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Nine Mile Creek Watershed District Summary of 2020 Water Monitoring Program

Prepared for
Nine Mile Creek Watershed District

April 2021

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1 Introduction

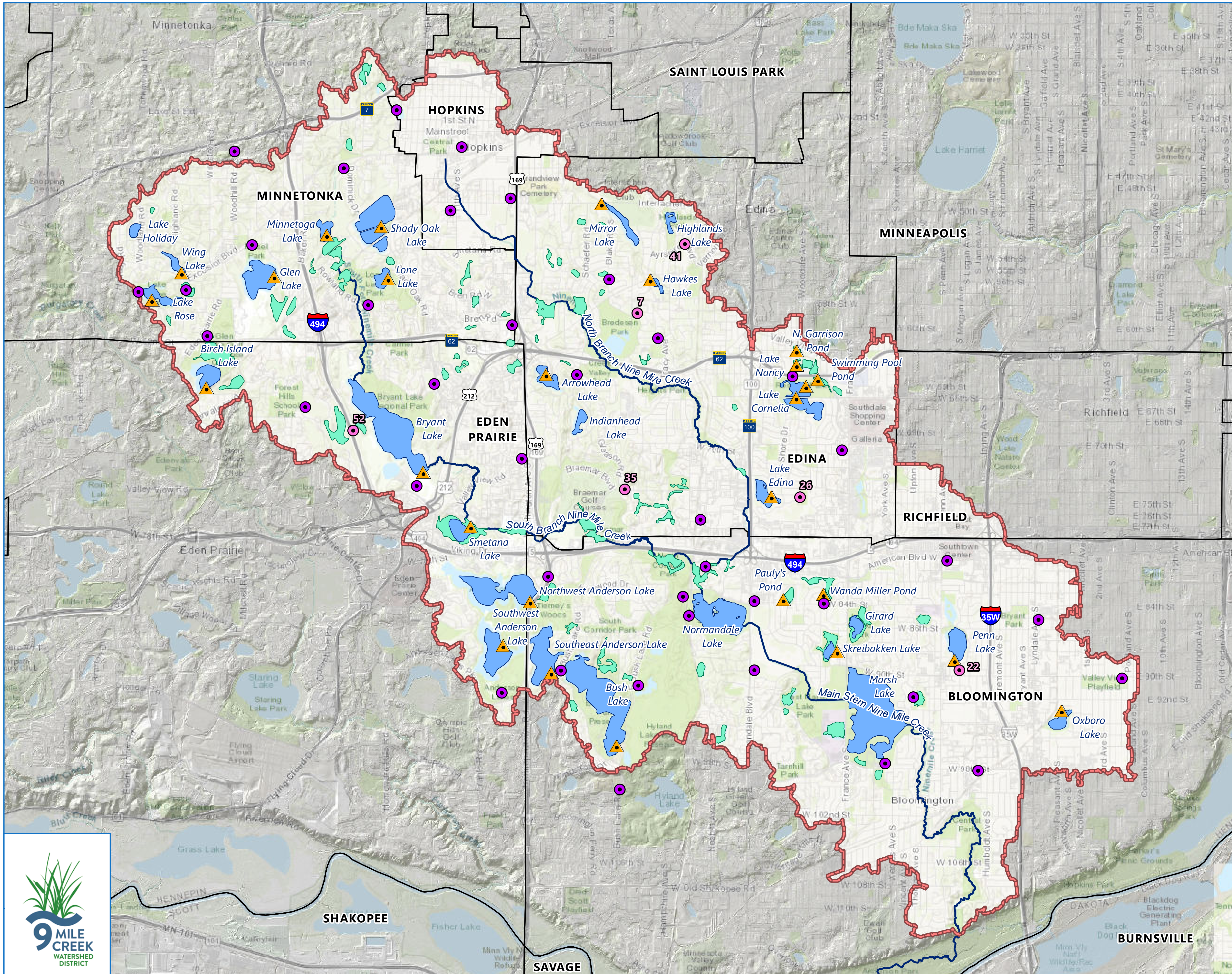
Monitoring of waterbodies in the Nine Mile Creek watershed is essential to developing an understanding of past and present conditions within the watershed and determining the need for action by the Nine Mile Creek Watershed District (District) or other entities. The District annually implements a lake, groundwater, and stream monitoring program designed to establish baseline conditions, track changes, inform additional studies (e.g., feasibility studies, lake management plans), and measure the effectiveness of past and/or ongoing improvement projects. The following report summarizes the lake, groundwater, and stream monitoring data collected by the District in 2020.

The District has been collecting lake levels and groundwater levels since 1960 and 1962, respectively. This information has been used by the District to monitor fluctuations in lake and groundwater levels, helping to understand the connections between groundwater and surface water throughout the watershed and providing important information during times of flooding and drought. In 2020, the District collected monthly levels at 29 lakes and six groundwater monitoring wells. Figure 1-1 shows the lake level and groundwater monitoring locations.

The District has been conducting its water quality monitoring program since the late-1960s. Protecting and enhancing the surface water quality of Nine Mile Creek and the lakes within the watershed has been an important goal of the District for many decades. To help accomplish this goal, the District operates an extensive lake and stream management program. Generally, the program includes:

- Data collection (monitoring)
- Assessment (e.g., studies)
- Implementation of projects and programs

The 2020 District water quality monitoring program included monitoring eight lakes (Arrowhead, Cornelia, Edina, Holiday, Indianhead, Normandale, Rose, and Wing) and Nine Mile Creek (Figure 1-2).



Level Monitoring Location

Inactive Groundwater Observation Wells

Active Groundwater Observation Wells

Nine Mile Creek

Lakes

Public Water Wetland

District Hydrologic Boundary

Municipal Boundaries

0 1 2

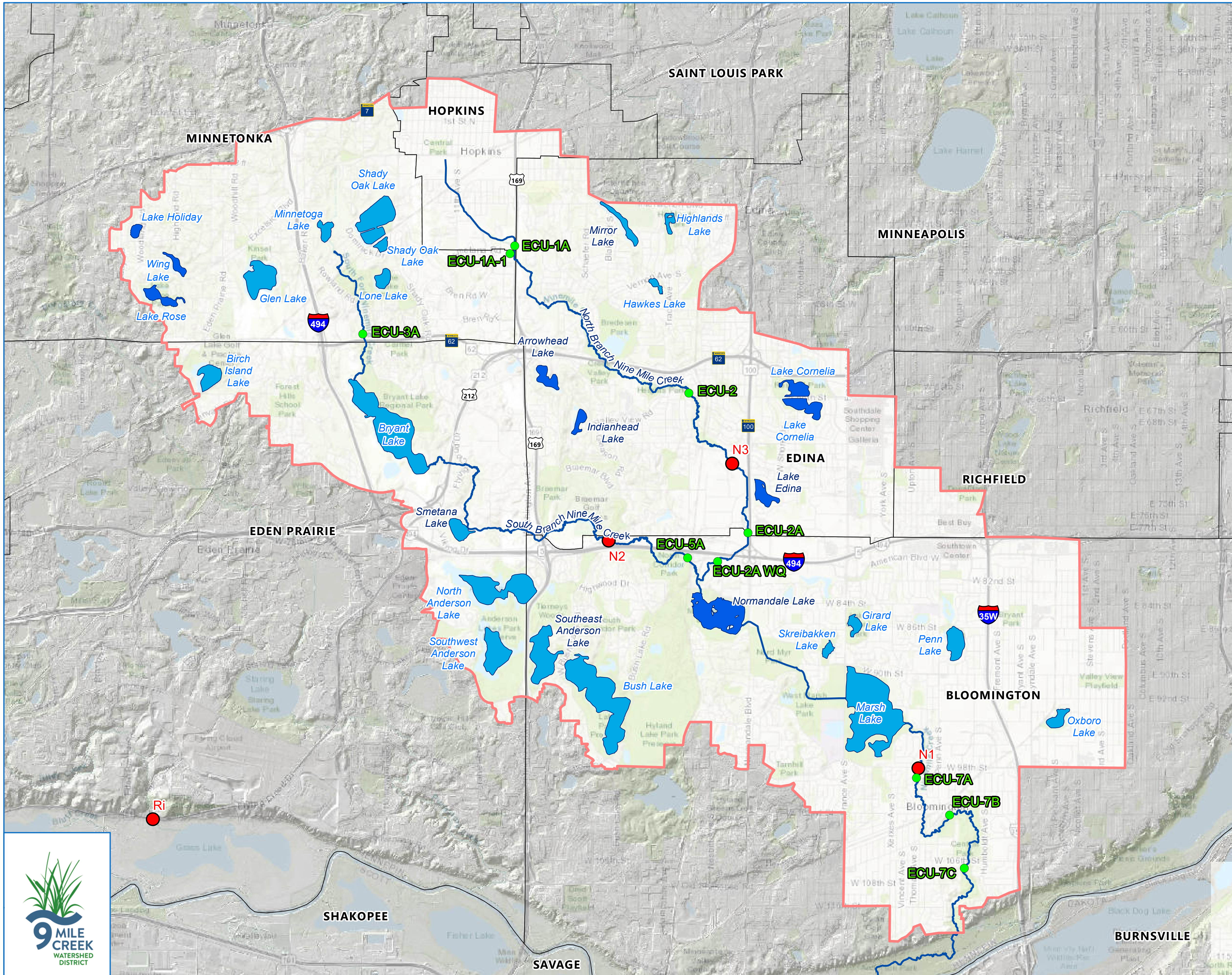
Miles

2020 LAKE AND GROUNDWATER LEVEL MONITORING LOCATIONS
Nine Mile Creek Watershed District
Hennepin County, Minnesota

Figure 1-1

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Barr Footer: ArcGIS 10.8.1, 2021-04-22 08:50 File: I:\Client\Nine_Mile_Creek_WD\Work_Orders\23270634_Project\Maps\2020_Stream_Report\Figure 1-1 2020 Lake and Groundwater Level Monitoring Locations.mxd User: kac2



- WOMP (Watershed Outlet Monitoring Point) Stream Monitoring Station
- Stream Monitoring Locations
- Lake
- Monitored Lake
- Nine Mile Creek
- District Legal Boundary
- Municipal Boundaries

0 1 2
Miles

2020 LAKE AND STREAM MONITORING LOCATIONS
Nine Mile Creek Watershed District
Hennepin County, Minnesota

Figure 1-2

2 Lake Water Quality Monitoring Conclusions and Recommendations

The Nine Mile Creek Watershed District monitors the water quality of its lakes on a rotating basis. The District's full lake monitoring program consists of water quality monitoring on six occasions (ice-out and five events during June through September), analysis of zooplankton and phytoplankton on five occasions (June through September), and qualitative aquatic plant (macrophyte) surveys during June and August. The water quality monitoring generally includes the following parameters: total phosphorus (TP), soluble reactive phosphorus (ortho phosphate), total nitrogen, total Kjeldahl nitrogen, nitrate plus nitrite nitrogen, pH, chlorophyll *a*, chloride, dissolved oxygen, Secchi disc, temperature, specific conductance, and turbidity). In 2020, the full lake water quality monitoring program was conducted for five lakes: **Arrowhead Lake**, **Lake Holiday**, **Indianhead Lake**, **Lake Rose**, and **Wing Lake** (Figure 1-2).

Additional targeted monitoring activities were conducted on three other lakes within the watershed to gather additional information needed for consideration of potential management activities or in preparation for proposed projects, or to measure the effectiveness of past and/or ongoing improvement projects. These targeted monitoring activities are briefly summarized below and discussed further in the following sections.

Lake Cornelia- water quality was monitored on six occasions from the north and south basins for selected parameters including: total phosphorus (TP), soluble reactive phosphorus (ortho phosphate), total nitrogen, total Kjeldahl nitrogen, nitrate plus nitrite nitrogen, pH, chlorophyll *a*, chloride, dissolved oxygen, temperature, specific conductance, turbidity, and Secchi disc. Phytoplankton samples were collected on six occasions.

Lake Edina- water quality was monitored on six occasions for selected parameters including: total phosphorus (TP), soluble reactive phosphorus (ortho phosphate), total nitrogen, total Kjeldahl nitrogen, nitrate plus nitrite nitrogen, pH, chlorophyll *a*, chloride, dissolved oxygen, temperature, specific conductance, turbidity, and Secchi disc. Phytoplankton samples were collected on seven occasions and zooplankton samples were collected on five occasions.

Normandale Lake- water quality was monitored on six occasions at two locations in Normandale Lake: from near the inlet on the western end of the lake and at the deepest location on the eastern end of the lake (the District's routine monitoring location for Normandale Lake). The monitored parameters included total phosphorus (TP), soluble reactive phosphorus (ortho phosphate), total nitrogen, total Kjeldahl nitrogen, nitrate plus nitrite nitrogen, pH, chlorophyll *a*, chloride, dissolved oxygen, temperature, specific conductance, turbidity, and Secchi disc. Phytoplankton and zooplankton samples were collected on two occasions. Point intercept and biomass aquatic plant (macrophyte) surveys were performed during June and August to assess plant species present and their density and biomass. A curly-leaf pondweed turion survey was completed during October to assess the number of turions remaining in the sediment.

Late summer blue-green algal blooms in several lakes resulted in additional sampling for blue-green algae identification and enumeration during late September and October to determine when the blue-green numbers declined below the World Health Organization (WHO) threshold for moderate probability of adverse health effects. An additional blue-green algae sample collected from Arrowhead Lake in late September documented that blue-green numbers had declined below the WHO threshold for moderate probability of adverse health effects. Additional blue-green algae samples collected from the north and south basins of Lake Cornelia, Lake Edina, and Lake Holiday in late September indicated blue-green numbers were still above the WHO threshold for moderate probability of adverse health effects. Blue-green numbers declined in October and late October samples from these lakes documented that blue-green algae numbers were below the WHO threshold for moderate probability of adverse health effects.

Results of the District's 2020 lake monitoring are summarized in detail by lake in Sections 3 through Section 10. Overall conclusions and recommendations from the 2020 lake monitoring are described below.

2.1 Arrowhead Lake

Monitoring results indicate Arrowhead Lake met the Minnesota Pollution Control Agency (MPCA) acute and chronic chloride criteria, but failed to meet MPCA water quality standards for a shallow lake in 2020 due to excess phosphorus and algae in the lake and poor water clarity. In 2020, summer average numbers of green algae declined while blue-green algae numbers increased, resulting in a poorer quality of food for the zooplankton community. During the September 9 monitoring event, a severe algal bloom was observed in the lake, but not at the routine sampling location. Blue-green numbers in a phytoplankton sample collected from the algal bloom area totaled 619,158 per milliliter, well above the World Health Organization (WHO) threshold of 100,000 per milliliter for a moderate probability of adverse health effects. The blue-green bloom was not observed during a late September monitoring event and a sample from the routine monitoring location indicated that blue-green numbers were low (1,321 per milliliter. The highest summer average zooplankton number to date was observed in 2020, indicating the zooplankton community provided an abundant supply of food for planktivorous fish in the lake. Aquatic plant data indicated the plant community had few species, was of poor quality, and failed to meet the MDNR Plant IBI thresholds. Lakes that score below the thresholds contain degraded plant communities and are likely stressed from anthropogenic eutrophication. Both number of species and FQI declined in Arrowhead Lake during 2019 and 2020 and, in 2020, the plant community had a lower number of species and FQI score than were observed in previous years.

One aquatic invasive species, purple loosestrife, was found in Arrowhead Lake in 2020 at two locations. The locations were similar to the locations where it has been observed since 2011.

The District is updating the Arrowhead Lake Use Attainability Analysis in 2021, as identified in the District's Water Management Plan (2017). As part of this water quality study, the District will identify potential management measures to improve the lake's water quality. Continuation of water quality and biological monitoring is recommended to periodically assess the condition of the lake's water quality and biological community and identify trends.

2.2 Lake Cornelia

Lake Cornelia is comprised of two basins, north basin and south basin. Monitoring results indicate chloride concentrations in the north basin exceeded the Minnesota Pollution Control Agency (MPCA) chronic criteria in April of 2020 but were all below the acute chloride criteria. Chloride concentrations in the south basin were below the state acute and chronic chloride standards in 2020. Both basins failed to meet State water quality standards for a shallow lake in 2020 due to excess phosphorus and algae in the lake and poor water clarity. In 2020, average summer numbers of blue-green algae increased in both basins, resulting in a poorer quality of food for the zooplankton community. A severe algae bloom was observed in the lake during the August through September monitoring events. Blue-green numbers during this period ranged from 179,200 per milliliter to 430,768 per milliliter in the north basin and from 211,364 per milliliter to 459,486 in the south basin, well above the World Health Organization (WHO) threshold of 100,000 per milliliter for a moderate probability of adverse health effects. A late October sample documented that blue-green numbers declined below the WHO threshold for moderate probability of adverse health effects in both basins.

The District completed a Use Attainability Analysis of Lake Cornelia and Lake Edina in July of 2019 to identify water quality improvement measures for both lakes. The UAA concluded that the poor water quality in Lake Cornelia is primarily due to excess phosphorus in the lake, which fuels algal production and decreases water clarity. The recommended management strategy to improve water quality in Lake Cornelia is to reduce watershed and internal phosphorus loading to the lake by implementing several management practices. An alum treatment was conducted by the District in spring of 2020 to reduce the release of phosphorus from lake bottom sediments. The city of Edina plans to conduct a spring 2021 herbicide treatment to reduce the presence of curly-leaf pondweed, an invasive aquatic plant that typically dies off in mid-summer, releasing phosphorus into the lake. Because the watershed is fully developed, significantly reducing watershed phosphorus loading can be particularly challenging and costly. Plans are underway for construction of a stormwater filtration Best Management Practice (BMP) in Rosland Park to reduce the amount of phosphorus to Lake Cornelia from the watershed.

Continuation of water quality and biological monitoring is recommended to periodically assess the condition of the lake’s water quality and biological community and identify trends.

2.3 Lake Edina

Monitoring results indicate Lake Edina met the Minnesota Pollution Control Agency (MPCA) acute and chronic chloride criteria, but failed to meet MPCA water quality standards for a shallow lake in 2020 due to excess phosphorus and algae in the lake and poor water clarity. In 2020, summer average numbers of blue-green algae increased, resulting in a poorer quality of food for the zooplankton community. A severe algal bloom was observed in the lake during the July through September monitoring events. Blue-green numbers during this period ranged from 210,215 per milliliter to 470,973 per milliliter, well above the World Health Organization (WHO) threshold of 100,000 per milliliter for a moderate probability of adverse health effects. A late October sample documented that blue-green numbers declined below the WHO threshold for moderate probability of adverse health effects. The highest summer average zooplankton number to date was observed in 2020, indicating the zooplankton community provided an abundant supply of food for planktivorous fish in the lake.

The District completed a Use Attainability Analysis of Lake Cornelia and Lake Edina in July of 2019 to identify water quality improvement measures for both lakes. The UAA concluded that the poor water quality in Lake Edina is primarily due to excess phosphorus in the lake, which fuels algal production and decreases water clarity. Phosphorus in Lake Edina primarily comes from runoff from the watershed (external sources) and flows from upstream Lake Cornelia. Modeling indicates that during 2017, flows from upstream Lake Cornelia comprised nearly two thirds of the annual phosphorus load to Lake Edina. Because the water quality of Lake Edina is highly influenced by the water quality of Lake Cornelia, a recommended management strategy to improve water quality in Lake Edina is to implement management practices to improve upstream Lake Cornelia. The District and city of Edina have initiated several improvement projects in the Lake Cornelia watershed (see Section 4.1.1.4). In 2021, the District is also evaluating a stormwater improvement project at the Bristol & Mavelle Park in the Lake Edina watershed, in partnership with the City of Edina.

Continuation of water quality and biological monitoring is recommended to periodically assess the condition of the lake's water quality and biological community and identify trends.

2.4 Lake Holiday

Monitoring results indicate Lake Holiday met the MPCA acute and chronic chloride criteria, but failed to meet MPCA water quality standards in 2020 due to excess phosphorus and algae in the lake and poor water clarity. A severe blue-green algal bloom was observed in the lake during the June and September sample events. Blue-green algae numbers in June and September were 178,868 per milliliter and 367,589 per milliliter, respectively, well above the WHO threshold of 100,000 per milliliter for a moderate risk of adverse health effects. Blue-green numbers were below the WHO threshold for a moderate risk of adverse health effects during July, August, and October. The 2020 data indicate the zooplankton community provided an abundant supply of food for planktivorous fish in the lake.

Aquatic plant data indicated the plant community had few species, was of poor quality, and failed to meet the MDNR Plant IBI thresholds. Lakes that score below the thresholds contain degraded plant communities and are likely stressed from anthropogenic eutrophication. Two aquatic invasive species were found in the lake in 2020, purple loosestrife and curly-leaf pondweed. Both species were first observed in the lake in 2008. Purple loosestrife was growing sporadically along the entire shoreline during June and August in both 2008 and 2020. Curly-leaf pondweed was prevalent throughout the lake and grew densely during June 2008 and June 2020. However, the data indicate both extent and density increased during this period.

The District is updating the Use Attainability Analysis for Holiday, Wing, and Rose Lakes in 2021, as identified in the District's Water Management Plan (2017). As part of this water quality study, the District will seek to identify management measures to improve the lake's water quality. Continuation of water quality and biological monitoring is recommended to periodically assess the condition of the lake's water quality and biological community and identify trends.

2.5 Indianhead Lake

Monitoring results indicate Indianhead Lake met the MPCA acute and chronic chloride criteria, but failed to meet MPCA water quality standards for a shallow lake in 2020 due to excess phosphorus and algae in the lake and poor water clarity. Blue-green numbers in the July sample totaled 144,738, above the WHO threshold of 100,000 per milliliter for a moderate probability of adverse health effects. Blue-green numbers declined to slightly below the WHO threshold for a moderate probability of adverse health effects by early August and then declined to below the threshold for low probability of adverse health effects during late August and September. The 2020 data indicate the zooplankton community provided an abundant supply of food for planktivorous fish in the lake.

Aquatic plant data indicated the plant community had few species, was of poor quality, and failed to meet the MDNR Plant IBI thresholds. Lakes that score below the thresholds contain degraded plant communities and are likely stressed from anthropogenic eutrophication. Two aquatic species were found in the lake in 2020, purple loosestrife and yellow iris. Purple loosestrife was first observed in 2019 along the eastern and western shorelines and continued to be observed at the same locations in 2020. Yellow iris has been prevalent along the lake's shoreline since plant surveys began in 2004 and continued to be prevalent in 2020.

The District is updating the Indianhead Lake Use Attainability Analysis in 2021, as identified in the District's Water Management Plan (2017). As part of this water quality study, the District will identify management measures to improve the lake's water quality. Continuation of water quality and biological monitoring is recommended to periodically assess the condition of the lake's water quality and biological community and identify trends.

2.6 Normandale Lake

In 2018, the District began implementation of a water quality improvement project for Normandale Lake, in partnership with the city of Bloomington. A drawdown of the lake was completed in fall of 2018 to expose the lake bed to a winter freeze and freeze out curly-leaf pondweed, an invasive plant species, which dies off in late-June, senesces, and adds phosphorus to the lake. This summer addition of phosphorus fuels algal growth and degrades lake water quality. The lake was treated with alum in spring of 2019 to reduce the release of phosphorus from lake bottom sediments into the water column. In the spring of 2020, an herbicide treatment was conducted within portions of Normandale Lake and Nine Mile Creek immediately upstream of Normandale Lake using diquat to control curly-leaf pondweed growing in these areas.

2020 results indicate that Normandale Lake met MPCA acute and chronic criteria for chlorides. The average summer phosphorus concentration did not meet the shallow lakes phosphorus criterion of 60 µg/L, but the summer average value of 61 µg/L was close. Summer average Secchi disc (measure of clarity), and chlorophyll *a* concentration met the state eutrophication criteria for shallow lakes. Monitoring results from 2020 also support the conclusion that nitrogen can be the "limiting nutrient" at times in Normandale Lake, meaning that the available quantity of this nutrient is in low proportion to the others and controls the rate at which algae and aquatic plants are produced. This conclusion underscores the importance of continued implementation of best management practices in the upstream watershed to minimize the amount of nutrients (both nitrogen and phosphorus) discharged to Nine Mile Creek and education of property owners regarding responsible use of fertilizer on lawns or other turf.

The late August and September numbers of blue-green algae observed in the lake were lower in 2020 than 2016 and the total number of zooplankton in 2020 was, on average, higher than previous years. Both changes are favorable for the lake. Filamentous algae occurred more frequently in June than previous years, but August frequency was within the historical range. Samples collected in August 2020 documented two species of filamentous green algae, *Pithophora* and *Rhizoclonium hieroglyphicum*. Both species were also present in samples collected from the lake in 2017. The lake's plant community met the MNDNR Plant IBI thresholds.

The water quality improvement project implemented in 2018 through 2020 has resulted in a reduced frequency and biomass of curly-leaf pondweed in the lake. Biomass of the total plant community was lower in June 2019 immediately following the drawdown, but increased during the 2019 and 2020 growing seasons and, by August 2020, was at the lower end of the range of biomass levels observed prior to the drawdown. In 2020, the three species with the highest average wet weight per sample point – coontail, common waterweed, and white water lily – were generally the three species with the highest average wet weight per sample point prior to the drawdown. Coontail and common waterweed were the two most frequently occurring species in 2020 while common watermeal, large duckweed, and small duckweed tied for the third most frequently occurring species. Native plant species in Normandale Lake varied in response to the project, some occurring at a higher frequency, some at a similar frequency, and some at a lower frequency in 2020 compared with frequencies observed before the project.

Continuation of water quality and biological monitoring is recommended in upcoming years to assess the impacts of the improvement project(s) on the condition of the lake's water quality and biological community.

2.7 Lake Rose

2020 monitoring results indicate Rose Lake met the MPCA acute and chronic chloride criteria. The 2020 summer average total phosphorus concentration failed to meet the Minnesota State Water Quality Standard for shallow lakes, but summer averages for chlorophyll *a* and Secchi disc both met the standard.

The lake's water quality and biological data indicate water quality has improved. Summer average total phosphorus concentrations were lower (better) during 2019 and 2020 than 2007 through 2016. Summer average chlorophyll *a* concentrations were lower (better) in 2016 through 2020 than in 2007 through 2011 and the 2020 summer average chlorophyll *a* concentration was the lowest to date. Summer average Secchi disc transparencies were higher (better) in 2016 through 2020 than in 2011. Lower numbers of phytoplankton and higher numbers of zooplankton were observed in 2020 than 2008. Both the number of plant species and the quality of the plant community measured by FQI increased in August 2020 and were better than the MNDNR Plant IBI thresholds. However, because only two years of data are available, a strong conclusion cannot be made from the data.

Two aquatic invasive species were observed in Rose Lake in both 2008 and 2020, CLP and purple loosestrife. Although CLP and purple loosestrife extent was similar both years, CLP density was lighter in the southern half of the lake in 2020.

The District is updating the Use Attainability Analysis for Holiday, Wing, and Rose Lakes in 2021, as identified in the District's Water Management Plan (2017). As part of this water quality study, the District will identify management measures to improve the lake's water quality. Continuation of water quality and biological monitoring is recommended to periodically assess the condition of the lake's water quality and biological community and identify trends.

2.8 Wing Lake

Monitoring results indicate Wing Lake met the MPCA acute and chronic chloride criteria, but failed to meet MPCA water quality standards in 2020 due to excess phosphorus and algae in the lake and poor water clarity. The data indicate both phytoplankton and zooplankton numbers were higher in 2020 than 2008. The dominant type of algae changed from green algae in 2008 to blue-green algae in 2020, resulting in a poorer quality of food for the zooplankton community.

Aquatic plant data indicated the plant community had few species, was of poor quality, and was poorer than the MNDNR Plant IBI thresholds. Lakes that score below the thresholds contain degraded plant communities and are likely stressed from anthropogenic conditions. Two aquatic invasive species were found in the lake in 2020, purple loosestrife and curly-leaf pondweed. Both species were first observed in the lake in 2008. Extent and density of the species were similar in 2008 and 2020.

The District is updating the Use Attainability Analyses for Holiday, Wing, and Rose Lakes in 2021, as identified in the District's Water Management Plan (2017). As part of this water quality study, the District will identify potential management measures to improve the lake's water quality. Continuation of water quality and biological monitoring is recommended to periodically assess the condition of the lake's water quality and biological community and identify trends.

3 Arrowhead Lake

Arrowhead Lake (Figure 3-1) is a small lake located in Edina. The lake has a surface area of approximately 22 acres and a maximum depth of approximately 7 feet. At the Ordinary High Water Level (OHW) elevation of 875.8 feet, the lake volume is approximately 136 acre-feet. The lake is land-locked; there is no gravity outlet and the estimated natural overflow elevation is 882.5 M.S.L. The lake is shallow enough for aquatic plants to grow over the entire lake bed.

In 2020, the Nine Mile Creek Watershed District monitored Arrowhead Lake for:

- Water chemistry- total phosphorus (TP), soluble reactive phosphorus (orthophosphate), total nitrogen, total Kjeldahl nitrogen, nitrate plus nitrite nitrogen, chlorophyll *a*, chloride, and turbidity.
- Water field measurements- dissolved oxygen, pH, temperature, specific conductance, and Secchi disc.
- Phytoplankton and zooplankton (microscopic plants and animals).
- Macrophytes (aquatic plants).

Water quality monitoring data are summarized in Appendix A, phytoplankton and zooplankton data in Appendix B, and macrophyte monitoring maps in Appendix C. Monitoring results are discussed in the following paragraphs and compared with historical data.

Figure 3-1 Arrowhead Lake

3.1 Total Phosphorus and Chlorophyll *a* Levels and Water Clarity (Secchi Depth)

Figure 3-2 shows the 2020 summer average conditions for total phosphorus, chlorophyll *a*, and Secchi disc transparency, in comparison with District monitoring results from past years. The lake's 2020 summer average total phosphorus concentration of 80 µg/L, the lake's summer-average chlorophyll *a* concentration of 26.7 µg/L, and the lake's summer average Secchi disc transparency of 0.5 meters failed to meet the Minnesota State Water Quality Standards for shallow lakes in the North Central Hardwood Forest Ecoregion published in Minnesota Rules 7050 (Minn. R. Ch. 7050.0222 Subp 4) (Figure 3-2). Minnesota State water quality standards for shallow lakes in the North Central Hardwood Forest Ecoregion are ≤60 µg/L, ≤20 µg/L, and ≥1 meter, respectively.

Historical water quality data have been collected from Arrowhead Lake by the Nine Mile Creek Watershed District during 2004, 2011, 2014, and 2019. During the period examined, summer average total phosphorus concentrations failed to meet the MPCA standard during all years except 2011. Summer average chlorophyll *a* concentrations failed to meet the MPCA standard during 2011, 2014, and 2020. Summer average Secchi disc transparencies failed to meet the MPCA standard during 2019 and 2020 (Figure 3-2).

The District is updating the Arrowhead Lake Use Attainability Analysis in 2021, as identified in the District's Water Management Plan (2017). As part of this water quality study, the District will identify management measures to improve the lake's water quality.

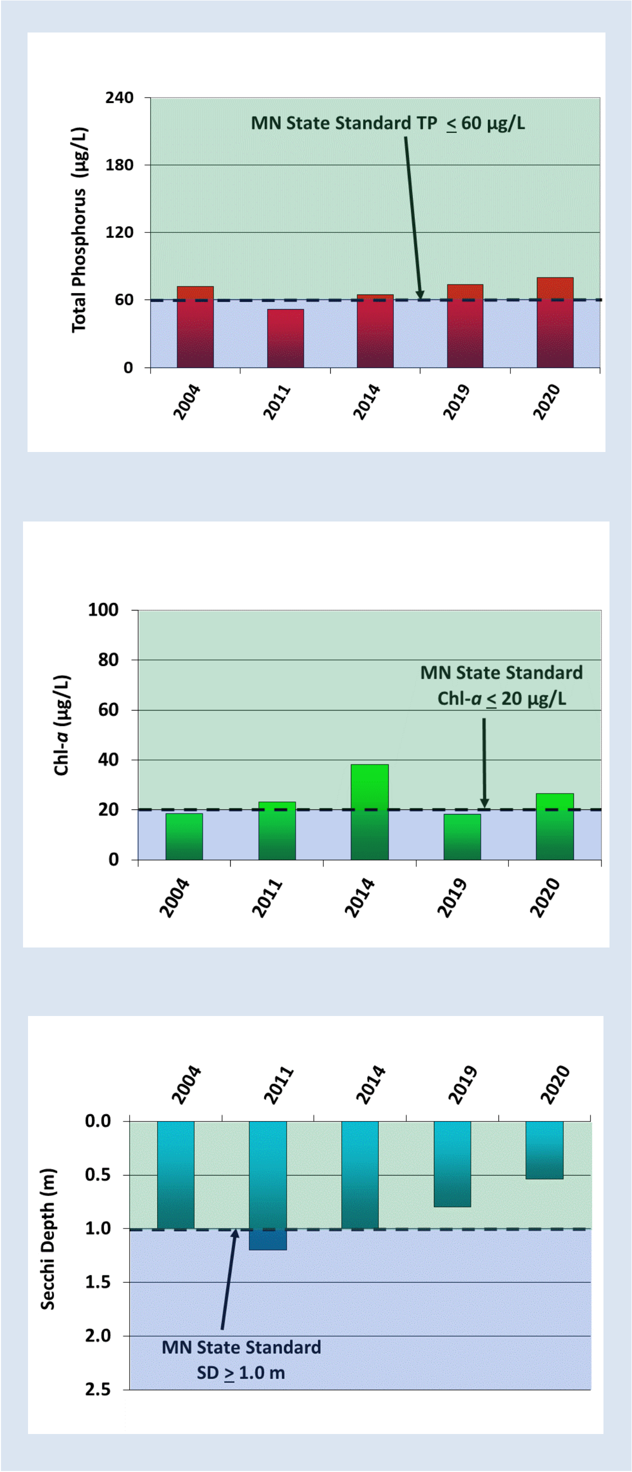


Figure 3-2 Arrowhead Lake historical summer average values
total phosphorus (top), chlorophyll *a* (middle), and Secchi disc (bottom)

3.2 Chlorides

Chloride concentrations in area lakes have increased since the early 1990s when many government agencies switched from sand or sand/salt mixtures to salt for winter road maintenance. When snow and ice melts, the salt goes with it, washing into lakes, streams, wetlands, and groundwater. It only takes 1 teaspoon of road salt to permanently pollute 5 gallons of water. And, once in the water, it is very difficult and expensive to remove.

Because high concentrations of chloride can harm fish and plant life, MPCA has established acute and chronic exposure chloride standards. A lake is considered impaired if two or more exceedances of chronic criterion (230 mg/L or less) occur within a three-year period or one exceedance of acute criterion (860 mg/L) is measured. Chloride concentrations were measured in 2011, 2014, 2019, and 2020, generally between April and September. All chloride measurements were below the acute and chronic MPCA criteria. The 2011 through 2020 chloride concentrations are summarized in Figure 3-3. 2020 data are summarized in Appendix A.

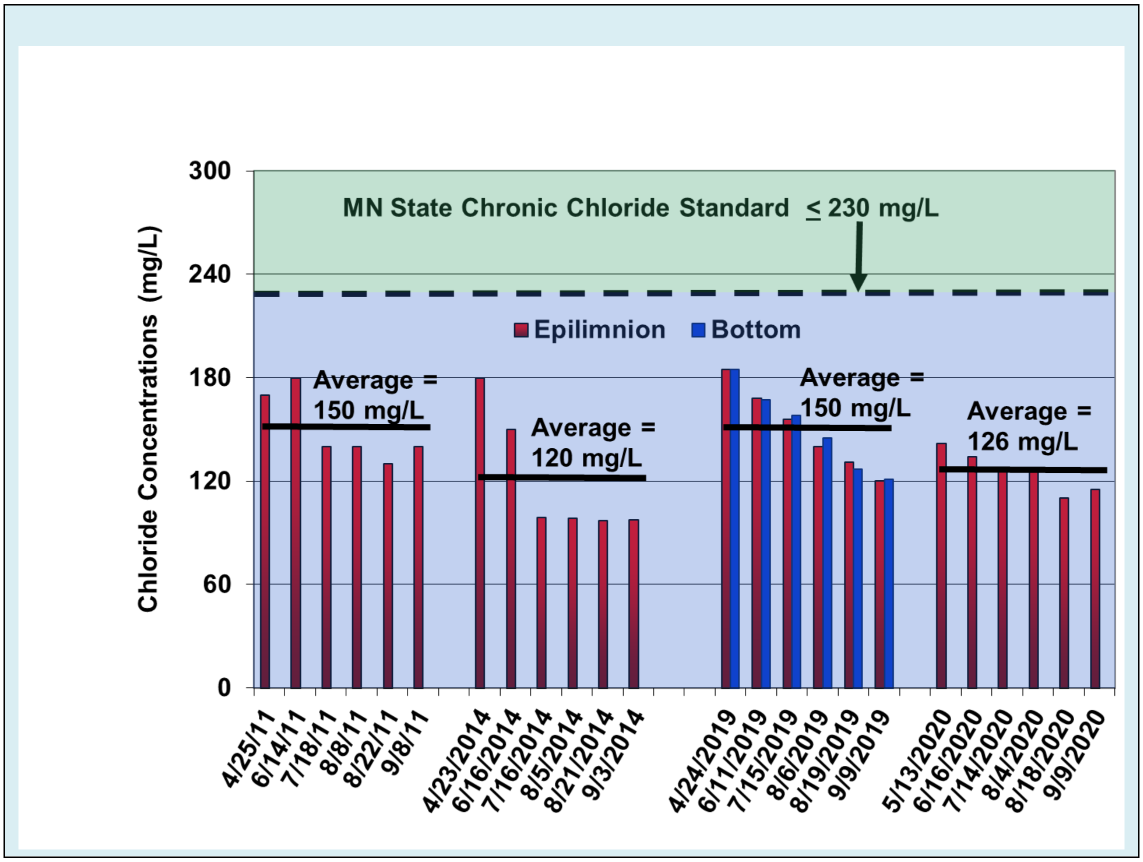


Figure 3-3 Arrowhead Lake historical chloride concentrations

3.3 Phytoplankton

Phytoplankton, also called algae, are small aquatic plants naturally present in lakes, including Arrowhead Lake. Phytoplankton derive energy from the sun through photosynthesis and provide food for several types of aquatic organisms, including zooplankton, which are in turn eaten by fish. An inadequate phytoplankton population limits a lake's zooplankton population, and indirectly limit fish production in a lake. Excess phytoplankton can reduce water clarity, which can then make recreational use of a lake less desirable.

Samples of phytoplankton, microscopic aquatic plants, were collected from Arrowhead Lake in 2020 to evaluate water quality and the quality of food available to zooplankton (microscopic animals). Identification and enumeration of the phytoplankton species was completed (Appendix B).

Figure 3-4 summarizes the summer average number and major groups of phytoplankton observed in Arrowhead Lake for monitored years. Phytoplankton numbers and blue-green algae numbers have followed a similar pattern as chlorophyll *a*. Phytoplankton numbers, blue-green algae numbers, and chlorophyll *a* concentrations have generally increased from 2004 through 2020, with the exception of 2019 (Figure 3-4 and Figure 3-2). Blue-green algae are a poor quality food because they may be toxic and may not be assimilated if ingested by zooplankton. Blue-green algae can also produce algal toxins, which can be harmful to humans or other animals. Green algae are a better quality food source than blue-green algae and contribute towards a healthier zooplankton community. Summer average numbers of green algae increased from 2004 to 2011 and then remained relatively consistent for monitored years through 2019 indicating the lake had an ample supply of good quality food for the zooplankton community (Figure 3-4). In 2020, summer average numbers of green algae declined in comparison with previous monitored years (Figure 3-4). The change was unfavorable because it resulted in a poorer quality of food for the zooplankton community.

While identification and enumeration of phytoplankton species has been part of the District's routine lake monitoring program for many years, increased frequency of observed blue-green algal blooms in recent years prompted the District to develop a protocol in 2020 for evaluating and reporting potential Harmful Algal Blooms (HAB). When District monitoring staff observe signs of a potential blue-green algal bloom on a lake while conducting routine monitoring, staff collect a water sample and expedite algal identification and enumeration. Upon enumeration, blue-green algae counts are compared to thresholds established by the World Health Organization (WHO) as guidelines for low, moderate or high probability of adverse health effects to recreational users. Under the District's current protocol approved December 2020, the District will notify the City, MPCA, Minnesota Department of Health (MDH) and other stakeholder partners of the findings if blue-green algae counts are above the low, medium, or high probability thresholds and post advisory information on the District's website. In addition, if blue-green algae counts are between the low and medium probability threshold, the District will advise public property owner(s) of the WHO recommendation to post advisory signs and if the blue-green algae counts are above the medium or high probability thresholds, the District will recommend that the public property owner(s) post advisory signs.

Comparison of blue-green numbers from the routine monitoring location to the World Health Organization thresholds for probability of adverse health effects indicates all 2020 values were below the threshold for moderate probability of adverse health effects and all values during 2004 and 2011 were below the threshold for low probability of adverse health effects (Figure 3-5).

During the September 9, 2020 monitoring event, a severe algal bloom was observed in the lake, but not at the routine sampling location. Blue-green numbers in a phytoplankton sample collected from the algal bloom area totaled 619,158 per milliliter, well above the World Health Organization (WHO) threshold of 100,000 per milliliter for a moderate probability of adverse health effects. The blue-green algal bloom was no longer observed during late September. A blue-green algae sample collected from the routine sample location near the lake's center in late September indicated blue-green numbers at low levels (1,321 per milliliter).

The Nine Mile Creek Watershed District posted a notification on its website alerting the public to the high blue-green algae levels in Arrowhead Lake on September 9. The notice informed the public that high levels of blue-green algae are a concern because this type of algae can produce algal toxins, which can pose a health threat for pets and people. The District urged residents to stay out of the water and to keep pets away from the water.

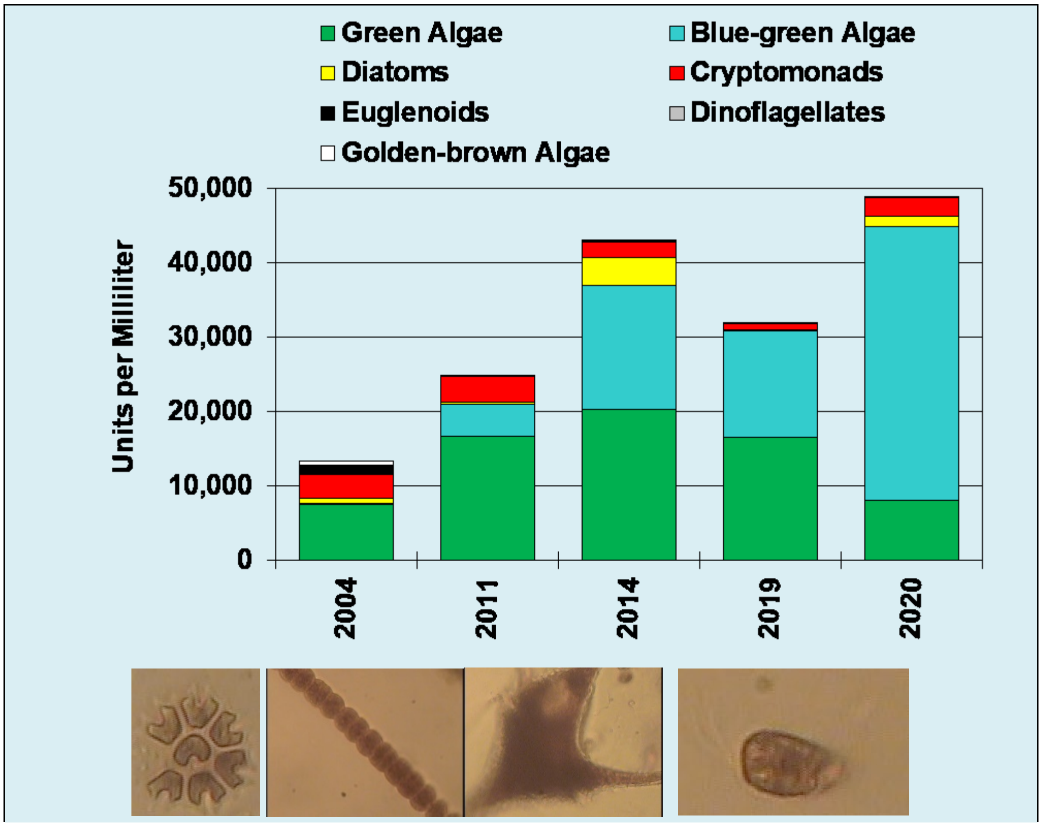


Figure 3-4 Arrowhead Lake summer average phytoplankton

Top, Summer average numbers and bottom, microscopic pictures of phytoplankton species found in the lake , from left to right, *Pediastrum boryanum* (green algae) *Dolichospermum affine* (blue-green algae), *Ceratium hirundinella* (dinoflagellate), and *Cryptomonas erosa* (cryptomonad).

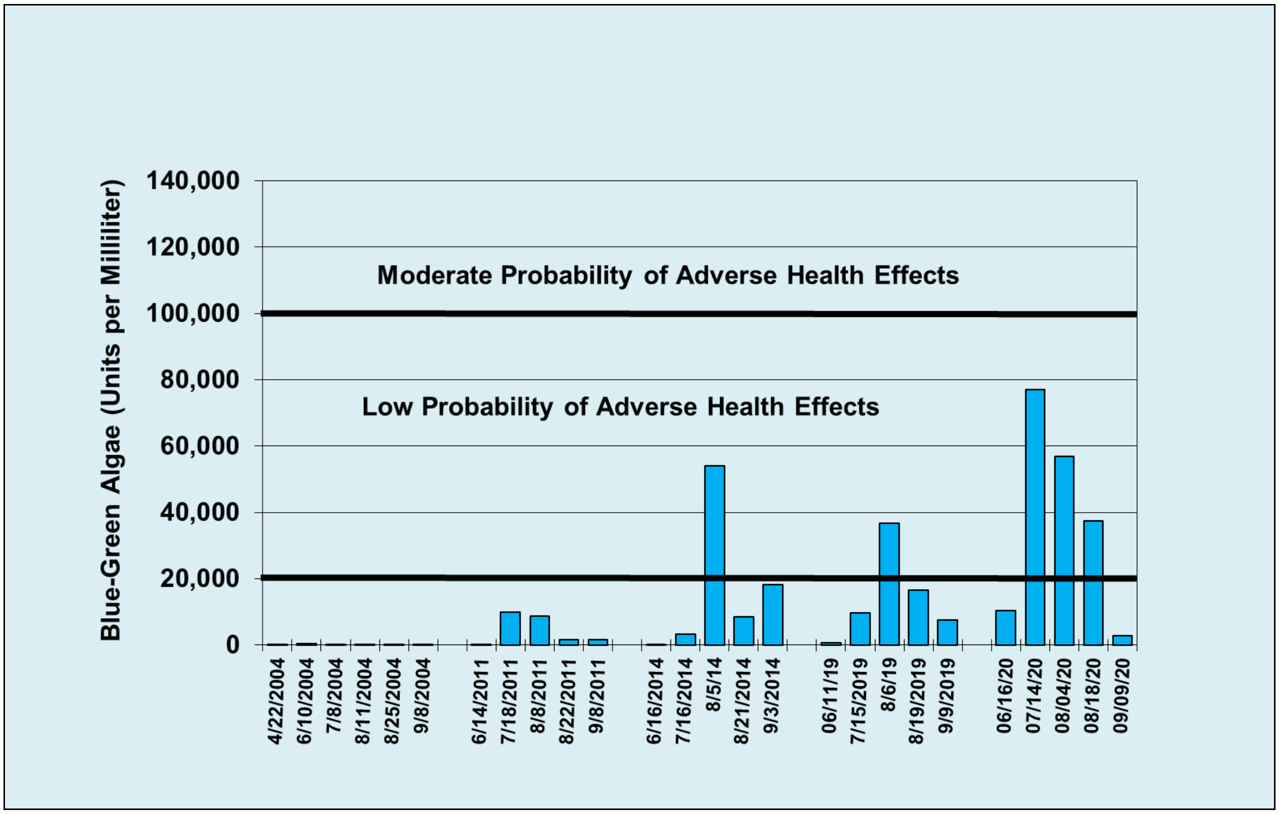


Figure 3-5 **Arrowhead Lake blue-green algae at routine sampling location compared with World Health Organization (WHO) thresholds for adverse health effects**

3.4 Zooplankton

Samples of zooplankton, microscopic aquatic animals, were collected from Arrrowhead Lake to evaluate the food available to planktivorous fish. Identification and enumeration of the zooplankton species was completed (Appendix B).

Figure 3-6 summarizes the summer average number and major groups of zooplankton and during the monitored period. All three groups of zooplankton (rotifers, copepods, and cladocerans) were observed in Arrowhead Lake in 2020. Summer average zooplankton numbers have generally increased since 2004, with the exception of 2014 in which zooplankton numbers were similar to 2004. The highest summer average zooplankton number to date was observed in 2020 (Figure 3-6). The data indicate the zooplankton community provided an abundant supply of food for planktivorous fish in the lake.

Figure 3-6 Arrowhead Lake summer average zooplankton

Top Summer average numbers and bottom, microscopic pictures of zooplankton species found in the lake, from left to right, Bosmina longirostris (cladoceran), nauplii (baby copepod), and *Keratella cochlearis* (rotifer).

3.5 Aquatic Plants

Eutrophication may have detrimental effects on a lake, including reductions in the quantity and diversity of aquatic plants. The ability to assess the biological condition of a lake plant community is a valuable tool in the conservation of Minnesota's lakes. With this objective in mind, the Minnesota Department of Natural Resources (MNDNR) developed a Lake Plant Eutrophication Index of Biological Integrity (IBI) to measure the response of a lake plant community to eutrophication. The MNDNR will use this Lake Plant Eutrophication IBI to identify lakes that are likely stressed from anthropogenic eutrophication. A healthy aquatic plant community is an essential part of lakes and provides many important benefits such as nutrient assimilation, sediment stabilization, and habitat for fish. The Plant IBI can provide important context to understanding information about water quality, shoreline health, and the fish community.

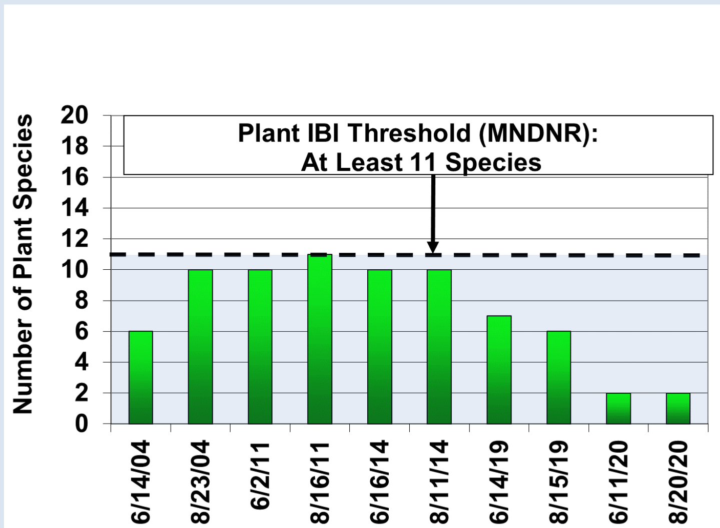


Figure 3-7.A

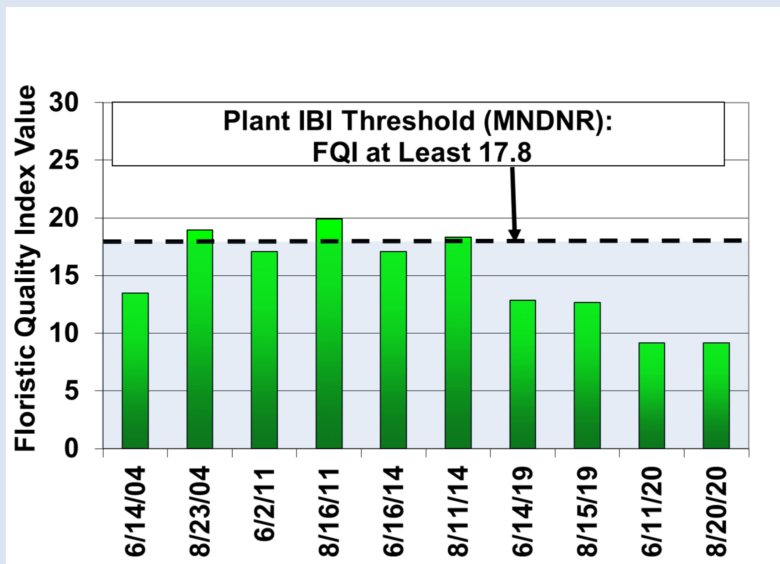


Figure 3-7.B

Figure 3-7 Arrowhead Lake Plant Index of Biotic Integrity (IBI) Values compared with Plant IBI Thresholds (MNDNR): Number of Plant Species (top) and Floristic Quality Index (FQI) Values (bottom).

The MDNR has developed metrics to determine the overall health of a lake's aquatic plant community. The Lake Plant Eutrophication IBI includes two metrics: (1) the number of species in a lake; and (2) the "quality" of the species, as measured by the floristic quality index (FQI). The MNDNR has determined a threshold for each metric. Lakes that score below the thresholds contain degraded plant communities and are likely stressed from anthropogenic eutrophication.

The District conducted qualitative aquatic plant surveys of Arrowhead Lake in June and August of 2020. Maps showing survey results are included in Appendix C. Plant survey data from 2004 through 2020 were assessed to determine plant IBI trends. Figure 3-7 shows the Arrowhead Lake number of species and FQI scores for that period compared to the MNDNR Plant IBI thresholds.

- **Number of species:** A shallow lake (maximum depth less than 15 feet) fails to meet the MNDNR Plant IBI threshold when it has fewer than 11 species. During the period examined, the number of species in Arrowhead Lake ranged from 2 to 11, meeting the MNDNR Plant IBI threshold only during August 2011 (Figure 3-7.A).
- **FQI values (quality of species):** The MNDNR Plant IBI threshold for shallow lakes, as measured by FQI, is a minimum value of 17.8. During the period examined, FQI values in Arrowhead Lake ranged from 9.2 to 19.9, bettering the MNDNR Plant IBI threshold during August 2004, August 2011, and August 2014(Figure 3-7.B).
- **2020 results:** Both the number of species in the lake and FQI values were poorer than the MNDNR Plant IBI thresholds. Both number of species and FQI declined in 2019 and 2020 and, in 2020, the plant community had a lower number of species and FQI score than were observed in previous years (Figure 3-7).

  One aquatic invasive species were found in Arrowhead Lake in 2020:

  Purple loosestrife (Lythrum salicaria) – This emergent species has been annually observed at one or two locations since 2011. In 2020, it was observed at one location along the southwestern shoreline in June and at two locations along the northern and southwestern shorelines in August (Appendix B). The locations were similar to the locations where it has been observed since 2011.

3.6 Conclusions and Recommendations

Monitoring results indicate Arrowhead Lake met the Minnesota Pollution Control Agency (MPCA) acute and chronic exposure chloride criteria, but failed to meet MPCA water quality standards for a shallow lake in 2020 due to excess phosphorus and algae in the lake and poor water clarity. In 2020, summer average numbers of green algae declined while blue-green algae numbers increased, resulting in a poorer quality of food for the zooplankton community. During the September 9 monitoring event, a severe algal bloom was observed in the lake, but not at the routine sampling location. Blue-green numbers in a phytoplankton sample collected from the algal bloom area totaled 619,158 per milliliter, well above the World Health Organization (WHO) threshold of 100,000 per milliliter for a moderate probability of adverse health effects. The blue-green bloom was not observed during a late September monitoring event and a sample from the routine monitoring location indicated that blue-green numbers were low (1,321 per milliliter. The highest summer average zooplankton number to date was observed in 2020, indicating the zooplankton community provided an abundant supply of food for planktivorous fish in the lake. Aquatic plant data indicated the plant community had few species, was of poor quality, and failed to meet the MDNR Plant IBI thresholds. Lakes that score below the thresholds contain degraded plant communities and are likely stressed from anthropogenic eutrophication. Both number of species and FQI declined in

Arrowhead Lake during 2019 and 2020 and, in 2020, the plant community had a lower number of species and FQI score than were observed in previous years.

One aquatic invasive species, purple loosestrife, was found in Arrowhead Lake in 2020 at two locations. The locations were similar to the locations where it has been observed since 2011.

The District is updating the Arrowhead Lake Use Attainability Analysis in 2021, as identified in the District's Water Management Plan (2017). As part of this water quality study, the District will identify potential management measures to improve the lake's water quality. Continuation of water quality and biological monitoring is recommended to periodically assess the condition of the lake's water quality and biological community and identify trends.

4 Lake Cornelia

4.1 Lake Cornelia

Lake Cornelia (Figure 4-1) is located in the north central portion of Edina. Lake Cornelia is comprised of two basins, north and south. The two basins are connected by a small equalizing culvert under 66th Street (invert elevation (I.E.) of 859.0 MSL) on the south side of the north basin. Ultimately the water levels in the north basin are controlled by the outlet structure at the south basin. The outflow from the south basin discharges over a 14-foot long weir structure with a control elevation of 859.1 MSL. Discharges from Lake Cornelia - South Basin are conveyed to Lake Edina through an extensive storm sewer network. Due to limited storm sewer capacity downstream of Lake Cornelia, stormwater runoff backs-up into the lake during large storm events, which provides temporary storage of the flood volumes.

The Minnesota Department of Natural Resources stocks the lake annually with bluegills for its Fishing in the Neighborhood Program.

In 2020, the Nine Mile Creek Watershed District monitored Lake Cornelia (North and South Basins) for:

- Water chemistry- total phosphorus (TP), soluble reactive phosphorus (ortho phosphate), total nitrogen, total Kjeldahl nitrogen, nitrate plus nitrite nitrogen, chlorophyll *a*, chloride, and turbidity.
- Water field measurements- dissolved oxygen, pH, temperature, specific conductance, and Secchi disc.
- Phytoplankton (microscopic plants).

Water quality monitoring results are summarized in Appendix A and phytoplankton results in Appendix B. Monitoring results are discussed in the following paragraphs and compared with historical data.

Figure 4-1 Lake Cornelia - North Basin (left) and Lake Cornelia - South Basin (right)

4.1.1 Lake Cornelia – North Basin

Lake Cornelia – North Basin (Figure 4-1) has a water surface area of approximately 19 acres, a maximum depth of 5 feet, and a mean depth of approximately 3 feet. The lake is shallow enough for aquatic plants to grow over the entire lake bed. It is a polymictic lake, mixing many times per year. The lake is currently on the MPCA's impaired waters list for excess nutrients (since 2008).

4.1.1.1 Total Phosphorus and Chlorophyll *a* Levels and Water Clarity (Secchi Depth)

In 2020, Lake Cornelia – North Basin water quality was poor. The lake's summer average total phosphorus and chlorophyll *a* concentrations were 150 µg/L and 56 µg/L, respectively (Figure 4-2). The lake's summer average Secchi disc transparency was 0.2 meters (Figure 4-2). All three summer averages failed to meet the Minnesota State water quality standards for shallow lakes in the North Central Hardwood Forest Ecoregion which are ≤60 µg/L, ≤20 µg/L, and ≥1 meter, respectively.

Water quality data have been collected from Lake Cornelia – North Basin by Nine Mile Creek Watershed District (NMCWD) during 2004, 2008, 2013, 2015, 2016, 2017, and 2020 and by the Metropolitan Council Environmental Services (MCES) Citizen Assisted Monitoring Program (CAMP) during 2003, 2005, 2006, 2007, 2009, 2013, 2014, and 2015. Poor water quality has been observed in the lake during the entire period of record. All summer average total phosphorus and chlorophyll *a* concentrations and Secchi disc transparency values failed to meet the Minnesota State water quality standards for shallow lakes in the North Central Hardwood Forest Ecoregion (Figure 4-2). While the lake's 2020 summer average total phosphorus and chlorophyll *a* concentrations were within the range observed in previous years, the 2020 summer average Secchi disc transparency was lower (poorer) than previous years (Figure 4-2).

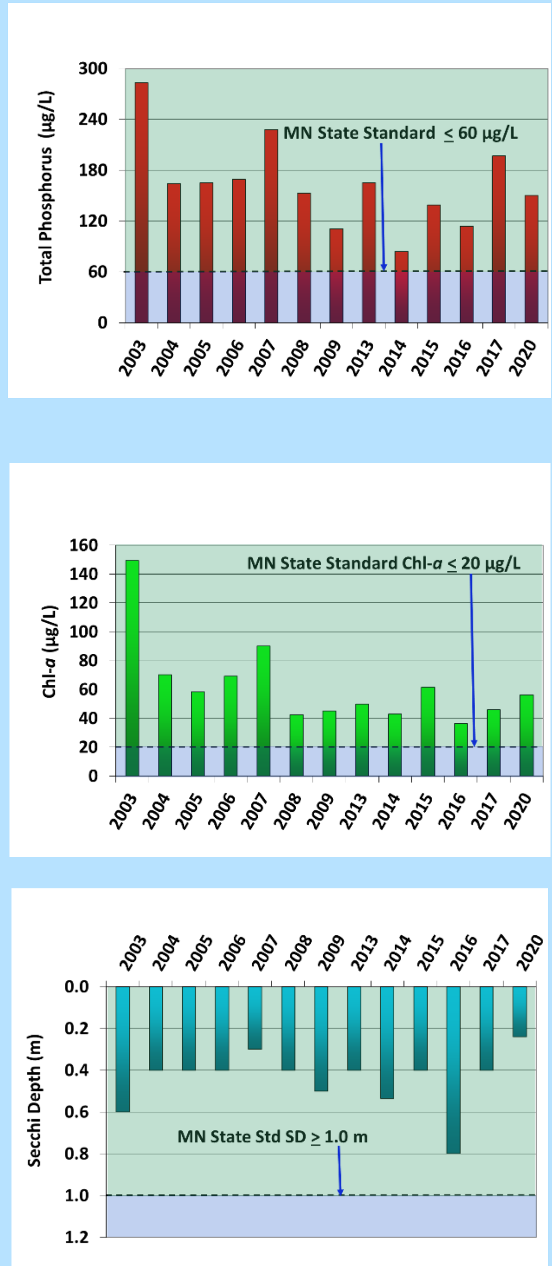


Figure 4-2 Lake Cornelia – North Basin historical summer average values
total phosphorus (top), chlorophyll *a* (middle), and Secchi disc transparency (bottom)

4.1.1.2 Chlorides

Chloride concentrations in area lakes have increased since the early 1990s when many government agencies switched from sand or sand/salt mixtures to salt for winter road maintenance. When snow and ice melts, the salt goes with it, washing into lakes, streams, wetlands, and groundwater. It only takes 1 teaspoon of road salt to permanently pollute 5 gallons of water. And, once in the water, it is very difficult and expensive to remove.

Because high concentrations of chloride can harm fish and plant life, MPCA has established acute and chronic exposure chloride standards. A lake is considered impaired if two or more exceedances of chronic criterion (230 mg/L or less) occur within a three-year period or one exceedance of acute criterion (860 mg/L) is measured. Chloride concentrations were measured in 2013, 2015, 2016, 2017, and 2020, generally between April and September. All measurements were below the acute criterion. Chloride measurements were above the chronic criterion in April/May during each of the years in which April/May samples were collected - 2013, 2015, 2016, and 2020. The 2013 through 2020 chloride concentrations are summarized in Figure 4-3. 2020 data are summarized in Appendix A.

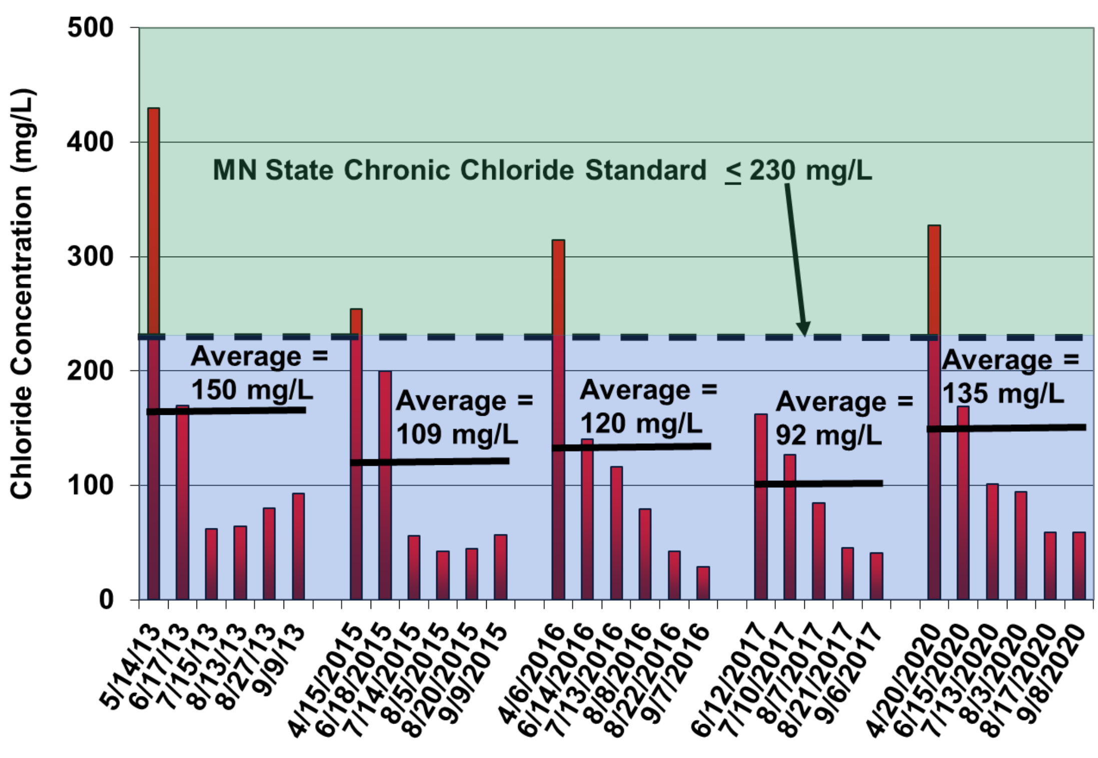


Figure 4-3 Lake Cornelia – North Basin historical chloride concentrations

4.1.1.3 Phytoplankton

Phytoplankton, also called algae, are small aquatic plants naturally present in lakes, including Lake Cornelia – North Basin. Phytoplankton derive energy from the sun through photosynthesis and provide food for several types of aquatic organisms, including zooplankton, which are in turn eaten by fish. An inadequate phytoplankton population limits a lake's zooplankton population, and indirectly limits fish production in a lake. Excess phytoplankton can reduce water clarity, which can then make recreational use of a lake less desirable.

Samples of phytoplankton, microscopic aquatic plants, were collected from Lake Cornelia – North Basin in 2020 to evaluate water quality and the quality of food available to zooplankton (microscopic animals). Identification and enumeration of the phytoplankton species was completed (Appendix B).

Figure 4-4 summarizes the number and major groups of phytoplankton observed in Lake Cornelia – North Basin for monitored years. Green algae, diatoms, and cryptomonads were present throughout the monitored period and provided a good quality food source for the zooplankton community. Blue-green algae numbers increased during 2013 and 2015. With the exception of August 8, 2016, blue-green numbers in 2016 and 2017 were lower than 2013 and 2015 numbers. An algaecide treatment on August 8, 2016 reduced blue-green numbers for the remainder of the 2016 monitoring period. Blue-green numbers again increased in 2020 to the highest numbers to date (Figure 4-4). The increases in blue-green algae numbers in 2013, 2015, and 2020 were unfavorable changes for the lake. Blue-green algae are a poor quality food for zooplankton. Blue-green algae may be toxic to zooplankton and may not be assimilated if ingested. Blue-green algae can also produce algal toxins, which can be harmful to humans or other animals.

While identification and enumeration of phytoplankton species has been part of the District's routine lake monitoring program for many years, increased frequency of observed blue-green algal blooms in recent years prompted the District to develop a protocol in 2020 for evaluating and reporting potential Harmful Algal Blooms (HAB). When District monitoring staff observe signs of a potential blue-green algal bloom on a lake while conducting routine monitoring, staff collect a water sample and expedite algal identification and enumeration. Upon enumeration, blue-green algae counts are compared to thresholds established by the World Health Organization (WHO) as guidelines for low, moderate or high probability of adverse health effects to recreational users. Under the District's current protocol approved December 2020, the District will notify the City, MPCA, Minnesota Department of Health (MDH) and other stakeholder partners of the findings if blue-green algae counts are above the low, medium, or high probability thresholds and post advisory information on the District's website. In addition, if blue-green algae counts are between the low and medium probability threshold, the District will advise public property owner(s) of the WHO recommendation to post advisory signs and if the blue-green algae counts are above the medium or high probability thresholds, the District will recommend that the public property owner(s) post advisory signs.

In 2020, a severe blue-green algal bloom was observed in the lake during the August through September sample events (Figure 4-5). Blue-green algae numbers in August and September ranged from 179,200 per milliliter to 430,768 per milliliter, well above the WHO threshold of 100,000 per milliliter for a moderate probability of adverse health effects (Figure 4-5). Blue-green numbers declined to 28,144 by late October which was below the WHO threshold for moderate probability of adverse health effects.

The Nine Mile Creek Watershed District posted a notification on its website alerting the public to the high blue-green algae levels in Lake Cornelia. The notice informed the public that high levels of blue-green algae are a concern because this type of algae can produce algal toxins, which can pose a health threat for pets and people. The District urged residents to stay out of the water and to keep pets away from the water.

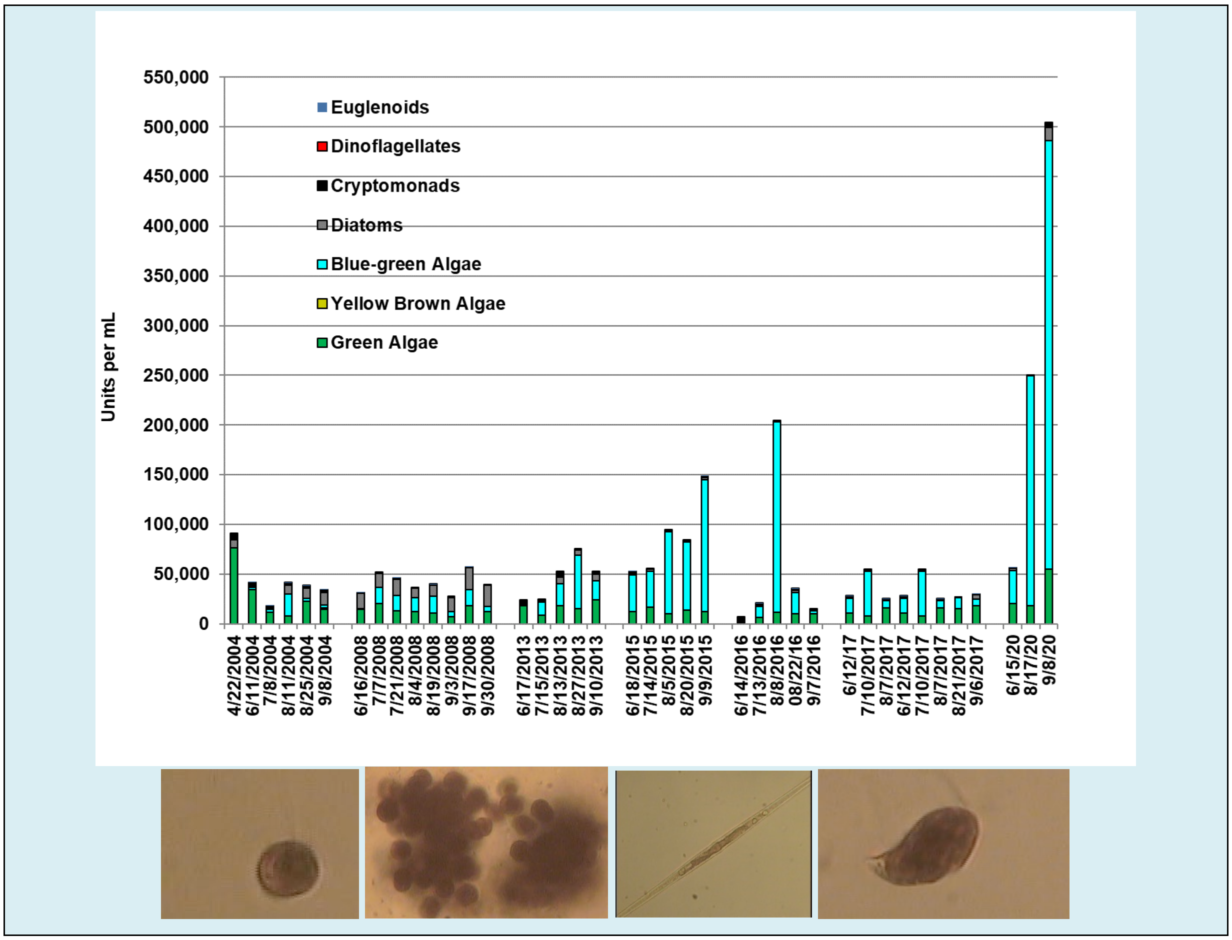


Figure 4-4 Lake Cornelia – North Basin phytoplankton

Top, Lake Cornelia – North Basin 2004, 2008, 2013, 2015, 2016, 2017, and 2020 phytoplankton numbers and bottom, microscopic pictures of phytoplankton species found in the lake, from left to right, *Chlamydomonas globosa* (green algae) *Microcystis aeruginosa* (blue-green algae), *Synedra ulna* (diatom), and *Cryptomonas erosa* (cryptomonad)

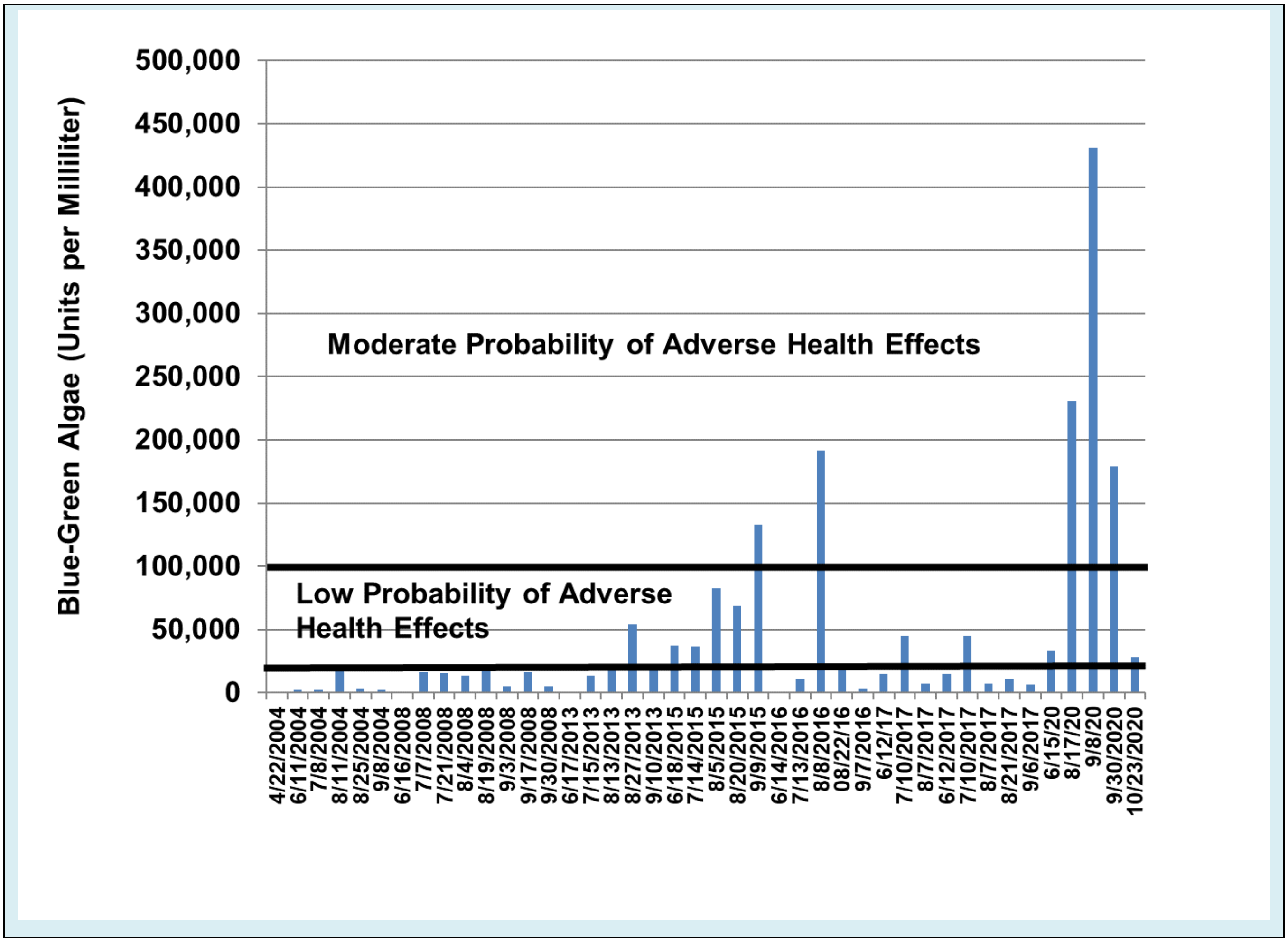


Figure 4-5 Lake Cornelia – North Basin blue-green algae compared with World Health Organization (WHO) thresholds for adverse health effects

4.1.1.4 Conclusions and Recommendations

Monitoring results indicate chloride concentrations in Lake Cornelia – North Basin exceeded the Minnesota Pollution Control Agency (MPCA) chronic criteria in April of 2020 but were all below the acute chloride criteria. The lake failed to meet State water quality standards for shallow lakes in 2020 due to excess phosphorus and algae in the lake and poor water clarity. In 2020, numbers of blue-green algae increased, resulting in a poorer quality of food for the zooplankton community. A severe algal bloom was observed in the lake during the August through September monitoring events. Blue-green numbers during this period ranged from 179,200 per milliliter to 430,768 per milliliter, well above the World Health Organization (WHO) threshold of 100,000 per milliliter for a moderate probability of adverse health effects. A late October sample documented that blue-green numbers declined below the WHO threshold for moderate probability of adverse health effects.

The District completed a Use Attainability Analysis of Lake Cornelia and Lake Edina in July of 2019 to identify water quality improvement measures for both lakes. The UAA concluded that the poor water quality in Lake Cornelia is primarily due to excess phosphorus in the lake, which fuels algal production and decreases water clarity. The recommended management strategy to improve water quality in Lake Cornelia is to reduce watershed and internal phosphorus loading to the lake by implementing several management practices. An alum treatment was conducted by the District in spring of 2020 to reduce the release of phosphorus from lake bottom sediments. The city of Edina plans to conduct a spring 2021 herbicide treatment to reduce the presence of curly-leaf pondweed, an invasive aquatic plant that typically dies off in mid-summer, releasing phosphorus into the lake. Because the watershed is fully developed, significantly reducing watershed phosphorus loading can be particularly challenging and costly. Plans are underway for construction of a stormwater filtration Best Management Practice (BMP) in Rosland Park to reduce the amount of phosphorus to Lake Cornelia from the watershed.

Continuation of water quality and biological monitoring is recommended to periodically assess the condition of the lake's water quality and biological community and identify trends.

4.1.2 Lake Cornelia – South Basin

Lake Cornelia – South Basin (Figure 4-1) has a water surface area of approximately 31 acres, a maximum depth of 7 feet, and a mean depth of 4.2 feet at a normal surface elevation of 859.1 MSL. The water level in the lake is controlled by the elevation of the weir structure at the south side of the lake. The lake is shallow enough for aquatic plants to grow over the entire lake bed. It is a polymictic lake, mixing many times per year. The lake is currently on the MPCA's impaired waters list for excess nutrients (since 2018).

4.1.2.1 Total Phosphorus and Chlorophyll *a* Levels and Water Clarity (Secchi Depth)

In 2020, Lake Cornelia – South Basin water quality was poor. The lake's summer average total phosphorus and chlorophyll *a* concentrations were 97 µg/L and 53 µg/L, respectively (Figure 4-6). The lake's summer average Secchi disc transparency was 0.2 meters (Figure 4-6). All three summer averages failed to meet the Minnesota State water quality standards for shallow lakes in the North Central Hardwood Forest Ecoregion in 2020 which are ≤ 60 µg/L, ≤ 20 µg/L, and ≥ 1 meter, respectively (Figure 4-6).

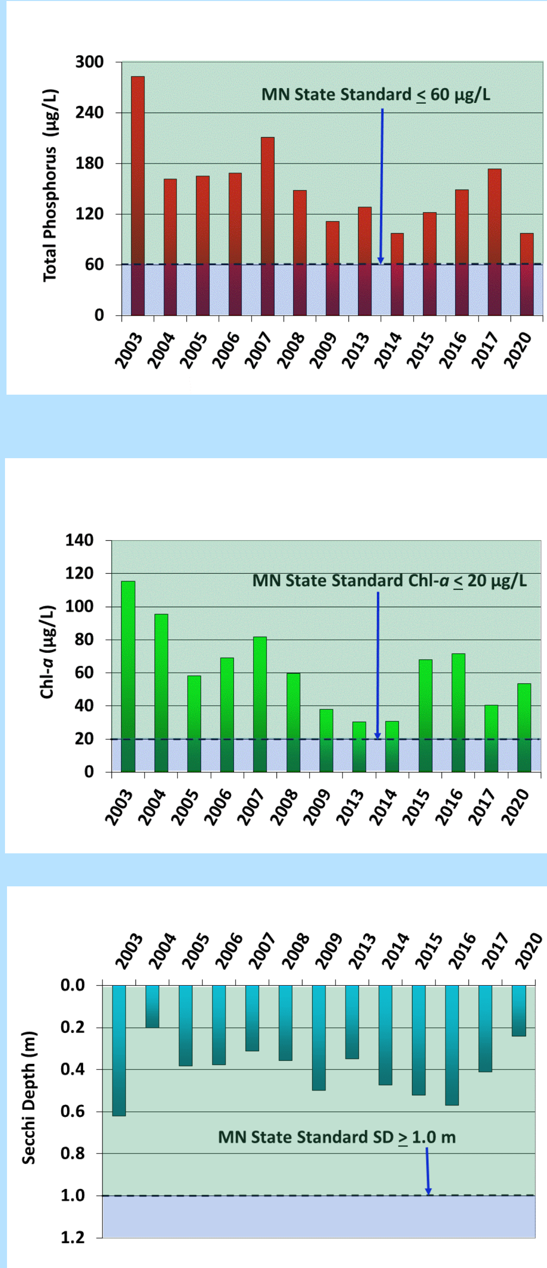


Figure 4-6 Lake Cornelia – South Basin historical summer average values
total phosphorus (top), chlorophyll *a* (middle), and Secchi disc (bottom)

Historical water quality data have been collected from Lake Cornelia – South Basin during 2003 through 2020. The poor water quality observed in 2020 was typical of the water quality observed in previous years. All summer average total phosphorus and chlorophyll *a* concentrations and Secchi disc transparency values failed to meet the Minnesota State water quality standards for shallow lakes in the North Central Hardwood Forest Ecoregion (Figure 4-6). The lake's 2020 summer average total phosphorus and chlorophyll *a* concentrations and Secchi disc transparency were within the range observed in previous years (Figure 4-6). However, the 2020 summer average total phosphorus concentration was tied with 2014 for the lowest summer average during the period of record.

4.1.2.2 Chlorides

Chloride concentrations in area lakes have increased since the early 1990s when many government agencies switched from sand or sand/salt mixtures to salt for winter road maintenance. When snow and ice melts, the salt goes with it, washing into lakes, streams, wetlands, and groundwater. It only takes 1 teaspoon of road salt to permanently pollute 5 gallons of water. And, once in the water, it is very difficult and expensive to remove.

Because high concentrations of chloride can harm fish and plant life, MPCA has established acute and chronic exposure chloride standards. A lake is considered impaired if two or more exceedances of chronic criterion (230 mg/L or less) occur within a three-year period or one exceedance of acute criterion (860 mg/L) is measured. Chloride concentrations were measured in 2013, 2015, 2016, 2017, and 2020, generally between April and September. All measurements were below the acute criterion and all but the May 2013 measurement were below the chronic criterion. The 2013 through 2020 chloride concentrations are summarized in Figure 4-7. 2020 data are summarized in Appendix A

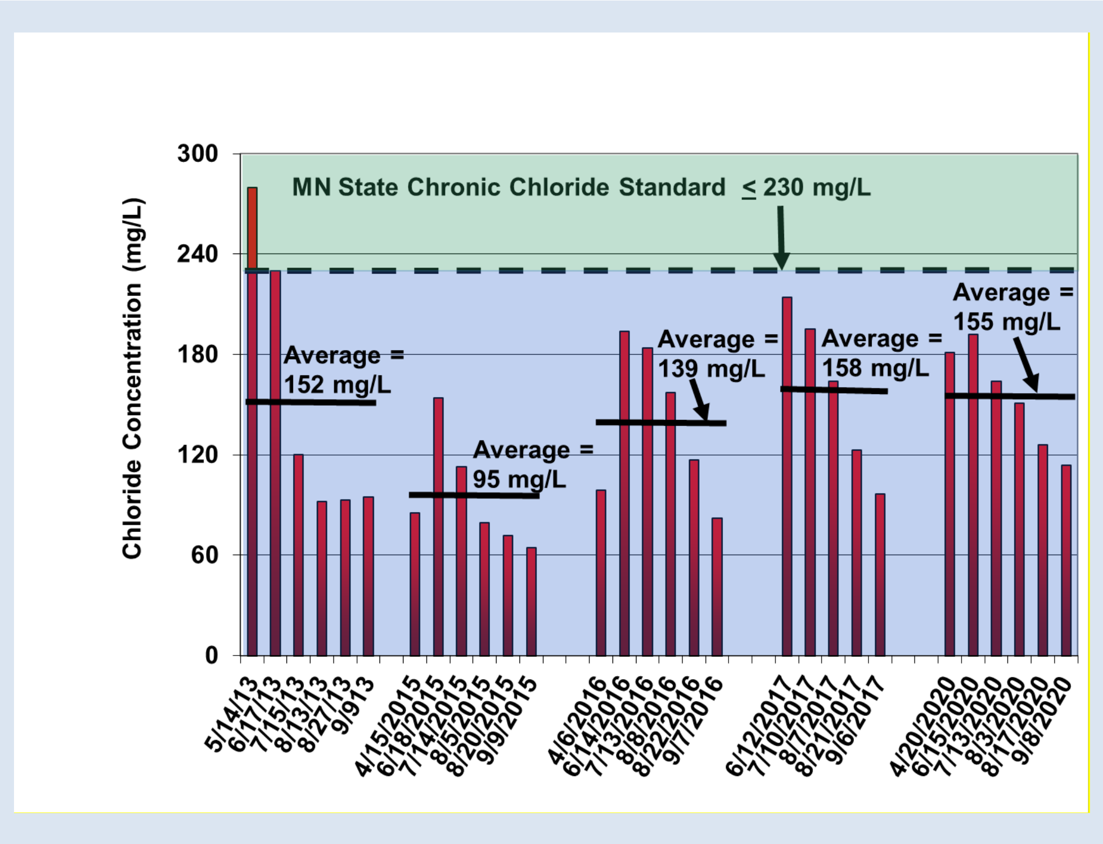


Figure 4-7 Lake Cornelia – South Basin historical chloride concentrations

4.1.2.3 Phytoplankton

Phytoplankton, also called algae, are small aquatic plants naturally present in lakes, including Lake Cornelia – South Basin. Phytoplankton derive energy from the sun through photosynthesis and provide food for several types of aquatic organisms, including zooplankton, which are in turn eaten by fish. An inadequate phytoplankton population limits a lake's zooplankton population, and indirectly limits fish production in a lake. Excess phytoplankton can reduce water clarity, which can then make recreational use of a lake less desirable.

Samples of phytoplankton, microscopic aquatic plants, were collected from Lake Cornelia – South Basin in 2020 to evaluate water quality and the quality of food available to zooplankton (microscopic animals). Identification and enumeration of the phytoplankton species was completed (Appendix B).

Figure 4-8 summarizes the number and major groups of phytoplankton observed in Lake Cornelia – South Basin for monitored years. Green algae, diatoms, and cryptomonads were present throughout the monitored period and provided a good quality food source for the zooplankton community. However, the phytoplankton community in Lake Cornelia – South Basin was generally dominated by blue-green algae throughout the period of record. Blue-green algae are a poor quality food for zooplankton. Blue-green algae may be toxic to zooplankton and may not be assimilated if ingested. Blue-green algae can also produce algal toxins, which can be harmful to humans or other animals. Numbers of blue-green algae increased during 2013, 2015 and until August 8, 2016 when an algaecide treatment, contracted by the City of Edina, reduced blue-green numbers for the remainder of the 2016 monitoring period. Blue-green numbers were lower in 2017 and then increased in 2020. The highest number of blue-green algae to date was observed on August 3, 2020 (Figure 4-8). The increase in blue-green algae numbers in 2020 was an unfavorable change for the lake.

While identification and enumeration of phytoplankton species has been part of the District's routine lake monitoring program for many years, increased frequency of observed blue-green algal blooms in recent years prompted the District to develop a protocol in 2020 for evaluating and reporting potential Harmful Algal Blooms (HAB). When District monitoring staff observe signs of a potential blue-green algal bloom on a lake while conducting routine monitoring, staff collect a water sample and expedite algal identification and enumeration. Upon enumeration, blue-green algae counts are compared to thresholds established by the World Health Organization (WHO) as guidelines for low, moderate or high probability of adverse health effects to recreational users. Under the District's current protocol approved December 2020, the District will notify the City, MPCA, Minnesota Department of Health (MDH) and other stakeholder partners of the findings if blue-green algae counts are above the low, medium, or high probability thresholds and post advisory information on the District's website. In addition, if blue-green algae counts are between the low and medium probability threshold, the District will advise public property owner(s) of the WHO recommendation to post advisory signs and if the blue-green algae counts are above the medium or high probability thresholds, the District will recommend that the public property owner(s) post advisory signs.

A severe blue-green algal bloom was observed in the lake during the August through September sample events (Figure 4-9). Blue-green algae numbers in August and September ranged from 211,364 per milliliter to 459,486 per milliliter, well above the WHO threshold of 100,000 per milliliter for a moderate probability of adverse health effects (Figure 4-9). Blue-green numbers declined to 30,154 by late October which was below the WHO threshold for a moderate probability of adverse health effects.

The Nine Mile Creek Watershed District posted a notification on its website alerting the public to the high blue-green algae levels in Lake Cornelia. The notice informed the public that high levels of blue-green algae are a concern because this type of algae can produce algal toxins, which can pose a health threat for pets and people. The District urged residents to stay out of the water and to keep pets away from the water.

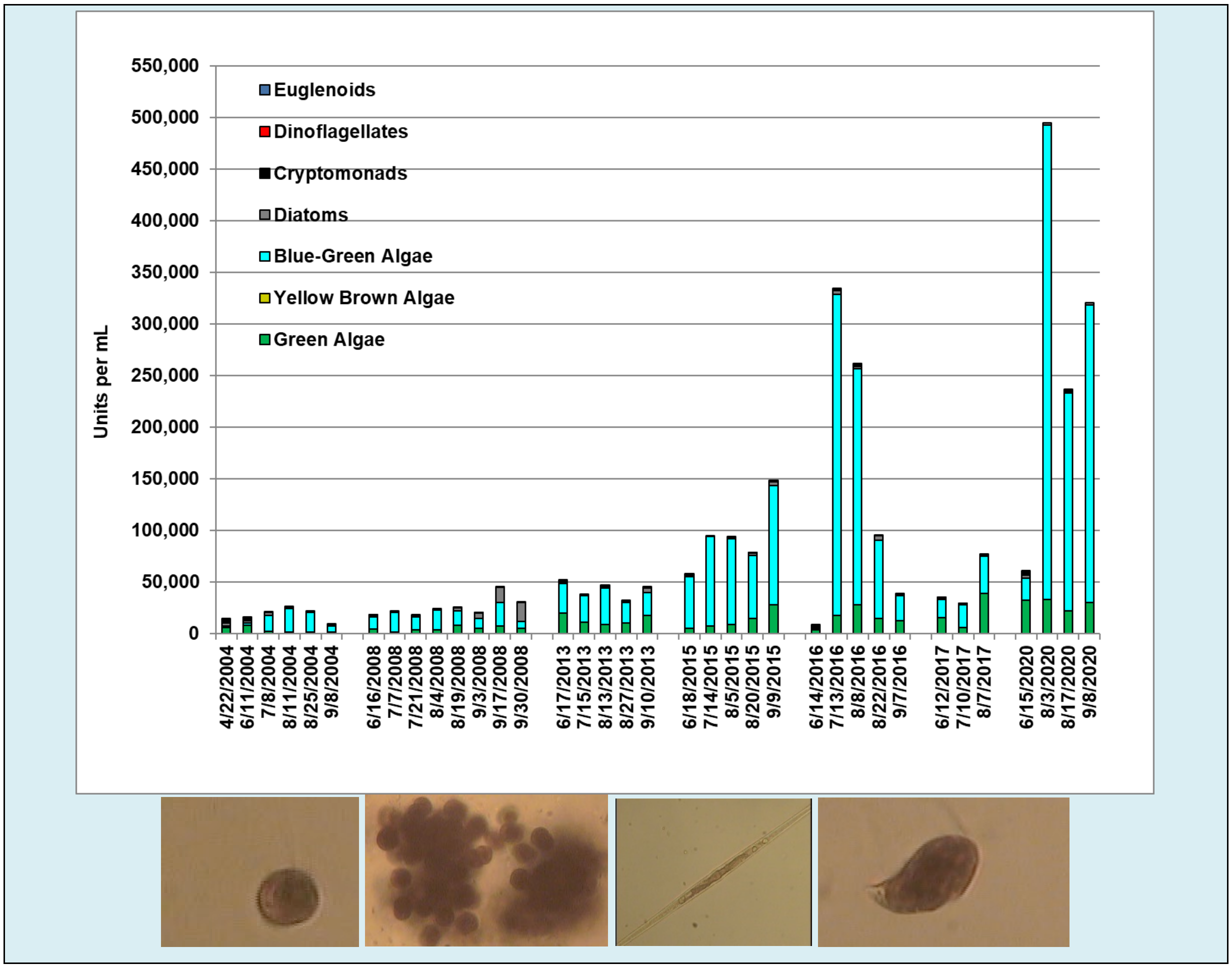


Figure 4-8 Lake Cornelia – South Basin phytoplankton

Top, Lake Cornelia – South Basin 2004, 2008, 2013, 2015, 2016, 2017, and 2020 phytoplankton numbers and bottom, microscopic pictures of phytoplankton species found in the lake, from left to right, *Chlamydomonas globosa* (green algae) *Microcystis aeruginosa* (blue-green algae), *Synedra ulna* (diatom), and *Cryptomonas erosa* (cryptomonad)

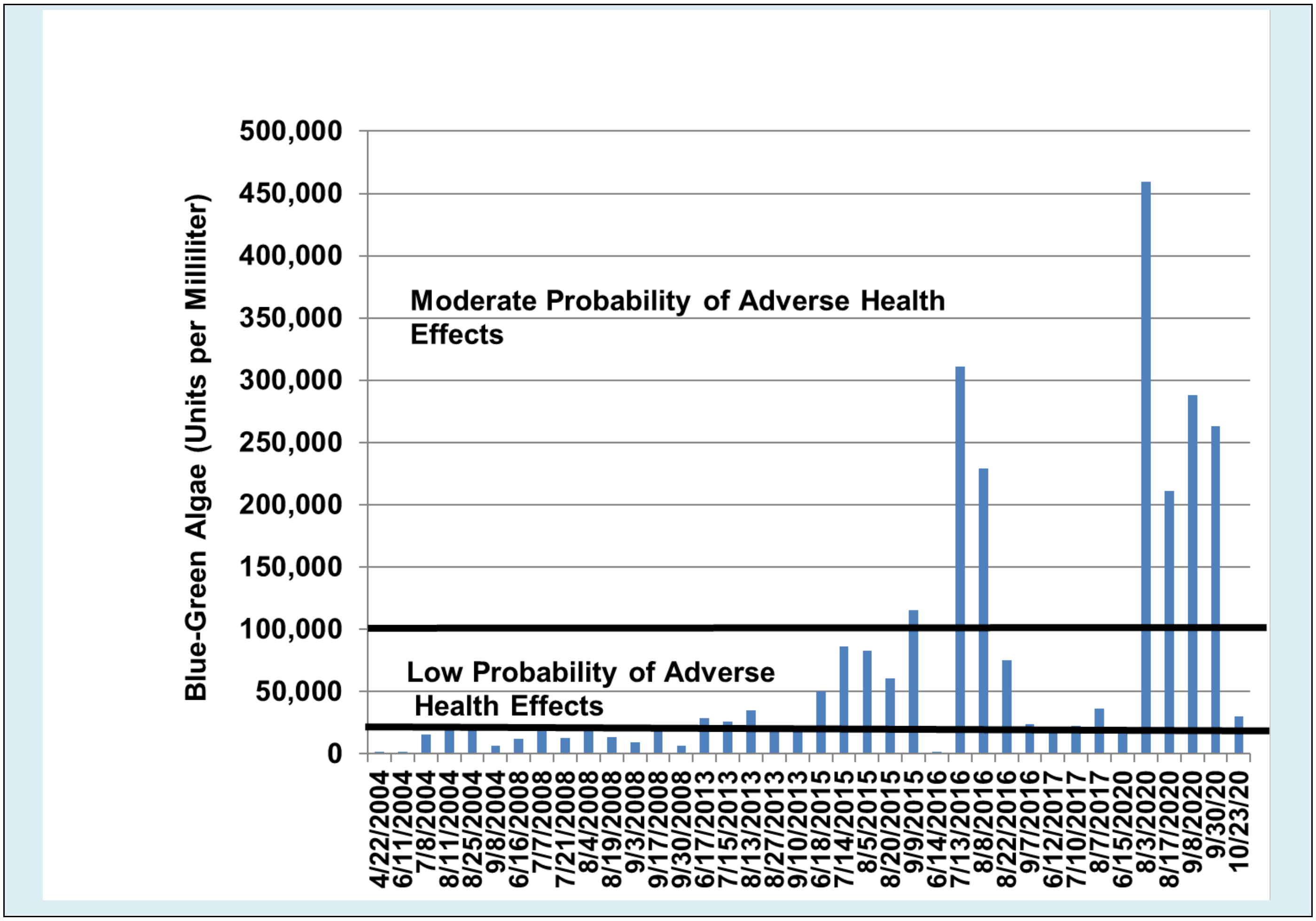


Figure 4-9 Lake Cornelia – South Basin blue-green algae compared with World Health Organization (WHO) thresholds for adverse health effects

4.1.2.4 Conclusions and Recommendations

Monitoring results indicate chloride concentrations in Lake Cornelia South Basin were below the Minnesota Pollution Control Agency (MPCA) acute and chronic chloride standards in 2020, but failed to meet State water quality standards for a shallow lake in 2020 due to excess phosphorus and algae in the lake and poor water clarity. In 2020, blue-green algae numbers increased, resulting in a poorer quality of food for the zooplankton community. A severe algal bloom was observed in the lake during the August through September monitoring events. Blue-green numbers during this period ranged from 211,645 per milliliter to 459,486 per milliliter, well above the World Health Organization (WHO) threshold of 100,000 per milliliter for a moderate probability of adverse health effects. A late October sample documented that blue-green numbers declined below the WHO threshold for moderate probability of adverse health effects.

5 Lake Edina

Lake Edina (Figure 5-1) is a small shallow lake located in Edina with a surface area of 24 acres and a maximum depth of approximately 4 feet. The lake is shallow enough for aquatic plants to grow over the entire lake bed. In addition, it is also a polymictic lake (mixing many times per year). The lake is currently on the MPCA's impaired waters list for excess nutrients (since 2008).

In 2020, the Nine Mile Creek Watershed District monitored Lake Edina for:

- Water chemistry- total phosphorus (TP), soluble reactive phosphorus (ortho phosphate), total nitrogen, total Kjeldahl nitrogen, nitrate plus nitrite nitrogen, chlorophyll *a*, chloride, and turbidity.
- Water field measurements- dissolved oxygen, pH, temperature, specific conductance, and Secchi disc.
- Phytoplankton and zooplankton (microscopic plants and animals)

Water quality monitoring results are summarized in Appendix A and phytoplankton and zooplankton results in Appendix B. Monitoring results are discussed in the following paragraphs and compared with historical data.

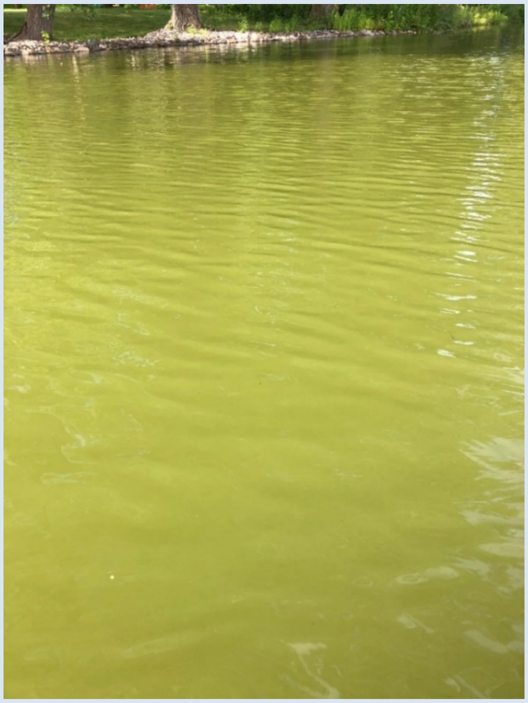


Figure 5-1 Lake Edina
Photo Credit: Endangered Resource Services, LLC.

5.1 Total Phosphorus and Chlorophyll *a* Levels and Water Clarity (Secchi Depth)

In 2020, Lake Edina water quality was poor. The lake's 2020 average summer total phosphorus concentration of 126 µg/L, the lake's average summer chlorophyll *a* concentration of 59.2 µg/L, and the lake's average summer Secchi disc transparency of 0.2 meters failed to meet the Minnesota State Water Quality Standards for shallow lakes in the North Central Hardwood Forest Ecoregion published in Minnesota Rules 7050 (Minn. R. Ch. 7050.0222 Subp 4) (Figure 5-2). Minnesota State water quality standards for shallow lakes in the North Central Hardwood Forest Ecoregion in 2020 are ≤ 60 µg/L, ≤ 20 µg/L, and ≥ 1 meter, respectively.

Historical water quality data have been collected from Lake Edina by NMCWD during 2004, 2005, 2008, 2012, 2015, 2017 and 2020 and by CAMP during 2004 and 2005. The poor water quality observed in 2020 was typical of the water quality observed in previous years. During the period examined, all summer average total phosphorus and Secchi disc values and all but the 2017 summer average chlorophyll *a* concentration failed to meet MPCA standards for shallow lakes (Figure 5-2). The 2020 summer average total phosphorus and chlorophyll *a* concentrations were within the range of previous years. However, the 2020 summer average Secchi disc value was the lowest observed during the period of record (Figure 5-2).

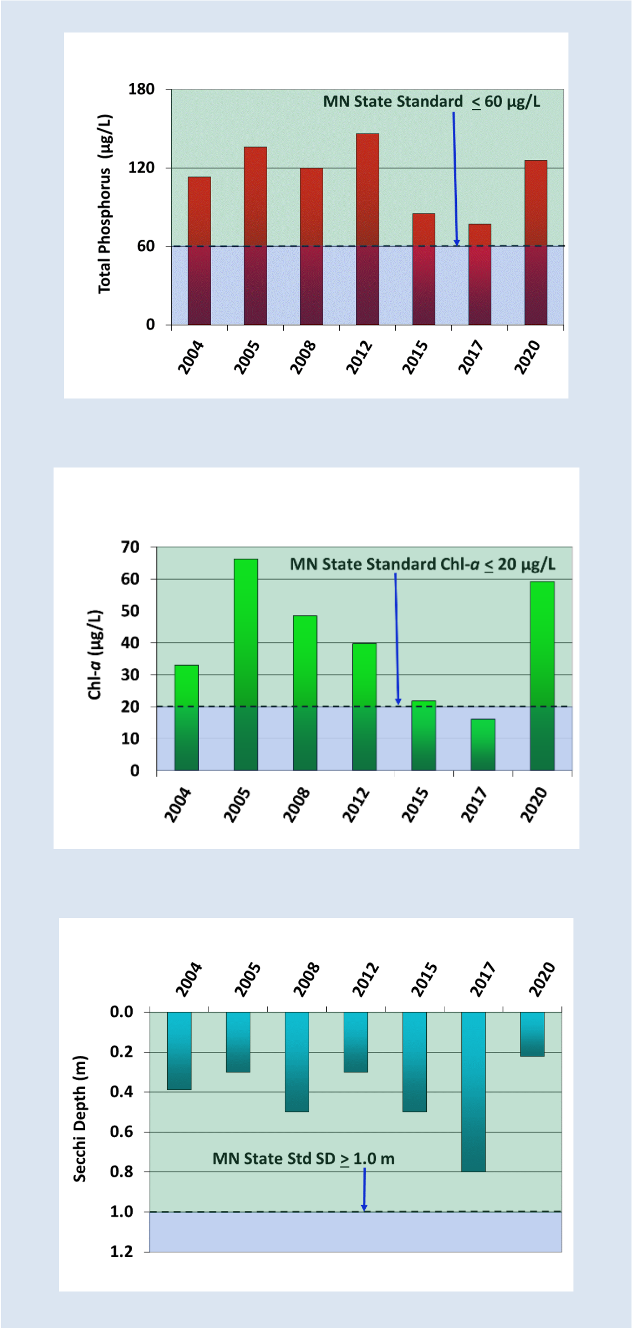


Figure 5-2 Lake Edina historical summer average values
total phosphorus (top), chlorophyll *a* (middle), and Secchi disc (bottom)

5.2 Chlorides

Chloride concentrations in area lakes have increased since the early 1990s when many government agencies switched from sand or sand/salt mixtures to salt for winter road maintenance. When snow and ice melts, the salt goes with it, washing into lakes, streams, wetlands, and groundwater. It only takes 1 teaspoon of road salt to permanently pollute 5 gallons of water. And, once in the water, it is very difficult and expensive to remove.

Because high concentrations of chloride can harm fish and plant life, MPCA has established acute and chronic exposure chloride standards. A lake is considered impaired if two or more exceedances of chronic criterion (230 mg/L or less) occur within a three-year period or one exceedance of acute criterion (860 mg/L) is measured. Chlorides were measured in Lake Edina in 2012, 2015, 2017, and 2020, generally between April and September. All chloride measurements were below the acute and chronic MPCA criteria. The chloride concentrations for years monitored by the District are summarized in Figure 5-3. 2020 data are summarized in Appendix A

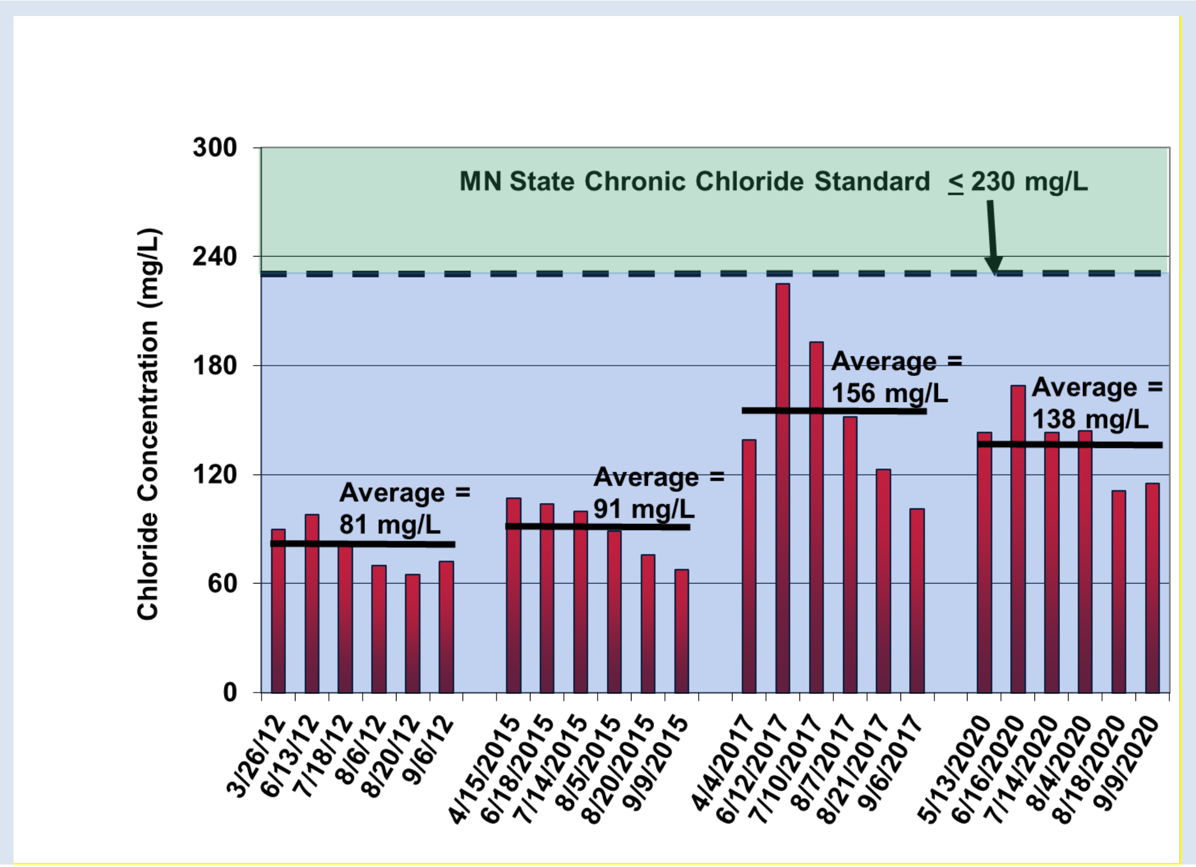


Figure 5-3 Lake Edina historical chloride concentrations

5.3 Phytoplankton

Phytoplankton, also called algae, are small aquatic plants naturally present in lakes, including Lake Edina. Phytoplankton derive energy from the sun through photosynthesis and provide food for several types of aquatic organisms, including zooplankton, which are in turn eaten by fish. An inadequate phytoplankton population limits a lake's zooplankton population, and indirectly limits fish production in a lake. Excess phytoplankton can reduce water clarity, which can then make recreational use of a lake less desirable.

Samples of phytoplankton, microscopic aquatic plants, were collected from Lake Edina in 2020 to evaluate water quality and the quality of food available to zooplankton (microscopic animals). Identification and enumeration of the phytoplankton species was completed (Appendix B). Figure 5-4 summarizes the summer average number and major groups of phytoplankton observed in Lake Edina for monitored years. The phytoplankton community in Lake Edina was dominated by blue-green algae in 2008, 2012, 2015, and 2020, but was dominated by green algae during 2017. Green algae are a good quality food source and contribute towards a healthy zooplankton community. Blue-green algae are a poor quality food for zooplankton. Blue-green algae may be toxic to zooplankton and may not be assimilated if ingested. Summer average numbers of blue-green algae consistently increased for monitored years during 2008 through 2020, with exception of 2017 (Figure 5-4). The increase in blue-green algae numbers in 2020 was an unfavorable change for the lake.

While identification and enumeration of phytoplankton species has been part of the District's routine lake monitoring program for many years, increased frequency of observed blue-green algal blooms in recent years prompted the District to develop a protocol in 2020 for evaluating and reporting potential Harmful Algal Blooms (HAB). When District monitoring staff observe signs of a potential blue-green algal bloom on a lake while conducting routine monitoring, staff collect a water sample and expedite algal identification and enumeration. Upon enumeration, blue-green algae counts are compared to thresholds established by the World Health Organization (WHO) as guidelines for low, moderate or high probability of adverse health effects to recreational users. Under the District's current protocol approved December 2020, the District will notify the City, MPCA, Minnesota Department of Health (MDH) and other stakeholder partners of the findings if blue-green algae counts are above the low, medium, or high probability thresholds and post advisory information on the District's website. In addition, if blue-green algae counts are between the low and medium probability threshold, the District will advise public property owner(s) of the WHO recommendation to post advisory signs and if the blue-green algae counts are above the medium or high probability thresholds, the District will recommend that the public property owner(s) post advisory signs.

In 2020, a severe blue-green algal bloom was observed in the lake during the July through September sample events (Figure 5-5). Blue-green numbers in July totaled 350,358 per milliliter, well above the WHO threshold of 100,000 per milliliter for a moderate probability of adverse health impacts (Figure 5-5). During August, blue-green numbers declined to 210,215 per milliliter, still above the WHO threshold, and then increased to 470,973 per milliliter by late September (Figure 5-5). Blue-green numbers declined to 72,244 per milliliter by late October which was below the WHO threshold for moderate probability of adverse health effects.

The Nine Mile Creek Watershed District posted a notification on its website alerting the public to the high blue-green algae levels in Lake Edina. The notice informed the public that high levels of blue-green algae are a concern because this type of algae can produce algal toxins, which can pose a health threat for pets and people. The District urged residents to stay out of the water and to keep pets away from the water.

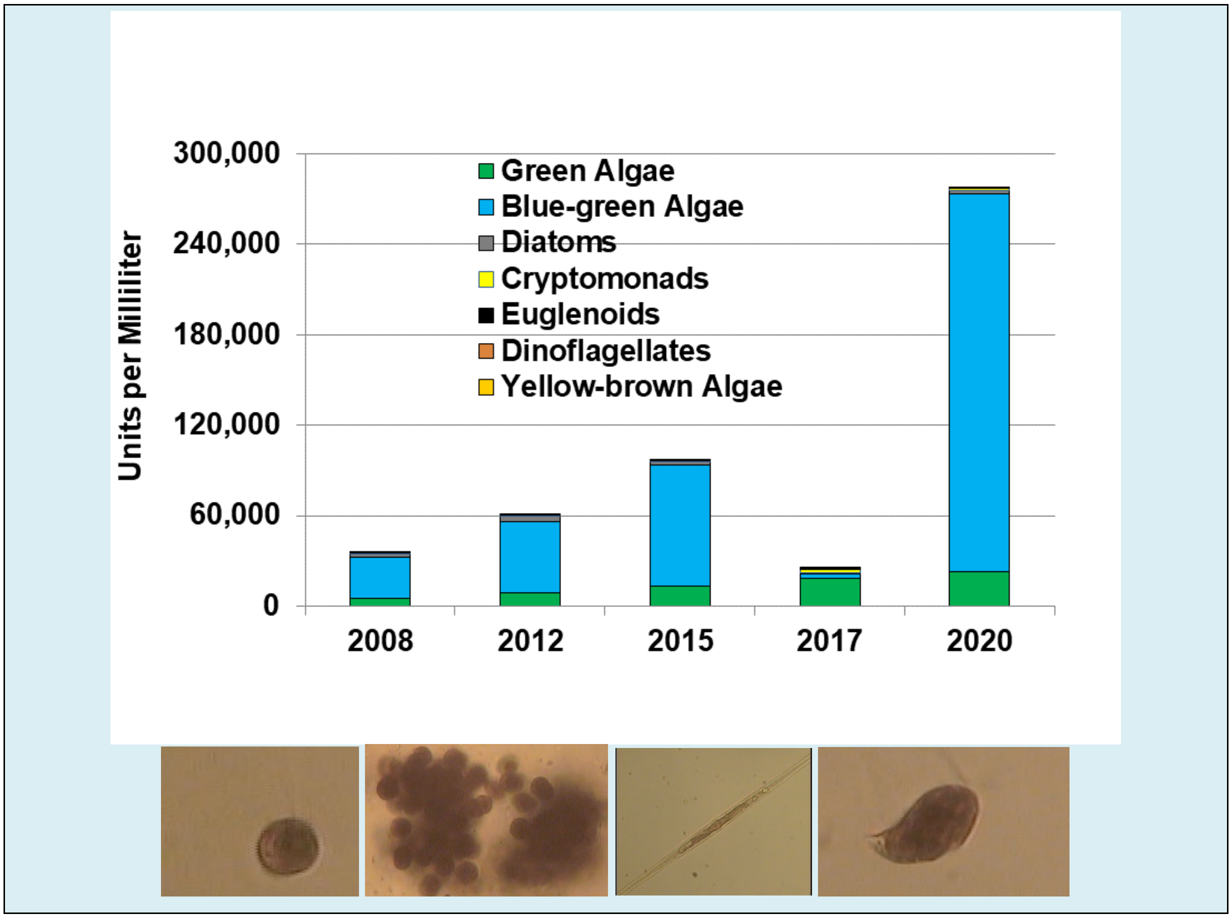


Figure 5-4   Lake Edina summer average phytoplankton

Top, Lake Edina 2008, 2012, 2015, 2017, and 2020 summer average phytoplankton numbers and bottom, microscopic pictures of phytoplankton species found in the lake, from left to right*, Chlamydomonas globosa* (green algae) *Microcystis aeruginosa* (blue-green algae), *Synedra ulna* (diatom), and *Cryptomonas erosa* (cryptomonad)

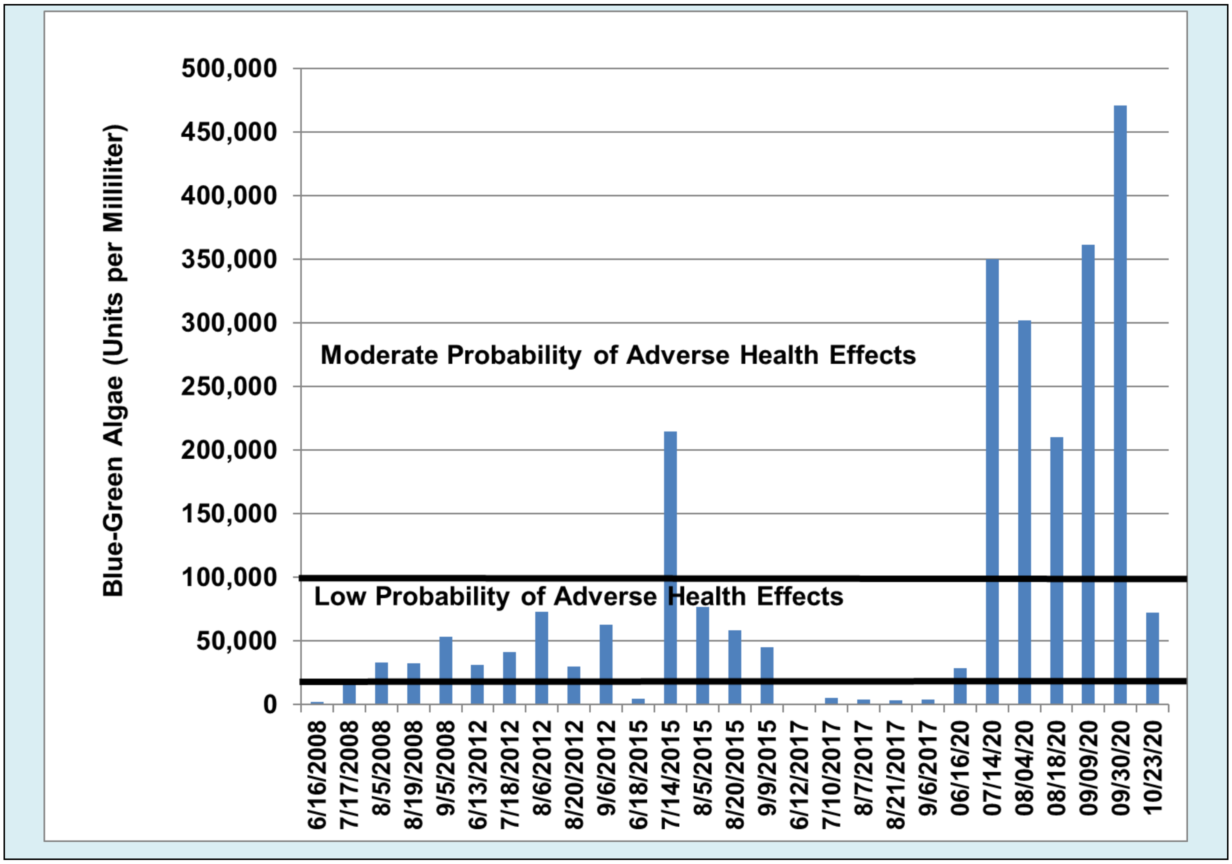


Figure 5-5 Lake Edina blue-green algae compared with World Health Organization (WHO) thresholds for adverse health effects

5.4 Zooplankton

Samples of zooplankton, microscopic aquatic animals, were collected from Lake Edina to evaluate the food available to planktivorous fish. Identification and enumeration of the zooplankton species was completed (Appendix B).

Figure 5-6 summarizes the summer average number and major groups of zooplankton and during the monitored period. All three groups of zooplankton (rotifers, copepods, and cladocerans) were represented in 2020 in Lake Edina. Numbers of cladocerans and copepods were, on average, higher in 2019 and 2020 than previous years resulting in a more even distribution between the 3 groups of zooplankton (Figure 5-6). Summer average zooplankton numbers have generally increased since 2008 for monitored years, although a decline was observed in 2015. The highest summer average zooplankton number to date was observed in 2020. The data indicate the zooplankton community provided an abundant supply of food for planktivorous fish in the lake.

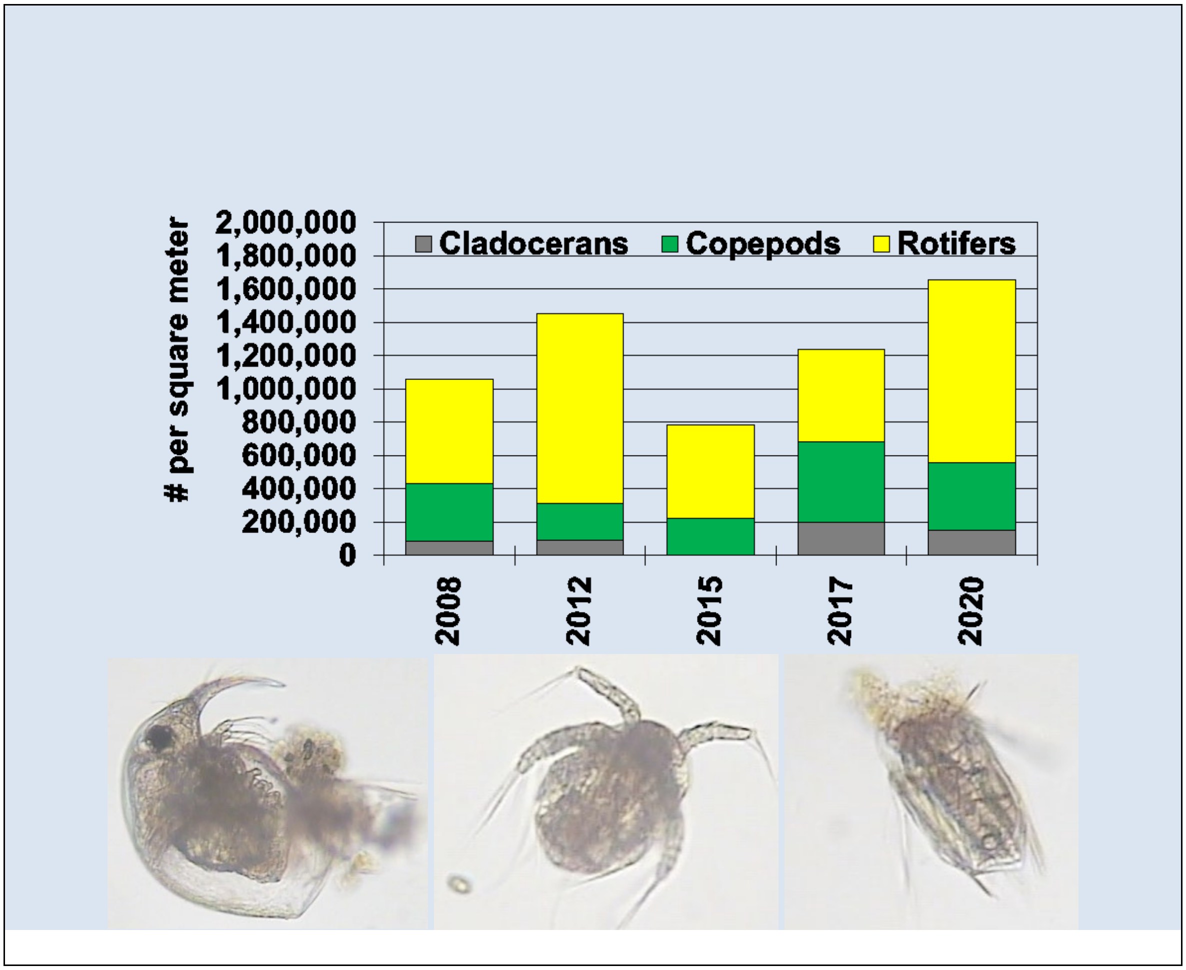


Figure 5-6 Lake Edina summer average zooplankton

Top, 2008, 2012, 2015, 2017, and 2020 Lake Edina zooplankton numbers and bottom, microscopic pictures of zooplankton species from the lake, from left to right, *Bosmina longirostris* (cladoceran), nauplii (baby copepod), and *Polyarthra vulgaris* (rotifer).

5.5 Conclusions and Recommendations

Monitoring results indicate Lake Edina met the Minnesota Pollution Control Agency (MPCA) acute and chronic chloride criteria, but failed to meet MPCA water quality standards for a shallow lake in 2020 due to excess phosphorus and algae in the lake and poor water clarity. In 2020, summer average numbers of blue-green algae increased, resulting in a poorer quality of food for the zooplankton community. A severe algal bloom was observed in the lake during the July through September monitoring events. Blue-green numbers during this period ranged from 210,215 per milliliter to 470,973 per milliliter, well above the World Health Organization (WHO) threshold of 100,000 per milliliter for a moderate probability of adverse health effects. A late October sample documented that blue-green numbers declined below the WHO threshold for moderate probability of adverse health effects. The highest summer average zooplankton number to date was observed in 2020, indicating the zooplankton community provided an abundant supply of food for planktivorous fish in the lake.

The District completed a Use Attainability Analysis of Lake Cornelia and Lake Edina in July of 2019 to identify water quality improvement measures for both lakes. The UAA concluded that the poor water quality in Lake Edina is primarily due to excess phosphorus in the lake, which fuels algal production and decreases water clarity. Phosphorus in Lake Edina primarily comes from runoff from the watershed (external sources) and flows from upstream Lake Cornelia. Modeling indicates that during 2017, flows from upstream Lake Cornelia comprised nearly two thirds of the annual phosphorus load to Lake Edina. Because the water quality of Lake Edina is highly influenced by the water quality of Lake Cornelia, a recommended management strategy to improve water quality in Lake Edina is to implement management practices to improve upstream Lake Cornelia. The District and City of Edina have initiated several improvement projects in the Lake Cornelia watershed (see Section 4.1.1.4). In 2021, the District is also evaluating a stormwater improvement project at the Bristol & Mavelle Park in the Lake Edina watershed, in partnership with the City of Edina.

Continuation of water quality and biological monitoring is recommended to periodically assess the condition of the lake's water quality and biological community and identify trends.

6 Lake Holiday

Lake Holiday (Figure 6-1) is a small waterbody with a water surface area of approximately 8 acres, a maximum depth of about 7 feet, and a mean depth of 3.7 feet at a water surface elevation of 936.7. At this elevation the lake volume is approximately 29 acre-feet. The water level in the lake is controlled by weather conditions (snowmelt, rainfall, and evaporation), inflow from Woodgate Pond, which provides pretreatment of approximately 170 acres of the Lake Holiday watershed, inflow from its direct subwatershed, and by a pumped outlet. The pumping capacity of the Lake Holiday outlet is 7.0 cfs.

In 2020, the Nine Mile Creek Watershed District monitored Lake Holiday for:

- Water chemistry- total phosphorus (TP), soluble reactive phosphorus (ortho phosphate), total nitrogen, total Kjeldahl nitrogen, nitrate plus nitrite nitrogen, chlorophyll *a*, chloride, and turbidity.
- Water field measurements- dissolved oxygen, pH, temperature, specific conductance, and Secchi disc.
- Phytoplankton and zooplankton (microscopic plants and animals)
- Macrophytes (aquatic plants)

Water quality monitoring results are summarized in Appendix A, phytoplankton and zooplankton data in Appendix B, and macrophyte monitoring maps in Appendix C. Monitoring results are discussed in the following paragraphs.

Figure 6-1 Lake Holiday

6.1 Total Phosphorus and Chlorophyll *a* Levels and Water Clarity (Secchi Depth

In 2020, water quality in Lake Holiday was poor. The lake's 2020 average summer total phosphorus and chlorophyll *a* concentrations were 194 µg/L, and 44 µg/L. The lake's summer average Secchi disc transparency was 0.3 meters. All three summer averages failed to meet the Minnesota State water quality standards for shallow lakes in the North Central Hardwood Forest Ecoregion which are <u><</u>60 µg/L, <u><</u>20 µg/L, and <u>></u>1 meter, respectively (Figure 6-2).

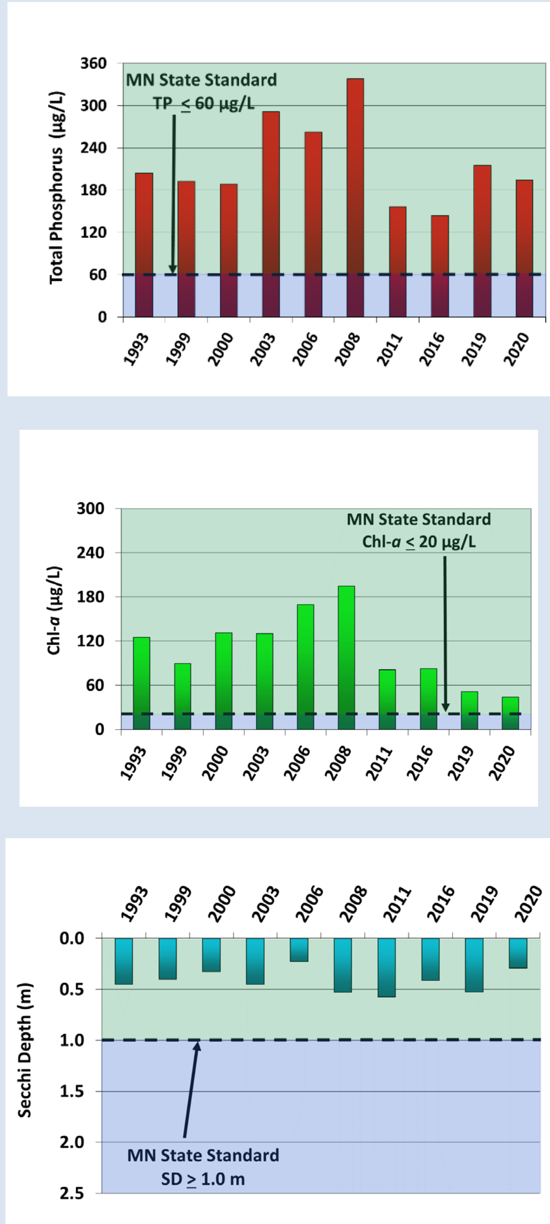


Figure 6-2 Lake Holiday historical summer average values
total phosphorus (top), chlorophyll a (middle), and Secchi disc (bottom)

Water quality data have been collected by the City of Minnetonka from Lake Holiday during 1993, 1999, 2000, 2003, 2006, 2008, 2011, 2016, and 2019, and by the Nine Mile Creek Watershed District in 2020. Poor water quality has been observed in the lake during the entire period of record. All summer average total phosphorus and chlorophyll *a* concentrations and Secchi disc transparency values failed to meet the Minnesota State water quality standards for shallow lakes in the North Central Hardwood Forest Ecoregion (Figure 6-2). Summer average total phosphorus and chlorophyll *a* concentrations were lower during 2011 through 2020 than 2003 through 2008. The 2020 summer average chlorophyll *a* concentration was the lowest on record (Figure 6-2).

The District is updating the Use Attainability Analysis for Holiday, Wing, and Rose Lakes in 2021, as identified in the District's Water Management Plan (2017). As part of this water quality study, the District will seek to identify management measures to improve the lake's water quality.

6.2 Chlorides

Chloride concentrations in area lakes have increased since the early 1990s when many government agencies switched from sand or sand/salt mixtures to salt for winter road maintenance. When snow and ice melts, the salt goes with it, washing into lakes, streams, wetlands, and groundwater. It only takes 1 teaspoon of road salt to permanently pollute 5 gallons of water. And, once in the water, it is very difficult and expensive to remove.

Because high concentrations of chloride can harm fish and plant life, MPCA has established acute and chronic exposure chloride standards. A lake is considered impaired if two or more exceedances of chronic criterion (230 mg/L or less) occur within a three-year period or one exceedance of acute criterion (860 mg/L) is measured. Chloride concentrations were measured during May through September 2020. All chloride measurements were below the acute and chronic MPCA criteria. The 2020 chloride concentrations are summarized in Figure 6-3 and Appendix A.

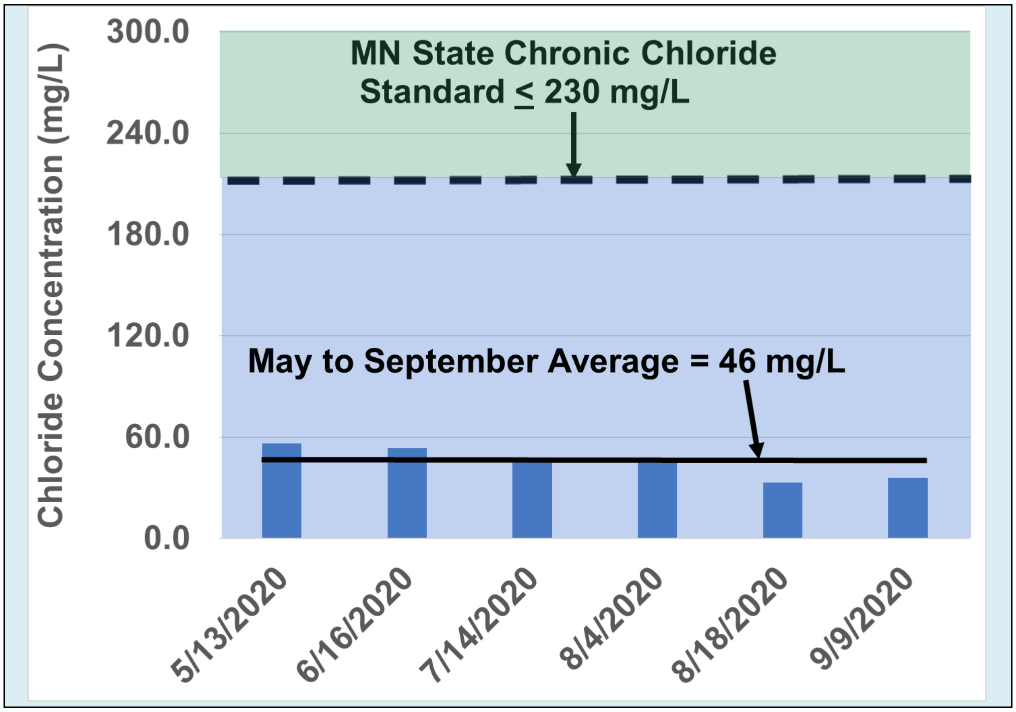


Figure 6-3 Lake Holiday 2020 chloride concentrations

6.3 Phytoplankton

Phytoplankton, also called algae, are small aquatic plants naturally present in lakes, including Lake Holiday. Phytoplankton derive energy from the sun through photosynthesis and provide food for several types of aquatic organisms, including zooplankton, which are in turn eaten by fish. An inadequate phytoplankton population limits a lake's zooplankton population, and indirectly limits fish production in a lake. Excess phytoplankton can reduce water clarity, which can then make recreational use of a lake less desirable.

Samples of phytoplankton, microscopic aquatic plants, were collected from Lake Holiday in 2020 to evaluate water quality and the quality of food available to zooplankton (microscopic animals). Identification and enumeration of the phytoplankton species was completed (Appendix B).

Figure 6-4 summarizes the summer average number and major groups of phytoplankton observed in Lake Holiday during 2020. The phytoplankton community in Lake Holiday was dominated by blue-green algae throughout 2020 (Figure 6-4). The dominance by blue-green algae is unfavorable for the lake because blue-green algae may be toxic to zooplankton and may not be assimilated if ingested. Blue-green algae can also produce algal toxins, which can be harmful to humans or other animals.

While identification and enumeration of phytoplankton species has been part of the District's routine lake monitoring program for many years, increased frequency of observed blue-green algal blooms in recent years prompted the District to develop a protocol in 2020 for evaluating and reporting potential Harmful Algal Blooms (HAB). When District monitoring staff observe signs of a potential blue-green algal bloom on a lake while conducting routine monitoring, staff collect a water sample and expedite algal identification and enumeration. Upon enumeration, blue-green algae counts are compared to thresholds established by the World Health Organization (WHO) as guidelines for low, moderate or high probability of adverse health effects to recreational users. Under the District's current protocol approved December 2020, the District will notify the City, MPCA, Minnesota Department of Health (MDH) and other stakeholder partners of the findings if blue-green algae counts are above the low, medium, or high probability thresholds and post advisory information on the District's website. In addition, if blue-green algae counts are between the low and medium probability threshold, the District will advise public property owner(s) of the WHO recommendation to post advisory signs and if the blue-green algae counts are above the medium or high probability thresholds, the District will recommend that the public property owner(s) post advisory signs.

Analyses of the 2020 phytoplankton samples indicate a severe blue-green algal bloom occurred in the lake during the June and September sample events (Figure 6-5). Blue-green algae numbers in June and September were 178,868 per milliliter and 367,589 per milliliter, respectively, well above the WHO threshold of 100,000 per milliliter for a moderate probability of adverse health effects (Figure 6-5). Blue-green numbers were below the WHO threshold for a moderate risk of adverse health effects during July, August, and October (Figure 6-5).

The Nine Mile Creek Watershed District posted a notification on its website alerting the public to the high blue-green algae levels in Lake Holiday following the September blue-green algal bloom. The notice informed the public that high levels of blue-green algae are a concern because this type of algae can produce algal toxins, which can pose a health threat for pets and people. The District urged residents to stay out of the water and to keep pets away from the water.

Microscopic analysis of the June sample was not completed until after the monitoring season, as the laboratory was closed until August due to COVID-19 safety precautions. Therefore, the District did not post a notification of the blue-green algal bloom that occurred during June.

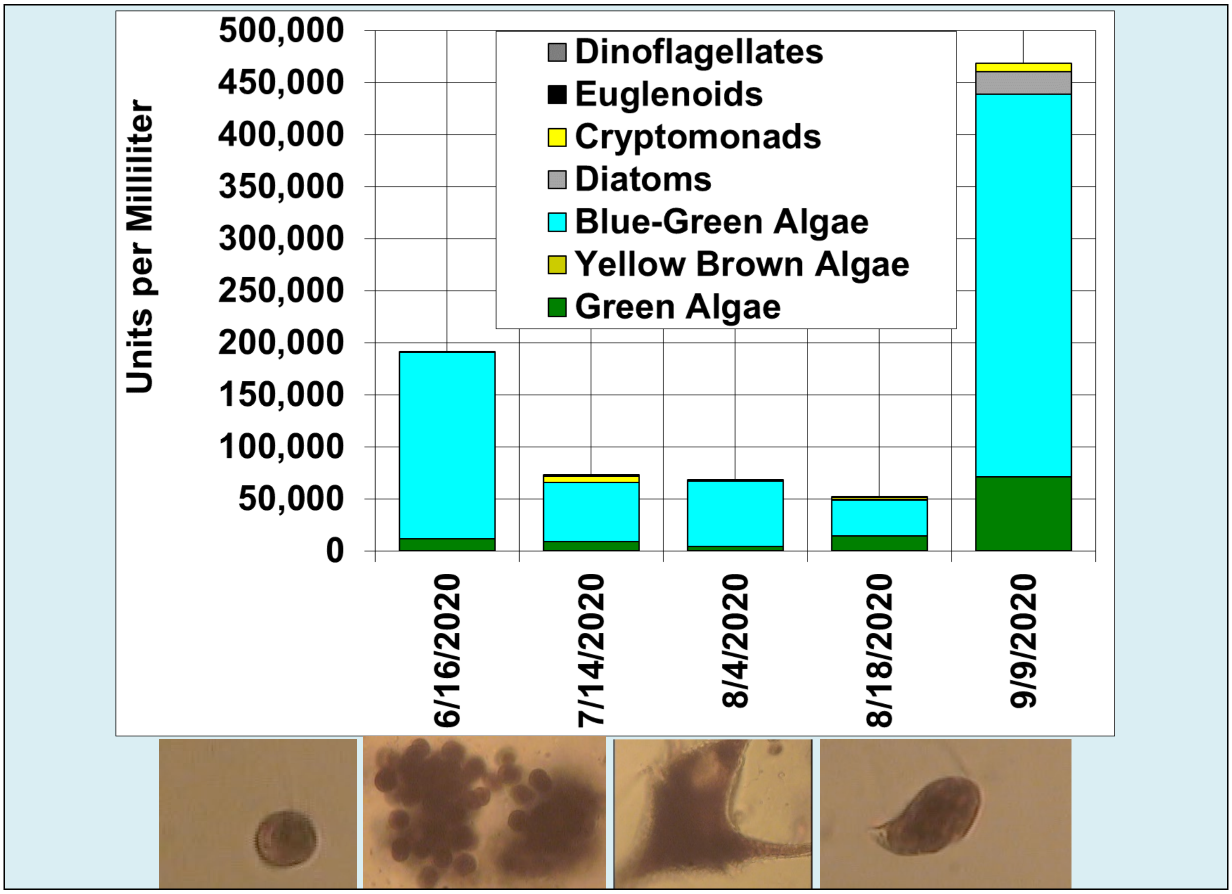


Figure 6-4 Lake Holiday 2020 phytoplankton

Top, Lake Holiday 2020 summer phytoplankton numbers and bottom, microscopic pictures of phytoplankton species found in the lake, from left to right*, Chlamydomonas globosa* (green algae) *Microcystis aeruginosa* (blue-green algae), *Ceratium hirundinella* (dinoflagellate)*, and Cryptomonas erosa* (cryptomonad)

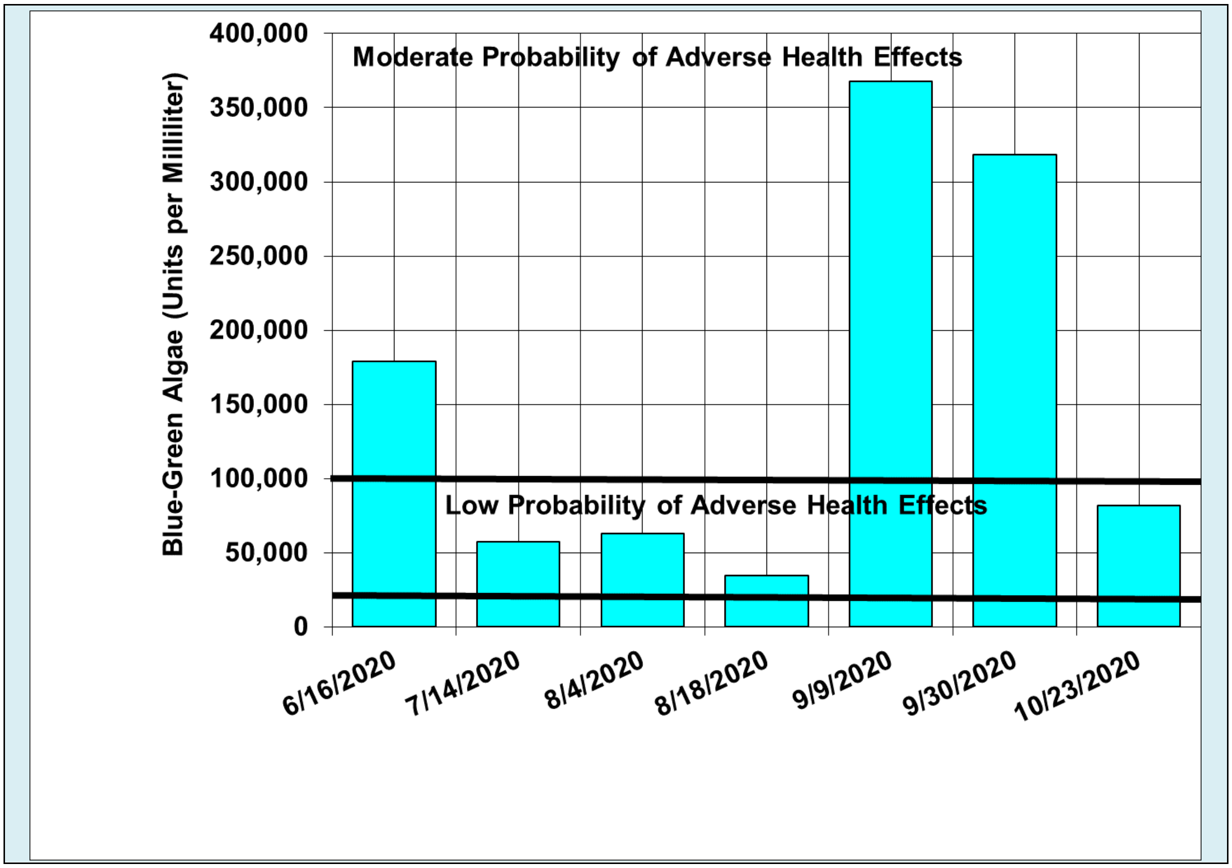


Figure 6-5 2020 Lake Holiday blue-green algae compared with World Health Organization (WHO) thresholds for adverse health effects

6.4 Zooplankton

Samples of zooplankton, microscopic aquatic animals, were collected from Lake Holiday to evaluate the food available to planktivorous fish. Identification and enumeration of the zooplankton species was completed (Appendix B).

Figure 6-6 summarizes the number and major groups of zooplankton observed in Lake Holiday during 2020. The zooplankton community in Lake Holiday was healthy and all three groups of zooplankton were present, cladocerans, copepods, and rotifers. Rotifers consistently dominated the community and few cladocerans were observed (Figure 6-6). Nonetheless, the 2020 data indicate the zooplankton community provided an abundant supply of food for planktivorous fish in the lake.

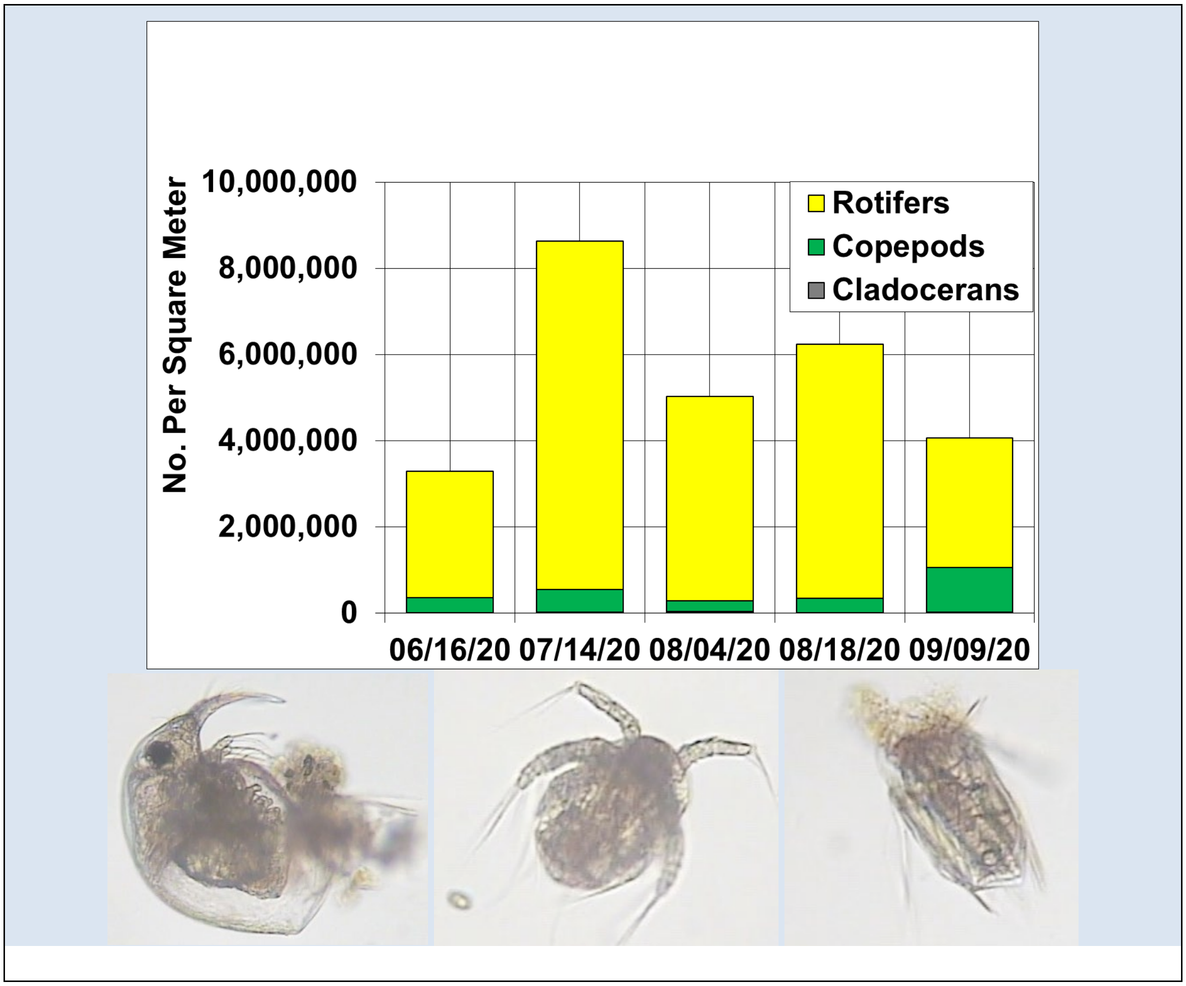


Figure 6-6 2020 Lake Holiday zooplankton
Top, 2020 Lake Holiday zooplankton numbers and bottom, microscopic pictures of zooplankton species from the lake, from left to right, *Bosmina longirostris* (cladoceran), nauplii (baby copepod), and *Polyarthra vulgaris* (rotifer).

6.5 Aquatic Plants

Eutrophication may have detrimental effects on a lake, including reductions in the quantity and diversity of aquatic plants. The ability to assess the biological condition of a lake plant community is a valuable tool in the conservation of Minnesota's lakes. With this objective in mind, the MNDNR developed a Lake Plant Eutrophication Index of Biological Integrity (IBI) to measure the response of a lake plant community to eutrophication. The MNDNR will use this Lake Plant Eutrophication IBI to identify lakes that are likely stressed from anthropogenic eutrophication. A healthy aquatic plant community is an essential part of lakes and provides many important benefits such as nutrient assimilation, sediment stabilization, and habitat for fish. The Plant IBI can provide important context to understanding information about water quality, shoreline health, and the fish community.

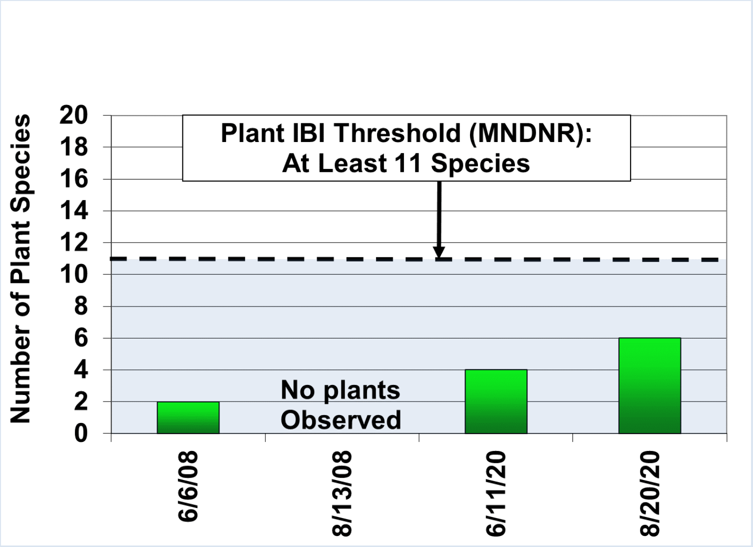


Figure 6-7.A

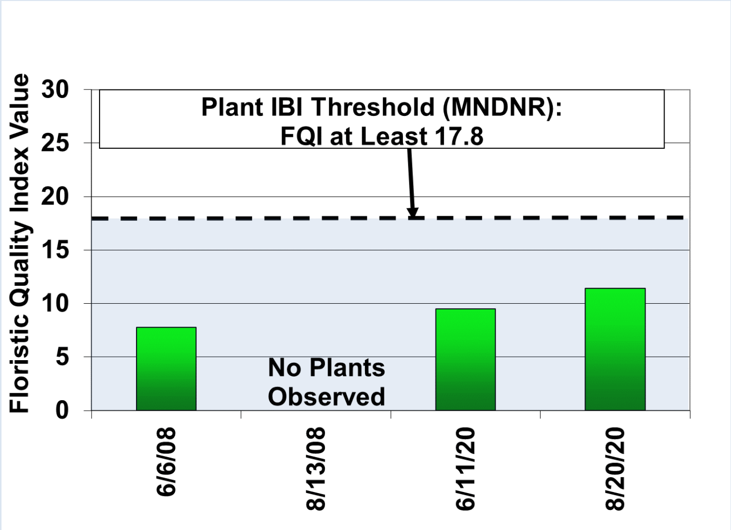


Figure 6-7.B

Figure 6-7 Lake Holiday Plant Index of Biotic Integrity (IBI) Values compared with Plant IBI Thresholds (MNDNR): Number of Plant Species (top) and Floristic Quality Index (FQI) Values (bottom).

The MDNR has developed metrics to determine the overall health of a lake's aquatic plant community. The Lake Plant Eutrophication IBI includes two metrics: (1) the number of species in a lake; and (2) the "quality" of the species, as measured by the floristic quality index (FQI). The MNDNR has determined a threshold for each metric. Lakes that score below the thresholds contain degraded plant communities and are likely stressed from anthropogenic eutrophication.

The District conducted qualitative aquatic plant surveys of Lake Holiday in June and August of 2020. Maps showing survey results are included in Appendix C. Plant survey data from 2008 and 2020 were assessed to determine plant IBI trends. Figure 6-7 shows the Lake Holiday number of species and FQI scores for 2008 and 2020 compared to the MNDNR Plant IBI thresholds.

- **Number of species:** A shallow lake (maximum depth less than 15 feet) fails to meet the MNDNR Plant IBI threshold when it has fewer than 11 species. During 2008 and 2020, the number of species in Lake Holiday ranged from 0 to 6 and was less (poorer) than the MNDNR Plant IBI threshold during both years (Figure 6-7.A).

- **FQI values (quality of species):** The MNDNR Plant IBI threshold for shallow lakes, as measured by FQI, is a minimum value of 17.8. During 2008 and 2020, FQI values ranged from 0 to 11.4 and was less (poorer) than the MNDNR Plant IBI threshold during both years (Figure 6-7.B).

- **2020 results:** Both the number of species in the lake and FQI values were poorer than the MNDNR Plant IBI thresholds (Figure 6-7).

Two aquatic invasive species were found in Lake Holiday in 2020:

- **Purple loosestrife (*Lythrum salicaria*)** – Purple loosestrife was first observed in the lake in 2008. In 2008 and 2020, this emergent species was growing sporadically along the entire shoreline during both June and August (Appendix C).

- **Curly-leaf pondweed (*Potamogeton crispus*)**– In 2020, a dense growth was found throughout the lake in June and a light growth was observed at the south end of the lake in August (Appendix C). Curly-leaf pondweed was first observed in the lake in 2008. Although this invasive species was prevalent and grew densely in many areas of the lake in June of 2008, the data indicate both extent and density increased from June 2008 to June 2020.

6.6 Conclusions and Recommendations

Monitoring results indicate Lake Holiday met the MPCA acute and chronic chloride criteria, but failed to meet MPCA water quality standards for a shallow lake in 2020 due to excess phosphorus and algae in the lake and poor water clarity. Analyses of the phytoplankton samples indicate a severe blue-green algal bloom occurred in the lake during the June and September sample events. Blue-green algae numbers in June and September ranged from 178,868 per milliliter to 367,589 per milliliter, well above the WHO threshold of 100,000 per milliliter for a moderate probability of adverse health effects. Blue-green numbers were below the WHO threshold for a moderate risk of adverse health effects during July, August, and October. The 2020 data indicate the zooplankton community provided an abundant supply of food for planktivorous fish in the lake.

Aquatic plant data indicated the plant community had few species, was of poor quality, and failed to meet the MDNR Plant IBI thresholds. Lakes that score below the thresholds contain degraded plant communities and are likely stressed from anthropogenic eutrophication. Two aquatic invasive species were found in the lake in 2020, purple loosestrife and curly-leaf pondweed. Both species were first observed in the lake in 2008. Purple loosestrife was growing sporadically along the entire shoreline during June and August in both 2008 and 2020. Curly-leaf pondweed was prevalent throughout the lake and grew densely during June 2008 and June 2020. However, the data indicate both extent and density increased during this period.

The District is updating the Use Attainability Analysis for Holiday, Wing, and Rose Lakes in 2021, as identified in the District's Water Management Plan (2017). As part of this water quality study, the District will seek to identify management measures to improve the lake's water quality. Continuation of water quality and biological monitoring is recommended to periodically assess the condition of the lake's water quality and biological community and identify trends.

7 Indianhead Lake

Indianhead Lake (Figure 7-1) is a small lake located in Edina. The lake has a surface area of approximately 14 acres and a maximum depth of approximately 6.5 feet. At the Ordinary High Water Level (OHWL) elevation of 863.7 feet, the lake volume is approximately 69 acre-feet. The lake is land-locked; there is no gravity outlet and the estimated natural overflow elevation is 886 M.S.L., based on MnDNR 2011 LiDAR data. The lake is shallow enough for aquatic plants to grow over the entire lake bed. The lake is a polymictic lake (mixing many times per year). The lake is fertile and generally experiences poor water quality.

In 2020, the Nine Mile Creek Watershed District monitored Indianhead Lake for:

- Water chemistry- total phosphorus (TP), soluble reactive phosphorus (ortho phosphate), total nitrogen, total Kjeldahl nitrogen, nitrate plus nitrite nitrogen, chlorophyll *a*, chloride, and turbidity.
- Water field measurements- dissolved oxygen, pH, temperature, specific conductance, and Secchi disc.
- Phytoplankton and zooplankton (microscopic plants and animals)
- Macrophytes (aquatic plants)

Water quality monitoring results are summarized in Appendix A, phytoplankton and zooplankton data in Appendix B, and macrophyte monitoring maps in Appendix C. Monitoring results are discussed in the following paragraphs.

Figure 7-1 Indianhead Lake

7.1 Total Phosphorus and Chlorophyll *a* Levels and Water Clarity (Secchi Depth)

In 2020, Indianhead Lake water quality data was poor. The lake's 2020 average summer total phosphorus and chlorophyll *a* concentrations were 115 µg/L, and 34 µg/L. The lake's average summer Secchi disc transparency was 0.5 meters. All three summer averages failed to meet the Minnesota State water quality standards for shallow lakes in the North Central Hardwood Forest Ecoregion which are $\leq$60 µg/L, $\leq$20 µg/L, and $\geq$1 meter, respectively (Figure 7-2).

Water quality data have been collected from Indianhead Lake by Nine Mile Creek Watershed District during 2004, 2011, 2014, 2019, and 2020. In 2020, summer average Secchi disc was lower than previous years. Lake water quality was poorer during 2019 and 2020 than previously monitored years. Total phosphorus concentrations were higher in 2019 and 2020 than 2014 and Secchi disc was lower in 2019 and 2020 than 2014 (Figure 7-2).

The District is updating the Indianhead Lake Use Attainability Analysis in 2021, as identified in the District's Water Management Plan (2017). As part of this water quality study, the District will identify management measures to improve the lake's water quality.

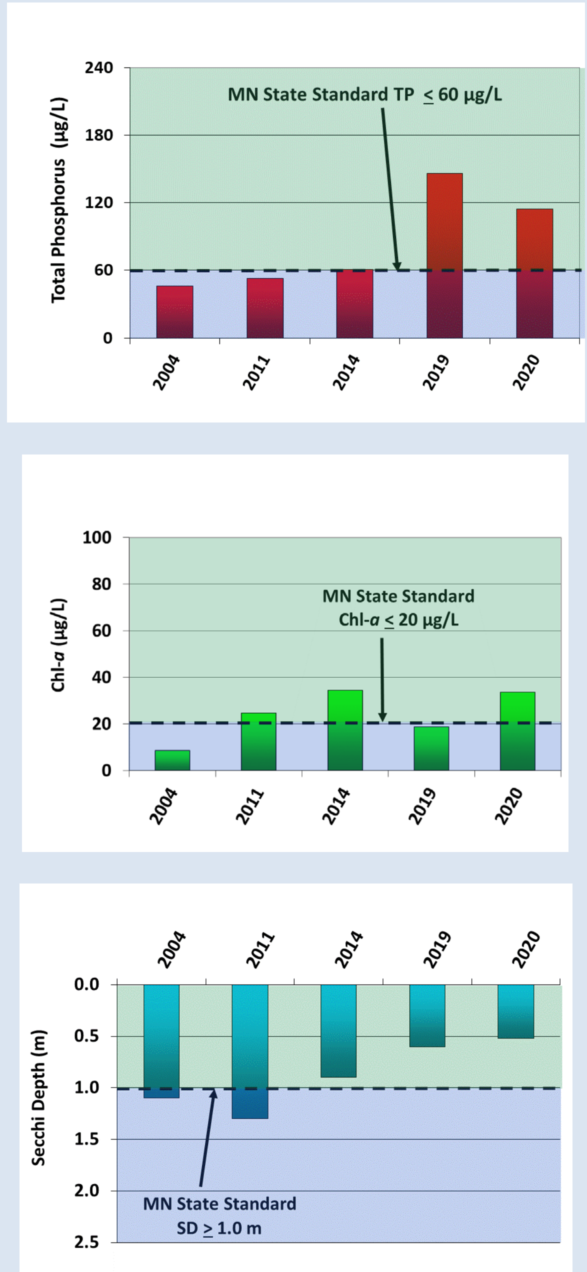


Figure 7-2 Indianhead Lake historical summer average values
total phosphorus (top), chlorophyll *a* (middle), and Secchi disc (bottom)

7.2 Chlorides

Chloride concentrations in area lakes have increased since the early 1990s when many government agencies switched from sand or sand/salt mixtures to salt for winter road maintenance. When snow and ice melts, the salt goes with it, washing into lakes, streams, wetlands, and groundwater. It only takes

1 teaspoon of road salt to permanently pollute 5 gallons of water. And, once in the water, it is very difficult and expensive to remove.

Because high concentrations of chloride can harm fish and plant life, MPCA has established acute and chronic exposure chloride standards. A lake is considered impaired if two or more exceedances of chronic criterion (230 mg/L or less) occur within a three-year period or one exceedance of acute criterion (860 mg/L) is measured. Chloride concentrations were measured during April/May through September in 2011, 2014, 2019, and 2020. All chloride measurements were below the acute and chronic MPCA criteria. The 2011 through 2020 chloride concentrations are summarized in Figure 7-3. 2020 data are summarized in Appendix A.

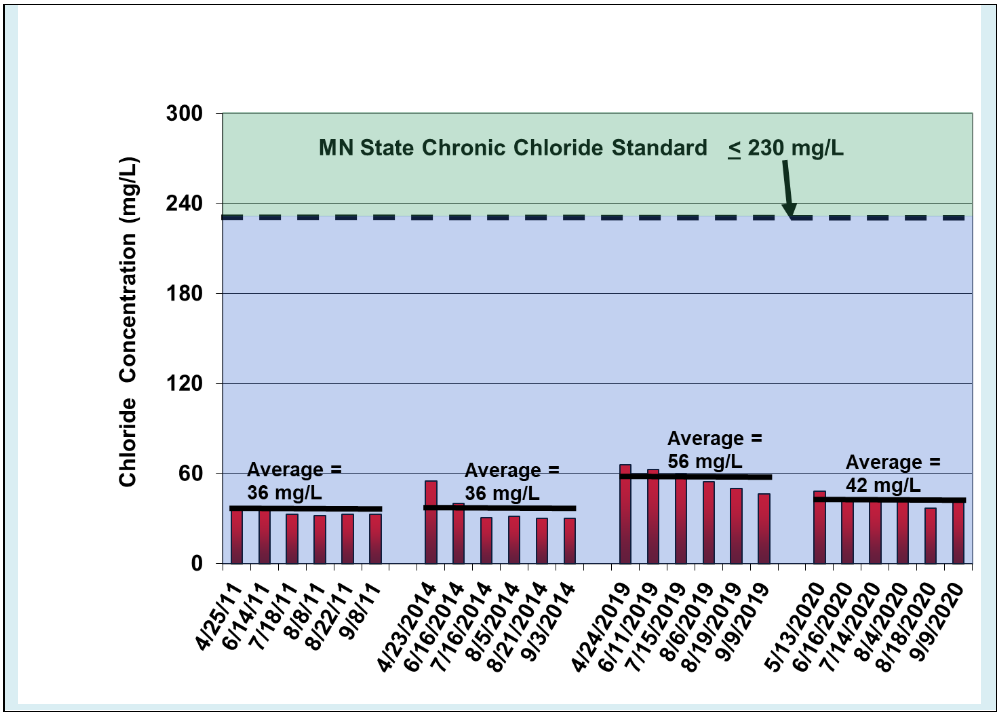


Figure 7-3   Indianhead Lake historical chloride concentrations

7.3 Phytoplankton

Phytoplankton, also called algae, are small aquatic plants naturally present in lakes, including Indianhead Lake. Phytoplankton derive energy from the sun through photosynthesis and provide food for several types of aquatic organisms, including zooplankton, which are in turn eaten by fish. An inadequate phytoplankton population limits a lake's zooplankton population, and indirectly limit fish production in a lake. Excess phytoplankton can reduce water clarity, which can then make recreational use of a lake less desirable.

Samples of phytoplankton, microscopic aquatic plants, were collected from Indianhead Lake to evaluate water quality and the quality of food available to zooplankton (microscopic animals. Identification and enumeration of the phytoplankton species was completed (Appendix B).

Figure 7-4 summarizes the summer average number and major groups of phytoplankton observed in Indianhead Lake for monitored years. During the period of record, the phytoplankton community in Indianhead Lake has consistently been altered using algaecides (chemicals which kill algae) and dyes (chemicals that inhibit algal growth by shading). Indianhead Lake treatment with the algaecide copper sulfate has been documented for 2004, 2011, and 2014. Addition of the dye, Aquashade, to the lake has been documented for 2004, 2011, 2014, 2019, and 2020. Because the phytoplankton community has been consistently altered, phytoplankton numbers documented by monitoring do not represent natural conditions. Nonetheless, the summer average number of phytoplankton has consistently increased since 2004. The summer average number of phytoplankton in 2020 was 80 percent higher than 2019 and the highest number to date (Figure 7-4).

The phytoplankton community in Indianhead Lake was dominated by green algae in monitored years during 2004 through 2019, but was dominated by blue-green algae in 2020 (Figure 7-4). Green algae are a good quality food source and contribute towards a healthy zooplankton community. The low numbers of blue-green algae in past years were favorable for the lake because blue-green algae are a poor quality food for zooplankton. The increase in blue-green algae numbers in 2020 was an unfavorable change for the lake because blue-green algae may be toxic to zooplankton and may not be assimilated if ingested. Blue-green algae can also produce algal toxins, which can be harmful to humans or other animals. Blue-green algae can also produce algal toxins, which can be harmful to humans or other animals.

While identification and enumeration of phytoplankton species has been part of the District's routine lake monitoring program for many years, increased frequency of observed blue-green algal blooms in recent years prompted the District to develop a protocol in 2020 for evaluating and reporting potential Harmful Algal Blooms (HAB). When District monitoring staff observe signs of a potential blue-green algal bloom on a lake while conducting routine monitoring, staff collect a water sample and expedite algal identification and enumeration. Upon enumeration, blue-green algae counts are compared to thresholds established by the World Health Organization (WHO) as guidelines for low, moderate or high probability of adverse health effects to recreational users. Under the District's current protocol approved December 2020, the District will notify the City, MPCA, Minnesota Department of Health (MDH) and other stakeholder partners of the findings if blue-green algae counts are above the low, medium, or high probability thresholds and post advisory information on the District's website. In addition, if blue-green algae counts are between the low and medium probability threshold, the District will advise public property owner(s) of the WHO recommendation to post advisory signs and if the blue-green algae counts are above the medium or high probability thresholds, the District will recommend that the public property owner(s) post advisory signs.

Analyses of the 2020 phytoplankton samples indicate a severe blue-green algal bloom occurred in the lake during the July sample event. Blue-green numbers in the July sample totaled 144,738, well above the WHO threshold of 100,000 per milliliter for a moderate probability of adverse health effects (Figure 7-5). The species causing the blue-green algal bloom was *Aphanizomenon flos-aque*. Blue-green numbers declined to slightly below the WHO threshold for a moderate probability of adverse health effects by early August and then significantly declined to below the threshold for a low probability of adverse health effects during late August and September (Figure 7-5).

Microscopic analysis of the July sample was not completed until after the monitoring season, as the laboratory was closed until August due to COVID-19 safety precautions. Therefore, the District did not post a notification of the blue-green algal bloom that occurred during July.

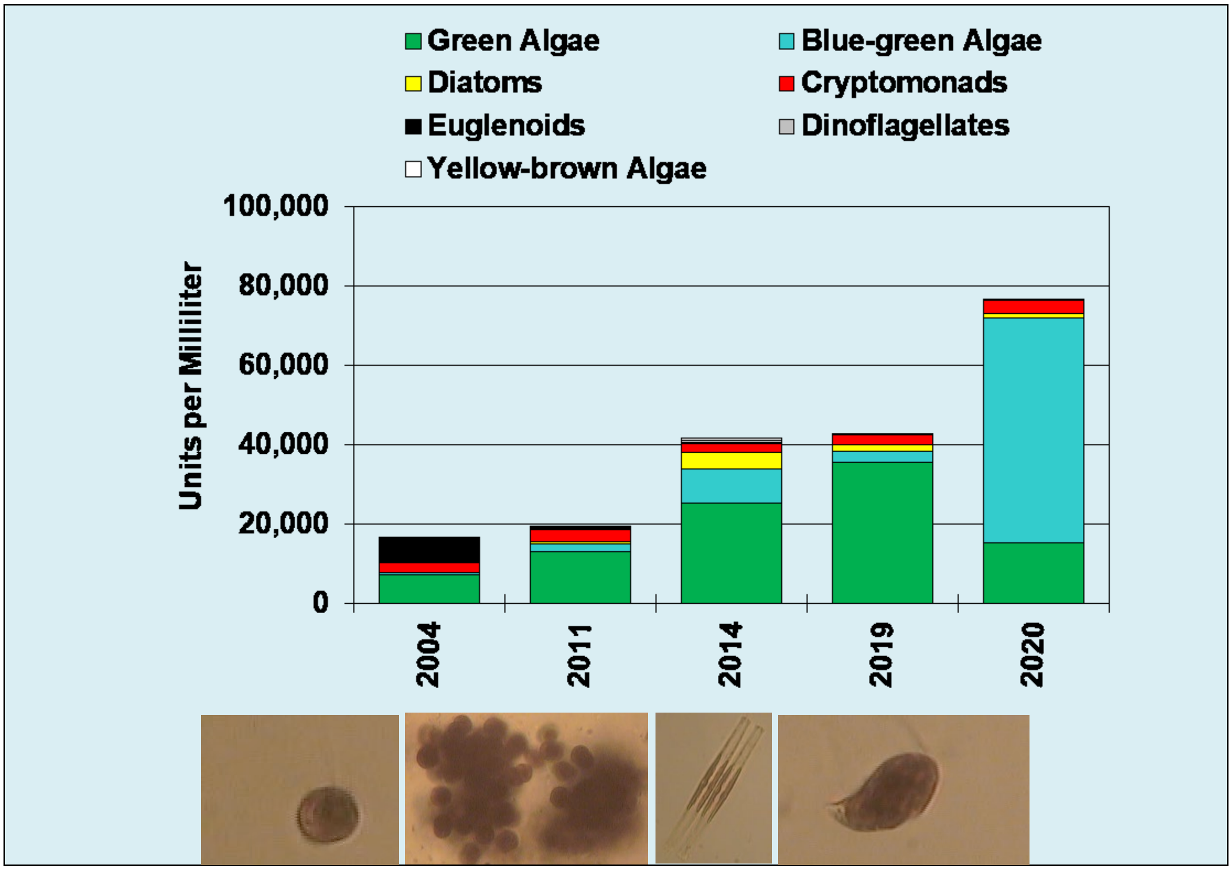


Figure 7-4 Indianhead Lake summer average phytoplankton
Top, Indianhead Lake 2004, 2011, 2014, 2019, and 2020 summer average phytoplankton numbers and bottom, microscopic pictures of phytoplankton species found in the lake, from left to right*, Chlamydomonas globosa* (green algae) *Microcystis aeruginosa* (blue-green algae), *Fragilaria crotonensis* (diatom)*, and Cryptomonas erosa* (cryptomonad)

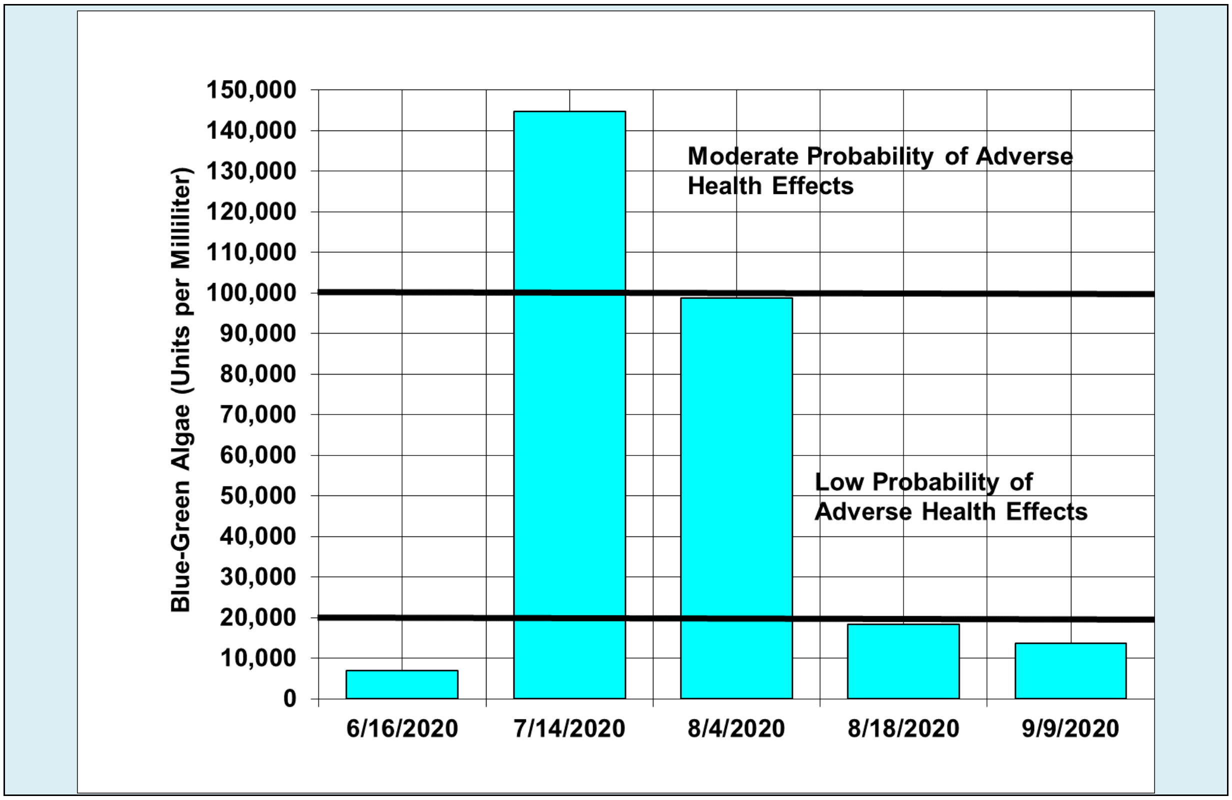


Figure 7-5 2020 Indianhead Lake blue-green algae compared with World Health Organization (WHO) thresholds for adverse health effects

7.4 Zooplankton

Samples of zooplankton, microscopic aquatic animals, were collected from Indianhead Lake and to evaluate the food available to planktivorous fish. Identification and enumeration of the zooplankton species was completed (Appendix B).

Figure 7-6 summarizes the summer average number and major groups of zooplankton during the monitored period. In 2020, the zooplankton community in Indianhead Lake was healthy and balanced between the three groups of zooplankton, cladocerans, copepods, and rotifers. Numbers of cladocerans and copepods were, on average, higher in 2019 and 2020 than previous years resulting in a more even distribution between the 3 groups of zooplankton (Figure 7-6). The total number of zooplankton in 2020 was, on average, higher than 2019, but lower than numbers observed in 2011 and 2014 (Figure 7-6). The year-to-year changes in numbers probably reflect impacts of fish predation. Nonetheless, the 2020 data indicate the zooplankton community provided an abundant supply of food for planktivorous fish in the lake.

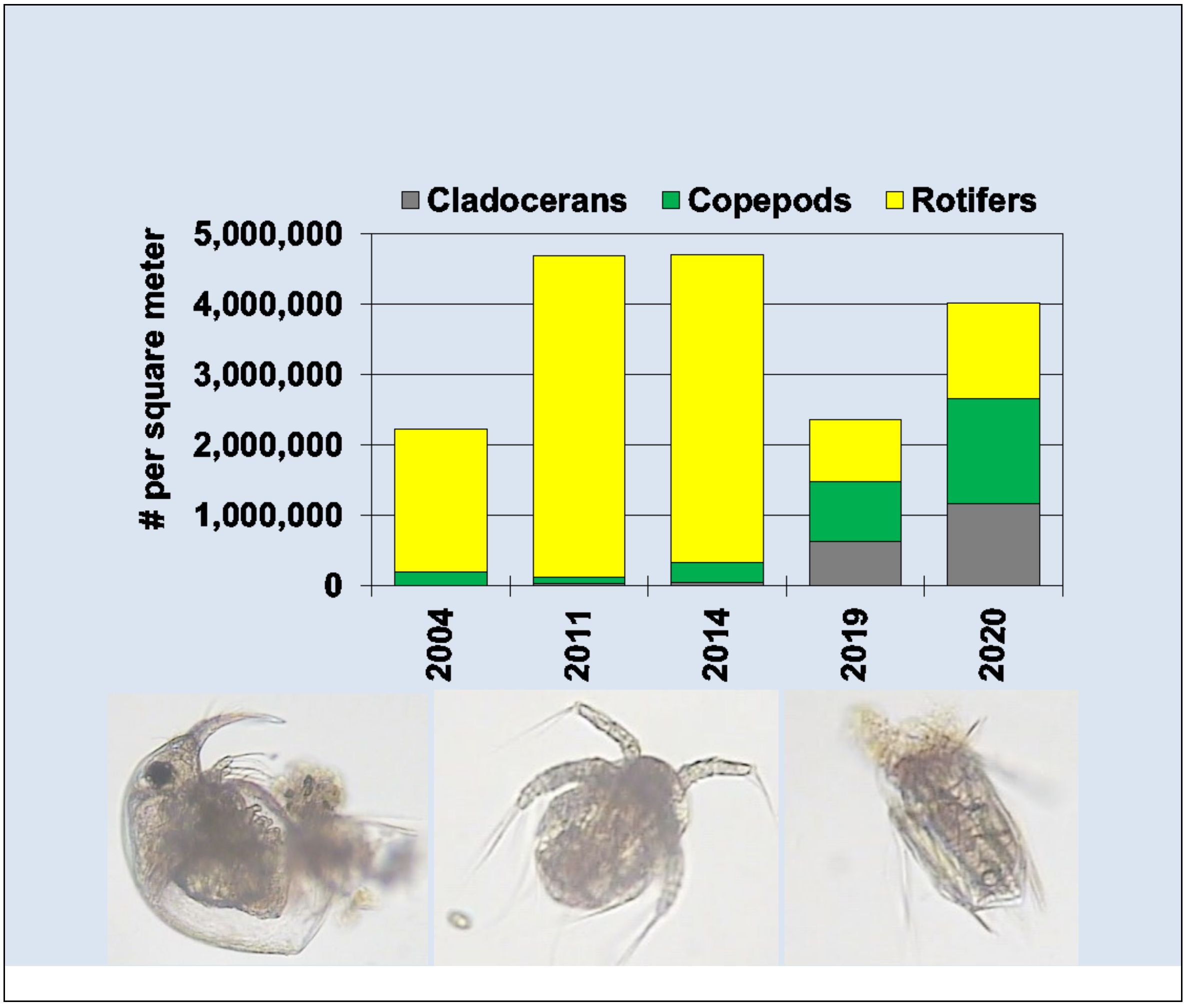


Figure 7-6 Indianhead Lake summer average zooplankton

Top, 2004, 2011, 2014, 2019, and 2020 Indianhead Lake zooplankton numbers and bottom, microscopic pictures of zooplankton species from the lake, from left to right, *Bosmina longirostris* (cladoceran), nauplii (baby copepod), and *Polyarthra vulgaris* (rotifer).

7.5 Aquatic Plants

Eutrophication may have detrimental effects on a lake, including reductions in the quantity and diversity of aquatic plants. The ability to assess the biological condition of a lake plant community is a valuable tool in the conservation of Minnesota's lakes. With this objective in mind, the MNDNR developed a Lake Plant Eutrophication Index of Biological Integrity (IBI) to measure the response of a lake plant community to eutrophication. The MNDNR will use this Lake Plant Eutrophication IBI to identify lakes that are likely stressed from anthropogenic eutrophication. A healthy aquatic plant community is an essential part of lakes and provides many important benefits such as nutrient assimilation, sediment stabilization, and habitat for fish. The Plant IBI can provide important context to understanding information about water quality, shoreline health, and the fish community.

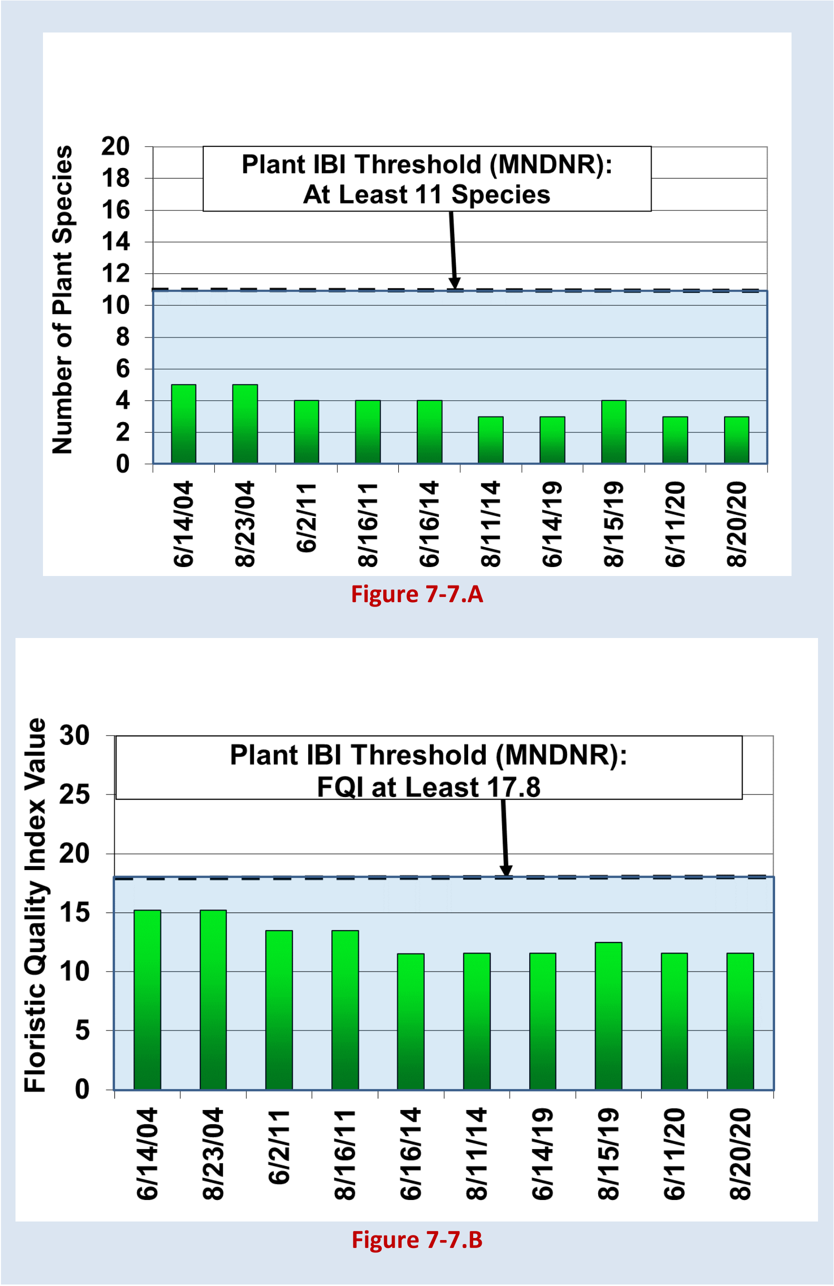


Figure 7-7 Indianhead Lake Plant Index of Biotic Integrity (IBI) Values compared with Plant IBI Thresholds (MNDNR): Number of Plant Species (top) and Floristic Quality Index (FQI) Values (bottom).

The MDNR has developed metrics to determine the overall health of a lake's aquatic plant community. The Lake Plant Eutrophication IBI includes two metrics: (1) the number of species in a lake; and (2) the "quality" of the species, as measured by the floristic quality index (FQI). The MNDNR has determined a threshold for each metric. Lakes that score below the thresholds contain degraded plant communities and are likely stressed from anthropogenic eutrophication.

The District conducted qualitative aquatic plant surveys of Indianhead Lake in June and August of 2020. Maps showing survey results are included in Appendix C. Plant survey data from monitored years during 2004 through 2020 were assessed to determine plant IBI trends. Figure 7-7 shows the Indianhead Lake number of species and FQI scores for that period compared to the MNDNR Plant IBI thresholds.

- **Number of species:** A shallow lake (maximum depth less than 15 feet) fails to meet the MNDNR Plant IBI threshold when it has fewer than 11 species. During the period examined, the number of species in Indianhead Lake ranged from 3 to 5 and has been less (poorer) than the MNDNR Plant IBI threshold during the entire period of record (Figure 7-7.A).

- **FQI values (quality of species):** The MNDNR Plant IBI threshold for shallow lakes, as measured by FQI, is a minimum value of 17.8. During the period examined, FQI values ranged from 11.5 to 15.2 and has been less (poorer) than the MNDNR Plant IBI threshold during the entire period of record (Figure 7-7.B).

- **2020 results:** Both the number of species in the lake and FQI values were poorer than the MNDNR Plant IBI thresholds (Figure 7-7.).

Two aquatic invasive species were found in Indianhead Lake in 2020:

- **Purple loosestrife (*Lythrum salicaria*)** – This emergent species was first observed in 2019 at multiple locations along the eastern and western shorelines in June and August and continued to be observed at the same locations in June and August of 2020 (Appendix C).

- **Yellow iris (*Iris pseudacorus*)**– was common along the shoreline in 2020. Yellow iris has consistently been prevalent along the lake's shoreline since plant surveys began in 2004 and continued to be prevalent in 2020 (Appendix C).

7.6 Conclusions and Recommendations

Monitoring results indicate Indianhead Lake met the MPCA acute and chronic chloride criteria, but failed to meet MPCA water quality standards for a shallow lake in 2020 due to excess phosphorus and algae in the lake and poor water clarity. Blue-green numbers in the July sample totaled 144,738, above the WHO threshold of 100,000 per milliliter for a moderate probability of adverse health effects (Figure 7-5). Blue-green numbers declined to slightly below the WHO threshold for a moderate probability of adverse health effects by early August and then declined to below the threshold for low probability of adverse health effects during late August and September (Figure 7-5). The 2020 data indicate the zooplankton community provided an abundant supply of food for planktivorous fish in the lake.

Aquatic plant data indicated the plant community had few species, was of poor quality, and failed to meet the MDNR Plant IBI thresholds. Lakes that score below the thresholds contain degraded plant communities and are likely stressed from anthropogenic eutrophication. Two aquatic species were found in the lake in 2020, purple loosestrife and yellow iris. Purple loosestrife was first observed in 2019 along the eastern and western shorelines and continued to be observed at the same locations in 2020. Yellow iris has been prevalent along the lake's shoreline since plant surveys began in 2004 and continued to be prevalent in 2020.

The District is updating the Indianhead Lake Use Attainability Analysis in 2021, as identified in the District's Water Management Plan (2017). As part of this water quality study, the District will identify management measures to improve the lake's water quality. Continuation of water quality and biological monitoring is recommended to periodically assess the condition of the lake's water quality and biological community and identify trends.

8 Normandale Lake

Normandale Lake is located in the northwestern portion of Bloomington. Normandale Lake was created as a direct result of the Mount Normandale Lake flood control project, implemented in the late-1970s. The lake has a water surface area of approximately 116 acres, maximum depth of approximately 9 feet, and a mean depth of 3.0 feet at the normal water surface elevation of approximately 808 feet. At this elevation, the lake volume is approximately 290 acre-feet.

The lake is shallow enough for aquatic plants (i.e., macrophytes) to grow over the entire lake bed. The water level in the lake is controlled mainly by the elevation of the outlet structure located at the east side of Normandale Lake and by weather conditions (snowmelt, rainfall, creek flows, and evaporation).

In 2018, the District began implementation of a water quality improvement project for Normandale Lake, in partnership with the city of Bloomington. A drawdown of the lake was completed in fall of 2018 to expose the lake bed to a winter freeze and freeze out curly-leaf pondweed, an invasive plant species, which dies off in late-June, senesces, and adds phosphorus to the lake. This summer addition of phosphorus fuels algal growth and degrades lake water quality. The lake was treated with alum in spring of 2019 to reduce the release of phosphorus from lakebottom sediments into the water column. In the spring of 2020, an herbicide treatment was conducted within portions of Normandale Lake and Nine Mile Creek immediately upstream of Normandale Lake using diquat to control curly-leaf pondweed growing in these areas.

In 2020, the Nine Mile Creek Watershed District monitored Normandale Lake for:

- Water chemistry- total phosphorus (TP), total dissolved phosphorus, soluble reactive phosphorus (ortho phosphate), total nitrogen, total Kjeldahl nitrogen, ammonia nitrogen, nitrate plus nitrite nitrogen, chlorophyll *a*, chloride, and turbidity.
- Water field measurements- dissolved oxygen, pH, temperature, specific conductance, and Secchi disc
- Phytoplankton and zooplankton (microscopic plants and animals)
- Macrophytes (aquatic plants)
- Turion survey (survey of curly-leaf pondweed turions in the sediment. Turions are the primary reproductive structures of curly-leaf pondweed.)

Water quality monitoring was conducted in two locations: on the east side at the deepest portion of the lake near the outlet (NMCWD's routine monitoring location) and at the inlet of Nine Mile Creek on the northwest side of the lake. Results are summarized in Appendix A. Phytoplankton and zooplankton results (sampled from NMCWD's routine monitoring location on the east side of the lake) are summarized in Appendix B. Macrophyte monitoring maps are provided in Appendix D. Results of the turion survey are provided in Appendix E. Monitoring results are discussed in the following paragraphs.

8.1 Total Phosphorus and Chlorophyll *a* Levels and Water Clarity (Secchi Depth)

Figure 8-1 presents summer average total phosphorus and chlorophyll *a* concentrations and Secchi disc transparency from the lake's routine monitoring location on the east side of the lake. In 2020, the lake's summer average total phosphorus and chlorophyll *a* concentrations were 61 µg/L and 14 µg/L respectively (Figure 8-1). The lake's summer average Secchi disc transparency (water clarity) was 1.0 meters (Figure 8-1). The lake's summer average total phosphorus concentration failed to meet the Minnesota State Water Quality Standard for shallow lakes in the North Central Hardwood Forest Ecoregion published in Minnesota Rules 7050 (Minn. R. Ch. 7050.0222 Subp 4), but was close to meeting the standard. The lake's summer average chlorophyll *a* concentration and summer average Secchi disc transparency met the State standard (Figure 8-1). Minnesota State water quality standards for shallow lakes in the North Central Hardwood Forest Ecoregion are $\leq$60 µg/L, $\leq$20 µg/L, and $\geq$1 meter, for total phosphorus, chlorophyll *a* and Secchi depth, respectively.

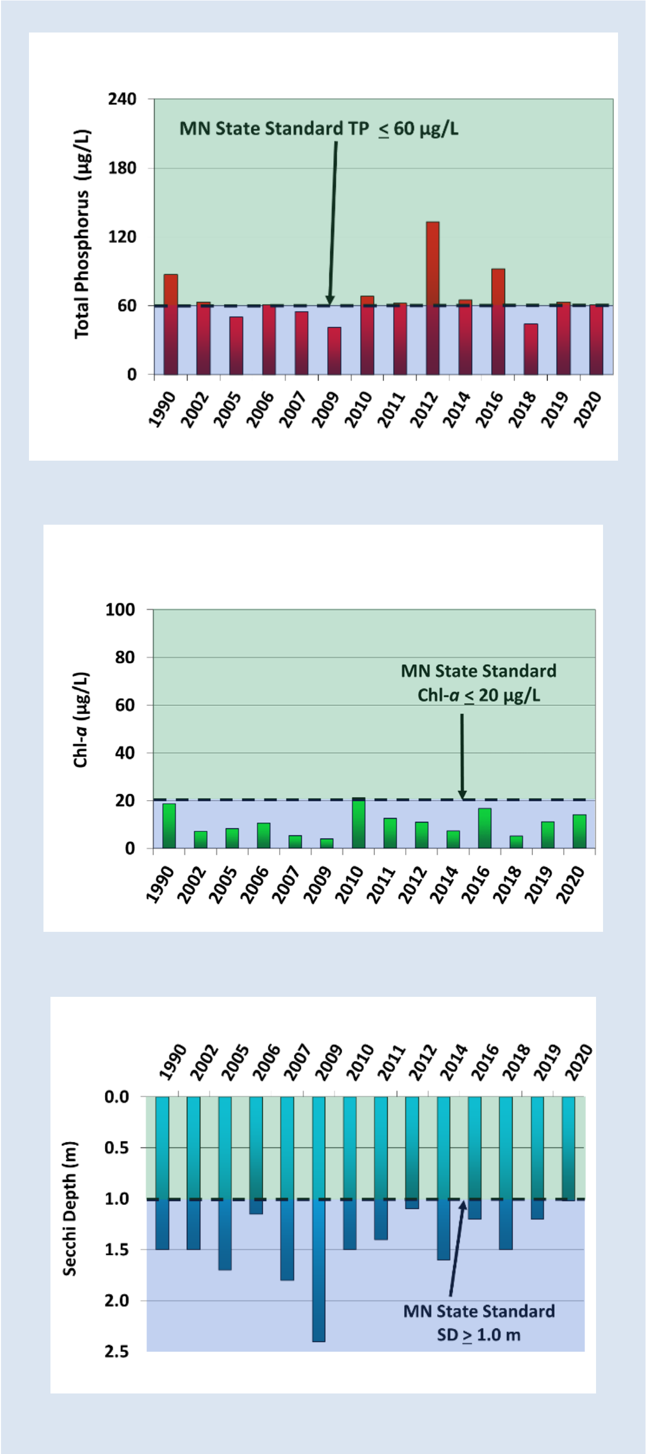


Figure 8-1 Normandale Lake historical summer average values.
total phosphorus (top), chlorophyll *a* (middle), and Secchi disc (bottom)

Water quality data were collected from Normandale Lake by Nine Mile Creek Watershed District during 1990, 2002, 2005, 2007, 2010, 2014, 2016, 2018, 2019, and 2020; by the CAMP during 2006, 2009, 2010, 2011, and 2012, and by the MPCA Citizen Lake Monitoring Program (CLMP) in 2020. The 2020 data indicate summer average total phosphorus and chlorophyll *a* concentrations were within the range of historical data (Figure 8-1), but the Secchi disc transparency was lower (poorer) than the historical range. All summer average chlorophyll *a* concentrations and summer average Secchi disc transparencies have met Minnesota State water quality standards. Summer average chlorophyll *a* concentrations have ranged from 4 µg/L to 21µg/L and summer average Secchi disc transparencies have ranged from 1.0 meter to 2.4 meters. Summer average total phosphorus concentrations failed to meet the Minnesota State water quality standard for numerous monitored years. Summer average total phosphorus concentrations have ranged from 41 µg/L to 133 µg/L (Figure 8-1) during the monitored period.

In 2020, the District also collected and analyzed monitoring data in the northwest part of the lake near the inlet of Nine Mile Creek. The 2018 Engineer's Report for the Normandale Lake water quality improvement project concluded that stormwater from the large watershed tributary to Normandale Lake, much of which is untreated prior to reaching Nine Mile Creek, contributes significant phosphorus loading to the lake. 2020 monitoring data indicate that phosphorus concentrations near the inlet of Nine Mile Creek are higher than concentrations measured near the lake outlet. As shown in Figure 8-2, comparison of the phosphorus concentrations collected by the District demonstrates that the lake removes phosphorus, likely through settling and uptake of nutrients by aquatic plants. Normandale Lake and the 2020 District monitoring locations are shown in Figure 8-3.

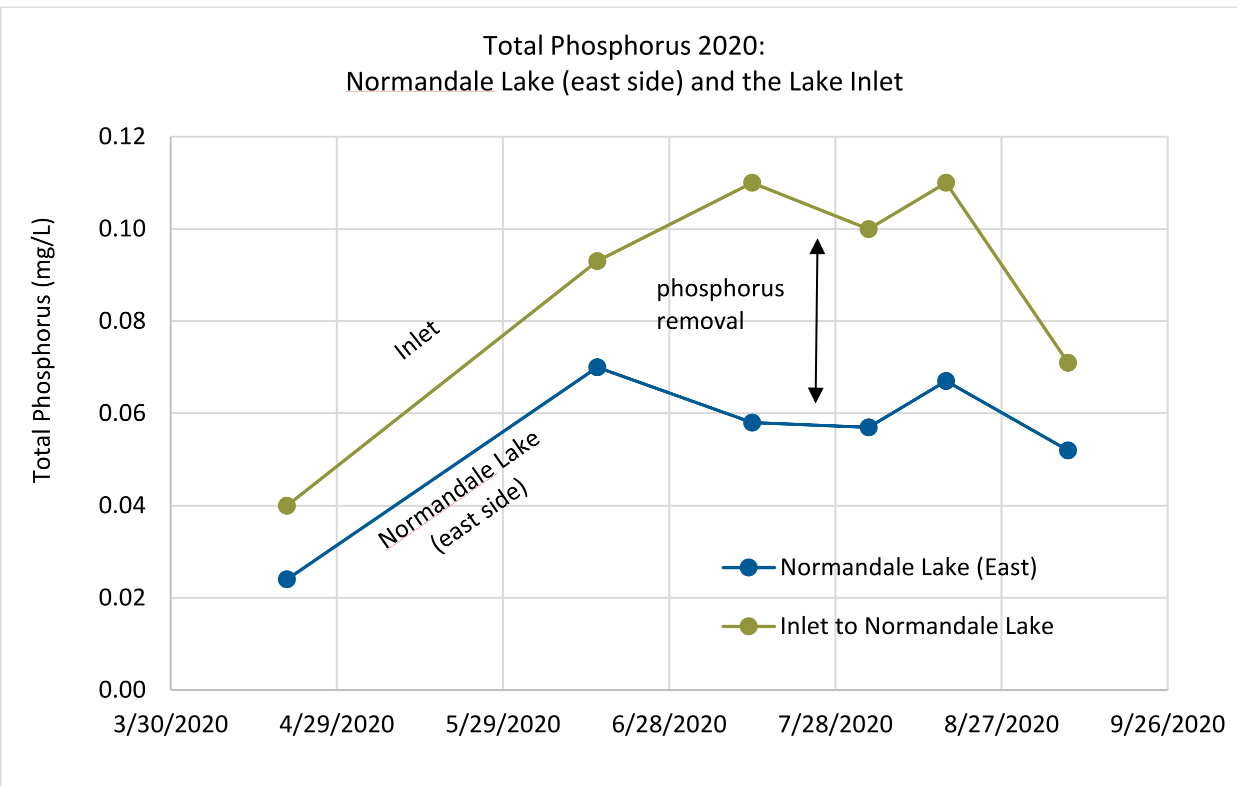


Figure 8-2 Normandale Lake total phosphorus concentrations measured at the lake inlet and on the east side at the deepest portion of the lake near the outlet (NMCWD's routine monitoring location)

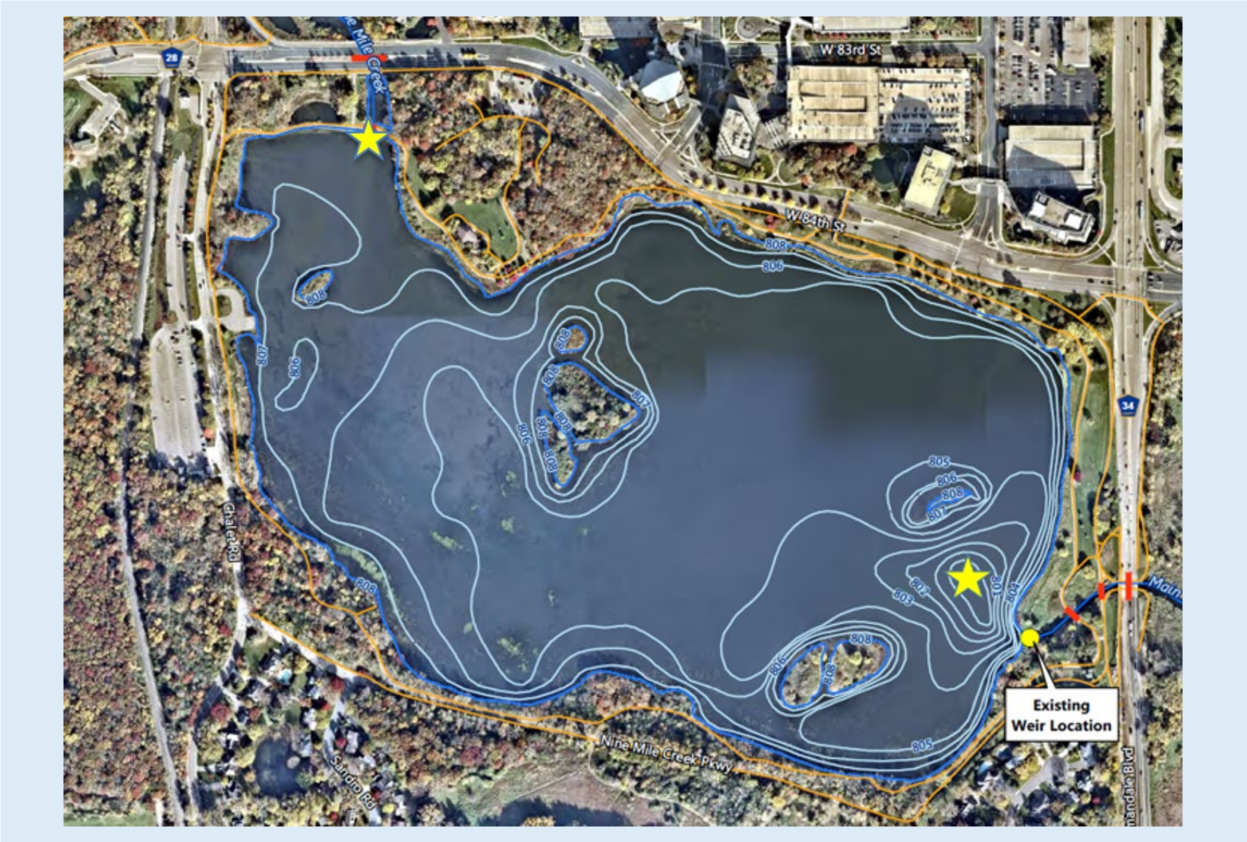


Figure 8-3 Normandale Lake 2020 District Sample Locations: on the east side at the deepest portion of the lake near the outlet (the NMCWD's routine monitoring location) and at the inlet of Nine Mile Creek on the northwest side of the lake.

8.2 Nitrogen

While total phosphorus and chlorophyll *a* concentrations and Secchi disc transparency are commonly measured to assess attainment of the water quality standards for shallow lakes, it is important to note that nitrogen also plays a significant role in the water quality of Normandale Lake. Algae and aquatic plants require nutrients to grow, including nitrogen and phosphorus. Phosphorus is often the "limiting nutrient" in lakes, meaning that the available quantity of this nutrient is in low proportion to the others and controls the rate at which algae and aquatic plants are produced. However, monitoring data from 2020 support the conclusion that nitrogen is the "limiting nutrient" at times in Normandale Lake. This conclusion highlights the importance of continued implementation of best management practices in the upstream watershed to minimize the amount of nutrients (both nitrogen and phosphorus) discharged to Nine Mile Creek and education of property owners regarding responsible use of fertilizer on lawns or other turf.

8.3 Chlorides

Chloride concentrations in area lakes have increased since the early 1990s when many government agencies switched from sand or sand/salt mixtures to salt for winter road maintenance. When snow and ice melts, the salt goes with it, washing into lakes, streams, wetlands, and groundwater. It only takes

1 teaspoon of road salt to permanently pollute 5 gallons of water. And, once in the water, it is very difficult and expensive to remove chloride.

Because high concentrations of chloride can harm fish and plant life, MPCA has established acute and chronic exposure chloride standards. A lake is considered impaired if two or more exceedances of chronic criterion (230 mg/L or less) within a three-year period or one exceedance of acute criterion (860 mg/L) is measured. Chloride concentrations were measured during April/May through September in 2010, 2014, 2016, 2018, 2019, and 2020. Chloride concentrations during April of 2014, April 2016, and April and June 2018 were above the MPCA chronic chloride criteria, but all other chloride measurements during 2010 through 2020 were below the chronic MPCA criterion. All measurements during 2010 through 2020 were below the acute MPCA criterion. 2020 chloride data are summarized in Appendix A. Chloride concentrations from 2010 through 2020 are summarized in Figure 8-4.

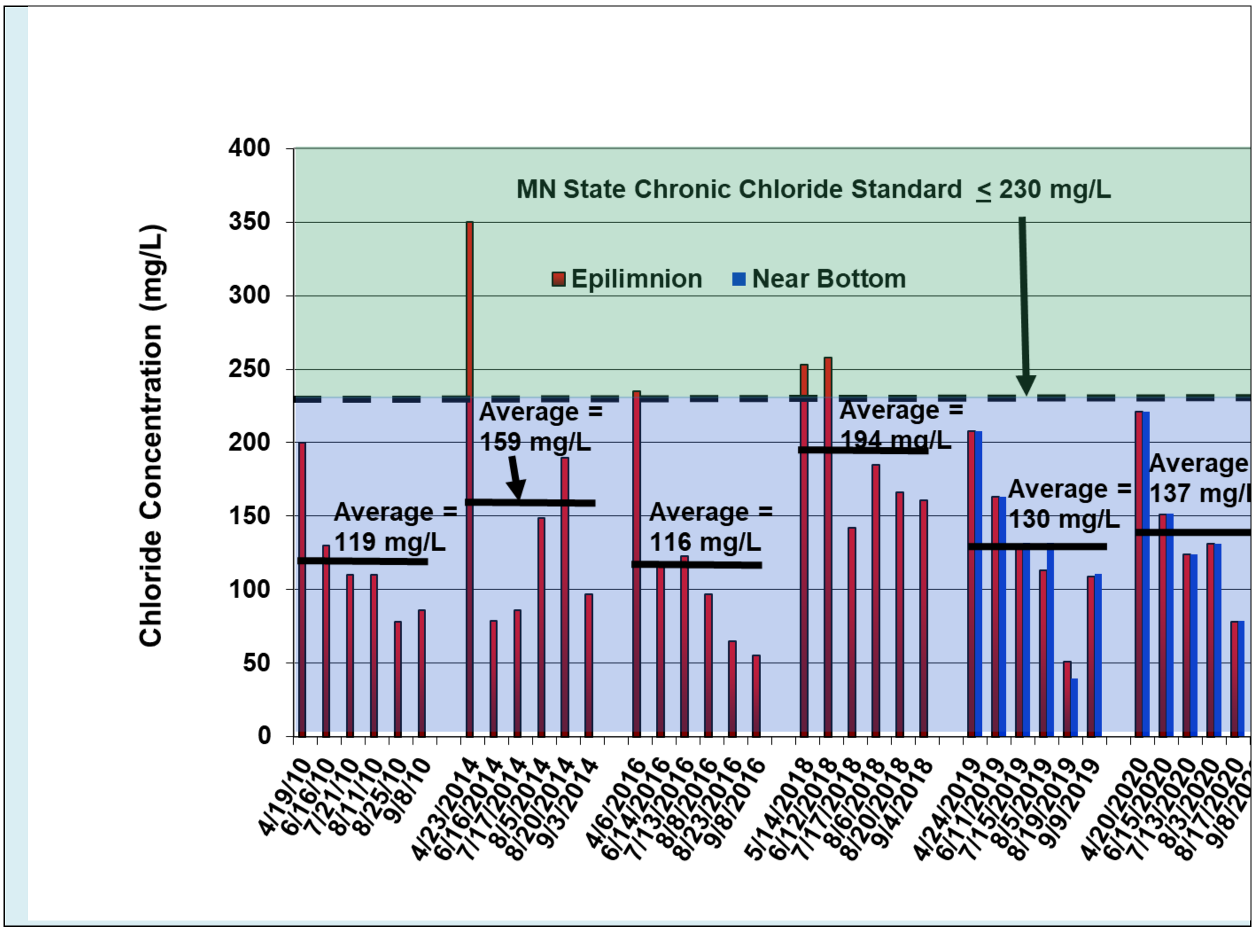


Figure 8-4   Normandale Lake historical chloride concentrations

8.4 Phytoplankton

Phytoplankton, also called algae, are small aquatic plants naturally present in lakes, including Normandale Lake. Phytoplankton derive energy from the sun through photosynthesis and provide food for several types of aquatic organisms, including zooplankton, which are in turn eaten by fish. An inadequate phytoplankton population limits a lake's zooplankton population, and indirectly limit fish production in a lake. Excess phytoplankton can reduce water clarity, which can then make recreational use of a lake less desirable.

Samples of phytoplankton, microscopic aquatic plants, were collected from Normandale Lake in August and September of 2020 to evaluate water quality and the quality of food available to zooplankton (microscopic animals). Identification and enumeration of the phytoplankton species was completed (Appendix B).

Figure 8-5 summarizes the summer number and major groups of phytoplankton observed in Normandale Lake in monitored years. Phytoplankton have generally been balanced between green algae, cryptomonads, diatoms, and blue-green algae. Green algae, diatoms, and cryptomonads are a good quality food source and contribute towards a healthy zooplankton community. With the exception of a late August sample in 2010 and the two August samples in 2016, phytoplankton numbers were less than 15,000 per milliliter in monitored years.

While identification and enumeration of phytoplankton species has been part of the District's routine lake monitoring program for many years, increased frequency of observed blue-green algal blooms in recent years prompted the District to develop a protocol in 2020 for evaluating and reporting potential Harmful Algal Blooms (HAB). When District monitoring staff observe signs of a potential blue-green algal bloom on a lake while conducting routine monitoring, staff collect a water sample and expedite algal identification and enumeration. Upon enumeration, blue-green algae counts are compared to thresholds established by the World Health Organization (WHO) as guidelines for low, moderate or high probability of adverse health effects to recreational users. Under the District's current protocol approved December 2020, the District will notify the City, MPCA, Minnesota Department of Health (MDH) and other stakeholder partners of the findings if blue-green algae counts are above the low, medium, or high probability thresholds and post advisory information on the District's website. In addition, if blue-green algae counts are between the low and medium probability threshold, the District will advise public property owner(s) of the WHO recommendation to post advisory signs and if the blue-green algae counts are above the medium or high probability thresholds, the District will recommend that the public property owner(s) post advisory signs.

Comparison of blue-green numbers from the routine monitoring location during the monitored period to the WHO thresholds for probability of adverse health effects indicates all values were below the threshold for low probability of adverse health effects (Figure 8-6). The low numbers of blue-green algae are favorable for lake users and for the lake's zooplankton. Blue-green algae are a poor quality food because they may be toxic and may not be assimilated if ingested by zooplankton. Blue-green algae can also produce algal toxins, which can be harmful to humans or other animals.

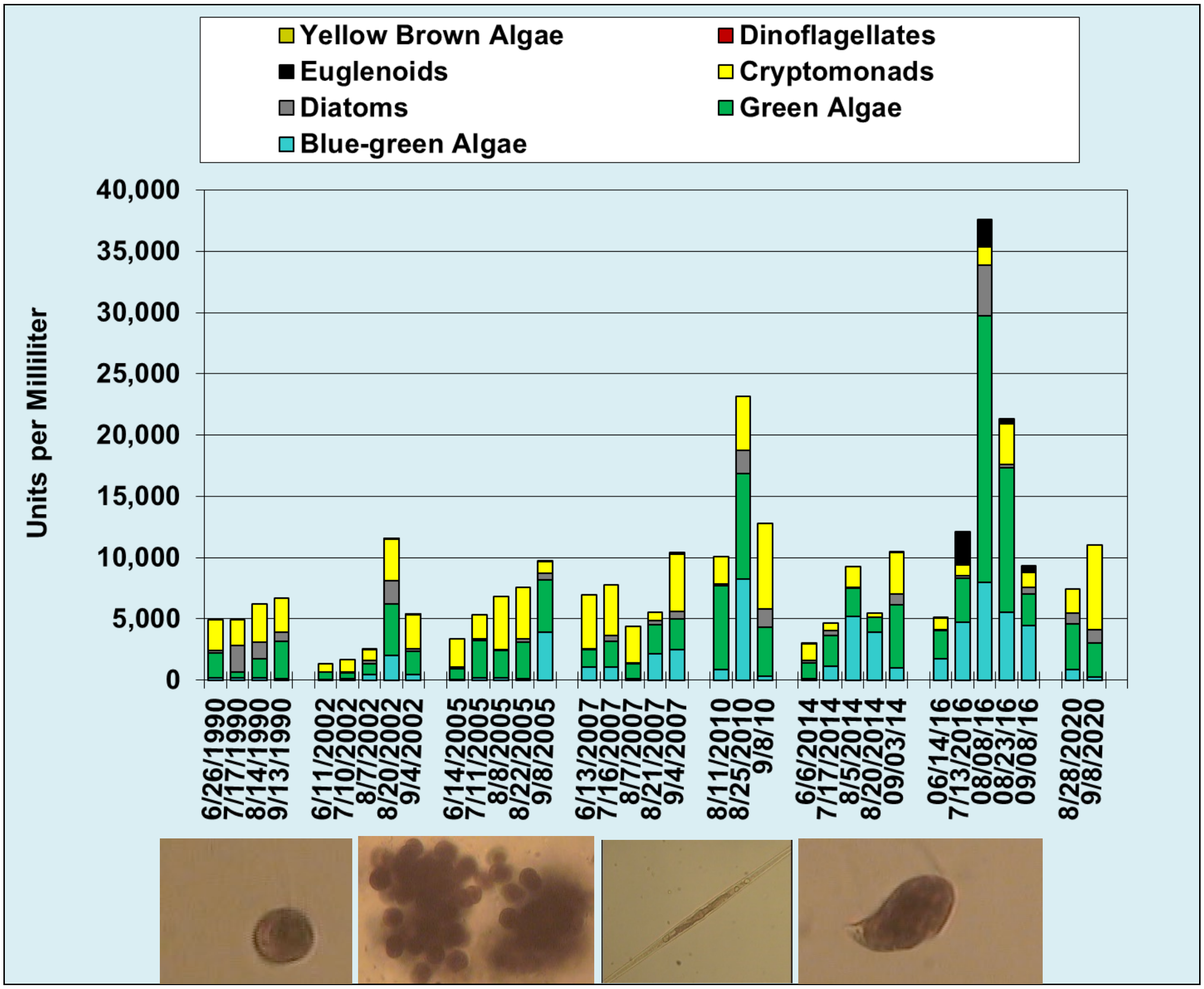


Figure 8-5 Normandale Lake summer phytoplankton

Top, Normandale Lake 1990, 2002, 2005, 2007, 2010, 2014, 2016, and 2020 summer phytoplankton numbers and bottom, microscopic pictures of phytoplankton species found in the lake, from left to right*, Chlamydomonas globosa* (green algae) *Microcystis aeruginosa* (blue-green algae), *Synedra ulna* (diatom), and *Cryptomonas erosa* (cryptomonad)

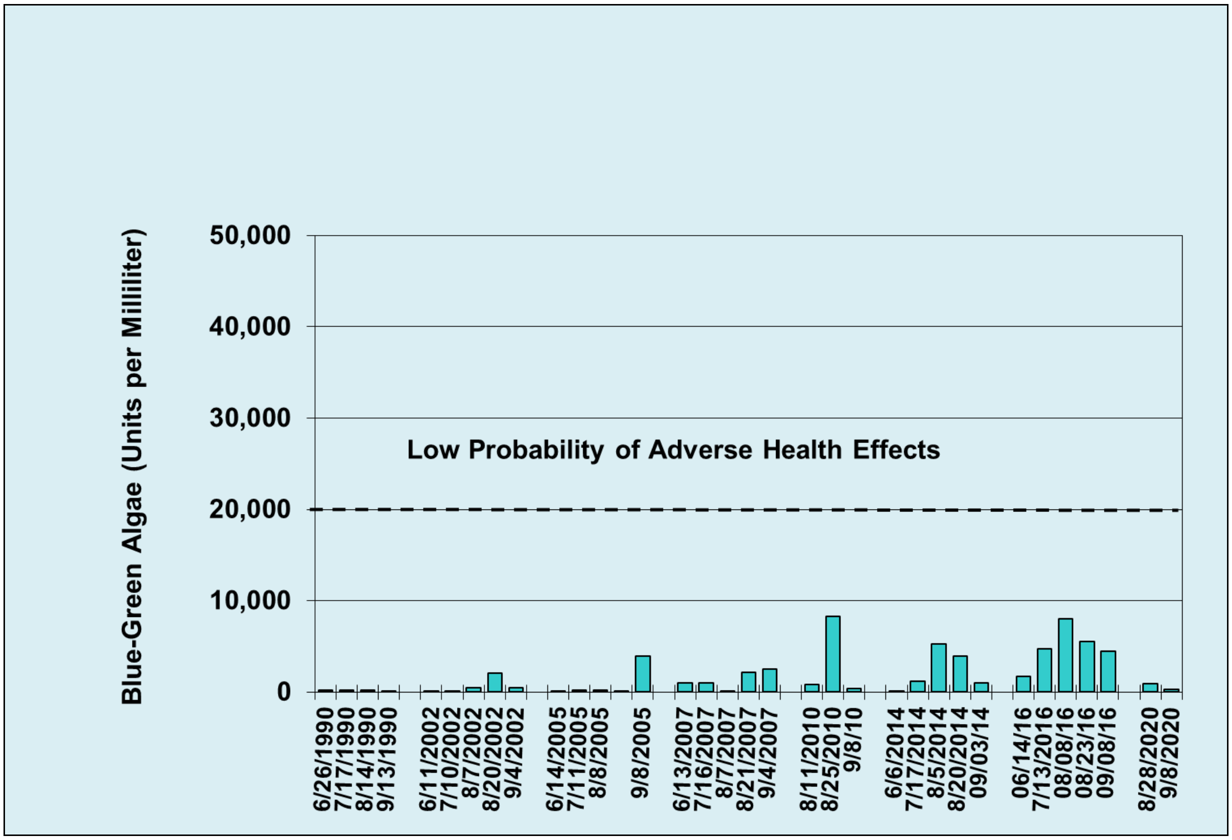


Figure 8-6 **Normandale Lake blue-green algae numbers compared with World Health Organization (WHO) thresholds for adverse health effects**

8.5 Zooplankton

Samples of zooplankton, microscopic aquatic animals, were collected from Normandale Lake in August and September of 2020 to evaluate the food available to planktivorous fish. Identification and enumeration of the zooplankton species was completed (Appendix B).

Figure 8-7 summarizes summer average number and major groups of zooplankton during the monitored period. In 2020, the zooplankton community in Normandale Lake was healthy and balanced between the three groups of zooplankton, cladocerans, copepods, and rotifers during the monitoring time period (August and September). The total number of zooplankton in 2020 was, on average, higher than previous years. Summer average zooplankton numbers during 1990 through 2016 ranged from a low of 148,306 per square meter in 2014 to a high of 1,832,674 per square meter in 1990 compared with 3,700,786 per square meter in 2020 (Figure 8-7). The increased number of zooplankton in 2020 was a favorable change for the lake and indicate the zooplankton community provided an abundant supply of food for planktivorous fish in the lake.

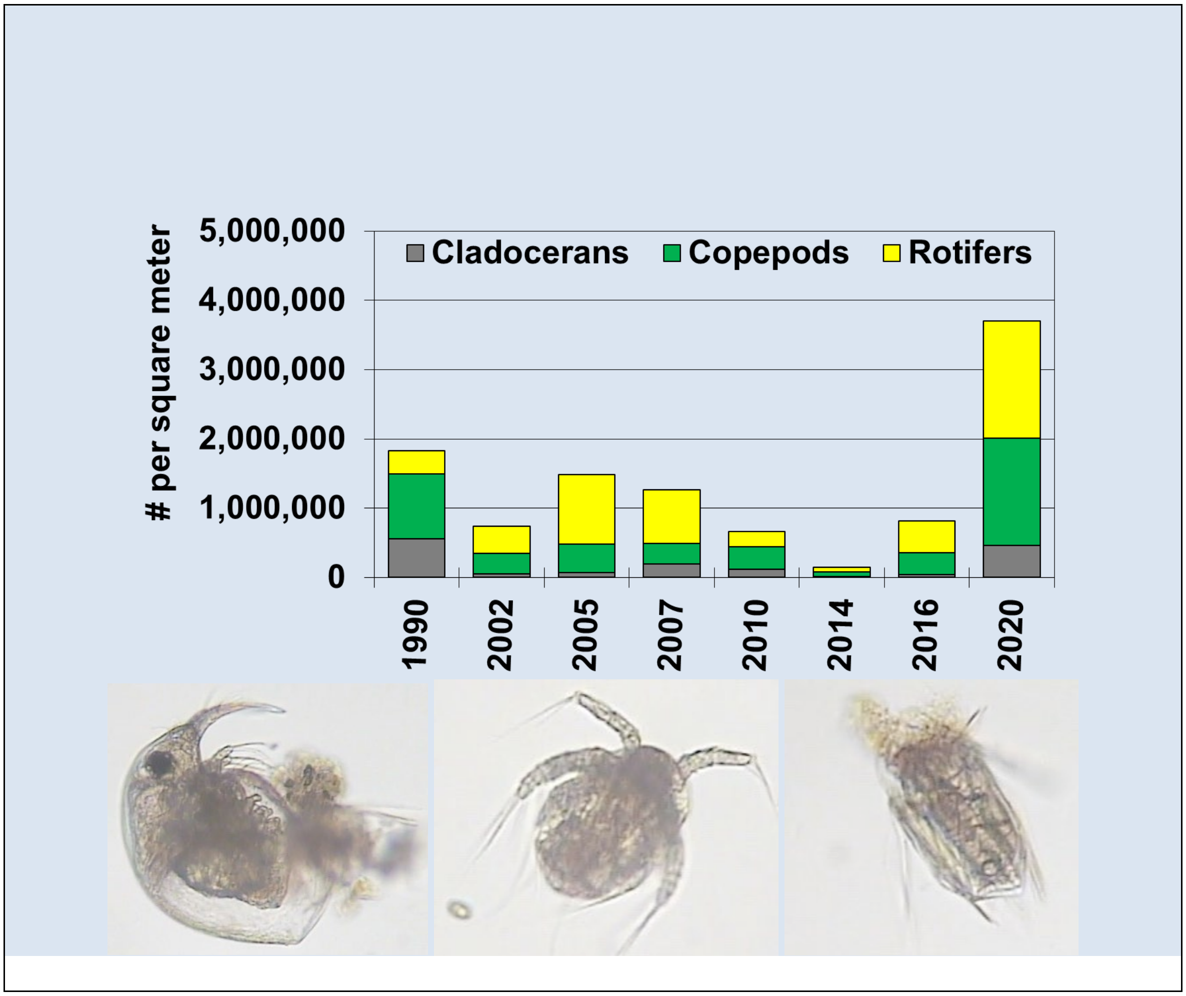


Figure 8-7 Normandale Lake summer average zooplankton

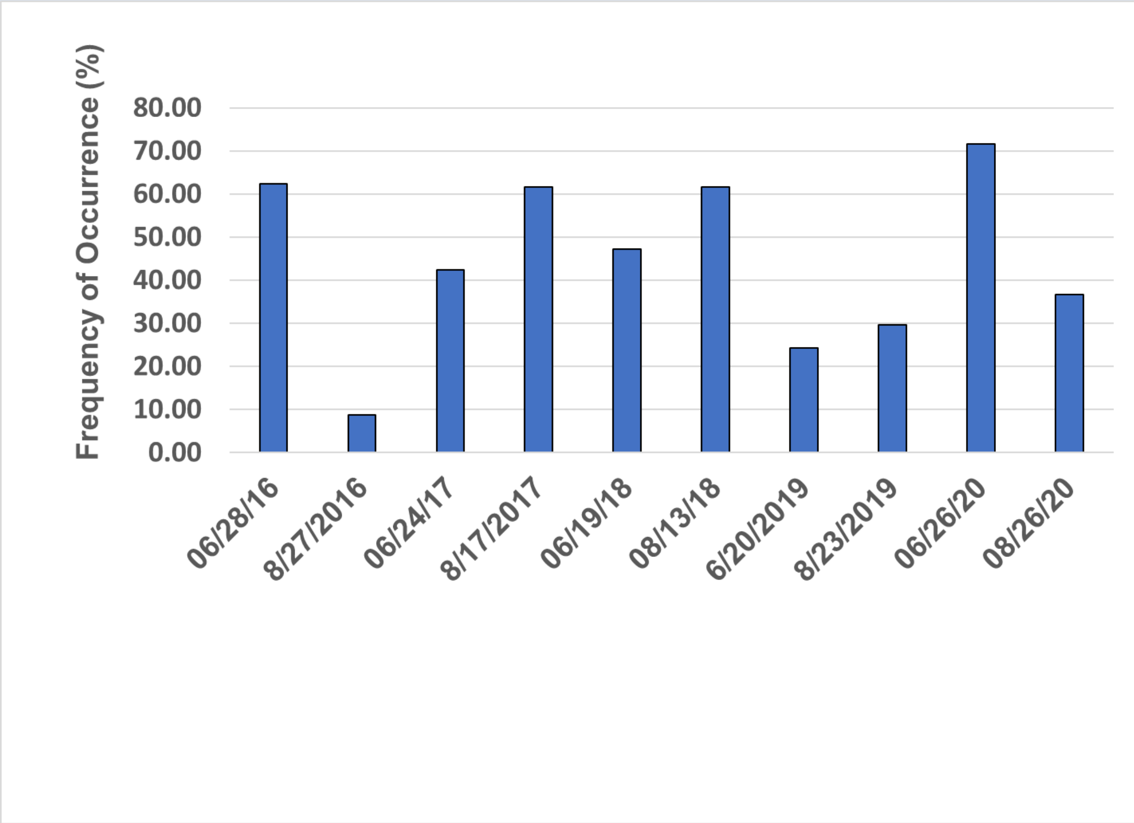
Top, 1990, 2002, 2005, 2007, 2010, 2014, 2016, and 2020 Normandale Lake zooplankton numbers and bottom, microscopic pictures of zooplankton species from the lake, from left to right, *Bosmina longirostris* (cladoceran), nauplii (baby copepod), and *Polyarthra vulgaris* (rotifer).

8.6 Filamentous Algae

Filamentous algae form infestations of free-floating mats that float on the surface of lakes when nutrient conditions are favorable for growth. Filamentous algae begin their growth on the bottom, attached to the substratum by holdfasts, and sporadically surface. When the algae are dense enough, gas bubbles are produced that become trapped and, in warmer water, the bubbles cause the algae to become buoyant and float to the surface. Disturbance of these algal mats by high wind or heavy rain events may cause them to temporarily sink to the bottom. This often gives a false impression that the growth has "disappeared", only to have it return to the surface within several days.

The frequency of filamentous algae in Normandale Lake was documented during plant surveys completed in 2016 through 2020. Filamentous algae frequency of occurrence at sampling points has ranged from a low of 9 percent on August 27, 2016 to a high of 72 percent on June 26, 2020 (Figure 8-8). Samples of filamentous algae were collected on August 17, 2017 and again on August 28, 2020 to determine the species comprising the filamentous algal mats. In 2017, three species of green algae were present: *Spirogyra, Rhizoclonium hieroglyphicum*, and *Pithophora*. In 2020, two species of green algae were present: *Rhizoclonium hieroglypicum* and *Pithophora*.

The growth potential of filamentous algae is dependent upon nutrient and light conditions. Nine Mile Creek provides a continuous supply of nutrients to fuel the growth of filamentous algae in Normandale Lake. Because the lake generally has adequate nutrients and light for the growth of filamentous algae, the lake could support the growth of filamentous algae throughout each growing season. Filamentous algae produce reproductive structures that fall to the lake bottom and, when conditions are favorable, the reproductive structures begin a new growth of filamentous algae, sustaining the presence of filamentous algae in the lake. The beginning of the filamentous algae growth season is generally triggered by the warming of the water to a threshold temperature (e.g., 59 to 68º F). The end of their growing season occurs when light, nutrient, or temperature conditions become unfavorable for growth of filamentous algae. The most effective management option for filamentous algae is nutrient reduction. Management of nuisance mats of algae by chemical treatment is not recommended because chemical treatments for filamentous algae would be copper-based. Both species of filamentous algae found in Normandale Lake in 2020 are resistant to copper and would require a relatively high dose of algaecide to attain control. Also, because filamentous algae can grow very rapidly, the benefit of a chemical treatment may only last a few days or a few weeks.



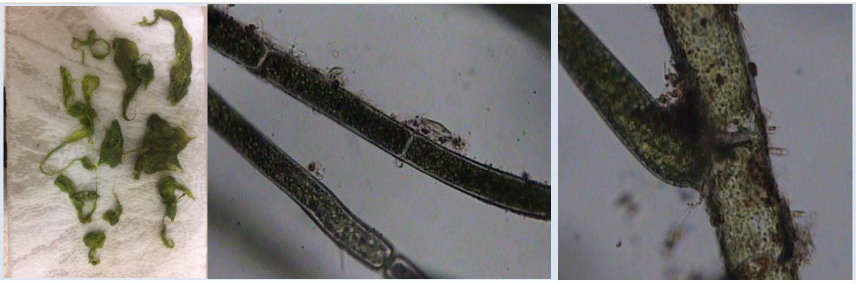


Figure 8-8 Normandale Lake filamentous algae frequency of occurrence

Top, 2016, 2017, 2018, 2019, and 2020 Normandale Lake filamentous algae frequency of occurrence and bottom, a picture of filamentous algae collected from Normandale Lake on August 28, 2020, left, and microscopic pictures of the two species of filamentous algae collected on August 28, 2020, *Rhizoclonium hieroglyphyicum* (green algae), middle, and *Pithophora* (green algae), right.

8.7 Aquatic Plants

Eutrophication may have detrimental effects on a lake, including reductions in the quantity and diversity of aquatic plants. The ability to assess the biological condition of a lake plant community is a valuable tool in the conservation of Minnesota's lakes. With this objective in mind, the MNDNR developed a Lake Plant Eutrophication Index of Biological Integrity (IBI) to measure the response of a lake plant community to eutrophication. The MNDNR will use this Lake Plant Eutrophication IBI to identify lakes that are likely stressed from anthropogenic eutrophication. A healthy aquatic plant community is an essential part of lakes and provides many important benefits such as nutrient assimilation, sediment stabilization, and habitat for fish. The Plant IBI can provide important context to understanding information about water quality, shoreline health, and the fish community.

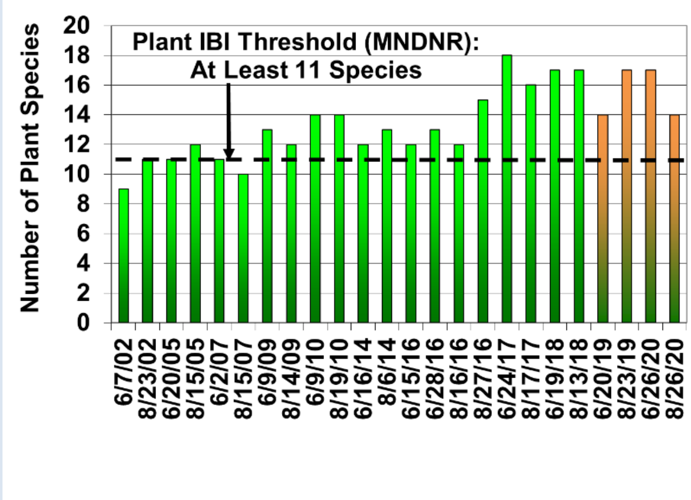


Figure 8-9.A

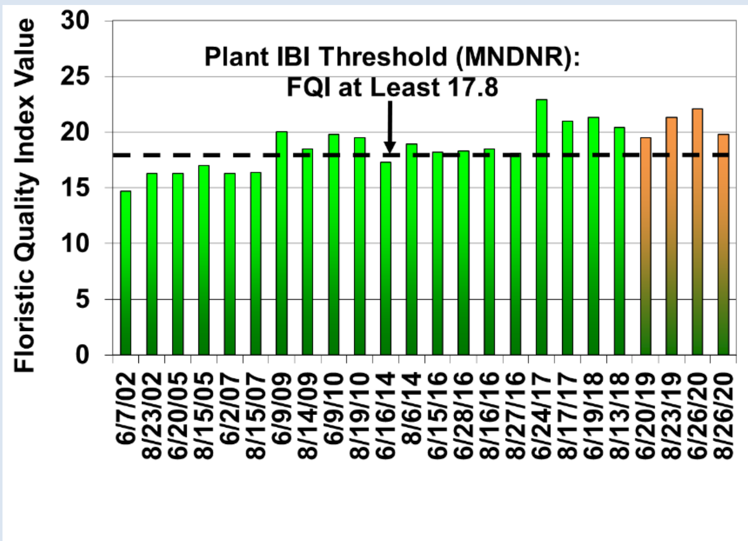


Figure 8-9.B

Figure 8-9 Normandale Lake Plant Index of Biotic Integrity (IBI) Values compared with Plant IBI Thresholds (MNDNR): Number of Plant Species (top) and Floristic Quality Index (FQI) Values (bottom)

The MDNR has developed metrics to determine the overall health of a lake's aquatic plant community. The Lake Plant Eutrophication IBI includes two metrics: (1) the number of species in a lake; and (2) the "quality" of the species, as measured by the floristic quality index (FQI). The MNDNR has determined a threshold for each metric. Lakes that score below the thresholds contain degraded plant communities and are likely stressed from anthropogenic eutrophication.

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The District conducted point-intercept and biomass aquatic plant surveys of Normandale Lake in June and August of 2020. Results are included in Appendix D. Plant survey data from 2002 through 2020 were assessed to determine plant IBI trends. Figure 8-9 shows the Normandale Lake number of species and FQI scores for that period compared to the MNDNR Plant IBI thresholds. The green bars depict data collected before beginning the water quality improvement project in fall of 2018. The orange bars depict data collected after initiation of the water quality treatment project (drawdown in fall of 2018, alum treatment in spring of 2019, and herbicide treatment of curly-leaf pondweed in spring of 2020).

- **Number of species:** A shallow lake (maximum depth less than 15 feet) fails to meet the MNDNR Plant IBI threshold when it has fewer than 11 species. During the period examined, the number of species in Normandale Lake ranged from 9 to 18. The number of species in the lake has been better than the MNDNR Plant IBI threshold since 2009. Higher numbers of plant species have been observed since August of 2016 than in previous years (Figure 8-9.A).

- **FQI values (quality of species):** The MNDNR Plant IBI threshold for shallow lakes, as measured by FQI, is a value of 17.8. During the period examined, FQI values ranged from 14.7 to 22.9. FQI scores have been consistently at or better than the MNDNR Plant IBI threshold since August 2014 (Figure 8-9.B).

- **2020 results:** Both the number of species in the lake and FQI values were better than the MNDNR Plant IBI thresholds (Figure 8-9).

8.7.1 Comparison of Pre- and Post-Project Curly-leaf Pondweed (CLP) Data to Assess CLP Changes After Initiation of Water Quality Improvement Project

The water quality improvement project implemented in 2018 through 2020 has resulted in a reduced frequency and biomass of CLP in the lake. The drawdown reduced the frequency of the targeted aquatic invasive species curly-leaf pondweed (CLP) (*Potamogeton crispus*) – from a range of 47 to 85 percent of sampling locations in June during 2016 through 2018 to 22 percent of sampling locations in June 2019 (Figure 8-10). CLP frequency was further reduced to 9 percent of sampling locations in June 2020, following a May 2020 diquat treatment of portions of Normandale Lake. The drawdown also reduced the biomass of CLP, measured as wet weight—from a range of 25 to 230 grams per sample location, on average, in June of 2017 and 2018, respectively, to an average of 6 grams per sample location in June 2019 (Figure 8-10).

In June 2020, CLP biomass remained lower than pre-treatment measurements, an average wet weight of 11 grams per sample location in (Figure 8-11). Although biomass of CLP in June of 2020 was lower than pre-treatment measurements, it was higher than CLP biomass measured in June of 2019, likely because the curly-leaf pondweed plants collected in June 2020 had a longer growth period prior to biomass measurement. Plants collected in June 2019 began growing in spring of 2019 after the lake filled with water and biomass was measured in June. Plants collected in June 2020 began growing in fall 2019 and biomass was measured in June 2020. The lower CLP frequency and biomass after completion of the water quality improvement project are favorable changes for the lake.

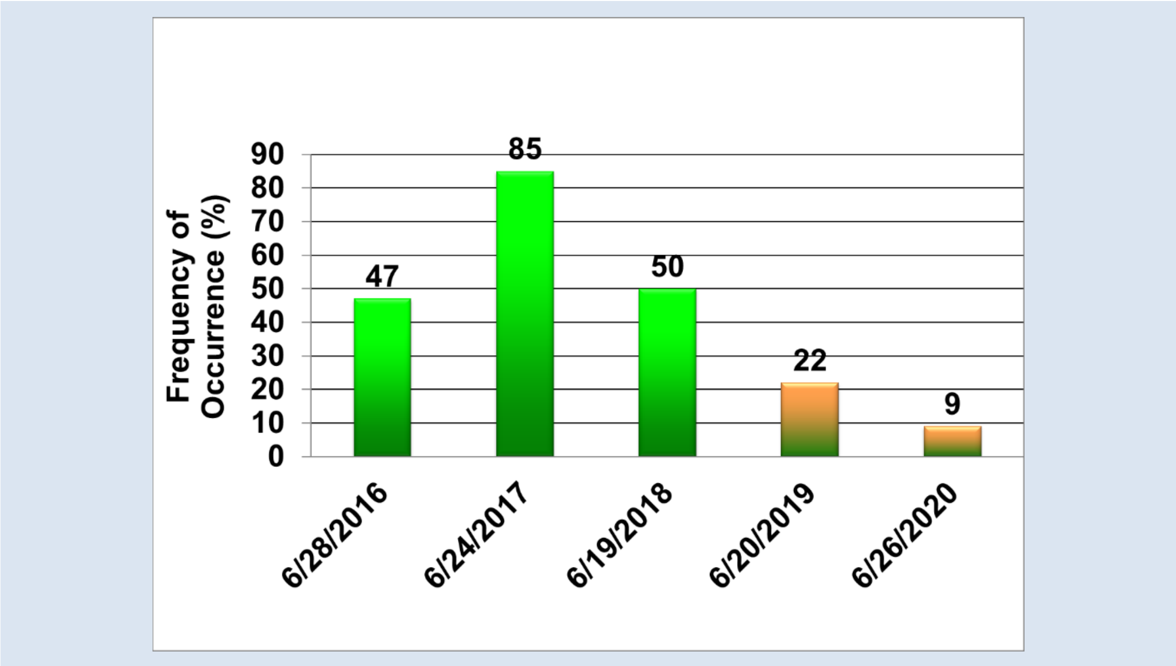

Figure 8-10 2016-2020 comparison of Normandale Lake curly-leaf pondweed frequency of occurrence in June prior to and after initiation of the water quality improvement project

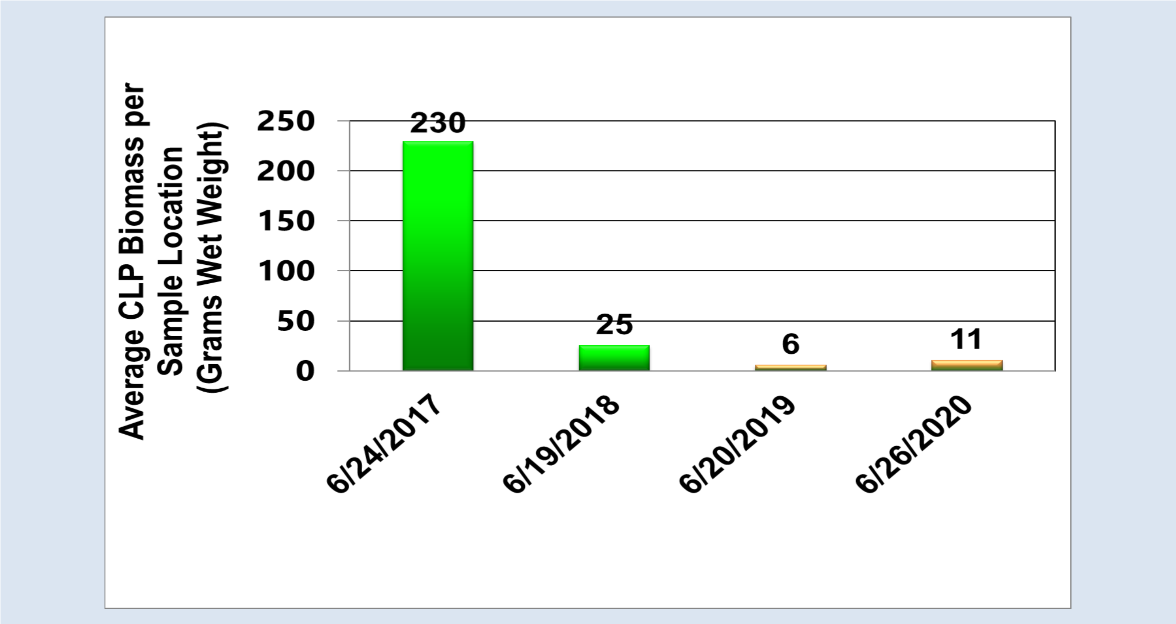

Figure 8-11 2016-2020 comparison of Normandale Lake curly-leaf pondweed biomass (average wet weight per sample location) in June prior to and after initiation of the water quality improvement project

8.7.2 Comparison of Pre- and Post-Project Plant Data to Assess Changes in Plant Community After Initiation of Water Quality Improvement Project

Plant biomass in Normandale Lake, measured as average wet weight of plants per sample point, was assessed before and after the water quality improvement project to determine whether the project impacted biomass of the plant community as a whole and/or individual species. The data indicate biomass of the plant community was lower in June 2019 immediately following the drawdown. Biomass increased during the 2019 and 2020 growing seasons and, by August 2020, was at the lower end of the range of biomass levels observed in 2017 through 2018 prior to the drawdown Figure 8-12). In 2020, the three species with the highest average wet weight per sample point – coontail, common waterweed, and white water lily – were generally the three species with the highest average wet weight per sample point prior to the drawdown (Figure 8-12).

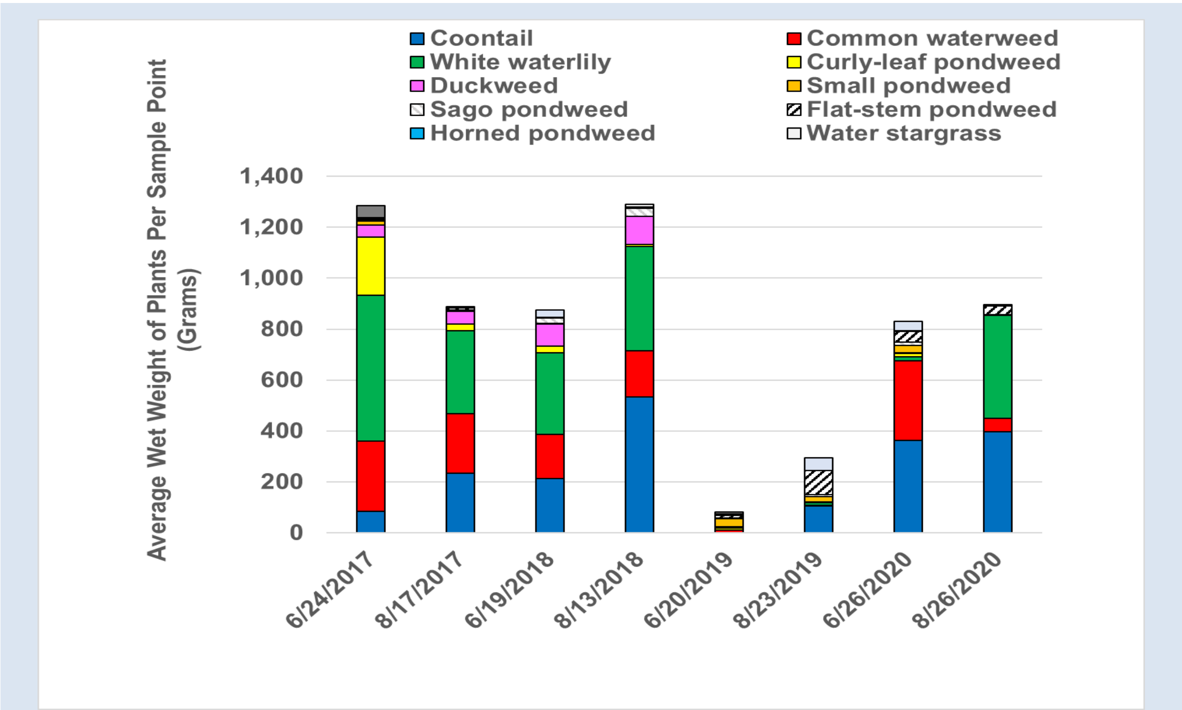

Figure 8-12 2017-2020 comparison of Normandale Lake average wet weight of plants per sample point
stacked bar graph above shows individual species wet weights (average per sample point) and the collective total of all species' average wet weights per sample point for each sample event

Plant surveys in Normandale Lake during 2016 through 2020 measured the frequency of occurrence of individual species in the plant community to assess impacts from the water quality improvement project. Plant species in Normandale Lake varied in response to the project, some occurring at a higher frequency, some at a similar frequency, and some at a lower frequency in 2020 compared with frequencies observed before the project. The 2016 through 2020 frequency of occurrence of the twelve most frequently occurring species in 2020 are discussed below (Figure 8-13).

- **Coontail**, the most frequently occurring species in 2020, occurred at a similar frequency in 2020 as before the project.

- **Common waterweed**, the second most frequently occurring species in 2020, occurred at a similar frequency in 2020 as before the project.

- **Common watermeal, large duckweed, and small duckweed,** tied for the third most frequently occurring species in 2020, occurred at a lower frequency in 2020 than before the project.

- **Small pondweed** frequency increased in 2019 after the drawdown and then declined in 2020 to a frequency similar to before the project.

- **Sago pondweed** occurred at a higher frequency in 2019 and 2020 than before the project

- **Curly-leaf pondweed** occurred at a lower frequency in 2019 and 2020 than before the project, when comparing June results. 2019 August sampling results showed higher frequency of occurrence than August results from before the project. This reflects the delayed growth cycle of the remaining CLP in 2019 immediately following the lake drawdown.

- **Flat-stem pondweed** occurred at a frequency in 2020 that was near the high end or higher than the frequency range observed before the project.

- **White water lily** occurred at a lower frequency in 2020 than before the project.

- **Water stargrass** occurred at a similar frequency in 2020 as before the project.

- **Long-leaf pondweed** occurred at a slightly higher frequency range in 2020 than before the project.

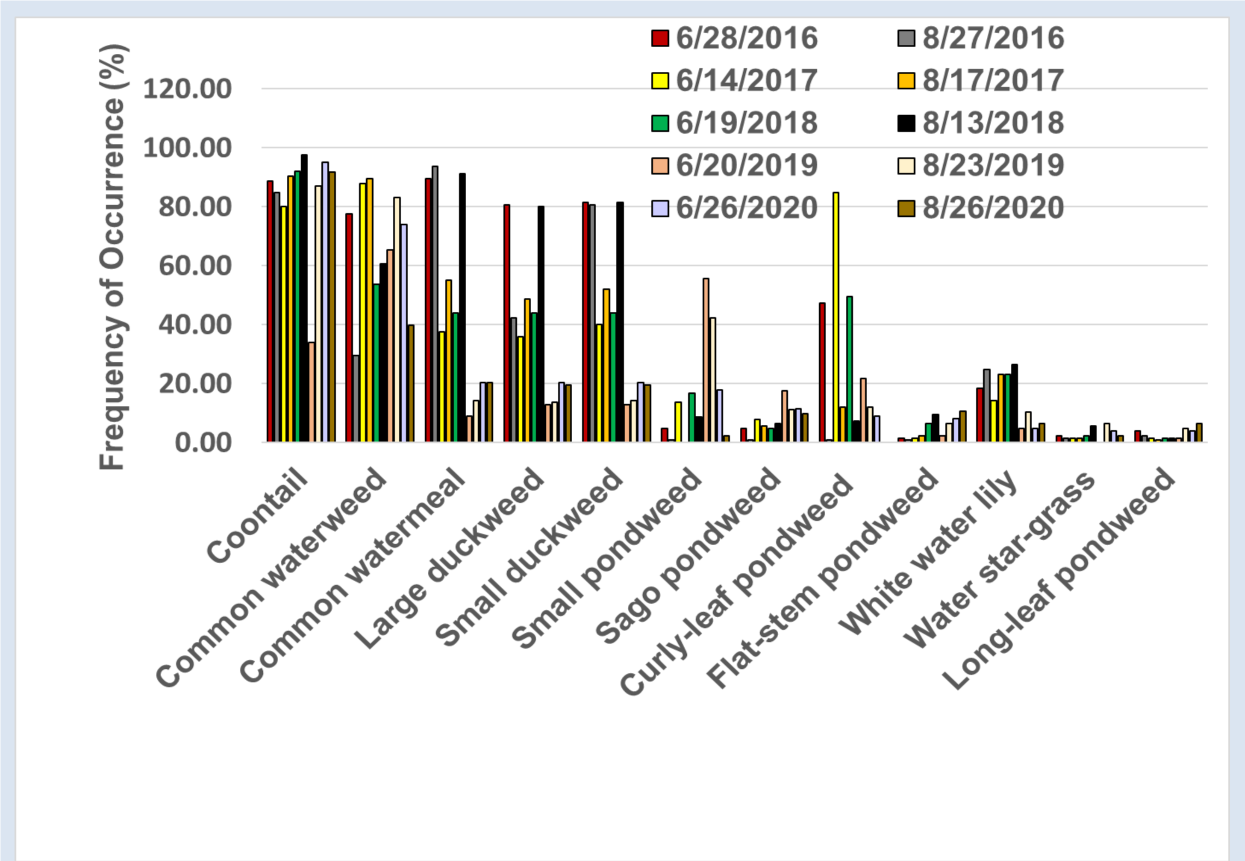

Figure 8-13 **2016-2020 comparison of Normandale Lake frequency of occurrence of individual species**
above graph shows the 2016-2020 frequency of occurrence of the twelve individual species occurring most frequently in Normandale Lake in 2020

8.7.3 Turion Survey Results

Location and density of turions in Normandale Lake were assessed after initiation of the water quality improvement project. Turions are the primary reproductive structures of curly-leaf pondweed and are found in the lake bottom. They are brown, typically a half-inch in size and look like sharp small pinecones (Figure 8-14). The goal of the drawdown was to freeze (or kill) as many turions as possible to reduce future curly-leaf pondweed growth in the lake. Turion surveys were conducted during October 2019 and October of 2020 to determine where turions were found in the lake, their density, and their size. Results of the turion survey are provided in Appendix E. The 2019 survey found some turions remaining in the lake sediment, although generally in low or very low densities. Turions were generally found along the stream channel that remained unfrozen and flowing throughout the winter of the drawdown. A patch of turions was also found in the northeastern portion of the lake. The turion survey conducted in the fall of 2020 found turions in fewer sampling locations than in 2019. Many of the locations with remaining turions were again along the stream channel in low or very low densities. Turions were found at 14 of 50 sample points in 2020, as compared to 19 sample points in 2019. 36 live turions were found in the fall of 2019 and 21 live turions were found in 2020. Most of the turions found in fall of 2020 were small, which may indicate they were produced by plants that germinated from seeds after the 2020 treatment. While results from the 2020 turion monitoring showed reductions in turions, the year-over-year differences were not statistically significant.

Figure 8-14 A germinating curly-leaf pondweed turion (Photo Credit: Endangered Resource Services, LLC)

8.8 Conclusions and Recommendations

In 2018, the District began implementation of a water quality improvement project for Normandale Lake. A drawdown of the lake was completed in fall of 2018 to expose the lake bed to a winter freeze and freeze out curly-leaf pondweed, an invasive plant species, which dies off in late-June, senesces, and adds phosphorus to the lake. This summer addition of phosphorus fuels algal growth and degrades lake water quality. The lake was treated with alum in spring of 2019 to reduce the release of phosphorus from lake bottom sediments into the water column. In the spring of 2020, an herbicide treatment was conducted within portions of Normandale Lake and Nine Mile Creek immediately upstream of Normandale Lake using diquat to control curly-leaf pondweed growing in these areas. 2020 results indicate that Normandale Lake met MPCA acute and chronic criteria for chlorides. The average summer phosphorus concentration did not meet the shallow lakes phosphorus criterion of 60 µg/L, but the summer average value of 61 µg/L was close. Summer average Secchi disc (measure of clarity), and chlorophyll *a* concentration met the state eutrophication criteria for shallow lakes. The late August and September numbers of blue-green algae observed in the lake were lower in 2020 than 2016 and the total number of zooplankton in 2020 was, on average, higher than previous years. Both changes are favorable for the lake. Filamentous algae occurred more frequently in June than previous years, but August frequency was within the historical range. Samples collected in August 2020 documented two species of filamentous green algae, *Pithophora* and *Rhizoclonium hieroglyphicum*. Both species were also present in samples collected from the lake in 2017. The lake’s plant community met the MNDNR Plant IBI thresholds.

The water quality improvement project implemented in 2018 through 2020 has resulted in a reduced frequency and biomass of curly-leaf pondweed in the lake. Biomass of the total plant community was lower in June 2019 immediately following the drawdown, but increased during the 2019 and 2020 growing seasons and, by August 2020, was at the lower end of the range of biomass levels observed prior to the drawdown. In 2020, the three species with the highest average wet weight per sample point – coontail, common waterweed, and white water lily – were generally the three species with the highest average wet weight per sample point prior to the drawdown. Coontail and common waterweed were the two most frequently occurring species in 2020 while common watermeal, large duckweed, and small duckweed tied for the third most frequently occurring species. Native plant species in Normandale Lake varied in response to the project, some occurring at a higher frequency, some at a similar frequency, and some at a lower frequency in 2020 compared with frequencies observed before the project.

Continuation of water quality and biological monitoring is recommended in upcoming years to assess the impacts of the improvement project(s) on the condition of the lake's water quality and biological community.

9 Lake Rose

Lake Rose (Figure 9-1) has a water surface area of approximately 26 acres, a maximum depth of about 14 feet, and a mean depth of 3.8 feet at a normal water surface elevation of 925.9 MSL. At this elevation the lake volume is approximately 102 acre-feet. The water level in the lake is controlled primarily by weather conditions (snowmelt, rainfall, and evaporation), groundwater seepage, inflow from its direct subwatershed, and inflow from Wing Lake. When water does outlet from Lake Rose, it is routed to Birch Island Lake. The lake is currently on the MPCA's impaired waters list for excess nutrients (since 2010).

In 2020, the Nine Mile Creek Watershed District monitored Lake Rose for:

- Water chemistry- total phosphorus (TP), soluble reactive phosphorus (ortho phosphate), total nitrogen, total Kjeldahl nitrogen, nitrate plus nitrite nitrogen, chlorophyll *a*, chloride, and turbidity.
- Water field measurements- dissolved oxygen, pH, temperature, specific conductance, and Secchi disc
- Phytoplankton and zooplankton (microscopic plants and animals)
- Macrophytes (aquatic plants)

Water quality monitoring results are summarized in Appendix A, phytoplankton and zooplankton data in Appendix B, and macrophyte monitoring maps in Appendix C. Monitoring results are discussed in the following paragraphs.

Figure 9-1 Lake Rose

9.1 Total Phosphorus and Chlorophyll *a* Levels and Water Clarity (Secchi Depth

The lake's 2020 average summer total phosphorus concentration of 72 µg/L failed to meet the Minnesota State Water Quality Standard for shallow lakes in the North Central Hardwood Forest Ecoregion published in Minnesota Rules 7050 (Minn. R. Ch. 7050.0222 Subp 4) (Figure 9-2). However, the chlorophyll *a* concentration of 15.5 µg/L and the Secchi disc transparency of 1.04 meters both met the standard. Minnesota State water quality standards for shallow lakes in the North Central Hardwood Forest Ecoregion are <u><</u>60 µg/L, <u><</u>20 µg/L, and <u>></u>1 meter, respectively. The lake is currently on the MPCA's impaired waters list for excess nutrients (since 2010).

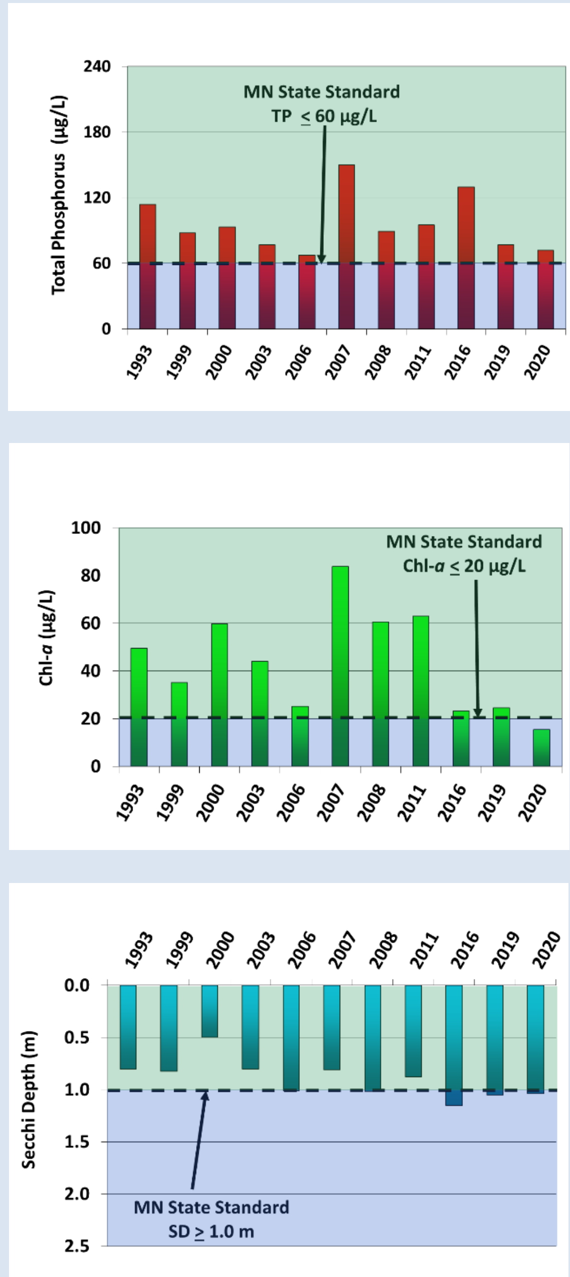

Figure 9-2 Lake Rose historical summer average values total phosphorus (top), chlorophyll *a* (middle), and Secchi disc (bottom)

Historical water quality data have been collected by the City of Minnetonka from Lake Rose during 1993, 1999, 2000, 2003, 2011, 2016, and 2019, by the City of Minnetonka and the Metropolitan Council Environmental Services (MCES) Citizen Assisted Monitoring Program (CAMP) in 2006, by the MCES CAMP in 2007, by the MCES CAMP and the Nine Mile Creek Watershed District in 2008, and by the Nine Mile Creek Watershed District in 2020. The water quality of Lake Rose has generally been poor. During the monitored period, all total phosphorus concentrations and all but the 2020 chlorophyll *a* concentration failed to meet the Minnesota State water quality standards for shallow lakes in the North Central Hardwood Forest Ecoregion (Figure 9-2). Secchi disc transparency failed to meet the standard during more than half of the monitored period, but met the standard in 2006, 2008, 2016, 2019, and 2020 (Figure 9-2).

The data indicate water quality in Lake Rose has improved. Summer average total phosphorus concentrations were lower (better) in 2019 and 2020 than in 2007 through 2016. Summer average chlorophyll *a* concentrations were lower (better) in 2016 through 2020 than in 2007 through 2011 and the

2020 summer average chlorophyll *a* concentration was the lowest to date. Summer average Secchi disc transparencies were higher (better) in 2016 through 2020 than in 2011 (Figure 9-2).

The District is updating the Use Attainability Analysis for Holiday, Wing, and Rose Lakes in 2021, as identified in the District's Water Management Plan (2017). As part of this water quality study, the District will identify management measures to improve the lake's water quality.

9.2 Chlorides

Chloride concentrations in area lakes have increased since the early 1990s when many government agencies switched from sand or sand/salt mixtures to salt for winter road maintenance. When snow and ice melts, the salt goes with it, washing into lakes, streams, wetlands, and groundwater. It only takes 1 teaspoon of road salt to permanently pollute 5 gallons of water. And, once in the water, it is very difficult and expensive to remove.

Because high concentrations of chloride can harm fish and plant life, MPCA has established acute and chronic exposure chloride standards. A lake is considered impaired if two or more exceedances of chronic criterion (230 mg/L or less) occur within a three-year period or one exceedance of acute criterion (860 mg/L) is measured. Chloride concentrations in Lake Rose were measured during May through September in 2020. All chloride measurements were below the MPCA acute and chronic criteria. The 2020 chloride concentrations are summarized in Figure 9-3 and Appendix A.

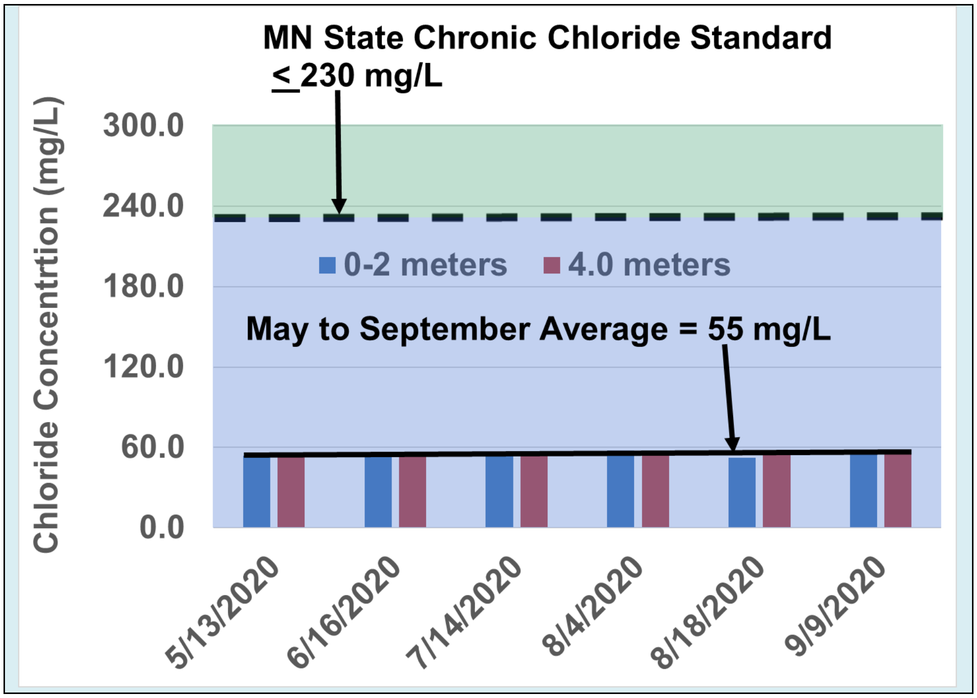

Figure 9-3 Lake Rose 2020 chloride concentrations

9.3 Phytoplankton

Phytoplankton, also called algae, are small aquatic plants naturally present in lakes, including Lake Rose. Phytoplankton derive energy from the sun through photosynthesis and provide food for several types of aquatic organisms, including zooplankton, which are in turn eaten by fish. An inadequate phytoplankton population limits a lake's zooplankton population, and indirectly limits fish production in a lake. Excess phytoplankton can reduce water clarity, which can then make recreational use of a lake less desirable.

Samples of phytoplankton, microscopic aquatic plants, were collected from Lake Rose in 2020 to evaluate water quality and the quality of food available to zooplankton (microscopic animals). Identification and enumeration of the phytoplankton species was completed (Appendix B).

Figure 9-4 summarizes summer average number and major groups of phytoplankton during the monitored period. The Lake Rose phytoplankton numbers were well distributed between green algae, blue-green algae, and cryptomonads during 2008 and 2020 (Figure 9-4). In 2008, blue-green algae numbers were highest while green algae numbers were highest in 2020 (Figure 9-4). Green algae and cryptomonads are a good quality food source and contribute towards a healthy zooplankton community.

While identification and enumeration of phytoplankton species has been part of the District's routine lake monitoring program for many years, increased frequency of observed blue-green algal blooms in recent years prompted the District to develop a protocol in 2020 for evaluating and reporting potential Harmful Algal Blooms (HAB). When District monitoring staff observe signs of a potential blue-green algal bloom on a lake while conducting routine monitoring, staff collect a water sample and expedite algal identification and enumeration. Upon enumeration, blue-green algae counts are compared to thresholds established by the World Health Organization (WHO) as guidelines for low, moderate or high probability of adverse health effects to recreational users. Under the District's current protocol approved December 2020, the District will notify the City, MPCA, Minnesota Department of Health (MDH) and other stakeholder partners of the findings if blue-green algae counts are above the low, medium, or high probability thresholds and post advisory information on the District's website. In addition, if blue-green algae counts are between the low and medium probability threshold, the District will advise public property owner(s) of the WHO recommendation to post advisory signs and if the blue-green algae counts are above the medium or high probability thresholds, the District will recommend that the public property owner(s) post advisory signs.

Blue-green algae numbers were below the WHO threshold for low probability of adverse health effects for all monitoring events in 2020 (Figure 9-5). The low numbers of blue-green algae are favorable for lake users and for the lake's zooplankton. Blue-green algae are a poor quality food for zooplankton. Blue-green algae can also produce algal toxins, which can be harmful to humans or other animals.

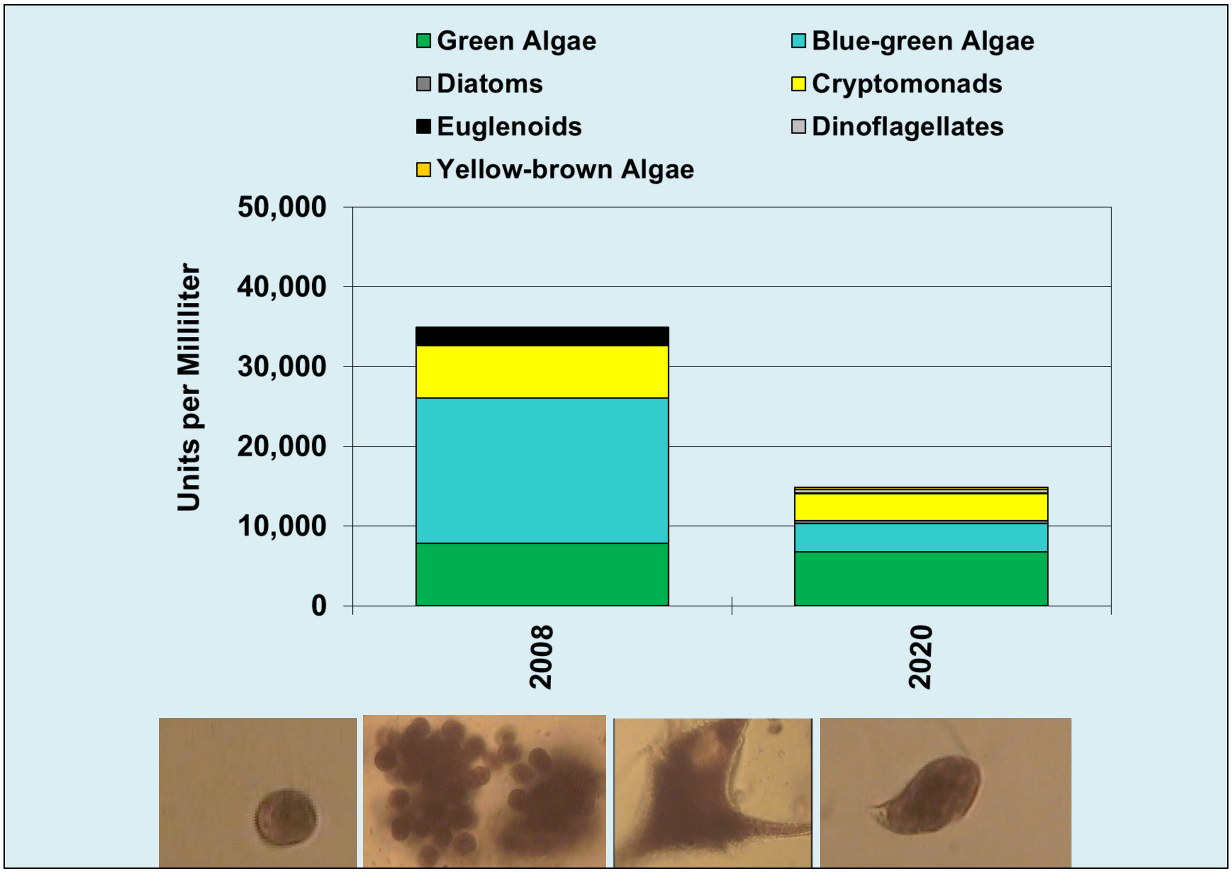

Figure 9-4 Lake Rose summer average phytoplankton

Top, Lake Rose 2020 summer average phytoplankton numbers and bottom, microscopic pictures of phytoplankton species found in the lake, from left to right*, Chlamydomonas globosa* (green algae) *Microcystis aeruginosa* (blue-green algae), *Ceratium hirundinella* (dinoflagellate)*, and Cryptomonas erosa* (cryptomonad)

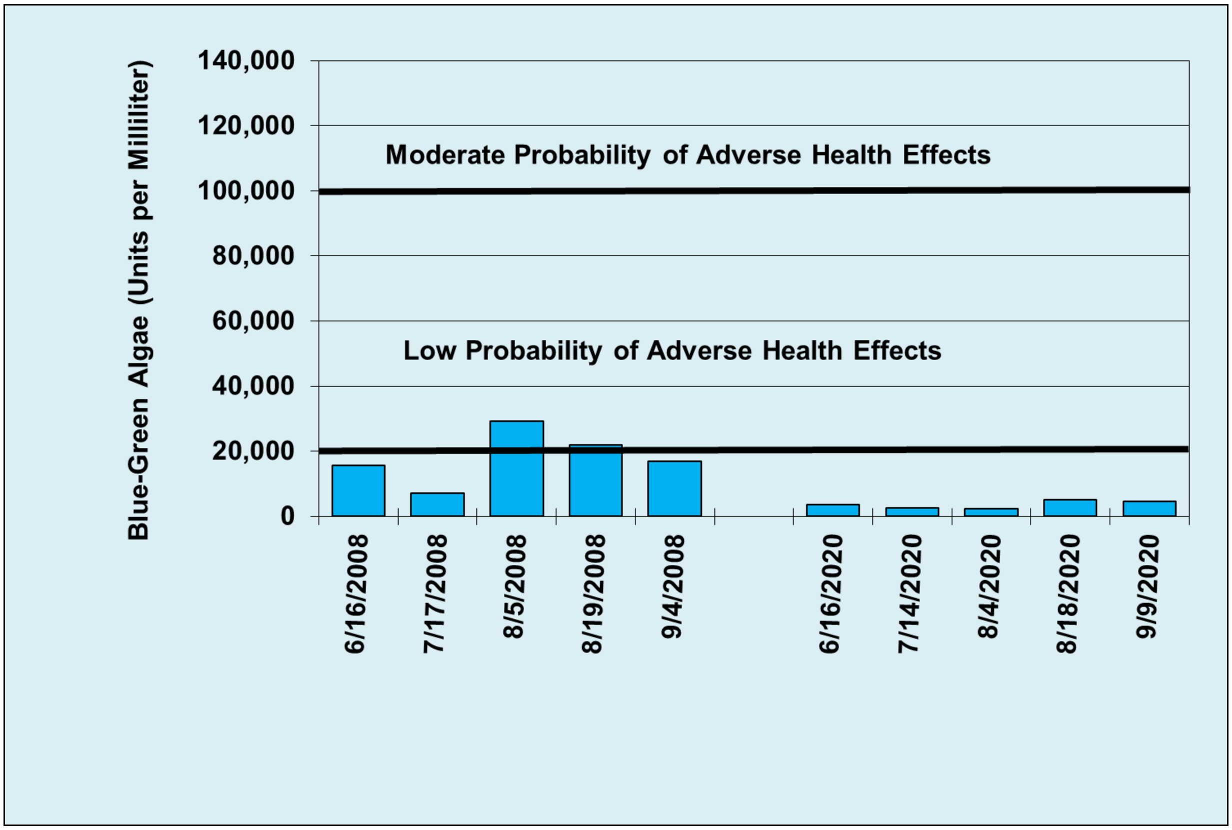

Figure 9-5 Lake Rose blue-green algae compared with World Health Organization (WHO) thresholds for adverse health effects

9.4 Zooplankton

Samples of zooplankton, microscopic aquatic animals, were collected from Lake Rose in 2020 to evaluate the food available to planktivorous fish. Identification and enumeration of the zooplankton species was completed (Appendix B).

Figure 9-6 summarizes the summer average number and major groups of zooplankton during the monitored period. In 2020, the zooplankton community in Lake Rose was healthy and all three groups of zooplankton were present: cladocerans, copepods, and rotifers. Rotifers consistently dominated the community during 2008 and 2020 and few cladocerans were observed (Figure 9-6). Higher numbers of zooplankton were observed in 2020 than 2008, a favorable change for the lake. The data indicate the zooplankton community has provided an abundant supply of food for planktivorous fish in the lake.

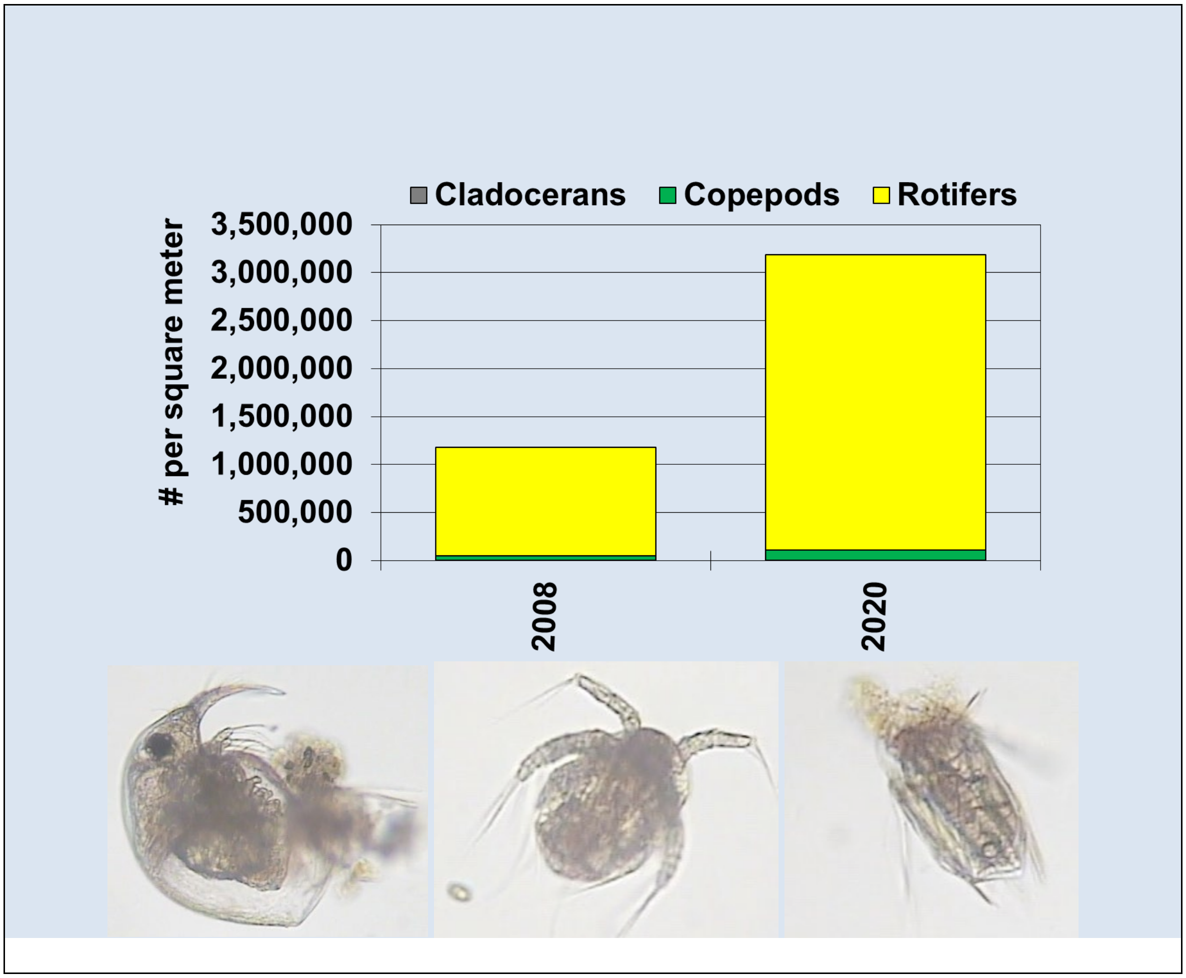

Figure 9-6 Lake Rose summer average zooplankton
Top, 2008 and 2020 Lake Rose zooplankton summer average numbers and bottom, microscopic pictures of zooplankton species from the lake, from left to right, *Bosmina longirostris* (cladoceran), nauplii (baby copepod), and *Polyarthra vulgaris* (rotifer).

9.5 Aquatic Plants

Eutrophication may have detrimental effects on a lake, including reductions in the quantity and diversity of aquatic plants. The ability to assess the biological condition of a lake plant community is a valuable tool in the conservation of Minnesota's lakes. With this objective in mind, the MNDNR developed a Lake Plant Eutrophication Index of Biological Integrity (IBI) to measure the response of a lake plant community to eutrophication. The MNDNR will use this Lake Plant Eutrophication IBI to identify lakes that are likely stressed from anthropogenic eutrophication. A healthy aquatic plant community is an essential part of lakes and provides many important benefits such as nutrient assimilation, sediment stabilization, and habitat for fish. The Plant IBI can provide important context to understanding information about water quality, shoreline health, and the fish community.

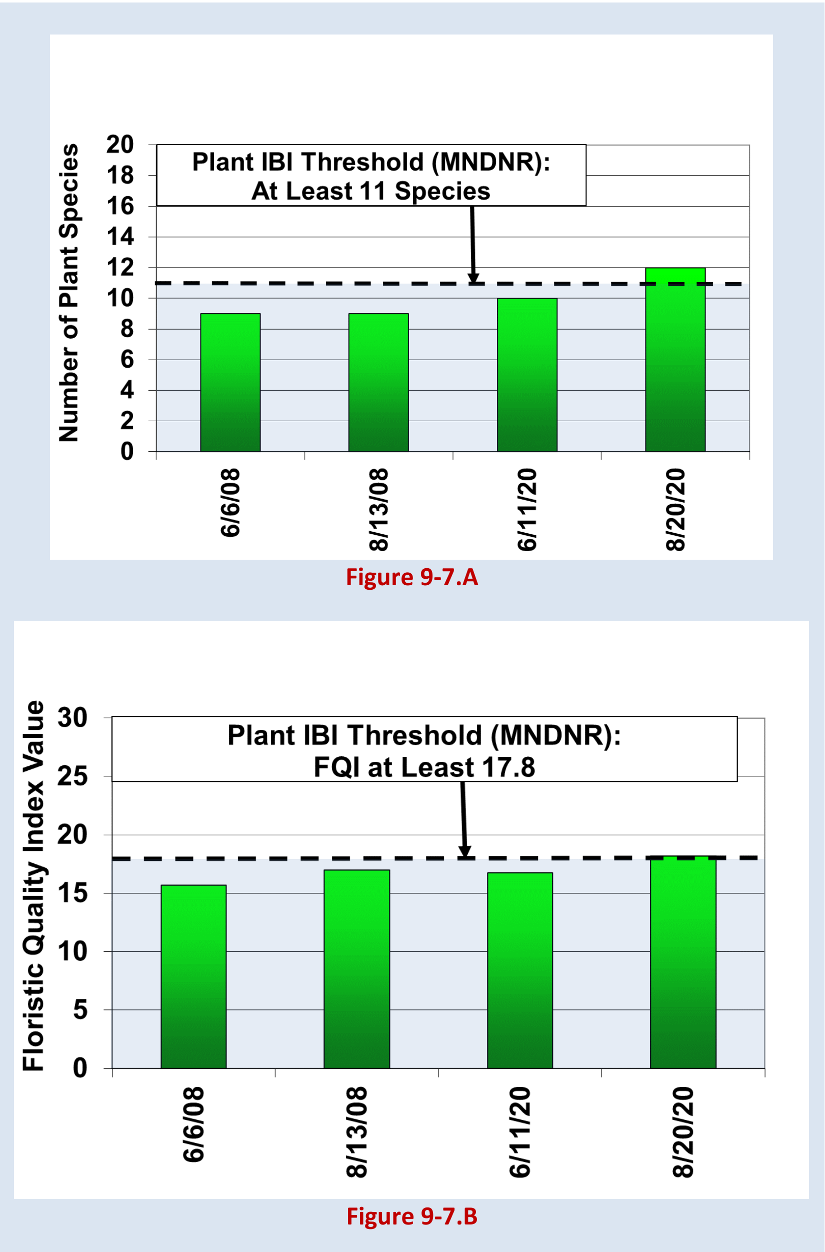

Figure 9-7 Lake Rose Plant Index of Biotic Integrity (IBI) Values compared with Plant IBI Thresholds (MNDNR): Number of Plant Species (top) and Floristic Quality Index (FQI) Values (bottom).

The MDNR has developed metrics to determine the overall health of a lake's aquatic plant community. The Lake Plant Eutrophication IBI includes two metrics: (1) the number of species in a lake; and (2) the "quality" of the species, as measured by the floristic quality index (FQI). The MNDNR has determined a threshold for each metric. Lakes that score below the thresholds contain degraded plant communities and are likely stressed from anthropogenic eutrophication.

The District conducted qualitative aquatic plant surveys of Lake Rose in June and August of 2020. Maps showing survey results are included in Appendix C. Plant survey data from 2008 and 2020 were assessed to determine plant IBI trends. Figure 9-7 shows the Lake Rose number of species and FQI scores for 2008 and 2020 compared to the MNDNR Plant IBI thresholds.

- **Number of species:** A shallow lake (maximum depth less than 15 feet) fails to meet the MNDNR Plant IBI threshold when it has fewer than 11 species. During 2008 and 2020, the number of species in Lake Rose ranged from 9 to 12 and was less (poorer) than the MNDNR Plant IBI threshold during June and August 2008 and during June 2020. The number of species in August 2020 was greater (better) than MNDNR Plant IBI threshold, an indication of a healthier plant community (Figure 9-7.A).

- **FQI values (quality of species):** The MNDNR Plant IBI threshold for shallow lakes, as measured by FQI, is a minimum value of 17.8. During 2008 and 2020, FQI values ranged from 15.7 to 18.2 and were less (poorer) than the MNDNR Plant IBI threshold during June and August 2008 and June 2020 (Figure 9-7.B). The FQI in August 2020 was greater (better) than the MNDNR Plant IBI threshold, an indication of a healthier plant community (Figure 9-7.A).

- **2020 results:** Both the number of species in the lake and FQI values were poorer than the MNDNR Plant IBI thresholds in June and better than the MNDNR Plant IBI thresholds in August (Figure 9-7).

Two aquatic invasive species were found in Lake Rose in 2020:

- **Purple loosestrife (*Lythrum salicaria*)** – The extent of this emergent species observed in 2020 was consistent with observations from 2008, when it was first observed in the lake. Purple loosestrife was observed sporadically along the entire perimeter of the lake during 2008 and 2020 (Appendix C).

- **Curly-leaf pondweed (*Potamogeton crispus*)**– This invasive species was prevalent throughout the lake in both 2008 and 2020 (Appendix C). A similar density of CLP was observed in the northern half of the lake in both years, but portions of the southern half of the lake observed a lighter density in 2020. In 2020, density was light in the northern half of the lake and ranged from light to moderate in the southern half of the lake. In 2008, density was light in the northern half of the lake, but ranged from moderate to heavy in the southern half of the lake.

9.6 Conclusions and Recommendations

2020 monitoring results indicate Lake Rose met the MPCA acute and chronic chloride criteria. The 2020 summer average total phosphorus concentration failed to meet the Minnesota State Water Quality Standard for shallow lakes, but summer averages for chlorophyll *a* and Secchi disc both met the standard.

The lake's water quality and biological data indicate water quality has improved. Summer average total phosphorus concentrations were lower (better) during 2019 and 2020 than 2007 through 2016. Summer average chlorophyll *a* concentrations were lower (better) in 2016 through 2020 than in 2007 through 2011 and the 2020 summer average chlorophyll *a* concentration was the lowest to date. Summer average Secchi disc transparencies were higher (better) in 2016 through 2020 than in 2011. Lower numbers of phytoplankton and higher numbers of zooplankton were observed in 2020 than 2008. Both the number of plant species and the quality of the plant community measured by FQI increased in August 2020 and were better than the MNDNR Plant IBI thresholds. However, because only two years of data are available, a strong conclusion cannot be made from the data.

Two aquatic invasive species were observed in Lake Rose in both 2008 and 2020, CLP and purple loosestrife. Although CLP and purple loosestrife extent was similar both years, CLP density was lighter in the southern half of the lake in 2020.

The District is updating the Use Attainability Analysis for Holiday, Wing, and Rose Lakes in 2021, as identified in the District's Water Management Plan (2017). As part of this water quality study, the District will identify management measures to improve the lake's water quality. Continuation of water quality and biological monitoring is recommended to periodically assess the condition of the lake's water quality and biological community and identify trends.

10 Wing Lake

Wing Lake (Figure 10-1) has a water surface area of approximately 14 acres, a maximum depth of about 8.5 feet, and a mean depth of 4.4 feet at a water surface elevation of 939.8 MSL. At this elevation the lake volume is approximately 63 acre-feet. The water level in the lake is controlled by weather conditions (snowmelt, rainfall, and evaporation), pumped inflow from Lake Holiday, inflow from its direct subwatershed, and the elevation of the Wing Lake outlet. The Wing Lake outlet structure has a design elevation of 939.8 MSL; there is a small orifice in the concrete structure at an elevation of approximately 938.8 MSL, allowing flow out of the lake at a lower elevation. Flow from the gravity outlet is routed to Lake Rose. The lake is currently on the MPCA's impaired waters list for excess nutrients (since 2010).

In 2020, the Nine Mile Creek Watershed District monitored Wing Lake for:

- Water chemistry- total phosphorus (TP), soluble reactive phosphorus (ortho phosphate), total nitrogen, total Kjeldahl nitrogen, nitrate plus nitrite nitrogen, chlorophyll *a*, chloride, and turbidity.
- Water field measurements- dissolved oxygen, pH, temperature, specific conductance, and Secchi disc
- Phytoplankton and zooplankton (microscopic plants and animals)
- Macrophytes (aquatic plants)

Water quality monitoring results are summarized in Appendix A, phytoplankton and zooplankton data in Appendix B, and macrophyte monitoring maps in Appendix C. Monitoring results are discussed in the following paragraphs.

Figure 10-1 Wing Lake

10.1 Total Phosphorus and Chlorophyll *a* Levels and Water Clarity (Secchi Depth

In 2020, Wing Lake water quality was poor. The lake's 2020 summer average total phosphorus concentration of 131 µg/L, the lake's summer average chlorophyll *a* concentration of 37 µg/L, and the lake's summer average Secchi disc transparency of 0.67 meters failed to meet the Minnesota State Water Quality Standards for shallow lakes in the North Central Hardwood Forest Ecoregion published in Minnesota Rules 7050 (Minn. R. Ch. 7050.0222 Subp 4) (Figure 10-2). Minnesota State water quality standards for shallow lakes in the North Central Hardwood Forest Ecoregion are ≤60 µg/L, ≤20 µg/L, and ≥1 meter, respectively. The lake is currently on the MPCA's impaired waters list for excess nutrients (since 2010).

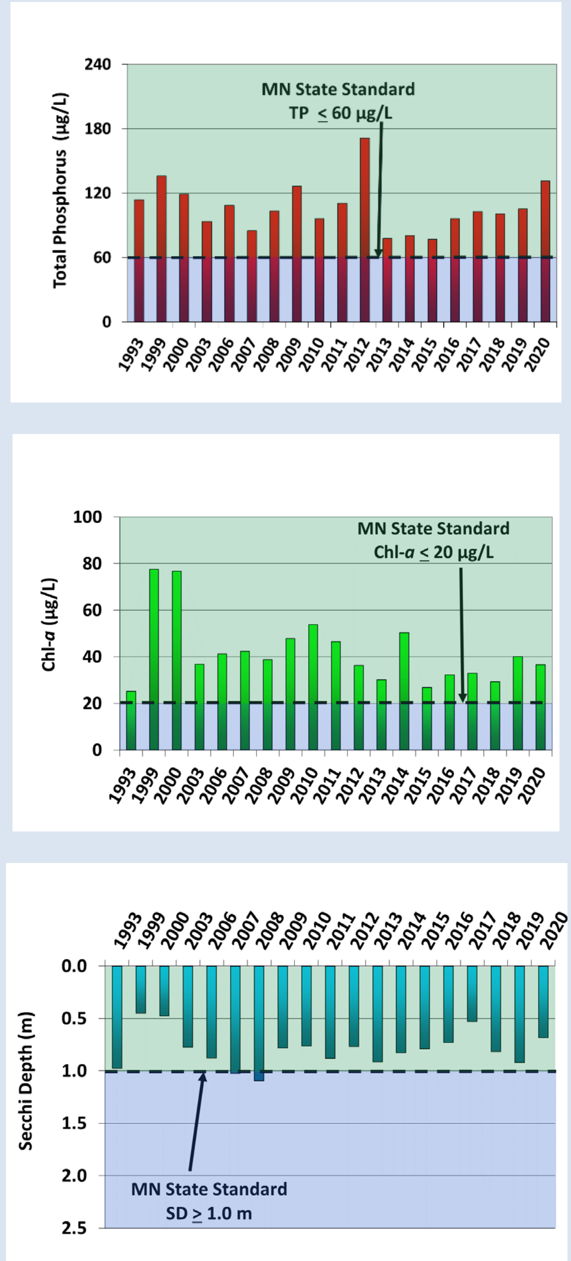

Figure 10-2 Wing Lake historical summer average values
total phosphorus (top), chlorophyll *a* (middle), and Secchi disc (bottom)

Historical water quality data have been collected by the City of Minnetonka from Wing Lake during 1993, 1999, 2000, 2003, by the City of Minnetonka and the Metropolitan Council Environmental Services (MECES) Citizen Assisted Monitoring Program (CAMP) in 2006, 2008, 2011, 2016, and 2019, by the MCES CAMP in 2007, 2009, 2010, 2012, 2013, 2014, 2015, 2017, and 2018, and by the Nine Mile Creek Watershed District and MCES CAMP in 2020. The poor water quality observed in 2020 was typical of the water quality observed in previous years. Summer average total phosphorus and chlorophyll *a* concentrations failed to meet Minnesota State water quality standards for shallow lakes in the North Central Hardwood Forest Ecoregion during the entire monitored period (Figure 10-2). Summer average Secchi disc transparency met the standard in 2007 and 2008, but failed to meet the standard during the rest of the monitored period. 2020 summer average total phosphorus and chlorophyll *a* concentrations and Secchi disc transparency were within the range of values observed in previous years (Figure 10-2).

The District is updating the Use Attainability Analysis for Holiday, Wing, and Rose Lakes in 2021, as identified in the District's Water Management Plan (2017). As part of this water quality study, the District will identify potential management measures to improve the lake's water quality.

10.2 Chlorides

Chloride concentrations in area lakes have increased since the early 1990s when many government agencies switched from sand or sand/salt mixtures to salt for winter road maintenance. When snow and ice melts, the salt goes with it, washing into lakes, streams, wetlands, and groundwater. It only takes 1 teaspoon of road salt to permanently pollute 5 gallons of water. And, once in the water, it is very difficult and expensive to remove.

Because high concentrations of chloride can harm fish and plant life, MPCA has established acute and chronic exposure chloride standards. A lake is considered impaired if two or more exceedances of chronic criterion (230 mg/L or less) occur within a three-year period or one exceedance of acute criterion (860 mg/L) is measured. Chloride concentrations were measured during May through September in 2020. All chloride measurements were below the MPCA acute and chronic criteria. The 2020 chloride concentrations are summarized in Figure 10-3 and Appendix A.

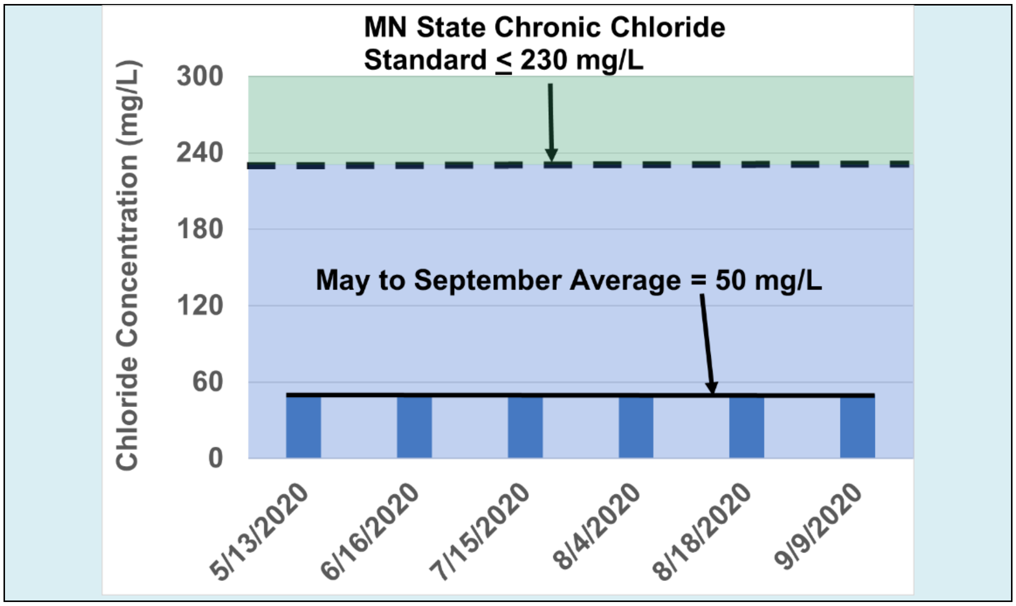

Figure 10-3 Wing Lake 2020 chloride concentrations

10.3 Phytoplankton

Phytoplankton, also called algae, are small aquatic plants naturally present in lakes, including Wing Lake. Phytoplankton derive energy from the sun through photosynthesis and provide food for several types of aquatic organisms, including zooplankton, which are in turn eaten by fish. An inadequate phytoplankton population limits a lake's zooplankton population, and indirectly limits fish production in a lake. Excess phytoplankton can reduce water clarity, which can then make recreational use of a lake less desirable.

Samples of phytoplankton, microscopic aquatic plants, were collected from Wing Lake in 2020 to evaluate water quality and the quality of food available to zooplankton (microscopic animals). Identification and enumeration of the phytoplankton species was completed (Appendix B).

Figure 10-4 summarizes the summer average number and major groups of phytoplankton observed in Wing Lake for monitored years. Between 2008 and 2020, the summer average number of phytoplankton in Wing Lake increased and the dominant type of algae changed from green algae in 2008 to blue-green algae in 2020 (Figure 10-4). Green algae are a good quality food source and contribute towards a healthy zooplankton community. Blue-green algae are a poor quality food for zooplankton. Blue-green algae can also produce algal toxins, which can be harmful to humans or other animals. The increase in number of algae and the change to dominance by blue-green algae in 2020 is an unfavorable change for the lake.

While identification and enumeration of phytoplankton species has been part of the District's routine lake monitoring program for many years, increased frequency of observed blue-green algal blooms in recent years prompted the District to develop a protocol in 2020 for evaluating and reporting potential Harmful Algal Blooms (HAB). When District monitoring staff observe signs of a potential blue-green algal bloom on a lake while conducting routine monitoring, staff collect a water sample and expedite algal identification and enumeration. Upon enumeration, blue-green algae counts are compared to thresholds established by the World Health Organization (WHO) as guidelines for low, moderate or high probability of adverse health effects to recreational users. Under the District's current protocol approved December 2020, the District will notify the City, MPCA, Minnesota Department of Health (MDH) and other stakeholder partners of the findings if blue-green algae counts are above the low, medium, or high probability thresholds and post advisory information on the District's website. In addition, if blue-green algae counts are between the low and medium probability threshold, the District will advise public property owner(s) of the WHO recommendation to post advisory signs and if the blue-green algae counts are above the medium or high probability thresholds, the District will recommend that the public property owner(s) post advisory signs.

Comparison of the numbers of blue-green algae in Wing Lake during 2008 and 2020 with the WHO threshold for probability of adverse health effects indicates blue-green numbers were below the threshold for a low probability of adverse health effects during all 2008 sample events and during all but the June 2020 sample event when the number of blue-green algae was above the threshold for a low probability of adverse health effects (Figure 10-5).

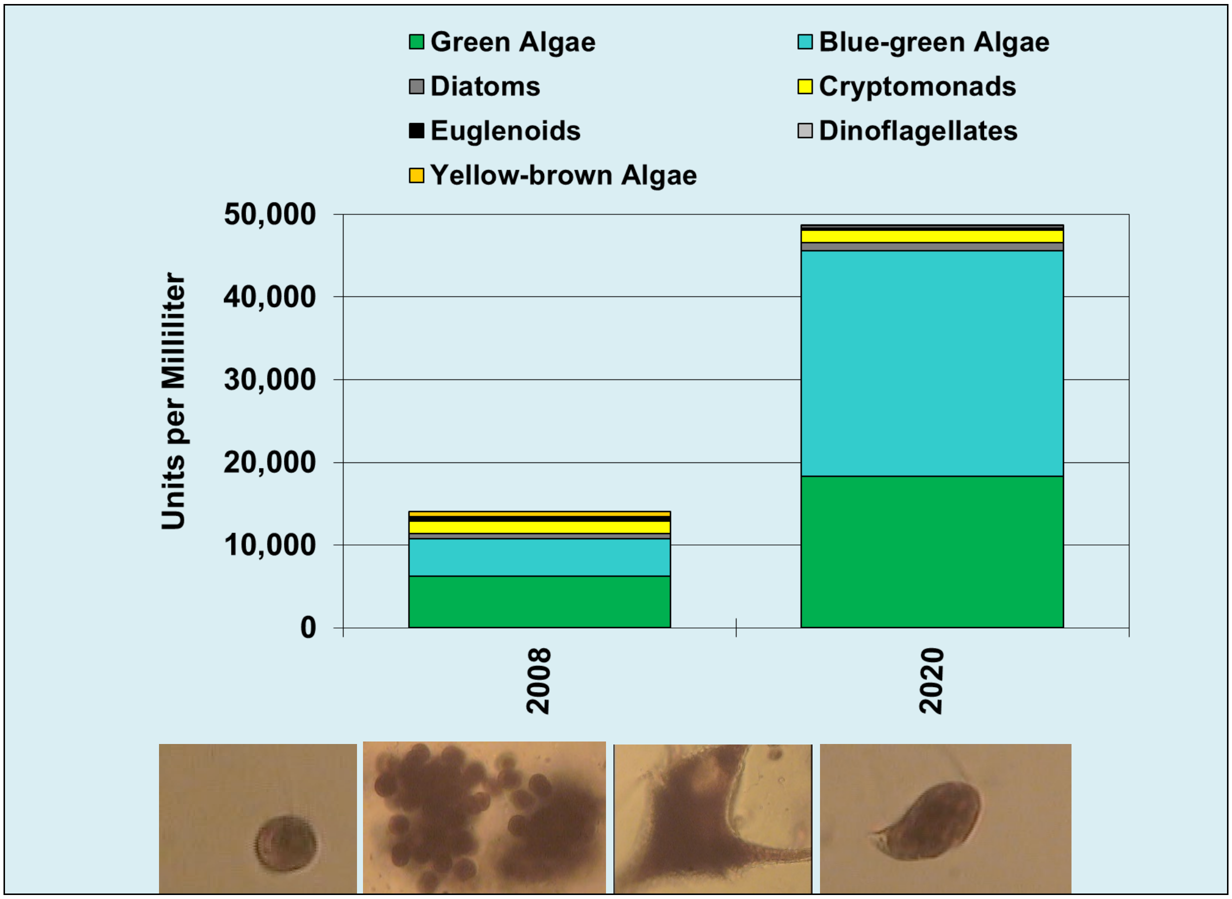

Figure 10-4 Wing Lake summer average phytoplankton

Top, Wing Lake 2008 and 2020 summer average phytoplankton numbers and bottom, microscopic pictures of phytoplankton species found in the lake, from left to right*, Chlamydomonas globosa* (green algae) *Microcystis aeruginosa* (blue-green algae), *Ceratium hirundinella* (dinoflagellate)*, and Cryptomonas erosa* (cryptomonad)

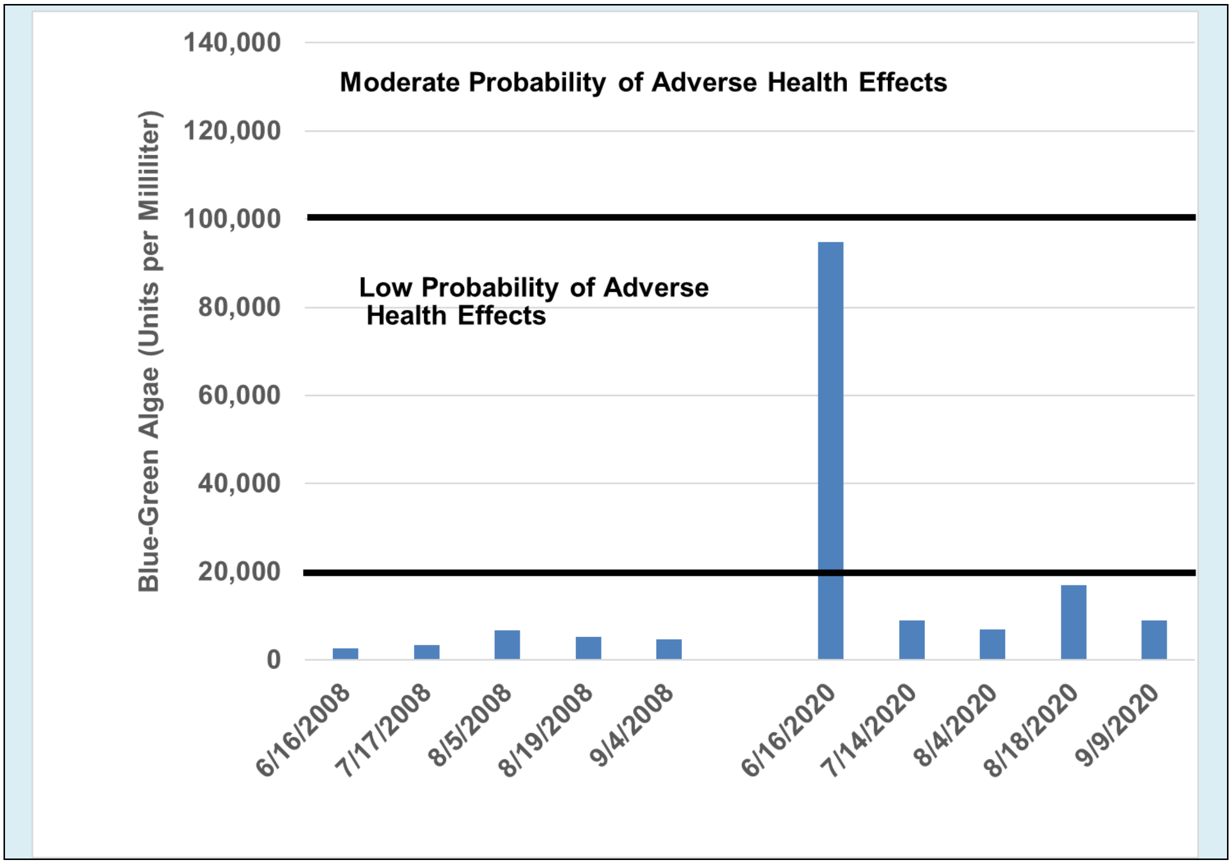

Figure 10-5 Wing Lake blue-green algae compared with World Health Organization (WHO) thresholds for adverse health effects

10.4 Zooplankton

Samples of zooplankton, microscopic aquatic animals, were collected from Wing Lake in 2020 to evaluate the food available to planktivorous fish. Identification and enumeration of the zooplankton species was completed (Appendix B).

Figure 10-6 summarizes the summer average number and major groups of zooplankton during the monitored period. In 2020, the zooplankton community in Wing Lake was healthy and all three groups of zooplankton were present, cladocerans, copepods, and rotifers. Rotifers consistently dominated the community during 2008 and 2020 and few cladocerans were observed (Figure 10-6). Higher numbers of zooplankton were observed in 2020 than 2008, a favorable change for the lake. The data indicate the zooplankton community has provided an abundant supply of food for planktivorous fish in the lake.

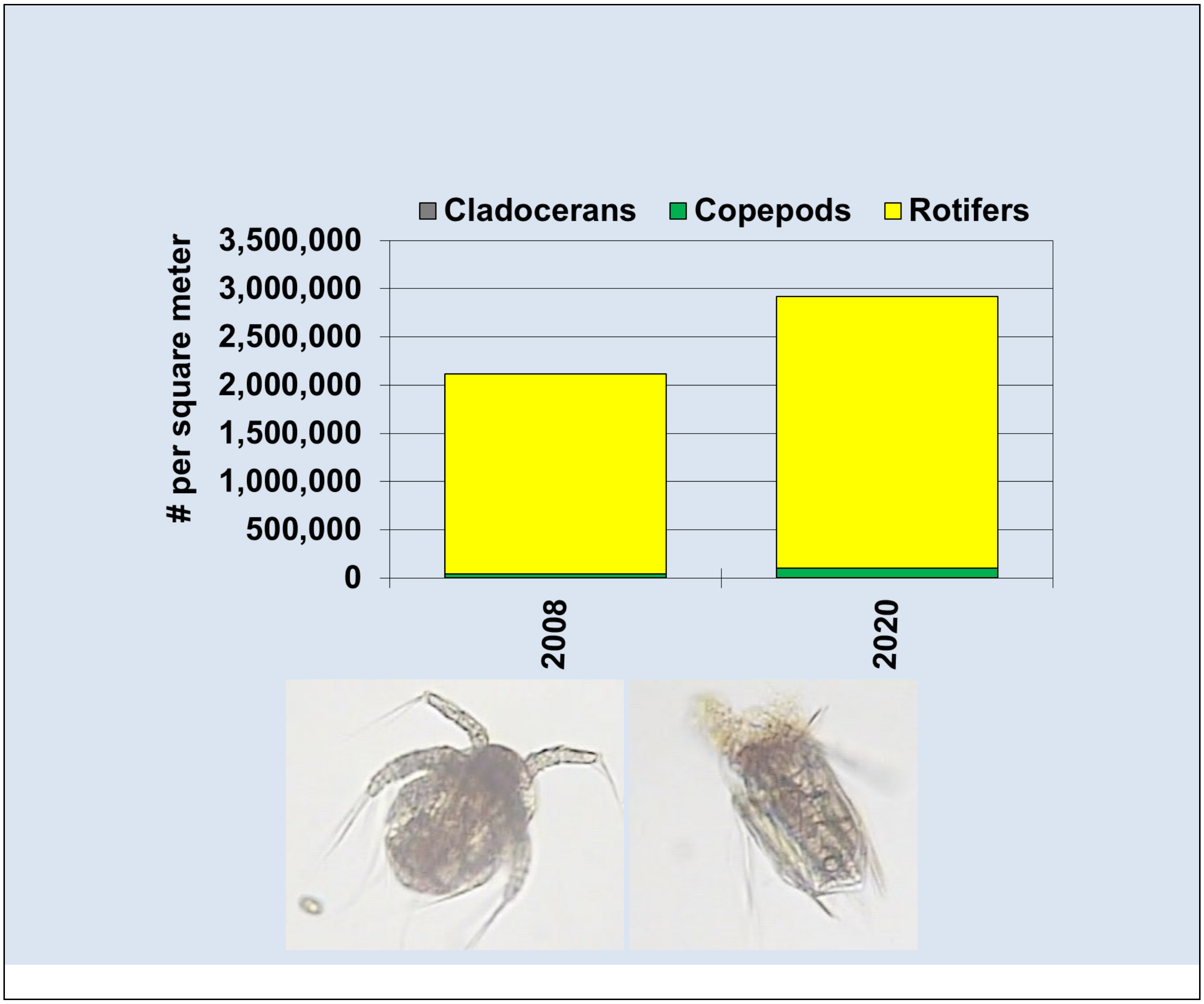

Figure 10-6 Wing Lake summer average zooplankton

Top, 2008 and 2020 Wing Lake summer average zooplankton numbers and bottom, microscopic pictures of zooplankton species from the lake, from left to right, nauplii (baby copepod), and *Polyarthra vulgaris* (rotifer).

10.5 Aquatic Plants

Eutrophication may have detrimental effects on a lake, including reductions in the quantity and diversity of aquatic plants. The ability to assess the biological condition of a lake plant community is a valuable tool in the conservation of Minnesota's lakes. With this objective in mind, the MNDNR developed a Lake Plant Eutrophication Index of Biological Integrity (IBI) to measure the response of a lake plant community to eutrophication. The MNDNR will use this Lake Plant Eutrophication IBI to identify lakes that are likely stressed from anthropogenic eutrophication. A healthy aquatic plant community is an essential part of lakes and provides many important benefits such as nutrient assimilation, sediment stabilization, and habitat for fish. The Plant IBI can provide important context to understanding information about water quality, shoreline health, and the fish community.

The MDNR has developed metrics to determine the overall health of a lake's aquatic plant community. The Lake Plant Eutrophication IBI includes two metrics: (1) the number of species in a lake; and (2) the "quality" of the species, as measured by the floristic quality index (FQI). The MNDNR has determined a threshold for each metric. Lakes that score below the thresholds contain degraded plant communities and are likely stressed from anthropogenic eutrophication.

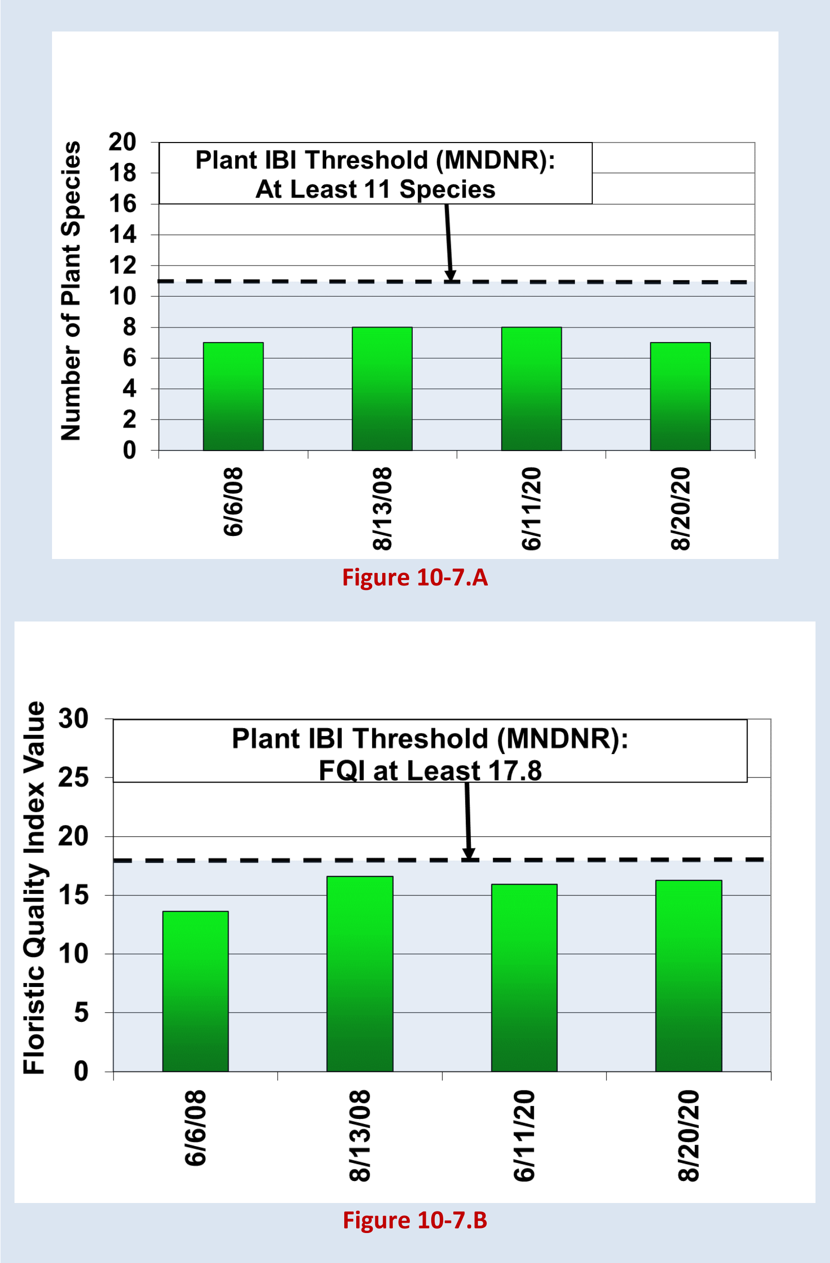

Figure 10-7 Wing Lake Plant Index of Biological Integrity (IBI) Values compared with Plant IBI Thresholds (MNDNR): Number of Plant Species (top) and Floristic Quality Index (FQI) Values (bottom).

The District conducted qualitative aquatic plant surveys of Wing Lake in June and August of 2020. Maps showing survey results are included in Appendix C. Plant survey data from 2008 and 2020 were assessed to determine plant IBI trends. Figure 10-7 shows the Wing Lake number of species and FQI scores for 2008 and 2020 compared to the MNDNR Plant IBI thresholds.

- **Number of species:** A shallow lake (maximum depth less than 15 feet) fails to meet the MNDNR Plant IBI threshold when it has fewer than 11 species. During 2008 and 2020, the number of species in Wing Lake ranged from 7 to 8 and was less (poorer) than the MNDNR Plant IBI threshold during both years (Figure 10-7.A).
- **FQI values (quality of species):** The MNDNR Plant IBI threshold for shallow lakes, as measured by FQI, is a minimum value of 17.8. During 2008 and 2020, FQI values ranged from 13.6 to 16.6 and were less (poorer) than the MNDNR Plant IBI threshold during both years (Figure 10-7.B)
- **2020 results:** Both the number of species in the lake and FQI values were poorer than MNDNR Plant IBI thresholds (Figure 10-7).

Two aquatic invasive species were found in Wing Lake in 2020:

- **Purple loosestrife (*Lythrum salicaria*)** – The extent of this emergent species has not changed since first observed in the lake in 2008—was observed sporadically along the entire perimeter of the lake during 2008 and 2020 (Appendix C)
- **Curly-leaf pondweed (*Potamogeton crispus*)**– A light density of this invasive species was prevalent in the lake during both 2008 and 2020 (Appendix C).

10.6 Conclusions and Recommendations

Monitoring results indicate Wing Lake met the MPCA acute and chronic chloride criteria, but failed to meet MPCA water quality standards for shallow lakes in 2020 due to excess phosphorus and algae in the lake and poor water clarity. The data indicate both phytoplankton and zooplankton numbers were higher in 2020 than 2008. The dominant type of algae changed from green algae in 2008 to blue-green algae in 2020, resulting in a poorer quality of food for the zooplankton community.

Aquatic plant data indicated the plant community had few species, was of poor quality, and did not meet the MNDNR Plant IBI thresholds. Lakes that score below the thresholds contain degraded plant communities and are likely stressed from anthropogenic conditions. Two aquatic invasive species were found in the lake in 2020, purple loosestrife and curly-leaf pondweed. Both species were first observed in the lake in 2008. Extent and density of the species were similar in 2008 and 2020.

The District is updating the Use Attainability Analysis for Holiday, Wing, and Rose Lakes in 2021, as identified in the District's Water Management Plan (2017). As part of this water quality study, the District will identify potential management measures to improve the lake's water quality. Continuation of water quality and biological monitoring is recommended to periodically assess the condition of the lake's water quality and biological community and identify trends.

11 Nine Mile Creek Stream Monitoring

Because the primary use of Nine Mile Creek is ecological—a place for fish and aquatic life to live—the focus of the Nine Mile Creek monitoring program is evaluation of the stream's fish and aquatic life community as well as the ecosystem components essential for the survival of fish and aquatic life (Figure 11-1). The 2020 Nine Mile Creek monitoring program included:

- March and May through October monthly measurements of specific conductance, dissolved oxygen, pH, temperature, turbidity, and flow. Monitoring was not conducted in April due to restrictions during the COVID-19 pandemic.
- Annual habitat monitoring during summer (i.e., stream substrate type, depth of fine sediment, percent embeddedness, and length of eroded streambank).
- Annual monitoring of the fish community during summer.
- Annual monitoring of the macroinvertebrate community during October.

Figure 11-1 Downstream Main Stem Location ECU-7C (Shorthead Redhorse Fish)
The primary use of Nine Mile Creek is a place for fish and aquatic life to live, such as the shorthead redhorse fish swimming in downstream Main Stem Location ECU-7C, pictured above.

Ten locations were monitored in 2020. Four locations were monitored on the North Fork, three locations on the South Fork, and three locations on the Main Stem. Monitoring locations are shown on Figure 1-2.

Data collected during 2020 were evaluated to determine whether:

- Specific conductance, dissolved oxygen, pH, and temperature levels met Minnesota Pollution Control Agency (MPCA) standards published in Minnesota Rule Chapter 7050.
- Flow and water quality data were consistent with historical values.
- 2020 fish and aquatic life communities were consistent with the stream's ecological use determined from assessments completed in 1997 and 2003.
- Fish data met MPCA Fish Index of Biotic Integrity (FIBI) standards for Class 2Bg southern headwaters stream standards published in Minnesota Rule Chapter 7050.
- Macroinvertebrate data collected from ECU-2, ECU-2A, ECU-3A, ECU-7A, ECU-7B, and ECU-7C met MPCA Macroinvertebrate Index of Biotic Integrity (MIBI) standards for Class 2Bg Southern Streams Riffle Run and macroinvertebrate data collected from ECU-1A and ECU-5A met MPCA MIBI standards for Class 2Bg Southern Forest Streams Glide Pool published in Minnesota Rule Chapter 7050.
- The 2020 fish and macroinvertebrate communities were consistent with historical data.

11.1 Nine Mile Creek Water Quality

In 2020, measurements for dissolved oxygen, temperature, specific conductance, pH, turbidity, and discharge occurred during March and monthly during May through October at 10 sample locations (Figure 1-2). Minnesota Rule Chapter 7050 specifies standards applicable to Minnesota streams to protect aquatic life. Nine Mile Creek is required to meet the most restrictive water quality standard for Classes 2B, 2C, or 2D; 3A, 3B, 3C, or 3D; 4A, 4B or 4C; and 5 (Minn. R. Pt. 7050.0220, Minn. R. Pt. 7050.0430, and Minn. R. Pt. 7050.0450). In 2020, the levels of dissolved oxygen, pH, and temperature in Nine Mile were compared to MPCA standards for Class 2B streams and specific conductance was compared with the MPCA standard for a Class 4A stream because they are the most restrictive water quality standards for these parameters. Overall, 87 percent of the 2020 observed values were within MPCA standards. The South Fork and Main Stem met MPCA standards most frequently (93 percent and 88 percent of observed values, respectively) followed by the North Fork (82 percent of observed values). The MPCA uses the data when assessing streams to determine whether aquatic life use is supported. Both biological data and water quality data are considered in the assessment.

Figure 11-2 Downstream North Fork Location ECU-2A
In 2020, the North Fork met the specific conductance standard less frequently than other locations. Pictured above is downstream North Fork location ECU-2A on 7/3/2020.

Figure 11-3 Downstream South Fork Location ECU-5A
In 2020, the South Fork met the MPCA dissolved oxygen standard 95% of the time. Pictured above is the downstream South Fork location ECU-5A on 6/3/2020.

Consistent with previous years, the specific conductance criterion was met less frequently in 2020 than other MPCA standards. All Nine Mile Creek temperature and pH measurements, 90 percent of the dissolved oxygen measurements, and 56 percent of the specific conductance measurements met MPCA standards. Specific conductance is a measure of the conductive ions in water from dissolved and inorganic materials such as alkalis, chlorides, sulfides, and carbonate compounds. High specific conductance measurements in Nine Mile Creek that fail to meet MPCA standards typically result from the discharge of excess chlorides from deicing chemicals (salt) to the creek. Other potential sources include synthetic fertilizers. The MPCA has listed Nine Mile Creek as impaired for chlorides since 2004.

Specific conductance measurements from Nine Mile Creek met the MPCA standard less frequently in 2020 than 2019—56 percent met the MPCA standard in 2020 compared with 74 percent in 2019. As in previous years, the

North Fork (Figure 11-2) locations met the MPCA standard for specific conductance less frequently than other sampling locations—25 percent of the North Fork measurements met the MPCA specific conductance standard in 2020 compared with 71 percent of Main Stem and 81 percent of South Fork measurements.

In 2020, 96 percent of the dissolved oxygen measurements from the North Fork were within the MPCA criterion, 95 percent of the dissolved oxygen measurements from the South Fork were within the MPCA criterion, and 81 percent of the dissolved oxygen measurements from the Main Stem were within the MPCA criterion. Main Stem dissolved oxygen measurements below the MPCA criterion included 3 measurements from the most upstream Main Stem location, ECU-7A, and one measurement from the middle Main Stem location, ECU-7B. All dissolved oxygen measurements from the downstream Main Stem location, ECU-7C, met the MPCA criterion.

In 2020, all temperature, pH, dissolved oxygen, specific conductance, and discharge values were within the range of values measured during the period in which data were collected. The turbidity value of 1.6 NTU measured at North Fork location N3 on October 1, 2020 was lower than values previously measured at this location. The lower value indicated the stream was less turbid, a favorable change for the stream.

Figure 11-4 Downstream Main Stem Location ECU-7C
In 2020, all temperature, pH, dissolved oxygen, specific conductance, discharge, and turbidity values were within the range of values measured during the period in which data were collected , including values measured at downstream Main Stem location ECU-7C, pictured above on 7/17/2020.

11.2 Ecological Use

Ecological use is a term used to describe the fish assemblage/aquatic life use that the stream has the capacity to support per the stream's flow, water quality, and habitat characteristics. The ecological uses are broken into the following categories:

- Coldwater Fish (Class A)
- Warmwater Sport Fish (Class B)
- Intolerant Forage Fish (Class C)
- Tolerant Forage Fish (Class D)
- Tolerant Macroinvertebrates (Class E)

The District completed a habitat assessment of Nine Mile Creek and evaluated historical flow, water quality, and fish data in 1997 to identify the stream's attainable ecological uses (types of fish communities the stream is able to support). During 1998 through 2001, flow, water quality, and fish data collected from the stream were annually assessed to determine whether the stream was consistently supporting its designated attainable ecological uses. In 2003 the District again completed a habitat assessment and evaluated historical flow, water quality, and fish data to identify any needed changes to the stream's designated attainable ecological uses. Since 2003, flow, water quality, and fish data have been annually evaluated to determine whether the stream has consistently supported its designated ecological uses. In 2020, flow, habitat, and water quality data indicated that all North Fork and South Fork locations and the middle and downstream Main Stem locations fully supported their designated attainable ecological uses. However, a low dissolved oxygen value of 1.8 at the upstream Main Stem location

ECU-7A (Figure 11-6) on July 3, 2020 did not support the designated attainable ecological use of intolerant forage fish for this location which requires a minimum dissolved oxygen level greater than 3 mg/L.

In 2020, the eight ecological use monitoring stations (Figure 1-2) were monitored for fish during late June through July. The 2020 fish communities in the North Fork, South Fork, and middle (ECU-7B) and downstream (ECU-7C) main Stem locations were consistent with their designated attainable ecological uses.

Figure 11-5 Upstream North Fork Location ECU 1A-1
Pictured above on 6/3/2020, the upstream North Fork Location ECU-1A-1 had an ecological use of tolerant forage fish in 2020, consistent with its attainable ecological use of tolerant forage fish.

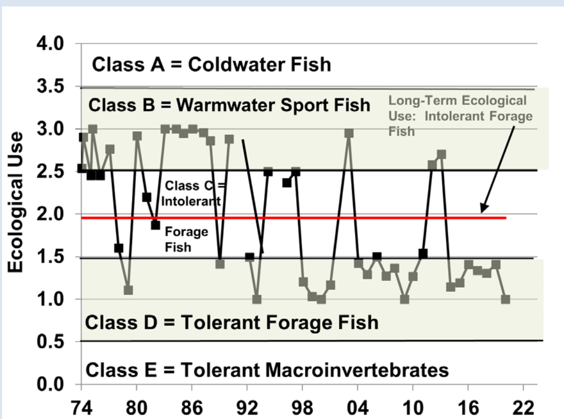

Figure 11-7 1974-2020 Main Stem ECU-7A Ecological Use (Type of Fish Community)

Figure 11-6 Upstream Main Stem Location ECU-7A
In 2020, a tolerant forage fish assemblage, an indicator of average to poor water quality, was observed at the most upstream Main Stem location, ECU-7A, pictured above on 7/16/2020. Hence the stream had an ecological use of tolerant forage fish.

The 2020 fish community found in the upstream Main Stem location (ECU-7A) (Figure 11-6) was poorer than its designated attainable ecological use. The fish community met the criteria for a tolerant forage fish community, an indicator of average to poor water quality and habitat, compared with its designated attainable ecological use of intolerant forage fish, an indicator of better water quality and habitat. Over time, frequent fluctuations in the fish community have been observed at this location varying between warmwater sportfish, intolerant forage fish, and tolerant forage fish (Figure 11-7). A comparison of 2019 and 2020 values indicates the fish community in 2020 was poorer than the fish community in 2019, although both were within the tolerant forage fish category. Changes in the fish community over time have been attributed to varying oxygen conditions due to impacts from upstream Marsh Lake. Water exiting the marsh may have either lower or higher oxygen levels than downstream locations, depending upon biological processes occurring within the marsh. As noted previously, a dissolved oxygen concentration of 1.8 mg/L measured at ECU-7A on July 3, 2020 did not support the designated attainable ecological use of intolerant forage fish for this location which requires a minimum dissolved oxygen level greater than 3 mg/L. This oxygen concentration, however, did support a tolerant forage fish community, which is the fish community observed at this location in 2020.

11.3 FIBI and MIBI

Figure 11-8 Middle Main Stem Location ECU-7B
The 2020 FIBI value at the middle Main Stem Location ECU-7B, pictured above on 7/16/2020, did not meet the FIBI standard.

Minnesota adopted changes to its water quality standards that establish biological water quality standards for all Minnesota streams and rivers, including Nine Mile Creek. A Fish Index of Biotic Integrity (FIBI) and a Macroinvertebrate Index of Biotic Integrity (MIBI) were added to MPCA standards published in Minn. Rule Chapter 7050.0222. The changes were approved by the United States Environmental Protection Agency on June 26, 2018. Although the MPCA had assessed streams for biological impairment in the past, previous MPCA water quality standards (Minn. Rule Chapters 7050 and 7052) did not contain biological criteria. The MPCA developed fish and macroinvertebrate Index of Biotic Integrity (IBI) tools and selected scores for the standards that are comparable with streams that have healthy fish and macroinvertebrate communities. The FIBI and MIBI standards distinguish between healthy fish and macroinvertebrate communities to be protected and unhealthy fish and macroinvertebrate communities in need of improvement.

Although the MPCA water quality standards published in Minn. Rule Chapter 7050 did not contain biological criteria prior to 2018, the MPCA assessed surface waters using fish bioassessment tools to identify biological impairment. Prior to 2018, Nine Mile Creek was assessed using a fish bioassessment tool developed for rivers and streams within the Minnesota River Watershed. The fish bioassessment tool was named the Minnesota Rapid Assessment Project Fish Index of Biotic Integrity (MRAP FIBI). The tool differed from the FIBI added to the MPCA water quality standards published in Minn. Rule Chapter 7050 in 2018. Based on the results of a fish bioassessment of Nine Mile Creek using the MRAP FIBI, Nine Mile Creek was listed on the MPCA impaired waters list as impaired for aquatic life (fish bioassessment) in 2004.

After biological criteria were added to the MPCA water quality standards published in Minn. Rule Chapter 7050 in 2018, the MPCA assessed Nine Mile Creek to determine whether the stream was impaired for aquatic life. The MPCA used data it had collected in 2014 from several reaches as well as data collected previously to complete a fish bioassessment of the stream using the FIBI and a benthic macroinvertebrate bioassessment of the stream using the MIBI to determine whether the stream met these MPCA criteria. Table 11-1summarizes the MPCA assessment results.

Table 11-1 Results of MPCA Aquatic Life Assessment on Nine Mile Creek Stream Reaches

Reach Name*	Reach Length (miles)*	Use Class*	FIBI*	MIBI*	Aquatic Life*	Year Added to Impaired Waters List**	Pollutant or Stressor**
Nine Mile Creek, South Fork, Smetana Lake to Nine Mile Creek	3.77	2Bg, 3C	Existing Impairment, Fails Standard	Existing Impairment, Fails Standard	Impaired	2018	Fish bioassessments and benthic macroinvertebrates bioassessments
Nine Mile Creek, Headwaters to Metro Blvd.	6.17	2Bg, 3C	Existing Impairment, Fails Standard	--	Impaired	2004	Fish bioassessments
Nine Mile Creek, Metro Blvd. to end of Unnamed Wetland	4.94	2Bm, 3C	Existing Impairment, Fails Standard	Existing Impairment, Fails Standard	Impaired	2018	Fish bioassessments and benthic macroinvertebrates bioassessments
Nine Mile Creek, Unnamed Wetland to Minnesota River	5.32	2Bg, 3C	Existing Impairment, Fails Standard	Existing Impairment, Fails Standard	Impaired	2018	Fish bioassessments and benthic macroinvertebrates bioassessments

* Source: MPCA's Nine Mile Creek Aggregated 12-HUC Summary from Monitoring and Assessment Report: HUC 0702001211-02

**Source: 2020 MPCA Impaired Waters List

For the assessment, the MPCA divided Nine Mile Creek into four stream reaches:

- South Fork from Smetana Lake to Nine Mile Creek
- Headwaters to Metro Boulevard (North Fork)
- Metro Boulevard to end of unnamed wetland
- Unnamed wetland to Minnesota River

The MPCA applied the FIBI to data collected from the North Fork of Nine Mile Creek by the Nine Mile Creek Watershed District in 2003, 2004, and 2005 and data collected by the MPCA in 2007. Based on the results, the MPCA retained the 2004 impaired waters listing of Nine Mile Creek from its headwaters to Metro Boulevard as impaired for aquatic life and listed the pollutant/stressor as fish bioassessments. Hence, the 2020 MPCA impaired waters list identifies this reach as impaired and 2004 as the year it was added to the impaired waters list. The impaired waters list indicates the pollutant or stressor as fish bioassessments.

The MPCA completed bioassessments of the other three reaches using data collected in 2014 as well as previously collected data. A fish bioassessment was completed on each reach using the FIBI and a benthic macroinvertebrate bioassessment was completed on each reach using the MIBI. Based upon the assessment results, the MPCA listed the three reaches of Nine Mile Creek (South Fork from Smetana Lake to Nine Mile Creek, Metro Boulevard to end of unnamed wetland, and unnamed wetland to Minnesota River) on the impaired waters list in 2018. The impaired waters list indicates the pollutant or stressor for each reach as fish bioassessments and benthic macroinvertebrates bioassessments.

11.3.1 Fish Index of Biotic Integrity (FIBI)

The MPCA has classified Minnesota streams into nine types corresponding to regional patterns in the composition of stream fishes; a unique FIBI and biocriterion were developed for each stream type. Stream type is differentiated by geographic region, contributing drainage area, reach-scale gradient, and thermal classification. Nine Mile Creek is a Class 2B Southern Headwaters stream because:

- Nine Mile Creek is a Class 2B stream located within the Minnesota River watershed;
- Nine Mile Creek is a warmwater stream;
- Nine Mile Creek sampling locations have a drainage area of less than 30 square miles;
- Nine Mile Creek fish monitoring locations have a gradient of more than 0.5 meters per kilometer.

As noted in Section 11.3, when the MPCA completed a bioassessment of Nine Mile Creek, the MPCA divided Nine Mile Creek into four stream reaches:

- South Fork from Smetana Lake to Nine Mile Creek
- Headwaters to Metro Boulevard (North Fork)
- Metro Boulevard to end of unnamed wetland
- Unnamed wetland to Minnesota River

The MPCA assigned a beneficial use classification to each reach. The headwaters of the North Fork of Nine Mile Creek to Metro Boulevard was classified as Class 2Bm, a beneficial use that means waters capable of supporting and maintaining a balanced, integrated, adaptive community of warm or cool water aquatic organisms having a species composition, diversity, and functional organization comparable to the median of biological condition gradient level 5 as established in Calibration of the Biological Condition Gradient for Streams of Minnesota (Minnesota Rules 7050.0222 Subp. 4c). The other three reaches were classified as Class 2Bg, a beneficial use that means waters capable of supporting and maintaining a balanced, integrated, adaptive community of warm or cool water aquatic organisms having a species composition, diversity, and functional organization comparable to the median of biological condition gradient level 4 as established in Calibration of Biological Condition Gradient for Streams of Minnesota (Minnesota Rules 7050.0222 Subp. 4c).

The MPCA FIBI is on a 0 to 100 scale with increasing scores indicating improving stream health. The FIBI standard applicable to the headwaters of the North Fork of Nine Mile Creek to Metro Boulevard is Class 2Bm Southern Headwaters stream, a value greater than 33. The FIBI standard applicable to the other reaches of Nine Mile Creek is a Class 2Bg Southern Headwaters stream, a value greater than or equal to 55. The MPCA has determined confidence limits around the standards to account for variability within the aquatic community because of natural spatial and temporal differences and sampling or method errors.

Fish collected from the eight ecological use monitoring stations (Figure 1-2) in Nine Mile Creek in 2017 through 2020 were assessed to determine the FIBI values and whether the values met the MPCA FIBI standard (Figure 11-11).

Figure 11-9 South Fork Upstream Location ECU-3A
The 2020 FIBI value at the upstream South Fork location, ECU-3A, pictured above on 6/30/2020, met the FIBI standard.

- **2020 results:** FIBI scores from the upstream South Fork location, ECU-3A (Figure 11-9), the downstream Main Stem location, ECU-7C (Figure 11-4), and the downstream North Fork location met the FIBI standard (Figure 11-11). The FIBI score from the upstream Main Stem location, ECU-7A, did not meet the standard, but its score of 52 is greater than the lower confidence limit of 48 (Figure 11-11) indicating it is relatively close to the standard. FIBI scores from the downstream South Fork location, ECU-5A, the middle Main Stem location, ECU-7B (Figure 11-8), and the two upstream North Fork locations, ECU-1A-1 (Figure 11-5) and ECU-2 did not meet the FIBI standard (Figure 11-11).

Figure 11-10 North Fork Middle Location ECU-2

The 2020 FIBI value at the North Fork middle location, ECU-2, pictured above on 7/1/2020, did not meet the FIBI standard during 2017 through 2020.

- **2017-2020 results:** FIBI scores from the downstream Main Stem location, ECU-7C, met the FIBI standard during all four years (Figure 11-11). FIBI scores from the upstream Main Stem location, ECU-7A, met the FIBI standard during 2018 and 2019, but not during 2017 and 2020 (Figure 11-11). As noted previously, the 2020 value was within the standard's confidence limits indicating it was fairly close to the standard. FIBI values from the upstream South Fork location, ECU-3A, met the FIBI standard during 2018 and 2020, but not during 2017 and 2019, although both values were within the standard's confidence limits indicating the values were fairly close to the standard (Figure 11-11). FIBI values from the South Fork downstream location, ECU-5A, met the FIBI standard during 2017 through 2019, but not during 2020 (Figure 11-11). FIBI scores from the downstream North Fork location, ECU-2A met the FIBI standard during 2018, 2019, and 2020, but not during 2017, although the value was within the standard's confidence limits indicating it was fairly close to the standard. FIBI scores from the two upstream North Fork locations, ECU-1A-1 and ECU-2, did not meet the FIBI standard during 2017 through 2020. However, the 2017 FIBI values from the two locations were within the standard's confidence limits indicating the values were fairly close to the standard (Figure 11-11).

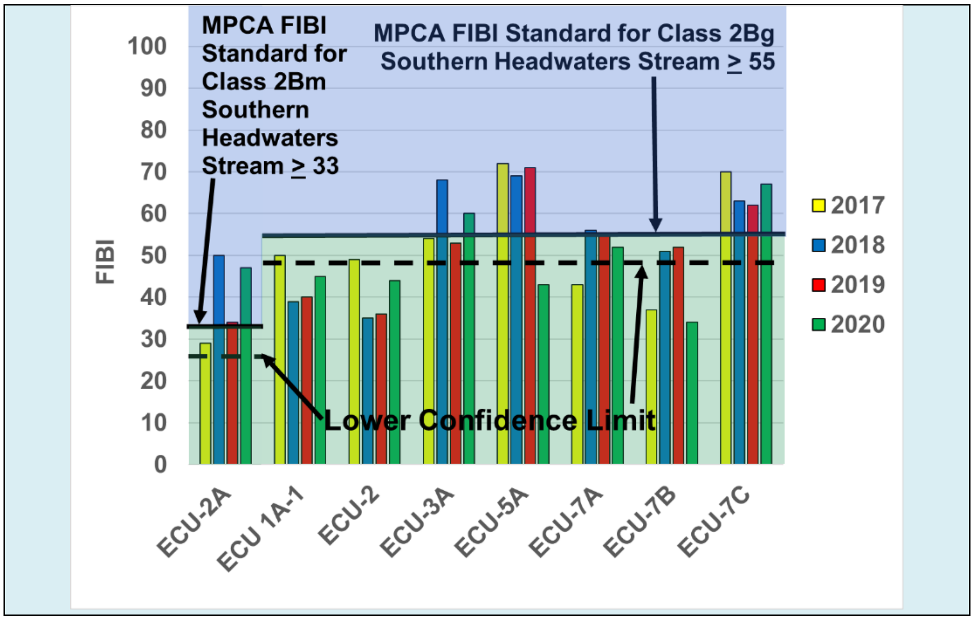

Figure 11-11 **2017-2020 Nine Mile Creek Fish Index of Biotic Integrity (FIBI) Values Compared with the MPCA FIBI Standards for a Class 2Bm Southern Headwaters Stream and a Class 2Bg Southern Headwaters Stream**

11.3.2 Minnesota River Assessment Project (MRAP) FIBI

The FIBI used to assess Nine Mile Creek prior to 2018 was developed during the Minnesota River Assessment Project (MRAP) during the mid-1990's. The MRAP FIBI was used by the MPCA to determine fish impairment in streams tributary to the Minnesota River, including Nine Mile Creek, from the mid-1990s through 2018. During this period, the MRAP FIBI defined impairment as failing to meet a threshold score of 30 or greater out of a possible score of 60. The MRAP FIBI was only used to assess streams with a watershed area of at least 5 square miles.

The 2020 MRAP Fish IBI values were assessed to determine whether the values met the MRAP FIBI impairment threshold minimum of 30. In 2020, four of the six Nine Mile Creek monitoring locations with a watershed area greater than 5 square miles had values higher (better) than the impairment threshold minimum – the three Main Stem locations, ECU-7A (Figure 11-6), ECU-7B (Figure 11-8), and ECU-7C (Figure 11-4) and the most downstream North Fork location, ECU-2A (Figure 11-2).

MRAP Fish IBI values from the most downstream location of Nine Mile Creek, ECU-7C, have been consistently higher (better) than the impairment threshold during the entire period of record (i.e., 2003 through 2020) (Figure 11-12). Values from all other locations have fluctuated and have sometimes been higher and sometimes lower than the impairment threshold. In 2006 and 2012, MRAP Fish IBI values from all Nine Mile Creek locations were higher than the impairment threshold Figure 11-12.

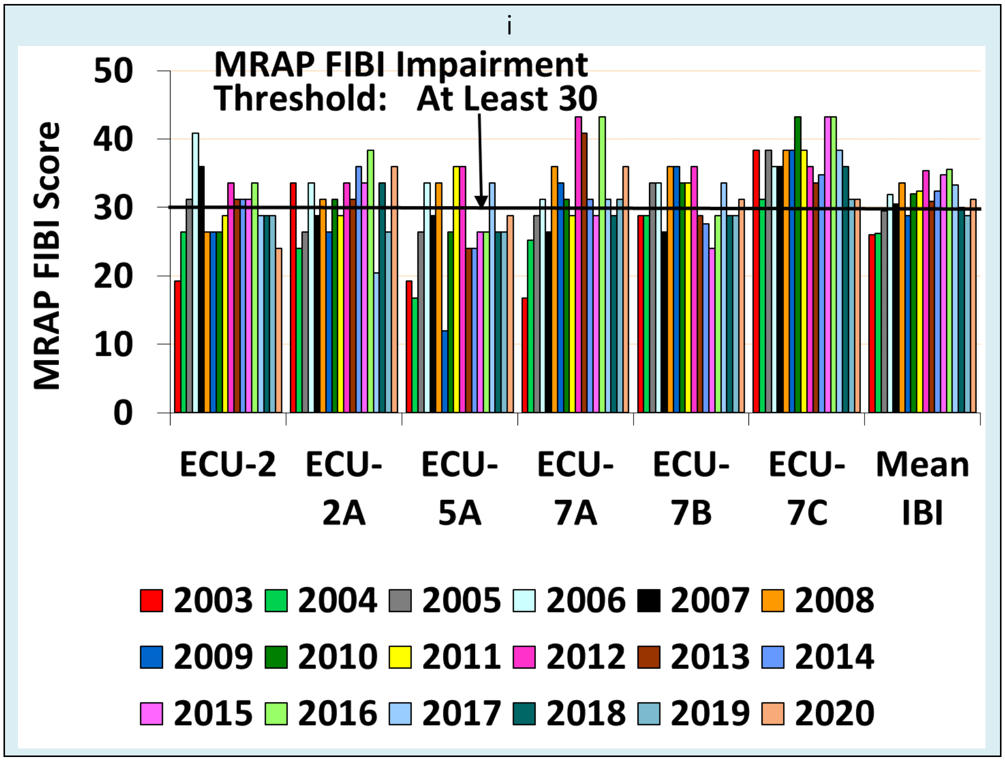

Figure 11-12 **2003-2020 Nine Mile Creek MRAP FIBI Values Compared with the MPCA MRAP FIBI Standard for streams within the Minnesota River watershed, including Nine Mile Creek**

11.3.3 Comparing 2020 FIBI and MRAP FIBI Results

2020 FIBI results were compared with 2020 MRAP FIBI results. The comparison indicated 4 stations met the MRAP FIBI standard while 3 stations met the FIBI standard. Two locations, the downstream Main Stem location, ECU-7A, and the most downstream North Fork location, ECU-2A, met the standards for both the FIBI and MRAP FIBI. The upstream South Fork location met the FIBI standard. However, because its watershed is less than 5 square miles, and the MRAP FIBI was only used to assess locations with a watershed area greater than 5 square miles, the MRAP FIBI was not used to assess ECU-3A. Two locations did not meet the FIBI standard, but met the MRAP FIBI standard – Main Stem locations, ECU-7A and ECU-7B. Two locations did not meet either standard – downstream South Fork location ECU-5A and the middle North Fork location, ECU-2. The upstream North Fork location did not meet the FIBI standard. However, because its watershed is less than 5 square miles, and the MRAP FIBI was only used to assess locations with a watershed area greater than 5 square miles, the MRAP FIBI was not used to assess ECU-1A-1.

11.3.4 MIBI

As noted in Section 11.3. Minnesota has added a MIBI to MPCA standards published in Minn. Rule Chapter 7050. The process of developing MIBI models and biocriteria for the models was similar to the process used to develop the FIBI models and biocriteria for the models. To account for natural differences in macroinvertebrate communities in Minnesota, streams were categorized into different stream types. A MIBI model was developed for each stream type and appropriate biocriteria were determined for each stream type. Each stream type uses a different MIBI model and biocriteria to determine the condition of the macroinvertebrate assemblage and attainment or nonattainment of the MIBI standard. The MPCA classified Minnesota streams into nine macroinvertebrate stream types based on the expected natural composition of stream macroinvertebrates. Stream type was differentiated by drainage area, geographic region, thermal regime, and gradient. These stream types were used to determine thresholds (i.e., biocriteria) that determine whether the calculated MIBI meets or fails to meet the aquatic life use goal for the stream. MIBIs were developed from five individual macroinvertebrate stream groups, with large rivers, wadeable high gradient, and wadeable low gradient stream types each being combined for the purposes of metric testing and evaluation. The MIBIs are on a 0 to 100 scale with increasing scores indicating improving stream health.

Nine Mile Creek is a Class 2B Southern warmwater stream because:

- Nine Mile Creek is located in the Minnesota River watershed;
- Nine Mile Creek is a warmwater stream;
- Nine Mile Creek has a drainage area less than 500 square miles.

As noted in Sections 11.3 and 11.3.1 the MPCA divided Nine Mile Creek into four stream reaches:

- South Fork from Smetana Lake to Nine Mile Creek
- Headwaters to Metro Boulevard (North Fork)
- Metro Boulevard to end of unnamed wetland
- Unnamed wetland to Minnesota River

The MPCA assigned a beneficial use classification to each reach. The headwaters of the North Fork of Nine Mile Creek to Metro Boulevard was classified as Class 2Bm. The other reaches of Nine Mile Creek were classified as Class 2Bg.

The MPCA subdivided the Southern warmwater streams into two types based on gradient. The wadeable high gradient streams were classified as Southern Streams Riffle Run (RR) and the wadeable low gradient streams were classified as Southern Forest Streams Glide Pool (GP). The primary habitat of Southern Streams RR is riffle run. Six of the eight Nine Mile Creek sample locations have riffle run as their primary habitat due to a stream gradient that is greater than 1 meter per kilometer and are classified as Southern Streams RR—the most upstream South Fork location, ECU-3A, the middle and downstream locations on the North Fork, ECU-2 and ECU-2A, and the three Main Stem locations, ECU-7A, ECU-7B, and ECU-7C. Two sample locations have no riffles due to a stream gradient of less than 1 meter per kilometer and are classified as Southern Forest Streams GP—the most upstream North Fork location, ECU-1A-1 and the most downstream South Fork location, ECU-5A. Unique MIBI and biocriterion were developed for each stream type—Southern Streams RR and Southern Forest Streams GP.

The MIBI standard applicable to the most upstream North Fork location, ECU-1A-1, and the most downstream South Fork Location, ECU-5A, is the MPCA MIBI standard for a Class 2Bg Southern Forest Streams GP. The MIBI standard is a value equal to or greater than 43. The MPCA has determined confidence limits around the standard to account for variability within the aquatic community because of natural spatial and temporal differences and sampling or method errors. The lower confidence limit for a Class 2Bg Southern Forest Streams GP is 29.4 and the upper confidence limit is 56.6.

The MIBI standard applicable to the most downstream North Fork location, ECU-2A, is the MPCA MIBI standard for a Class 2Bm Southern Streams RR. The standard is a value equal to or greater than 24. The MPCA has determined confidence limits around the standard to account for natural spatial and temporal differences and sampling method or method errors. The lower confidence limit for a Class 2Bm Southern Streams RR is 11.4 and the upper confidence limit is 36.6.

The MPCA MIBI standard for a Class 2Bg Southern Streams RR is a value equal to or greater than 37. The MPCA has determined confidence limits around the standard to account for natural spatial and temporal differences and sampling method or method errors. The lower confidence limit for a Class 2Bg Southern Streams RR is 24.4 and the upper confidence limit is 49.6.

Nine Mile Creek macroinvertebrates (bugs that can be seen with the naked eye) were monitored at the eight ecological use monitoring stations (Figure 1-2) during October and assessed to determine whether the MIBI values met the MPCA MIBI standards (Figure 11-13).

2020 results: MIBI values from all eight sample locations failed to meet applicable MPCA MIBI standards in 2020. However, the MIBI values from the downstream Main Stem location and the downstream North Fork locations were greater than their respective lower confidence limits indicating the values were fairly close to the standards. The MIBI values from the other six locations were less than the MIBI standards and less than the lower confidence limits.

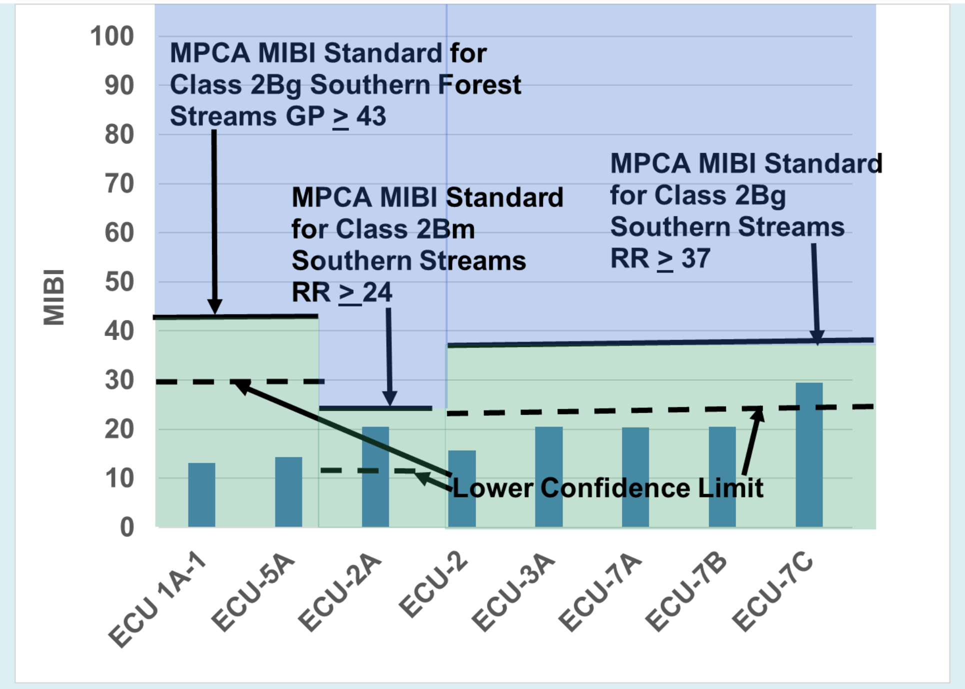

Figure 11-13 2020 Nine Mile Creek Macroinvertebrate Index of Biotic Integrity (MIBI) Values Compared with the MPCA MIBI Standard for a Class 2Bg Southern Forest Streams GP (ECU-1A-1 and ECU-5A) or a Class 2Bg Southern Streams RR (ECU-2, ECU-2A, ECU-3A, ECU-7A, ECU-7B, and ECU-7C).

11.4 Hilsenhoff Biotic Index (HBI) and Invertebrate Community Index (ICI)

Prior to the development of the MIBI, Nine Mile Creek was annually assessed using two biological indices, the HBI and the ICI. The HBI was used to assess the long-term oxygen content of the stream. HBI assesses stream oxygen by determining the average tolerance of the macroinvertebrate community to low oxygen conditions. A second index, the ICI, provided a broader view of the stream's water quality than the HBI, determining the average tolerance of the macroinvertebrate community to a wide range of pollutants. The 2020 Nine Mile Creek macroinvertebrate data were assessed with the HBI and the ICI to evaluate consistency with historical data.

In 2020, HBI scores from all locations were within the range of past scores. The data indicate 2020 oxygen levels were consistent with past levels.

Although the 2020 HBI score for the downstream South Fork location (ECU-5A) was within the range of past scores, the 2020 score of 8.03 was significantly poorer (higher) than the 2019 HBI score of 6.68 (Figure 11-14). The increase in HBI score in 2020 reversed an improvement in score documented in 2019. The 2019 HBI score was the best (lowest) score observed at this location during the period examined and was significantly better (lower) than the 2018 HBI score of 7.92 (Figure 11-14). The fluctuations in scores during 2018 through 2020 were likely due to weather related changes in stream flow. According to the MDNR, 2019 was the wettest year on record for the Minneapolis St. Paul International Airport (MSP) weather station. The wetter weather resulted in increased flows and better oxygen levels in the stream in 2019. 2020 was a relatively dry year. The drier weather resulted in decreased flow and poorer oxygen levels in the stream in 2020. As noted previously, the 2020 HBI score was within the range of past values.

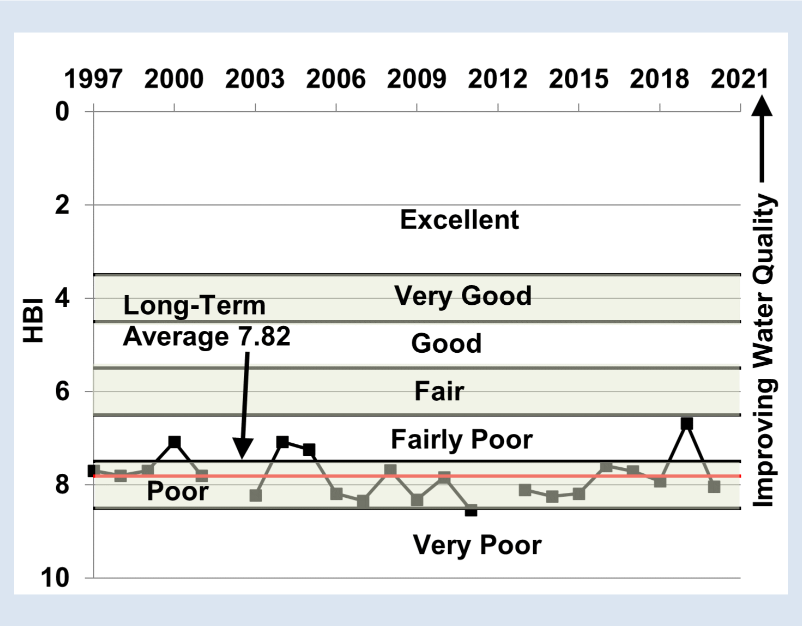

Figure 11-14 1997-2020 Nine Mile Creek HBI: Downstream South Fork Location, ECU-5A

In 2020, ICI scores from all locations were within the range of past scores. The data indicate stream water quality in 2020 was consistent with past water quality.

11.5 Stream Monitoring Conclusions

All Nine Mile Creek temperature and pH measurements, 90 percent of the dissolved oxygen measurements, and 56 percent of the specific conductance measurements met MPCA standards in 2020. As in previous years, the North Fork locations met the MPCA standard for specific conductance less frequently in 2020 than other sampling locations.

Ecological use is a term used to describe the fish assemblage/aquatic life use that the stream has the capacity to support per the stream's flow, water quality, and habitat characteristics. In 2020, flow, habitat, and water quality data indicated that all North Fork and South Fork locations and the middle and downstream Main Stem locations fully supported their designated attainable ecological uses. However, a low dissolved oxygen value at the upstream Main Stem location, ECU-7A, on July 3, 2020 did not support the designated attainable ecological use of intolerant forage fish for this location. The 2020 fish communities in the North Fork, South Fork, and middle (ECU-7B) and downstream (ECU-7C), Main Stem locations were consistent with their attainable ecological uses, but the 2020 fish community found in the upstream Main Stem location (ECU-7A) was poorer than its designated attainable ecological use. The fish community at ECU-7A met the criteria for a tolerant forage fish community, an indicator of average to poor water quality and habitat, compared with its designated attainable ecological use of intolerant forage fish, an indicator of better water quality and habitat. The low oxygen concentration measured at this location on July 3, 2020 supported a tolerant forage fish community, the fish community observed at this location in 2020, but not an intolerant forage fish community, its designated attainable ecological use.

In 2018, Minnesota adopted changes to its water quality standards that establish biological water quality standards for all Minnesota streams and rivers, including Nine Mile Creek. A Fish Index of Biotic Integrity (FIBI) and a Macroinvertebrate Index of Biotic Integrity (MIBI) were added to MPCA standards published in Minn. Rule Chapter 7050.0222.

Although the MPCA water quality standards published in Minn. Rule Chapter 7050.0222 did not contain biological criteria prior to 2018, the MPCA had assessed surface waters within Minnesota using fish bioassessment tools. In 2004, Nine Mile Creek was listed on the MPCA impaired waters list as impaired for aquatic life (fish bioassessment) based on the Minnesota Rapid Assessment Project Fish Index of Biotic Integrity (MRAP FIBI).

After biological standards were added to the MPCA water quality standards published in Minn. Rule Chapter 7050.0222 in 2018, the MPCA assessed Nine Mile Creek to determine whether the stream was impaired for aquatic life. For the assessment, the MPCA divided Nine Mile Creek into four stream reaches:

- South Fork from Smetana Lake to Nine Mile Creek
- Headwaters to Metro Boulevard (North Fork)
- Metro Boulevard to end of unnamed wetland
- Unnamed wetland to Minnesota River

The MPCA applied the FIBI to data collected by the Nine Mile Creek Watershed District in 2003, 2004, and 2005 and data collected by the MPCA in 2007. Based on the results, the MPCA retained the 2004 impaired waters listing of Nine Mile Creek from its headwaters to Metro Boulevard as impaired for aquatic life and listed the pollutant/stressor as fish bioassessments.

The MPCA completed bioassessments of the other three reaches using data collected in 2014 as well as previously collected data. A fish bioassessment was completed on each reach using the FIBI. A benthic macroinvertebrate bioassessment was completed on each reach using the MIBI. Based upon the assessment results, the MPCA listed the three reaches of Nine Mile Creek (South Fork from Smetana Lake to Nine Mile Creek, Metro Boulevard to end of unnamed wetland, and unnamed wetland to Minnesota River) on the impaired waters list in 2018 as impaired for Aquatic Life. The 2020 impaired waters list indicates the pollutant or stressor for each reach as fish bioassessments and benthic macroinvertebrates bioassessments.

Fish data collected from the eight Nine Mile Creek ecological use sample locations during 2017 through 2020 were assessed to determine whether Nine Mile Creek met the FIBI standard. FIBI scores from the downstream Main Stem location, ECU-7C, met the FIBI standard during all four years. FIBI scores from the upstream Main Stem location, ECU-7A, met the FIBI standard during 2018 and 2019, but not during 2017 and 2020. However, the 2020 value was within the standard's confidence limits indicating it was relatively close to the standard. FIBI values from the upstream South Fork location, ECU-3A, met the FIBI standard during 2018 and 2020, but not during 2017 and 2019, although both values were within the standard's confidence limits indicating the values were relatively close to the standard. FIBI values from the South Fork downstream location, ECU-5A, met the FIBI standard during 2017 through 2019, but not during 2020. FIBI scores from the downstream North Fork location, ECU-2A met the FIBI standard during 2018, 2019, and 2020, but not during 2017, although the value was within the standard's confidence limits indicating it was fairly close to the standard. FIBI scores from the two upstream North Fork locations, ECU-1A-1 and ECU-2, did not meet the FIBI standard during 2017 through 2020. However, the 2017 FIBI values from the two locations were within the standard's confidence limits indicating the values were fairly close to the standard.

The FIBI used to assess Nine Mile Creek prior to 2018 was developed during the Minnesota River Assessment Project (MRAP) during the mid-1990's. The MRAP FIBI was used by the MPCA to determine fish impairment in streams tributary to the Minnesota River, including Nine Mile Creek, from the mid-1990s through 2018. 2020 FIBI results were compared with MRAP FIBI results. The comparison indicated 4 stations met the MRAP FIBI standard while 3 stations met the FIBI standard. The downstream Main Stem location, ECU-7A, and the most downstream North Fork location, ECU-2A, met the standard for both the FIBI and MRAP FIBI in 2020. The upstream South Fork location met the FIBI standard. However, because its watershed is less than 5 square miles, and the MRAP FIBI was only used to assess locations with a watershed area greater than 5 square miles, the MRAP FIBI was not used to assess ECU-3A. Two locations did not meet the FIBI standard, but met the MRAP FIBI standard – Main Stem locations, ECU-7A and ECU-7B. Two locations did not meet either standard – downstream South Fork location ECU-5A and the middle North Fork location, ECU-2. The upstream North Fork location did not meet the FIBI standard. However, because its watershed is less than 5 square miles, and the MRAP FIBI was only used to assess locations with a watershed area greater than 5 square miles, the MRAP FIBI was not used to assess ECU-1A-1.

Macroinvertebrate data collected from the eight Nine Mile Creek ecological use sample locations during 2020 were assessed to determine whether Nine Mile Creek met the MIBI standards. MIBI values from all eight sample locations failed to meet applicable MPCA MIBI standards in 2020. However, the MIBI values from the downstream Main Stem location, ECU-7C, and the downstream North Fork location, ECU-2A, were greater than the lower confidence limit indicating they were relatively close to the standards. The MIBI values from the other six locations were less than the MIBI standards and less than the lower confidence limits.

Prior to the development of the MIBI, Nine Mile Creek was annually assessed using two biological indices, the Hilsenhoff Biotic Index (HBI) and the Invertebrate Community Index (ICI). In 2020, HBI and ICI scores from all locations were within the range of past scores.

12 Lake Level Monitoring

12.1 Lake Level Observations

The lake level recording program initiated by the Nine Mile Creek Watershed District in 1960 was comprised of the three Anderson Lakes and Bush Lake. The program was enlarged in 1963 to include Hawkes Lake, Mirror Lake, and Shady Oak Lake. The following year the program was again expanded to monitor a total of 26 lakes in the watershed. Measurements of Mud Lake (Bredesen Park) and of Girard Pond were discontinued in 1964 because extensive weed growth in the summer made periodic readings impractical. In 1973, Lakes Minnetoga and Smetana were added to the program. Since then, the number of lakes being monitored has fluctuated over time in response to specific data needs.

In 2020, the Nine Mile Creek Watershed District recorded monthly lake levels at 29 lakes and public waters throughout the Nine Mile Creek watershed. The locations of the lake gages are shown in Figure 1-1. Lake level readings are taken monthly, usually at the same time the groundwater levels are measured. The levels of the lakes are generally measured using an engineering level from permanent structures along the shore. Lake levels in Normandale Lake are measured using a continuous gage installed within the bypass manhole near the lake outlet.

Lake levels are influenced by groundwater conditions, local precipitation, size of the drainage area, land surface area, outlet elevation and configuration, local land use, and a variety of other factors. The effects of these influences on the lakes differ. As a consequence, there is no general uniformity in the fluctuation of lake levels in the watershed. Table 12-1 summarizes the net change in lake levels between the beginning of 2020 and end of 2020, as well as the historic high and low water elevations. Graphs showing measured lake levels from January 2000 through early-January 2021 are included in Appendix F.

During 2020, all of the monitored lake levels dropped from the beginning to the end of the year, with exception of Lake Nancy, which showed no net change. The lowered lake levels reflect that 2020 was a drier year, as compared with 2019 which was the wettest year on record for the Twin Cities metropolitan area. The declining lake levels also generally reflect that groundwater levels in the region were also declining in the latter part of 2020. The most notable net drop in lake level was Birch Island Lake in Eden Prairie, which dropped 3.6 feet from January 2020 to January 2021.

Table 12-1. Summary of 2020 Monthly Observed Lake Levels

Lake	Measured Lake Level- January 2020 (1/3/2020)	Measured Lake Level- January 2021 (1/6/2021)	Net Change in Measured Lake Levels (1/6/2021 - 1/3/2020)	Historical High Water Elevation		Historical Low Water Elevation	
	[feet MSL]	[feet MSL]	[feet]	[feet MSL]	Date	[feet MSL]	Date
NW Anderson	839.4	839.1	-0.3	841.8	7/24/1987	833	1/5/2009
SE Anderson	839.9	839.0	-1.0	841.8	7/24/1987	833.1	2/28/2013
SW Anderson	839.6	839.1	-0.5	841.8	7/24/1987	835.1	12/8/1964
Arrowhead[1]	875.8	874.9	-0.9	878.6	7/24/1987	871.4	2/18/1981
Birch Island[3]	887.7	884.1	-3.6	891.2	3/24/1969	875.1	2/28/2013
Bryant	851.3	851.0	-0.3	854.8	7/24/1987	849.3	1/14/1977
Bush[2]	833.8	832.0	-1.8	836.9*	6/11/1999*	826	8/8/1964
N Cornelia	859.7	859.0	-0.7	864.1	7/24/1987	858.1	12/8/1967
S Cornelia	859.2	859.0	-0.2	864.1	7/24/1987	858.1	12/8/1967
Edina	822.3	821.1	-1.1	825.4	7/24/1987	817.8	2/9/1982
N Garrison	863.2	863.0	-0.2	864.8	4/10/1965	860.7	2/28/2012
Nancy (formerly S. Garrison)	861.8	861.7	0.0	863.3	4/10/1965	860.7	12/30/2011
Glen	904.7	903.4	-1.3	905	8/6/1965	898.2	7/30/2010
Hawkes[2]	886.7	884.9	-1.9	892.2	7/24/1987	881.6	1/14/1977
Indianhead[1]	863.8	863.6	-0.2	865.2	5/31/2019	861.0	2/28/2013
Lone[1]	901.6	900.4	-1.2	901.6	10/25/2019	895.4	2/6/1990
Minnetoga	896.5	896.4	-0.1	899.1	7/24/1987	894.1	2/6/1990
Mirror[2]	908.3	907.2	-1.1	912.1	7/24/1987	901.8	1/14/1977
Normandale	808.8[4]	808.3[5]	-0.5	815.8	7/24/1987	-	-
Oxboro	804.0	803.5	-0.5	813.3	7/24/1987	797.9	1/15/1991
Pauly's Pond	817.4	816.0	-1.3	821.2	7/24/1987	811.8	7/29/1988
Penn (Lower)	808.0	807.5	-0.5	816.6	7/24/1987	802.3	2/28/2013
Rose	925.3	924.9	-0.4	928.4	4/4/1966	919.6	1/8/1990
Shady Oak[1]	903.7	903.2	-0.5	905.6	5/31/2019	897.8	1/29/1990
Skriebakken	804.9	803.4	-1.6	811.3	7/24/1987	801.2	1/22/1977
Smetana	835.2	835.2	-0.1	840.6	7/24/1987	830.2	11/8/1976
Wing	939.9	938.8	-1.1	941.5	7/24/1987	933.5	1/31/1989
Swimming Pool Pond (formerly Valley View)	863.0	862.4	-0.6	865.4	7/24/1987	860.1	2/28/2012
Wanda Miller	821.9	820.2	-1.7	826.7	7/24/1987	814.8	2/28/2013

[1] Land-locked lakes

[2] Pumped outlet

[3] High surface outlet. Hasn't discharged since 1987.

[4] Lake surface elevation observed on 12/31/2019

[5] Lake surface elevation observed on 11/30/2020. Ice conditions prevented gage operation in December and January

13 Groundwater Well Monitoring

13.1 Groundwater Well Observations

The Nine Mile Creek Watershed District's groundwater monitoring program began in 1962 when 18 groundwater observation wells were installed at various locations throughout the watershed. The following year, the program was augmented by the installation of 20 additional wells. Since inception of the program, the number of groundwater wells being monitored has fluctuated over time, with wells being added in response to specific information needs and other monitoring wells being lost as land development occurred. In 1989, sixteen groundwater monitoring wells were in operation. In 1999, 12 wells were active. In 2020, only six of the groundwater observation wells remain active.

Table 13-1 summarizes the groundwater level observations from 2020. The table includes measured groundwater observations from the beginning of 2020 (1/3/2020) and end of 2020 (1/5/2021), as well as the corresponding net change in groundwater levels during that time period. In 2020, the net change in groundwater elevation ranged from a 0.2 feet increase in Well 22 (south of Penn Lake in Bloomington) to a 1.5 foot drop in Well 35 (east of Braemar Golf Course in Edina). Table 13-1 also lists the maximum fluctuation of each well during 2020. The maximum fluctuation observed throughout 2020 ranged from an approximately 0.1 foot drop at Well 26 (east of Lake Edina in Edina) to a 3.2 feet drop at Well 35, with an average maximum fluctuation of 1.4 feet.

Table 13-1 also summarizes the highest and lowest readings of the water table at each well and the date of occurrence. A record high water level was recorded in Well 41 in 2019 (8/26/2019).

Graphs of the observed groundwater levels for each active monitoring site from January 2000 through January 2021 are included in Appendix G.

Table 13-1. Summary of 2020 Monthly Observed Groundwater Levels.

Well ID	Measured Groundwater Level-January 2020 (1/2/2020) [feet MSL]	Measured Groundwater Level January 2021 (1/5/2021) [feet MSL]	Net Change (1/5/2021 - 1/2/2020) [feet]	Maximum 2020 Fluctuation [feet]	Historical High Water Elevation		Historical Low Water Elevation	
					[feet MSL]	Date	[feet MSL]	Date
7	879.42	878.56	-0.9	1.3	894.88	3/25/2004	857.20	10/17/1989
22	800.00	800.21	0.2	0.8	802.30	5/3/1966	791.00	5/31/1990
26	820.82	820.90	0.1	0.1	827.93	4/29/2003	813.40	12/1/1964
35	843.99	842.44	-1.5	3.2	848.65	3/15/2005	834.10	1/1/1964
41	884.86	883.73	-1.1	1.7	885.80	8/26/2019	871.00	8/10/1977
52	853.39	852.36	-1.0	1.1	854.96	3/17/2003	849.10	9/15/1994

Appendices

available as separate PDFs