2024 YEAR END REPORT

TEN MILE LAKE

TEN MILE LAKE ASSOCIATION

PREPARED BY:
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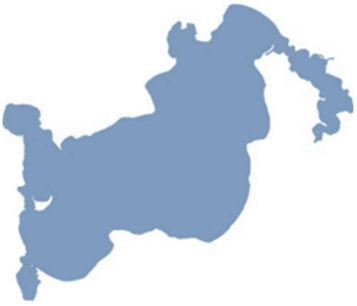
TEN MILE LAKE 11-0413-00

CASS COUNTY



Ten Mile Lake is located between the cities of Hackensack and Walker in Cass County, Minnesota. The lake has a surface area of 5,080.43 acres, making it one of the largest lakes in the state. It is also one of the deepest lakes in Minnesota, with a maximum depth of 208 feet and a mean depth of 52.4 feet (Table 1). Ten Mile Lake has zero inlets and one outlet, which classifies it as a groundwater drainage lake. It is the headwaters of the Boy River, which flows south from Ten Mile and then east and north through a chain of 15 or 16 lakes before emptying into the east side of Leech Lake. The Leech Lake River then exits Leech Lake and joins the Mississippi River.

Water quality data have been collected on Ten Mile Lake since 1974. These data show that the lake is oligo-mesotrophic. Oligo-mesotrophic lakes are deep with clear water all summer and are excellent for recreation.

The Ten Mile Lake Association was first formed in 1946. The association has been involved in numerous activities including water quality monitoring, education, lake management planning, and conservation easements. It is also a member of the Association of Cass County Lakes (ACCL).

Table 1. Ten Mile Lake location data and key physical characteristics.

LOCATION DATA

MN Lake ID	11-0413-00
County	Cass
Ecoregion	Northern Lakes & Forests
Major Drainage Basin	Upper Mississippi River
Latitude / Longitude	46.95833 / -94.58361

PHYSICAL CHARACTERISTICS

Surface Area (acres)	5,080.43
Littoral Area (acres)	1,316
Max Depth (ft)	208
Mean Depth (ft)	52.4
Shore Length (miles)	24.83

Table 2. Availability of primary data types for Ten Mile Lake.

DATA AVAILABILITY

Transparency Data	Excellent data source from 1979 – 2024.
Chemical Data	Excellent data source from 1994 – 2024.

INTRODUCTION

Lakes go through a life process from birth to death, where the birth of a lake results from filling a hole in the earth with water, and the death is the formation of a bog or meadow. The nutrient input to the lake is a result of activities going on in the watershed, the size of the watershed, wind-blown deposits, and the quality of the water reaching the lake via precipitation, groundwater, and flowing streams. Reducing nutrient inputs extends a lake's lifespan by slowing the natural aging process.

In northern Minnesota, the process of making lakes was reinstated by relatively recent glacial excavation, which ended about 8,000 to 10,000 years ago, and lake basins were filled by melting glacial ice. Watersheds were formed and lake basins were connected by streams and rivers. Bacteria, algae, plants, invertebrates, and vertebrates, which include the fish species, moved down and up the streams and into the new aquatic environments.

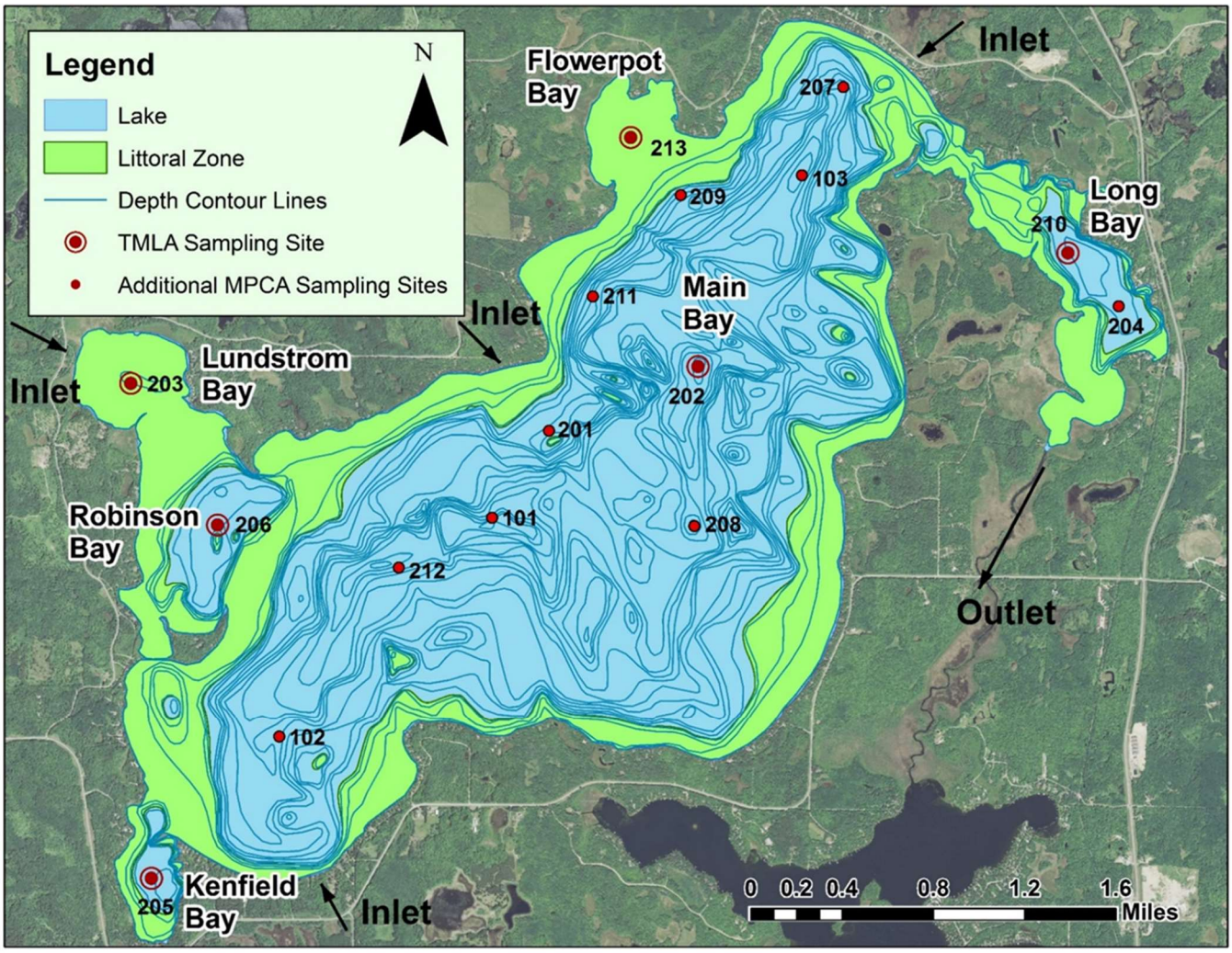


Figure 1. Map of Ten Mile Lake with 2010 aerial imagery and illustrations of lake depth contour lines, littoral area, sample site locations, inlets and outlets, and public access points.

Ten Mile Lake is made up of six separate basins. These include Long Bay, Flowerpot Bay, Lundstrom's Bay, Robinson's Bay, Kenfield Bay, and the Main Basin (Figure 1).

The terrestrial watershed of Ten Mile Lake is relatively small: 3 miles to the north, 2.5 miles west, 0.5 miles east, and 7.8 miles southwest.

In the 1991 Hydraulic Assessment, MPCA reported that Ten Mile Lake receives approximately 50% of its water from groundwater. The area where groundwater flows into Ten Mile Lake begins with the east shore of Long Bay, continues around the north shore, through Flowerpot Bay, around the northwest shore, through Lundstrom's Bay, down the west shoreline and Robinson's Bay, around the west side of Kenfield Bay, and to the east end of the Chub Lake flowage.

The area where groundwater flows out of the lake begins at the east end of the Chub Lake flowage, goes around the east side of the lake, to the Boy River outlet at Highway 6. This flowage is from Ten Mile Lake south to Birch Lake. There is probably a continuous flow from the east side of Ten Mile Lake to the Boy River through the marshes.

This monitoring project was started in 1994 with the intention of developing a body of data that could be used to manage Ten Mile Lake in the future. It was also intended to identify environmental problems both on the lake and within the flowage. Samples for laboratory analysis are collected over the deepest depression in each of the basins to be tested. The sampling sites were designated and located by the Minnesota Pollution Control Agency.

There are six sampling sites (Figure 1). In the past, three sites – the Main Basin, Kenfield Bay, and Long Bay – were designated as primary sites and were sampled in mid-May, mid-July, and mid-September. Of those, the Main Basin and Long Bay were also tested for water clarity by Secchi disk measurement. Three secondary sites – Flowerpot Bay, Lundstrom's Bay, and Robinson's Bay – were chosen as rotational or alternate sites, where samples are drawn for laboratory examination. Starting in 2015, all six sites were monitored each month in the summer.

WATER QUALITY MONITORING PROGRAM HISTORY

Ten Mile Lake has been monitored by many different organizations over the years (Table 3). Ten Mile Lake Association has been monitoring the lake since 1974. This is some of the earliest water quality data collected by citizens in the state of Minnesota.

In 2008, the Minnesota Department of Natural Resources (DNR) started their Sentinel Lakes Program, also called SLICE (Sustaining Lakes in a Changing Environment). This program was set up to monitor a sample of Minnesota lakes that are representative of the state's most common aquatic environments. Information gathered will be used to develop management approaches that can mitigate or minimize negative impacts caused by conventional "high-impact" residential development and agriculture, aquatic plant removal, invasive species, and climate change. Ten Mile Lake is one of the selected SLICE sample lakes due to its deep cold water characteristics. The DNR hopes to continue this monitoring program into the future to document lake changes. To read more about the SLICE program, visit: http://www.dnr.state.mn.us/fisheries/slice/index.html.

Table 3. Ten Mile Lake monitoring sites and associated monitoring programs. Monitoring programs include the Citizen Lake Monitoring Program (CLMP), Minnesota Pollution Control Agency (MPCA), DNR Sentinel Lakes Program (SLICE), Ten Mile Lake Association (TMLA), Whitefish Area Property Owners Association (WAPOA), and Outdoor Corps (OC).

SITE	DEPTH (FT)	MONITORING PROGRAMS
101	150	**MPCA**: 1989, 1991
102	90	**MPCA**: 1989, 1991; **SLICE**: 2008-2017; **TMLA**: 2024
103	126	**MPCA**: 1991
201	40	**CLMP**: 1974-1975; **SLICE**: 2016
202[1]	208	**CLMP**: 1979-1991, 1994-2015; **MPCA**: 1979-1981; **SLICE**: 2008-2020; **TMLA**: 1994-2024
203	10	**MPCA**: 1979; **TMLA**: 1994-2024
204	35	**CLMP**: 1980-1991, 1994-2015; **MPCA**: 1980-1981; **TMLA**: 1994-2024
205	35	**CLMP**: 2003; **OC**: 2003; **WAPOA**: 2001-2002; **TMLA**: 1994-2024
206	45	**CLMP**: 2003; **OC**: 2003; **WAPOA**: 2001-2002; **TMLA**: 1994-2024
207	40	**CLMP**: 2003; **TMLA**: 2024
208	98	**SLICE**: 2008-2011
209	40	**TMLA**: 1994, 1997, 2000, 2003
210	42	**OC**: 2003; **WAPOA**: 2001-2002; **TMLA**: 1980-2024
211	100	**OC**: 2003
212	140	**SLICE**: 2010
213	10	**TMLA**: 1994-2024

[1] Primary monitoring site

WATER QUALITY CHARACTERISTICS HISTORICAL MEANS & RANGES

Minnesota is divided into 7 ecoregions based on land use, vegetation, precipitation, and geology (Figure 2). The Minnesota Pollution Control Agency (MPCA) has developed a way to determine the "average range" of water quality expected for lakes in each ecoregion. From 1985-1988, MPCA evaluated the lake water quality for reference lakes. These reference lakes are not considered pristine but are representative of the typical lakes within the ecoregion. The "average range" refers to the 25th - 75th percentile range for data within each ecoregion.

Ten Mile Lake is located in the Northern Lakes and Forests ecoregion. The mean total phosphorus, chlorophyll *a*, and Secchi depth for Ten Mile Lake are better than the ecoregion expected ranges.

Figure 2. Map of Minnesota ecoregions.

Table 4. Ten Mile Lake water quality data through 2024 compared to ecoregion expected ranges and the impaired waters standard. Data for total phosphorus, chlorophyll a, and Secchi depth are from 2015 through 2024 at primary site 202 only. All other parameters are a composite of all available historical data at all sites.

PARAMETER	HISTORICAL MEAN	ECOREGION RANGE	IMPAIRED WATERS STANDARD[2]	INTERPRETATION
Total Phosphorus (µg/L)	7.7	14 – 27	> 30	Total phosphorus, chlorophyll-*a*, and Secchi depth (transparency) are **better than the expected range** for lakes in the Northern Lakes and Forests ecoregion, indicating good water quality.
[3] **Chlorophyll *a*** (µg/L)	2.2	< 10	> 9	
Max Chlorophyll *a* (µg/L)	5.3	< 15		
Secchi Depth (ft)	20	8 – 15	< 6.5	
Dissolved Oxygen	*See page 16.*	N/A		Dissolved oxygen depth profiles show that **the lake is dimictic**, meaning that it experiences two periods of mixing or turnover per year.
Ammonia Nitrogen (mg/L)	0.05	N/A		Indicates **safe levels** for fish. High ammonia levels can damage fish tissues and potentially lead to death for sensitive species.

[2] For further information regarding the Impaired Waters Assessment program, refer to http://www.pca.state.mn.us/water/tmdl/index.html.

[3] Chlorophyll *a* measurements have been corrected for pheophytin.
Units: 1 mg/L (ppm) = 1,000 µg/L (ppb)

Total Kjeldahl Nitrogen (mg/L)	0.4	< 0.4 – 0.75	**Levels are low**, indicating insufficient levels of nitrogen to support nitrogen-induced algae blooms.
Inorganic Nitrogen (NO_2 + NO_3) (mg/L)	0.2	< 0.01	
Alkalinity (mg/L)	110	40 – 140	Indicates **low sensitivity to acid rain** and a **good buffering capacity**.
Calcium (mg/L)	25	N/A	Indicates **hard water** that is **suitable to zebra mussels**, an invasive species that requires significant amounts of calcium to build and maintain their shells. Ten Mile Lake was listed as infested with zebra mussels in 2019.
Color (Pt-Co Units)	6	10 – 35	Indicates **clear water** with little to no tannins (brown stain).
pH	7.9	7.2 – 8.3	Indicates **hard water**. Lake water with a pH that is less than 6.5 can affect fish spawning and the solubility of metals in the water.
Chloride (mg/L)	1.5	0.6 – 1.2	**Level is low** but indicates some runoff from roads and parking areas.
Total Suspended Solids (mg/L)	3.0	< 1 – 2	Indicates a **low level of suspended particles** like sediment, algae, and other materials in the water column.
Specific Conductance (µS/cm)	210	50 – 250	**Within the expected range** for the Northern Lakes and Forests ecoregion. Specific conductance, also called conductivity, is related to the concentration of dissolved ions in the water.
TN:TP Ratio	30:1	25:1 – 35:1	Indicates that **the lake is phosphorus limited**. This means that phosphorus is the nutrient in shortest supply relative to what algae needs to grow. Increased phosphorus input can directly lead to algal blooms.

Tables 5-7. Water quality means and ranges for Ten Mile Lake from 2015 - 2024.

TOTAL PHOSPHORUS (UG/L)	**202**	203	205	206	210	213
Range (Min – Max)	< 3 - 17	< 3 - 35	< 3 - 23	< 3 - 16	< 3 - 25	< 3 – 14
Number of Observations	94	49	49	49	48	49
Mean	7.7	12.8	9.5	8.0	11.4	7.5

CHLOROPHYLL *A* (UG/L)	**202**	203	205	206	210	213
Range (Min – Max)	< 1 – 5.3	< 1 – 4.5	< 1 – 8.0	< 1 – 6.2	< 1 – 4.9	< 1 – 3.3
Number of Observations	70	48	47	48	48	47
Mean	2.2	2.2	2.5	2.4	2.4	1.8

SECCHI DEPTH (FT)	**ALL**[4]
Range (Min – Max)	12.5 – 26.9
Number of Observations	248
Mean	19.5

Figures 3-6. Ten Mile Lake trophic state index, total phosphorus, chlorophyll a, and Secchi depth historical means and ranges at primary site 202 from 2015 - 2024. The arrows represent the ranges, and the black dots represent the historical means.

[4] Secchi depth data includes sites 102, 202, 204, 205, and 206.
Data obtained from MPCA: https://webapp.pca.state.mn.us/surface-water/impairment/11-0413-00.

TRANSPARENCY SECCHI DEPTH

Transparency is how easily light can pass through a substance. In lakes, it is how deep sunlight penetrates through the water. Plants and algae need sunlight to grow, so they are only able to grow in areas of lakes where the sun penetrates. Water transparency depends on the concentration of particles in the water. An increase in particulates results in a decrease in transparency. The transparency varies year to year due to changes in weather, precipitation, lake use, flooding, temperature, lake levels, etc. (Figure 7).

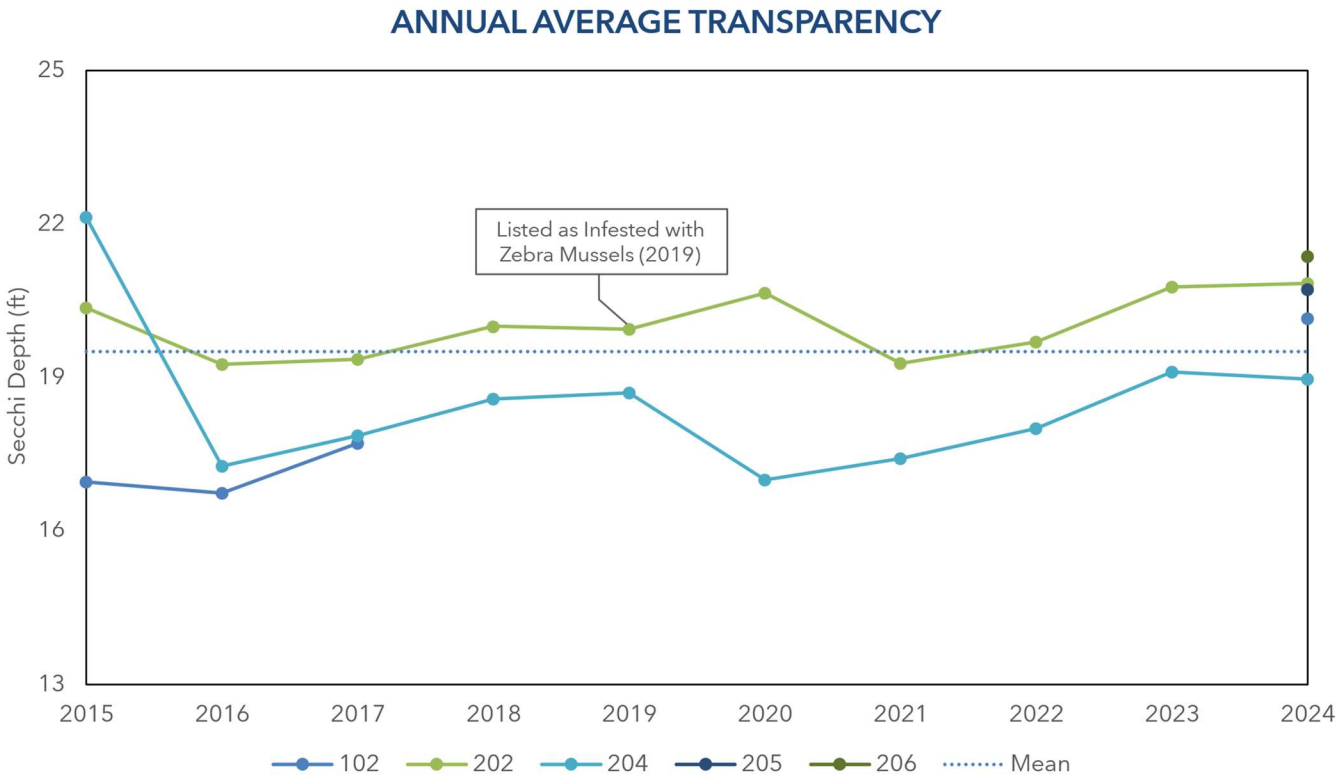


Figure 7. Annual average transparency with long-term mean from 2015 to 2024.

Ten Mile Lake transparency ranges from 12.5 feet to 26.9 feet, with a historical mean of 20 feet at site 202. Of all the sites, primary site 202 has the highest transparency. This can be expected because it is the deepest site and is located in the middle of the main lake basin.

Zebra mussels were confirmed in Ten Mile Lake in 2019 and may contribute to future increases in water clarity by filtering suspended particles from the water column. However, zebra mussels also release nutrients through their waste, which can increase phosphorus availability and contribute to algae blooms under certain conditions. Transparency monitoring should be continued at least monthly at site 202 every summer in order to track future water quality changes.

The water clarity in Ten Mile Lake follows a typical pattern for an oligotrophic Minnesota lake. The maximum Secchi disk readings are usually obtained in early summer, and transparency slightly declines into August and September, but remains relatively high (Figure 8). There are not enough nutrients to fuel late summer algae blooms, which would cause transparency to decline. Lake transparency dynamics are related to algae and zooplankton population interaction and lake turnover.

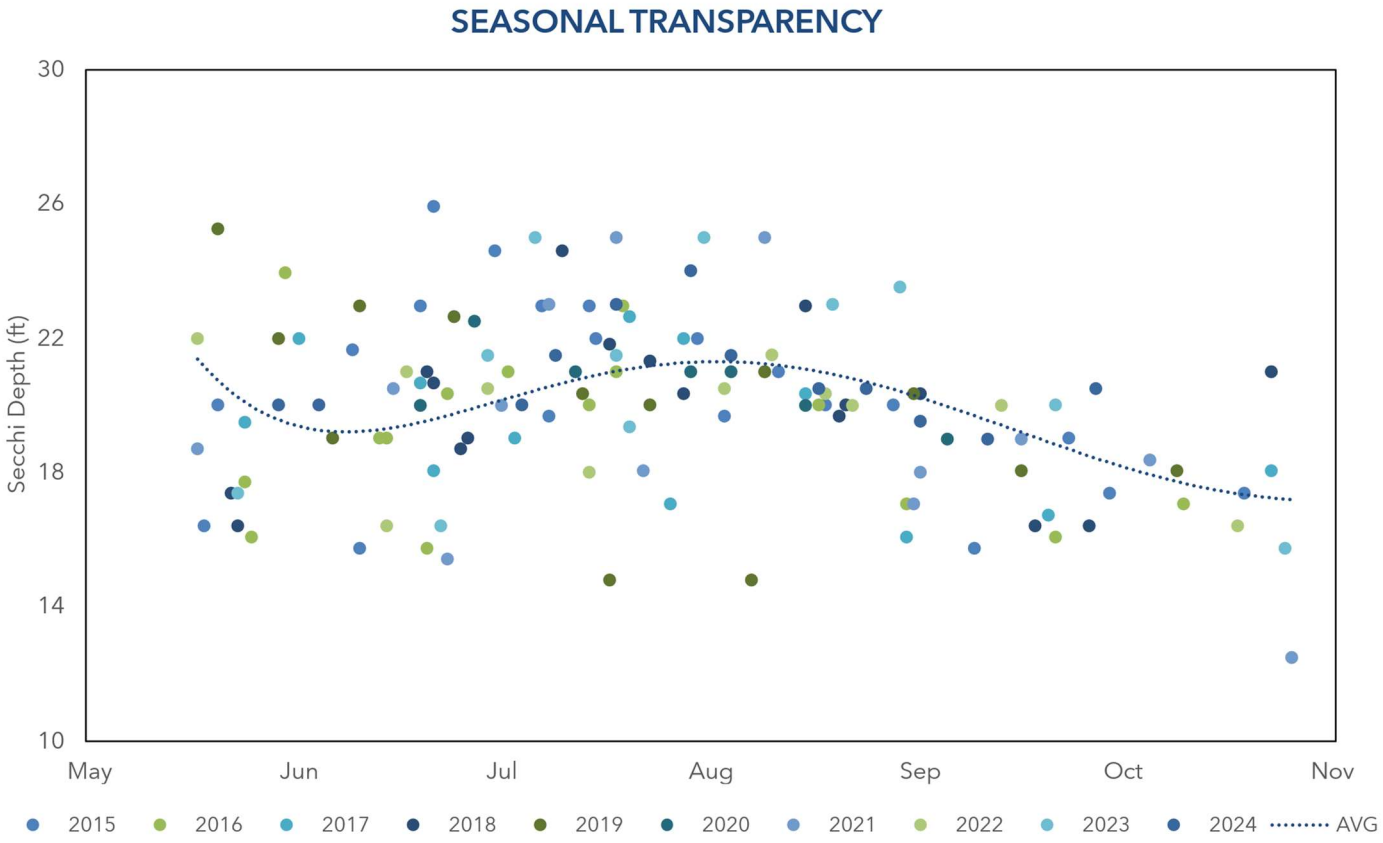


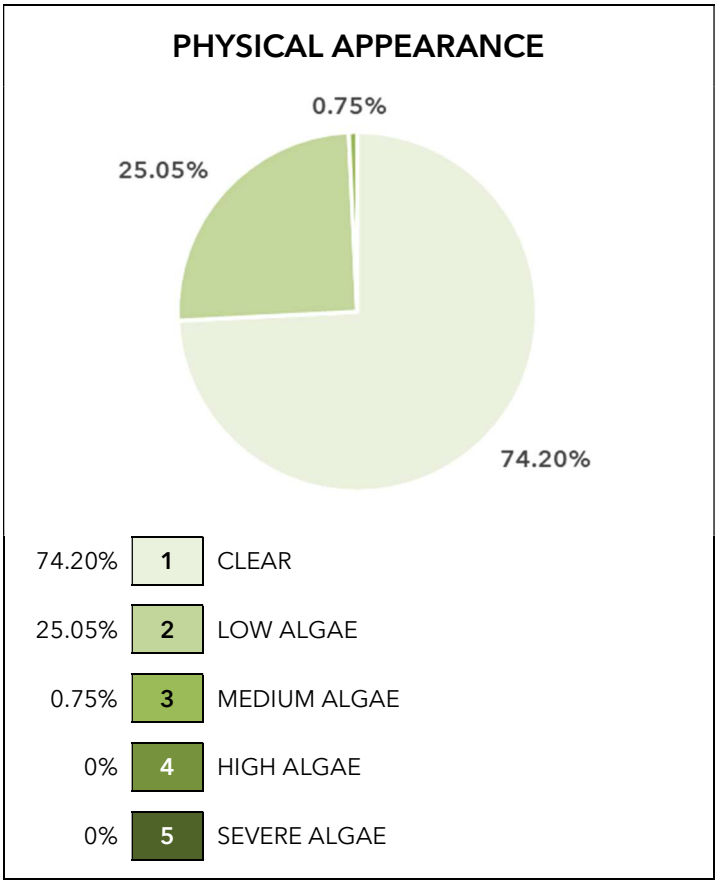
Figure 8. Seasonal transparency dynamics for Ten Mile Lake from 2015 to 2024 at site 202. The dotted line is based on monthly averages across years and represents the seasonal trend.

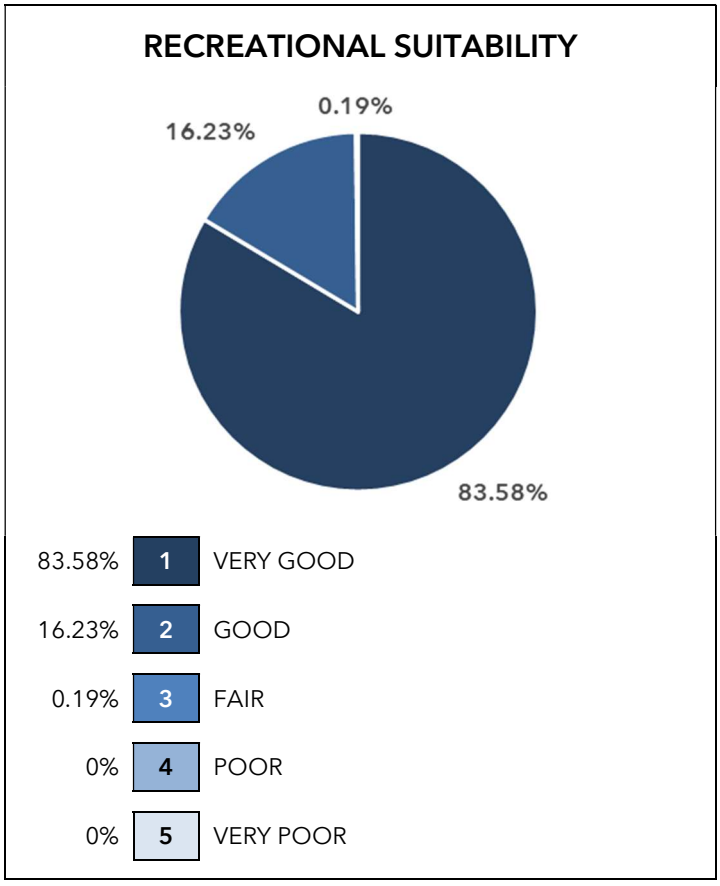
It is important for lake residents to understand the seasonal transparency dynamics in their lake so that they are not worried about why their transparency is lower in August than it is in June. It is typical for a lake to vary in transparency throughout the summer.

USER PERCEPTION RATINGS

When volunteers collect Secchi depth readings, they record their perceptions of the water based on the physical appearance and recreational suitability. These perceptions can be compared to water quality parameters to see how the lake "user" would experience the lake at that time.

As the Secchi depth decreases, perception of the lake's physical appearance and recreational suitability both decrease. At primary site 202, Ten Mile Lake's physical appearance was rated as "clear" 74.2% of the time and recreational suitability was rated as "very good" 83.58% of the time from 1987 to 2024 (Figures 9-10). Ten Mile Lake has clear water and excellent recreational potential.





Figures 9-10. Ten Mile Lake physical appearance and recreational suitability ratings by samplers.

TOTAL PHOSPHORUS

Ten Mile Lake is phosphorus limited, which means that algae and aquatic plant growth is dependent upon available phosphorus. At primary site 202, total phosphorus ranges from <3 µg/L to 17 µg/L, with a historical mean of 7.7 µg/L. The Main Bay consistently has the lowest phosphorus concentrations of all the monitored sites in Ten Mile Lake (Figure 11). This can be expected because the site is 200 feet deep and is located in the middle of the lake. Total phosphorus tends to be higher in the shallower bays, but the data still generally falls within the range expected for a mesotrophic lake.

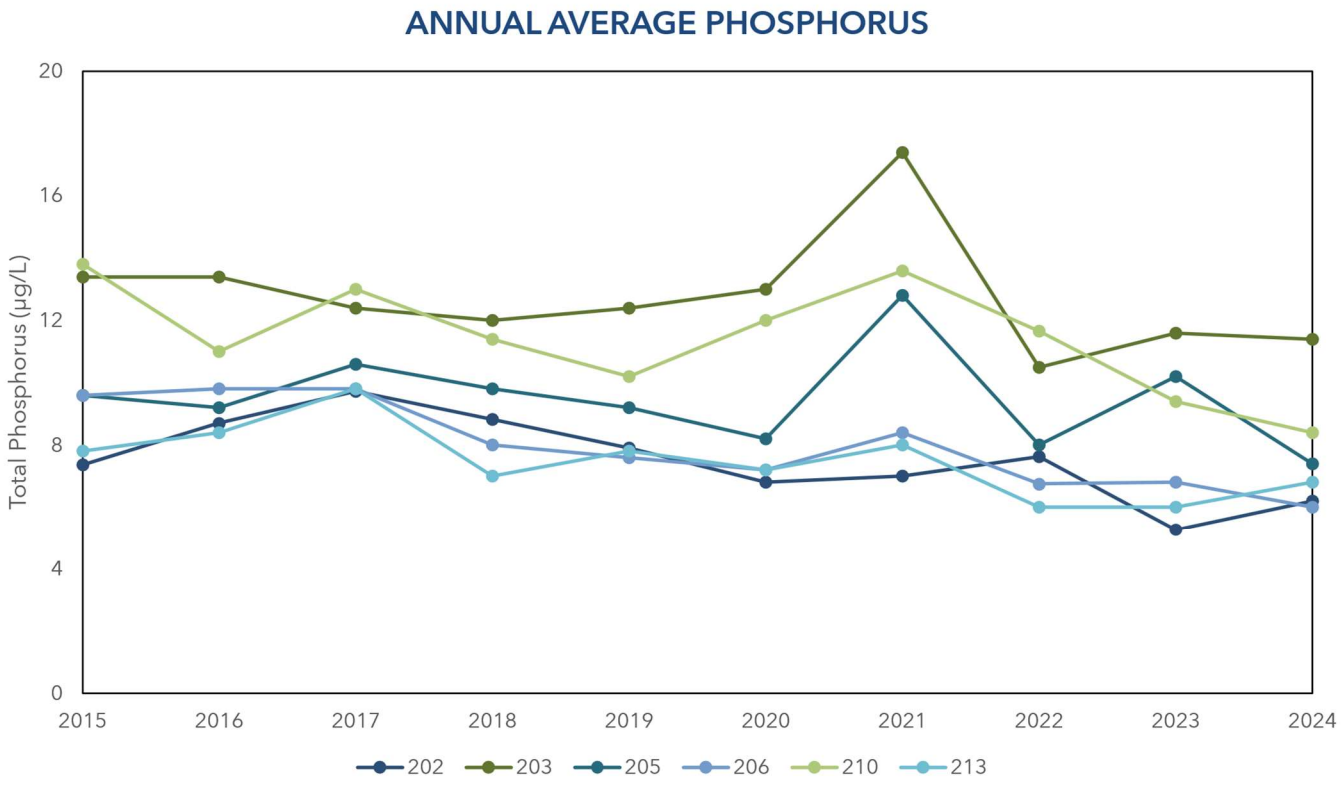


Figure 11. Site comparison of annual average total phosphorus concentrations (µg/L) in Ten Mile Lake from 2015 - 2024.

Zebra mussels may begin to impact phosphorus cycling by filtering suspended particles and excreting nutrients. This can increase phosphorus concentrations near the lake bottom and contribute to internal loading, especially in shallow areas. Total phosphorus monitoring should continue to track any future changes in water quality.

CHLOROPHYLL *A*

Chlorophyll is the pigment that makes plants and algae green. Chlorophyll *a* is tested in lakes to determine the algae concentration or how "green" the water is. Chlorophyll *a* concentrations greater than 10 µg/L are perceived as a mild algae bloom, while concentrations greater than 20 µg/L are perceived as a nuisance.

At primary site 202, chlorophyll *a* ranges from <1 µg/L to 5.3 µg/L, with a historical mean of 2.2 µg/L. All of the bays have very low chlorophyll *a* concentrations, indicating clear water throughout the entire lake (Figure 12). The highest concentration ever recorded in Ten Mile Lake was 8.86 µg/L, which is still below the minor algae bloom theshold of 10 µg/L.

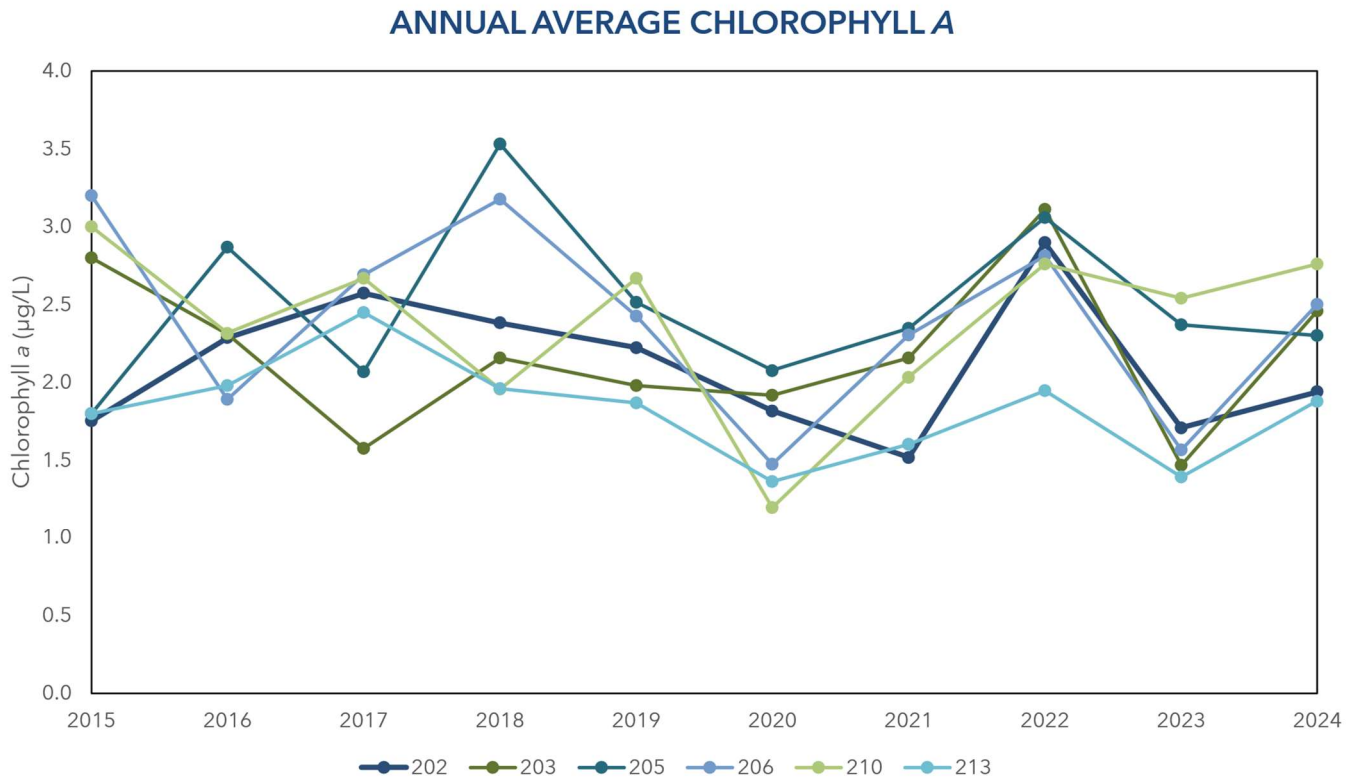


Figure 12. Site comparison of annual average chlorophyll a concentrations (µg/L) for Ten Mile Lake from 2015 - 2024.

Even during the warm summer months, chlorophyll *a* concentrations remain very low in Ten Mile Lake. There is a slight peak in August, but levels remain well below the minor algae bloom threshold of 10 µg/L (Figure 13). Chlorophyll *a* monitoring should continue to track any future changes in water quality.

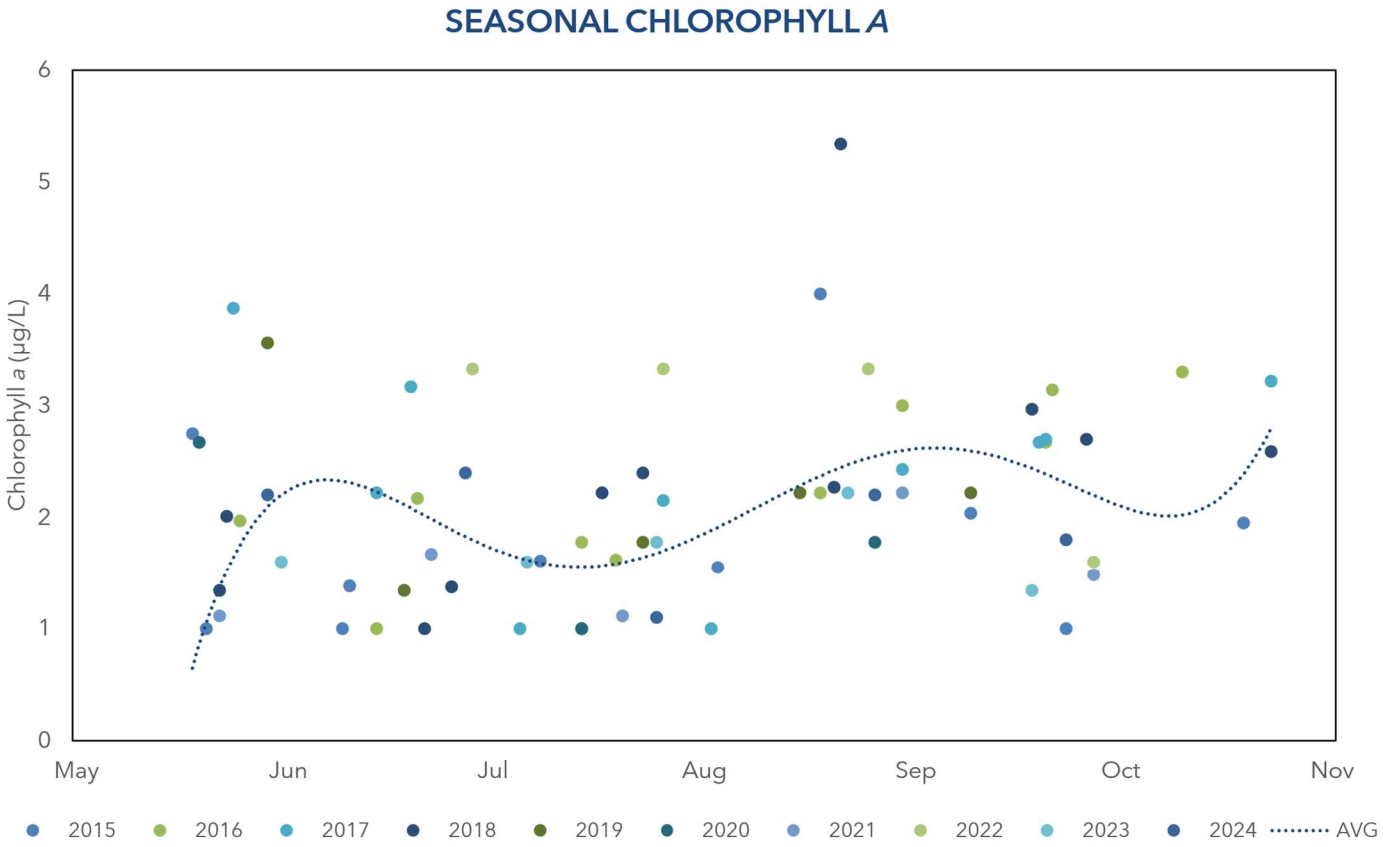


Figure 13. Seasonal chlorophyll a dynamics for Ten Mile Lake from 2015 to 2024 at site 202. The dotted line is based on monthly averages across years and represents the seasonal trend.

DISSOLVED OXYGEN

Dissolved Oxygen (DO) is the amount of oxygen dissolved in lake water. Oxygen is necessary for all living organisms to survive except for some bacteria. Living organisms breathe in oxygen that is dissolved in the water. Dissolved oxygen levels of <5 mg/L are typically avoided by game fisheries.

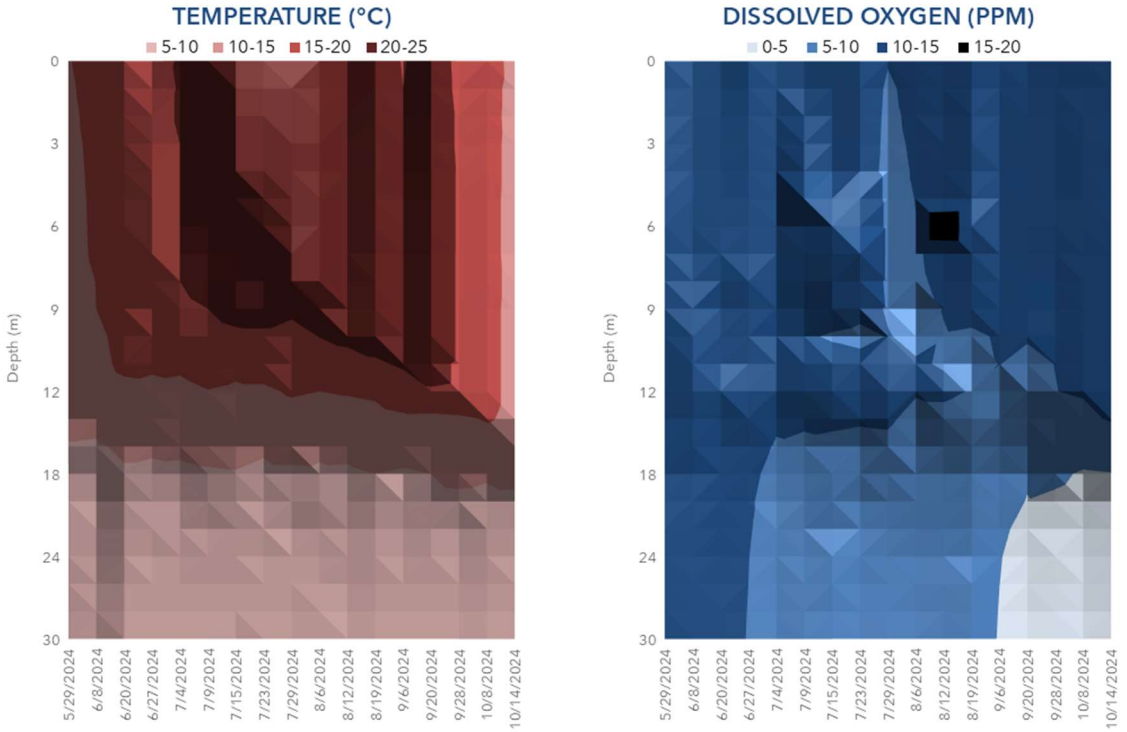
Figure 14. Cisco (MN DNR).

Ten Mile Lake is a deep lake, with a maximum depth of 208 feet. Dissolved oxygen profiles from data collected in 2024 show stratification developing in June (Figure 17). However, oxygen levels in the hypolimnion stay high until late August. Based on 2024 data, the lake is still stratified into late September.

Figure 15. Lake Whitefish (MN DNR).

The oxygen shows an interesting pattern in that it is highest from 8-12.5 meters (26-41 feet). This pattern is called a Metalimnetic Oxygen Maxima. It is caused by algae producing oxygen in that area of 26-46 feet deep. This pattern is usually only observed in lakes with good transparency and a very strongly stratified deep basin, which applies to site 202 in Ten Mile Lake.

Because oxygen levels remain over 5 mg/L in the hypolimnion for most of the summer, Ten Mile Lake is good habitat for cold water fish species such as Cisco (Figure 14). In fact, Ten Mile Lake is considered a Tier 1 Cisco refuge lake by the Minnesota DNR. Cisco require cold, oxygenated water to survive, and the loss of Cisco can indicate eutrophication in lakes. Ten Mile Lake also supports a lake whitefish population, which also requires cold, well-oxygenated water (Figure 15).



Figures 16-17. 2024 temperature and dissolved oxygen profile isopleths for Ten Mile Lake at site 202.

TROPHIC STATE INDEX

Trophic State Index (TSI) is a standard measure or means for calculating the trophic status or productivity of a lake. More specifically, it is the total weight of living algae (algae biomass) in a waterbody at a specific location and time. Three variables – chlorophyll *a*, Secchi depth, and total phosphorus – independently estimate algal biomass.

Phosphorus (nutrient), chlorophyll *a* (algal concentration), and Secchi depth (transparency) are related. As phosphorus increases, there is more food available for algae, resulting in increased algal concentrations. When algal concentrations increase, the water becomes less transparent, and the Secchi depth decreases. If all three TSI numbers are within a few points of each other, they are strongly related. If they deviate from one another, there are other dynamics influencing the lake's productivity, and TSI mean should not be reported for the lake.

It is important to understand that Trophic States are defined divisions of a continuum in phosphorus and algal concentration. The TSI ranges from 0-100. 0-30 is Oligotrophic, where water is very clear, phosphorus is low, and algae is sparse. 30-50 is an in-between stage where the number of aquatic plants algae increase due to more available phosphorus (Table 8).

Trophic State Index is not necessarily interchangeable with water quality. Water quality is subjective and depends on how you intend to use the water body. A lake that is good for duck hunting may not be good for water skiing. Likewise, a lake that is great for swimming may not be great for bass fishing.

Table 8. Trophic states and corresponding lake and fisheries conditions.[5]

TSI	ATTRIBUTES	FISHERIES & RECREATION
< 30	**OLIGOTROPHIC:** Clear water, oxygen throughout the year at the bottom of the lake, very deep cold water.	Trout fisheries dominate.
30 - 40	Bottom of shallower lakes may become anoxic (no oxygen).	Trout fisheries in deep lakes only. Walleye, Tullibee present.
40 - 50	**MESOTROPHIC:** Water moderately clear most of the summer. May be "greener" in late summer.	No oxygen at the bottom of the lake results in loss of trout. Walleye may predominate.
50 - 60	**EUTROPHIC:** Algae and aquatic plant problems possible. "Green" water most of the year.	Warm-water fisheries only. Bass may dominate.
60 - 70	Blue-green algae dominate, algal scums and aquatic plant problems.	Dense algae and aquatic plants. Low water clarity may discourage swimming and boating.
70 - 80	**HYPEREUTROPHIC:** Dense algae and aquatic plants.	Water is not suitable for recreation.
> 80	Algal scums, few aquatic plants.	Rough fish (carp) dominate; summer fish kills possible.

[5] Adapted from Carlson, R.E. 1997. A trophic state index for lakes. *Limnology and Oceanography*. 22:361-369.

The mean TSI for Ten Mile Lake falls into the oligo-mesotrophic range. There is good agreement between the TSI for all three parameters, indicating that these variables are strongly related (Table 9). When all the TSI values are within less than five points of each other, it indicates that the lake is most likely phosphorus limited and that most of the light attenuation is by algae. The greater the deviation between the TSI parameters, the greater the probability that something other than phosphorus limits algae growth.

The best indicator of lake trophic state is not the average TSI, but the TSI for chlorophyll *a* (Carlson 1983). This value shows how much production the lake's nutrients are fueling. The chlorophyll *a* TSI value is in the mid-30s, which shows oligo-mesotrophic conditions.

Table 9. Trophic State Index for Ten Mile Lake, based on data collected between June and September from 2015 to 2024.

PARAMETER	TROPHIC STATE INDEX (TSI)	TROPHIC STATE
Total Phosphorus	35	Oligo-mesotrophic
Chlorophyll *a*	38	Oligo-mesotrophic
Transparency	34	Oligo-mesotrophic
Mean	36	Oligo-mesotrophic

Oligo-mesotrophic lakes are characteristic of extremely clear water throughout the summer and sandy or rocky shores. They are excellent for recreation. Some very deep oligo-mesotrophic lakes are able to support a trout fishery. Ten Mile Lake supports healthy cisco (tullibee) and whitefish populations due to the deep, cold nature of the lake.

Figure 18. Trophic state index chart with corresponding trophic status for Ten Mile Lake (Mean TSI = 36).

TREND ANALYSIS

For detecting trends, a minimum of 8-10 years of consecutive data with 4 or more readings per season is recommended. The minimum confidence accepted by the Minnesota Pollution Control Agency is 90%. This means that there is a 90% chance that the data are showing a true trend and a 10% chance that the trend is a random result of the data. Only short-term trends can be determined with just a few years of data because there can be different wet years and dry years, water levels, weather, etc., that affect the water quality naturally.

Ten Mile Lake had sufficient data available to perform a trend analysis for phosphorus, chlorophyll-*a*, and transparency at the primary site (Table 10). The data was analyzed using the Mann-Kendall Statistical Analysis.

Table 10. 10-year trend analysis for Ten Mile Lake at primary site 202.

SITE	PARAMETER	DATE RANGE	TREND	PROBABILITY
202	**Total Phosphorus**	2015 - 2024	Decreasing	99.9%
202	**Chlorophyll *a***	2015 - 2024	No significant trend exists	N/A
202	**Transparency**	2015 - 2024	No significant trend exists	N/A

Ten Mile Lake shows evidence of decreasing total phosphorus over the last 10 years of data with 99.9% confidence. No significant trends exist for chlorophyll *a* and transparency from 2015 to 2024, indicating stable water quality (Table 10). Continued monitoring will allow these trends to be tracked into the future.

LAKESHED VITALS

The lakeshed vitals table identifies where to focus organizational and management efforts for the lake (Table 11). Criteria were developed using limnological concepts to determine the effect on lake water quality.

KEY

- Possibly detrimental to the lake
- Warrants attention
- Beneficial to the lake
- Descriptive

Table 11. Ten Mile Lake lakeshed vitals.

LAKESHED VITALS		RATING
Lake Area	5,080.43 acres	
Littoral Zone Area	1,316 acres	
Lake Max Depth	208 ft (63.4 m)	
Lake Mean Depth	53 ft (16.2 m)	
Water Residence Time	13.2 years	
Miles of Stream	0.43	
Inlets	0	
Outlets	1 – Boy River	
Major Watershed	Leech Lake River	
Ecoregion	Northern Lakes & Forests	
Total Lakeshed to Lake Area Ratio[6]	3.5:1	
Standard Watershed to Lake Basin Ratio[7]	5:1	
Wetland Coverage	9.5%	
Aquatic Invasive Species	Zebra Mussel, Chinese Mystery Snail, Banded Mystery Snail, Purple Loosestrife	
Public Drainage Ditches	None	
Public Lake Accesses	1	
Miles of Shoreline	24.83	
Shoreline Development Index	2.5	
Public Land to Private Land Ratio	1.7:1	
Development Classification	General Development	
Miles of Road	34.4	
Municipalities in Lakeshed	None	
Forestry Practices	None within 200 feet from shore	
Feedlots	None	
Sewage Management	Individual waste treatment systems	
Lake Management Plan	Current: 2019 – 2021, http://www.tenmilelake.org/	
Lake Vegetation Survey / Plan	Survey completed July 2008	

[6] Total lakeshed includes lake area
[7] Standard watershed includes lake areas

LAND COVER / LAND USE

The activities that occur on the land within the lakeshed can greatly impact a lake. Land use planning helps ensure the use of land resources in an organized fashion so that the needs of present and future generations can be best addressed. The basic purpose of land use planning is to ensure that each area of land will be used in a manner that provides maximum social benefits without degradation of the land resource.

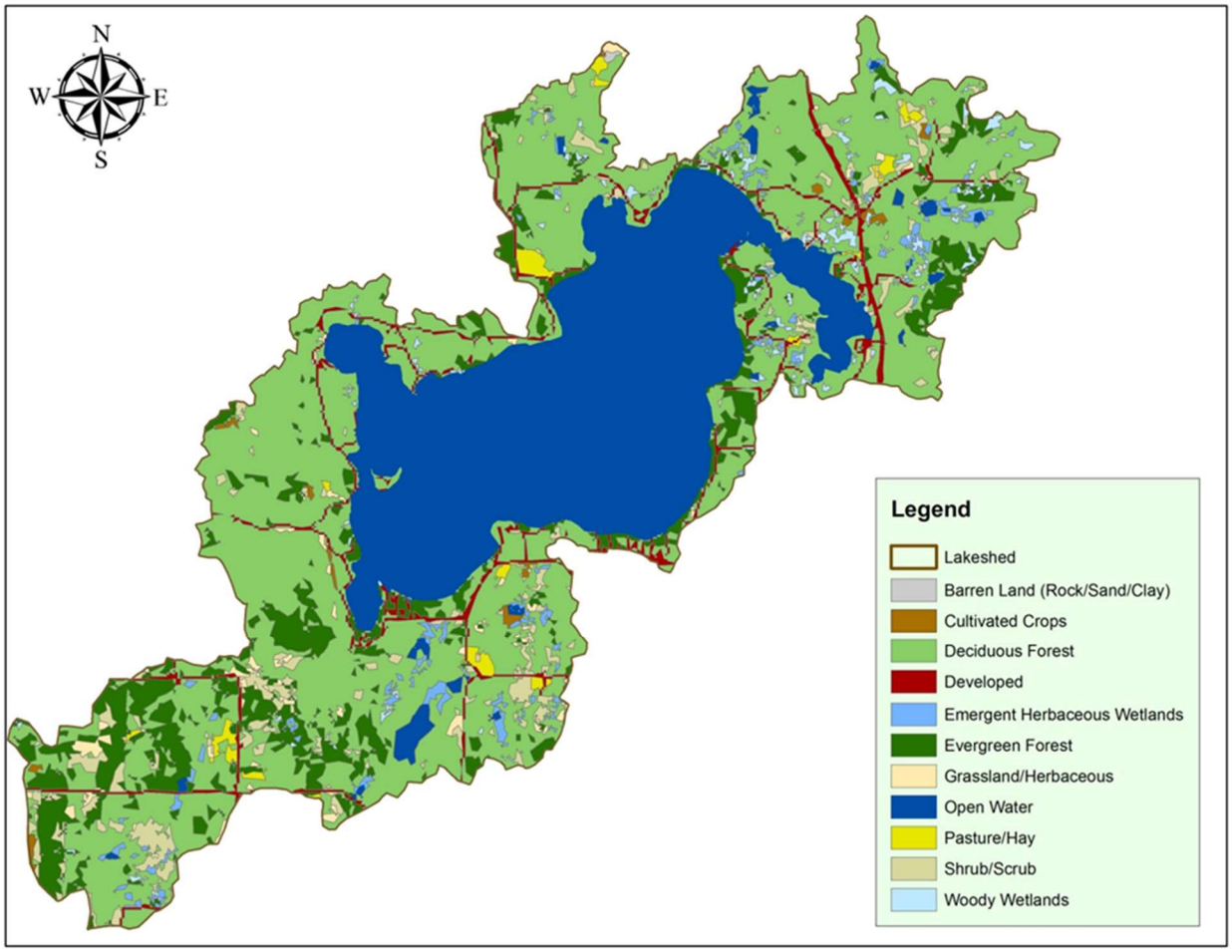


Figure 19. Land use in the Ten Mile Lake lakeshed (801900). Data source: 2011 National Land Cover Data Set.

Table 12. Ten Mile Lake lakeshed land cover.

LAND COVER	ACRES	PERCENTAGE
Cultivated Crops	68.8	0.4%
Deciduous Forest	8,471.7	48.0%
Emergent Herbaceous Wetlands	251.6	1.4%
Evergreen Forest	1,896.5	10.7%
Grassland/Herbaceous	174.9	1.0%
Open Water	5,199.7	29.5%
Pasture / Hay	167.1	0.9%
Shrub / Scrub	622.4	3.5%
Woody Wetlands	221.4	1.3%
Developed	574.9	3.3%

The majority of the Ten Mile Lake Lakeshed is covered by forests (Table 12). This is the best land use for protecting water quality. Only a very small percentage of land use includes developed and cultivated crops, which have the highest phosphorus export of the land use categories (Tables 12-13).

LAKESHED WATER QUALITY PROTECTION STRATEGY

Each lakeshed has a different makeup of public and private lands. Looking in more detail at the makeup of these lands can give insight on where to focus protection efforts. The protected lands (easements, wetlands, public land) are the future water quality infrastructure for the lake. Developed land and agriculture have the highest phosphorus runoff coefficients, so this land should be minimized for water quality protection.

Most of the privately-owned land within Ten Mile Lake's lakeshed is forested (Table 13). This land can be the focus of development and protection efforts in the lakeshed.

Table 13. Land ownership, land use/land cover, estimated phosphorus loading, and ideas for protection and restoration in the lakeshed (Sources: County parcel data and the 2011 National Land Cover Dataset)

	PRIVATE (42.3%)					34.6%	**PUBLIC** (23.1%)		
	DEVELOPED	**AGRICULTURE**	**FORESTED UPLANDS**	**OTHER**	**WETLANDS**	**OPEN WATER**	**COUNTY**	**STATE**	**FEDERAL**
LAND USE (%)	1.9%	0.2%	35.1%	3.5%	1.6%	34.6%	0%	14.3%	8.8%
RUNOFF COEFFICIENT LBS OF PHOSPHORUS/ ACRE/YEAR	0.45 – 1.5	0.26 – 0.9	0.09		0.09		0.09	0.09	0.09
DESCRIPTION	Focused on Shoreland	Cropland	Focus of development and protection efforts	Open pasture, grass-land, shrub-land	Protected				
IDEAS FOR PROTECTION AND RESTORATION	Shoreline restoration	Restore wetlands, CRP	Forest stewardship planning		Protected by Wetland Conservation Act		County Tax Forfeit Lands	State Forest	National Forest

DNR FISHERIES APPROACH FOR LAKE PROTECTION & RESTORATION

Credit: Peter Jacobson and Michael Duval, Minnesota DNR Fisheries

In an effort to prioritize protection and restoration efforts of fishery lakes, the MN DNR has developed a ranking system by separating lakes into two categories: those needing protection and those needing restoration. Modeling by the DNR Fisheries Research Unit suggests that total phosphorus concentrations increase significantly over natural concentrations in lakes that have watershed with disturbance greater than 25%. Therefore, lakes with watersheds that have less than 25% disturbance need protection and lakes with more than 25% disturbance need restoration (Table 14). Watershed disturbance was defined as having urban, agricultural and mining land uses. Watershed protection is defined as publicly owned land or conservation easement.

Table 14. Suggested approaches for watershed protection and restoration of DNR-managed fish lakes in Minnesota.

Watershed Disturbance (%)	Watershed Protected (%)	Management Type	Comments
< 25%	> 75%	**Vigilance**	Sufficiently protected – Water quality supports healthy and diverse native fish communities. Keep public lands protected.
	< 75%	**Protection**	Excellent candidates for protection – Water quality can be maintained in a range that supports healthy and diverse native fish communities. Disturbed lands should be limited to less than 25%.
25-60%	N/A	**Full Restoration**	Realistic chance for full restoration of water quality and improve quality of fish communities. Disturbed land percentage should be reduced and BMPs implemented.
> 60%	N/A	**Partial Restoration**	Restoration will be very expensive and probably will not achieve water quality conditions necessary to sustain healthy fish communities. Restoration opportunities must be critically evaluated to assure feasible positive outcomes.

The next step was to prioritize lakes within each of these management categories. DNR Fisheries identified high value fishery lakes, such as cisco refuge lakes. Ciscos (*Coregonus artedi*) can be an early indicator of eutrophication in a lake because they require cold hypolimnetic temperatures and high dissolved oxygen levels. These watersheds with low disturbance and high value fishery lakes are excellent candidates for priority protection measures, especially those that are related to forestry and minimizing the effects of landscape disturbance. Forest stewardship planning, harvest coordination to reduce hydrology impacts, and forest conservation easements are some potential tools that can protect these high value resources for the long term.

Ten Mile Lake's lakeshed is classified with having just over 75% of the watershed protected and 3.7% of the watershed disturbed (Figure 20). The lake is over the 75% protected threshold, so this lakeshed should have a vigilance focus. Goals for the lake should be to limit any increase in disturbed land use. Ten Mile Lake has three other lakesheds flowing into it, but they are well protected (Figure 21).

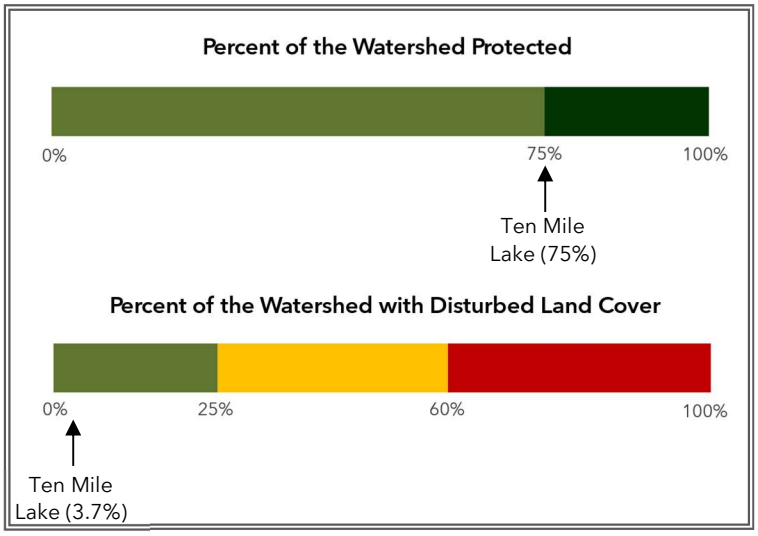


Figure 20. Ten Mile Lake lakeshed percentage of watershed protected and disturbed.

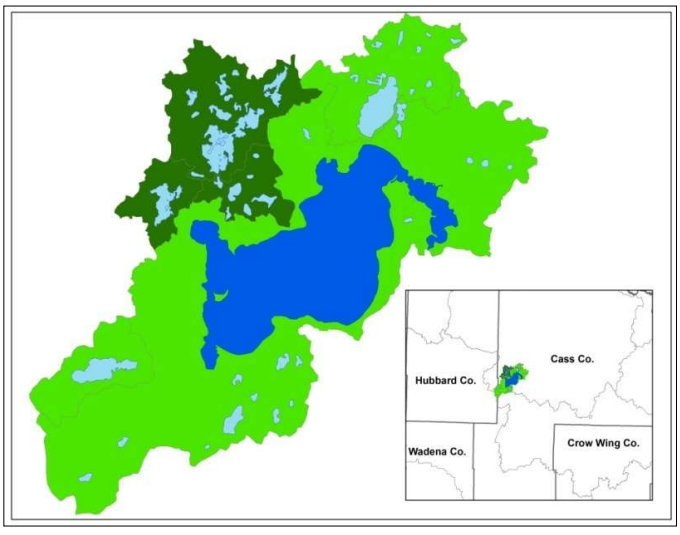


Figure 21. Lakesheds that contribute water to the Ten Mile Lake lakeshed, color-coded based on management focus (Table 14).

CONSERVATION EASEMENT POTENTIAL

In an ever-growing society, today's landscapes are being urbanized more and more to sustain the ever-growing population and behavior of recreational usage. In Minnesota, the land of ten thousand lakes, it is only natural to develop properties within the boundaries and beauty of our lakes and streams. Conservation efforts to limit or slow down the development process can only assist in the preservation of the lakeshed and inevitably the water quality of water bodies found within. Figure 22 identifies parcels within the lakeshed that are large enough to warrant the investigation of parcel conservation practices and purchase. This map was created in 2008, so some of these parcels may have already been enrolled into conservation easements, such as the ones on Lundstrom's Bay.

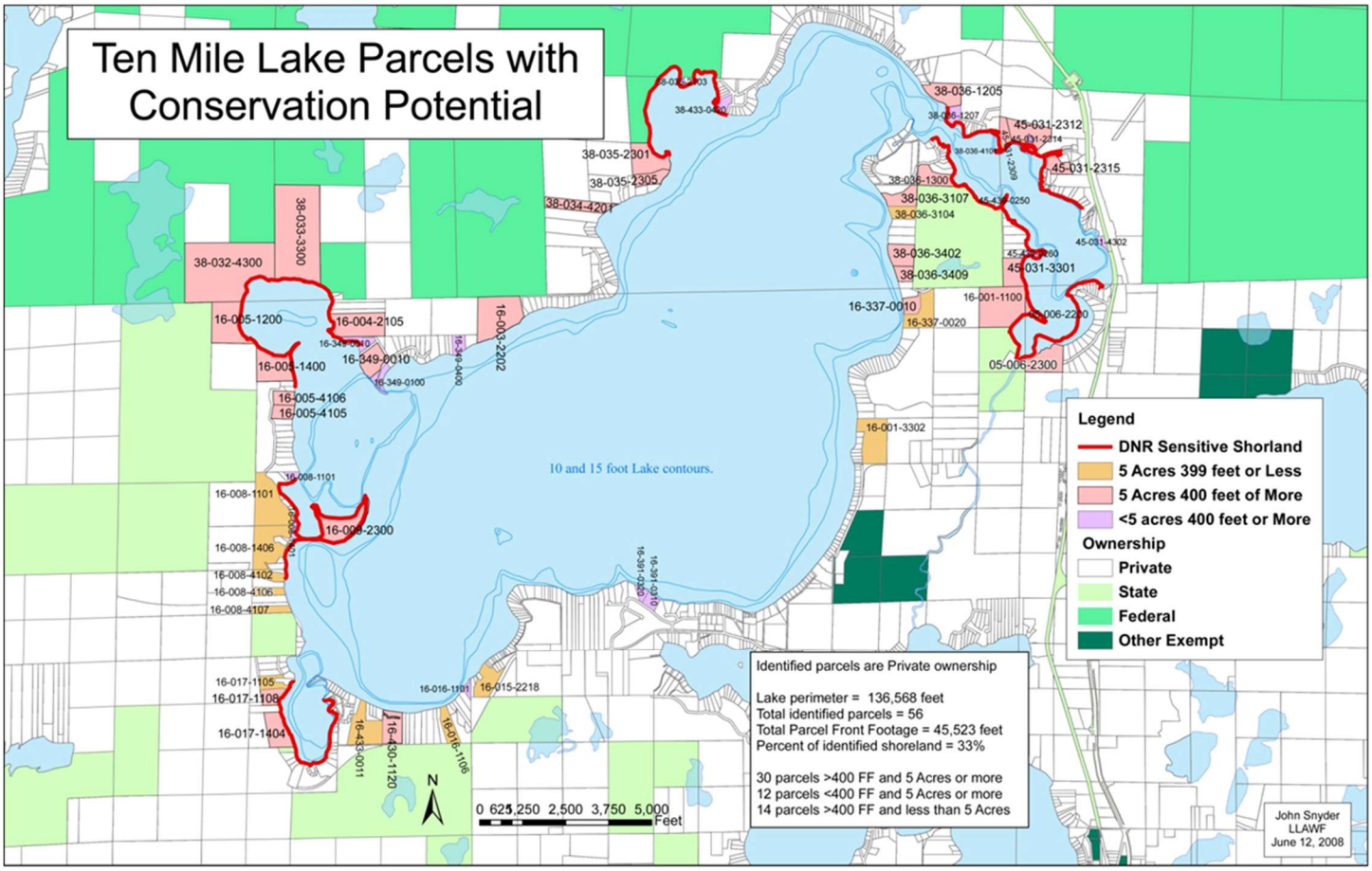


Figure 22. Lake parcels with conservation potential (developed by John Snyder, LLAWF, 2008).

STATUS OF THE FISHERY (MN DNR)

Ten Mile Lake is a 5,080-acre lake with 24.8 miles of shoreline and a maximum depth of 208 feet located north of Hackensack, MN. A Minnesota Department of Natural Resources (MNDNR) owned public access is located on the western shore. The DNR has classified Minnesota's lakes into 43 different classes based on physical, chemical and other characteristics. Ten Mile Lake is in Lake Class 22; lakes in this class are generally clear, large, deep lakes with a low percentage of shallow water area and have very irregularly shaped shorelines with many bays or points. Other area lakes in this class include Little Boy, Steamboat, and Wabedo lakes. The lake is primarily managed for Largemouth Bass, Northern Pike, Smallmouth Bass and Walleye and secondarily for Bluegill, Black Crappie, Lake Whitefish, Tullibee (Cisco), and Yellow Perch. A standard survey was completed on Ten Mile Lake in 2024.

Northern Pike abundance was comparable to previous surveys meeting the management goal (<10 fish per net). Sampled pike ranged in length from 10 to 33 inches with an average length of 18.5 inches. Walleye abundance was comparable to the 2021 survey, though catch rates show a declining trend since 2013 and fell below the management goal (six fish per net). Walleye ranged in length from 7 to 28.5 inches with an average length of 18.5 inches. Largemouth and Smallmouth Bass provide additional quality fishing opportunities to anglers. Largemouth Bass measuring up to 18 inches and Smallmouth Bass measuring 19 inches long were sampled. Additional sampling targeting these species is required to develop management goals. Yellow Perch populations persist at low abundance and generally consist of small fish. Lake Whitefish are present with fish up to 20 inches sampled. Bluegill abundance was below the management goal with fish up to 8 inches sampled, and moderate numbers of Black Crappie up to 13 inches were present in catch.

Other fish species sampled include Bowfin (dogfish), Brown Bullhead, Hybrid Sunfish, Pumpkinseed, Rock Bass, White Sucker, and Yellow Bullhead.

People can have significant impacts on lakes and the fish populations they support. Harvest, lakeshore development, removal of shoreline vegetation, and introductions of invasive species can all adversely affect fish populations. Currently the aquatic invasive species (AIS) that have been identified in Ten Mile Lake include Zebra Mussels, Chinese Mystery Snail and Purple Loosestrife. AIS are moved from infested to non-infested waters by anglers, boaters, and lake shore owners and can adversely impact lakes and fish populations. To avoid spreading AIS, lake users are required to remove all aquatic plants or animals from their watercraft and drain all water from their boat before leaving the access. If you suspect an infestation of an invasive species in this lake, save a specimen and report it to a local natural resource office. Additional information on all of these topics can be found on the DNR website (www.dnr.state.mn.us) or by contacting the Walker Area Fisheries office.

Source: Minnesota Department of Natural Resources, 8/26/2024.

WATER LEVELS

Ten Mile Lake is groundwater fed, so its water levels can be tied to groundwater and precipitation.

Table 15. Ten Mile Lake water level data.

Period of Record	11-12-1973 to 11-1-2024
Number of Readings	1985
Highest Recorded	1380.23 ft (6-14-2001)
Lowest Recorded	1377.49 ft (11-23-1976)
Recorded Range	2.74 ft
Ordinary High Water Level (OHW) Elevation	1379.9 ft
Datum	NGVD 29 (ft)

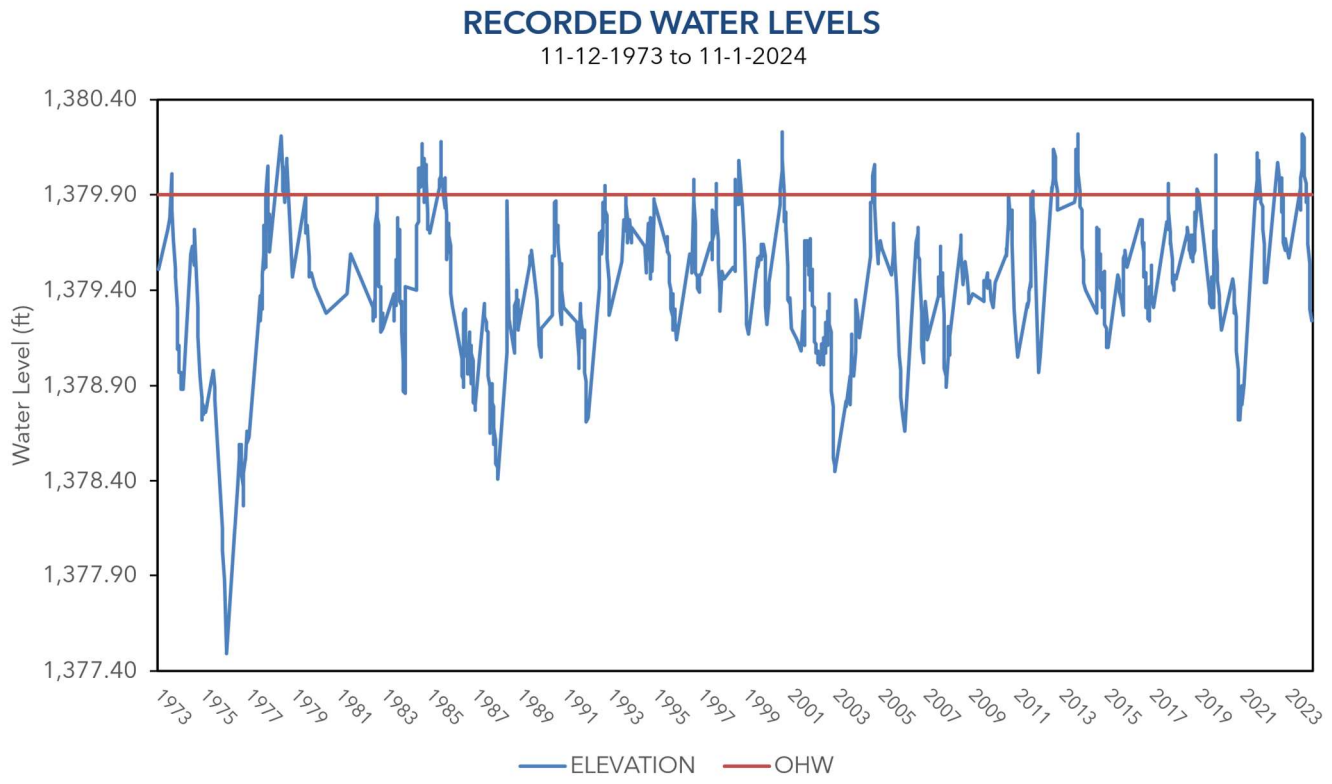


Figure 23. Ten Mile Lake water levels from 1973 to 2024. The red line represents the ordinary high water mark.[8]

[8] Data obtained from MN DNR: https://www.dnr.state.mn.us/lakefind/showlevel.html?id=11041300.

GROUND WATER & DRINKING WATER

Ten Mile Lake Association has completed six drinking water studies with RMB Environmental Laboratories. On July 18, 2015, 60 wells were tested, on July 15, 2017, 64 wells were tested, and on July 5, 2018, RMB staff collected samples from 5 wells and samples were tested. On August 12, 2019, 78 wells were tested. On July 10, 2021, 85 wells were tested. On July 15, 2023, 79 wells were tested. Another drinking water study will take place in July 2025.

Samples in 2015, 2017, 2019, 2021, and 2023 were collected by individual property owners. All of these samples were received on the same day they were collected, so they all met the necessary holding time for laboratory analysis. All results were sent to the association to be distributed to the property owners. Below is a summary of the most recent project results in total.

NITRATES

The EPA's allowable safe limit is 10 mg/L. All the Ten Mile Lake property owner samples were well below the EPA's allowable safe limit for nitrates in 2015, 2017, 2018, 2019, 2021, and 2023. In fact, all the results in 2023 were under 1 mg/L except for 1 property, which was 2.02 mg/L.

BACTERIA

The Total Coliform Bacteria test is a presence/absence test. Of the 79 tests in 2023, 5 tested positive for Coliform Bacteria. These 5 samples were then tested for E.coli bacteria, and those results were negative.

KEY FINDINGS & RECOMMENDATIONS

MONITORING RECOMMENDATIONS

Transparency, total phosphorus, and chlorophyll *a* monitoring at site 202 should be continued annually to track trends in water quality. The surrounding small bays can be monitored periodically to detect and track any water quality changes. No major changes have been detected over the past few years.

Since Ten Mile Lake is at least 50% groundwater fed, implementation of groundwater monitoring should continue. In the past, groundwater was monitored from designated well locations around the lake. Additional drinking water monitoring for arsenic levels should also be implemented. The area is known to have arsenic in drinking water, which is unsafe at any level.

OVERALL SUMMARY

Ten Mile Lake is an oligo-mesotrophic lake (TSI = 36) with evidence of a stable or improving water quality trends (Table 10). Total phosphorus, chlorophyll *a*, and transparency are better than expected ranges for lakes in the Northern Lakes and Forests ecoregion (Table 4). Ten Mile Lake is an exceptional water resource in Minnesota. It is one of the deepest lakes in the state and has some of the best water quality. Even the shallow bays surrounding the main lake have TSI values in the high 30s to low 40s, which indicate excellent water quality.

Only three percent (3.7%) of the Ten Mile Lake lakeshed is disturbed by development and agriculture (Figure 20). The threshold of disturbance where water quality tends to decline is 25%. Ten Mile Lake is well under this threshold. Nearly a third of the lakeshed is publicly owned, which protects that land from development (Table 13). Three quarters (75%) of the lakeshed is protected, which will help protect and maintain water quality.

Ten Mile Lake has the advantage of a very small watershed, with a 5:1 watershed to lake area ratio. The lake does not have any major inlets or rivers flowing into it, which means that it is primarily groundwater fed. The MPCA reported that Ten Mile Lake receives approximately 50% of its water from groundwater (1991 Hydraulic Assessment). The lake's natural outlet, the Boy River, helps alleviate any high water level issues that could cause shoreline erosion and damage.

Because of the small watershed and lack of major inlets, the priority impact to Ten Mile Lake is the land practices around the shoreline. Impervious surface and turfgrass lawns export nutrients during rain events directly into the lake through runoff. Much of the private land around the lake has been developed in the first tier, but most of the second tier remains in large parcels and has not been subdivided for development (Figure 22).

The Ten Mile Lake Association does an outstanding job with lake stewardship and water quality protection. They are involved in promoting conservation easements for land protection and septic system checks for residents. These practices will be effective for protecting the lake's excellent water quality into the future. Sensitive shoreline areas shown in Figure 22 should be the first priority for protection.

BEST MANAGEMENT PRACTICES RECOMMENDATIONS

The management focus for Ten Mile Lake should be to protect the current water quality and lakeshed. Efforts should be focused on managing and/or decreasing the impact caused by additional development and impervious surface area on existing lots.

Current lakeshore homeowners can decrease their impact on water quality by planting or maintaining the existing trees on their properties. Forested uplands contribute significantly less phosphorus (lbs/acre/year) than developed land cover (Table 13). Native plant buffers can be installed along shorelines to filter nutrients from the runoff reaching the water's edge. Septic systems should be pumped and inspected regularly.

The Ten Mile Lake lakeshed still has large undeveloped shoreline parcels (Figure 22). Because a lot of undeveloped private land still exists, there is a great potential for protecting this land with conservation easements and aquatic management areas (AMAs). Conservation easements can be set up easily and with little cost with help from organizations such as the Board of Soil and Water Resources and the Minnesota Land Trust. AMAs can be set up through the local DNR fisheries office.

Property owners who own large, forested tracts of land can work with the Soil and Water Conservation District or the Minnesota Forest Resources Council to set up forest stewardship plans. These plans help ensure the long-term health of the forest and the lake.

PROJECT IMPLEMENTATION

The best management practices above can be implemented by a variety of entities. Some possibilities are listed below.

Table 16. Best management practice project ideas for Ten Mile Lake.

INDIVIDUAL PROPERTY OWNERS	Shoreline restoration Rain gardens Aquatic plant bed protection (only remove a small area for swimming) Conservation easements Forest stewardship planning
LAKE ASSOCIATION	Lake condition monitoring Watershed runoff mapping by a consultant Shoreline inventory study by a consultant Conservation easements Forest stewardship planning
SWCD / NRCS	Shoreline restoration Stream buffers Wetland restoration Forest stewardship planning Work with farmers to restore wetlands, implement conservation farming practices, and implement land retirement programs such as the Conservation Reserve Program

ORGANIZATIONAL CONTACTS

TEN MILE LAKE ASSOCIATION
P.O. Box 412, Hackensack, MN 56452
http://www.tenmilelake.org/

CASS COUNTY ENVIRONMENTAL SERVICES DEPARTMENT
303 Minnesota Avenue W, P.O. Box 3000, Walker, MN 56484
(218) 547-7241
http://www.co.cass.mn.us/government/county_directory/environmental_services/index.php

CASS COUNTY SOIL AND WATER CONSERVATION DISTRICT (SWCD)
303 Minnesota Avenue W, P.O. Box 3000, Walker, MN 56484
(218) 547-7241
https://www.cassswcd.org/

DNR FISHERIES OFFICE
7316 State Hwy 371 NW, Walker, MN 56484
(218) 547-1683
http://www.dnr.state.mn.us/lakefind/index.html

MINNESOTA POLLUTION CONTROL AGENCY (MPCA) REGIONAL OFFICE
7678 College Road, Suite 105, Baxter, MN 56425
(218) 828-2492
http://www.pca.state.mn.us

BOARD OF SOIL AND WATER RESOURCES (BWSR) REGIONAL OFFICE
1601 Minnesota Drive, Brainerd, MN 56401
(218) 828-2383
http://www.bwsr.state.mn.us

RMB ENVIRONMENTAL LABORATORIES, INC.
22796 County Highway 6, Detroit Lakes, MN 56501
(218) 846-1465
http://www.rmbel.com