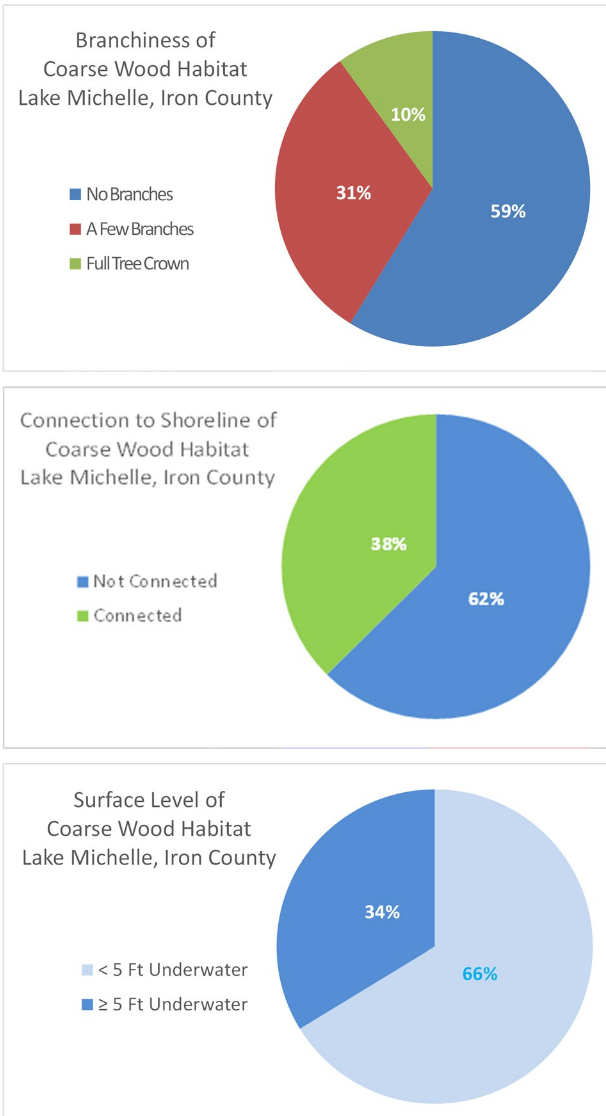


Figure 25. 2024 Coarse woody habitat results, Lake Michelle.

In addition to the number of large wood pieces identified, each piece of wood was further evaluated for: the "branchiness" of the wood, if the wood structure contacted the shoreline, and to the degree it was submerged under water or above the water surface. Figure 25, illustrates the findings of these three characteristics from the Lake Michelle woody structure survey. These characteristics of woody structure are known to promote various habitat conditions for a wide variety of species that utilize the shoreline area to live. The following is just three examples – a full tree crown of branchiness would provide excellent protection from predation for small fish, while wood structure connected to the shoreline provides a bridge from land to water, or wood pieces that extend out of water may be perfect for an emerging dragonfly nymph to molt into the terrestrial adult fly. While even no branches on wood structure provides ecosystem benefits, only 10% of the woody structure found in the lakes exhibited a full crown of branchiness. To make improvements to the fishery for any lake, it would be wise to let fallen trees lie. Not only would there be increased safe habitat for small fish to grow, but more wood structure under the water to house invertebrates for their food. Only 30 wood pieces of the 80 total (38%) provided a bridge from land to water. This bridge helps increase living habitat opportunities for many species using the lake edge for food, water, or even a resting place to soak up the sun (warming space)*.

*Note: Several painted turtles were observed in Lake Michelle on the exposed logs over the summer months of 2024.

5.0 PROJECT CONCLUSIONS

The data collections for this project have revealed interesting conclusions about Lake Michelle and its' surrounding watershed. There now is a much greater understanding and appreciation of the physical characteristics, the chemical processes that make the lake unique, and the biological interactions that take place in a lake ecosystem. Lake Michelle is currently holding its own but is starting to show definite signs of stress. The impounded headwater drainage lake is a shallow ecosystem, and shallow lakes respond differently to chemical and biological interactions than deeper lakes do. Lake Michelle is a small system that receives a large volume of nutrient-laden runoff from its surrounding watershed. For these reasons, extreme care must be taken in any management actions within and around its adjacent surroundings.

5.1 LAKE & WATERSHED MODELING:

Modelling allows lake managers to make educated predictions about the amount of nutrient a waterbody receives annually based on factors like soil types, watershed size, precipitation levels, and more. Lake Michelle is in the Welsh Creek-Montreal River watershed which is approximately 46 square miles in size, but the direct drainage area of Lake Michelle is slightly over 2 square miles. The ratio of drainage basin to lake is 42:1, which means that for every acre of lake size, there are 42 acres of watershed land that eventually drain to it. This means that Lake Michelle has a greater potential to be negatively affected by the large amounts nutrient and sediment that could be carried to the lake from the watershed during rain and snowmelt. The ways in which land is used is very important to the health of the receiving waters adjacent to it. The drainage basin for Lake Michelle consists of 50% forestland, followed by 21% open spaces (i.e. parking lots, roads, golf course, etc). The remaining watershed land consists of wetlands, residential, grasslands, water, agriculture, and commercial. The PRESTO-Lite model estimate of average non-point source contributions of total phosphorus nutrient delivered to the lake annually is 95 pounds (range likely between 46 to 196 pounds).

The Lake Michelle watershed was also modelled using a program called WiLMS (Wisconsin Lake Modelling Suite). WiLMS predicted that Lake Michelle receives approximately 188 pounds of phosphorus annually, which is twice that of the PRESTO-Lite prediction. But, when taking into consideration the range given by PRESTO-Lite, the two outcomes look very similar.

Phosphorus loading to a lake may also occur internally from the lake bottom sediments. When the bottom sediments are anoxic (no oxygen), a chemical reaction occurs which allows otherwise bound-up phosphorus to release into the water column. Over the course of the summer, it is likely that Lake Michelle experiences weak and short-lived periods of anoxia, as witnessed by the dissolved oxygen profiles, thus adding more soluble phosphorus and enriching plant growth in the lake.

5.2 WATER QUALITY:

The total phosphorus observations categorize Lake Michelle as mesotrophic, yet the actual productivity level observed within the lake was closer to a eutrophic system. Impoundments tend to experience water quality problems at some point during their existence because they possess higher concentrations of nutrients (phosphorus) and higher accumulations of sediment than natural lakes. Lake Michelle is no exception as it is subjected to tremendous sediment and nutrient loads entering from the watershed (see Chapter 3) (on top of winter accumulation of soluble forms of phosphorus). The lake's shallow depth, high density shoreland development, location near urbanized impervious areas, may all be contributing to phosphorus and sediment inputs which are starting to affect the water quality.

Lake Michelle was visibly very clear throughout the sampling season. The mean total phosphorus reading was significantly below the impairment threshold of ≥40 *μg/L* from the 4 sampling occasions at 19 *μg/L*. The soluble form of phosphorus for each of the four sampling occurrences was non-detected. This result suggests that most of the chemically available phosphorus within the lake water column was taken up for growth by aquatic plants. The chlorophyll-a results for Lake Michelle were significantly below the WisCALM impairment threshold for Fish & Aquatic Life. This result concurs with the observed crystal clarity of the lake, as well as with the Secchi disk readings. The calculated N:P ratio for Lake Michelle is 37:1, thus gives a defined indication that it is a phosphorus-limited system and plant growth is controlled by the availability of soluble phosphorus nutrient within the water column. Chloride concentrations increased over the summer months, which alerts lake managers that there may be pollution entering the lake from either agriculture and/or septic systems. The average conductivity reading over the summer was 135 μS, which is over two times the hardness level. This finding is indicative of potential pollutants entering the lake. The springtime potassium value was high at 0.810 mg/L and by July the level dropped to 0.193 mg/L. This finding indicates that the spring snow melt may have been contaminated with potash fertilizer from one or more sources within the lake's watershed, and by July it was flushing downstream. The pH readings for Lake Michelle were 7.8 and 8.1 which are located on the higher end of the normal range for lakes in Wisconsin. Lake Michelle predictably measures low on the calcium carbonate scale and exhibits soft water. Lake Michelle fits into the soft water category (Calcium Carbonate 48-50 mg/L), which makes it an excellent buffer against the effects of acid rain, but soluble phosphorus is readily available for plant growth in soft water systems.

5.3 AQUATIC PLANTS:

A total of 21 different species of aquatic plants were found. Of the 21 different plants, Lake Michelle contains 5 high value plant species. The Simpson's Diversity Index test revealed that Lake Michelle has a moderately high biodiversity in number of species present (0.85), but the lower C value (5.9) reveals that the plants that are present are species that are more tolerant of disturbed lake conditions. In the regional lake comparison, the aquatic plant community in Lake Michelle was found to be slightly compromised and tolerant of a more disturbed ecosystem (FQI 23.5) than similar lakes in the Northern Lakes and Forests region (FQI 24.3). The amount of muck sediment present in the lake (130 of the 139 sampled sites) coincides with many years' worth of organic matter decomposition, revealing a disturbed ecosystem with an imbalance of the aquatic plant population. Lake Michelle also has the ideal depth and morphometry for the dense growth of aquatic plants, as past research studies have shown.

5.4 INVASIVE PLANTS & ANIMALS:

The invasive Narrow-leaf Cattail and Purple Loosestrife were both observed and present in the plant survey for Lake Michelle in addition to Chinese and Banded Mystery Snails. While there are no legal management strategies available in Wisconsin for the invasive snails (other than hand-picking them up), there are some actions available for reducing the invasive plant populations.

5.5 SHORELAND CONDITION:

Numerous studies have shown that a healthy and intact shoreline habitat contributes substantially to the overall health of the lake ecosystem. Forty parcels around the lake were evaluated for health status and the entire shoreline was evaluated for existing woody structure. We estimated 4.6 piers per mile of shoreline which is good enough to maintain a high-quality fishery diversity, yet because of other types of structures found around the shoreline (but not included in the calculated pier density), fishery habitat is likely more disturbed than initially thought. Ninety six percent of the buffer was covered by lawn and a short herbaceous cover layer, and the remaining 4% was made up of impervious surfaces and open duff / soil. Individual sites along the shoreline were found to be in rough shape when considering the health benefits that shorelands can contribute to lake health. Twelve sites exhibited lawn and/or soil sloping toward the lake, and five sites had noticeable exposed soil patches that would likely erode during rainstorms. In total, 27 potential areas of erosion or other runoff concerns were identified around Lake Michelle. There was a total of 80 pieces of coarse woody structure found along the 1.54 mile Lake Michelle shoreline. This amounts to a density rating of 52 pieces of structure per mile. Scientific research tells us that a minimum structure density of 92 pieces per mile is necessary to sustain a healthy ecosystem function for lakes. There is room for improving the number of woody structure pieces around Lake Michelle. In addition, the placement of, and diversity of the woody structure pieces are also a factor in creating habitat opportunities for fish and wildlife. Only 10% of the wood pieces recorded during the survey exhibited a full tree crown of branches, where 59% had no branches at all. Further, only 38% of the structures counted in the survey acted as a "connecting bridge" from the land to the water.

6.0 METHODS

All surveys mentioned below were completed by following the WDNR Directed Lakes protocols, 2016 revision (Hein and Ferry, 2016), unless otherwise noted.

6.1 WATER QUALITY SAMPLING:

Utilizing the *Lancet Satellite* schedule for Paths 26/25, water quality sampling occurred on four occasions throughout the open water season of 2024. We align dates of lake water quality sampling as close to the satellite schedule as possible to be able to compare results of clarity depth readings and lake trophic status calculations. In addition, periodic quality assurance checks for volunteer data collections utilize satellite calculations for comparison. Temperature and dissolved oxygen profiles were measured at the deep hole of Lake Michele using a YSI ProODO meter. Deep hole grab samples of lake water were collected approximately 6 inches below the water surface using sterile plastic bottles and sent into the University of Wisconsin-Stevens Point Water & Environmental Laboratory for analysis. Random "blank" and "duplicate" samples were also collected for quality assurance purposes. All data results were compared to criteria outlined in the 2024 WisCALM guidance document for a Shallow Headwater Drainage Lake (Impoundment). The following parameters were tested by month:

May & July: Profiles of temperature and dissolved oxygen; Secchi transparency; total phosphorus; total kjeldahl nitrogen; ammonium; sulfate; lab conductivity; pH; alkalinity; chloride; chlorophyll-a; total hardness; turbidity; calcium; magnesium; potassium; and sodium

August & September: Profiles of temperature and dissolved oxygen; Secchi transparency; total phosphorus; total kjeldahl nitrogen; ammonium; lab conductivity; chloride; and chlorophyll-a.

The Trophic State Index (TSI) for Lake Michelle could not officially be determined at this time because a minimum of 3 contiguous years of data collection is required in the averaging of results for total phosphorus, Secchi transparency, and chlorophyll-a.

6.2 AQUATIC PLANT SURVEY:

Understanding the dynamics of aquatic plant populations in Wisconsin waterbodies has become increasingly important because of the introduction and spread of aquatic invasive species (AIS) which are non-native species that can have detrimental effects to healthy, diverse, and balanced lake ecosystems. For example, a lake with Eurasian watermilfoil may have problems with proper drainage, aesthetics, navigation, recreation, property values, habitat for fish and wildlife, and overall water quality. Because all lakes in Wisconsin belong to the public, it is important for the WDNR to be able to determine the health of those resources prior to any management or bio-manipulation by assessing the health of those ecosystems. This includes thorough assessment of the diversity and abundance of aquatic plant population through fieldwork sampling and statistical analysis of the data collection.

Plant Field Methods: A grid-based map for point-intercept sampling sites (146 points) was created by WDNR staff and the shapefile was shared with the consultant (Figure 26). The Minnesota DNR GPS application software and a Garmin 76CX unit was used to download all the points onto a lake map for navigating to each sample site. As indicated in the Directed Lakes protocols, the standard Wisconsin Point Intercept methods were used for surveying the aquatic plants in Lake Michelle (Hauxwell et.al. 2010). On August 17 and August 23, 2023, Iron County Land & Water Conservation personnel, with support from the Wisconsin DNR staff, navigated to all possible sampling points with canoes and took a sample of plants. Site depth and sediment type were noted at each sample point. Using a double-sided telescopic pole for sites at <15 feet depth (which was the whole lake), aquatic plants were sampled and identified throughout the entire lake. A rake fullness rating was given for total coverage of plants on the rake and a separate rake fullness rating for each species present were recorded (Figure 27). Any survey points that were inaccessible were recorded as such and no sample was taken. Aquatic plants found within 6 feet of the sample point but not found on the rake were counted as visual observations. Occurrence of species greater than 6 feet from any survey point were recorded to note their

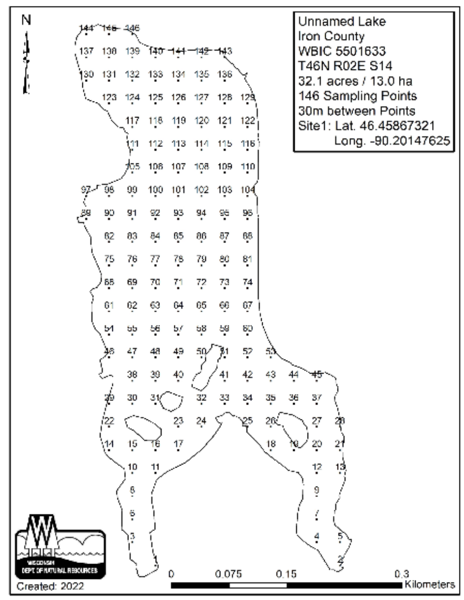
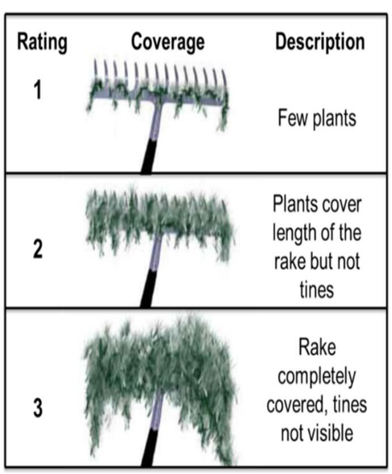


Figure 26. Map showing the aquatic plant survey sampling points.

Figure 27. Illustration of rake fullness ratings.



presence as part of a boat survey but were not counted in statistical calculations. These boat survey species were only recorded if their roots were in standing water. A specimen of each species that was collected during the assessment was then pressed and sent to *Robert W. Freckmann Herbarium* for vouchering and permanent record. Macrophytes were identified using various resources: Aquatic Plants of the Upper Midwest 2nd Edition (Skawinski), Through the Looking Glass 2nd Edition (Borman et. al.), Manual of Vascular Plants of the Northeastern United States and Canada 2nd Edition (Gleason and Cronquist), and "Identifying Pondweeds – A Brief Summary" (Knight).

Plant Data Analysis & Statistics: Data results were entered into the Aquatic Plant Survey Data Workbook (Aquatic Plant Management in WI), where the imbedded formulas automatically calculated relevant statistics including Simpson's Diversity Index, Species Richness, Floristic Quality, and the Average Value of Conservatism. Summary statistics provide a general overview of the plant community and can be used to compare Lake Michelle to other lakes in the region or the state. Floristic Quality Index (FQI) is summarized in Table 9, Chapter 4. Elaborating on this metric developed by Nichols (1999) is worthwhile. Aquatic plant species native to Wisconsin have a Coefficient of Conservatism (C) ranging from 0 to 10. The C value estimates the likelihood of that plant species occurring in an environment that is relatively unaltered from pre-settlement conditions. As human disturbance increases around a lake, species with a lower C value occur more frequently while more sensitive species with a higher C value occur less frequently. To calculate floristic quality, the mean C value of all species found in the lake is multiplied by the square root of the total number of plant species in the lake. Only plants found on the rake are included in the calculations. In other words, the FQI metric helps us understand how close the aquatic plant community is to one of undisturbed conditions. A higher FQI value assumes a healthier aquatic plant community. Floristic quality values can be compared on a statewide basis, but Nichols recommends comparing values within one of the four ecoregional-lake types. Individual species statistics assess the plant species composition in a lake and allow for comparisons of the plant community within the lake. Relative frequency values are particularly helpful because they consider the number of times a given species is found divided by the total number of times vegetation occurred in a sample.

6.3 SHORELAND HABITAT SURVEY:

Coarse Wood Habitat: Coarse wood habitat was surveyed in the spring of 2024 according to the Lake Shoreland & Shallows Habitat Monitoring Field Protocol (Hein et.

al.). Coarse wood (at least 4 inches in diameter and 5 feet long) situated between the ordinary high watermark and the 2 foot depth contour was noted and mapped. A cell phone app called "GPS Coordinates" was used to mark each piece of wood seen along the shoreline. Certain features of the wood pieces were noted in the data collection: "Branchiness" (none, a few, or a full tree crown); "Crossing" the ordinary high watermark (touching shore, not touching shore); and is the 5ft of the wood submerged or not submerged. The data collection was then used to create a map of results in ArcMap Online.

Shoreland Habitat Assessment: Shoreland habitat data was collected on September 2, 2023. The protocol stated in the previous section was used to collect information along the entire perimeter of the lake by using parcel boundaries as start and stop points. The purpose of this assessment was to document the condition of the riparian buffer zone, the bank areas, and the littoral zone (see Figure 28). To prepare for the survey, a map was created for the entire shoreline of Lake Michelle. A "centroid" marker for each parcel was placed on the map along with a boundary marker line on shore that clearly marked the 35 ft inland riparian zone. These markers were used as parcel guidance during the survey. Two kayaks maneuvered around the shoreline and stopped at each centroid marker on the map. An electronic rangefinder was used to determine distances from the ordinary high watermark as a "check" until a comfort level was established for estimating distance. **Riparian Zone** data that was collected includes: percent cover (canopy, shrubs, herbaceous, impervious surfaces, manicured lawn, agriculture, and other); human structures (buildings, boats on shore, fire pits, and other); runoff concerns (point source, channelized flow/gully, straight stair/trail/road to lake, lawn/soil sloping to lake, bare soil, sand/silt deposits, and other). Data collected on the **Bank Zone** were horizontal lengths of the following: vertical sea wall; rock rip rap; other erosion control structures; artificial beach; bank erosion >1 ft. face; and bank erosion < 1ft. face. Data collected for the **Littoral Zone** were the number human structures: piers, boat lifts, swim

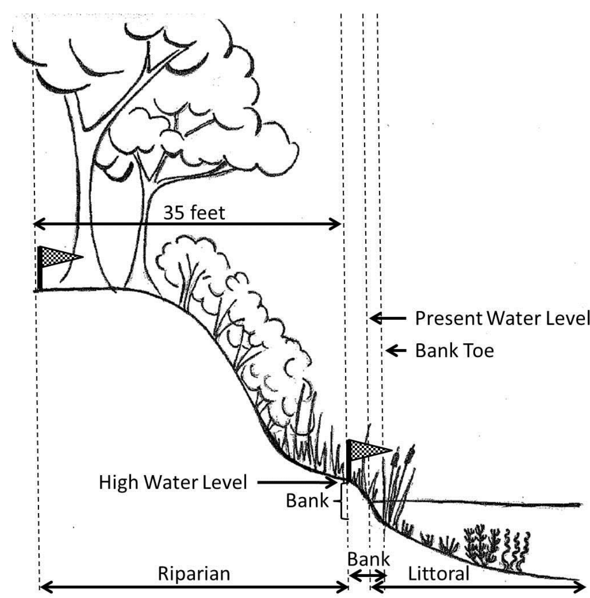


Figure 28. Shoreland areas assessed included the Riparian Buffer Zone, Bank Zone, and Littoral Zone (Source WDNR).

rafts/water trampolines, boathouses, and marinas. Presence / absence of aquatic emergent and floating plants and signs of aquatic plant removal were also noted.

7.0 MANAGEMENT RECOMMENDATIONS

Maintaining a healthy lake is as challenging as lake ecosystems are complex. If care is taken by the lake's stakeholder community and decision makers, a well-planned and implemented management plan is crucial to meeting that challenge. Long-term rewards can be reached and enjoyed by us today and for many generations to come. Simply put, "Protect the Best and Restore the Rest". The goals outlined in this chapter adhere to this mantra. Both protection and restoration are important management steps to achieve a healthy lake ecosystem.

Now that more detail is understood about Lake Michelle, specific and realistic actions can be accomplished that will focus on specific needs of the lake. Disturbances & threats to Lake Michelle can be placed into many categories and overlap does occur. For this reason, restorations and other management actions should not occur in a vacuum. Several actions should be coordinated to take place concurrently, all working together as a whole for the lake. A healthy, functional lake ecosystem and lake district will involve the cooperation of all the stakeholders to make improvements to the watershed, the lake, and the shoreland areas.

The recommendations for future management of Lake Michelle are listed below under the following categories: Stakeholders, Stream and Watershed, Lake and Shorelands. Included under each category, there will be visions for the future, followed by recommended action steps to assist in realizing them.

7.1 STAKEHOLDERS

District Commissioners: The Commissioners are elected officials that have a responsibility to manage a public resource and make sound and informed decisions about the finances of the district and management actions taken for the lake.

VISION 1: Lake District Commissioners understand their roles and duties regarding the management of Lake Michelle as a public natural resource which is reflected in clearly defined business operations.

Recommendation 1-1: Lake District Commissioners understand their roles and responsibilities.

Cost: Individual's time / Minimal $

Technical Contact(s): UW Extension Lakes website

To fully understand their specific roles and responsibilities of being an elected decision maker for Lake Michelle, it is recommended that each Commissioner complete a minimum of one annual online training that is available through the UW Extension Lakes program. There is always something new to learn. There are also many written and online training resources on the UW Extension Lakes website. Each individual commissioner should be provided a written copy of the publication People of the Lakes (Chapter 5 and Appendix F), that is available for download on the UW Extension Lakes website. Place this guidance in a 3-ring binder for each district member, along with other district business materials. In addition, there are half-day or whole-day workshops available for Commissioners at the annual WI Lakes & Rivers Conference held in the spring of each year. Many lake groups will reimburse representatives to attend this conference because there is considerable value in networking with other lake people, getting to know professionals in the lake field, and hearing about lake-related research and educational topics.

Action:

1) Complete a minimum of one annual online training session for commissioners.
2) Provide a hard copy of People of the Lakes for each commissioner (Chapter 5 and App F).
3) Optional. Participate in a half-day or whole day workshop at the annual WI Lakes & Rivers Conference.

Recommendation 1-2: Distribute the workload of the Commissioner Board.

Cost: Individual's time / Free $

Technical Contact(s): N/A

There is continuous work to do when living on and managing a lake, especially when there are temporary or on-going projects. Besides the defined roles of President, Vice President, Secretary and

Treasurer, there may be sub-committees responsible for carrying out temporary projects, writing or administering grants for a project, creating project partnerships, coordinating volunteers for fieldwork events, updating a website or creating / distributing newsletters for the district members. The best approach is to divide and conquer the given tasks. Everyone has a talent(s) or "comfort zone" that can be utilized on a board. Practice the WHAT, WHO, WHEN approach. For any given project or work event, define what work will need to be completed, who will accomplish it, and when the deadline is for completing it. This may seem like an obvious concept, but many times board members will discuss something at a meeting, only to move on to the next agenda item without assigning "to-do" tasks if applicable.

Action:

1) Place this item for discussion on a meeting agenda if there are upcoming projects.
2) Decide as a group using the WHAT, WHO, WHEN approach.

Recommendation 1-3: Create a workforce through a sub-committee structure.

Cost: Individual's time / Free $

Technical Contact(s): N/A

A sub-committee structure is created to ease and further distribute the workload of the board of commissioners. This will become more important as new projects are set up or as state grants are set in motion for projects. Sub-committees could be established for numerous activities that the Board of Commissioners would need to accomplish, and a sub-committee representative would then give a brief status report at each of the board meetings (written or in person). A few examples for sub-committees are: Grants Committee, Watershed Committee, Invasive Species Committee, Shoreland Committee, Education Committee, or Communications Committee. The idea is that committees are created as needed and they can be temporary or permanently established. Committees can be made up of <u>any</u> volunteer or partners, including people or groups that don't live directly on the lake. It is typical that at least one representative from the board participates on the committee to ensure progress is being made, but it isn't required. Committees have planning meetings and "to-do" lists of things to accomplish before the next meeting (WHAT, WHO, WHEN can be used). This not only distributes and eases the workload for the board of commissioners, but it can foster long-lasting partnerships and a community wide lake stewardship ethic.

Action:

1) Include this item on a commissioner board meeting agenda. Discuss the possibilities of creating sub-committees and who might consider being on them (besides the board members).
2) Ask potential sub-committee members face to face if they would consider helping. Anticipate their questions about time commitments, # of meetings, tasks, etc.

3) Keep asking around and don't give up until you have at least 2-3 people (or more) on a working sub-committee.

Recommendation 1-4: Establish partnerships that will help lessen the workload. Utilize the unique talents, interests, and abilities of different people to maximize lake stewardship efforts in the community.

Cost: Individual's time / Free $

Technical Contact(s): Land & Water Conservation

Depending on the future project or task, establish partnerships early on so that they will be ready when you need them. For example, if you plan to make improvements on the land so that water drainage from the golf course doesn't travel directly to Lake Michelle, discuss this idea with golf course owners/staff a year in advance. If you apply for a grant to do this project, you will need their support early on. Another example is to create a partnership with the Town of Hurley or Iron County Conservation so they can sponsor the lake district in the grant application process. Since Lake Michelle does not have a public landing, you will need their help to receive grant funding. Other partnerships may be the High School biology teacher, the local gardening club, a landscape professional, a retired botanist. The point is to make these contacts early, be clear in what you are asking them to do and be persistent.

Action:

1) Begin discussions with potential partners early, so they don't feel pressured. Talk about potential ideas that could be accomplished together.
2) Keep lines of communication open and talk regularly.

District Operations: There is an increased business formality for a lake district, as it operates under state statutory authority (WI Chapter 33). As such, government accountability practices should be utilized for vigilant spending of taxpayer money and legal formality in business operations, like open meetings law, public meeting notices, meeting minutes, etc.

VISION 2: All the business operations of the Lake Michelle District are formal and running according to the laws of the Chapter 33, Wisconsin Statutes and through other documented guidance.

Recommendation 2-1: Create a guide document that defines all the procedural and business operations of the Commissioner Board.

Cost: Individual's time / Free / Minimal $

Technical Contact(s): UW Extension Lakes website; Hire a consultant

It is true that the business operations of a lake district are to be legally conducted according to Chapter 33, but not all activities are clearly defined within the statute. For example, how to conduct formal membership voting is not detailed in the statute. The business operations of voluntary lake associations typically operate from a written by-laws document. By-laws will define voting rules & structure, set an annual meeting date and time, define permanent or temporary sub-committees, define how to dissolve the organization, and much more. There are "model" by-laws available that can help groups define and clarify their business operations. It makes annual operations easier (especially when there is board member turnover), when these items are written down to reference. Another helpful item for groups to have on hand are mission and vision statements. This can help a group define what their organization values are and helps develop future strategies to achieve the organization's goals.

Action:

1) Include this item on a board meeting agenda. Decide if this is a document you would like to develop for your group.
2) Decide if this is a task that a board member could draft, or if you would rather hire someone to do the work.
3) If a consultant is to complete the document, meet with them regularly to discuss specifics to include in the document.

Recommendation 2-2: Create an online presence where members can access lake district information at their convenience.

Cost: Individual's time / Constant Contact Fees Moderate $$

Technical Contact(s): Website or Constant Contact Server

Results from the stakeholder survey indicate some riparian landowners (or renters) do not feel as if they are receiving regular or timely news about the lake or the business of the lake district. Since people assimilate their news in different ways, it is best to offer varied formats in your communications. Some people like hardcopy newsletters, others may go to a website to find answers, yet others may read their emails or social media regularly. Create an online presence to share any news from the commissioners or about things happening in or around the lake. Consultants or school-aged kids may be able to help you create the website or an email list serve to send out mass emailed newsletters through a tool called 'Constant Contact'. CC is a wonderful online tool to reach many people with short spurts of news and information through a simple email.

Action:

1) Create the website and/or the email server group. Be sure to update the site regularly.
2) If Constant Contact is used, subscribe to it online. Collect email addresses for your entire

membership. Have one person responsible for doing a monthly or bi-monthly email update. Be consistent with the timing of the news updates.

Lake District Members: The members of the lake district consist of all landowners and property managers of all parcels located within the boundary of the Lake Michelle District. All renters of these properties are legally obliged to live by the rules and regulations of the Lake Michelle District. Together, all lake district members have a vested interest in the success of the district and the sustained health of Lake Michelle.

VISION 3: Stakeholders of the Lake Michelle District are consistently informed and have become increasingly engaged in lake stewardship activity.

Recommendation 3-1: Offer educational information to the membership at annual meetings, training sessions or workshops, and through written communications.

Cost: Free / Minimal $

Technical Contact(s): Professionals Listed Below

The more people know about the lake, the more interested they will become in keeping Lake Michelle healthy. Offer an educational component at the annual meeting to keep it interesting and something the members would like to attend. Speakers are willing to come and talk to groups about their organization or topic of interest. Another idea would be to host workshops that are interesting and educational. Workshops could be offered at any time of year for your members, the community, and/or for municipal maintenance staff. They can be held in person or as a webinar online. Listed here are some examples of available organizations that could offer something in the way of a workshop or presentation: Salt Wise; North Lakeland Discovery Center; Iron County Land & Water Conservation; Iron County Zoning Shoreland Development Guide; local hunting/fishing clubs, various consultants, a local landscape business, UW Extension Lakes staff, WDNR staff. Listed below are a few ideas for educational topics that could be offered at an annual meeting or in written communications: Why aquatic plants are important in lakes; Shoreland Zoning rules and regulations; Aquatic Invasive Species; Turtles and Frogs; Why maintaining or restoring shorelines is important to the overall health of a lake; Water quality monitoring reports; How volunteers can help the lake district; The effects of road salting on lakes. There are a lot more topics to learn about but let this list get you started thinking about what might interest your members.

Action:

1) Create an Sub-Committee to help organize workshops or speakers for meetings.

2) Contact and secure a potential speaker for the annual meetings.
3) Be sure to include the speaker name and topic on any meeting agendas. Advertise them via the website or Constant Contact email to draw interest in attendance.

Recommendation 3-2: Get stakeholders active in the stewardship of the lake and/or the business of the lake district.

Cost: Individual's time / Free

Technical Contact(s): N/A

Encourage the members of the lake district (including repeat renters) to step up and volunteer by having a specific task or position to ask for. Some activities require physical labor, but others do not. Some volunteer tasks would be localized in nature, where others could be completed long distance, or at any time of the year. Anticipate questions that a potential volunteer might have about the task or position. What would it require from them? How much time or energy would the volunteer activity take? Is it temporary or permanent? People are more likely to step up when there are defined and specific tasks and they know what they are getting into if they say yes. If possible, separate tasks into "bite sized" pieces so people are more likely to say yes if asked to do something. You will often find that once someone is involved and invested in something, they will gladly continue it. Ask people for specific activities that they may have expertise in. For example, if you know someone that has had (or currently has) a career as a manager or a budget planner, ask that person to put their talent to work for the lake! They could help coordinate volunteers, administer a grant project, or even write a grant application. The key is asking eye to eye for a specific item or task and answering their questions as thoroughly as possible. People are less likely to say "no" when asked in person. Some examples of tasks you may have could be letter writing, becoming a commissioner, serving on a sub-committee, website design or maintenance, grant writing, newsletter distribution, lake or stream monitoring, or labor for a shore restoration. The work list is endless and would evolve as time moves forward.

Action:

1) Include this item on a board meeting agenda. Discuss the possibilities of getting volunteers for a specific task or tasks, and who might be good at doing that task.
2) Ask potential volunteers face to face if they would consider helping on a defined task. Anticipate their questions about time commitments, # of meetings, tasks, etc.
3) Seek volunteers on the website or newsletter. Be specific, and be sure to have someone listed that they could contact if they have questions or want to volunteer.
4) Keep asking around and don't give up. This will be a constant ask, especially if you have projects in mind. If kids and grandkids want to help, even better.

7.2 STREAM & WATERSHED

VISION 4: Known contributions of non-point source pollution from the watershed have been addressed and improvements in the water quality of Lake Michelle are being observed.

Recommendation 4–1: Utilize a partnership(s) to stop or change fertilizer usage at the Eagle Bluff Golf Course.

Cost: Individual's time / Free – Minimal $

Technical Contact(s): Iron County Land & Water Conservation

To decrease the amount of phosphorus entering Lake Michelle from the watershed, the use of fertilizers for lawns or the golf course will need to change. Fertilizers on the market consist of three big nutrients: Nitrogen (N) (which "greens up" a lawn); Phosphorus (P) (which supplies energy for plant growth); and Potassium (K) (necessary for plant photosynthesis and seed development). The ingredients are listed as N-P-K on a bag of fertilizer, with P being the middle number. There are effective fertilizers on the market today that have "0" phosphorus levels. Set up a meeting with managers from the golf course and staff from the Iron County Land and Water Conservation office to discuss the various ways they can lessen or change their use of fertilizers. Explain to them that you are trying to improve the water quality of Lake Michelle and explain how they could help you achieve that goal. At the same meeting, begin to discuss other ways that the golf course could prevent stormwater runoff from reaching the lake.

Action:

1) Contact managers or staff from the golf course and Land and Water Conservation to schedule a face-to-face meeting. Give them an idea of what the topic is about.
2) Discuss ideas about minimizing stormwater runoff to the lake and about changing fertilizer usage.
3) It might be pertinent to ask them for a walking tour of where their stormwater runoff goes. This action may provide everyone in the group with a better understanding of what needs to be addressed.
4) If appropriate, ask the golf course staff if they would like to partner on a future project.

Recommendation 4–2: Utilize a partnership(s) to place appropriate best management practices (BMPs) where stormwater is draining off the golf course to Lake Michelle.

Cost: Grants Available (Iron County Conservation or WDNR Healthy Lakes)

Technical Contact(s): Land and Water Conservation or WDNR

There are many types of best management practices (BMPs) that can be placed on the landscape to help slow or stop direct stormwater drainage to Lake Michelle. Two programs are available that can help achieve this goal. The Iron County Land and Water Conservation staff are professionals in your community that can assist you in getting started with projects of this type. They will meet you on site and discuss various options that could help abate runoff problems. They could also discuss their cost sharing program which may be able to lessen the financial burden in doing this kind of project. Another option available to individual property owners or lake organizations is a WDNR program called Healthy Lakes. This program offers grant money for "shovel ready" projects that address various shoreland drainage issues. The state will reimburse project costs up to $1,000 per installed practice. Either program would be helpful in getting drainage issues abated and stopping the direct flow of water to Lake Michelle.

Action:

1) Meet with knowledgeable staff on specific sites to learn about what BMPs would address the existing runoff issue(s) and ask if there are programs to help lessen costs.
2) Learn more about cost sharing programs and ask who could help with planning and implementing the BMPs.
3) Ask appropriate entities to help you get started. Start planning BMPs.

Recommendation 4-3: Minimize the use of road salt throughout the watershed,

Cost: Individual's time / Free $

Technical Contact(s): Wisconsin Salt Wise

Encourage road maintenance crews around your community to stop or lessen the amount of road salt they use for winter driving. We have used salt on winter roads for generations in Wisconsin, but we have a better understanding of the negative impacts on surface waters by continuing this practice. Fisheries and wildlife populations are most certainly being affected. The Wisconsin Salt Wise organization is an excellent resource to learn more about this concept. They even offer webinars or in-person workshops to get the training necessary (one is offered in Ashland, September 2025). There are a lot of resources available on their website also, which may create a great newsletter or website topic for stakeholder education.

Action:

1) Pursue the Salt Wise website to learn more about the program and potential workshops that may be available for road maintenance crews.
2) Talk to county and town maintenance crews about lessening the use of road salt on all roads within the Lake Michelle watershed (not just those adjacent to lakes). Learn what alternatives are available for addressing ice on roads (on Salt Wise website). Tell them what you are trying to achieve with Lake Michelle water quality.

3) Follow-up with road maintenance supervisors to find out how alternate measures are working for ice conditions.

VISION 5: Kominski Creek is consistently monitored for the purpose of protecting the water quality of Lake Michelle and the waters that exist downstream.

Recommendation 5-1: Assign a volunteer to monitor Kominski Creek for chlorides and phosphorus through the Water Action Volunteers (WAV) program.

Cost: Individual's time / Free $

Technical Contact(s): Water Action Volunteers River Representative or a WDNR Stream Biologist

Once the road salt usage is addressed in the watershed (Recommendation 4-3), it would be helpful to know if the quality of the stream water flowing in at the inlet and/or flowing out at the outlet area of Lake Michelle is improving. Monitoring a stream is easy and can be accomplished once per month by a volunteer over the open water season. After taking some information about the physical aspects of the stream, like temperature and flow, a water sample is collected and prepared for the laboratory to analyze. Training and equipment for monitoring is available for volunteers. Contact the local WDNR Stream Biologist or a river representative from the WAV Water Action Volunteers program for assistance in getting set up. Let your contact person know why you're asking to do it, so they are encouraged to add the project on to their funding mechanisms each year.

Action:

1) Contact the local WDNR Stream Biologist about monitoring the Lake Michelle inlet creek. Ask them if they could sample chloride levels after road salt usage stops.
2) Ask a volunteer to help with the monthly monitoring of the creek. Help the volunteer get in touch with the WAV Coordinator to get started.
3) The volunteer gets the training needed to conduct the monitoring and take a water sample if applicable. Volunteer begins.

7.3 LAKE & ADJACENT SHORELAND

The overall ecological health of Lake Michelle is moderately compromised by inputs of non-point source pollutants, the presence of invasive plants and animals, and high density shoreland development. Below is a listing of actions that the Lake Michelle District and its' membership can move forward so that the declines in quality can be slowed or reversed and improvements to the health of the lake environment may be achieved over time.

Water Quality

The water quality of Lake Michelle is starting to show some signs of stress. Although the water is crystal clear, chemistry lab results indicate high levels of phosphorus which are likely incorporated into the growth of aquatic plants. Spring levels of potassium were higher than later in the summer, indicating concentrated fertilizers carried in from the watershed. In addition, chloride levels showed an increase over the summer months which may indicate agriculture or septic contamination.

VISION 6: The nutrient water quality of Lake Michelle has improved and is being consistently monitored and protected from degradation.

Recommendation 6-1: Encourage private landowners to maintain their septic systems properly.

Cost: Individual property owners / Minimal $

Technical Contact(s): Iron County Zoning; local Septic Pumping Services

For a small size waterbody, Lake Michelle has a high density of shoreland development. Fortunately, the condominiums that surround the lake are maintained on the city sewer system. The same may not be true of the single-family residential homes that dot the shoreline. Make sure that all properties that are not on the city sewer system are maintaining their septic systems on a regular schedule. Septic pumping service providers will pump out the tank effluent and conduct an inspection of the holding tank to make sure it is sound and working properly. If problems are found, the homeowner will need to address the issue(s) quickly to protect the lake (and downstream waters) from effluent leakage and potential degradation of lake water quality.

Action:

1) Contact the county zoning office to find out about septic system usage on Lake Michelle.
2) Teach residents of the Lake District about the importance of keeping their septic tanks properly maintained. Write a newsletter article, have the County Zoning staff talk to you at an annual meeting, or place this type of information on your website.

Recommendation 6-2: Continue to monitor Lake Michelle water clarity via a citizen volunteer and expand monitoring to include water sampling for phosphorus and chloride.

Cost: Water Clarity Free $ / Water Sample Lab Analysis Moderate $$

Technical Contact(s): Citizen Lake Monitoring Network; Iron County Conservation; UWSP Water Analysis Lab

Monitoring consistently is important and will establish a long-term data set that can be used to calculate an accurate glimpse of the lake's current water quality and, the ability to compare data from year to year. Seek training (or refresher training) through the WDNR Citizen Lake Monitoring Network or contact Iron County Conservation staff to help you get started. Monitor the clarity with a Secchi disk once or twice per month around the same time from May through October. Consistency is the key to establishing a good data set and to seeing improvements (or decline) in water quality over time. Enter the clarity readings into the online database (SWIMS). Expand monitoring after one year. The volunteer could be trained to collect water samples to be tested for total phosphorus and chlorophyll-a, and for chloride levels. These water sample collections are completed at the same time as the clarity data collections and sent in to the UWSP Water Analysis Lab for analysis.

Action:

1) Go to the Citizen Lake Monitoring Network website to find out about Spring training sessions in your area. Sign up for a training session. All your questions about citizen lake monitoring will be addressed in the training.
2) Monitor your lake clarity each month during the open water season (May through October).
3) Submit your data onto the SWIMS website.
4) After year 1, collect a water sample each month during the open water season and send the samples to the UWSP Water Analysis Lab for analysis of phosphorus, chlorophyll-a, and chloride. Water sample collections will incur a reasonable cost to the Lake District.

Recommendation 6-3: Keep the lake bottom sediments as undisturbed as possible.

Cost: Free $

Technical Contact(s): NA

Maintaining the crystal-clear shallow water of Lake Michelle will require that the sediments of the lake remain as undisturbed as possible. Shallow lakes have two, and only two, states of biological equilibrium: 1) Clear water with high levels of aquatic plant growth; or 2) Turbid water with high levels of algae growth. Keeping sediment suspension levels low will help the lake from balancing into the latter state. The nutrients that are stored in the sediments will remain bound up and unavailable for additional growth of plants or algae.

Action:

1) No management action is needed.
2) An education or communications sub-committee should share this information with the lake district membership, so that they understand that additional dredging of the lake may not be healthy or wise.

Native & Invasive Aquatic Plants

The plant survey revealed that the Lake Michelle plant community is slightly compromised and tolerant of a more disturbed ecosystem when compared to similar lakes in the northern region. However, it showed that the lake has moderately high species diversity and includes five high value species. Two non-native and invasive plants species were confirmed during the study as well.

Aquatic plants are an essential part of healthy lake ecosystems and contribute many benefits (see Chapter 4). Aquatic plants play an especially integral role in keeping shallow lakes (like Lake Michelle) clear and free from harmful and unsightly algae blooms, because available phosphorus in the lake is used by plants during their growth. For this reason, caution is advised when manipulating and managing any plant population in the lake.

VISION 7: The native aquatic plants within Lake Michelle are conserved and the invasive aquatic plants are carefully managed so that the delicate shallow lake equilibrium within the lake is maintained.

Recommendation 7-1: Maintain the native aquatic plant growth in the lake.

Cost: Free $

Technical Contact(s): NA

Shallow lakes have the potential to support rooted aquatic plants across the entire bottom of the lake. Lake Michelle is a shallow water system and is a prime example of this fact. The high-density plant growth should be embraced as a good thing for Lake Michelle, because as a shallow waterbody the nutrients in the lake are being utilized for plant growth instead of the growth of unsightly algae. The recommendation to maintain the status quo for native aquatic plant growth is important to keeping the water clear and relatively free of algae. Caution is advised when managing the plant population.

Action:

1) No management action is needed, other than reducing pollution inputs to the lake.

2) It is suggested that an education or communications sub-committee share this information with the Lake Michelle District members, so it is understood that by removing native aquatic plants, they may harm the clear water they currently enjoy.

Recommendation 7-2: Selectively manage the invasive cattail growth around the lake.

Cost: Individuals' time / Free $ - High $$$

Technical Contact(s): WDNR AIS Staff; Hire a consultant

Although the cattails that surround Lake Michelle have caused problems for recreational access and viewing enjoyment, they are also providing an ecosystem benefit for the water quality of Lake Michelle by assimilating significant amounts of soluble phosphorus for their annual growth. The immense amount of soluble phosphorus that the cattails utilize for growth would otherwise be available for increased aquatic plant or unsightly algae growth if they were eliminated.

It will not be possible to manage the cattail population to the point that it no longer exists. Instead, selective management of the species will be the only option. This will be no small or easy task because there are different methods used to manage cattails that could be utilized concurrently based on cost, permit requirements, and available labor. Prior to any management activity, the WDNR AIS Staff must be contacted. They will help your group through the steps you will need to accomplish this project. There are two options available that may have favorable results and will depend on what is permitted by the WDNR:

Mechanical Option: Cut live and dead stems (including seedheads) at least 3 inches below the water level in late summer or early fall. This will require annual seasonal maintenance for the entire growing season. Dispose of the cattail stems and seedheads by bagging in thick plastic bags, sealing, and disposing in a landfill. Do not compost. Only cut enough plant material to provide for viewing, navigational, or recreational access.

Chemical Option: Foliar spray with aquatic approved imazapyr applied to the leaves. If this option is approved for use by the WDNR, instructions will be included on the permit. A licensed consultant will need to be used for this option which will increase the price of treatment.

Action:

1) Establish an invasive species management sub-committee. This committee will meet to discuss possible actions, and who does what to make the projects happen.

2) Contact the WDNR AIS Coordinator for your area to ask them what you need to do to get started. *Note: At the time of this writing, only Madison staff is available. Contact either Maureen Kalcheur maureen.kalcheur@wisconsin.gov; or Amy Kretlow Amy.Kretlow@wisconsin.gov.
3) Hire a licensed consultant to manage the cattails. Consultant Listings
4) Apply for a treatment permit through the WDNR.

Recommendation 7-3: Manage all the purple loosestrife on the shoreline of the lake.

Cost: Individuals' time; Minimal $

Technical Contact(s): Iron County Land & Water Conservation Department

The relatively small population of purple loosestrife that has been identified around the lake should be managed biologically using Galerucella beetles so there is no further spread of the species. There is an existing purple loosestrife management program ongoing through the Iron County Conservation Department that can be used for the project.

Action:

1) Establish an invasive species management sub-committee. This committee will meet to discuss possible actions, and who does what to make the projects happen.
2) Contact the Iron County Conservation staff member who manages the purple loosestrife beetle rearing program. Learn about their program, permit requirements, and what you need to do to get started.
3) Secure some volunteers who may be interested in helping on this project.
4) Work with county staff to place beetles on the plants at the appropriate time(s).

Recommendation 7-4: Remove invasive buckthorn and honeysuckle from the island areas.

Cost: Individuals' time; Minimal $

Technical Contact(s): Iron County Land & Water Conservation Department

During the winter months, remove the terrestrial invasive honeysuckle and buckthorn brush from the island areas. This activity would be in partnership with the Iron County Land & Water Conservation Department.

Action:

1) Establish an invasive species management sub-committee. This committee will meet to discuss possible actions, and who does what to make the projects happen.
2) Contact the Iron County Conservation staff member who is involved with terrestrial invasive species management.
3) Secure some volunteers who may be interested in helping on this project.
4) Work with county staff to remove invasive buckthorn and honeysuckle from the islands.

Shoreland Habitat

The shoreland areas around Lake Michelle are not considered bad, yet there is room for improvement that would be helpful to the lake ecosystem. The results of the shoreline habitat survey revealed a minimum of five areas of open soil that may erode into the lake, and that a three-layered vegetation buffer does not exist around large expanses of the shoreline. Steps should be taken to reduce areas of open soil and to establish healthy buffer areas around the entire shoreline.

VISION 8: Non-point sources of pollution coming from around the lakeshore have been addressed and improvements to the water quality of Lake Michelle are being observed.

Recommendation 8-1: Stop any use of lawn fertilizer around the entire shoreline of the lake.

Cost: Free $

Technical Contact(s): NA

The goal of this recommendation is to reduce the amount of nutrients and pollution from entering the lake during snow melt or rain events. Lawn fertilizer greens up lawns AND lakes! Lawn fertilizers may be one contributor of nutrients to Lake Michelle that could easily be managed.

Action:

1) The Board of Commissioners (or a communications sub-committee) communicates this message to the entire membership of the lake district through newsletter, email list, or website.
2) If fertilizer must be used, select one that contains no phosphorus. Look for #-0-# on the front of the fertilizer bag (0 as the middle number) to indicate that it contains no phosphorus.

Recommendation 8-2: Repair areas around the shoreline that have active signs of soil erosion.

Cost: Minimal $ to Moderate $$ (Grants available)

Technical Contact(s): Iron County Land & Water Conservation Department; Hire a consultant

Soil can contribute significant loads of phosphorus and sediment, and the goal of this recommendation is to decrease soil delivery to the lake. Iron County staff should be able to help with ideas and best management practices for reducing soil erosion. They may also have some cost share money available to help offset the costs of installing these projects. Staff may not be able to complete the work for you but could help review your plans to repair your project sites. It is important to address and repair the open soil areas before they become bigger problems. Grant money and technical assistance may be available through the Iron County Conservation office.

Actions:

1) Establish a sub-committee of the commissioner board to work on Vision 8 action steps. The sub-committee will act as both project planners and active volunteers or volunteer coordinators.
2) Sub-committee representative(s) contact Iron County Land & Water staff to discuss practices that address soil erosion problems and potential grant money.
3) Sub-committee contacts landowners that have soil erosion issues to discuss how to fix the problem (Appendix 4 will help identify sites of need).
4) Gather a small group of volunteers who will contribute labor at the project site(s), or hire a consultant that completes this kind of work. Consultant Listings
5) Landowners, volunteers, and/or sub-committee will plan out and fix minor erosion issues. Target a minimum of two project installations per year.

Recommendation 8-3: Establish healthy vegetation buffers around the entire shoreline.

Cost: Moderate $$ (Grants available)

Technical Contact(s): WDNR Lake Coordinator; Healthy Lakes Grant Program; Hire a consultant

Shoreland areas are immensely important to the overall health of the lake ecosystem. The shoreland habitat survey for the lake revealed that the ideal three-layered vegetated buffer is minimal along the shoreline of Lake Michelle. The three-layer structure consists of trees, shrubs, and low cover. The goal of this recommendation is to restore healthy shoreline buffers to benefit the health of the entire Lake Michelle ecosystem. The stakeholders that indicated that wildlife viewing and relaxation were high priorities for their enjoyment of the lake will also reap the benefits of this recommendation. Restore shoreline buffer vegetation to a layered structure along much of the Lake Michelle shoreline. This can be accomplished without destroying viewing corridors and can be accomplished in phases as volunteers are available. Grant money may be available through the WDNR Healthy Lakes Grant Program to help finance these projects.

Actions:

1) A communications sub-committee writes and shares a specific news article for the district members about the importance of intact buffers on shorelines. The articles should mention how buffers reduce soil erosion, decrease nutrient and sediment inputs, and how they benefit the wildlife around the lake.
2) The Vision 8 sub-committee reviews and discusses the options for native buffer vegetation that are available in the Healthy Lakes Grant Program. The website can help with planning out these simple projects, or a landscape consultant that specializes in native shoreland restorations may be hired.

3) Areas around the shoreline are selected for restoration (Appendix 4 will help identify areas of need). Discuss project ideas with landowners. Shovel-ready projects need to be submitted with the Healthy Lakes grant application. The sub-committee plans the project(s) and applies for the grant. Target three or more sites each year (all if there's a consultant). Note: Site selections may be the same as soil repairs needed in Recommendation 8-2.
4) As needed, gather a small group of volunteers who will contribute labor to install plants into the ground and water plants until established.

Recommendation 8-4: Maintain and increase coarse woody habitat around the shoreline.

Cost: Free - Minimal $

Technical Contact(s): Healthy Lakes Grant Program

Coarse wood is great habitat for a lake shoreline. It is important to leave as much of it around a lakeshore as possible because it provides food resources, living space, and travel corridors for many species. In fact, submersed logs are prime nursery areas for a multitude of fish. The goal of this recommendation is to maintain the existing amount or increase as much of the coarse wood structure along the shoreline areas as possible. The rule of thumb is that if a downed tree or branches are not in the way of navigation, leave it be (down tree, let it be). Some organization like to add wood structure to shorelines through the Healthy Lakes Grant Program. They call them "Fish Sticks".

Action:

1) No management action is needed, unless "Fish Sticks" are to be placed. If that is the case, include fish stick plans into the Recommendation 8-3 Healthy Lakes projects.
2) The Board of Commissioners (or a communications sub-committee) communicates this message (importance of wood structure on lakeshores) to the entire membership of the lake district through newsletter, email list, or website.

SOURCES & LITERATURE CITED

Bryson, J. M. (1995). *Strategic Planning for Public and Nonprofit Organizations.* San Francisco: Jossey-Bass Publishers.

Christensen, D.L., B.R. Herwig, D.E. Schindler and S.R. Carpenter. (1996). Impacts of lakeshore residential development on coarse woody debris in north temperate lakes. *Ecological Applications*, **6**(4), p.p.1143-1149

Duarte C.M. and Jacob Kalff (1986). Littoral Slope as a Predictor of the Maximum Biomass of Submerged Macrophyte Communities. *Limnology and Oceanography* **31**(5):1072-1080.

Elias, J.E., and Meyer, M.W. (2003). Comparisons of Undeveloped and Developed Shorelands, Northern Wisconsin, and Recommendations of Restoration. *Wetlands*, **23**(4): 800-816.

Epstein, E.J., E.J. Judziewicz and W.A Smith (1997). Priority wetland sites of Wisconsin's Lake Superior Basin. (PUB ER-096 99). Madison, WI: Wisconsin Department of Natural Resources.

Haskell, Daniel E., C.R. Webster, A.L. Bales, M.W. Meyer, and David J. Flaspholer. 2017. Assessment of Wildlife Habitat Attributes at Restoration Projects on Northern Wisconsin Lakeshores. *Northeastern Naturalist* **24**(4):391-412.

Horne, Alexander J. and Charles R. Goldman. *Limnology, Second Edition*. McGraw-Hill, Inc. 1994.

Hauxwell, J., S. Knight, K. Wagner, A. Mikulyuk, M. Nault, M. Porzky, and S. Chase. 2010. Recommended baseline monitoring of aquatic plants in Wisconsin: sampling design, field and laboratory procedures, data entry and analysis, and applications. Wisconsin Department of Natural Resources Bureau of Science Services, PUB-SS-1068. 2010. Madison, Wisconsin, USA.

Hein, Katie and Maureen Ferry. Directed Lakes Protocol. Wisconsin Department of Natural Resources. 3 May 2016.

Hein, Katie, Scott Van Egeren, Patricia Cicero, Paul Cunningham, Kevin Gauthier, Patrick Goggin, Derek Kavanaugh, Jodi Lepsch, Dan McFarlane, Kevin Olson, Alex Smith, Buzz Sorge, Shelly Smith, and Pamela Toshner. "DRAFT Lake Shoreland & Shallows Habitat Monitoring Field Protocol". Wisconsin Department of Natural Resources. 27 May 2016.

Invasion in North American Wetlands: Biology, Regional Problems, Impacts, Ecosystem Services, and Management. *Wetlands* (2019) **39**:645-684.

Jacobson, Peter C., Timothy K. Cross, Donna L. Dustin, & Michael Duval. "A Fish Habitat Conservation Framework for Minnesota Lakes. *Fisheries*, **41**(6), 2016, pp. 302-317, doi: 10.1080/03632415.2016.1172482.

Jennings, M.J., E.E. Hatzenbeler, G.R. Edwards, and Bozak M.A. (2003). Is littoral habitat affected by residential development and landuse in watersheds of Wisconsin lakes? *Lake and Reservoir Management,* **19**(3): 272-279.

Kaufmann, Philip R., David V. Peck, Steven G. Paulsen, Curt W. Seeliger, Robert M. Hughes, Thomas R. Whittier & Neil C. Kamman (2014). Lakeshore and littoral physical habitat structure in a national lakes assessment. *Lake and Reservoir Management* **30**(2),192-215, doi: 10.1080/10402381.2014.906524

Lake Champlain Basin Program. (2013). Measuring and Modeling the Effects of Lakeshore Development on Littoral Habitat and Biota in Mallets BAY, Vermont. Technical Report No. 75.

Lawson L. and Jackson DA. 2021. Salty summertime streams—road salt contaminated watersheds and estimates of the proportion of impacted species. FACETS 6: 317–333. doi:10.1139/facets-2020-0068

Lawson, Zach J., Jereme W. Gaeta & Stephen R. Carpenter (2011) Coarse Woody Habitat, Lakeshore Residential Development, and Largemouth Bass Nesting Behavior, North American Journal of Fisheries Management, **31**(4), 666-670, doi: 10.1080/02755947.2011.608990

Lindsay, A., Gillum, S., and Meyer, M. (2002). Influence of lakeshore development on breeding bird communities in a mixed northern forest. *Biological Conservation* **107**:1-11.

Nichols, S.A. 1999. Floristic Quality Assessment of Wisconsin Lake Plant Communities with Example Applications. *Journal of Lake and Reservoir Management* **15**(2):133-141. doi: 10.1080/07438149909353957.

Omernik, J.M. 1987. Ecoregions of the conterminous United States. *Annals of the Association of American Geographers*. **77**:118-125.

Panuska, John C. and R.A. Lilly, 1995. Phosphorus Loadings from Wisconsin Watersheds: Recommended Export Coefficients for Agricultural and Forested Watersheds. WDNR Research Management Findings. No. 38, 4p.

Panuska, J., and J. Kreider (2003). Wisconsin Lake Modeling Suite Program Documentation and User's Manual, V 3.3 Wisconsin Department of Natural Resources.

Shaw, Byron, Christine Mechenich, and Lowell Klessig. "Understanding Lake Data". Board of Regents of the University of Wisconsin System. 2004. UW Extension PUB G3582.

Skawinski, Paul M. *Aquatic Plants of the Upper Midwest, 2nd edition*. 2014.

Surface Water Data Viewer. WI Department of Natural Resources. https://dnrmaps.wi.gov/H5/?Viewer=SWDV. 23 Sep 2019.

University of Wisconsin-Madison, 2001. *Wisconsin Floristic Quality Assessment* (WFQA). http://www.botany.wisc.edu/WFQA.asp

Vasistha, Prachi, & Ganguly, Rajiv. (2020). *Water quality assessment of natural lakes and its importance: An overview*. Materials Today: Proceedings. 32.10.1016/j.matpr.2020.02.092.

Wisconsin Cartographers Office – Online Historical Digital Aerial Photography

Wisflora Herbarium, <https://wisflora.herbarium.wisc.edu/index.php>

Wisconsin Consolidated Assessment and Listing Methodology (WisCALM) for Clean Water Act Section 303(d) and 305(b) Integrated Reporting 2024. Wisconsin Department of Natural Resources.

Woodford, J., and Meyer, M. (2003). Impact of lakeshore development on Green Frog abundance. *Biological Conservation*, **110**:277-284.

Appendix 1. Responses to Lake Michelle Stakeholder Survey

SECTION 1: FAMILIARITY with LAKE MICHELE

1) Do you rent or own property on Michele Lake?

Q1	Total	%
Property Renter	3	8
Property Owner	31	92
TOTAL	34	100

2) How many years ago did you first visit the lake? ______ year(s)

Q2	Total
1 - 10 Years	10
11 - 20 Years	9
> 20 Years	15

3) How long have you owned or rented your property on the lake? ______ year(s)

Q3	Total
1 - 10 Years	17
11 - 20 Years	5
> 20 Years	12

4) Is your Lake Michele property used as a primary or seasonal residence?

Primary Seasonal*

**If seasonal, approximately how many days each year is your lake property used by you or others?*______ day(s)

Q4	Total
Primary Residence	10
Seasonal, 1-100 Days	10
Seasonal, 101-200 Days	11
Seasonal, >200 Days	2

5) Has your lake property been owned by a previous family member?

Q5	Total
No Previous Family	33
Previous Family Owned	2

SECTION 2: RECREATION

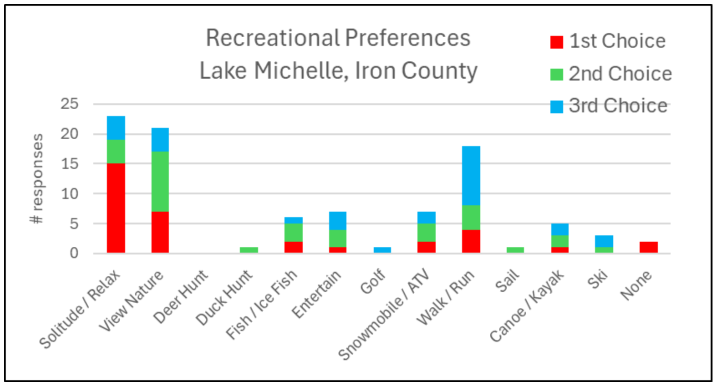
6) How many days each year do you recreate on or around Lake Michele? ______day(s)

Q6	Total
0-100 Days	28
101-200 Days	4
> 200 Days	2

7) Circle all activities that are important to you on (or around) Lake Michele.

Q7	Total
Solitude / Relax	29
View Nature	29
Deer Hunt	3
Duck Hunt	1
Fish / Ice Fish	11
Entertain	14
Golf	9
Snowmobile / ATV	12
Walk / Run	26
Sail	1
Canoe / Kayak	8
Ski	2
None	1

8) From the list in question 7, rank <u>your top three</u> important activities on or around Michelle Lake.



9) Which type(s) of watercraft do you use on Lake Michele? Check all that apply

Q9	Total
Rowboat	2
Paddleboat	3
Canoe	4
Kayak	8
Sailboat	1
None	23

SECTION 3: FISHERY

10) Have you ever fished Lake Michele? Circle One

Q10	Total
Yes	12
No	21

11) How many years have you fished on the lake? _______ year(s)

Q11	Total
1 - 15 Years	8
16 - 30 Years	3
No Response	23

12) Have you fished on the lake in the past 5 years?

Q12	Total
Yes	8
No	4

13) What species do you try catching on Lake Michele? Check ALL that apply

Q13	Total
Northern Pike	6
Bass	4
Yellow Perch	6
Bluegill	6
Black Crappie	4
Other	0

14) From the fish listed in question 13, the species you catch most is: List One

Q14	Total
Northern Pike	3
Bass	0
Yellow Perch	2
Bluegill	3
Black Crappie	0

15) Of the fish you listed in question 14, how frequently do you practice catch and release?

Q15	Total
Never	0
Sometimes	1
Always	8

16) How would you rate the quality of fishing on Lake Michele?

Q16	Total
Poor	6
Good	2
Excellent	0
Unsure	7

Q16 Difficult to fish because of all the weeds

Q16 Need more access/Fishing pier

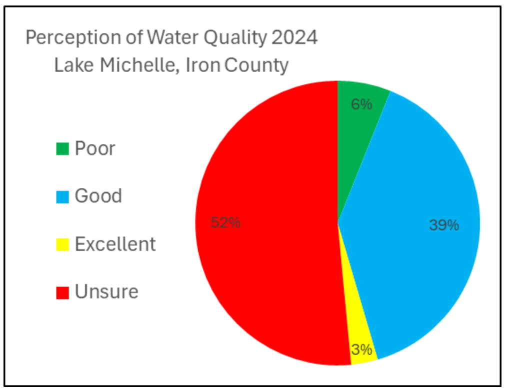
Q16 Not many fish, a lot of cattails, weeds, algae

17) Has the quality of fishing changed during the years you have fished Lake Michele?

Q17	Total
Yes, for the better	0
Yes, for the worse	6
No Change	1
Unsure	11

SECTION 4: WATER QUALITY

18) Would you say the water quality of Lake Michele is:



19) Since you first visited the lake, the water quality has:

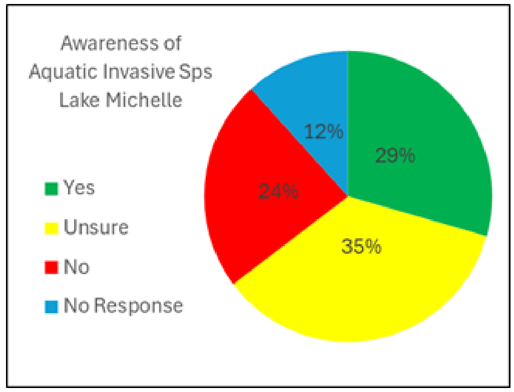
Q19	Total
Gotten worse	10
Stayed the same	12
Improved	0
Unsure	11

SECTION 5: AQUATIC INVASIVE SPECIES (AIS)

20) Prior to this survey, had you ever heard about Aquatic Invasive Species before?

26 Yes; 7 No

21) Are you aware of any invasive species in or around the lake?

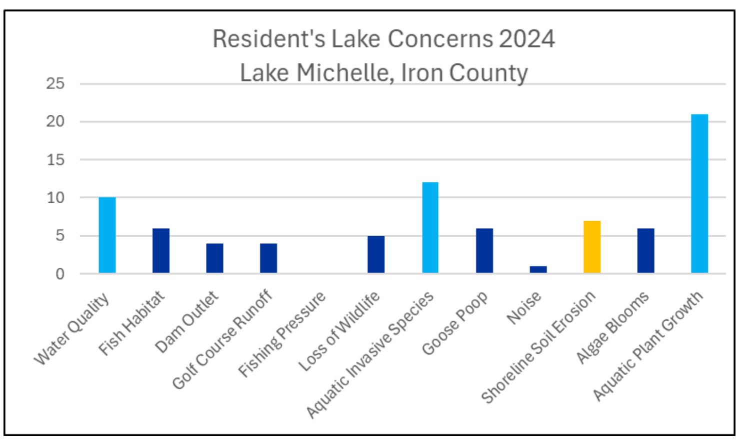


22) If you answered yes in question 21, which AIS are you aware of in or around the lake?

Q22	Total
Rusty Crayfish	
Cattail, Non-Native	8
Pale Yellow Iris	
Purple Loosestrife	4
Zebra Mussel	2
Flowering Rush	1
Eurasian Watermilfoil	
Carp	
Chinese Mystery Snail	1

SECTION 6: GENERAL

23) From the list below, rank your top three concerns regarding Lake Michele.



24) How often do aquatic plants and/or algae affect your enjoyment of the lake?

Q24	Total
Never	9
Sometimes	13
Always	10

25) Do you believe aquatic plant management is needed in Lake Michele?

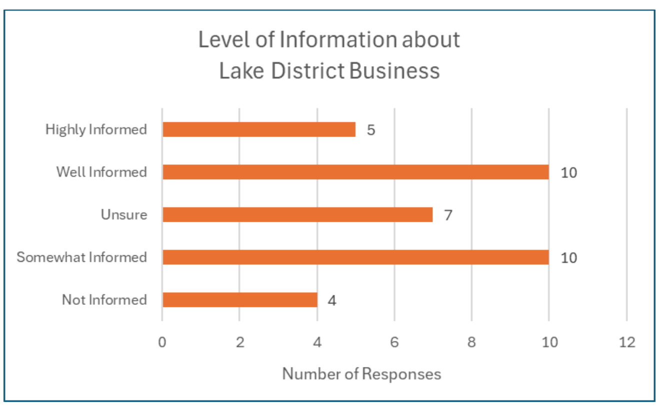
Q25	Total
Yes	20
No	1
Need more information	13

26) On a scale from 1-3 (1= approve; 2= oppose; 3= unsure), what would be your comfort level for each of the following plant management techniques?

Q26	Approve	Oppose	Unsure
Chemical Treatment	11	8	9
Water Level Control	11	3	12
Hand-Pulling	18	0	8
Combination	21	1	8
Do Nothing	1	15	10

SECTION 7: LAKE DISTRICT

27) How well informed have the district leaders kept you regarding Lake Michele business?



28) Before completing this survey, had you ever heard of the *Lake Michele District*?

28 Yes; 5 No

29) Have you ever attended the annual business meeting of the Lake Michele District?

Q29	Total
Yes, every year	4
Yes, a few times	5
Have never attended	22
Unsure	0

30) From the list below, which topics would you like to learn more about?

17 Aquatic invasive species
17 Water quality monitoring
10 Citizen volunteer monitoring
7 Human impacts on lakes
9 Wisconsin shoreland zoning and development laws (NR 115)
16 Methods to restore and/or maintain natural shorelines
6 Methods to minimize stormwater runoff
11 How aquatic invasive species are spread between lakes
6 Not interested in learning about any of these subjects
0 Other

31) The Lake Michele District could serve their membership (or the lake) better by:

-Figuring out a way to get residents more involved in finding solutions to lake problems & planning for future.

-The district charged me $150 last year. I'd like to see them dredge and aerate the lake to be more attractive for boating and fishing.

-Being involved with the experts and take professional advise when needed.

-Sharing more information regularly.

-Don't study the weeds & cattails, just get rid of them.

-Planting fish & better access to the water

-Everyone needs to get involved in saving the lake. The assessment needs to be presented to the owners. -I have great concern for the future of the lake.

-Clean up the shoreline. Allow us to see the lake and we will love it more.

-Put information online (Facebook Page?) for members.

-Keeping us informed year-round on lake improvements and watching for degradation of water and shoreline.

-This district does well to share information.

-Removing invasive species

-Getting rid of the cattails and making a nice shoreline.

-Host the meetings online as well so that people from out of town can be present.

-Become proactive, Clean the lake apply for grants

-More frequent updates - email perhaps?

-Doing something!

- Is it possible to remove the cattails?

-Could lake be made swimmable?

-Create open areas along shore for swimming, create launch areas for canoes and kayaks

END

Appendix 2 – WiLMS Model Results – Lake Michelle

Date: 8/5/2024   Scenario: 2

Lake Id: Michele
Watershed Id: 0

Hydrologic and Morphometric Data

Tributary Drainage Area: 1014.1 acre
Total Unit Runoff: 14.00 in.
Annual Runoff Volume: 1183.1 acre-ft
Lake Surface Area <As>: 33.5 acre
Lake Volume <V>: 0.0 acre-ft
Lake Mean Depth <z>: 0.0 ft
Precipitation - Evaporation: 7.0 in.
Hydraulic Loading: 1202.7 acre-ft/year
Areal Water Load <qs>: 35.9 ft/year
Lake Flushing Rate <p>: 0.00 1/year
Water Residence Time: 0.00 year
Observed spring overturn total phosphorus (SPO): 0.0 mg/m^3
Observed growing season mean phosphorus (GSM): 0.0 mg/m^3
% NPS Change: 0%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre (ac)	Low	Most Likely	High	Loading %	Low	Most Likely	High
		|---- Loading (kg/ha-year) ----|				|----- Loading (kg/year) ----|		
Row Crop AG	0.0	0.50	1.00	3.00	0.0	0	0	0
Mixed AG	39.80	0.30	0.80	1.40	15.5	5	13	23
Pasture/Grass	76.73	0.10	0.30	0.50	11.2	3	9	16
HD Urban (1/8 Ac)	10.67	1.00	1.50	2.00	7.8	4	6	9
MD Urban (1/4 Ac)	107.41	0.30	0.50	0.80	26.1	13	22	35
Rural Res (>1 Ac)	0.0	0.05	0.10	0.25	0.0	0	0	0
Wetlands	117.87	0.10	0.10	0.10	5.7	5	5	5
Forest	661.64	0.05	0.09	0.18	28.9	13	24	48
Lake Surface	33.5	0.10	0.30	1.00	4.9	1	4	14

POINT SOURCE DATA

Point Sources	Water Load (m^3/year)	Low (kg/year)	Most Likely (kg/year)	High (kg/year)	Loading %

–

SEPTIC TANK DATA

Description	Low	Most Likely	High	Loading %

Septic Tank Output (kg/capita-year)		0.30	0.50	0.80
# capita-years	0.0			
% Phosphorus Retained by Soil		98.0	90.0	80.0
Septic Tank Loading (kg/year)		0.00	0.00	0.00

0.0

TOTALS DATA

Description	Low	Most Likely	High	Loading %
Total Loading (lb)	98.8	183.8	326.3	100.0
Total Loading (kg)	44.8	83.3	148.0	100.0
Areal Loading (lb/ac-year)	2.95	5.49	9.74	
Areal Loading (mg/m^2-year)	330.53	614.81	1091.79	
Total PS Loading (lb)	0.0	0.0	0.0	0.0
Total PS Loading (kg)	0.0	0.0	0.0	0.0
Total NPS Loading (lb)	95.8	174.8	296.4	100.0
Total NPS Loading (kg)	43.5	79.3	134.5	100.0

Date: 8/5/2024 Scenario: 3

Lake Id: Michele
Watershed Id: 0

Hydrologic and Morphometric Data

Tributary Drainage Area: 1014.1 acre
Total Unit Runoff: 14.00 in.
Annual Runoff Volume: 1183.1 acre-ft
Lake Surface Area <As>: 33.5 acre
Lake Volume <V>: 0.0 acre-ft
Lake Mean Depth <z>: 0.0 ft
Precipitation - Evaporation: 7.0 in.
Hydraulic Loading: 1202.7 acre-ft/year
Areal Water Load <qs>: 35.9 ft/year
Lake Flushing Rate <p>: 0.00 1/year
Water Residence Time: 0.00 year
Observed spring overturn total phosphorus (SPO): 0.0 mg/m^3
Observed growing season mean phosphorus (GSM): 0.0 mg/m^3
% NPS Change: 0%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre (ac)	Low	Most Likely	High	Loading %	Low	Most Likely	High
		|---- Loading (kg/ha-year) ----|				|----- Loading (kg/year) ----|		
Row Crop AG	0.0	0.50	1.00	3.00	0.0	0	0	0
Mixed AG	39.80	0.30	0.80	1.40	15.5	5	13	23
Pasture/Grass	76.73	0.10	0.30	0.50	11.2	3	9	16
HD Urban (1/8 Ac)	10.67	1.00	1.50	2.00	7.8	4	6	9
MD Urban (1/4 Ac)	107.41	0.30	0.50	0.80	26.1	13	22	35
Rural Res (>1 Ac)	0.0	0.05	0.10	0.25	0.0	0	0	0
Wetlands	117.87	0.10	0.10	0.10	5.7			

5	5	5			
Forest	661.64	0.05	0.09	0.18	28.9
13	24	48			
Lake Surface	33.5	0.10	0.30	1.00	4.9
1	4	14			

POINT SOURCE DATA

Point Sources	Water Load (m^3/year)	Low (kg/year)	Most Likely (kg/year)	High (kg/year)	Loading %

SEPTIC TANK DATA

Description		Low	Most Likely	High
Loading %				
Septic Tank Output (kg/capita-year)		0.30	0.50	0.80
# capita-years	0.0			
% Phosphorus Retained by Soil		98.0	90.0	80.0
Septic Tank Loading (kg/year)		0.00	0.00	0.00
0.0				

TOTALS DATA

Description	Low	Most Likely	High	Loading %
Total Loading (lb)	98.8	183.8	326.3	100.0
Total Loading (kg)	44.8	83.3	148.0	100.0
Areal Loading (lb/ac-year)	2.95	5.49	9.74	
Areal Loading (mg/m^2-year)	330.53	614.81	1091.79	
Total PS Loading (lb)	0.0	0.0	0.0	0.0
Total PS Loading (kg)	0.0	0.0	0.0	0.0
Total NPS Loading (lb)	95.8	174.8	296.4	100.0
Total NPS Loading (kg)	43.5	79.3	134.5	100.0

Date: 8/5/2024 Scenario: 4

Lake Id: Michele
Watershed Id: 0

Hydrologic and Morphometric Data

Tributary Drainage Area: 1014.1 acre
Total Unit Runoff: 14.00 in.
Annual Runoff Volume: 1183.1 acre-ft
Lake Surface Area <As>: 33.5 acre
Lake Volume <V>: 0.0 acre-ft
Lake Mean Depth <z>: 0.0 ft
Precipitation - Evaporation: 7.0 in.
Hydraulic Loading: 1202.7 acre-ft/year
Areal Water Load <qs>: 35.9 ft/year
Lake Flushing Rate <p>: 0.00 1/year
Water Residence Time: 0.00 year
Observed spring overturn total phosphorus (SPO): 0.0 mg/m^3
Observed growing season mean phosphorus (GSM): 0.0 mg/m^3
% NPS Change: 0%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre (ac)	Low	Most Likely	High	Loading %	Low	Most Likely	High
		|---- Loading (kg/ha-year) ----|						

						|----- Loading (kg/year) ----|		
Row Crop AG	0.0	0.50	1.00	3.00	0.0	0	0	0
Mixed AG	39.8	0.30	0.80	1.40	15.5	5	13	23
Pasture/Grass	76.7	0.10	0.30	0.50	11.2	3	9	16
HD Urban (1/8 Ac)	10.7	1.00	1.50	2.00	7.8	4	6	9
MD Urban (1/4 Ac)	107.4	0.30	0.50	0.80	26.1	13	22	35
Rural Res (>1 Ac)	0.0	0.05	0.10	0.25	0.0	0	0	0
Wetlands	117.9	0.10	0.10	0.10	5.7	5	5	5
Forest	661.6	0.05	0.09	0.18	28.9	13	24	48
Lake Surface	33.5	0.10	0.30	1.00	4.9	1	4	14

POINT SOURCE DATA

Point Sources	Water Load **(m^3/year)**	Low **(kg/year)**	Most Likely **(kg/year)**	High **(kg/year)**	Loading %

_

SEPTIC TANK DATA

Description		**Low**	**Most Likely**	**High**	**Loading %**
Septic Tank Output (kg/capita-year)		0.30	0.50	0.80	
# capita-years	0.0				
% Phosphorus Retained by Soil		98.0	90.0	80.0	
Septic Tank Loading (kg/year)		0.00	0.00	0.00	0.0

TOTALS DATA

Description	**Low**	**Most Likely**	**High**	**Loading %**
Total Loading (lb)	98.8	183.8	326.3	100.0
Total Loading (kg)	44.8	83.3	148.0	100.0
Areal Loading (lb/ac-year)	2.95	5.49	9.74	
Areal Loading (mg/m^2-year)	330.53	614.81	1091.79	
Total PS Loading (lb)	0.0	0.0	0.0	0.0
Total PS Loading (kg)	0.0	0.0	0.0	0.0
Total NPS Loading (lb)	95.8	174.8	296.4	100.0
Total NPS Loading (kg)	43.5	79.3	134.5	100.0

Date: 8/5/2024   Scenario: 5

Lake Id: Michele
Watershed Id: 0

Hydrologic and Morphometric Data

Tributary Drainage Area: 1014.1 acre
Total Unit Runoff: 14.00 in.
Annual Runoff Volume: 1183.1 acre-ft
Lake Surface Area <As>: 33.5 acre
Lake Volume <V>: 0.0 acre-ft
Lake Mean Depth <z>: 0.0 ft

Precipitation - Evaporation: 7.0 in.
Hydraulic Loading: 1202.7 acre-ft/year
Areal Water Load <qs>: 35.9 ft/year
Lake Flushing Rate <p>: 0.00 1/year
Water Residence Time: 0.00 year
Observed spring overturn total phosphorus (SPO): 0.0 mg/m^3
Observed growing season mean phosphorus (GSM): 0.0 mg/m^3
% NPS Change: 0%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre (ac)	Low	Most Likely	High	Loading %	Low	Most Likely	High
		Loading (kg/ha-year)				Loading (kg/year)		
Row Crop AG	0.0	0.50	1.00	3.00	0.0	0	0	0
Mixed AG	39.8	0.30	0.80	1.40	15.5	5	13	23
Pasture/Grass	76.7	0.10	0.30	0.50	11.2	3	9	16
HD Urban (1/8 Ac)	10.7	1.00	1.50	2.00	7.8	4	6	9
MD Urban (1/4 Ac)	107.4	0.30	0.50	0.80	26.1	13	22	35
Rural Res (>1 Ac)	0.0	0.05	0.10	0.25	0.0	0	0	0
Wetlands	117.9	0.10	0.10	0.10	5.7	5	5	5
Forest	661.6	0.05	0.09	0.18	28.9	13	24	48
Lake Surface	33.5	0.10	0.30	1.00	4.9	1	4	14

POINT SOURCE DATA

Point Sources	Water Load (m^3/year)	Low (kg/year)	Most Likely (kg/year)	High (kg/year)	Loading %

SEPTIC TANK DATA

Description		Low	Most Likely	High	Loading %
Septic Tank Output (kg/capita-year)		0.30	0.50	0.80	
# capita-years	0.0				
% Phosphorus Retained by Soil		98.0	90.0	80.0	
Septic Tank Loading (kg/year)		0.00	0.00	0.00	0.0

TOTALS DATA

Description	Low	Most Likely	High	Loading %
Total Loading (lb)	98.8	183.8	326.3	100.0
Total Loading (kg)	44.8	83.3	148.0	100.0
Areal Loading (lb/ac-year)	2.95	5.49	9.74	
Areal Loading (mg/m^2-year)	330.53	614.81	1091.79	
Total PS Loading (lb)	0.0	0.0	0.0	0.0
Total PS Loading (kg)	0.0	0.0	0.0	0.0

Total NPS Loading (lb)	95.8	174.8	296.4	100.0
Total NPS Loading (kg)	43.5	79.3	134.5	100.0

Date: 8/5/2024 Scenario: 6

Lake Id: Michele
Watershed Id: 0

Hydrologic and Morphometric Data

Tributary Drainage Area: 1014.1 acre
Total Unit Runoff: 14.00 in.
Annual Runoff Volume: 1183.1 acre-ft
Lake Surface Area <As>: 33.5 acre
Lake Volume <V>: 0.0 acre-ft
Lake Mean Depth <z>: 0.0 ft
Precipitation - Evaporation: 7.0 in.
Hydraulic Loading: 1202.7 acre-ft/year
Areal Water Load <qs>: 35.9 ft/year
Lake Flushing Rate <p>: 0.00 1/year
Water Residence Time: 0.00 year
Observed spring overturn total phosphorus (SPO): 0.0 mg/m^3
Observed growing season mean phosphorus (GSM): 0.0 mg/m^3
% NPS Change: 0%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre (ac)	Low	Most Likely	High	Loading %	Low	Most Likely	High
		|---- Loading (kg/ha-year) ----|				**|----- Loading (kg/year) ----|**		
Row Crop AG	0.0	0.50	1.00	3.00	0.0	0	0	0
Mixed AG	39.8	0.30	0.80	1.40	15.5	5	13	23
Pasture/Grass	76.7	0.10	0.30	0.50	11.2	3	9	16
HD Urban (1/8 Ac)	10.7	1.00	1.50	2.00	7.8	4	6	9
MD Urban (1/4 Ac)	107.4	0.30	0.50	0.80	26.1	13	22	35
Rural Res (>1 Ac)	0.0	0.05	0.10	0.25	0.0	0	0	0
Wetlands	117.9	0.10	0.10	0.10	5.7	5	5	5
Forest	661.6	0.05	0.09	0.18	28.9	13	24	48
Lake Surface	33.5	0.10	0.30	1.00	4.9	1	4	14

POINT SOURCE DATA

Point Sources	Water Load **(m^3/year)**	Low **(kg/year)**	Most Likely **(kg/year)**	High **(kg/year)**	Loading %

SEPTIC TANK DATA

Description	**Low**	**Most Likely**	**High**	**Loading %**

Septic Tank Output (kg/capita-year)		0.30	0.50	0.80
# capita-years	0.0			
% Phosphorus Retained by Soil		98.0	90.0	80.0
Septic Tank Loading (kg/year)		0.00	0.00	0.00
0.0				

TOTALS DATA

Description	Low	Most Likely	High	Loading %
Total Loading (lb)	98.8	183.8	326.3	100.0
Total Loading (kg)	44.8	83.3	148.0	100.0
Areal Loading (lb/ac-year)	2.95	5.49	9.74	
Areal Loading (mg/m^2-year)	330.53	614.81	1091.79	
Total PS Loading (lb)	0.0	0.0	0.0	0.0
Total PS Loading (kg)	0.0	0.0	0.0	0.0
Total NPS Loading (lb)	95.8	174.8	296.4	100.0
Total NPS Loading (kg)	43.5	79.3	134.5	100.0

Date: 8/5/2024 Scenario: 7

Lake Id: Michele
Watershed Id: 0

Hydrologic and Morphometric Data

Tributary Drainage Area: 1014.1 acre
Total Unit Runoff: 14.00 in.
Annual Runoff Volume: 1183.1 acre-ft
Lake Surface Area <As>: 33.5 acre
Lake Volume <V>: 0.0 acre-ft
Lake Mean Depth <z>: 0.0 ft
Precipitation - Evaporation: 7.0 in.
Hydraulic Loading: 1202.7 acre-ft/year
Areal Water Load <qs>: 35.9 ft/year
Lake Flushing Rate <p>: 0.00 1/year
Water Residence Time: 0.00 year
Observed spring overturn total phosphorus (SPO): 0.0 mg/m^3
Observed growing season mean phosphorus (GSM): 0.0 mg/m^3
% NPS Change: 0%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre	Low	Most Likely	High	Loading %	Low	Most Likely	High
	(ac)	**|---- Loading (kg/ha-year) ----|**				**|----- Loading (kg/year) ----|**		
Row Crop AG	0.0	0.50	1.00	3.00	0.0	0	0	0
Mixed AG	39.8	0.30	0.80	1.40	15.5	5	13	23
Pasture/Grass	76.7	0.10	0.30	0.50	11.2	3	9	16
HD Urban (1/8 Ac)	10.7	1.00	1.50	2.00	7.8	4	6	9
MD Urban (1/4 Ac)	107.4	0.30	0.50	0.80	26.1	13	22	35
Rural Res (>1 Ac)	0.0	0.05	0.10	0.25	0.0	0	0	0
Wetlands	117.9	0.10	0.10	0.10	5.7			

						5	5	5
Forest	661.6	0.05	0.09	0.18	28.9	13	24	48
Lake Surface	33.5	0.10	0.30	1.00	4.9	1	4	14

POINT SOURCE DATA

Point Sources	Water Load **(m^3/year)**	Low **(kg/year)**	Most Likely **(kg/year)**	High **(kg/year)**	Loading %

_

SEPTIC TANK DATA

Description		**Low**	**Most Likely**	**High**	**Loading %**
Septic Tank Output (kg/capita-year)		0.30	0.50	0.80	
# capita-years	0.0				
% Phosphorus Retained by Soil		98.0	90.0	80.0	
Septic Tank Loading (kg/year)		0.00	0.00	0.00	0.0

TOTALS DATA

Description	**Low**	**Most Likely**	**High**	**Loading %**
Total Loading (lb)	98.8	183.8	326.3	100.0
Total Loading (kg)	44.8	83.3	148.0	100.0
Areal Loading (lb/ac-year)	2.95	5.49	9.74	
Areal Loading (mg/m^2-year)	330.53	614.81	1091.79	
Total PS Loading (lb)	0.0	0.0	0.0	0.0
Total PS Loading (kg)	0.0	0.0	0.0	0.0
Total NPS Loading (lb)	95.8	174.8	296.4	100.0
Total NPS Loading (kg)	43.5	79.3	134.5	100.0

Date: 8/5/2024 Scenario: 9

Lake Id: Michele
Watershed Id: 0

Hydrologic and Morphometric Data

Tributary Drainage Area: 1014.1 acre
Total Unit Runoff: 14 in.
Annual Runoff Volume: 1183.1 acre-ft
Lake Surface Area <As>: 33.5 acre
Lake Volume <V>: 0.0 acre-ft
Lake Mean Depth <z>: 0.0 ft
Precipitation - Evaporation: 7 in.
Hydraulic Loading: 1202.7 acre-ft/year
Areal Water Load <qs>: 35.9 ft/year
Lake Flushing Rate <p>: 0.00 1/year
Water Residence Time: 0.00 year
Observed spring overturn total phosphorus (SPO): 0.0 mg/m^3
Observed growing season mean phosphorus (GSM): 0.0 mg/m^3
% NPS Change: 0%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre **(ac)**	Low	Most Likely	High	Loading %	Low	Most Likely	High
		|---- Loading (kg/ha-year) ----|						

						Loading (kg/year)		
Row Crop AG	0.0	0.50	1.00	3.00	0.0	0	0	0
Mixed AG	39.8	0.30	0.80	1.40	15.5	5	13	23
Pasture/Grass	76.7	0.10	0.30	0.50	11.2	3	9	16
HD Urban (1/8 Ac)	10.7	1.00	1.50	2.00	7.8	4	6	9
MD Urban (1/4 Ac)	107.4	0.30	0.50	0.80	26.1	13	22	35
Rural Res (>1 Ac)	0.0	0.05	0.10	0.25	0.0	0	0	0
Wetlands	117.9	0.10	0.10	0.10	5.7	5	5	5
Forest	661.6	0.05	0.09	0.18	28.9	13	24	48
Lake Surface	33.5	0.10	0.30	1.00	4.9	1	4	14

POINT SOURCE DATA

Point Sources	Water Load **(m^3/year)**	Low **(kg/year)**	Most Likely **(kg/year)**	High **(kg/year)**	Loading %

SEPTIC TANK DATA

Description		**Low**	**Most Likely**	**High**	**Loading %**
Septic Tank Output (kg/capita-year)		0.30	0.50	0.80	
# capita-years	0.0				
% Phosphorus Retained by Soil		98.0	90.0	80.0	
Septic Tank Loading (kg/year)		0.00	0.00	0.00	0.0

TOTALS DATA

Description	**Low**	**Most Likely**	**High**	**Loading %**
Total Loading (lb)	98.8	183.8	326.3	100.0
Total Loading (kg)	44.8	83.3	148.0	100.0
Areal Loading (lb/ac-year)	2.95	5.49	9.74	
Areal Loading (mg/m^2-year)	330.53	614.81	1091.79	
Total PS Loading (lb)	0.0	0.0	0.0	0.0
Total PS Loading (kg)	0.0	0.0	0.0	0.0
Total NPS Loading (lb)	95.8	174.8	296.4	100.0
Total NPS Loading (kg)	43.5	79.3	134.5	100.0

Phosphorus Prediction and Uncertainty Analysis Module

Date: 8/5/2024   Scenario: 1
Observed spring overturn total phosphorus (SPO): 0.0 mg/m^3
Observed growing season mean phosphorus (GSM): 0.0 mg/m^3
Back calculation for SPO total phosphorus: 0.0 mg/m^3
Back calculation GSM phosphorus: 0.0 mg/m^3
% Confidence Range: 70%
Nurenberg Model Input - Est. Gross Int. Loading: 0 kg

Lake Phosphorus Model	**Low**	**Most Likely**	**High**

Predicted % Dif. -Observed (mg/m^3)	Total P (mg/m^3)	Total P (mg/m^3)	Total P (mg/m^3)
Walker, 1987 Reservoir			
Canfield-Bachmann, 1981 Natural Lake			
Canfield-Bachmann, 1981 Artificial Lake			
Rechow, 1979 General			
Rechow, 1977 Anoxic			
Rechow, 1977 water load<50m/year			
Rechow, 1977 water load>50m/year			
Walker, 1977 General			
Vollenweider, 1982 Combined OECD			
Dillon-Rigler-Kirchner			
Vollenweider, 1982 Shallow Lake/Res.			
Larsen-Mercier, 1976			
Nurnberg, 1984 Oxic			

Lake Phosphorus Model	**Back** Calculation (kg/year)	**Model** Type	**Confidence** Lower Bound	**Confidence** Upper Bound	**Parameter** Fit?
Walker, 1987 Reservoir		GSM			
Canfield-Bachmann, 1981 Natural Lake		GSM			
Canfield-Bachmann, 1981 Artificial Lake		GSM			
Rechow, 1979 General		GSM			
Rechow, 1977 Anoxic		GSM			
Rechow, 1977 water load<50m/year		GSM			
Rechow, 1977 water load>50m/year		GSM			
Walker, 1977 General		SPO			
Vollenweider, 1982 Combined OECD		ANN			
Dillon-Rigler-Kirchner		SPO			
Vollenweider, 1982 Shallow Lake/Res.		ANN			
Larsen-Mercier, 1976		SPO			
Nurnberg, 1984 Oxic		ANN			

APPENDIX 3. *Summary & Individual Statistics Explanations*

	Summary Statistic	Explanation
1	Total number of sites visited	The total number of sites sampled, which is not necessarily equal to the number of survey points because some sites may not be accessible or are too deep.
2	Total number of sites with vegetation	Number of sites where at least one plant was found on the rake (does not include moss, sponges, algae, or liverworts).
3	Maximum depth of plants	Depth of deepest site where at least one plant was found on the rake (does not include moss, sponges, algae, or liverworts).
4	Total number of sites shallower than maximum depth of plants	Number of sites where depth was less than or equal to the maximum depth where at least one plant was found on the rake.
5	Frequency of occurrence at sites shallower than maximum depth of plants	Total number of sites with vegetation (2) / Total number of sites shallower than maximum depth of plants (4).
6	Average number of species per site (split into four subcategories)	a) Shallower than maximum depth – the average number of species found per site at sites less than or equal to the maximum depth where at least one plant was found on the rake (4).
		b) Vegetated sites only – the average number of species found per site at sites where at least one plant was found on the rake (2).
		c) Native species shallower than maximum depth – Same explanation as 6(a), non-native species excluded from average.
		d) Native species at vegetated sites only – Same explanation as 6(b), non-native species excluded from average.
7	Species Richness (split into two subcategories)	a) Total number of species found on the rake at all sites (does not include moss, sponges, algae, or liverworts
		b) Including visuals – Same explanation as 7(a) and including visual observations within 6 feet of the sample sight
8	Simpson Diversity Index	Estimates the heterogeneity of a community by calculating the probability that two individuals randomly selected from the data set will be different species. The index ranges from 0-1, and the closer the value is to one, the more diverse the community. Visual observations (within 6 feet of sample point) are not included in calculation of index.
9	Coefficient of Conservatism (C)	This is not a statistical calculation, but rather a value assigned to each plant species based on how sensitive that species is to disturbance. C values range from 1 to 10 with higher values assigned to species that are more sensitive to disturbance (Nichols, 1999).
10	Floristic Quality Index	How similar the aquatic plant community is to one that is undisturbed (Nichols, 1999). This index only factors species raked at survey points and does not include non-native species. The FQI is calculated using coefficient of conservatism (C) values (9).

	Individual Statistic	Explanation
11	Average Rake Fullness	Mean rake fullness rating ranging from 1 to 3.
12	Number of sites where a species was found	The total number of survey points where a particular species was found on the rake.
13	Number of visual sightings	The total number of times a particular species was visually observed within 6 feet of a sampling point, but not collected on the rake
14	Frequency of Occurrence (split into two subcategories	a) Among vegetated sites only – The number of sites at which a particular species is found on the rake divided by the total number of vegetated sites b) Among sites shallower than the maximum depth of plants – The number of sites at which a particular species is found on the rake divided by the total number of sites less than or equal to the maximum depth of plants
15	Relative frequency (%)	This value represents the degree to which a particular species contributes to the total of all observations. The sum of all relative frequencies is 100%.