Nine Mile Creek Watershed District

Summary of 2021 Water Monitoring Program

Prepared for
Nine Mile Creek Watershed District

May 2022

4300 MarketPointe Drive, Suite 200
Minneapolis, MN 55435
952.832.2600
www.barr.com

Nine Mile Creek Watershed District

Summary of 2021 Water Monitoring Program

April 2022

Contents

List of Tables

List of Figures

List of Appendices

1 Introduction

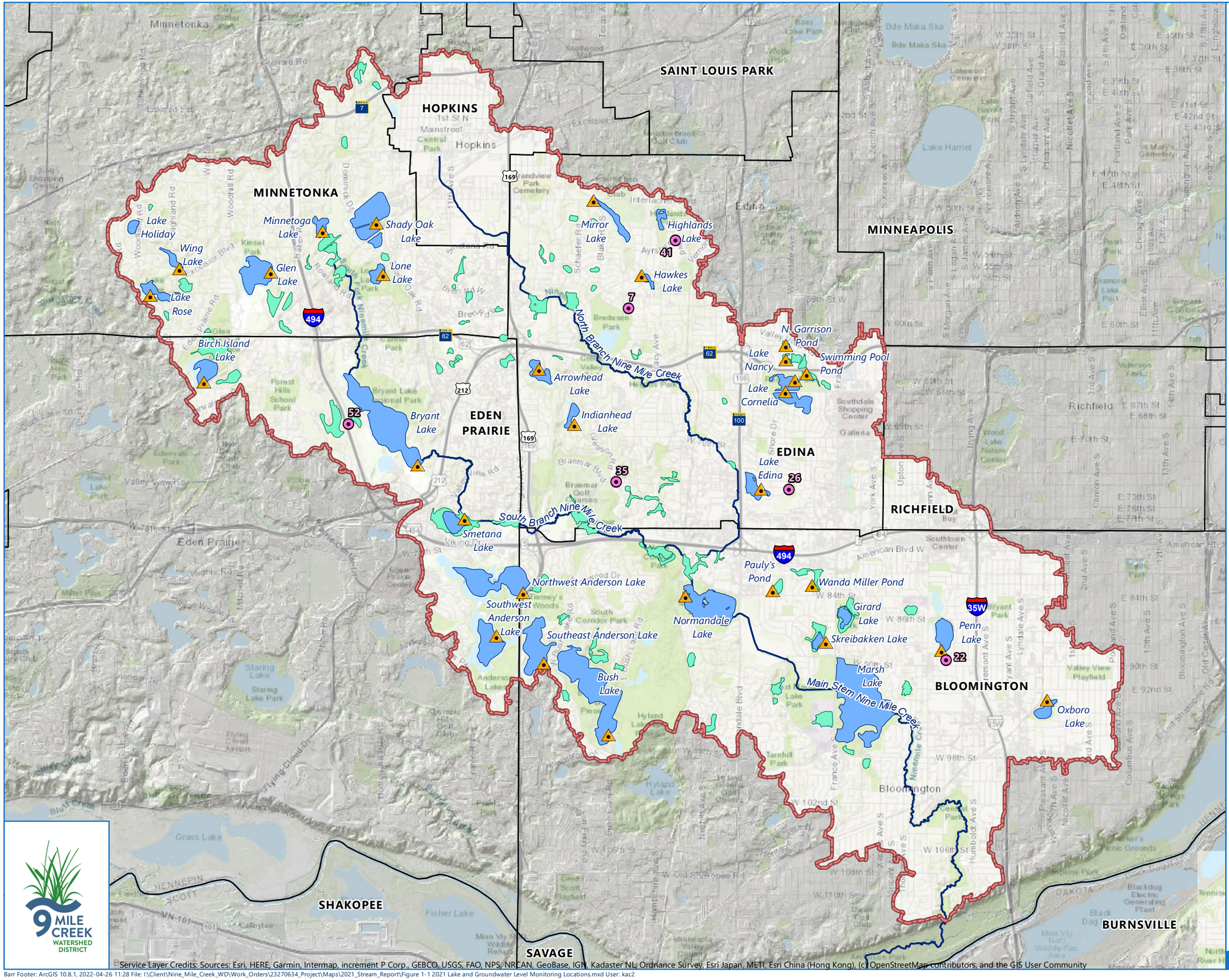
Monitoring of waterbodies in the Nine Mile Creek watershed is essential to developing an understanding of past and present conditions within the watershed and determining the need for action by the Nine Mile Creek Watershed District (District) or other entities. The District annually implements a lake, groundwater, and stream monitoring program designed to establish baseline conditions, track changes, inform additional studies (e.g., feasibility studies, water quality studies), 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 2021.

The District has been collecting lake levels and groundwater levels since 1960 and 1962, respectively. This information has been used 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 2021, 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

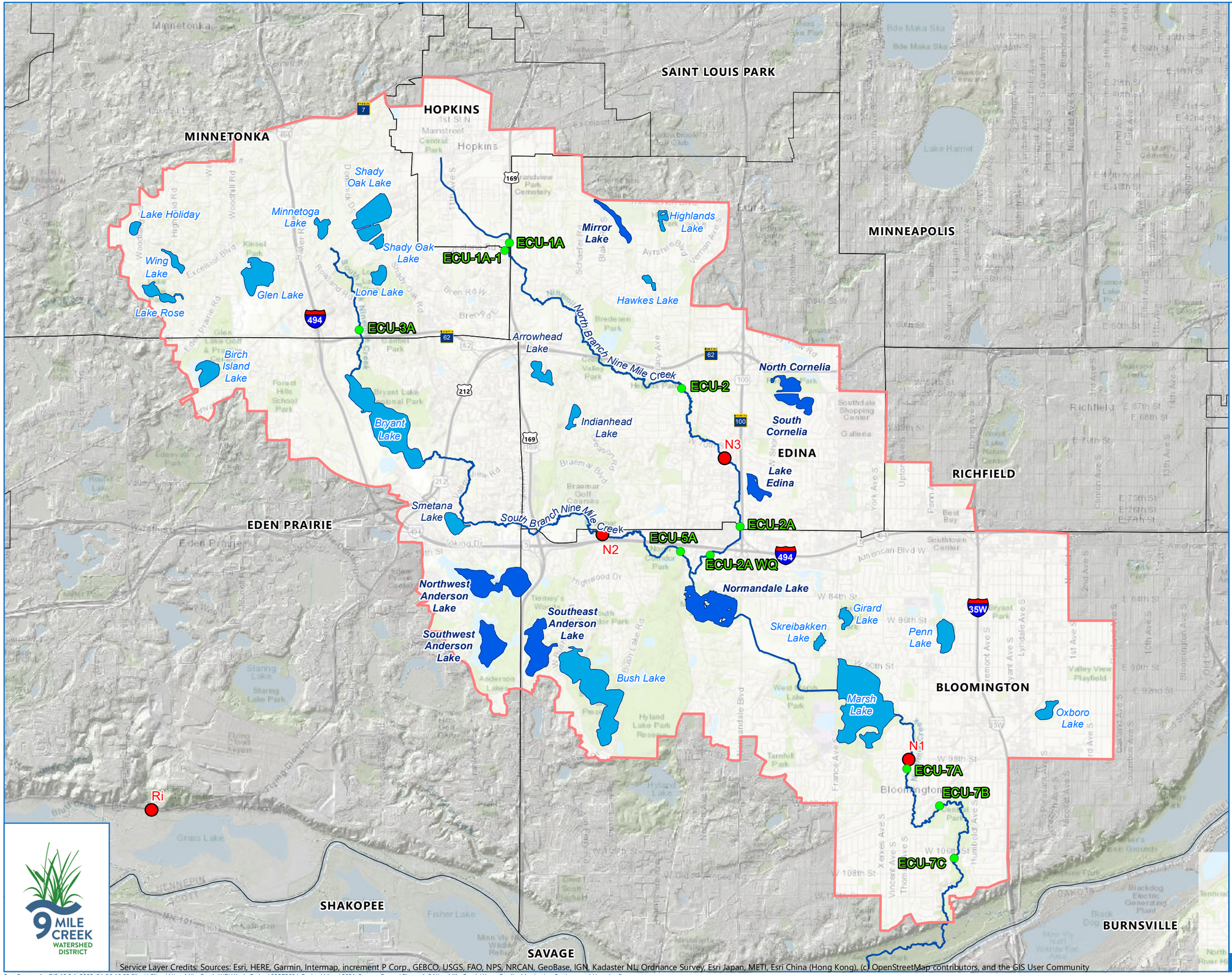
The 2021 District water quality monitoring program included monitoring seven lakes (Northwest Anderson, Southwest Anderson, Southeast Anderson, Cornelia, Edina, Mirror, and Normandale), and Nine Mile Creek (Figure 1-2).



2021 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



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

2021 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. Lakes to be monitored in a given year are selected to track water quality conditions, gather additional information needed for consideration of potential management activities, to prepare for proposed projects, and/or to measure the effectiveness of past or ongoing improvement projects.

The District's full lake monitoring program typically 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 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.

Table 2-1 Summary of 2021 Lake Monitoring Program

Lake	Water Quality Monitoring	Phytoplankton	Zooplankton	Aquatic Plant Surveys
Mirror	X	X[1]	X	(1)
Northwest Anderson	X			(2)
Southwest Anderson	X			(2)
Southeast Anderson	X			(2)
Lake Cornelia- North and South	X	X[2]		
Lake Edina	X	X[2]		
Normandale Lake	X	X[1]		(3)

(1) Qualitative plant survey conducted.
(2) Point intercept aquatic plant surveys conducted.
(3) Point intercept aquatic plant surveys and biomass surveys conducted.
[1] Phytoplankton samples collected as part of routine monitoring program.
[2] Phytoplankton samples collected in accordance with the Nine Mile Creek Watershed District's Potential Harmful Algal Bloom (HAB) Monitoring & Analysis Protocol

Results of the District's 2021 lake monitoring are summarized in detail by lake in Sections 3 through Section 9. Overall conclusions and recommendations from the 2021 lake monitoring are described below.

2.1 Northwest Anderson Lake

Water quality was good in Northwest Anderson Lake in 2021. Monitoring results indicate Northwest Anderson Lake met the Minnesota Pollution Control Agency (MPCA) shallow lake eutrophication water quality standards for summer average total phosphorus and chlorophyll *a* concentrations and Secchi disc depth and the MPCA chloride criteria for acute and chronic exposure.

Both the number of aquatic plant species in the lake and Floristic Quality Index (FQI) values were better than the MNDNR Plant Index of Biotic Integrity (IBI) thresholds. Both number of species and FQI increased in 2018 and 2021 and, in 2021, the plant community had the highest number of species and FQI score on record. Three species were observed for the first time in 2021 – bearded stonewort, hooded arrowhead, a rare, drought-tolerant species in Minnesota listed by the MNDNR as threatened, and floating pennywort.

Four invasive species were observed in Northwest Anderson Lake in 2021: curly-leaf pondweed (3 locations), purple loosestrife (1 location), reed canary grass (1 location), and narrow-leaved cattail, which was scattered along the northern and southern shoreline. Given that curly-leaf pondweed was observed in three locations in 2021, the District could consider spot treating. No rooted curly-leaf pondweed plants were observed in the lake in 2018, which was the last year a plant survey was conducted by the District.

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 Southwest Anderson Lake

Water quality was good in Southwest Anderson Lake in 2021. Monitoring results from 2021 indicate Southwest Anderson Lake met the Minnesota Pollution Control Agency (MPCA) shallow lake eutrophication water quality standards for summer average total phosphorus and chlorophyll *a* concentrations and Secchi disc depth and the MPCA chloride criteria for acute and chronic exposure.

Both the number of species in the lake and FQI values were better than the MNDNR Plant IBI thresholds. Both number of species and FQI increased in 2021 and, in 2021, the plant community had a higher number of species and FQI score than were observed in previous years. Three species were observed for the first time in 2021 – bearded stonewort, hooded arrowhead, a rare species in Minnesota listed by the MNDNR as threatened, and floating pennywort.

Two invasive species were observed in Southwest Anderson Lake in 2021: curly-leaf pondweed (four locations) and narrow-leaved cattail, which was scattered along the shoreline and observed at 36 locations. Given that curly-leaf pondweed was observed in four locations in 2021, the District could consider spot treating or other removal mechanisms in these locations. No curly-leaf pondweed plants were observed in the lake in 2018, which was the last year a plant survey was conducted by the District.

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 Southeast Anderson Lake

2021 water quality in Southeast Anderson Lake was the best on record. Monitoring results indicate Southeast Anderson Lake met the Minnesota Pollution Control Agency (MPCA) shallow lake eutrophication water quality standards for summer average total phosphorus and chlorophyll *a* concentrations and Secchi disc depth and the MPCA chloride criteria for acute and chronic exposure.

Both the number of species in the lake and FQI values were better than the MNDNR Plant IBI thresholds. Both number of species and FQI increased in 2021 and, in August 2021, the plant community had a higher number of species and FQI score than were observed in previous years. Bearded stonewort was observed for the first time in 2021.

Four invasive species were observed in Southeast Anderson Lake in 2021: Eurasian watermilfoil (103 locations in June and 89 locations in August), curly-leaf pondweed (5 locations in June) narrow-leaved cattail (6 locations in June and 10 locations in August), and reed canary grass (not observed in June and observed at 1 location in August). Eurasian watermilfoil significantly increased in frequency between June 2019 and June 2021 while curly-leaf pondweed significantly decreased in frequency between June 2019 and June 2021. The curly-leaf pondweed decline appears to be due to natural causes. Reed canary grass significantly declined in frequency between June 2019 and June 2021, but the August frequency was the same during both years. Narrow-leaved cattail did not significantly change in frequency between 2019 and 2021.

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 Cornelia

Water quality in Lake Cornelia was especially poor in 2021. 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 through August of 2021 while chloride concentrations in the south basin exceeded chronic criteria in July and August of 2021. All chloride concentrations in the north basin and south basin were below the acute chloride criteria. Both basins failed to meet State eutrophication water quality standards for a shallow lake in 2021 due to excess phosphorus and algae in the lake and poor water clarity.

In 2021, numbers of blue-green algae increased. Blue-green algae can produce algal toxins, which can be harmful to humans or other animals. Blue-green algae are also a poor quality food for zooplankton. A severe blue-green algal bloom was observed in the lake during the July through October monitoring events, with blue-green counts well above the World Health Organization (WHO) threshold of 100,000 per milliliter for a moderate probability of adverse health effects. Although there can be many causes of blue-green algal blooms, the especially warm spring of 2021 and hot, dry summer conditions likely contributed to the growth and persistence of the blue-green algal population throughout the summer months.

The District completed a water quality study of Lake Cornelia and Lake Edina in July of 2019 to identify water quality improvement measures for both lakes. The study 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 was 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. Sediment cores collected from the lake in 2021 indicate that the alum treatment successfully converted iron-bound phosphorus into aluminum bound phosphorus. Iron-bound phosphorus is the sediment fraction that is responsible for internal phosphorus loading when oxygen is low, whereas aluminum bound phosphorus is stable under low oxygen conditions and does not cause internal loading. However, the core data also showed that organically bound phosphorus is still high in North and South Cornelia. Hence, internal phosphorus loading may still be occurring (although at a lower rate) as a result of organically bound phosphorus decay in lake bottom sediments.

Other watershed and internal lake management practices are underway to help improve Lake Cornelia. The city of Edina plans to conduct a spring 2022 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. Construction of a stormwater filtration Best Management Practice (BMP) in Rosland Park is underway to reduce the amount of phosphorus to Lake Cornelia from the watershed.

Continuation of water quality and biological monitoring is recommended to assess the condition of the lake's water quality and biological community, evaluate impacts of the management activities, and identify trends.

2.5 Lake Edina

Water quality of Lake Edina was especially poor in 2021. Monitoring results indicate Lake Edina met the Minnesota Pollution Control Agency (MPCA) acute and chronic chloride criteria, but failed to meet eutrophication water quality standards for shallow lakes in 2021 due to excess phosphorus and algae in the lake and poor water clarity. The 2021 summer average phosphorus and chlorophyll *a* concentrations were the highest on record for Lake Edina.

In 2021, numbers of blue-green algae increased. Blue-green algae can produce algal toxins, which can be harmful to humans or other animals. Blue-green algae are also a poor quality food for zooplankton. A severe algal bloom was observed in the lake during the July through October monitoring events, with blue-green numbers well above the World Health Organization (WHO) threshold of 100,000 per milliliter for a moderate probability of adverse health effects. The highest numbers of blue-green algae to date were observed in August. Although there can be many causes of blue-green algal blooms, the especially warm spring of 2021 and hot, dry summer conditions likely contributed to the growth and persistence of the blue-green algal population throughout the summer months.

The District completed a water quality study of Lake Cornelia and Lake Edina in July of 2019 to identify water quality improvement measures for both lakes. The study 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. In addition, the District is also in the process of designing 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 assess the condition of the lake's water quality and biological community, evaluate impacts of the management activities, and identify trends.

2.6 Mirror Lake

Monitoring results indicate Mirror Lake met the MPCA acute and chronic chloride criteria in 2021, but failed to meet eutrophication water quality standards for shallow lakes due to excess phosphorus and algae in the lake and poor water clarity.

The phytoplankton population was dominated by blue-green algae throughout 2021. Blue-green algae can produce algal toxins, which can be harmful to humans or other animals. Blue-green algae are also a poor quality food for zooplankton. A severe blue-green algal bloom occurred in the lake during the late-August through October sample events, with blue-green algae numbers well above the WHO threshold of 100,000 per milliliter for a moderate probability of adverse health effects. Blue-green numbers during late-August through October were the highest numbers to date (Figure 8-5). Although there can be many causes of blue-green algal blooms, the especially warm spring of 2021 and hot, dry summer conditions likely contributed to the growth and persistence of the blue-green algal population throughout the summer months.

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 2021, purple loosestrife and curly-leaf pondweed. Both species have been observed in the lake since aquatic plant surveys began in 2001. In 2021, curly-leaf pondweed was prevalent throughout the lake and grew densely. While its extent and density have varied during the past 20 years, it has frequently been prevalent at a high density during June.

The District is conducting a water quality study of Mirror Lake in 2022, as identified in its 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.

2.7 Normandale Lake

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 aquatic plant that dies off in late June, releasing phosphorus to the lake as it decays which can fuel algal growth and reduce 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 and 2021, herbicide treatments were 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.

2021 results indicate that the average summer total phosphorus and chlorophyll *a* concentrations and summer average Secchi disc (measure of clarity) met the State eutrophication criteria for shallow lakes. Chloride concentrations in April and June exceeded the MPCA chronic chloride criterion, but all 2021 chloride concentrations met the MPCA acute chloride criterion.

The phytoplankton communities in Normandale Lake in 2021 were generally dominated by green algae and cryptomonads, with some diatoms and blue-green algae observed. Green algae, diatoms, and cryptomonads are a good quality food source and contribute towards a healthy zooplankton community, whereas blue-green algae are a poor quality food source for zooplankton. Blue-green algae can produce algal toxins, which can be harmful to humans or other animals. The blue-green algae numbers observed at the District's routine monitoring location during the monitored period were below the World Health Organization (WHO) guideline threshold for low probability of adverse health effects to recreational users.

In 2021, filamentous algae frequency of occurrence at sample points throughout the lake ranged from 52 percent to 62 percent based on the June and August plant surveys, which was within the range observed during 2016 through 2020.

A primary objective of the lake drawdown and subsequent herbicide treatments was to reduce the amount of curly-leaf pondweed in Normandale Lake. Aquatic plant surveys conducted in June and August of 2021 indicate the frequency and biomass of curly-leaf pondweed continue to be lower than levels prior to implementation of the water quality improvement project. The biomass of curly-leaf pondweed observed in June 2021 was similar to levels observed in 2019. However, the frequencies of occurrence of curly-leaf pondweed observed in June and August 2021 were higher than the respective frequencies observed in 2019 and 2020.

The lake's plant community in 2021 met the MNDNR Plant IBI thresholds, with the highest number of species to date observed in August of 2021. Plant biomass in Normandale Lake 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 2019-2021 data show a moderate decrease in biomass of the plant community after the project. The dominant species observed in 2021 included coontail, common waterweed, and white water lily, which were generally the three species with the greatest biomass prior to the drawdown. The frequencies of the twelve most commonly occurring species

in 2021 were compared with frequencies observed before the water quality improvement project. The comparison indicated 4 species occurred at a similar frequency in 2021 as before the project (coontail, common waterweed, small pondweed, and water star-grass), 4 species occurred at a lower frequency in 2021 as before the project (large duckweed, small duckweed, common watermeal, and white water lily), 3 species occurred at a higher frequency in 2021 as before the project (sago pondweed, flat-stem pondweed, and long-leaf pondweed), and curly leaf pondweed occurred at a lower frequency of occurrence in June 2021 as it did in June prior to the project and at a similar frequency in August 2021 as it did in August prior to 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.

3 Northwest Anderson Lake

Northwest Anderson Lake (Figure 3-1) is located in Eden Prairie. The lake is quite shallow, especially in comparison with its large surface area of approximately 185 acres. It has a maximum depth of approximately 10 feet and a mean depth of approximately 4 feet. The lake is shallow enough for plants to grow over the entire lake. It is a polymictic lake, mixing many times per year.

Water quality improvement projects were completed on Northwest Anderson Lake during 2008 through 2013 to reduce internal phosphorus loading as part of the District's Eden Prairie Lakes Water Quality Improvement Project. The project focus was reduction of curly-leaf pondweed, an invasive aquatic plant that dies off in late June, releasing phosphorus to the lake as it decays which can fuel algal growth and reduce lake water quality. A partial drawdown of the lake was completed during the fall of 2008 to expose the lake bed to a winter freeze and freeze out curly-leaf pondweed. The drawdown successfully controlled curly-leaf pondweed throughout the lake, with exception of the lake's eastern bay which was not drained. Herbicide treatments were conducted in 2010 through 2013 to control curly-leaf pondweed in the lake's eastern bay. The Eden Prairie Lakes Water Quality Improvement Project also included expansion of a stormwater treatment pond on the west side of Northwest Anderson Lake.

In 2021, the Nine Mile Creek Watershed District monitored Northwest Anderson Lake for:

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

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

Figure 3-1 Northwest Anderson Lake on August 19, 2021

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

Figure 3-2 shows the 2021 summer average (June through September) conditions for total phosphorus, chlorophyll *a*, and Secchi disc transparency, in comparison with District monitoring results from past years. The lake's 2021 summer average total phosphorus concentration of 22 µg/L, the lake's summer-average chlorophyll *a* concentration of 7.8 µg/L, and the lake's summer average Secchi disc transparency of 1.9 meters met 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 Northwest Anderson Lake by the Nine Mile Creek Watershed District during 1988, 1991, 1996, 2000, 2001, 2007, 2010, 2011, 2012, 2013, 2014, 2018, and 2021. During the monitored years, summer average total phosphorus and chlorophyll *a* concentrations and Secchi disc depth failed to meet the MPCA standard prior to 2007, but met the standard during 2007 through 2021, except for the 2010 summer average chlorophyll *a* concentration (Figure 3-2).

Monitoring data indicate that the management activities completed as part of the Eden Prairie Lakes Water Quality Improvement Project have improved the lake's water quality. For the monitored period prior to the start of the water quality improvement project (1988-2007), the average summer total phosphorus and chlorophyll *a*

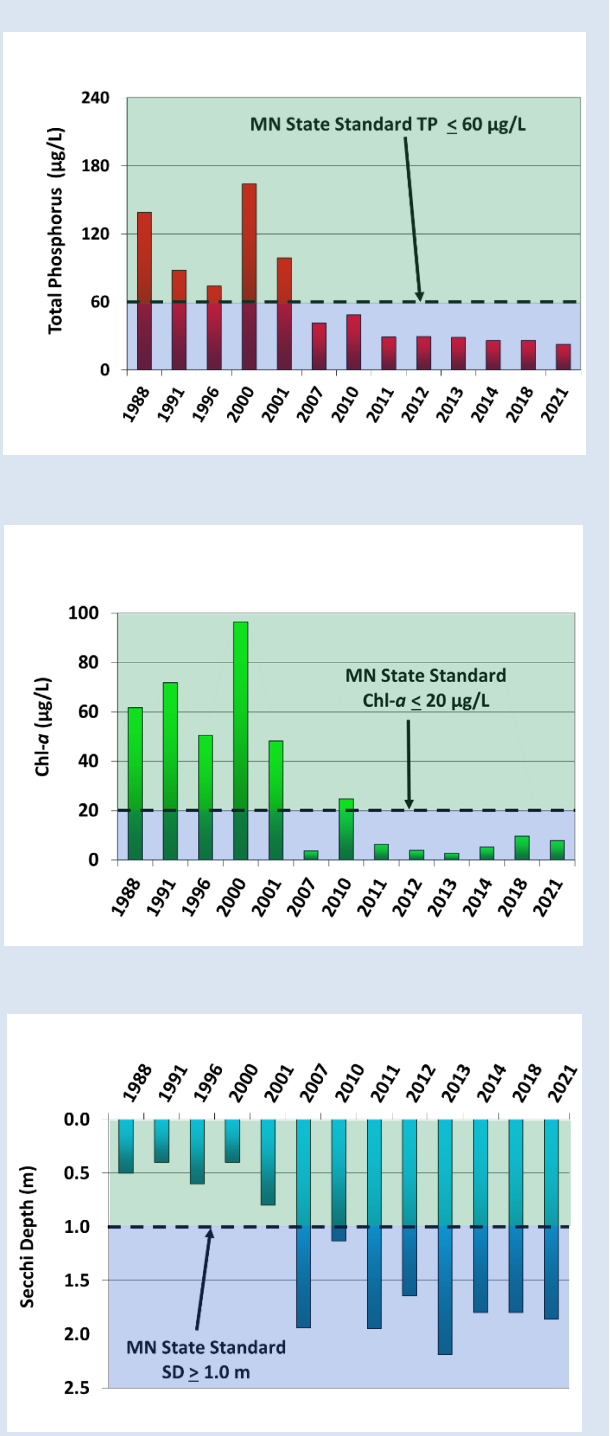


Figure 3-2 Northwest Anderson Lake historical summer average values
total phosphorus (top), chlorophyll *a* (middle), and Secchi disc (bottom)

concentrations were 101 and 55 µg/L and the average summer Secchi disc transparency was 0.8 meters. For the period after the completion of the water quality improvement project (2014-2021), the average summer total phosphorus and chlorophyll *a* concentrations were 25 and 8 µg/L and the average Secchi disc transparency was 1.8 meters. All water quality measurements after the completion of the water quality improvement project have met the State eutrophication standards for shallow lakes in the North Central Hardwood Forest Ecoregion published in Minnesota Rules 7050 (Minn. R. Ch. 7050.0222 Subp 4).

3.2 Chlorides

Chloride concentrations were measured in 2010, 2011, 2012, 2013, 2014, 2018, and 2021, generally between April and September. Figure 3-3 shows the observed 2021 chloride concentrations, in comparison with historical observations. The observed 2021 chloride concentrations were similar but somewhat higher than in past years. 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. All chloride measurements were below the acute and chronic MPCA criteria. The 2021 data are summarized in Appendix A.

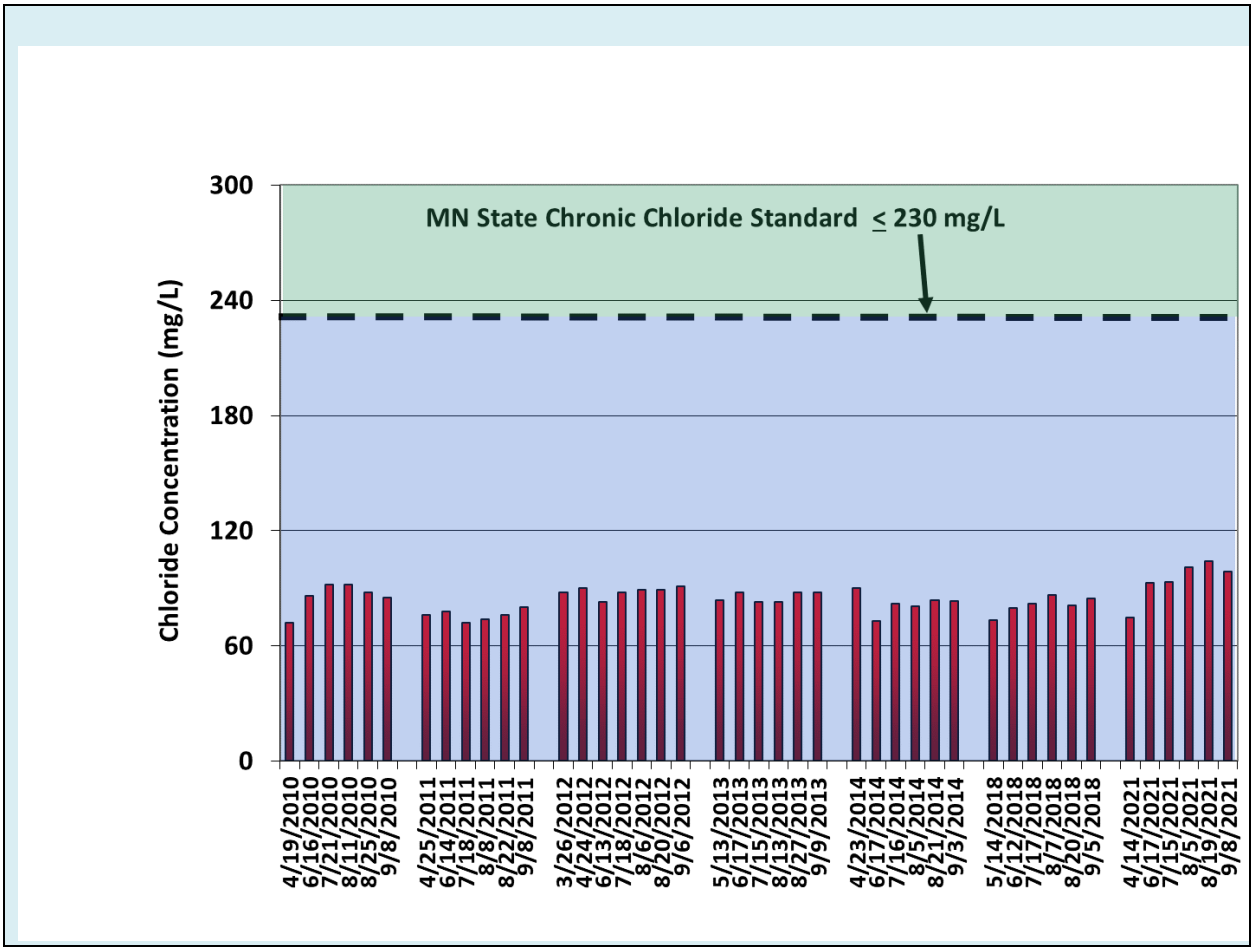


Figure 3-3 Northwest Anderson Lake historical chloride concentrations

3.3 Aquatic Plants

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. 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. The Plant IBI can provide important context to understanding information about water quality, shoreline health, and the fish community.

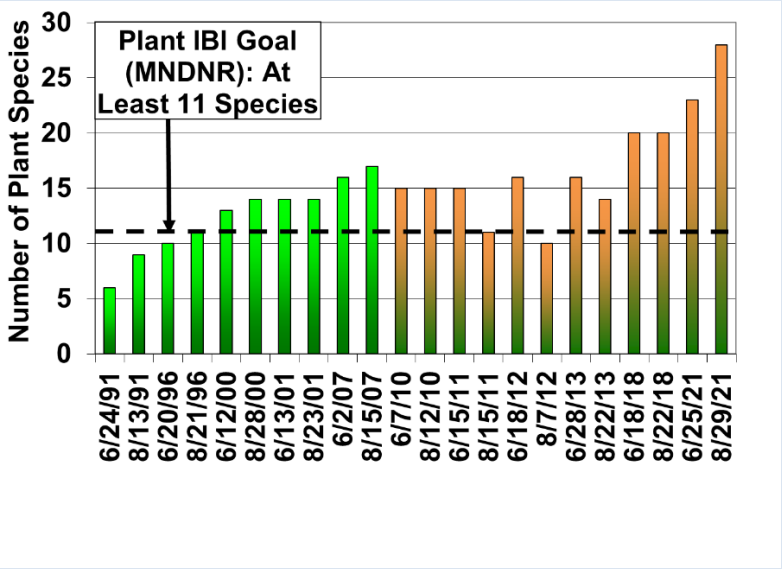


Figure 3-4.A

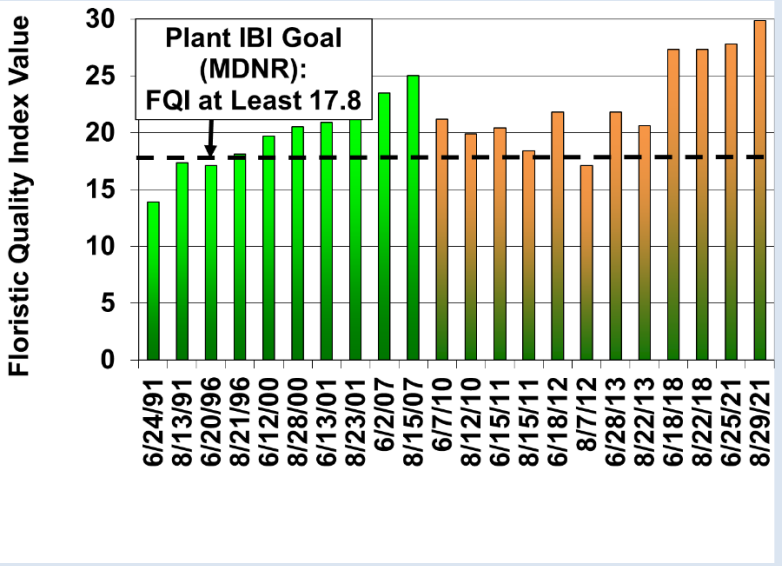


Figure 3-4.B

Figure 3-4 Northwest Anderson 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). Note: orange bars indicate post-lake drawdown.

The MNDNR 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 point intercept plant surveys of Northwest Anderson Lake in June and August of 2021. Maps showing survey results are included in Appendix C. Plant survey data from 1991 through 2021

were assessed to track changes in plant IBI scores. Figure 3-4 shows the number of species and FQI scores in Northwest Anderson Lake 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 Northwest Anderson Lake ranged from 6 to 28, bettering the MNDNR Plant IBI threshold during August 1996 through June 2012 and from June 2013 through August 2021 (Figure 3-4.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 Northwest Anderson Lake ranged from 13.9 to 29.9, bettering the MNDNR Plant IBI threshold during August 1996 through June 2012 and from June 2013 through August 2021 (Figure 3-4.B)
- **2021 results:** Both the number of species in the lake and FQI values were better than the MNDNR Plant IBI thresholds. Both number of species and FQI increased in 2018 and 2021 and, in 2021, the plant community had a higher number of species and FQI score than were observed in previous years (Figure 3-4).

In 2021, bearded stonewort (*Lychnothamnus barbatus*) was first observed in Northwest Anderson Lake (Figure 3-5). Bearded stonewort is in the family Characeae, an algae that resembles rooted aquatic plants and obtains all of its nutrients from the water. This nutrient absorber can reduce phosphorus concentrations and improve water quality. Although first observed in 2021, bearded stonewort was the dominant plant species in the lake, observed at 88 locations in June (68 percent of sample locations) and had an average rake density of 2.6 (high density) (Appendix F). Bearded stonewort expanded to 93 locations by August (72 percent of sample locations) and increased its density to an average rake density of 2.7 (high density).

A second species observed for the first time in 2021 was hooded arrowhead (*Sagittaria calycina*), a rare species in Minnesota listed by the MNDNR as threatened (Figure 3-5). This species is drought tolerant, thriving on large, exposed mud flats and preferring soft mud (silt) to firm substrates. The dry conditions in 2021 provided favorable conditions for hooded arrowhead, which was observed at two locations in the far northwest corner of the lake in June at low density (average rake density of 1.0). In August, hooded arrowhead was found at two locations in the far northwest corner of the lake, one location on the south side of the lake, and at one location near the canoe landing in the southeast corner at low to moderate density (average rake density of 1.5).

A third species observed for the first time in 2021 was floating pennywort (*Hydrocotyle ranuncoloides*), observed at one location near the canoe landing in the southeast corner in June (Figure 3-5).

Figure 3-5 Left, bearded stonewort, middle, hooded arrowhead, and right, floating pennywort

Four aquatic invasive species were found in Northwest Anderson Lake in 2021:

Curly-leaf pondweed (*Potamogeton crispus*) – observed at three locations along the southern side of the lake in June.

Purple loosestrife (*Lythrum salicaria*) – observed at one location along the southern side of the lake in August.

Reed canary grass (*Phalaris arundinaceae*)– Observed at one location on the southern side of the lake in June and August.

Narrow-leaved cattail (***Typha angustifolia***) – Scattered along the shoreline; observed at 13 locations in June and 19 locations in August.

3.4 Conclusions and Recommendations

Water quality was good in Northwest Anderson Lake in 2021. Monitoring results indicate Northwest Anderson Lake met the Minnesota Pollution Control Agency (MPCA) acute and chronic exposure chloride criteria, as well as the MPCA shallow lake eutrophication water quality standards for total phosphorus and chlorophyll *a* and Secchi disc depth.

Both the number of aquatic plant species in the lake and FQI values were better than the MNDNR Plant IBI thresholds. Both number of species and FQI increased in 2018 and 2021 and, in 2021, the plant community had the highest number of species and FQI score on record. Three species were observed for the first time in 2021 – bearded stonewort, hooded arrowhead, a rare, drought-tolerant species in Minnesota listed by the MNDNR as threatened, and floating pennywort. Although first observed in 2021, bearded stonewort was the dominant plant species in the lake. Continued monitoring of the aquatic plant community is recommended to track changes and evaluate potential impacts of bearded stonewort on other plant species.

Four invasive species were observed in Northwest Anderson Lake in 2021: curly-leaf pondweed (3 locations), purple loosestrife (1 location), reed canary grass (1 location), and narrow-leaved cattail, which was scattered along the northern and southern shoreline. Given that curly-leaf pondweed was observed in three locations in 2021, the District could consider spot treating or other removal methods. No rooted curly-leaf pondweed plants were observed in the lake in 2018, which was the last year a plant survey was conducted by the District.

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 Southwest Anderson Lake

Southwest Anderson Lake (Figure 4-1) is located in Eden Prairie. The lake is quite shallow, especially in comparison with its large surface area of approximately 110 acres (the open water area is variable, depending upon the seasonally varying coverage of the lake's cattail fringe). It has a maximum depth of approximately 8 feet and a mean depth of approximately 4 feet. The lake is shallow enough for plants to grow over the entire lake. It is a polymictic lake, mixing many times per year.

Water quality improvement projects were completed on Southwest Anderson Lake during 2008 through 2012 to reduce internal phosphorus loading as part of the District's Eden Prairie Lakes Water Quality Improvement Project. A partial drawdown of the lake was completed during the fall of 2008 to expose the lake bed to a winter freeze and freeze out curly-leaf pondweed , an invasive aquatic plant that dies off in late June, releasing phosphorus to the lake as it decays which can fuel algal growth and reduce lake water quality. This summer addition of phosphorus fuels algal growth and reduces lake water quality. The drawdown successfully controlled curly-leaf pondweed except for the lake's center that was not drained. Herbicide treatments were conducted in 2010 and 2011 to control curly-leaf pondweed in the lake's center. An alum treatment was completed in fall of 2012 to reduce the release of phosphorus from lake bottom sediments into the water column.

In 2021, the Nine Mile Creek Watershed District monitored Southwest Anderson Lake for:

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

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

Figure 4-1 Southwest Anderson Lake on June 17, 2022

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

Figure 4-2 shows the 2021 summer average conditions for total phosphorus, chlorophyll *a*, and Secchi disc transparency, in comparison with District monitoring results from past years. The 2021 summer average total phosphorus concentration of 21 µg/L, summer-average chlorophyll *a* concentration of 5.7 µg/L, and summer average Secchi disc transparency of 1.1 meters met 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 4-2). 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.

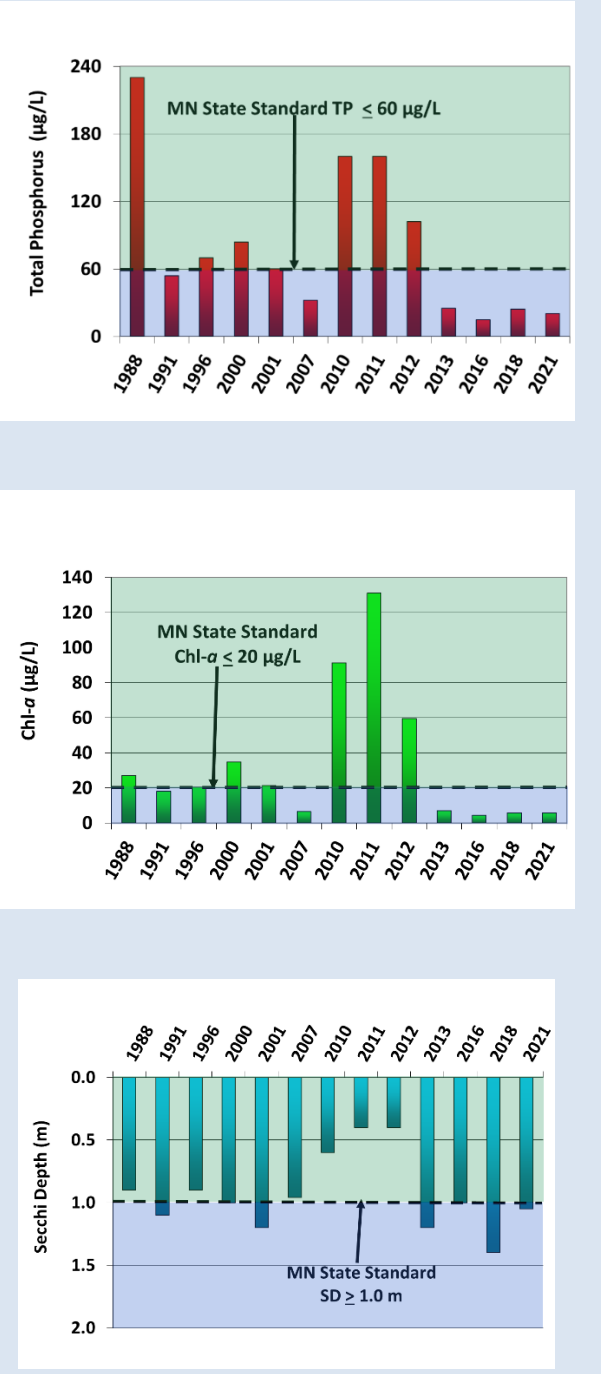


Figure 4-2 Southwest Anderson Lake historical summer average values
total phosphorus (top), chlorophyll *a* (middle), and Secchi disc (bottom)

Historical water quality data have been collected from Southwest Anderson Lake by the Nine Mile Creek Watershed District during 1988, 1991, 1996, 2000, 2001, 2007, 2010, 2011, 2012, 2013, 2016, 2018, and 2021. During the monitored years, summer average total phosphorus and chlorophyll concentrations and Secchi disc depth failed to meet the MPCA standard during 1988, 1996, 2010, 2011, and 2012, summer average total phosphorus and chlorophyll concentrations failed to meet the MPCA standard in 2000, and the summer average chlorophyll *a* concentration failed to meet the MPCA standard in 2001 (Figure 4-2).

Monitoring data indicate that the management activities completed as part of the Eden Prairie Lakes Water Quality Improvement Project have substantially improved the lake's water quality. For the monitored period prior to the start of the water quality improvement project (1988-2007), the average summer total phosphorus and chlorophyll *a*

concentrations were 100 and 24 µg/L and the average summer Secchi disc transparency was 1.0 meters. For the period after the completion of the water quality improvement project (2013-2021), the average summer total phosphorus and chlorophyll *a* concentrations were 21 and 6 µg/L and the average Secchi disc transparency was 1.2 meters. All water quality measurements after the completion of the water quality improvement project have met the State eutrophication standards for shallow lakes in the North Central Hardwood Forest Ecoregion published in Minnesota Rules 7050 (Minn. R. Ch. 7050.0222 Subp 4).

4.2 Chlorides

Chloride concentrations were measured in 2010, 2011, 2012, 2013, 2016, 2018, and 2021, generally between April and September. Figure 4-3 shows the observed 2021 chloride concentrations, in comparison with historical observations. The observed 2021 chloride concentrations were significantly higher than in past years. 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. All chloride measurements were below the acute and chronic MPCA criteria. 2021 data are summarized in Appendix A.

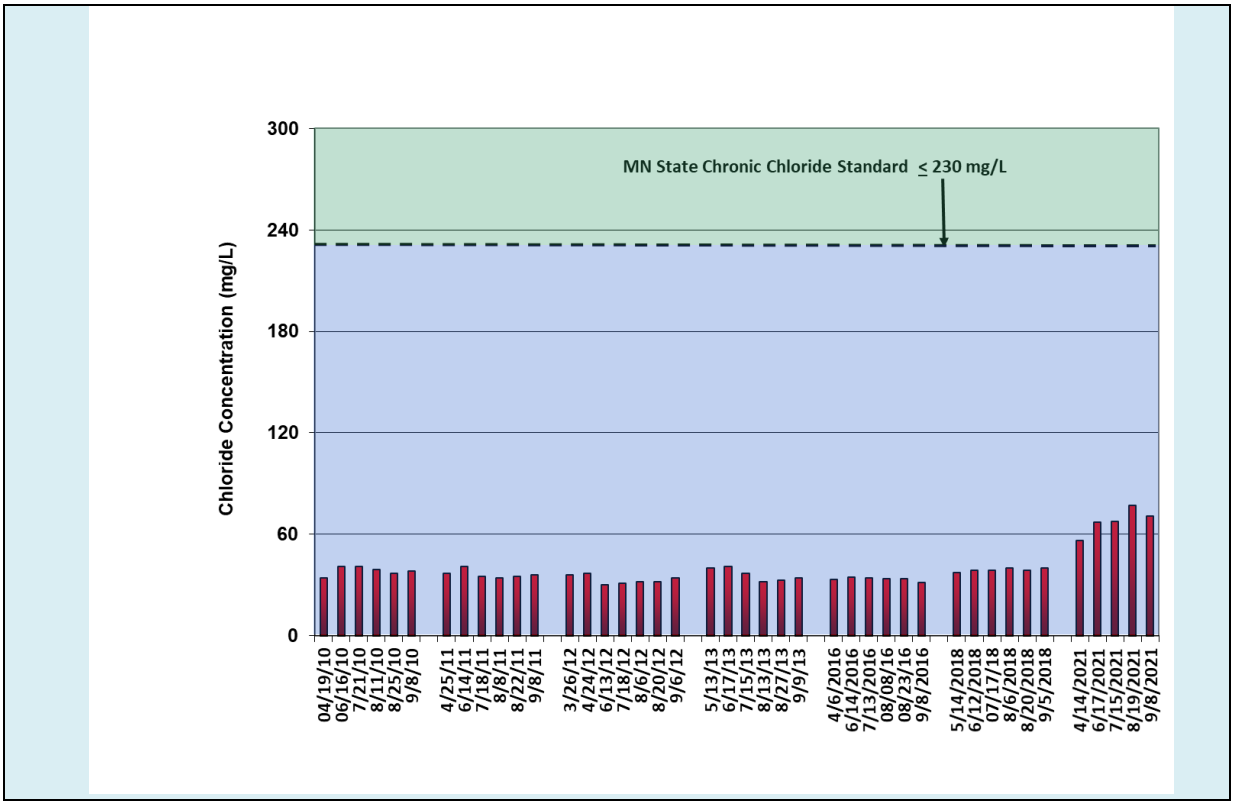


Figure 4-3 Southwest Anderson Lake historical chloride concentrations

4.3 Aquatic Plants

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. 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. The Plant IBI can provide important context to understanding information about water quality, shoreline health, and the fish community.

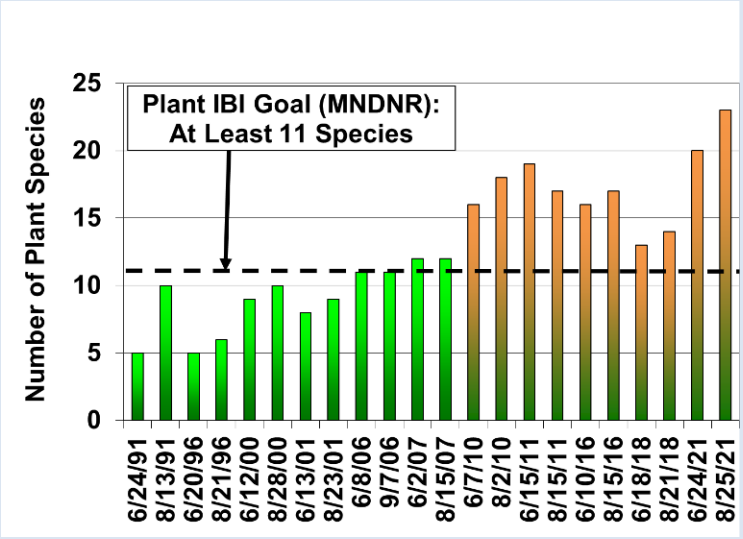


Figure 4-4.A

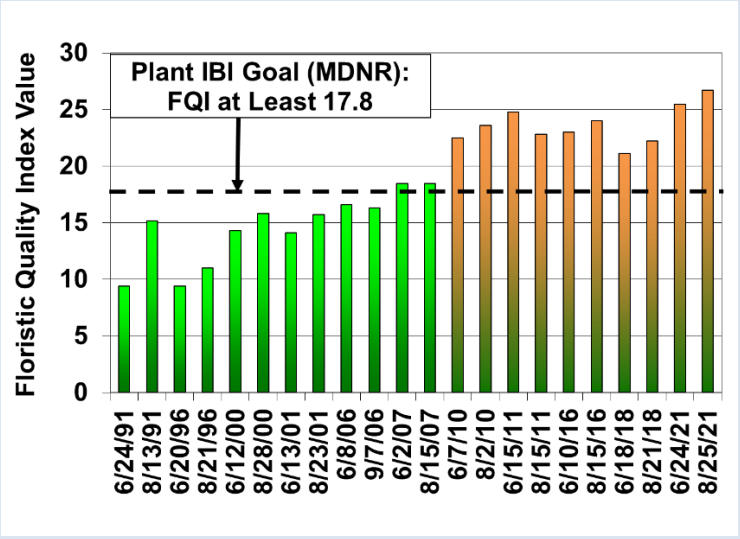


Figure 4-4.B

Figure 4-4 Southwest Anderson 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). Note: orange bars indicate post-lake drawdown.

The MDNR 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 point intercept plant surveys of Southwest Anderson Lake in June and August of 2021. Maps showing survey results are included in Appendix D. Plant survey data from 1991 through 2021 were assessed to track changes in plant IBI scores. Figure 4-4 shows the number of species and FQI scores in Southwest Anderson Lake 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 Southwest Anderson Lake ranged from 5 to 23, bettering the MNDNR Plant IBI threshold during 2006 through 2021 (Figure 4-4.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 Southwest Anderson Lake ranged from 9.4 to 26.7, bettering the MNDNR Plant IBI threshold during 2007 through 2021 (Figure 4-4.B).

- **2021 results:** Both the number of species in the lake and FQI values were better than the MNDNR Plant IBI thresholds. Both number of species and FQI increased in 2021 and, in 2021, the plant community had a higher number of species and FQI score than were observed in previous years

In 2021, bearded stonewort (*Lychnothamnus barbatus*) was first observed in Southwest Anderson Lake (Figure 4-5). Bearded stonewort is in the family Characeae, an algae that resembles rooted aquatic plants and obtains all of its nutrients from the water. This nutrient absorber can reduce phosphorus concentrations and improve water quality. Although observed for the first time in 2021, bearded stonewort was observed at 35 locations in June (28 percent of sample locations) and 43 locations in August (34 percent of sample locations), the third most dominant species in August. It had an average rake density of 2.6 (high density).

A second species observed for the first time in 2021, was hooded arrowhead (*Sagittaria calycina*), a rare species in Minnesota listed by the MNDNR as threatened (Figure 4-5). This species is drought tolerant, thriving on large, exposed mud flats and preferring soft mud (silt) to firm substrates. The dry conditions in 2021 provided favorable conditions for hooded arrowhead, which was observed at three locations in August (at the northeast corner and two locations on the east side) at low density (average rake density of 1.0).

A third species observed for the first time in 2021 was floating pennywort (*Hydrocotyle ranuncoloides*), visually observed at one location in June in the southwest corner (Figure 4-5). By August it had expanded to four locations (one at northeast corner and three at or near the southwest corner) at low to moderate density (average rake density of 1.7).

Figure 4-5 Top left, bearded stonewort, top right, hooded arrowhead, and bottom, floating pennywort

Two aquatic invasive species were found in Southwest Anderson Lake in 2021:

Curly-leaf pondweed (*Potamogeton crispus*) – observed at four locations in the southeastern area of the lake in June at low density (average rake density of 1.0).

Narrow-leaved cattail (***Typha angustifolia***) – Scattered along the shoreline and observed at 36 locations in June and August.

4.4 Conclusions and Recommendations

Water quality was good in Southwest Anderson Lake in 2021. Monitoring results from 2021 indicate Southwest Anderson Lake met the Minnesota Pollution Control Agency (MPCA) shallow lake eutrophication water quality standards for summer average total phosphorus and chlorophyll *a* concentrations and Secchi disc depth. While observed chloride concentrations in Southwest Anderson Lake in 2021 were well below the MPCA criteria for acute and chronic exposure, the concentrations were significantly higher than in past years. It is difficult to ascertain the cause for increased chloride concentrations in Southwest Anderson Lake in 2021. Review of storm sewer locations on Trunk Highway 169 indicates most runoff from the highway drains to Southeast Anderson Lake (versus Southwest Anderson Lake), and 2021 chloride levels in Southeast Anderson Lake were generally similar to or lower

than previous years. Continued periodic monitoring of chloride levels in Southwest Anderson Lake is recommended.

Both the number of species in the lake and FQI values were better than the MNDNR Plant IBI thresholds. Both number of species and FQI increased in 2021 and, in 2021, the plant community had a higher number of species and FQI score than were observed in previous years. Three species were observed for the first time in 2021 – bearded stonewort, hooded arrowhead, a rare species in Minnesota listed by the MNDNR as threatened, and floating pennywort. Although first observed in 2021, bearded stonewort was the third most dominant plant species in the lake. Continued monitoring of the aquatic plant community is recommended to track changes and evaluate potential impacts of bearded stonewort on other plant species.

Two invasive species were observed in Southwest Anderson Lake in 2021: curly-leaf pondweed (four locations) and narrow-leaved cattail, which was scattered along the shoreline and observed at 36 locations. Given that curly-leaf pondweed was observed in four locations in 2021, the District could consider spot treating or other removal mechanisms in these locations. No curly-leaf pondweed plants were observed in the lake in 2018, which was the last year a plant survey was conducted by the District.

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.

5 Southeast Anderson Lake

Southeast Anderson Lake (Figure 5-1) is located in Bloomington. The lake is quite shallow, especially in comparison with its large surface area of approximately 81 acres. It has a maximum depth of approximately 9 feet and a mean depth of approximately 5 feet. The lake is shallow enough for plants to grow over the entire lake. It is a polymictic lake, mixing many times per year.

Southeast Anderson Lake was annually treated with herbicide during 2009 through 2014 to control curly-leaf pondweed and reduce internal phosphorus loading. Curly-leaf pondweed is an invasive aquatic plant that dies off in late June, releasing phosphorus to the lake as it decays which can fuel algal growth and reduce lake water quality. In 2021, the Nine Mile Creek Watershed District monitored Southeast Anderson Lake for:

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

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

Figure 5-1 Southeast Anderson Lake on August 19, 2021

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

2021 water quality in Southeast Anderson Lake was the best on record. Figure 5-2 shows the 2021 summer average conditions for total phosphorus, chlorophyll *a*, and Secchi disc transparency, in comparison with District monitoring results from past years. The lake's 2021 summer average total phosphorus concentration of 15 µg/L, chlorophyll *a* concentration of 3.0 µg/L, and Secchi disc transparency of 1.8 meters met 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 are ≤60 µg/L, ≤20 µg/L, and ≥1 meter, respectively.

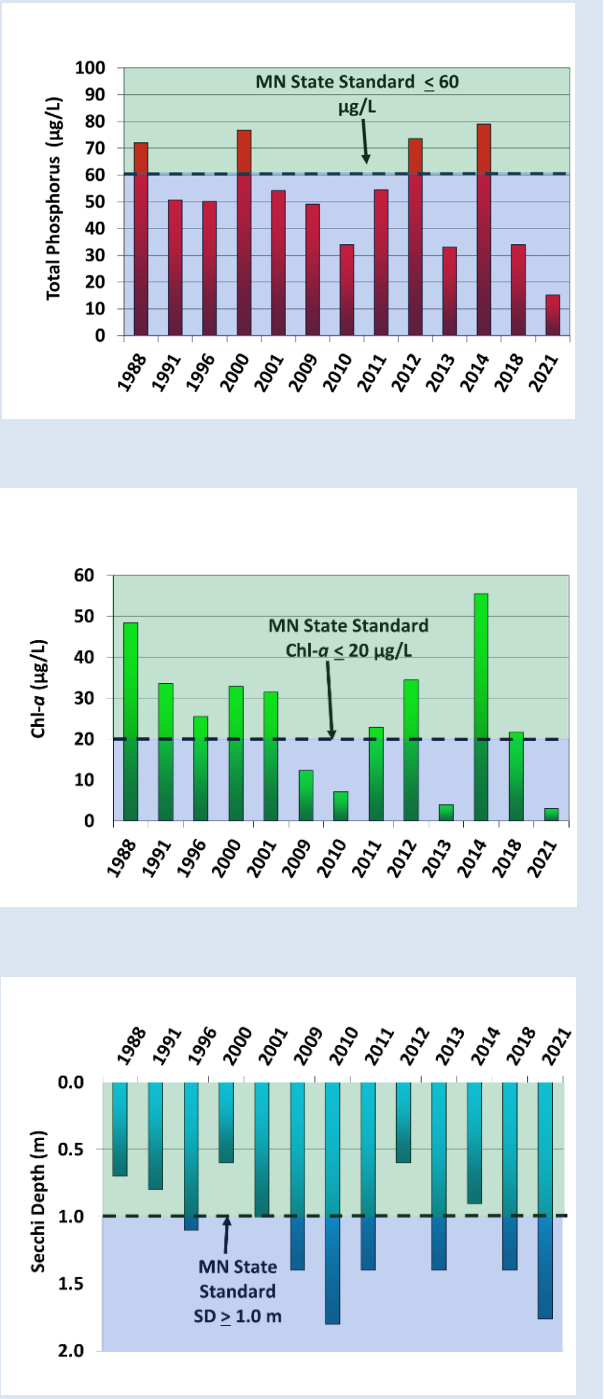


Figure 5-2 Southeast Anderson Lake historical summer average values
total phosphorus (top), chlorophyll *a* (middle), and Secchi disc (bottom)

Historical water quality data have been collected from Southeast Anderson Lake by the Nine Mile Creek Watershed District during 1988, 1991, 1996, 2000, 2001, 2009, 2010, 2011, 2012, 2013, 2014, 2018, and 2021. As shown in Figure 5-2, , summer average total phosphorus and chlorophyll concentrations and Secchi disc depth have occasionally failed to meet the MPCA standard during the years monitored

The District water quality improvement projects have substantially improved the lake's water quality. For the monitored period prior to the start of the lake's water quality improvement projects (1988-2001), the average summer total phosphorus and chlorophyll *a* concentrations were 61 and 34 µg/L and the average summer Secchi disc transparency was 0.8 meters. For the period after the completion of the water quality improvement project (2018-2021), the average summer total phosphorus and chlorophyll *a*

concentrations were 25 and 12 µg/L and the average Secchi disc transparency was 1.6 meters (Figure 5-2). Water quality measurements after the completion of the water quality improvement project have met the Minnesota State eutrophication standards for shallow lakes in the North Central Hardwood Forest Ecoregion published in Minnesota Rules 7050 (Minn. R. Ch. 7050.0222 Subp 4) except the 2018 summer average chlorophyll *a* concentration which slightly exceeded the standard (Figure 5-2).

5.2 Chlorides

Chloride concentrations in Southeast Anderson Lake were measured in 2009, 2010, 2011, 2012, 2013, 2014, 2018, and 2021, generally between April and September. Figure 5-3 shows the observed chloride concentrations from 2009 through 2021. 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. All chloride measurements were below the acute and chronic MPCA criteria. 2021 data are summarized in Appendix A.

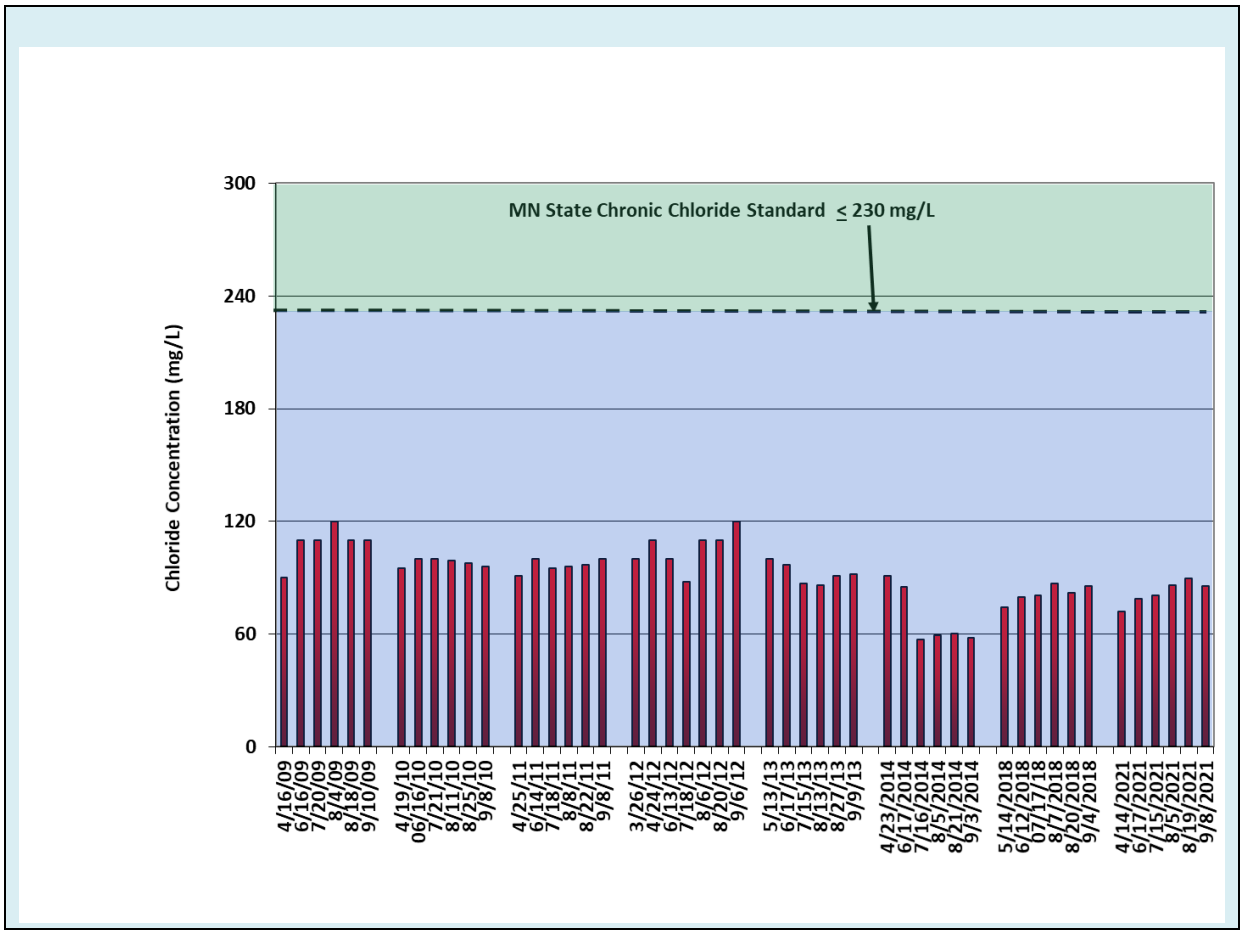


Figure 5-3 Southeast Anderson Lake historical chloride concentrations

5.3 Aquatic Plants

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. 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. The Plant IBI can provide important context to understanding information about water quality, shoreline health, and the fish community.

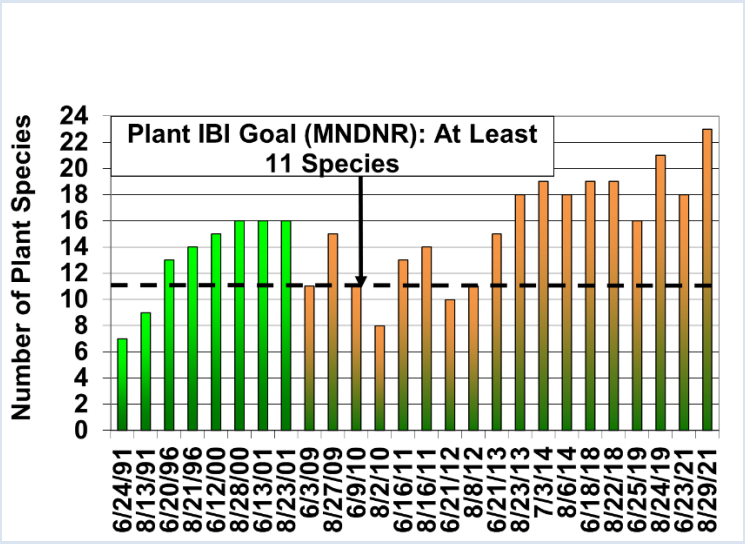


Figure 5-4.A

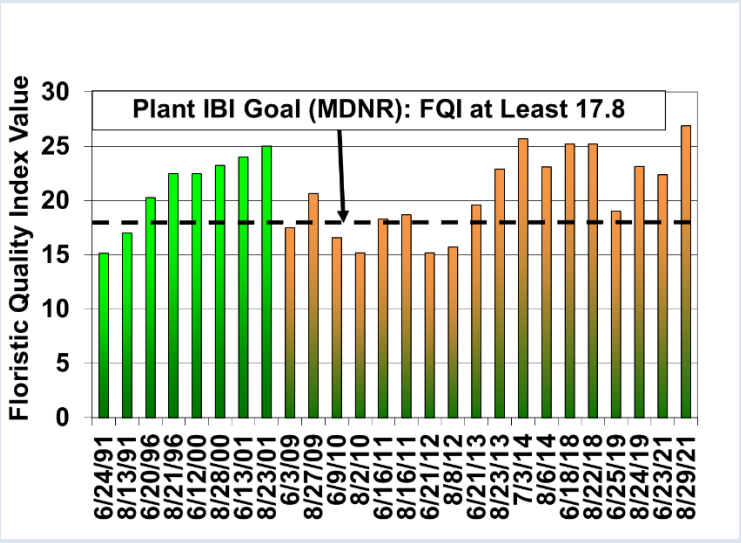


Figure 5-4.B

Figure 5-4 Southeast Anderson 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). Note: Green bars indicate prior to water quality improvement project and orange bars indicate during and after water quality improvement project.

The MDNR 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 point intercept plant surveys of Southeast Anderson Lake in June and August of 2021. Maps showing survey results are included in Appendix E. Plant survey data from 1991 through 2021 were assessed to track changes in plant IBI scores. Figure 5-4 shows the Southeast Anderson 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 Southeast Anderson Lake ranged from 7 to 23, bettering the MNDNR Plant IBI threshold during 1996 through 2021 except August 2, 2010 and June 21, 2012 (Figure 5-4.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 Southwest Anderson Lake ranged from 15.1 to 26.9, bettering the MNDNR Plant IBI threshold during 1996 through 2021 except 2010 and 2012 (Figure 5-4.B).
- **2021 results:** Both the number of species in the lake and FQI values were better than the MNDNR Plant IBI thresholds. Both number of species and FQI increased in 2021 and, on August 29, 2021, the plant community had a higher number of species and FQI score than were observed in previous years (Figure 5-4).

In 2021, bearded stonewort (*Lychnothamnus barbatus*) was first observed in Southeast Anderson Lake (Figure 5-5). It was found at a single location in the southeastern portion of the lake during both June and August (Appendix E). Bearded stonewort is in the family Characeae, an algae that resembles rooted aquatic plants and obtains all of its nutrients from the water. This nutrient absorber can reduce phosphorus concentrations and improve water quality.

Figure 5-5 Bearded stonewort

Four aquatic invasive species were found in Southeast Anderson Lake in 2021:

Eurasian watermilfoil (*Myriophyllum spicatum*) – found throughout the lake at 103 locations in June and 89 locations in August at a moderate density (average rake density of 1.8 in June and 1.6 in August). Eurasian watermilfoil frequency significantly increased between June 2019 and June 2021. In June 2019, Eurasian watermilfoil was observed at 54 locations compared with 103 locations in June 2021.

Curly-leaf pondweed (*Potamogeton crispus*) – observed at 11 locations in June at low density (average rake density of 1.2). Curly-leaf pondweed frequency significantly declined between June 2019 and June 2021. In 2019, curly-leaf pondweed was the dominant species in the lake, observed at 98 locations in June and had an average rake density of 1.8 compared with 11 locations in June 2021 and an average rake density of 1.2. Although the cause of the decline is unknown, the decline appears to be due to natural causes.

Narrow-leaved cattail (***Typha angustifolia***) – Scattered along the shoreline, observed at 6 locations in June and 10 locations in August at high density (average rake density of 2.7 in June and 2.8 in August). Narrow-leaved cattail did not significantly change in frequency between 2019 and 2021, collected on the rake at 7 locations in June and August 2019 compared with 6 locations in June and August 2021 and visually observed near 2 sample locations in August 2019 compared with 3 locations in August 2021.

Reed canary grass (*Phalaris arundinaeae*) –Reed canary grass was observed at 1 location in August, but not observed in June. Reed canary grass frequency significantly declined between June 2019 and June 2021. It was observed at 4 locations in June 2019, but not observed in June 2021. It was observed at a single location both in August 2019 and August 2021.

5.4 Conclusions and Recommendations

2021 water quality in Southeast Anderson Lake was the best on record. Monitoring results indicate Southeast Anderson Lake met the Minnesota Pollution Control Agency (MPCA) shallow lake eutrophication water quality standards for summer average total phosphorus and chlorophyll *a* concentrations and Secchi disc depth and the MPCA chloride criteria for acute and chronic exposure.

Both the number of species in the lake and FQI values were better than the MNDNR Plant IBI thresholds. Both number of species and FQI increased in 2021 and, in August 2021, the plant community had a higher number of species and FQI score than were observed in previous years. Bearded stonewort was observed for the first time in 2021.

Four invasive species were observed in Southeast Anderson Lake in 2021: Eurasian watermilfoil (103 locations in June and 89 locations in August), curly-leaf pondweed (5 locations in June) narrow-leaved cattail (6 locations in June and 10 locations in August), and reed canary grass (not observed in June and observed at 1 location in August). Eurasian watermilfoil significantly increased in frequency between June 2019 and June 2021 while curly-leaf pondweed significantly decreased in frequency between June 2019 and June 2021. The curly-leaf pondweed decline appears to be due to natural causes. Reed canary grass significantly declined in frequency between June 2019 and June 2021, but the August frequency was the same during both years. Narrow-leaved cattail did not significantly change in frequency between 2019 and 2021.

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 Cornelia

6.1 Lake Cornelia

Lake Cornelia (Figure 6-1) 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 2021, 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 6-1 Lake Cornelia - North Basin (left) and Lake Cornelia - South Basin (right) on August 18, 2021.

6.1.1 Lake Cornelia – North Basin

Lake Cornelia – North Basin (Figure 6-1) 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).

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

In 2021, Lake Cornelia – North Basin water quality was poor. The lake's summer average total phosphorus and chlorophyll *a* concentrations were 161 µg/L and 157 µg/L, respectively (Figure 6-2). The lake's summer average Secchi disc transparency was 0.2 meters (Figure 6-2). All three summer averages failed to meet the Minnesota water quality standards for shallow lakes in the North Central Hardwood Forest Ecoregion in 2021 which are ≤60 µg/L, ≤20 µg/L, and ≥1 meter for total phosphorus, chlorophyll *a*, and Secchi disc transparency, respectively.

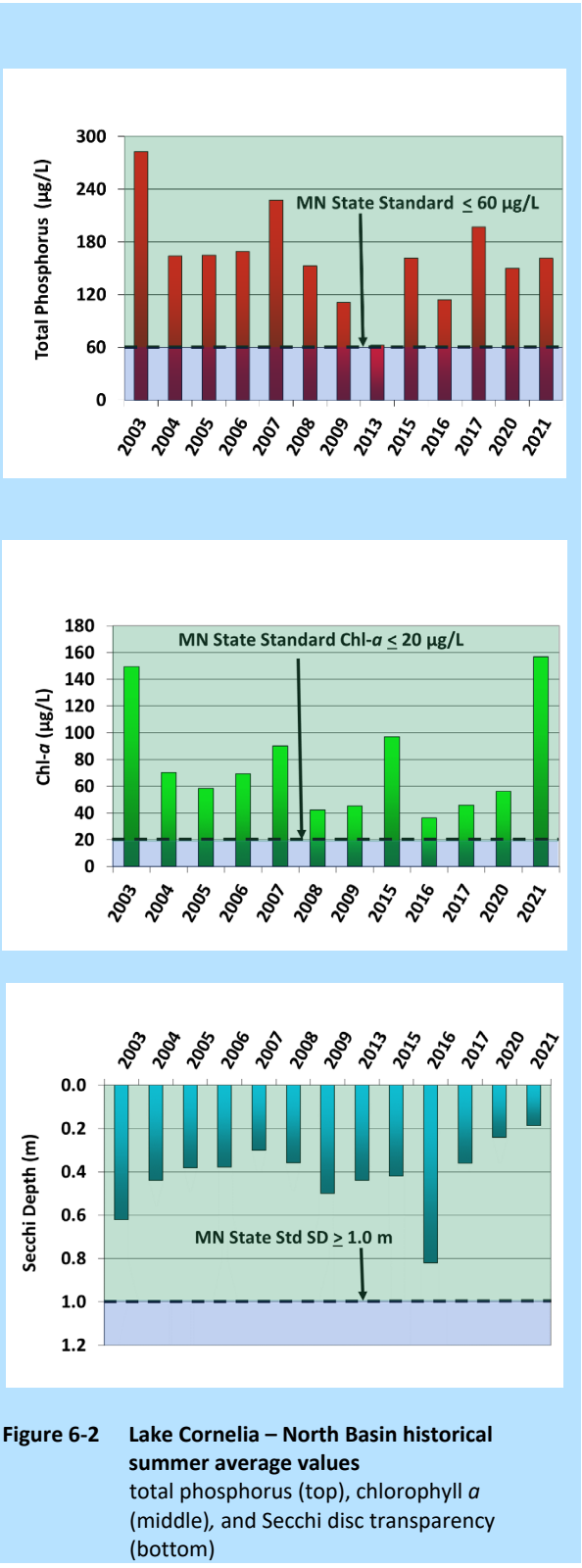


Figure 6-2 Lake Cornelia – North Basin historical summer average values
total phosphorus (top), chlorophyll *a* (middle), and Secchi disc transparency (bottom)

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, 2020, and 2021 and by the Metropolitan Council Environmental Services (MCES) Citizen Assisted Monitoring Program (CAMP) during 2003, 2004, 2005, 2006, 2007, 2008, and 2009. 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). While the lake's 2021 summer average total phosphorus concentration was within the range observed in previous years, the 2021 summer average chlorophyll *a*

concentration was higher (poorer) and Secchi disc transparency was lower (poorer) than previous years (Figure 6-2).

6.1.1.2 Chlorides

Chloride concentrations were measured in 2013, 2015, 2016, 2017, 2020, and 2021, generally between April and September. The observed chloride concentrations from 2013 through 2021 are summarized in Figure 6-3. 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. 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, 2020, and 2021. In 2021, all chloride measurements except the September measurement were above the chronic criterion. The 2021 annual average chloride concentration (263 mg/L) was the highest to date and was nearly double the 2020 annual average (135 mg/L). 2021 data are summarized in Appendix A.

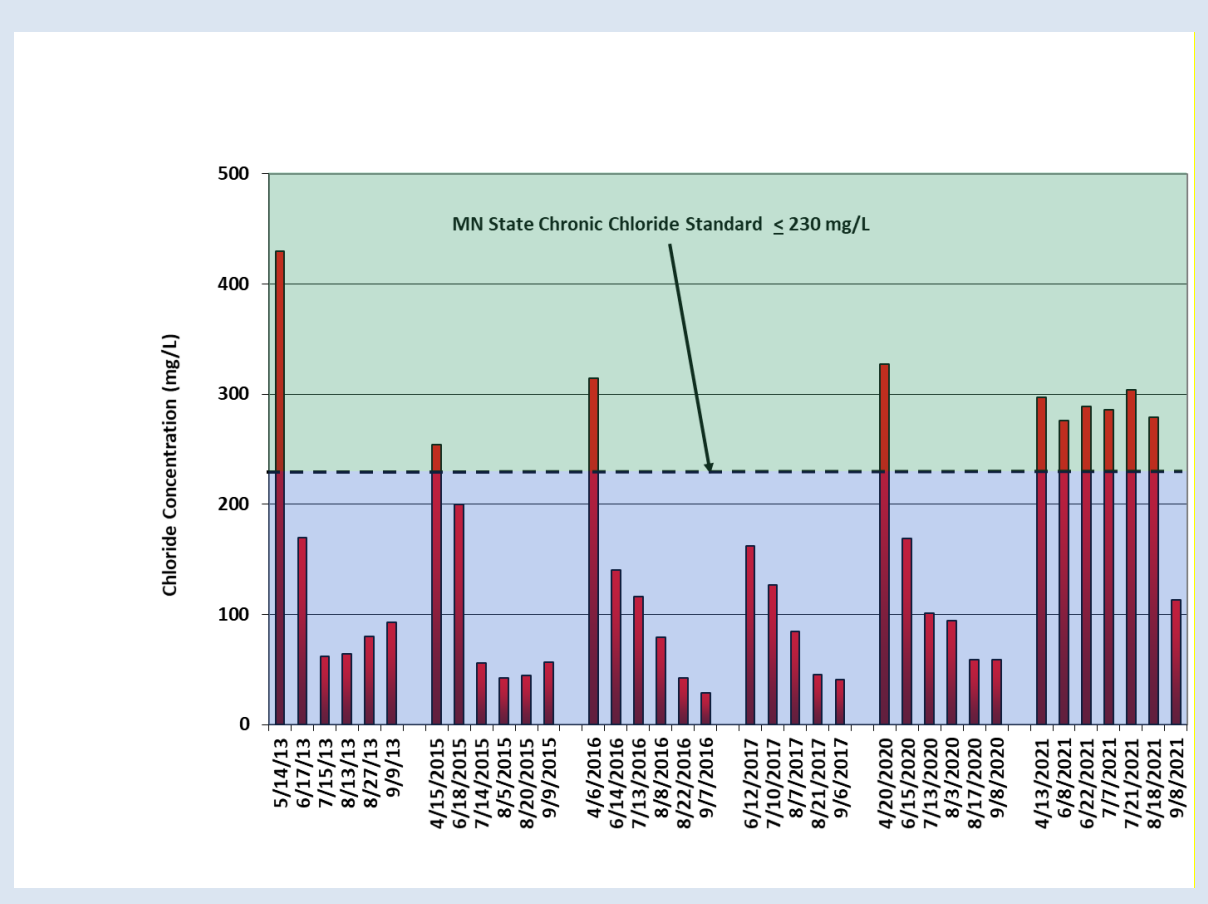


Figure 6-3 Lake Cornelia – North Basin historical chloride concentrations

6.1.1.3 Phytoplankton

Phytoplankton, also called algae, are small aquatic plants naturally present in lakes. 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.

The District has historically monitored the phytoplankton community as part of its routine monitoring program, including identification and enumeration of the phytoplankton species to help evaluate water quality and the quality of food available to zooplankton (microscopic animals). The phytoplankton monitoring has included blue-green algae, which is actually a type of bacteria called cyanobacteria. This type of bacteria thrives in warm, nutrient-rich water and can grow rapidly under certain conditions, causing "blooms". Blue-green algae can produce algal toxins, which can be harmful to humans or other animals. Blue-green algae are also a poor quality food for zooplankton; they can be toxic to zooplankton and may not be assimilated if ingested.

While identification and enumeration of phytoplankton species has generally 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. The District's current protocol, approved December 2020, identifies notification procedures if blue-green algae counts are above the WHO low, medium, or high probability thresholds. A copy of the District's HAB protocol is included in Appendix F.

In 2021, the District did not monitor the phytoplankton community as part of the District's routine monitoring program, but rather in response to observed lake conditions that suggested a potential blue-green algal bloom. Samples of phytoplankton from Lake Cornelia – North Basin were collected and analyzed in July, August (twice), September, and October. Results of the 2021 identification and enumeration of the phytoplankton species can be found in Appendix B.

Figure 6-4 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 have generally increased during the monitored period, with the highest observed counts to date in 2021 (Figure 6-5). The increase in blue-green algae numbers is an unfavorable change for the lake.

In 2021, a severe blue-green algal bloom was observed in the lake during the July through October sample events (Figure 6-5). Blue-green algae numbers during this period ranged from 130,954 units per milliliter in October to 874,041 units per milliliter in August, well above the WHO threshold of 100,000 per

milliliter for a moderate probability of adverse health effects (Figure 6-5). Although there can be many causes of blue-green algal blooms, the especially warm spring of 2021 and hot, dry summer conditions likely contributed to the growth and persistence of the blue-green algal population throughout the summer months.

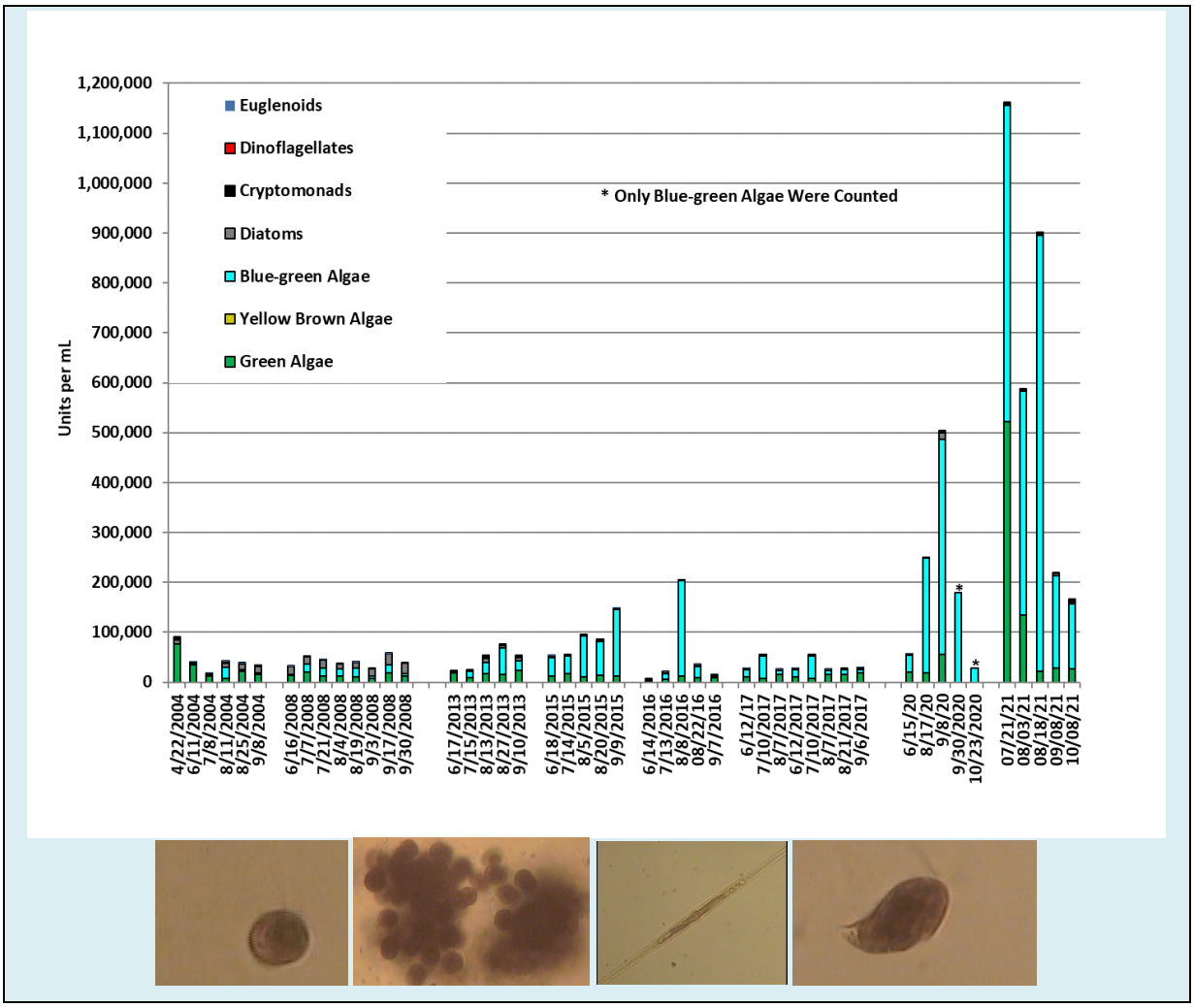


Figure 6-4 Lake Cornelia – North Basin phytoplankton

Top, Lake Cornelia – North Basin 2004, 2008, 2013, 2015, 2016, 2017, 2020, and 2021 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)

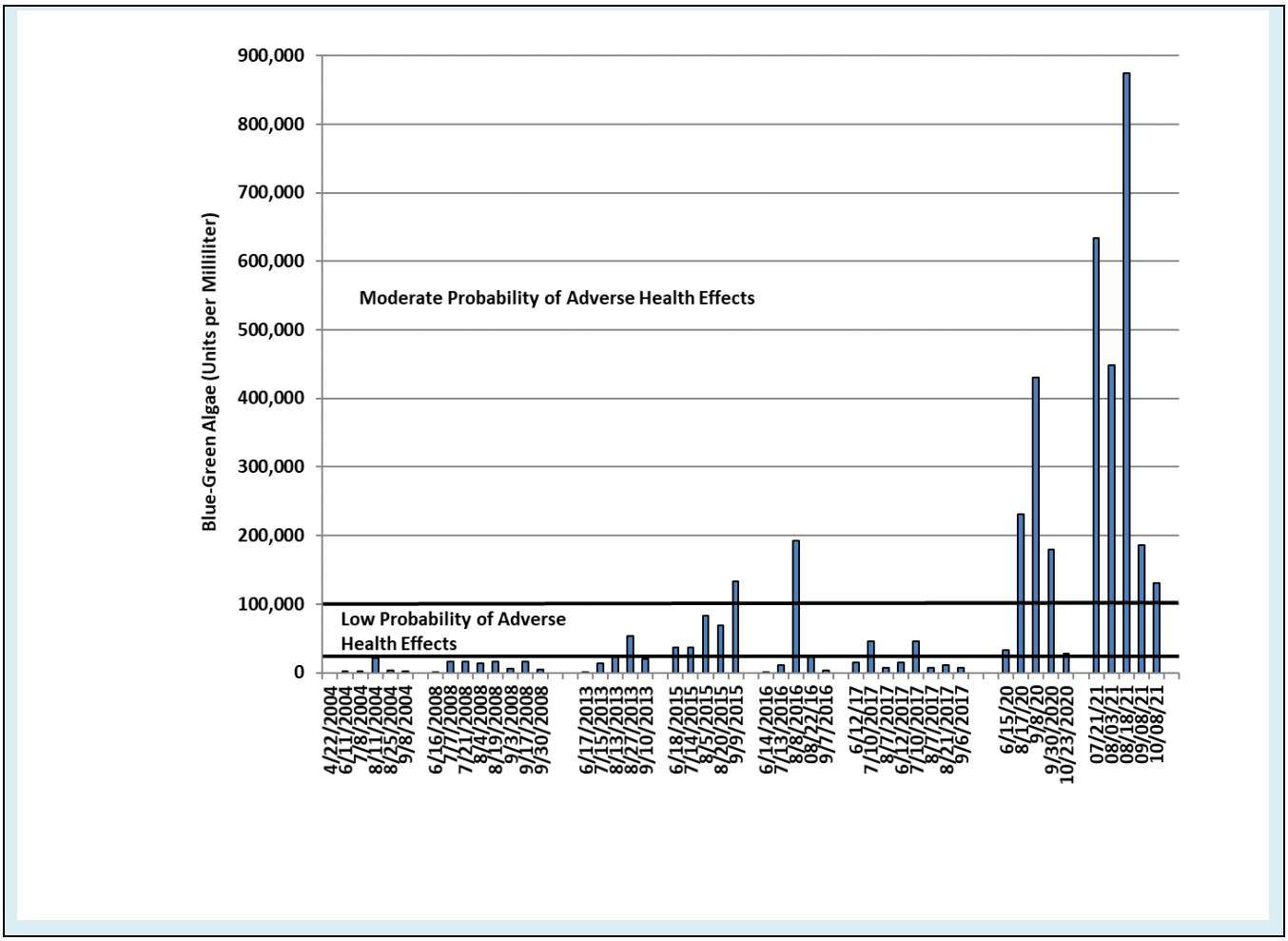


Figure 6-5 Lake Cornelia – North Basin blue-green algae compared with World Health Organization (WHO) thresholds for adverse health effects

6.1.1.4 Conclusions and Recommendations

Water quality of Lake Cornelia – North Basin was especially poor in 2021. Chloride concentrations in Lake Cornelia – North Basin were the worst on record, on average, exceeding the Minnesota Pollution Control Agency (MPCA) chronic criteria in April through August of 2021. The lake failed to meet State eutrophication water quality standards for shallow lakes in 2021 due to excess phosphorus and algae in the lake and poor water clarity. In 2021, numbers of blue-green algae increased. Blue-green algae can produce algal toxins, which can be harmful to humans or other animals. Blue-green algae are also a poor quality food for zooplankton. A severe blue-green algal bloom was observed in the lake during the July through October monitoring events, with blue-green counts well above the World Health Organization (WHO) threshold of 100,000 per milliliter for a moderate probability of adverse health effects. Although there can be many causes of blue-green algal blooms, the especially warm spring of 2021 and hot, dry summer conditions likely contributed to the growth and persistence of the blue-green algal population throughout the summer months.

The District completed a water quality study of Lake Cornelia and Lake Edina in July of 2019 to identify water quality improvement measures for both lakes. The study 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 was 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. Sediment cores collected from the lake in 2021 indicate that the alum treatment successfully converted iron-bound phosphorus into aluminum bound phosphorus. Iron-bound phosphorus is the sediment fraction that is responsible for internal phosphorus loading when oxygen is low, whereas aluminum bound phosphorus is stable under low oxygen conditions and does not cause internal loading. However, the core data also showed that organically bound phosphorus is still high in North and South Cornelia. Hence, internal phosphorus loading may still be occurring (although at a lower rate) as a result of organically bound phosphorus decay in lake bottom sediments.

Other watershed and internal lake management practices are underway to help improve Lake Cornelia. The city of Edina plans to conduct a spring 2022 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. Construction of a stormwater filtration Best Management Practice (BMP) in Rosland Park is underway to reduce the amount of phosphorus to Lake Cornelia from the watershed.

Continuation of water quality and biological monitoring is recommended to assess the condition of the lake's water quality and biological community, evaluate impacts of the management activities, and identify trends.

6.1.2 Lake Cornelia – South Basin

Lake Cornelia – South Basin (Figure 6-1) 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).

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

In 2021, Lake Cornelia – South Basin water quality was poor. The lake's summer average total phosphorus and chlorophyll *a* concentrations were 97 µg/L and 93 µg/L, respectively (Figure 6-6). The lake's summer average Secchi disc transparency was 0.2 meters (Figure 6-6). All three summer averages failed to meet the Minnesota State water quality standards for shallow lakes in the North Central Hardwood Forest Ecoregion in 2021 which are ≤ 60 µg/L, ≤ 20 µg/L, and ≥ 1 meter for total phosphorus, chlorophyll *a*, and Secchi disc transparency, respectively (Figure 6-6).

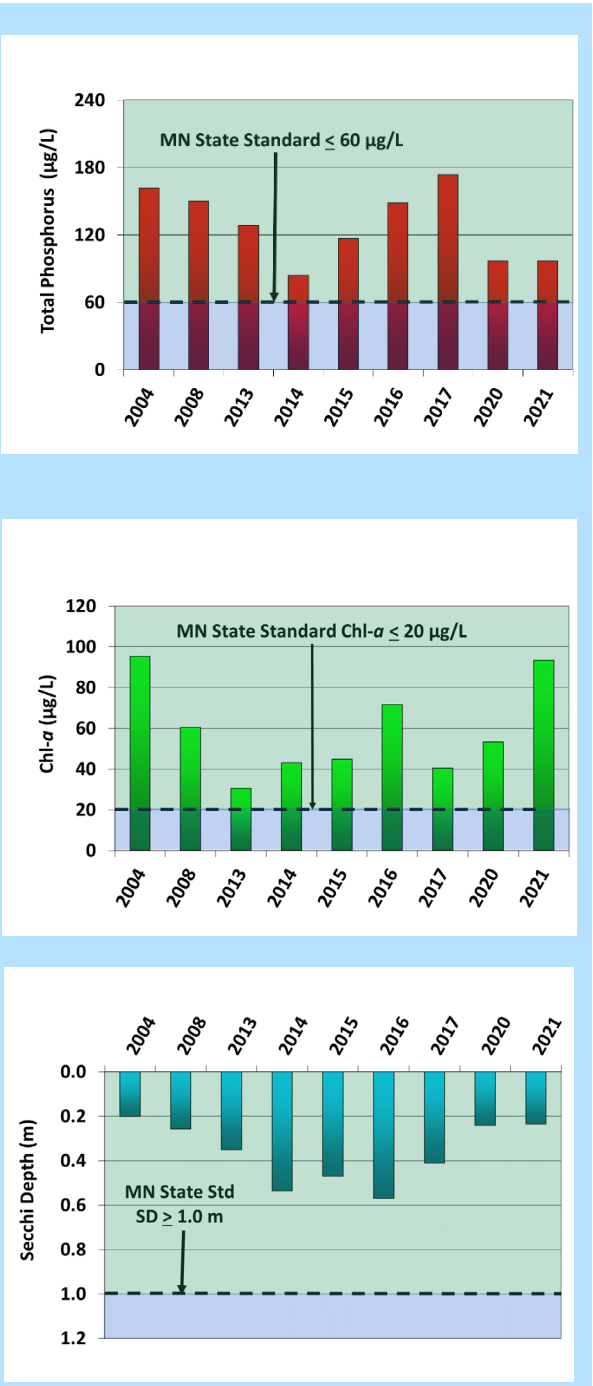


Figure 6-6 Lake Cornelia – South Basin historical summer average values
total phosphorus (top), chlorophyll *a* (middle), and Secchi disc (bottom)

Water quality data were collected from Lake Cornelia – South Basin by Nine Mile Creek Watershed District (NMCWD) during 2004, 2008, 2013, 2015, 2016, 2017, 2020, and 2021 and by the Metropolitan Council Environmental Services (MCES) Citizen Assisted Monitoring Program (CAMP) during 2013 and 2015. The poor water quality observed in 2021 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 State eutrophication water quality standards for shallow lakes in the North Central Hardwood Forest Ecoregion (Figure 6-6). The lake's 2021 summer average total phosphorus and

chlorophyll *a* concentrations and Secchi disc transparency were within the range observed in previous years (Figure 6-6).

6.1.2.2 Chlorides

Chloride concentrations were measured in 2013, 2015, 2016, 2017, 2020, and 2021 generally between April and September. The observed chloride concentrations from 2013 to 2021 are summarized in Figure 6-7. 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. All 2021 measurements were below the acute criterion; concentrations from two sampling events, July 21, 2021, and August 18, 2021, exceeded the chronic criterion. The 2021 annual average chloride concentration (218 mg/L) was the highest to date and was approximately 40 percent higher than the 2020 annual average (155 mg/L). 2021 data are summarized in Appendix A.

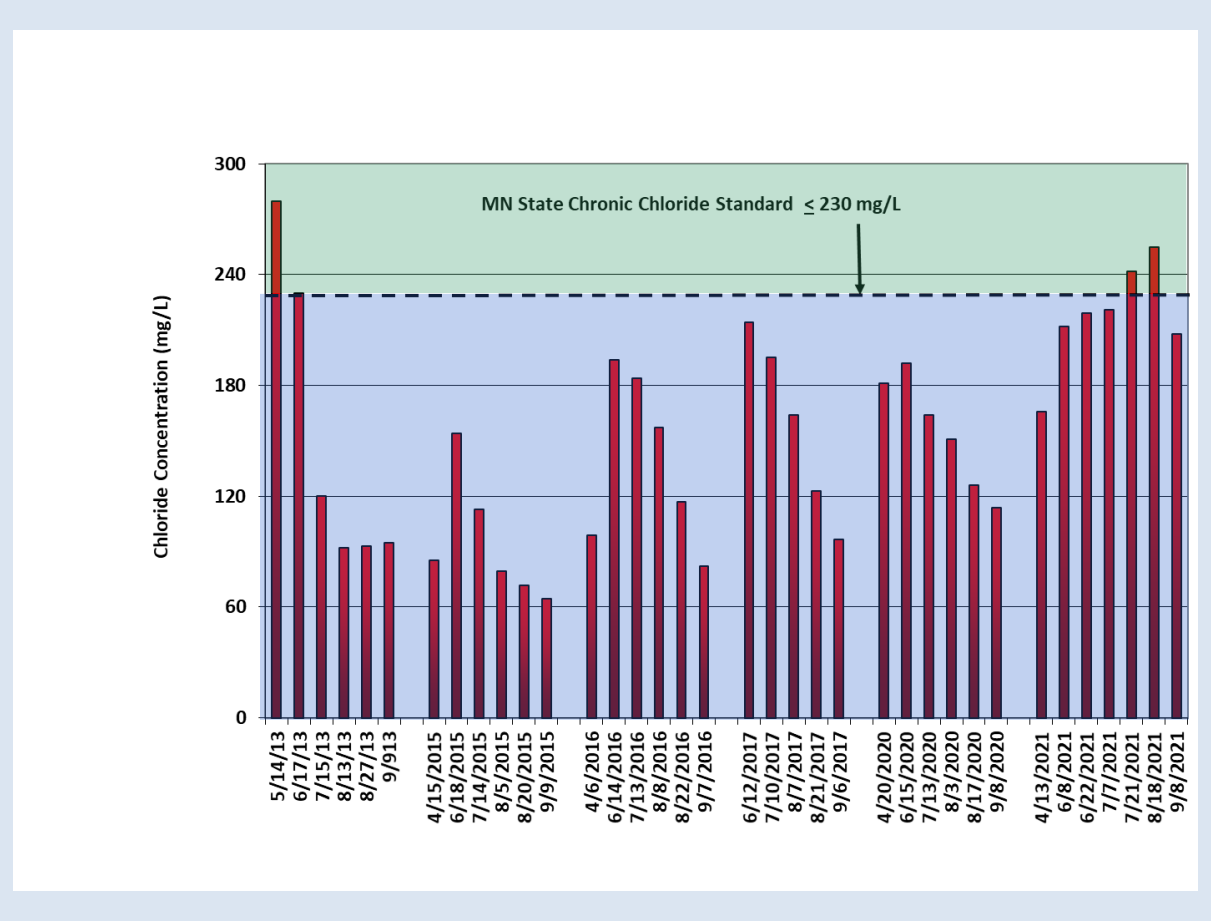


Figure 6-7 Lake Cornelia – South Basin historical chloride concentrations

6.1.2.3 Phytoplankton

In 2021, the District monitored the phytoplankton community in July, August (twice), September, and October in response to observed lake conditions that suggested a potential blue-green algal bloom. Results of the 2021 identification and enumeration of the phytoplankton species can be found in Appendix B.

Figure 6-8 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 can produce algal toxins, which can be harmful to humans or other animals. Blue-green algae are also a poor quality food for zooplankton; they can be toxic to zooplankton and may not be assimilated if ingested. Numbers of blue-green algae have generally increased during the monitored period, with the highest observed blue-green algae counts to date observed in 2021 (Figure 6-8). The increase in blue-green algae numbers in 2021 is an unfavorable change for the lake.

In 2021, a severe blue-green algal bloom was observed in the lake during the July through October sample events (Figure 6-9). Blue-green algae numbers ranged from 313,599 units per milliliter to 490,502 units per milliliter, well above the WHO threshold of 100,000 per milliliter for a moderate probability of adverse health effects (Figure 6-9). Although there can be many causes of blue-green algal blooms, the especially warm spring of 2021 and hot, dry summer conditions likely contributed to the growth and persistence of the blue-green algal population throughout the summer months.

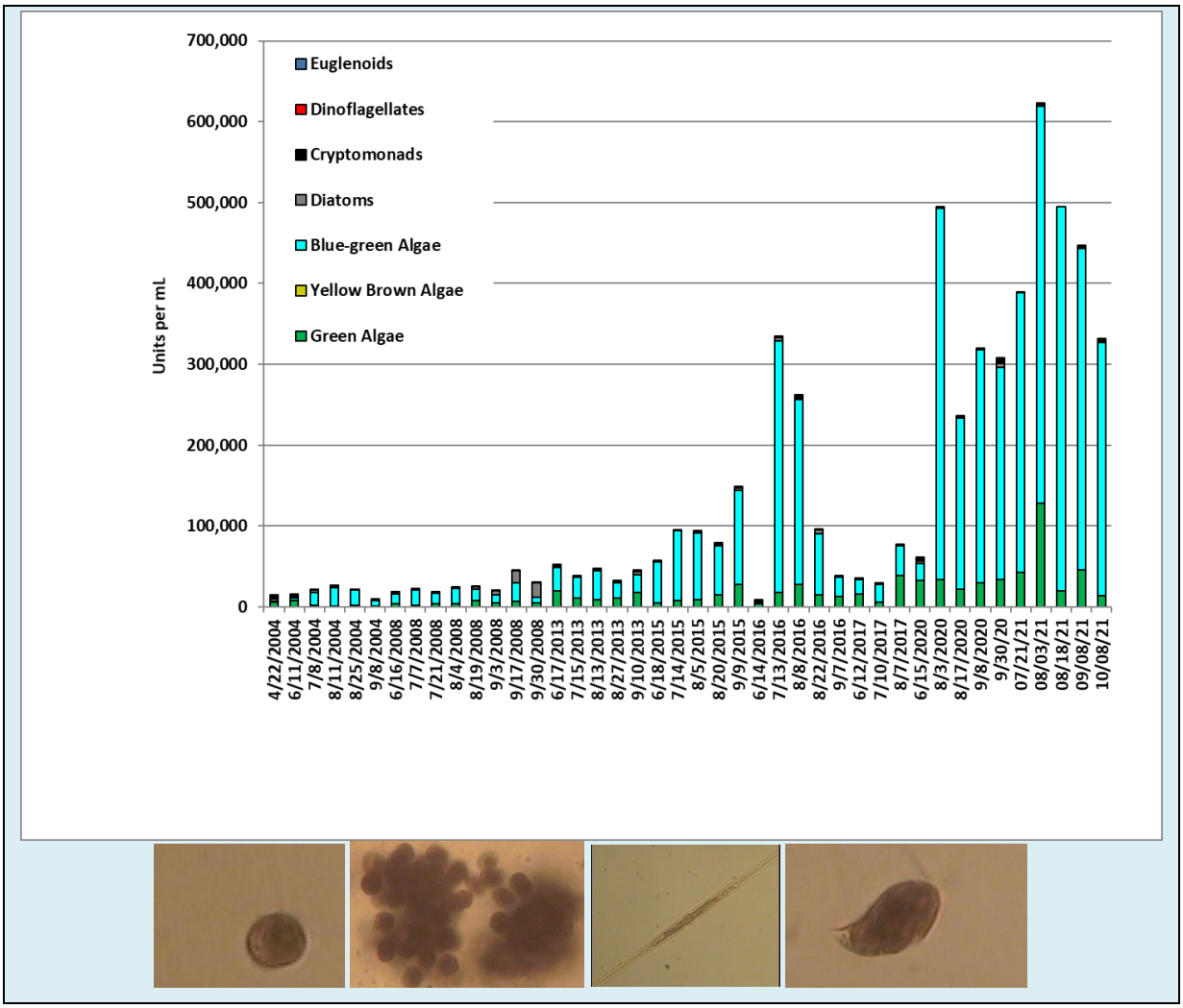


Figure 6-8 Lake Cornelia – South Basin phytoplankton

Top, Lake Cornelia – South Basin 2004, 2008, 2013, 2015, 2016, 2017, 2020, and 2021 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)

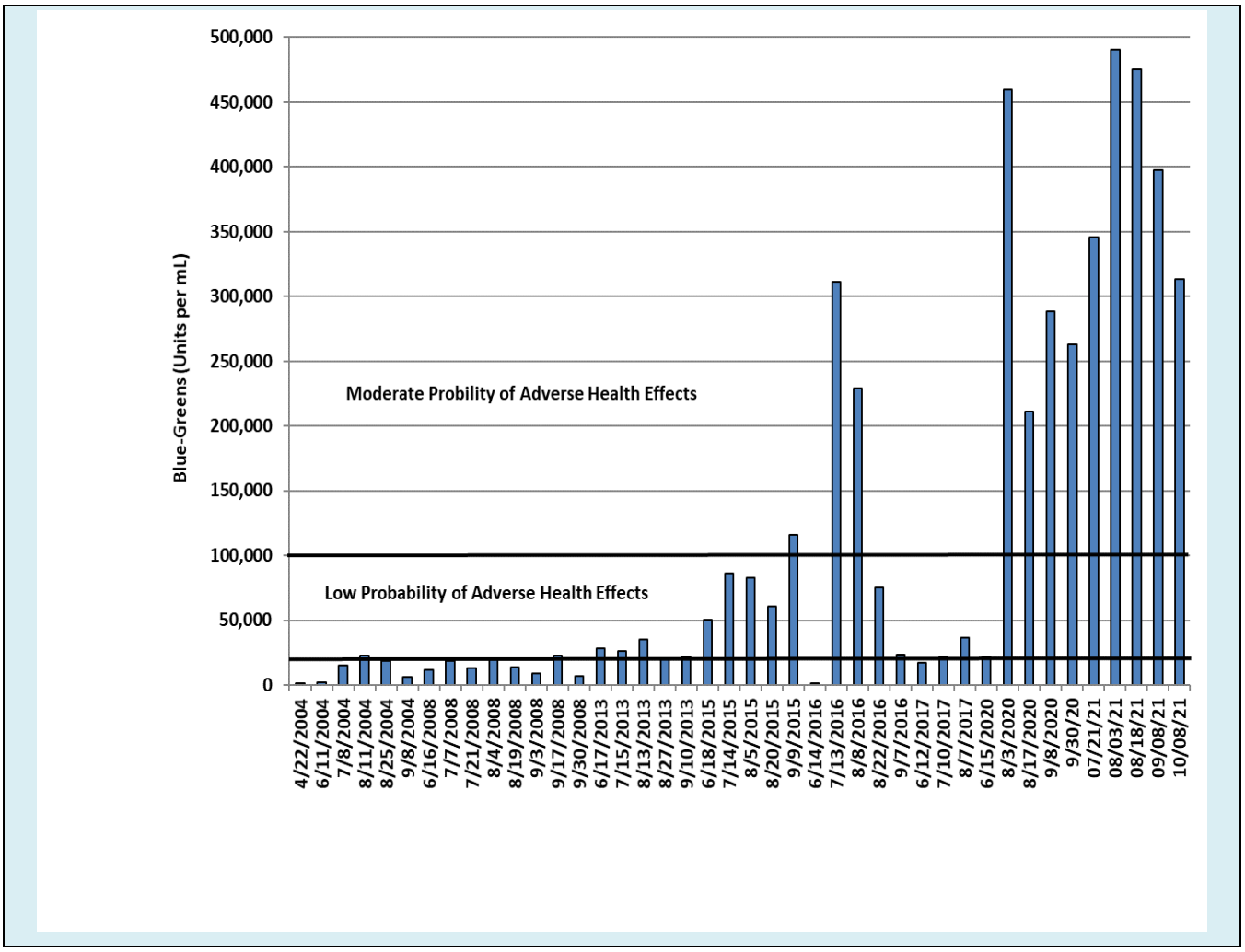


Figure 6-9 Lake Cornelia – South Basin blue-green algae compared with World Health Organization (WHO) thresholds for adverse health effects

6.1.2.4 Conclusions and Recommendations

Water quality of Lake Cornelia – South Basin was especially poor in 2021. Chloride concentrations in Lake Cornelia – South Basin were the worst on record, on average, exceeding the MPCA chronic criteria on July 21 and August 18, 2021. The lake failed to meet State eutrophication water quality standards for shallow lakes in 2021 due to excess phosphorus and algae in the lake and poor water clarity. In 2021, numbers of blue-green algae increased. Blue-green algae can produce algal toxins, which can be harmful to humans or other animals. Blue-green algae are also a poor quality food for zooplankton. A severe blue-green algal bloom was observed in the lake during the July through October monitoring events, with blue-green numbers well above the World Health Organization (WHO) threshold of 100,000 per milliliter for a moderate probability of adverse health effects. Although there can be many causes of blue-green algal blooms, the especially warm spring of 2021 and hot, dry summer conditions likely contributed to the growth and persistence of the blue-green algal population throughout the summer months.

Continuation of water quality and biological monitoring is recommended to assess the condition of the lake's water quality and biological community, evaluate impacts of the management activities, and identify trends.

7 Lake Edina

Lake Edina (Figure 7-1) 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 2021, 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 (microscopic plants)

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 7-1 Lake Edina on June 17, 2021

.

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

In 2021, Lake Edina water quality was poor. The lake's 2021 summer average total phosphorus concentration of 189 µg/L, summer average chlorophyll *a* concentration of 128 µg/L, and summer average Secchi disc transparency of 0.2 meters failed to meet the Minnesota 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 7-2). Minnesota water quality standards for shallow lakes in the North Central Hardwood Forest Ecoregion in 2020 are $\leq$ 60 µg/L, $\leq$ 20 µg/L, and $\geq$ 1 meter, respectively.

Historical water quality data have been collected from Lake Edina by NMCWD during 2008, 2012, 2015, 2017, 2020, and 2021and by the Metropolitan Council Environmental Services (MCES) Citizen Assisted Monitoring Program (CAMP) during 2004 and 2005. The poor water quality observed in 2021 was typical of the water quality observed in previous years. During the period examined, all summer average total phosphorus and Secchi disc transparency values and all but the 2017 summer average chlorophyll *a* concentration failed to meet MPCA standards for shallow lakes (Figure 7-2). The 2021 summer average total phosphorus and chlorophyll *a* concentrations were the highest on record. The 2021 observed summer average Secchi disc transparency was similar to the 2020 value, which was the lowest observed during the period of record (Figure 7-2).

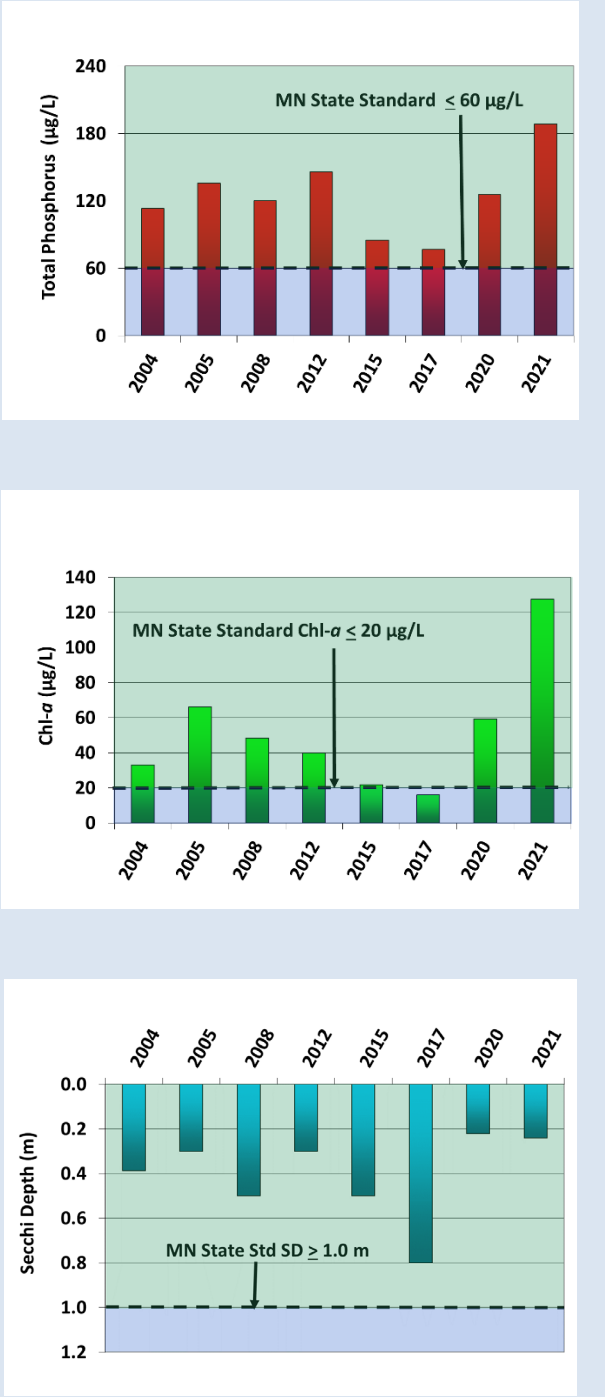


Figure 7-2 Lake Edina historical summer average values
total phosphorus (top), chlorophyll *a* (middle), and Secchi disc (bottom)

7.2 Chlorides

Chloride concentrations were measured in Lake Edina in 2012, 2015, 2017, 2020, and 2021 generally between April and September. The observed chloride concentrations for years monitored by the District are summarized in Figure 7-3. 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. All chloride measurements were below the acute and chronic MPCA criteria. The 2021 average chloride concentration was within the range of previous years. 2021 data are summarized in Appendix A.

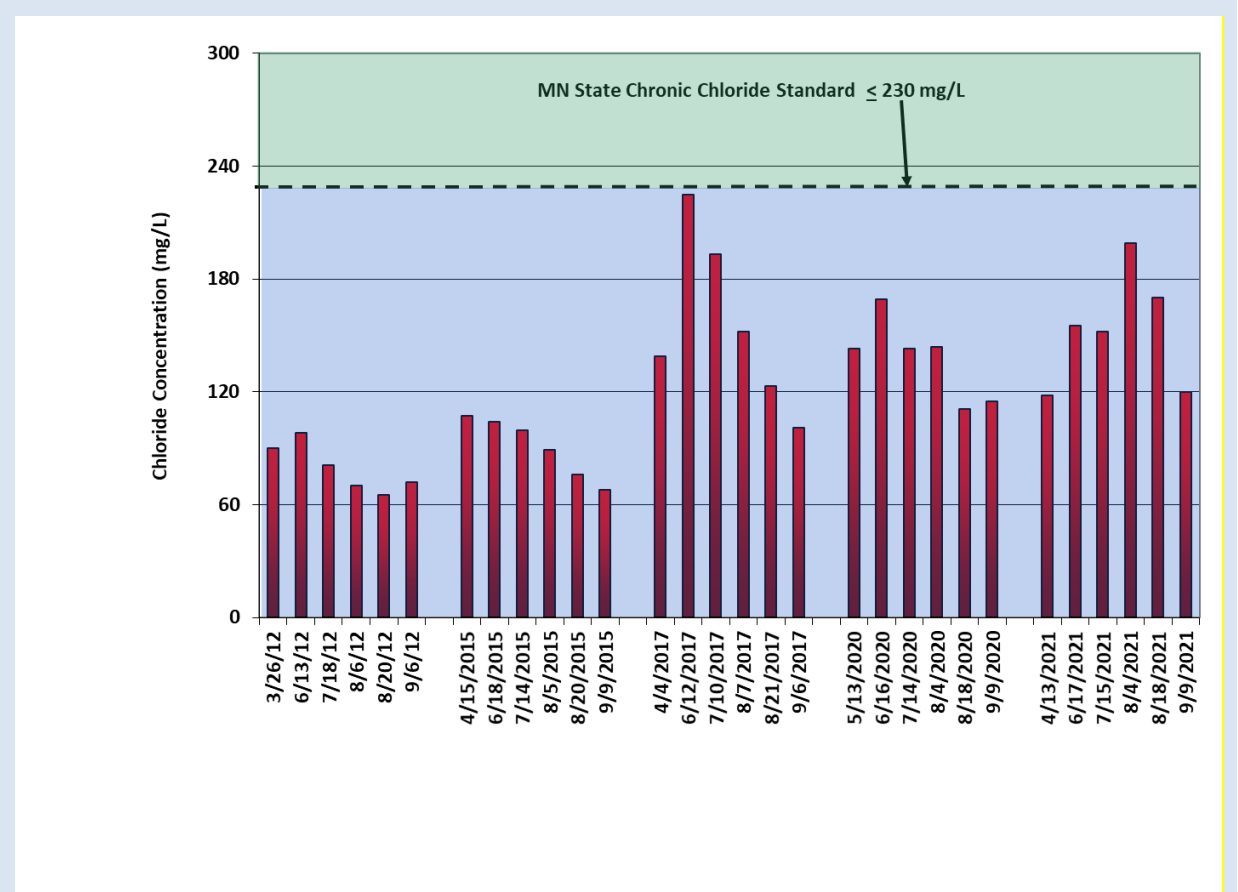


Figure 7-3 Lake Edina historical chloride concentrations

7.3 Phytoplankton

In 2021, the District monitored phytoplankton, microscopic aquatic plants, in July, August (twice), September, and October in response to observed lake conditions that suggested a potential blue-green algal bloom. Results of the 2021 identification and enumeration of the phytoplankton species can be found in Appendix B.

Figure 7-4 summarizes the 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 all monitored years, with exception of 2017 when it was dominated by green algae. Green algae are a good quality food source and contribute towards a healthy zooplankton community, whereas blue-green algae are a poor quality food for zooplankton. Blue-green can 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 numbers in 2021 were the highest to date. The increase in blue-green algae numbers in 2021 was an unfavorable change for the lake.

In 2021, a severe blue-green algal bloom was observed in the lake during the July through October sample events (Figure 7-5). Blue-green algae numbers ranged from 153,928 units per milliliter to 1,217,449 units per milliliter, well above the WHO threshold of 100,000 per milliliter for a moderate probability of adverse health effects (Figure 7-5). The highest numbers of blue-green algae to date were observed in August. Although there can be many causes of blue-green algal blooms, the especially warm spring of 2021 and hot, dry summer conditions likely contributed to the growth and persistence of the blue-green algal population throughout the summer months.

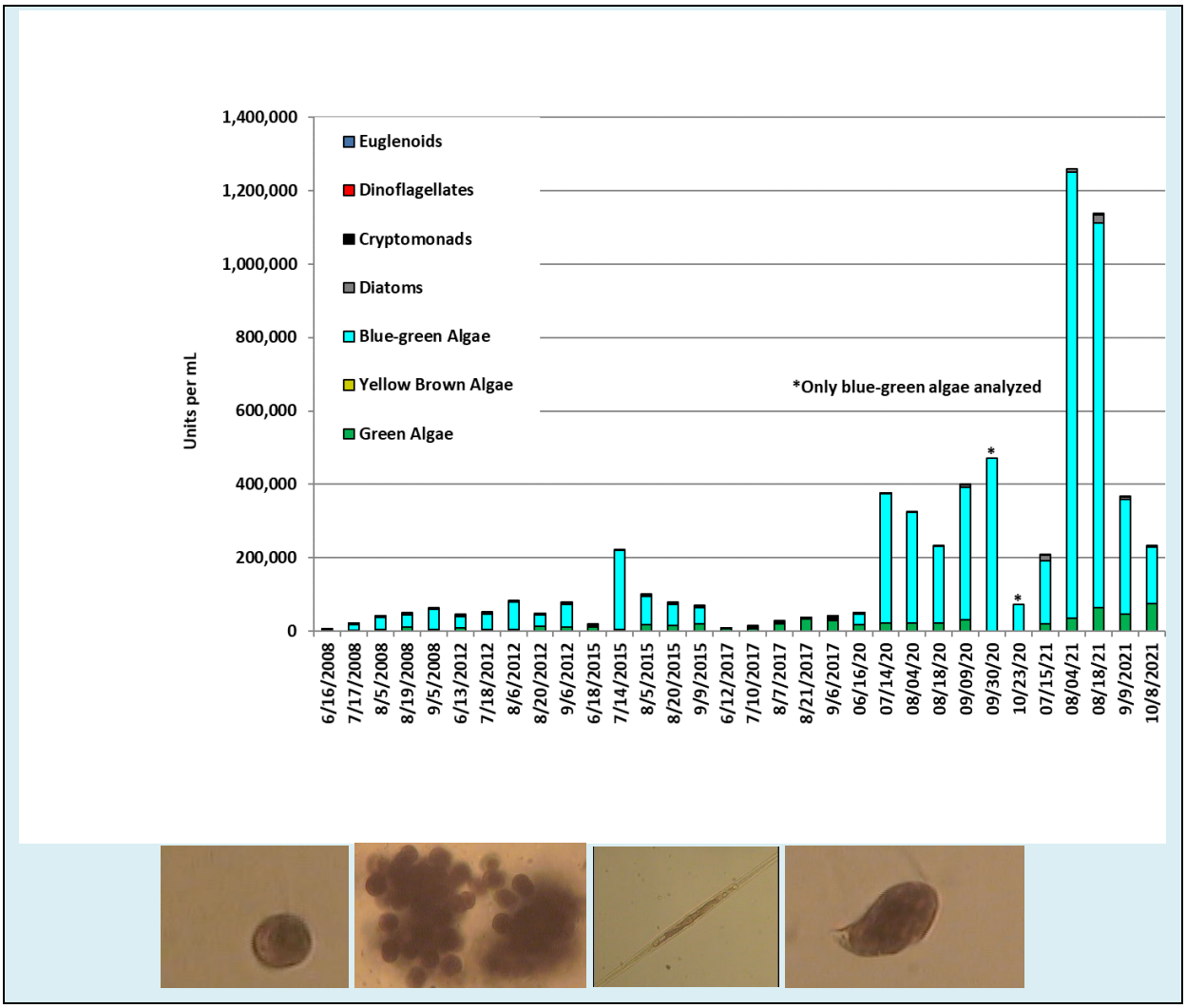


Figure 7-4 Lake Edina phytoplankton

Top, Lake Edina 2008, 2012, 2015, 2017, 2020, and 2021 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)

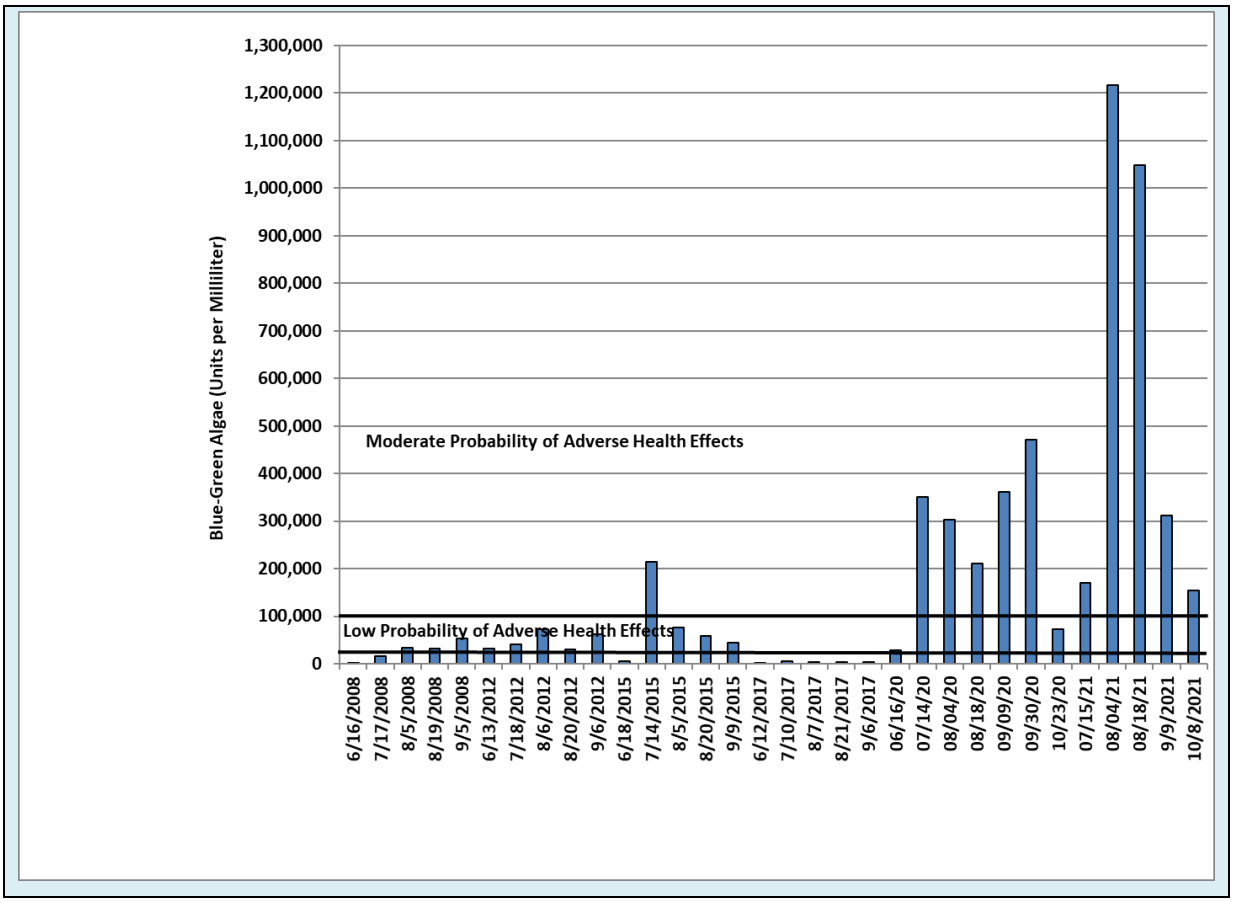


Figure 7-5 Lake Edina blue-green algae compared with World Health Organization (WHO) thresholds for adverse health effects

7.4 Conclusions and Recommendations

Water quality of Lake Edina was especially poor in 2021. Monitoring results indicate Lake Edina met the Minnesota Pollution Control Agency (MPCA) acute and chronic chloride criteria, but failed to meet eutrophication water quality standards for shallow lakes in 2021 due to excess phosphorus and algae in the lake and poor water clarity. The 2021 summer average phosphorus and chlorophyll *a* concentrations were the highest on record for Lake Edina.

In 2021, numbers of blue-green algae increased. Blue-green algae can produce algal toxins, which can be harmful to humans or other animals. Blue-green algae are also a poor quality food for zooplankton. A severe algal bloom was observed in the lake during the July through October monitoring events, with blue-green numbers well above the World Health Organization (WHO) threshold of 100,000 per milliliter for a moderate probability of adverse health effects. The highest numbers of blue-green algae to date were observed in August.

The District completed a water quality study of Lake Cornelia and Lake Edina in July of 2019 to identify water quality improvement measures for both lakes. The study 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. The District is also in the process of designing 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 assess the condition of the lake's water quality and biological community, evaluate impacts of the management activities, and identify trends.

8 Mirror Lake

Mirror Lake is located in the northwestern portion of Edina (Figure 8-1). The lake is divided into three basins; the main lake and two smaller basins to the northwest, separated from the main lake by Blake Road. The entire lake has a water surface of approximately 27 acres, with the main lake spanning just over 23 acres. The main lake has a maximum depth of approximately 25 feet and a mean depth of 12.5 feet at a water surface elevation of 904 feet MSL. At this elevation the lake volume is approximately 274 acre-feet.

The water level in the lake is controlled mainly by weather conditions (snowmelt, rainfall, and evaporation), seepage and a pumped outlet on the southwest side of the lake. Historically, Mirror Lake was considered to be landlocked. A pumped outlet from Mirror Lake was installed after 1995 to alleviate high lake levels.

In 2021, the Nine Mile Creek Watershed District monitored Mirror 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 (microscopic plants) and zooplankton (microscopic 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 G. Monitoring results are discussed in the following paragraphs.

Figure 8-1 Mirror Lake on August 17, 2021

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

In 2021, water quality in Mirror Lake was poor. The lake's 2021 average summer total phosphorus and chlorophyll *a* concentrations were 98 µg/L, and 65 µg/L. The lake's summer average 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 ≤60 µg/L, ≤20 µg/L, and ≥1 meter, respectively (Figure 8-2)

Water quality data have been collected from Mirror Lake by the Nine Mile Creek Watershed District during 1990, 2001, 2004, 2012, 2019, and 2021and Secchi disc transparency data were collected by the MPCA Citizen Lake Monitoring Program (CLMP) annually during 2005 through 2012 and during 2015, 2017, 2019, and 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 all but the 2020 Secchi disc transparency values failed to meet the Minnesota State water quality standards for shallow lakes in the North Central Hardwood Forest Ecoregion (Figure 8-2). The 2021 summer average total phosphorus, chlorophyll *a*, and Secchi disc values were within the range of previous years (Figure 8-2).

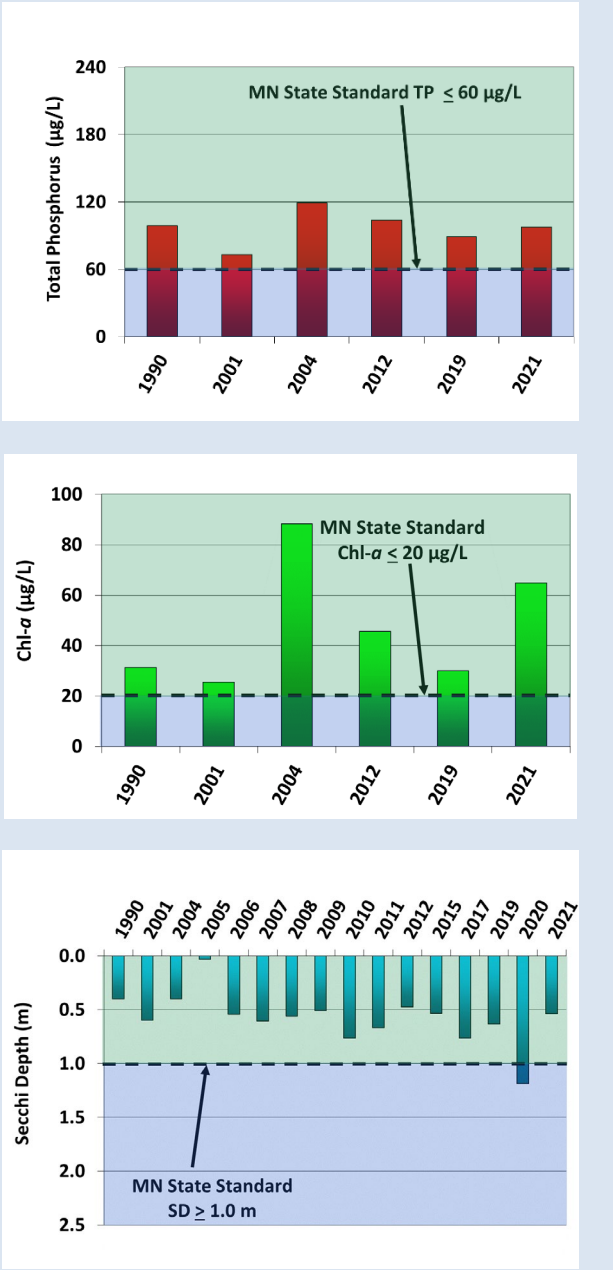


Figure 8-2 Mirror Lake historical summer average values
total phosphorus (top), chlorophyll a (middle), and Secchi disc (bottom)

A Use Attainability Analysis (UAA) of Mirror Lake developed by the District in 2004 found the lake's poor water quality results from excess phosphorus added to the lake from both external (watershed runoff) and internal sources, including release of phosphorus from the lake bottom sediment and mid-season die-back of curly-leaf pondweed. The District is updating the Mirror Lake water quality study in 2022, 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.

8.2 Chlorides

Chlorides were measured in Mirror Lake in 2012, 2019, and 2021 generally between April and September. Figure 8-3 summarizes the chloride concentrations for years monitored by the District .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. All 2021 chloride measurements were well below the acute and chronic MPCA criteria and similar to observed values from previous years. 2021 data are summarized in Appendix A

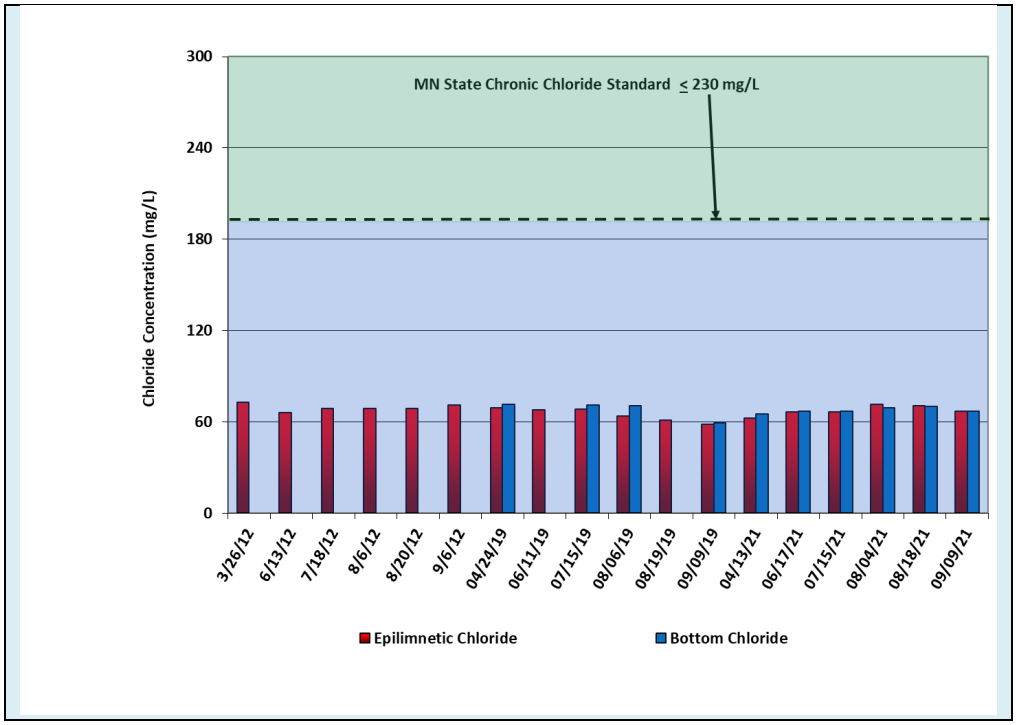


Figure 8-3 Mirror Lake 2021 chloride concentrations

8.3 Phytoplankton

In 2021, the District monitored phytoplankton, microscopic aquatic plants, in Mirror Lake as part of its routine monitoring program. Results of the 2021 identification and enumeration of the phytoplankton species can be found in Appendix B.

Figure 8-4 summarizes the number and major groups of phytoplankton observed in Mirror Lake during 2021. The phytoplankton community in Mirror Lake was dominated by blue-green algae in all monitored years, including 2021 (Figure 8-4). 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.

In 2021, a severe blue-green algal bloom occurred in the lake during the late August through October sample events (Figure 8-5). Blue-green algae numbers during late-August through October ranged from 116,020 units per milliliter to 1,144,502 units per milliliter, well above the WHO threshold of 100,000 per milliliter for a moderate probability of adverse health effects. Blue-green numbers during late-August through October were the highest numbers to date in Mirror Lake (Figure 8-5). Although there can be many causes of blue-green algal blooms, the especially warm spring of 2021 and hot, dry summer conditions likely contributed to the growth and persistence of the blue-green algal population throughout the summer months.

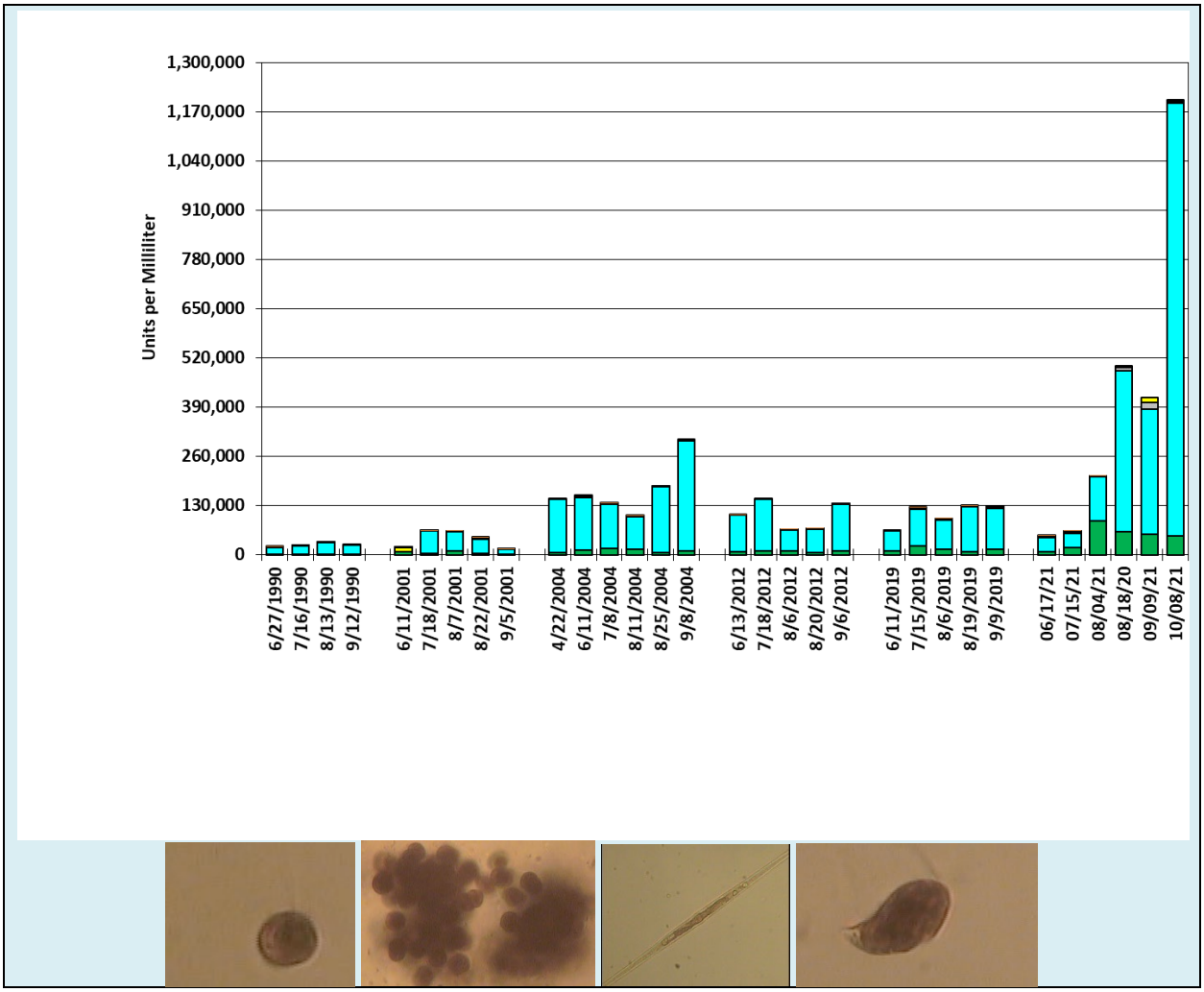


Figure 8-4 Mirror Lake phytoplankton

Top, Mirror Lake 1990, 2001, 2004, 2012, 2019, and 2021 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)

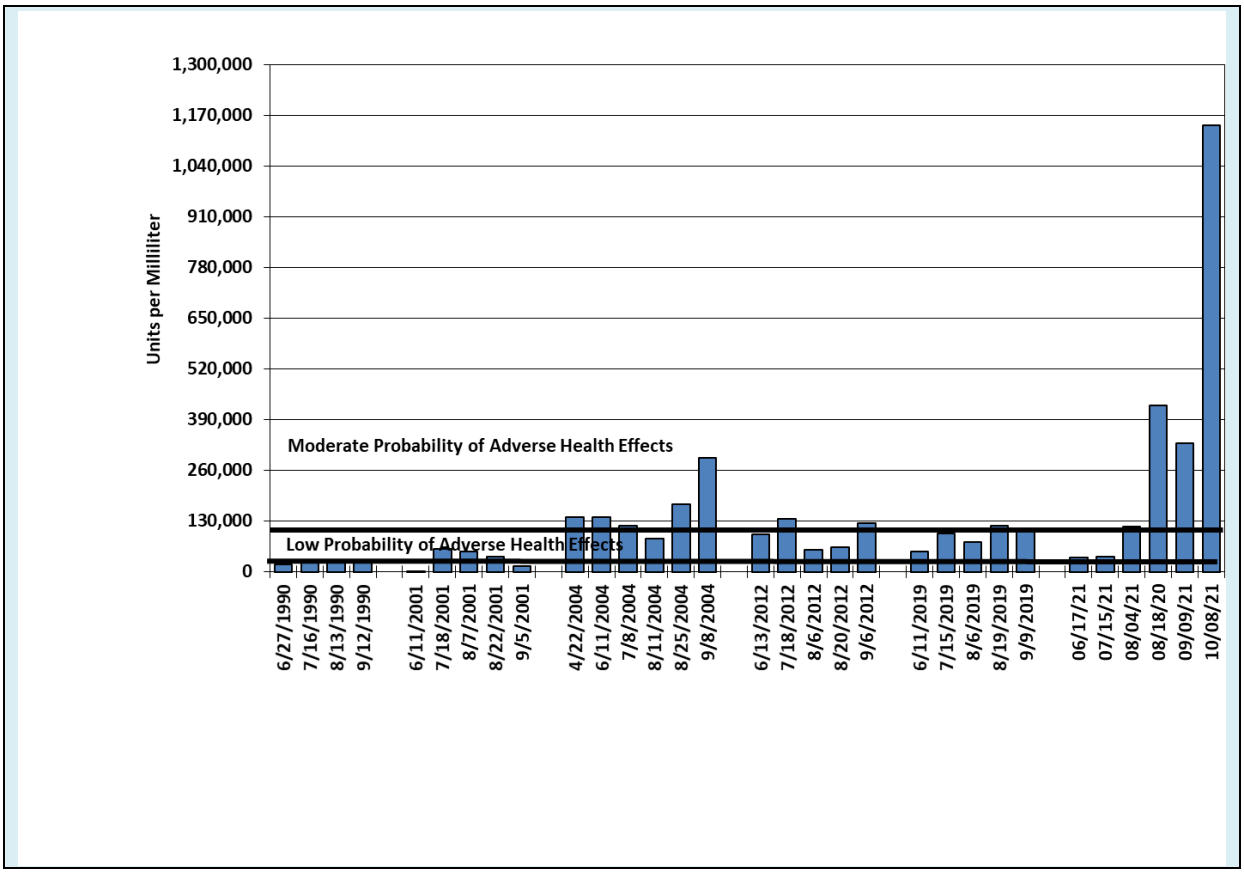


Figure 8-5 Mirror Lake blue-green algae compared with World Health Organization (WHO) thresholds for adverse health effects

8.4 Zooplankton

Samples of zooplankton, microscopic aquatic animals, were collected from Mirror Lake to evaluate the food available to planktivorous fish. Identification and enumeration of the zooplankton species was completed and results are included in Appendix B.

Figure 8-6 summarizes the number and major groups of zooplankton observed in Mirror Lake during 2021. The zooplankton community in Mirror Lake 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 8-6). Nonetheless, the 2021 data indicate the zooplankton community provided an abundant supply of food for planktivorous fish in the lake. The 2021 zooplankton numbers were within the range of previous years.

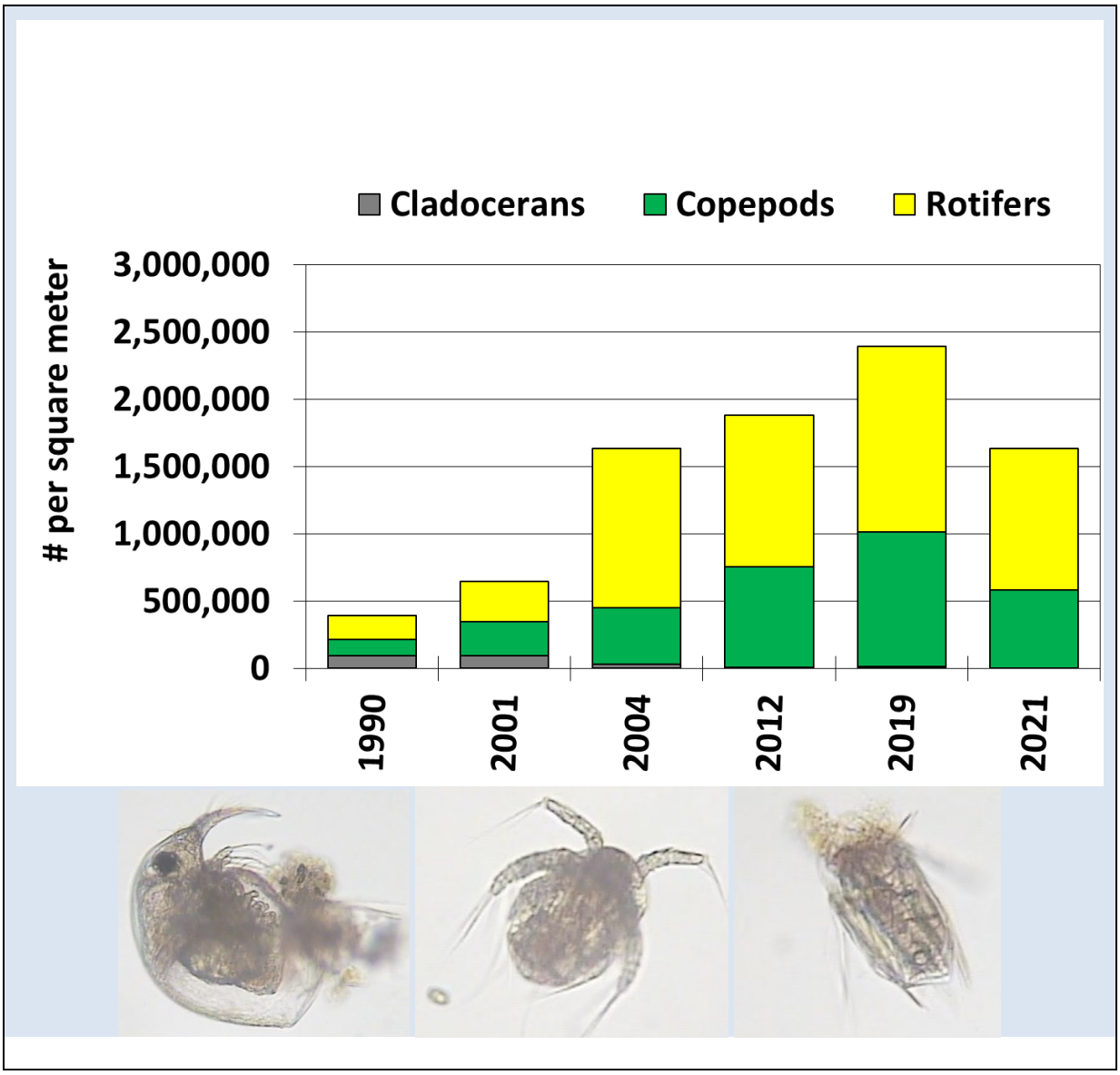


Figure 8-6 Mirror Lake zooplankton

Top, Mirror Lake 1990, 2001, 2004, 2012, 2019, and 2021 summer average 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).

8.5 Aquatic Plants

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. 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. The Plant IBI can provide important context to understanding information about water quality, shoreline health, and the fish community.

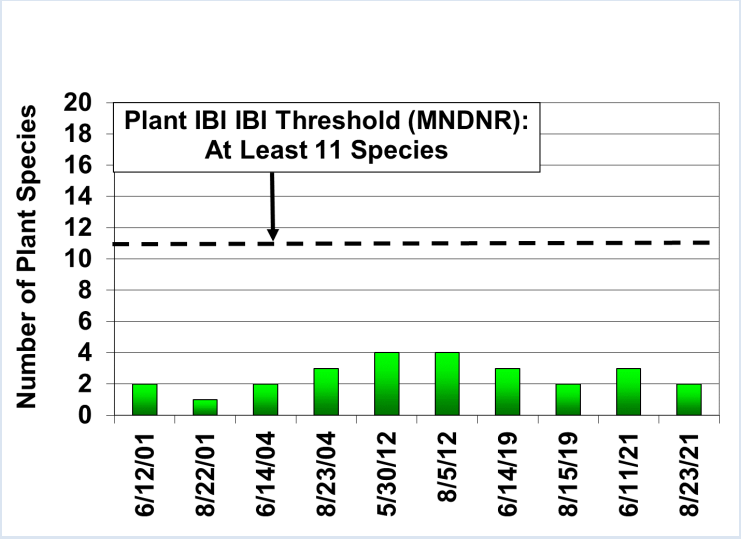


Figure 8-7.A

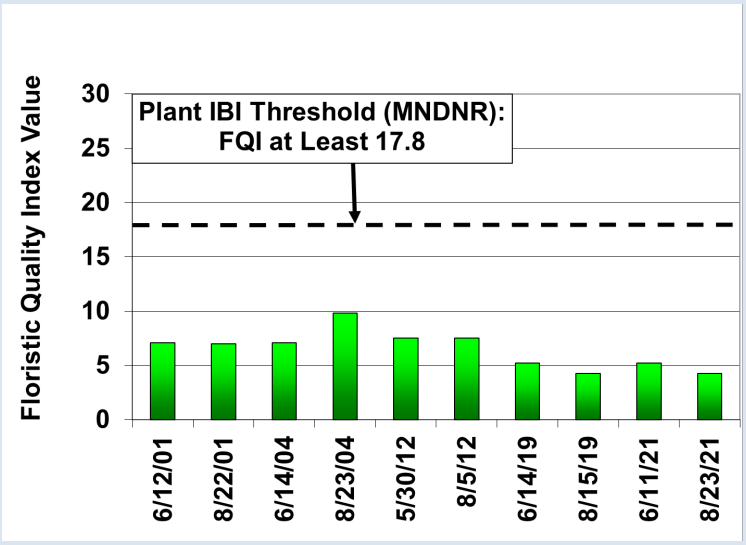


Figure 8-7.B

Figure 8-7 Mirror 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 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 Mirror Lake in June and August of 2021. Maps showing survey results are included in Appendix G. Plant survey data from 2001, 2004, 2012, 2019, and 2021 were assessed to determine plant IBI trends. Figure 8-7 shows the Mirror Lake number of species and FQI scores for 2001 through 2021 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 2001 through 2021, the number of species in Mirror Lake ranged from 1 to 4 and was below (poorer than) the MNDNR Plant IBI threshold during all years (Figure 8-7.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 2001 through 2021, FQI values ranged from 4.2 to 9.8 and were below (poorer than) the MNDNR Plant IBI threshold during all years (Figure 8-7.B).

- **2021 results:** Both the number of species in the lake and FQI values were poorer than the MNDNR Plant IBI thresholds, but were within the range of values observed in previous years.

Two aquatic invasive species were found in Mirror Lake in 2021:

- **Purple loosestrife (*Lythrum salicaria*)**– In 2021, this emergent species was growing in the northwest corner of the lake in June and August and was also growing sporadically along the eastern shoreline in August (Appendix G). Purple loosestrife has been observed in Mirror Lake since plant surveys began in 2001, generally at the same locations observed in August 2021 plus an additional location along the western shoreline of the lake.

- **Curly-leaf pondweed (Potamogeton crispus)**– In 2021, a dense growth was found throughout the lake in June, was not observed in August (Appendix G). The absence of curly-leaf pondweed in August was due to its unique life cycle. Curly-leaf pondweed dies off at the end of June and begins its new growing season in fall. Curly-leaf pondweed has been observed in Mirror Lake since plant surveys began in 2001. While its extent and density have varied, it has frequently been prevalent at a high density during June.

8.6 Conclusions and Recommendations

Monitoring results indicate Mirror Lake met the MPCA acute and chronic chloride criteria in 2021, but failed to meet eutrophication water quality standards for shallow lakes due to excess phosphorus and algae in the lake and poor water clarity.

The phytoplankton population was dominated by blue-green algae throughout 2021. Blue-green algae can produce algal toxins, which can be harmful to humans or other animals. Blue-green algae are also a poor quality food for zooplankton. A severe blue-green algal bloom occurred in the lake during the late-August through October sample events, with blue-green algae numbers well above the WHO threshold of 100,000 per milliliter for a moderate probability of adverse health effects. Blue-green numbers during late-August through October were the highest numbers to date (Figure 8-5). Although there can be many causes of blue-green algal blooms, the especially warm spring of 2021 and hot, dry summer conditions likely contributed to the growth and persistence of the blue-green algal population throughout the summer months. 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 2021, purple loosestrife and curly-leaf pondweed. Both species

have been observed in the lake since aquatic plant surveys began in 2001. In 2021, curly-leaf pondweed was prevalent throughout the lake and grew densely. While its extent and density have varied during the past 20 years, it has frequently been prevalent at a high density during June.

The District is conducting a water quality study of Mirror Lake in 2022, as identified in its 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.

9 Normandale Lake

Normandale Lake (Figure 9-1 and Figure 9-2) 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 the Normandale Lake Water Quality Improvement Project, 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 aquatic plant that dies off in late June, releasing phosphorus to the lake as it decays which can fuel algal growth and reduce lake water quality. This summer addition of phosphorus can fuel algal growth and degrade 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 and the spring of 2021, herbicide treatments were 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 2021, 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 (microscopic plants)
- 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 (the District'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 the District's routine monitoring location on the east side of the lake) are summarized in Appendix B. Macrophyte monitoring maps are provided in Appendix H. Results of the turion survey are provided in Appendix I. Monitoring results are discussed in the following paragraphs.

Figure 9-1 Normandale Lake on August 25, 2021 (Photo Credit: Endangered Resource Services, LLC)

Figure 9-2 Normandale Lake on August 25, 2021 (Photo Credit: Endangered Resource Services, LLC)

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

Figure 9-3 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 2021, the lake's summer average total phosphorus and chlorophyll *a* concentrations of 37 µg/L and 6 µg/L respectively, and the lake's summer average Secchi disc transparency (water clarity) of 2.1 meters (Figure 9-3) met 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). 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, for total phosphorus, chlorophyll *a* and Secchi depth, respectively.

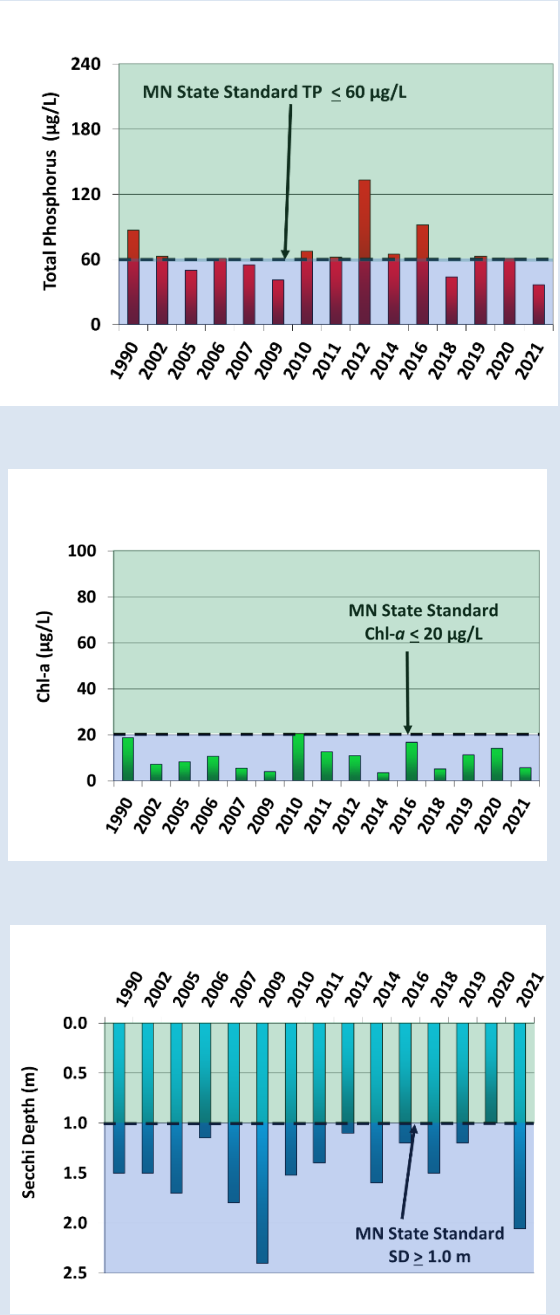


Figure 9-3 Normandale Lake historical summer average values.
total phosphorus (top), chlorophyll *a* (middle), and Secchi disc (bottom)

Water quality data were collected from Normandale Lake by Nine Mile Creek Watershed District during 1990, 2002, 2005, 2007, 2010, 2014, 2016, 2018, 2019, 2020, and 2021, by the Metropolitan Council Environmental Services (MCES) Citizen Assisted Monitoring Program (CAMP) during 2006, 2009, 2010, 2011, and 2012; and by the MPCA Citizen Lake Monitoring Program (CLMP) in 2020 and 2021. Data from these sources has generally been included in computation of the historic summer average values shown in Figure 9-3 when sampling was conducted at a location consistent with the District's routine monitoring location. Although Secchi depth was monitored in 2021 as part of the MPCA CLMP program, data from a monitoring location consistent with the District's routine monitoring location was not available from the MPCA's web-based database at the time of this report development.

The 2021 data indicate the summer average total phosphorus concentration in Normandale Lake was the lowest concentration to date (Figure 9-3). The 2021 summer average chlorophyll *a* concentration and Secchi disc depth were within the range of historical data (Figure 9-3). All observed summer average chlorophyll *a* concentrations and Secchi disc transparencies throughout the period of record have met Minnesota State eutrophication water quality standards for shallow lakes. Summer average chlorophyll *a* concentrations have ranged from 4 µg/L to 20 µg/L and summer average Secchi disc transparencies have ranged from 1.0 meter to 2.4 meters. Summer average total phosphorus concentrations have ranged from 37 µg/L to 133 µg/L (Figure 9-3) during the monitored period and have failed to meet the Minnesota State water quality standard 67 percent of monitored years. In the years since implementation of the Normandale Lake Water Quality Improvement Project (2019 and beyond), the summer average total phosphorus concentration has been near or below the State standard for shallow lakes.

In 2020 and 2021, 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 and 2021 monitoring data indicate that phosphorus concentrations near the inlet of Nine Mile Creek are generally higher than concentrations measured near the lake outlet. As shown in Figure 9-4, 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 2020-2021 District monitoring locations are shown in Figure 9-5.

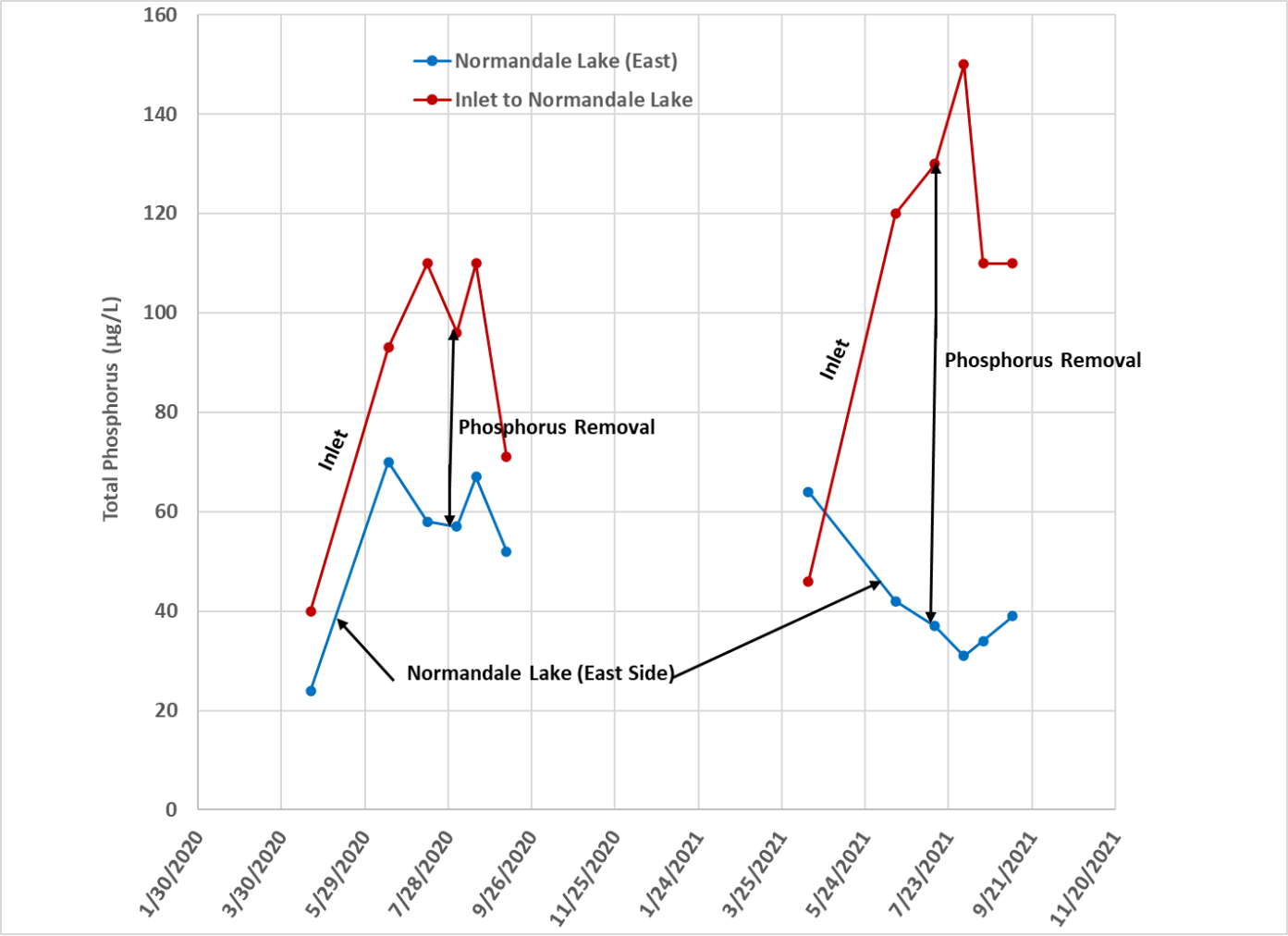


Figure 9-4 **2020-2021 Normandale Lake total phosphorus concentrations measured at the lake inlet and on the east side at the deepest portion of the lake near the outlet (District's routine monitoring location)**

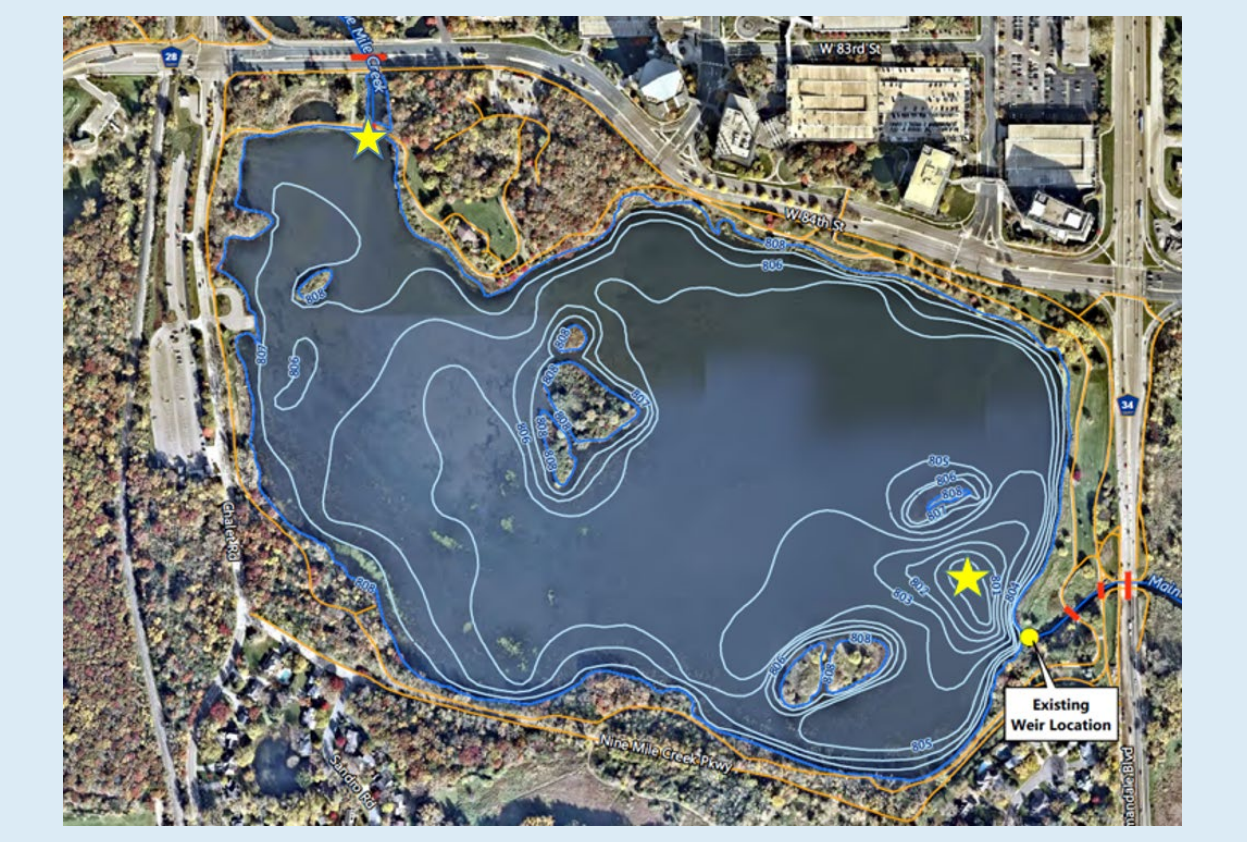


Figure 9-5 **Normandale Lake 2020-2021 District Sample Locations: on the east side at the deepest portion of the lake near the outlet (the District's routine monitoring location) and at the inlet of Nine Mile Creek on the northwest side of the lake.**

9.2 Nitrogen

While total phosphorus and chlorophyll *a* concentrations and Secchi disc transparency are commonly measured to assess attainment of the eutrophication 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 obtaining nutrients from the water column are produced. However, monitoring data support the conclusion that nitrogen is the "limiting nutrient" at times, phosphorus and nitrogen are colimiting at times, and phosphorus is the "limiting nutrient" at times. 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) in Nine Mile Creek and education of property owners regarding responsible use of fertilizer on lawns or other turf.

9.3 Chlorides

Chloride concentrations were measured during April/May through September in 2010, 2014, 2016, 2018, 2019, 2020, and 2021. Figure 9-7 summarizes the observed chloride concentrations from 2010 through

2021. 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 observed during April of 2014, April 2016, April and June 2018, and April and June of 2021 were above the MPCA chronic chloride criteria, but all other chloride measurements during 2010 through 2021 were below the chronic MPCA criterion. All measurements during 2010 through 2021 were below the acute MPCA criterion. 2021 chloride data are summarized in Appendix A.

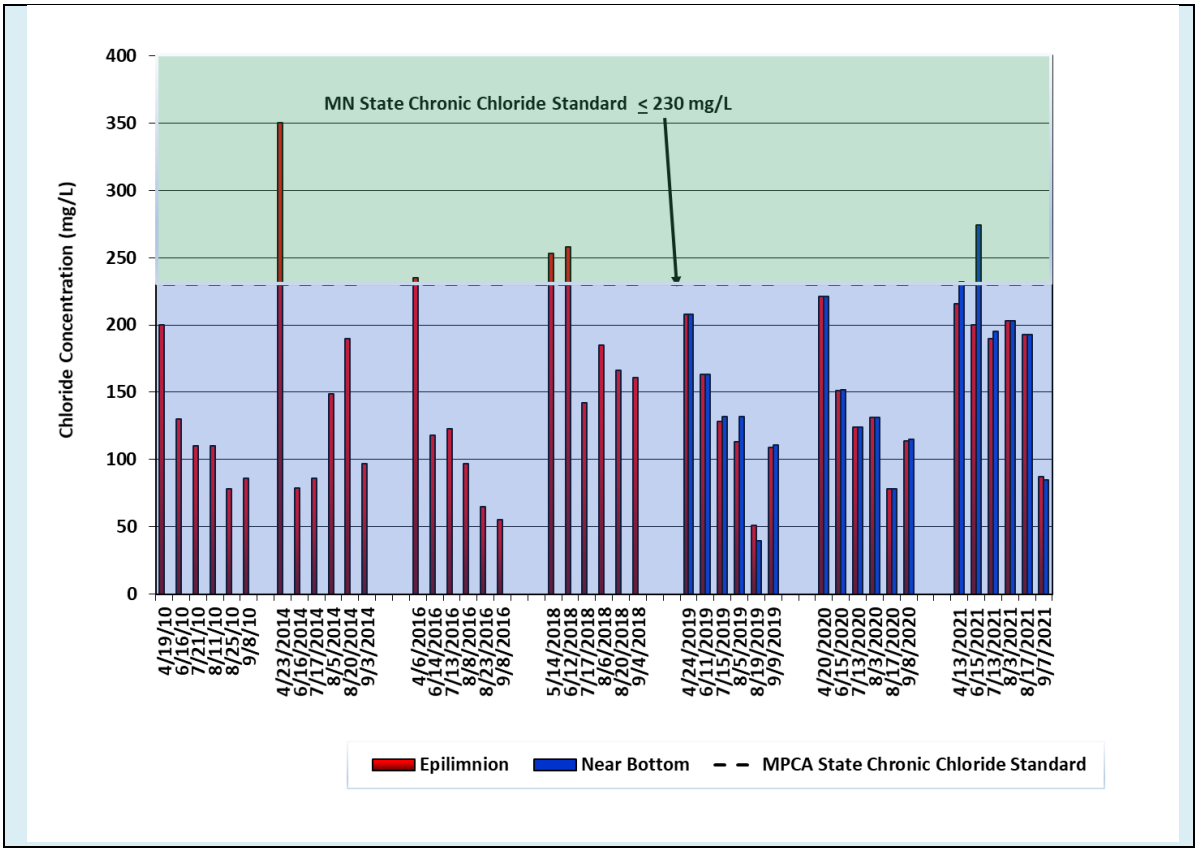


Figure 9-6 Normandale Lake historical chloride concentrations

9.4 Phytoplankton

In 2021, the District monitored phytoplankton, microscopic aquatic plants, in Normandale Lake as part of its routine monitoring program. Results of the 2021 identification and enumeration of the phytoplankton species can be found in Appendix B.

Figure 9-7 summarizes the number and major groups of phytoplankton observed in Normandale Lake in monitored years. The observed data indicates that phytoplankton in Normandale Lake 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. Blue-green algae are a poor-quality food for zooplankton; they can 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.

Figure 9-9 summarizes the blue-green algae numbers at the District's routine monitoring location in Normandale Lake. Comparison of blue-green numbers during the monitored period to the World Health Organization (WHO) guideline thresholds for probability of adverse health effects to recreational users indicates all observed values have been below the threshold for low probability of adverse health effects.

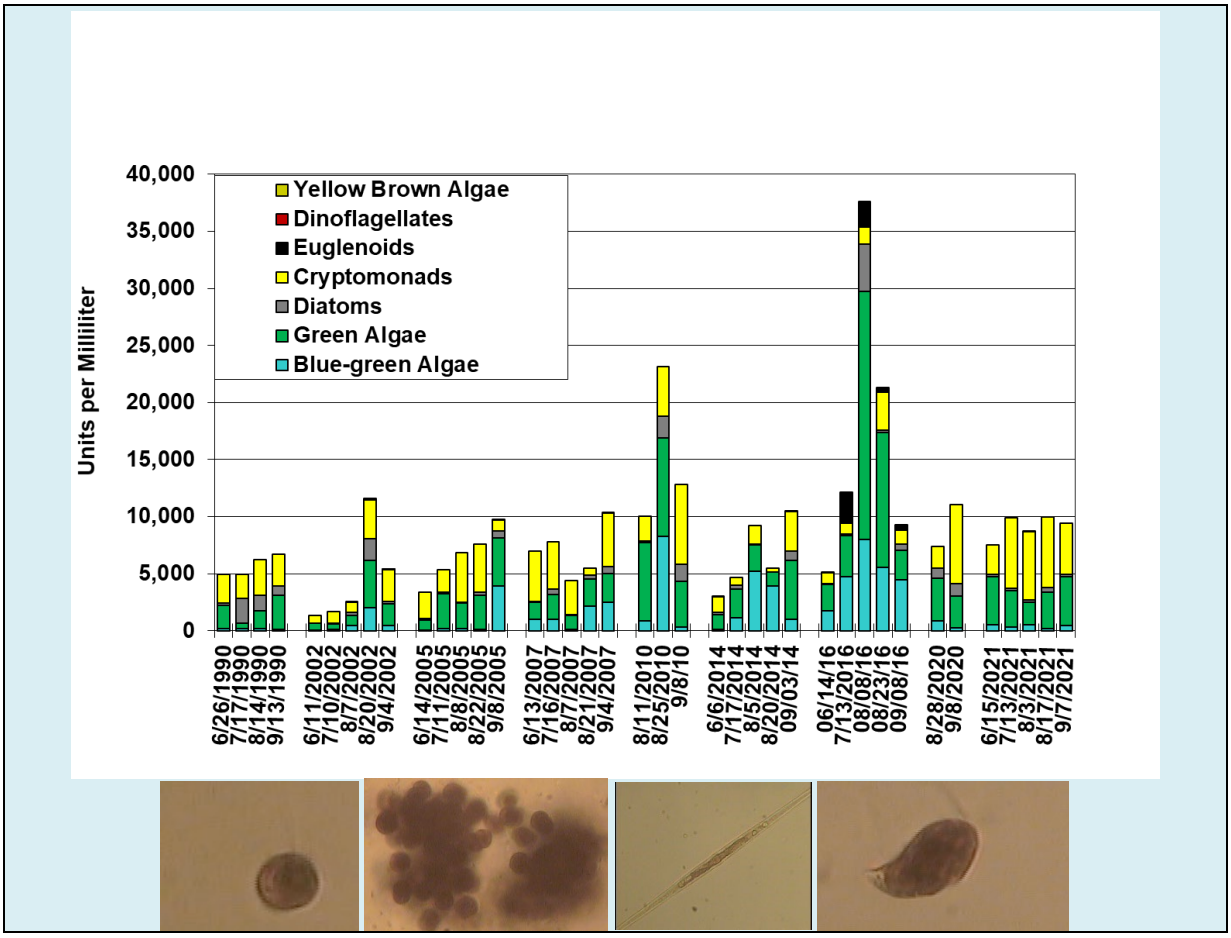


Figure 9-7 Normandale Lake summer phytoplankton

Top, Normandale Lake 1990, 2002, 2005, 2007, 2010, 2014, 2016, 2020, and 2021 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)

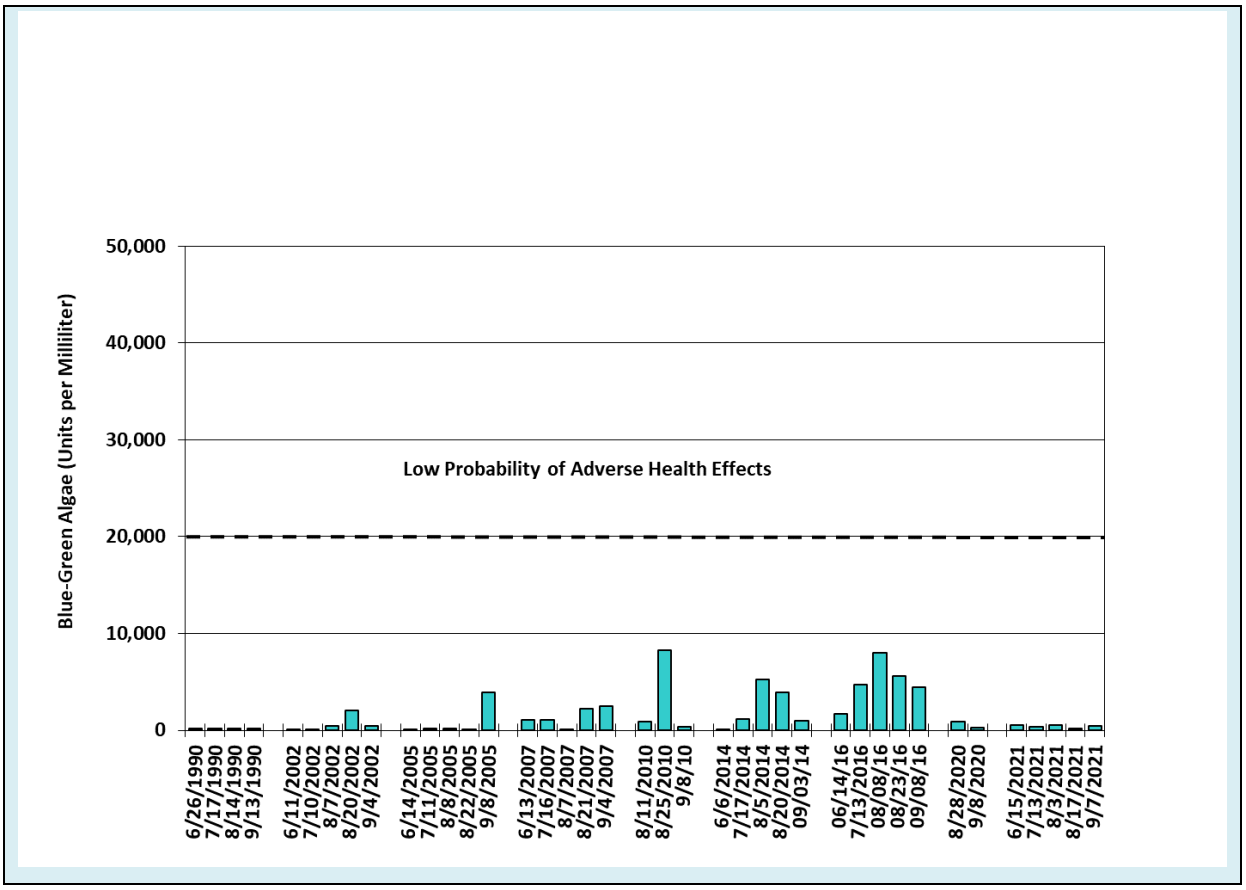


Figure 9-8 Normandale Lake blue-green algae numbers compared with World Health Organization (WHO) thresholds for adverse health effects

9.5 Filamentous Algae

Filamentous algae are colonies of microscopic plants in which single cells link together to form long visible chains, threads, or mesh-like filaments and, when nutrient conditions are favorable, form mats that float on the surface of lakes or ponds. Where there is good transparency and where sunlight reaches the bottom, these algae begin their growth on the bottom of waterbodies, attached to bottom sediments or submerged objects. As the algae grow, they produce oxygen that gets trapped in the entangled strands of algae. This trapped oxygen makes the algae buoyant, causing them to rise to the surface where they form floating mats of algae. Disturbance of these algal mats by high wind or heavy rain events may cause them to temporarily sink to the bottom due to the removal of the trapped oxygen bubbles that caused them to be buoyant. This can give a false impression that the growth has "disappeared", only to have the algal mats return to the surface within several days after new oxygen bubbles became trapped in the entangled strands of algae, thus making the mats buoyant once again.

Figure 9-11 summarizes the frequency of filamentous algae in Normandale Lake during plant surveys completed in June and August of years 2016 through 2021. 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 9-9). In 2021, filamentous algae frequency of occurrence at sample points ranged from 52 percent to 62 percent (Figure 9-9).

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 Normandale Lake. 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 generally 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 these algae, the lake can support their growth 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 these 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 long-term management option for filamentous algae is nutrient reduction.

Figure 9-9 Normandale Lake filamentous algae frequency of occurrence

Top, 2016, 2017, 2018, 2019, 2020, and 2021 Normandale Lake filamentous algae frequency of occurrence at the 125 sample locations throughout Normandale Lake 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.

9.6 Aquatic Plants

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. 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. The Plant IBI can provide important context to understanding information about water quality, shoreline health, and the fish community.

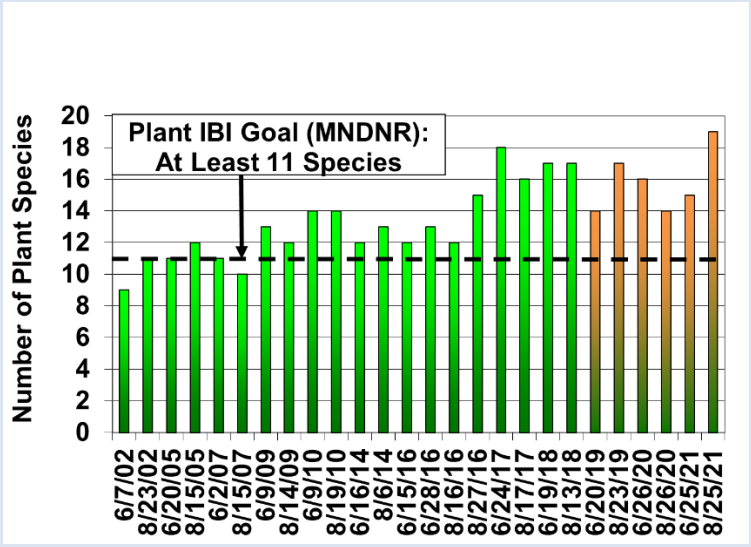


Figure 9-10.A

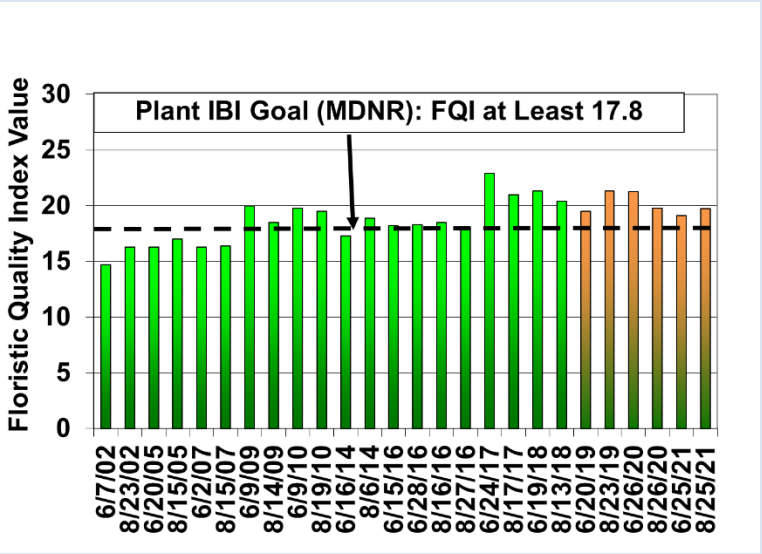


Figure 9-10.B

Figure 9-10 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 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 point-intercept and biomass aquatic plant surveys of Normandale Lake in June and August of 2021. Results are included in Appendix H. Plant survey data from 2002 through 2021 were assessed to determine plant IBI trends. Figure 9-10 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 and 2021).

- **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 19. 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 and the highest number to date was observed in August of 2021 (Figure 9-10.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 in monitored years since August 2014 (Figure 9-10.B).

- **2021 results:** Both the number of species in the lake and FQI values were better than the MNDNR Plant IBI thresholds (Figure 9-10). The highest number of species observed to date was in August of 2021.

9.6.1 Comparison of Pre- and Post-Project Curly-leaf Pondweed Data to Assess Changes After Initiation of Water Quality Improvement Project

Plant survey data indicate an overall reduction in frequency of curly-leaf pondweed in the lake since implementation of the water quality improvement project (drawdown occurred in winter of 2018-2019). The frequency of the targeted aquatic invasive species curly-leaf pondweed –decreased from a range of 47 to 85 percent of sampling locations in June during 2016 through 2018 to a range of 9 to 31 percent of sampling locations in June 2019 through 2021 (Figure 9-11). However, the observed frequencies of curly-leaf pondweed in June and August 2021 were higher than the respective frequencies observed in 2019 and 2020.

Plant survey data indicate an overall reduction in biomass of curly-leaf pondweed in the lake since implementation of the water quality improvement project (drawdown occurred in winter of 2018-2019). The biomass of curly-leaf pondweed, measured as wet weight, decreased 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 to 11 grams per sample location in June 2019 through 2021 (Figure 9-12).

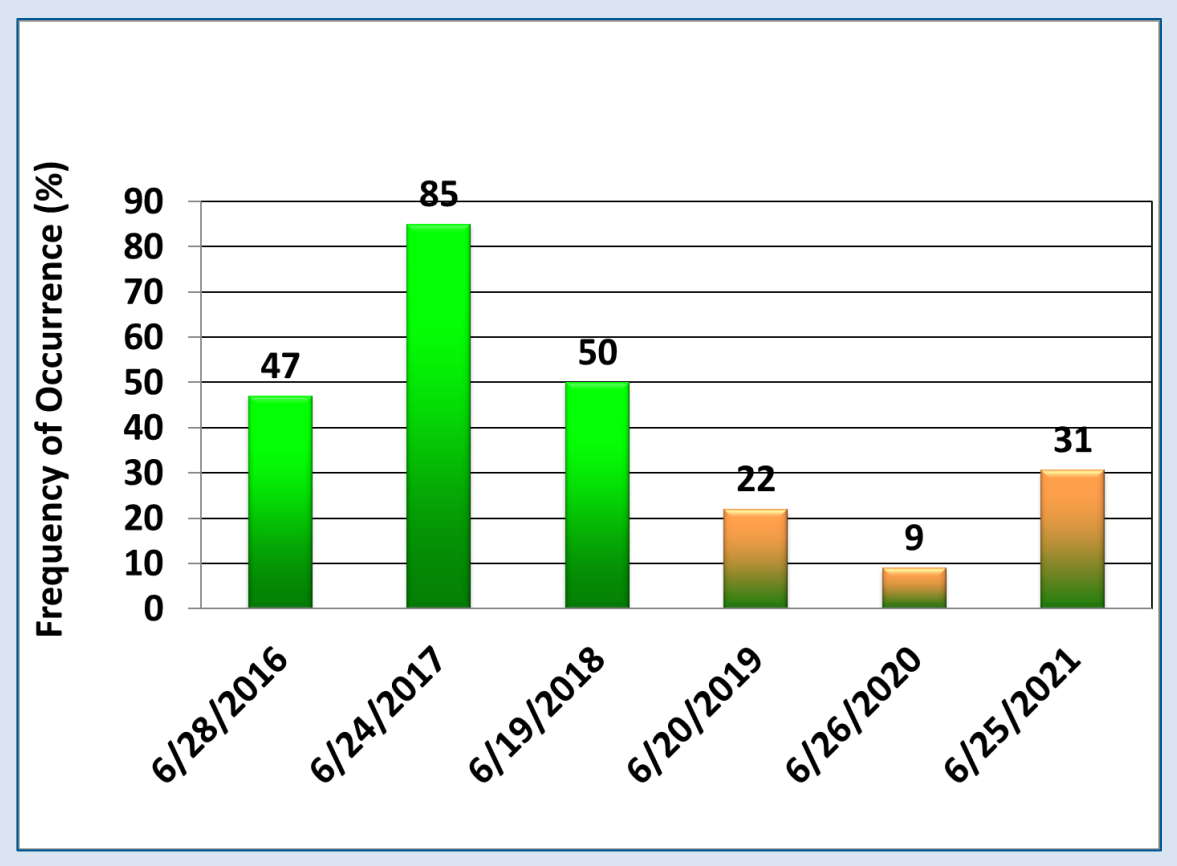


Figure 9-11 **2016-2021 comparison of Normandale Lake curly-leaf pondweed frequency of occurrence in June prior to and after initiation of the water quality improvement project. Note: green bars indicate values prior to water quality improvement project and orange bars indicate values during water quality improvement project (i.e., after drawdown and/or during years in which curly-leaf pondweed was treated with herbicide).**

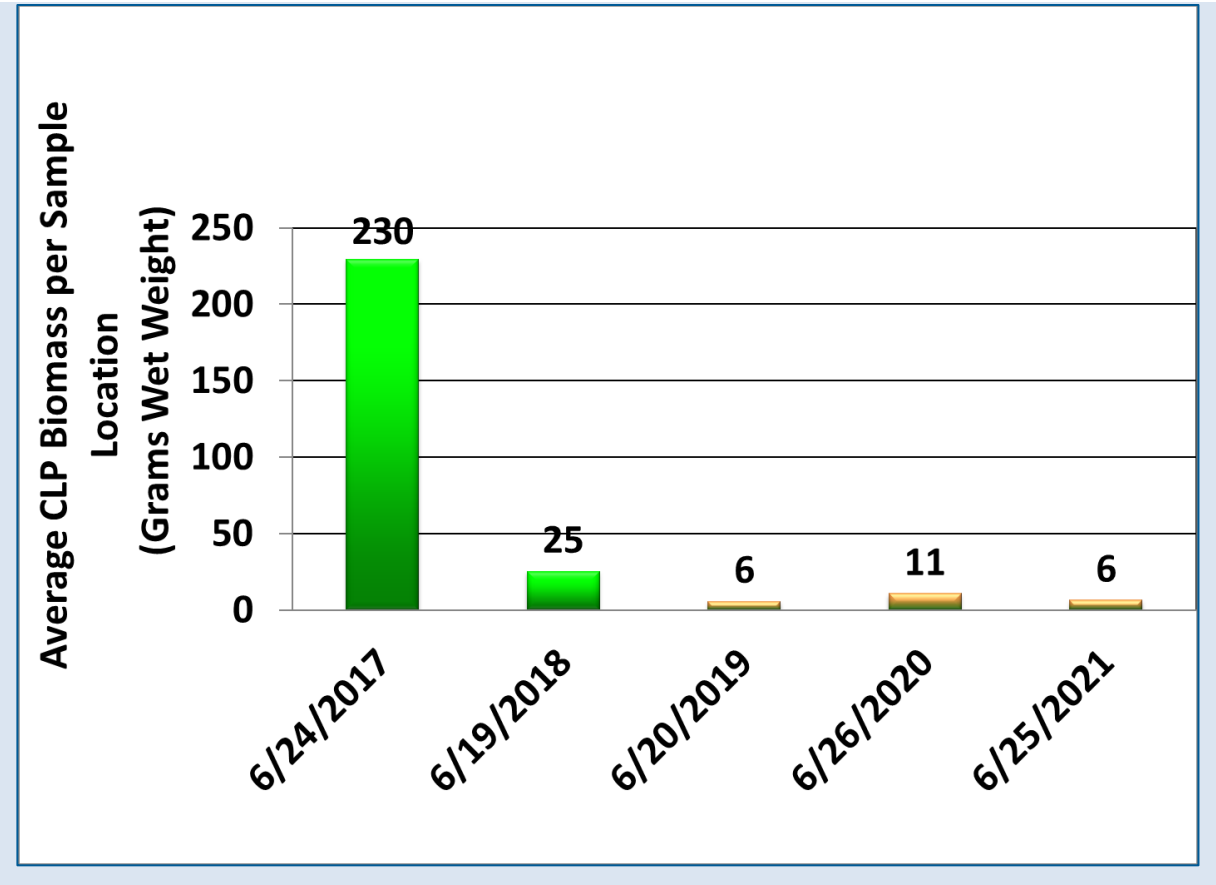


Figure 9-12 **2016-2021 comparison of Normandale Lake curly-leaf pondweed biomass (average wet weight per sample location) in June prior to and after initiation of the water quality improvement project. Note: green bars indicate values prior to water quality improvement project and orange bars indicate values during water quality improvement project (i.e., after drawdown and/or during years in which curly-leaf pondweed was treated with herbicide).**

9.6.2 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 show an overall decrease in biomass of the plant community after the project. The data indicate biomass of the plant community was lower than pre-project levels in June and August of 2019, the summer immediately following the drawdown. Plant biomass in 2020 and 2021 was similar to the lower end of the range of biomass levels observed in 2017 and 2018 prior to the drawdown (Figure 9-13). Biomass in June 2021 was similar to biomass in June 2020. Biomass in August 2021 was lower than biomass observed in 2020 and also lower than biomass observed prior to the water quality improvement project.

The data in Figure 9-15 also show the dominant species throughout the period of record. In 2021, 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 9-13).

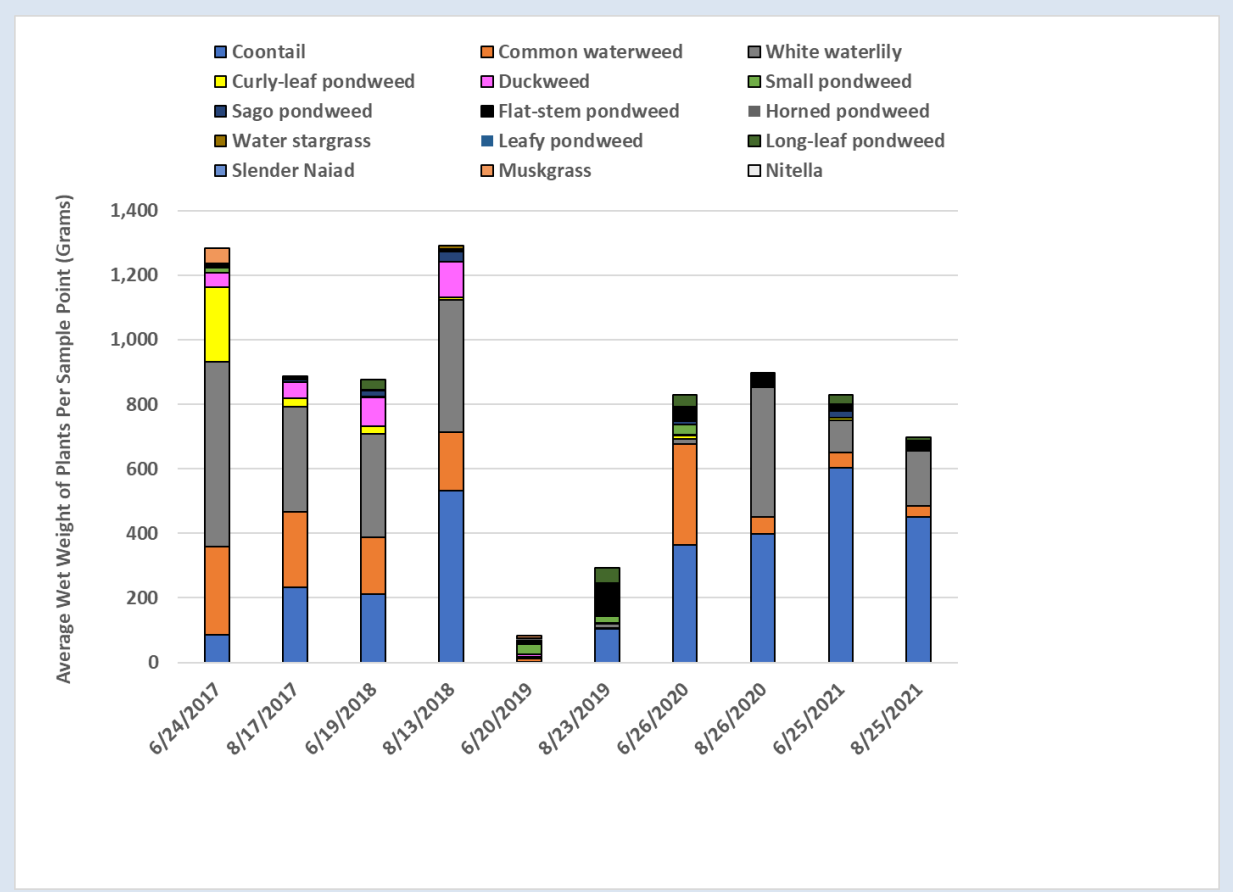


Figure 9-13 2017-2021 comparison of Normandale Lake biomass, measured as average wet weight of plants per sample point. The stacked bar graph above shows individual species wet weights (average per sample point) and the collective total of all species' average wet weights per sample point for each sample event

The frequency of occurrence of individual species in the plant community was measured in Normandale Lake during 2016 through 2021 to help assess impacts of the water quality improvement project. Plant species in Normandale Lake have varied since the project began, some occurring at a higher frequency, some at a similar frequency, and some at a lower frequency than pre-project levels. The frequency of occurrence of the twelve most frequently occurring species in 2021 were compared with frequencies observed before the water quality improvement project. The results of this comparison are discussed below (Figure 9-14).

- **Coontail, common waterweed, small pondweed, and water star-grass** occurred at similar frequencies in 2021 as before the project.
- **Curly-leaf pondweed** occurred at a lower frequency in June 2021 as before the project while the August 2021 frequency was within the range of frequencies observed before the project.
- **Large duckweed, small duckweed, common watermeal, and white water lily** occurred at lower frequencies in 2021 as before the project.
- **Sago pondweed, flat-stem pondweed, and long-leaf pondweed** occurred at higher frequencies in 2021 than before the project.

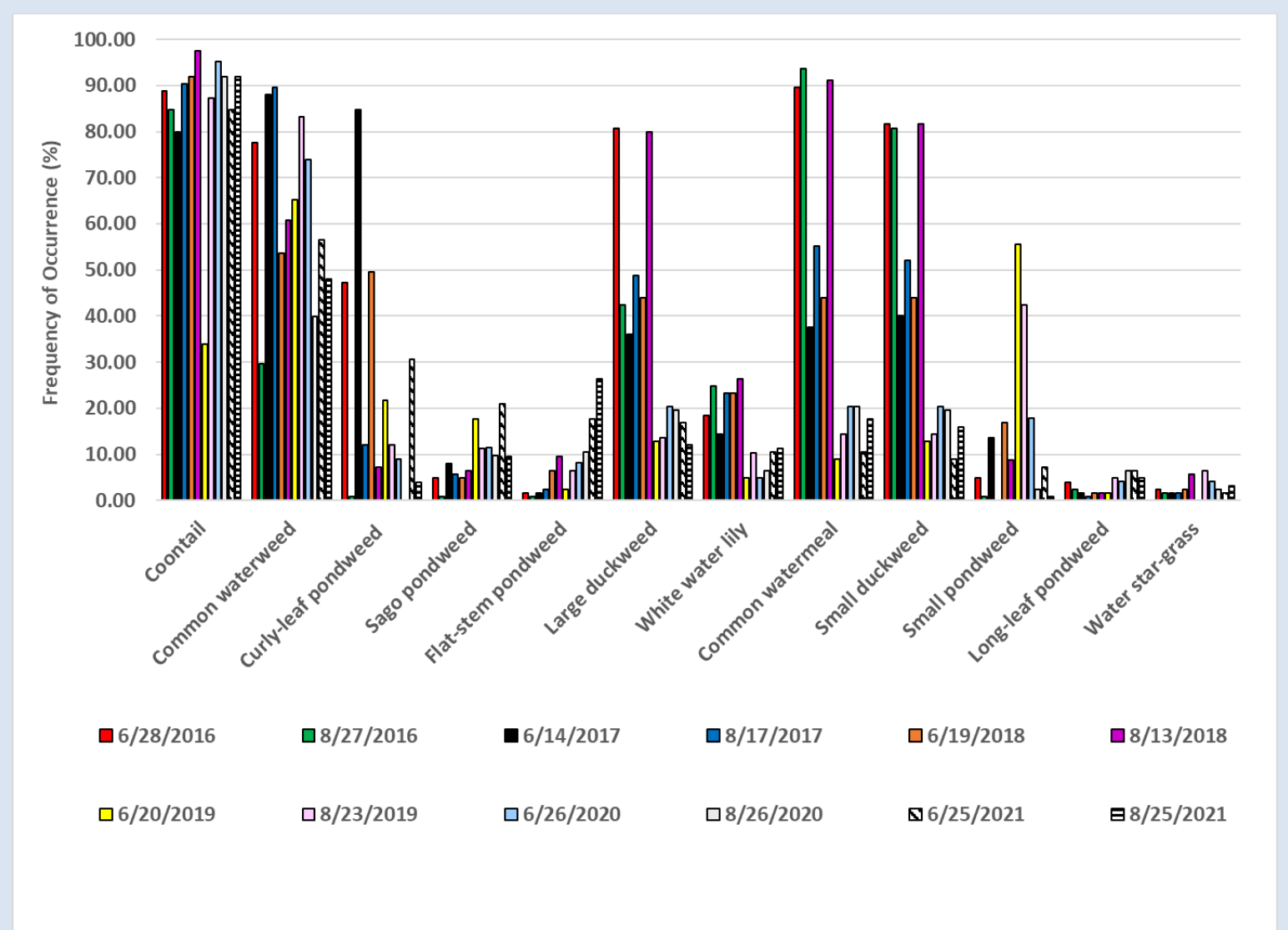


Figure 9-14 2016-2021 comparison of Normandale Lake frequency of occurrence of individual species. Above graph shows the 2016-2021 frequency of occurrence of the twelve individual species occurring most frequently in Normandale Lake in 2021

9.6.3 Turion Survey Results

Location and density of curly-leaf pondweed turions in Normandale Lake were assessed following the lake drawdown. Turions are the primary reproductive structures of curly-leaf pondweed and are found in the lake bottom. They are brown, typically half-inch in size, and look like sharp small pinecones (Figure 9-15). The objective 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 through 2021 to determine where turions were found in the lake, their density, and their size. Results of the turion surveys are provided in Appendix I.

The 2019 survey found some turions remaining in the lake sediment following the drawdown that occurred in the winter of 2018-2019, 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.

During 2019, live turions were found at 19 of the 50 sample points (38 percent) compared with live turions found at 14 sample points in 2020 (28 percent) and 17 sample points in 2021 (34 percent) (Figure 9-16). During 2019, a total of 36 live turions were collected from all 50 sample points compared with 21 live turions collected in 2020 and 27 live turions collected in 2021 (Figure 9-17). While results from the 2020 and 2021 turion monitoring showed fewer locations with turions and fewer turions than 2019, the year-over-year differences were not statistically significant.

Figure 9-15 A germinating curly-leaf pondweed turion (Photo Credit: Endangered Resource Services, LLC)

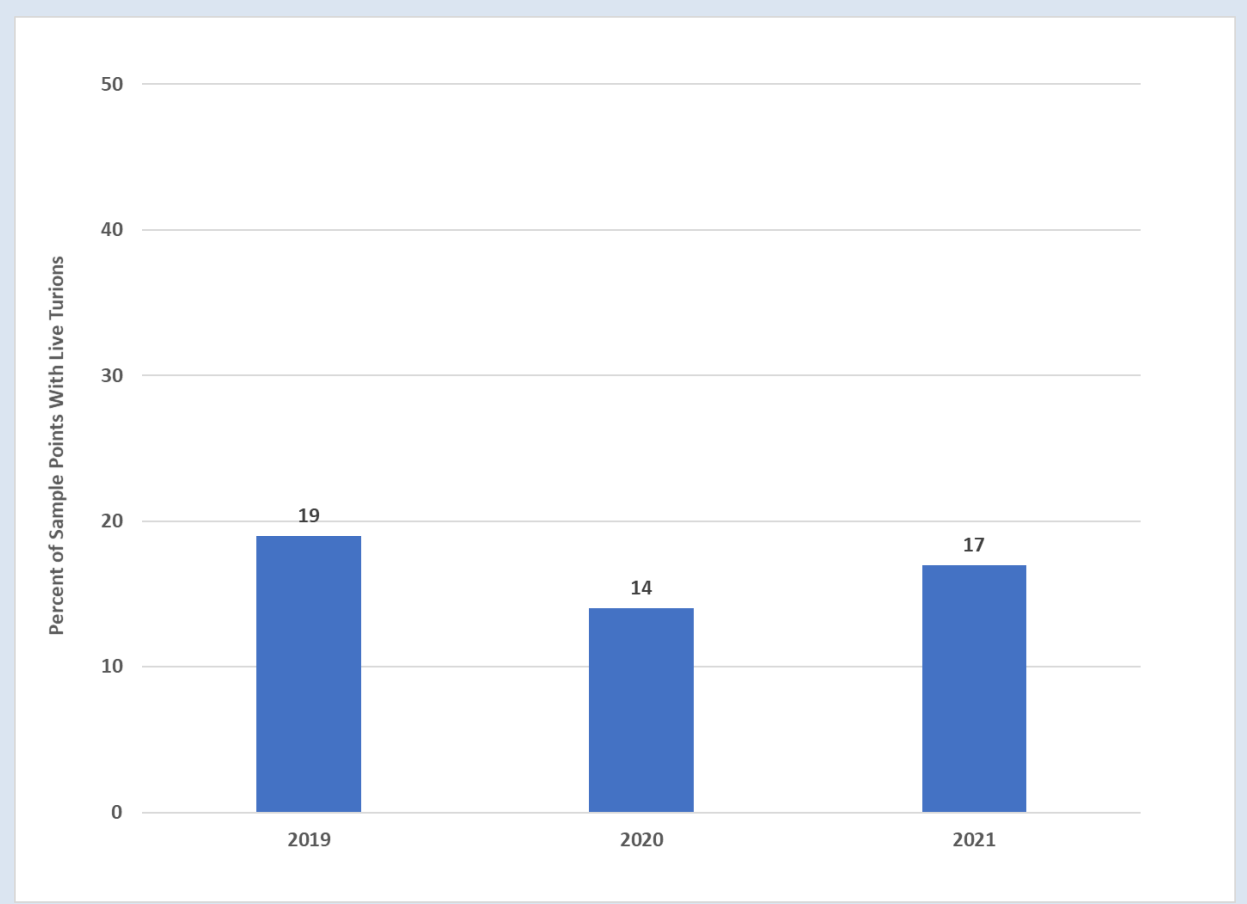


Figure 9-16 Percent of Sample Points in Normandale Lake with Live Turions During 2019-2021

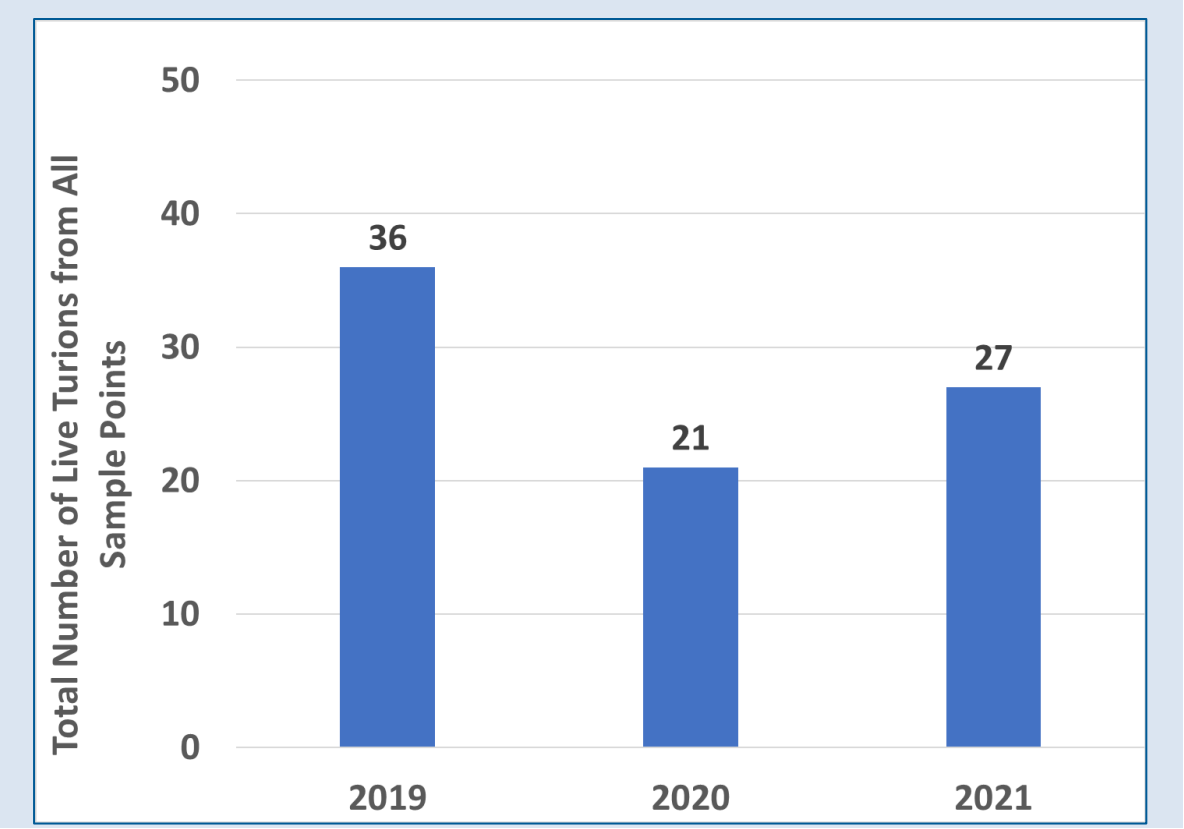


Figure 9-17 Total Number of Live Turions Collected from all Normandale Sample Points in 2019-2021

9.7 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 aquatic plant that dies off in late June, releasing phosphorus to the lake as it decays which can fuel algal growth and reduce 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 and 2021, herbicide treatments were 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.

2021 results indicate that chloride concentrations in April and June exceeded the MPCA chronic chloride criterion, but all 2021 chloride concentrations met the MPCA acute chloride criterion. The average summer total phosphorus and chlorophyll *a* concentrations and summer average Secchi disc (measure of clarity) met the State eutrophication criteria for shallow lakes.

The phytoplankton communities in Normandale Lake in 2021 were generally dominated by green algae and cryptomonads, with some diatoms and blue-green algae observed. Green algae, diatoms, and cryptomonads are a good quality food source and contribute towards a healthy zooplankton community, whereas blue-green algae are a poor quality food source for zooplankton. Blue-green algae can produce

algal toxins, which can be harmful to humans or other animals. The blue-green algae numbers observed at the District's routine monitoring location during the monitored period were below the World Health Organization (WHO) guideline threshold for low probability of adverse health effects to recreational users.

In 2021, filamentous algae frequency of occurrence at sample points throughout the lake ranged from 52 percent to 62 percent based on the June and August plant surveys, which was within the range observed during 2016 through 2020.

A primary objective of the lake drawdown and subsequent herbicide treatments was to reduce the amount of curly-leaf pondweed in Normandale Lake. Aquatic plant surveys conducted in June and August of 2021 indicate the frequency and biomass of curly-leaf pondweed continues to be lower than levels prior to implementation of the water quality improvement project. The biomass of curly-leaf pondweed observed in June 2021 was similar to levels observed in 2019. However, the frequencies of occurrence of curly-leaf pondweed observed in June and August 2021 were higher than the respective frequencies observed in 2019 and 2020.

The lake's plant community in 2021 met the MNDNR Plant IBI thresholds, with the highest number of species to date observed in August of 2021. Plant biomass in Normandale Lake 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 2019-2021 data show a moderate decrease in biomass of the plant community after the project. The dominant species observed in 2021 included coontail, common waterweed, and white water lily, which were generally the three species with the greatest biomass prior to the drawdown. The frequencies of the twelve most commonly occurring species in 2021 were compared with frequencies observed before the water quality improvement project. The comparison indicated 4 species occurred at a similar frequency in 2021 as before the project (coontail, common waterweed, small pondweed, and water star-grass), 4 species occurred at a lower frequency in 2021 as before the project (large duckweed, small duckweed, common watermeal, and white water lily), 3 species occurred at a higher frequency in 2021 as before the project (sago pondweed, flat-stem pondweed, and long-leaf pondweed), and curly leaf pondweed occurred at a lower frequency of occurrence in June 2021 as it did in June prior to the project and at a similar frequency in August 2021 as it did in August prior to 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.

10 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 10-1). The 2021 Nine Mile Creek monitoring program included:

- March through October monthly measurements of specific conductance, dissolved oxygen, pH, temperature, turbidity, and flow.
- Annual monitoring of the fish community during summer.
- Annual monitoring of the macroinvertebrate community during October.
- Annual habitat monitoring during summer (i.e., stream substrate type, depth of fine sediment, percent embeddedness, and length of eroded streambank).

Ten locations were monitored in 2021, including four locations 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.

Figure 10-1 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.

Data collected during 2021 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.
- Fish data met MPCA Fish Index of Biotic Integrity (FIBI) standards published in Minnesota Rule Chapter 7050.
- Macroinvertebrate data met MPCA Macroinvertebrate Index of Biotic Integrity (MIBI) standards published in Minnesota Rule Chapter 7050.

Flow and water quality results are summarized in Appendix J. Fish and macroinvertebrate results are summarized in Appendix K.

10.1 Nine Mile Creek Water Quality

In 2021, measurements for dissolved oxygen, temperature, specific conductance, pH, turbidity, and discharge occurred monthly during March 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). 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, 85 percent of the 2021 observed values were within MPCA standards. The South Fork (89 percent of observed values) and Main Stem (88 percent of observed values) met MPCA standards most frequently followed by the North Fork (81 percent of observed values). In 2021, all observed values from the upstream South Fork location, ECU-3A, met the MPCA standard (Figure 10-2). All Nine Mile Creek temperature and pH measurements, 86 percent of the dissolved oxygen measurements, and 55 percent of the specific conductance measurements met MPCA standards.

Figure 10-2 Upstream South Fork Location ECU-3A
In 2021, 89% of South Fork conductance, dissolved oxygen, pH, and temperature values met the MPCA standards. At the South Fork upstream location, ECU-3A pictured above, these levels met the MPCA standards 100 percent of the time.

Figure 10-3 Downstream North Fork Location ECU-2A
In 2021, the North Fork met the specific conductance standard less frequently than other locations. Pictured above is downstream North Fork location ECU-2A.

Consistent with previous years, the specific conductance criterion was met less frequently in 2021 than other 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 with a slightly lower frequency in 2021 than 2020—55 percent met the MPCA standard in 2021 compared with 56 percent in 2020. Specific conductance was high in the fall at several locations. As in previous years, the North Fork locations met the MPCA standard for specific conductance less frequently than other sampling locations—38 percent of the North Fork measurements met the MPCA specific conductance standard in 2021 compared with 63 percent of Main Stem and 71 percent of South Fork measurements. Specific

conductance measurements from station ECU-1A-1 (North Fork just upstream of Hopkins/Edina boundary) exceeded the water quality criteria during each sampling event (March through October) in 2021. During the period of record (2009 through 2021), 90 percent of specific conductance measurements at this location have exceeded the MPCA standard (Figure 10-4). Specific conductance measurements from North Fork locations ECU-2 (near Cahill Road and Brook Drive in Edina), N2 (at Metro Boulevard in Edina), and ECU-2A (downstream of Interstate 494 and immediately upstream of 81st Street in Bloomington) exceeded the water quality criteria during April through June and during October of 2021. During the period of record (1997 through 2021), 45 percent of specific conductance measurements from ECU-2 and 55 percent of specific conductance measurements from ECU-2A have failed to meet the MPCA standard (Figure 10-5 and Figure 10-6).

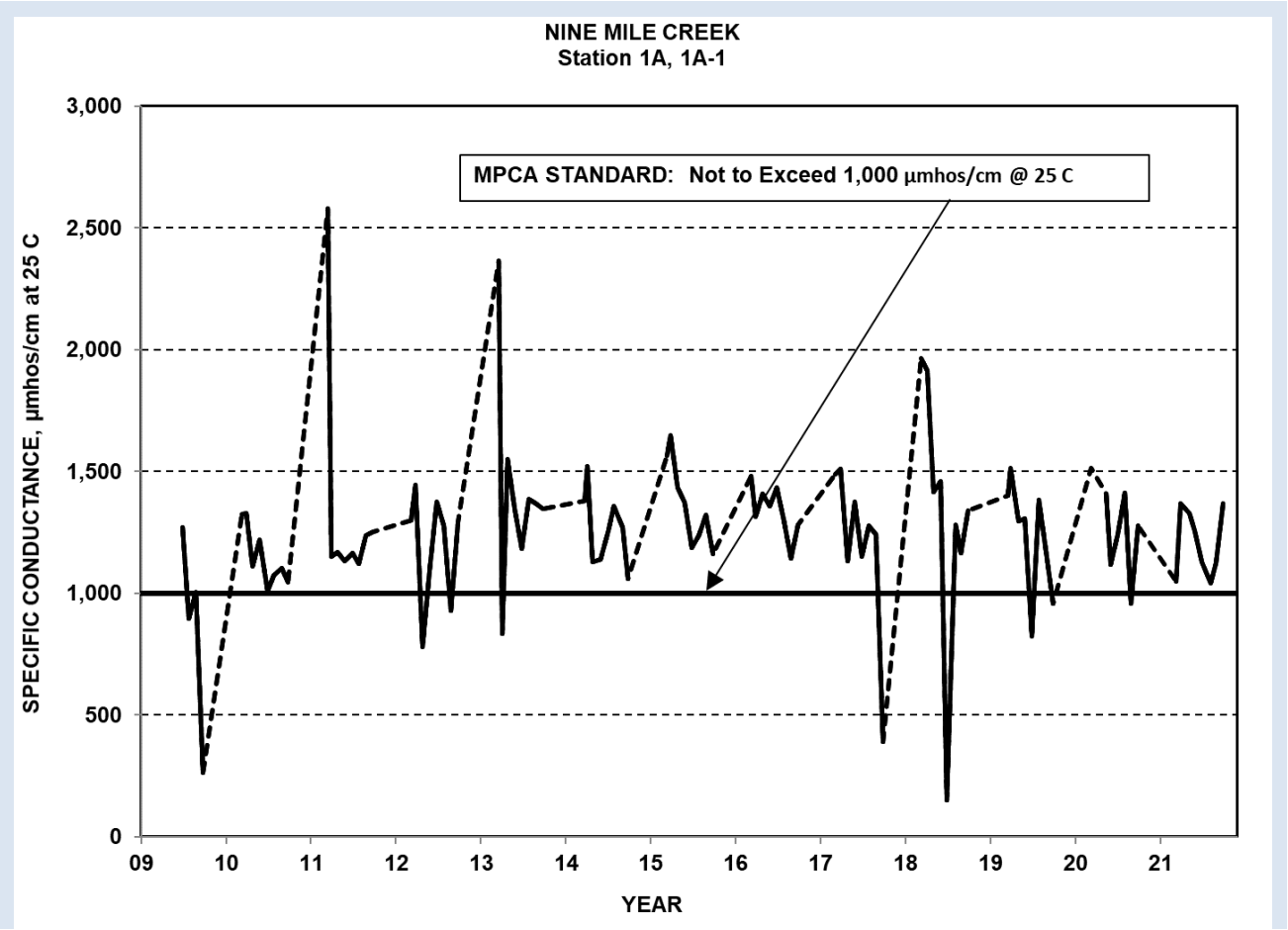


Figure 10-4 2009-2021 Specific Conductance Measurements from Station ECU-1A-1 (North Fork Just Upstream of the Hopkins/Edina Boundary) Compared with the MPCA Standard

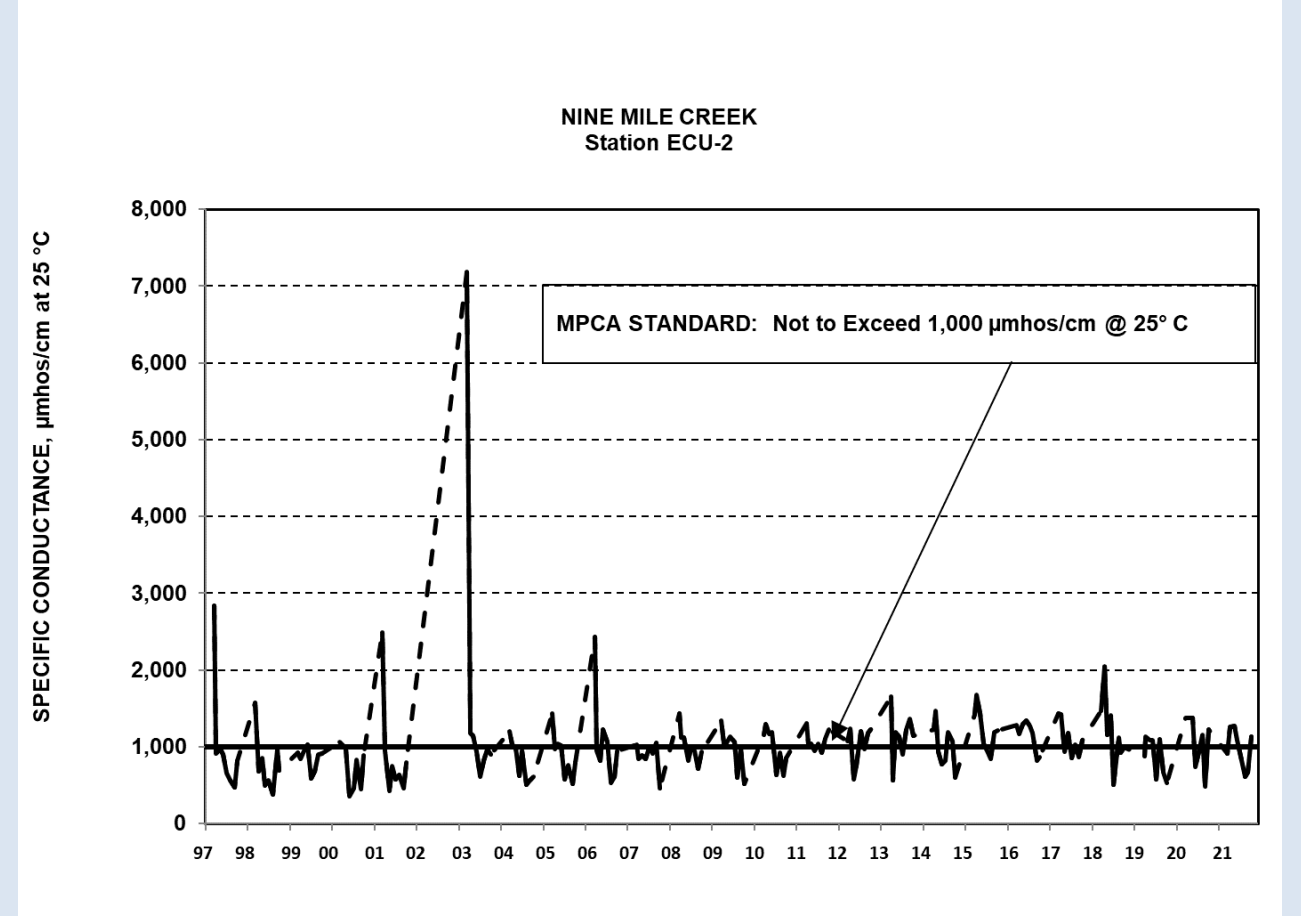


Figure 10-5 1997-2021 Specific Conductance Measurements from Station ECU-2 (North Fork near Cahill Road and Brook Drive) Compared with the MPCA Standard

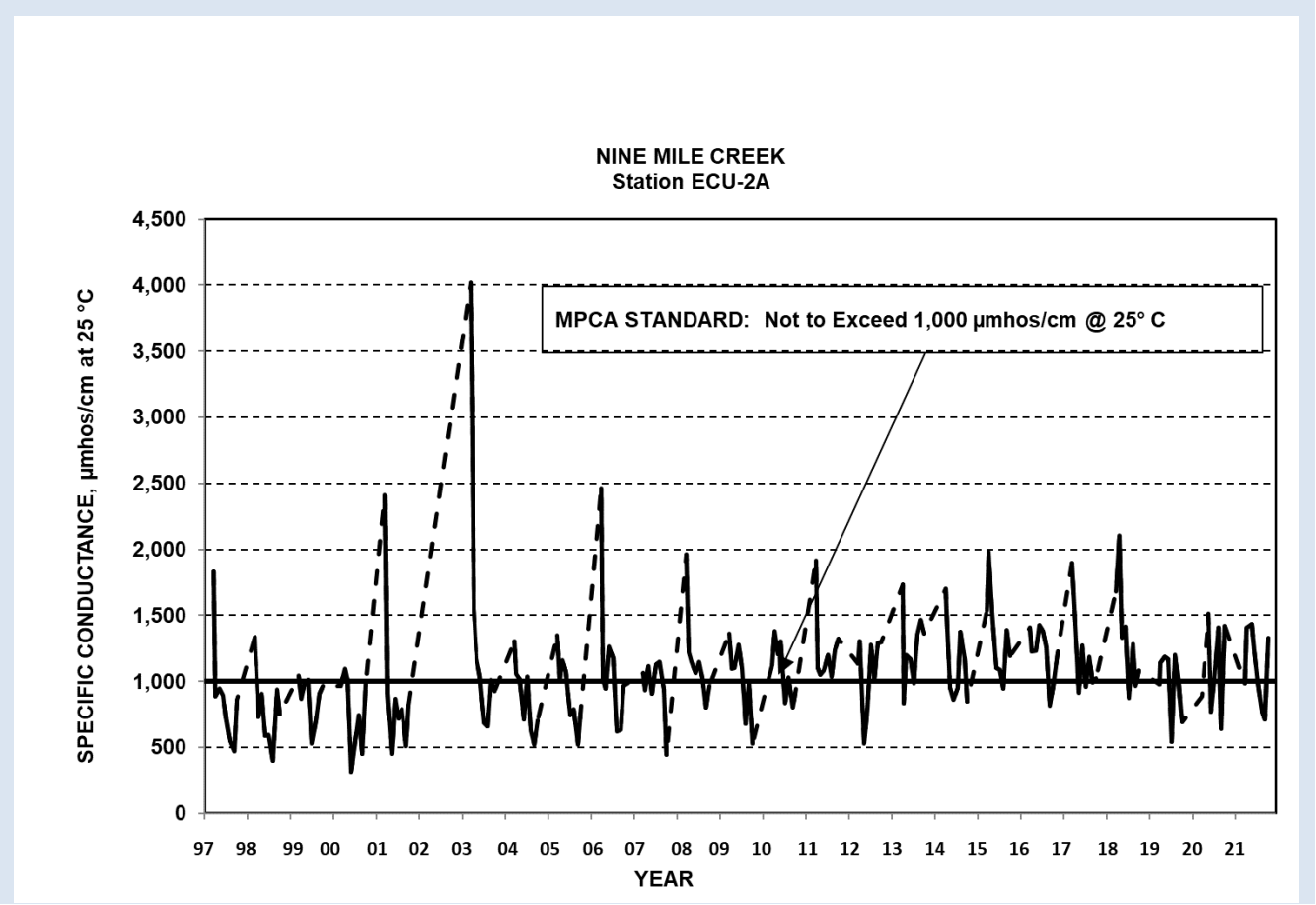


Figure 10-6 1997-2021 Specific Conductance Measurements from Station ECU-2A (North Fork Downstream of Interstate 494 and immediately upstream of 81st Street in Bloomington) Compared with the MPCA Standard

The consistent exceedance of the MPCA specific conductance standard in the North Fork of Nine Mile Creek during the period of record has been unfavorable for the aquatic life in the stream. The *Nine Mile Creek Biological Stressor Identification* prepared for the Minnesota Pollution Control Agency in November 2010 identified ionic strength due to chlorides as one of the stressors to the biological community in the North Fork of Nine Mile Creek. The study concluded that inadequate dissolved oxygen and high sediment from watershed runoff were the primary stressors causing the stream's fish impairment, but that high chloride concentrations also stressed the stream's biological community.

Dissolved oxygen measurements from Nine Mile Creek met the MPCA standard with a similar, but slightly lower frequency in 2021 than 2020—86 percent met the MPCA standard in 2021 compared with 90 percent in 2020. In 2021, the South Fork met the MPCA standard for dissolved oxygen less frequently than other sampling locations — 83 percent of the dissolved oxygen measurements from the South Fork were within the MPCA criterion in 2021 compared with 88 percent of North Fork and 88 percent of Main Stem measurements.

In 2021, dissolved oxygen levels were below (poorer than) the MPCA standard at the following locations:

- ECU-2 (North Fork near Cahill Road and Brook Drive in Edina) during June, July, September, and October;
- N2 (South Fork at West 78th Street in Bloomington) during August and September;
- ECU-5A (South Fork in Corridor Park immediately downstream from Interstate 494 in Bloomington and west of East Bush Lake Road) during August and October; and
- ECU-7A/N1 (Main Stem of Nine Mile Creek, downstream of Marsh Lake and immediately downstream of 98th Street in Bloomington) during July, August, and September

The *Nine Mile Creek Biological Stressor Identification* (November 2010) concluded the low dissolved oxygen levels in the North Fork and South Fork of Nine Mile Creek were primarily related to reduced flow resulting from low precipitation as well as diel effects (reduced oxygen during the night due to respiration by plants and/or algae when there is no photosynthesis to add oxygen to the stream). 2021 data collected from North Fork location ECU-2 (near Cahill Road and Brook Drive in Edina) and South Fork location ECU-5A (in Corridor Park immediately downstream from Interstate 494 in Bloomington and west of East Bush Lake Road) indicate the stream's low dissolved oxygen levels occurred during periods of low flow (Figure 10-7 and Figure 10-8).

The biological stressor identification study found that low dissolved oxygen concentrations at the upstream Main Stem location, ECU-7A/N1 (downstream of Marsh Lake and immediately downstream of 98th Street in Bloomington), were due to the influence of Marsh Lake on downstream waters. Oxygen levels within Marsh Lake fluctuate due to biological activity within the marsh – plant photosynthesis raises oxygen levels and plant decay lowers oxygen levels. Hence, water flowing from the marsh may have either lower or higher oxygen levels than downstream locations, depending upon biological processes occurring within the marsh. 2021 data from ECU-7A/N1 indicate the stream was receiving flow from Marsh Lake when low oxygen levels were measured (Figure 10-9). The likely cause of the low oxygen levels at this location in 2021 is water flowing from the marsh with low oxygen levels due to biological activity within the marsh.

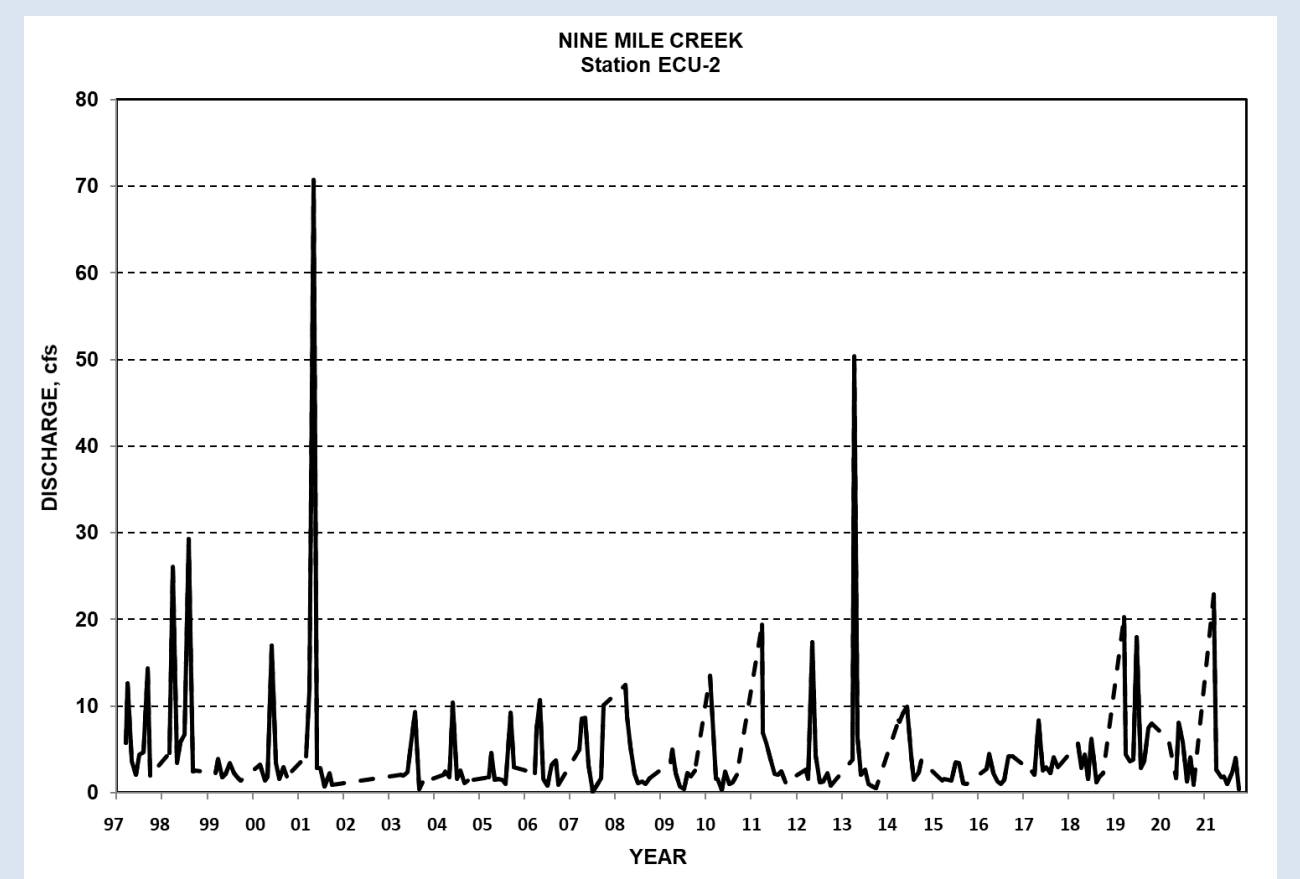


Figure 10-7 1997-2021 Discharge Measurements from Station ECU-2 (North Fork near Cahill Road and Brook Drive in Edina)

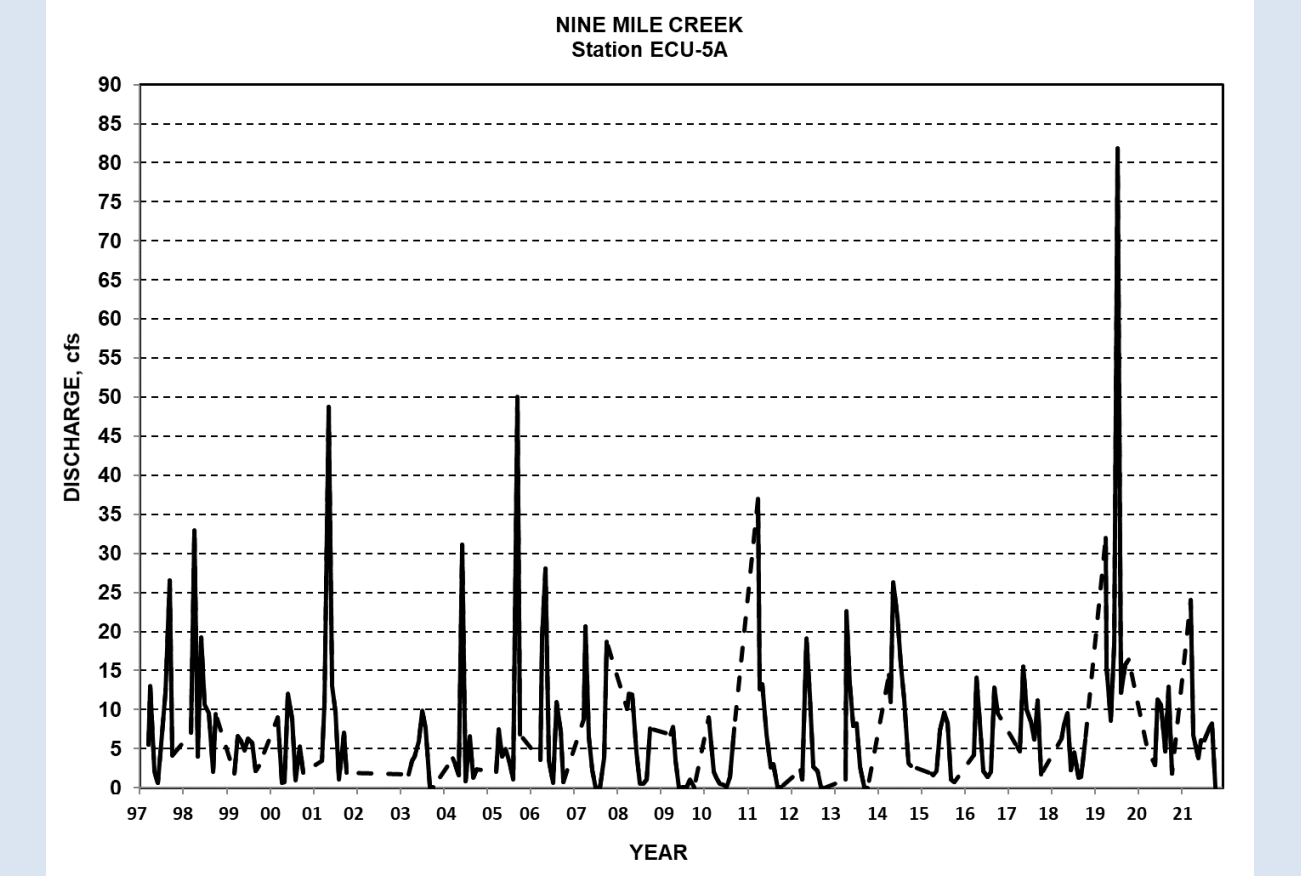


Figure 10-8 **1997-2021 Discharge Measurements from Station ECU-5A (South Fork in Corridor Park immediately downstream from Interstate 494 in Bloomington and west of East Bush Lake Road)**

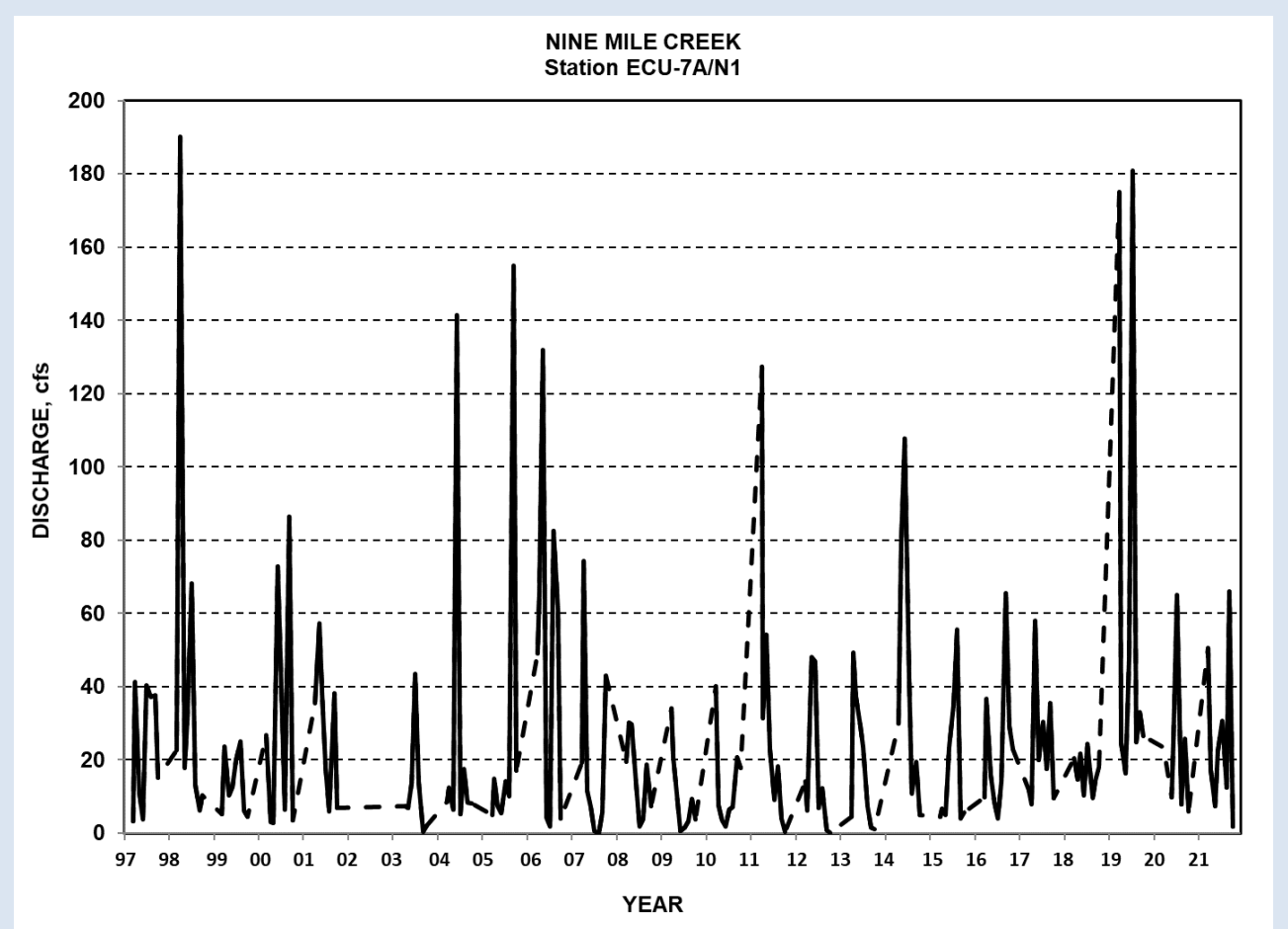


Figure 10-9 1997-2021 Discharge Measurements from Station ECU-7A/N1 (Main Stem downstream of Marsh Lake and immediately downstream of 98th Street in Bloomington)

In 2021, 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 values of 1.8 NTU and 2.1 NTU measured at North Fork locations ECU-1A-1 (just upstream of the Hopkins/Edina Boundary) and ECU-2 (near Cahill Road and Brook Drive in Edina), respectively, on October 1, 2021 were lower than values previously measured at these locations. The lower values indicated the stream was less turbid, a favorable change for the stream. Low flow was observed at both locations during the October 1 sample event (1.2 cfs at ECU-1A-1 and 0.4 cfs at ECU-2) due to low precipitation. Hence, the lower turbidity measurement was likely due to reduced sediment loading resulting from reduced stormwater runoff to the stream.

Although the North Fork observed the lowest turbidity values to date at its two most upstream locations on October 1, high turbidity values were measured at all North Fork locations on March 11. Turbidity measures the relative clarity of the stream and provides an indication of the quantity of sediment in the stream. Minnesota state standards included a turbidity standard of 25 Nephalometric Units (NTU) from the 1960's through 2014, when the MPCA replaced the turbidity standard with a total suspended solids standard, a more appropriate standard for computing total maximum daily loads (TMDL). Turbidity

measurements from the North Fork during the period of record are shown in Figure 10-10, Figure 10-11, and Figure 10-12. All 2021 March turbidity measurements from North Fork locations exceeded the former state standard of 25 NTU for turbidity, ranging from 30 NTU at ECU-2 (Figure 10-11) to 50 NTU at ECU-2A (Figure 10-12). The high March values indicate high sediment concentrations were present in the stream following spring snowmelt. The *Nine Mile Creek Biological Stressor Identification* (November 2010) concluded that sediment, together with inadequate dissolved oxygen, were primary stressors of the North Fork biological community, followed by ionic strength due to excess chlorides.

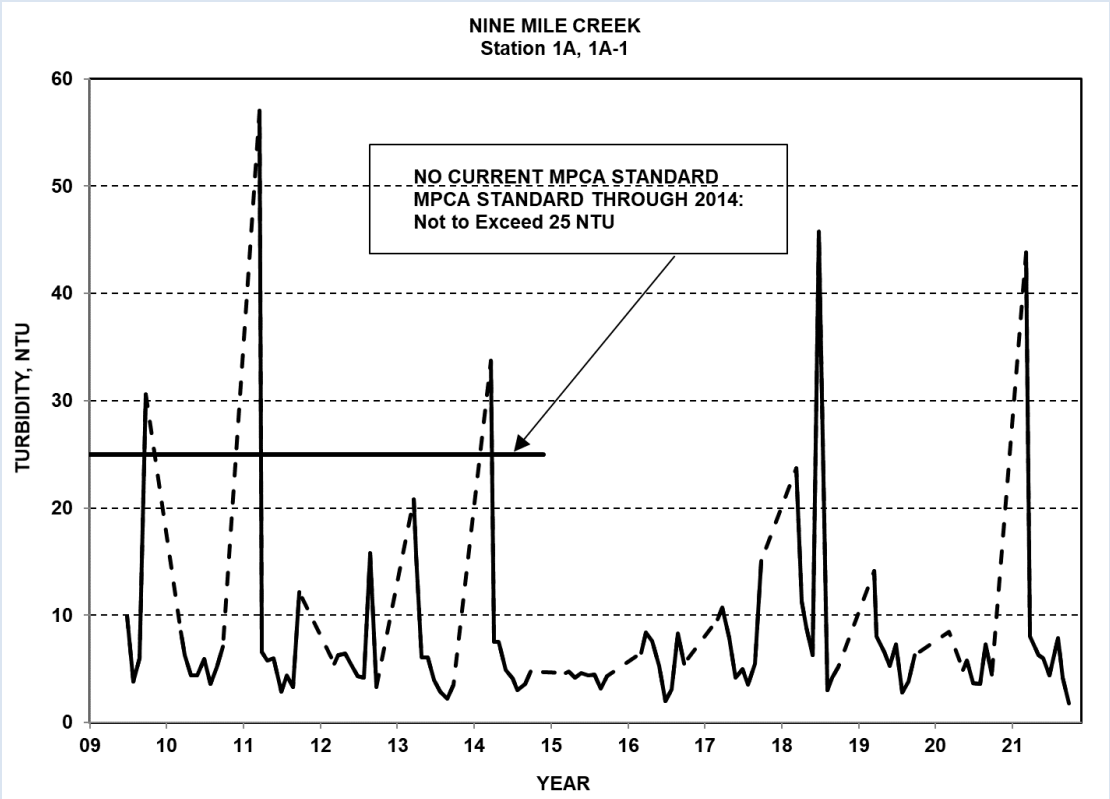


Figure 10-10 **2009-2021 Turbidity Measurements from Station ECU-1A-1 (North Fork Just Upstream of the Hopkins/Edina Boundary) Compared with the MPCA Standard for Turbidity during 2009-2014**

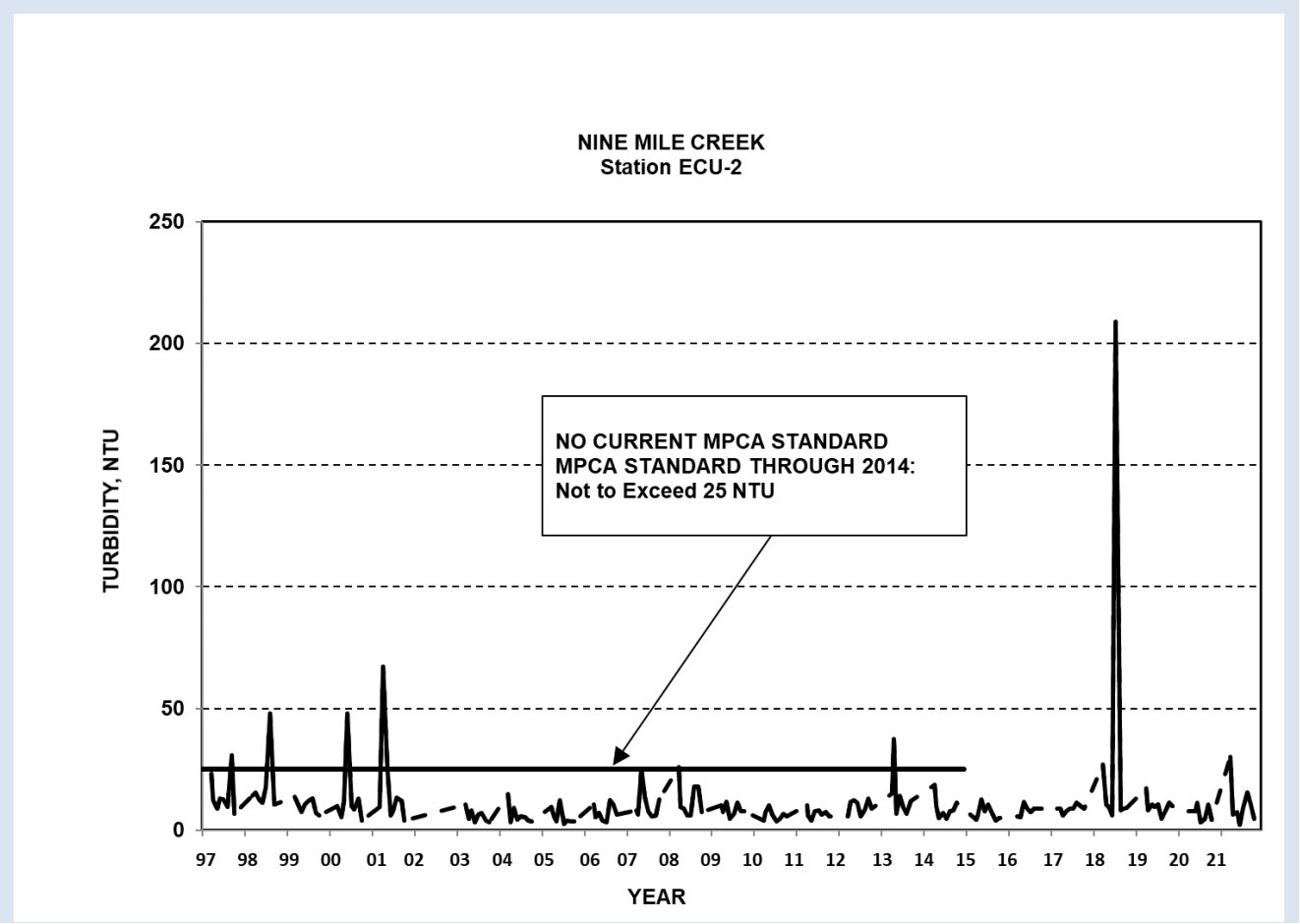


Figure 10-11 **Turbidity Measurements from Station ECU-2 (North Fork near Cahill Road and Brook Drive in Edina) Compared with the MPCA Standard for Turbidity during 2009-2014**

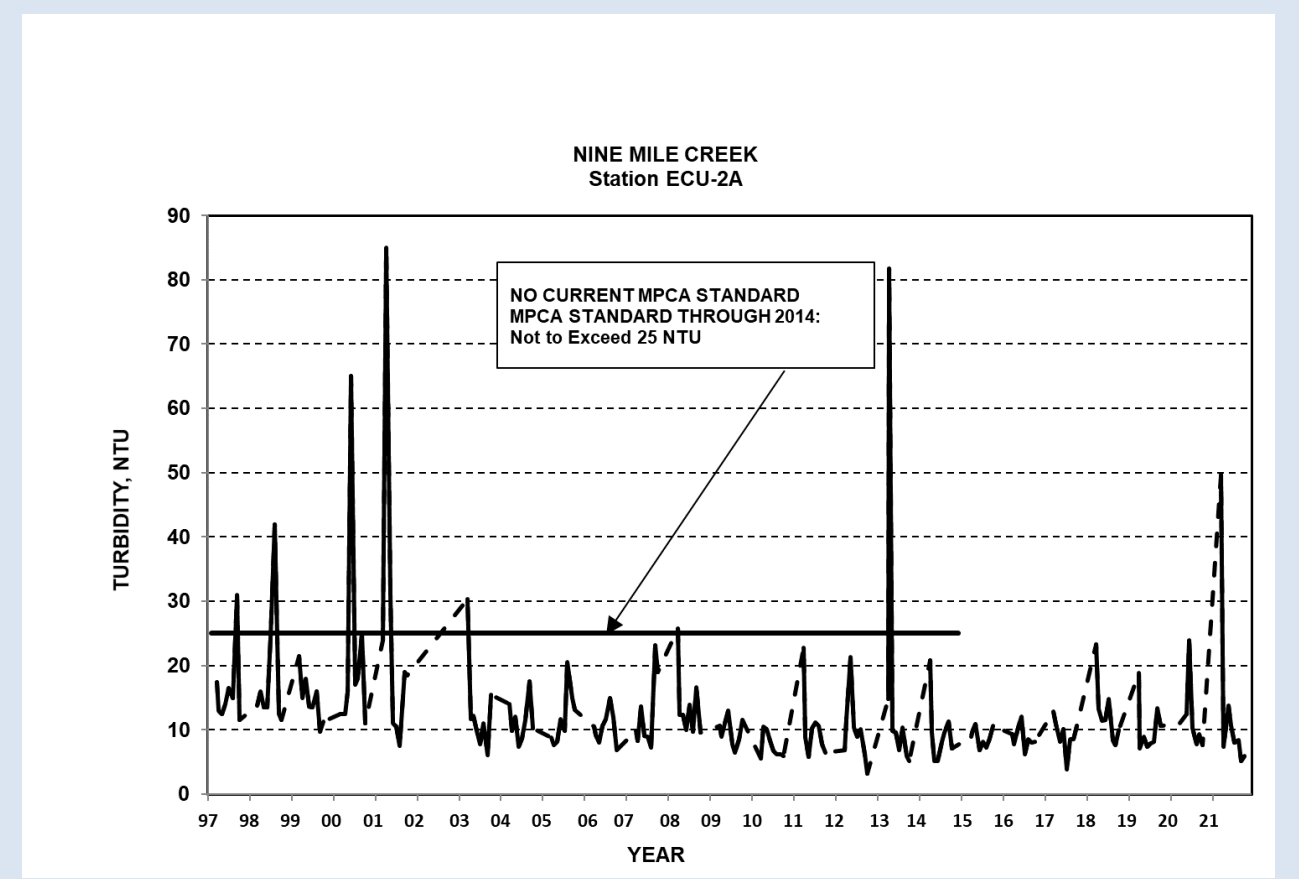


Figure 10-12 **Turbidity Measurements from Station ECU-2A (North Fork Downstream of Interstate 494 and immediately upstream of 81st Street in Bloomington in Edina) Compared with the MPCA Standard for Turbidity during 2009-2014**

10.2 FIBI and MIBI

10.2.1 MPCA Development of FIBI and MIBI

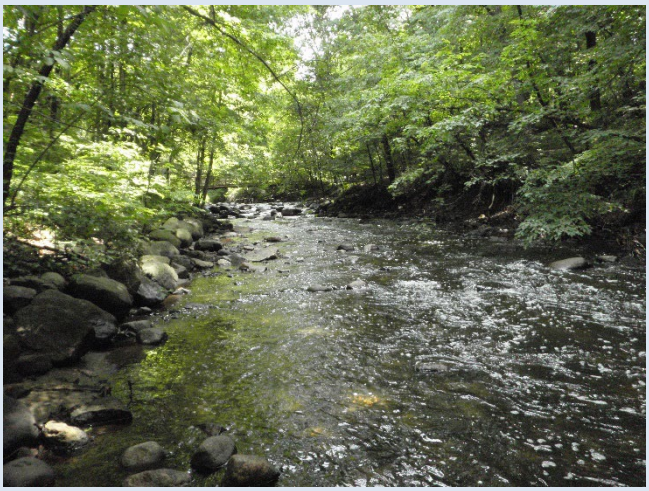


Figure 10-13 Downstream Main Stem Location ECU-7C
In 2021, all temperature, pH, dissolved oxygen, specific conductance, discharge, and turbidity values from downstream Main Stem location ECU-7C, pictured above, were within the range of values measured during the period in which data were collected.

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 10-1 summarizes the MPCA assessment results.

Table 10-1 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.

10.2.2 Fish Index of Biotic Integrity (FIBI)

Background

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 10.2, 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

Figure 10-14 Middle Main Stem Location ECU-7B
The 2021 FIBI value at the middle Main Stem Location ECU-7B, pictured above, did not meet the FIBI standard.

The MPCA assigned a beneficial use classification to each reach. The North Fork of Nine Mile Creek from Metro Boulevard to end of unnamed wetland 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 North Fork of Nine Mile Creek from Metro Boulevard to end of unnamed wetland 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.

Monitoring Results

Fish collected from the eight ecological use monitoring stations (Figure 1-2) in Nine Mile Creek in 2017 through 2021 were assessed to determine the FIBI values and whether the values met the MPCA FIBI standard Figure 10-15

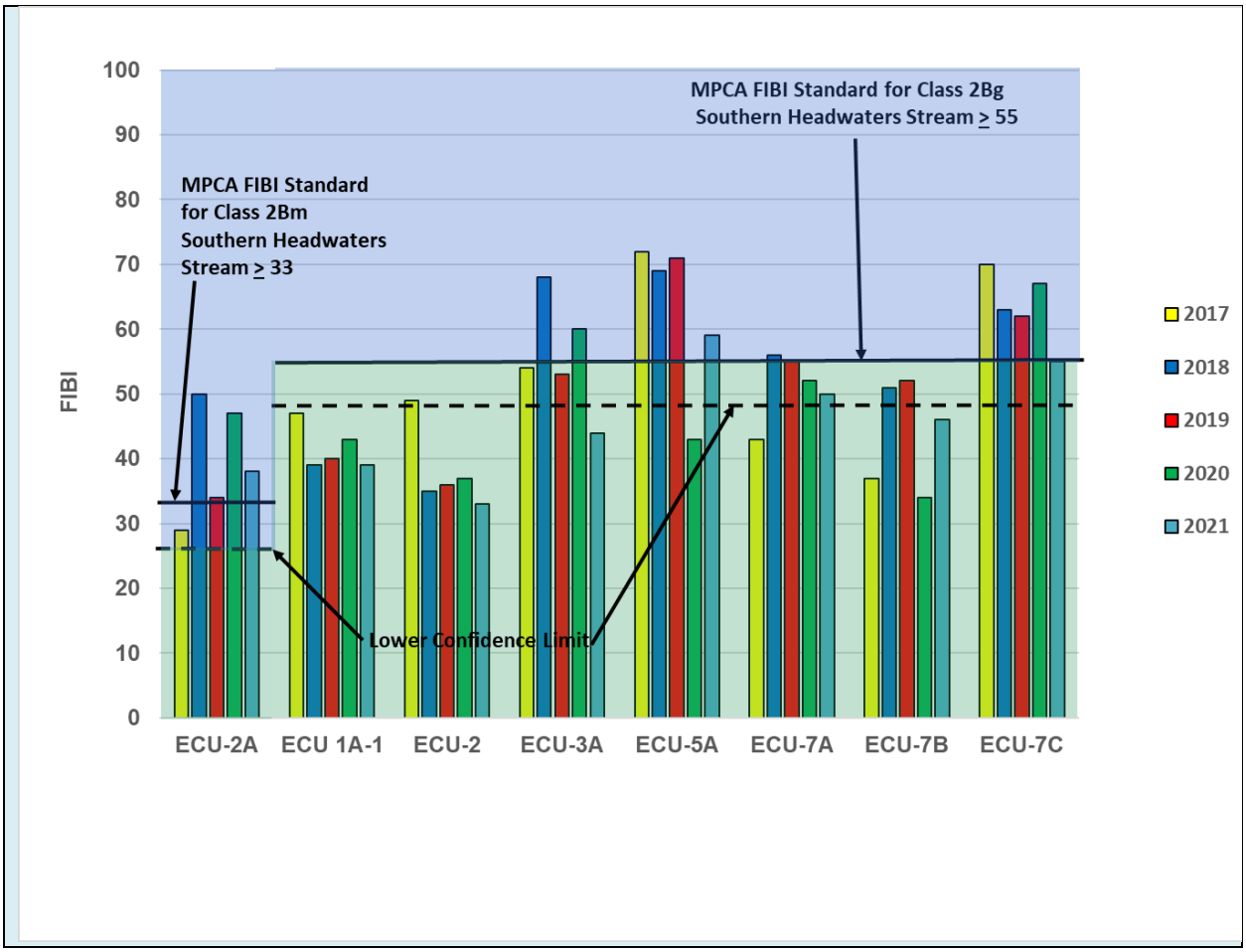


Figure 10-15 **2017-2021 Nine Mile Creek Fish Index of Biotic Integrity (FIBI) Values Compared with the MPCA FIBI Standards for a Class 2Bm Southern Headwaters Stream and a Class 2Bg Southern Headwaters Stream**

- **2021 results:** FIBI scores from the downstream South Fork location, ECU-5A (Figure 10-16), the downstream Main Stem location, ECU-7C (Figure 10-13), and the downstream North Fork location, ECU-2A (Figure 10-3), met the FIBI standard (Figure 10-15). The FIBI score from the upstream Main Stem location, ECU-7A (Figure 10-17) did not meet the standard, but its score of 50 is greater than the lower confidence limit of 48 (Figure 10-15) indicating it is relatively close to the standard. FIBI scores from the upstream South Fork location, ECU-3A (Figure 10-2), the middle Main Stem location, ECU-7B (Figure 10-14), and the two upstream North Fork locations, ECU-1A-1 (Figure 10-20) and ECU-2 (Figure 10-21) did not meet the FIBI standard (Figure 10-15).

Figure 10-16 South Fork Downstream Location ECU-5A
The 2021 FIBI value at the downstream South Fork location, ECU- 5A, pictured above, met the FIBI standard.

- **2017-2021 results:** FIBI scores from the downstream Main Stem location, ECU-7C, met the FIBI standard during all five years (Figure 10-15 and Figure 10-13). However, the 2021 score was lower than previous years and was at the impairment threshold. The lower score was likely influenced by lower flows in 2021 than previous years. Observed flows on the day of fish surveys completed during 2017 through 2021 are shown in Figure 10-18. The observed flow during the 2021 fish survey of 15 cubic feet per second (cfs) compares with flows ranging from 19 to 33 cfs during the 2017 through 2020 fish surveys.

Figure 10-17 Main Stem Upstream Location ECU-7A
The 2021 FIBI value at the upstream Main Stem location, ECU- 7A, pictured above, did not meet the FIBI standard, but its score was greater than the lower confidence limit, indicating it was close to the standard.

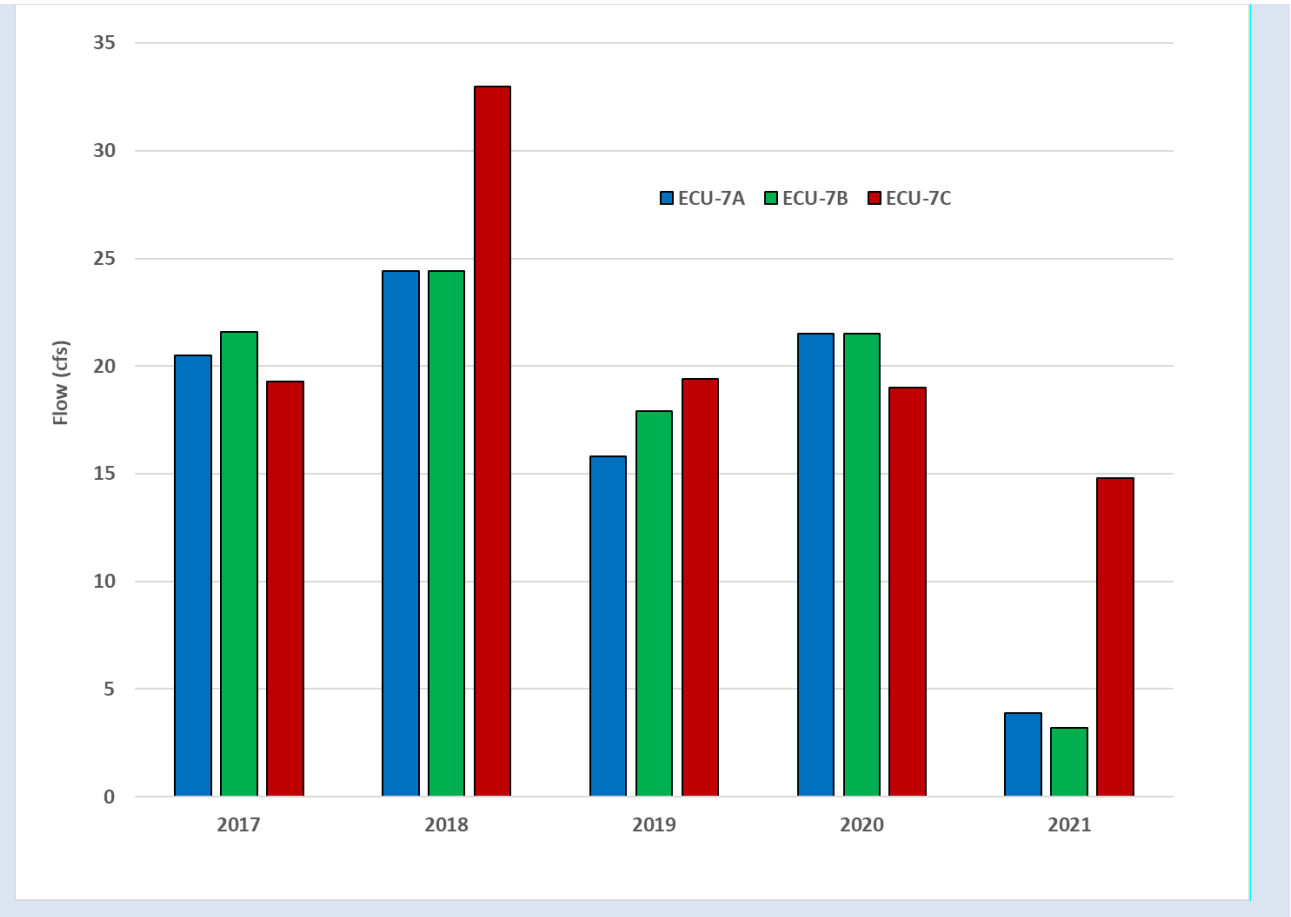


Figure 10-18 Observed Flows at the Main Stem Locations ECU-7A, ECU-7B, and ECU-7C During the 2017-2021 Fish Surveys

- FIBI scores from the upstream Main Stem location, ECU-7A, met the FIBI standard during 2018 and 2019, but not during 2017, 2020, and 2021 (Figure 10-15 and Figure 10-17). However, the 2020 and 2021 values were within the standard's confidence limits indicating the scores were relatively close to the standard (Figure 10-15). The 2021 score was higher than the 2017 score, but lower than scores observed in 2018 through 2020. The lower score in 2021 was likely influenced by lower flows in 2021. Observed flows on the day of fish surveys completed during 2017 through 2021 are shown in Figure 10-18. The flow during the 2021 fish survey of 4 cfs compares with flows ranging from 16 to 24 cfs during the 2017 through 2020 fish surveys.
- FIBI values from the upstream South Fork location, ECU-3A, met the FIBI standard during 2018 and 2020, but not during 2017, 2019, and 2021, although the 2017 and 2019 values were within the standard's confidence limits indicating the values were fairly close to the standard (Figure 10-15 and Figure 10-2). The lower score in 2021 was likely influenced by lower flows in 2021 than previous years. Observed flows on the day of fish surveys completed during 2017 through 2021 are shown in Figure 10-19. The flow during the 2021 fish survey of 0.1 cfs compares with flows ranging from 0.4 to 2.6 cfs during the 2017 through 2020 fish surveys.

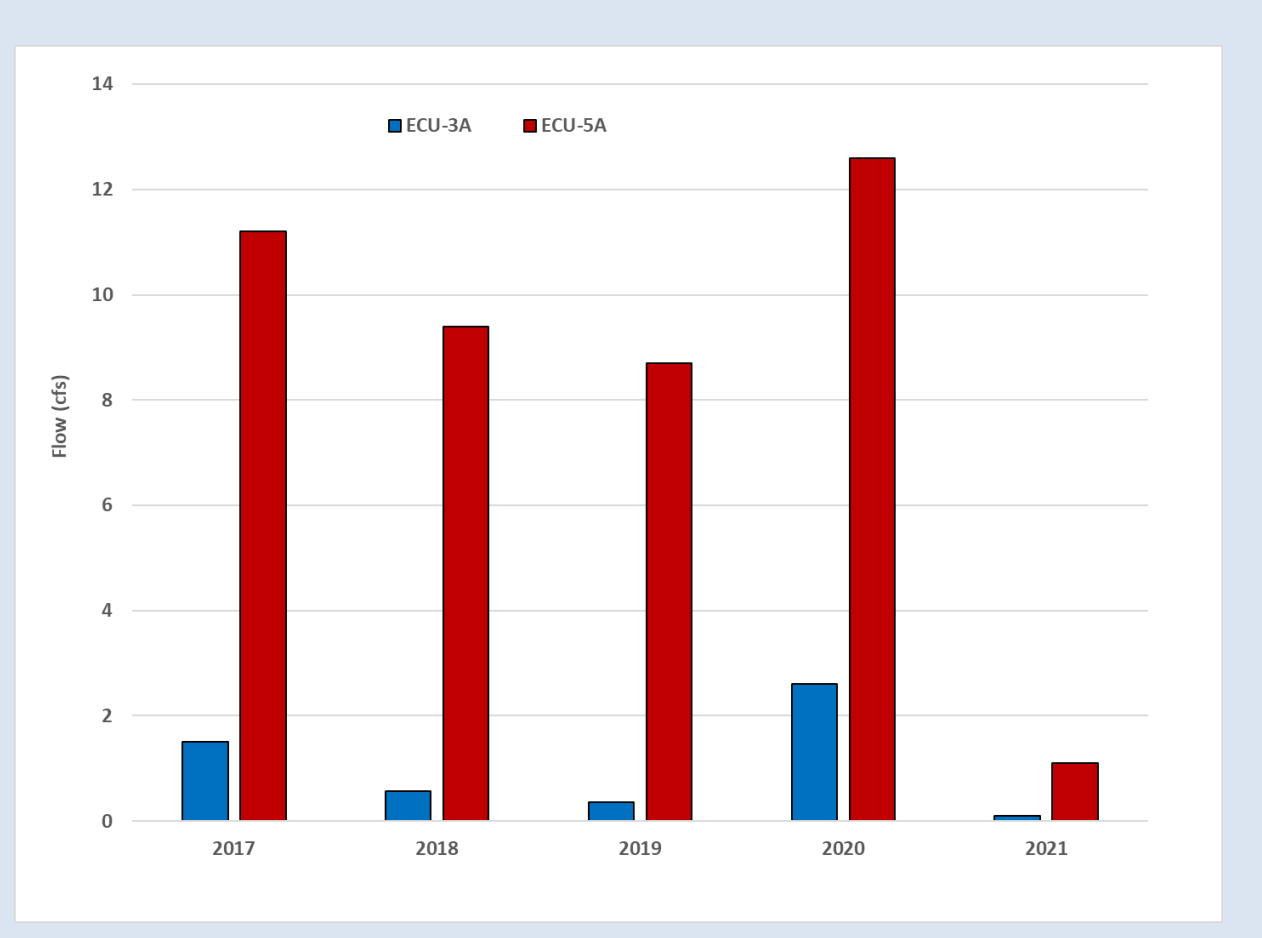


Figure 10-19 Observed Flows at South Fork Locations ECU-3A and ECU-5A During the 2017-2021 Fish Surveys

FIBI values from the South Fork downstream location, ECU-5A, met the FIBI standard during 2017 through 2019 and in 2021, but not during 2020 (Figure 10-15 and Figure 10-16). FIBI scores from the downstream North Fork location, ECU-2A, met the FIBI standard during 2018, 2019, 2020, and 2021, but not during 2017, although the value was within the standard's confidence limits indicating it was fairly close to the standard (Figure 10-15 and Figure 10-3).

FIBI scores from the two most upstream North Fork locations, ECU-1A-1 (North Fork Just Upstream of the Hopkins/Edina Boundary) and ECU-2 (North Fork near Cahill Road and Brook Drive in Edina), did not meet the FIBI standard during 2017 through 2021 (Figure 10-15, Figure 10-20, and Figure 10-21). The *Nine Mile Creek Biological Stressor Identification* (November 2010) concluded the primary stressors to the North Fork fish community were inadequate dissolved oxygen followed by excess sediment and then ionic strength due to excess chloride in the stream. As noted previously, the 2021 data indicated these same stressors were present in the stream during 2021. Inadequate oxygen was observed at ECU-2 during June, July, September, and October (Appendix A). High turbidity values at all North Fork locations, including ECU-1A-1 and ECU-2 in March indicated excess sediment was present in the stream during that time (Figure 10-10, Figure 10-11, and Figure 10-12). High specific conductance measurements at ECU - 1A- 1 during all 2021 monitoring events (Figure 10-4) and at all other North Fork locations, including ECU-2 (Figure 10-5) in

April through June and in October indicated excess chloride in the stream was likely a stressor for the fish community.

Figure 10-20 Upstream North Fork Location 1A-1
The 2021 FIBI value at the North Fork upstream location, ECU-1A-1, pictured above, did not meet the FIBI standard during 2017-2021.

Figure 10-21 North Fork middle location ECU-2
The 2021 FIBI value at the North Fork middle location, ECU-2, pictured above, did not meet the FIBI standard during 2017 through 2021.

10.2.3 Macroinvertebrate Index of Biotic Integrity (MIBI)

Background

As noted in Section 10.2, 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 10.2 and 10.2.1, 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 North Fork of Nine Mile Creek from Metro Boulevard to end of unnamed wetland 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.

Monitoring Results

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 10-22).

2021 results: In 2021, the downstream North Fork location, ECU-2A (Figure 10-3), was the only location that met the applicable MPCA standard (Figure 10-22). Although the MIBI values from the middle North Fork location, ECU- 2 (Figure 10-21), and the three Main Stem locations, ECU-7A (Figure 10-17), ECU-7B (Figure 10-14), and ECU- 7C (Figure 10-13), did not meet the applicable MPCA standard, their MIBI values were greater than their respective lower confidence limits indicating they were close to the MPCA standard (Figure 10-22). The MIBI values from the upstream North Fork location, ECU-1A-1 (Figure 10-20) and the two South Fork locations, ECU-3A (Figure 10-2) and ECU-5A (Figure 10-16) were less than the applicable MPCA standards and less than the lower confidence limits.

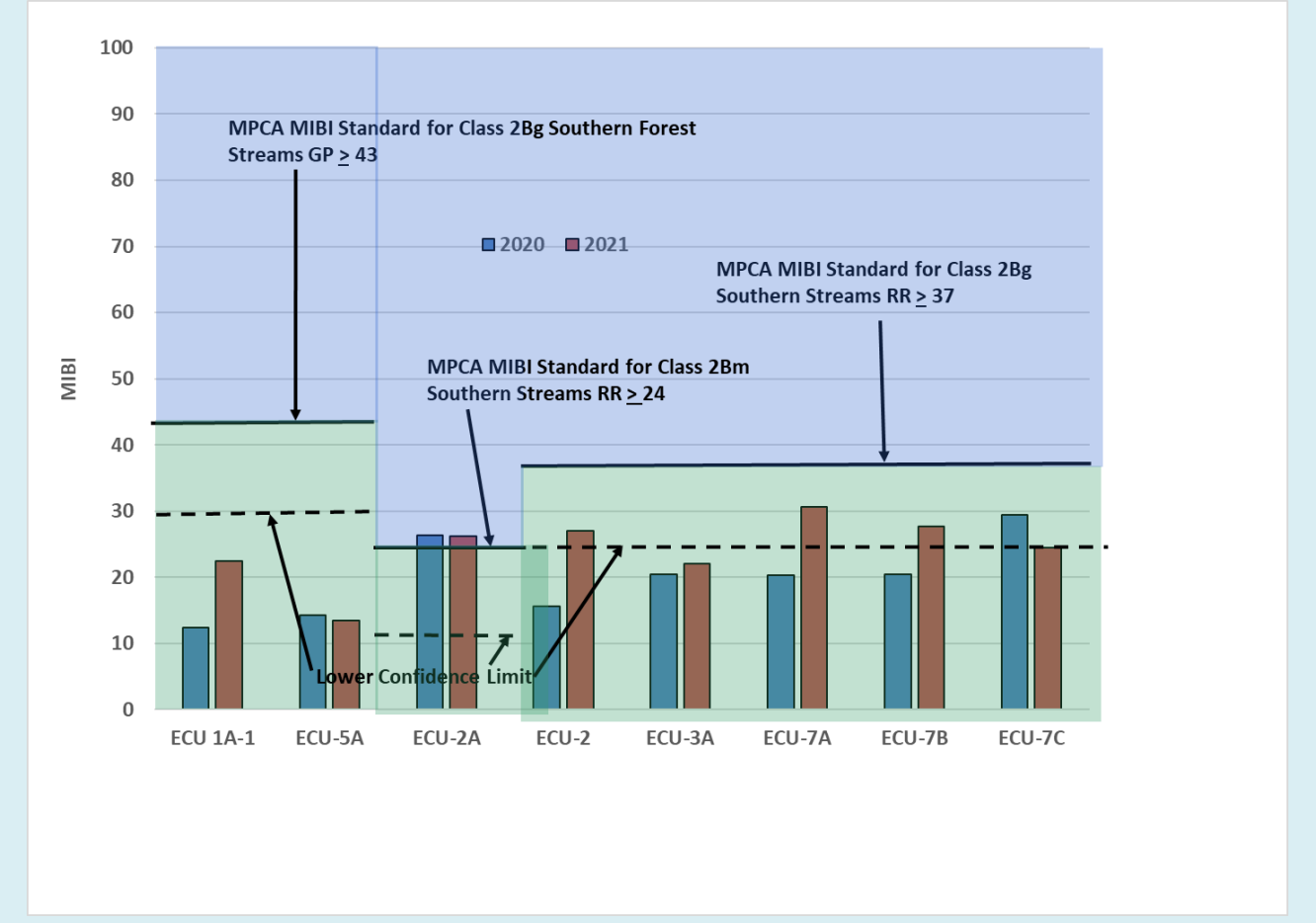


Figure 10-22 **2020-2021 Nine Mile Creek Macroinvertebrate Index of Biotic Integrity (MIBI) Values Compared with the MPCA MIBI Standard for a Class 2Bg Southern Forest Streams GP (ECU 1A 1 and ECU 5A) or a Class 2Bm Southern Streams RR (ECU-2A), or a Class 2Bg Southern Streams RR (ECU-2, ECU-3A, ECU-7A, ECU-7B, and ECU-7C).**

2020-2021 results: In 2021, MIBI values increased (improved) at 5 locations and decreased (worsened) at 3 locations (Figure 10-22), in comparison with 2020 observations (MIBI scores not available for prior years). In 2021, MIBI scores:

- Increased at the upstream and middle North Fork locations, ECU 1A-1 (45 percent) and ECU-2 (42 percent), the upstream South Fork location, ECU-3A (7 precent), and the upstream and middle Main Stem locations, ECU-7A (34 percent) and ECU-7B (26 percent) (Figure 10-22).

- Decreased at the downstream Main Stem location, ECU-7C (20 percent), the downstream South Fork location, ECU-5A (6 percent) and the downstream North Fork location, ECU-2A (0.4 percent) (Figure 10-22).

The downstream North Fork location, ECU-2A, met the applicable MPCA standard during both 2020 and 2021 (Figure 10-13). The downstream Main Stem location did not meet the applicable MPCA standard during 2020 and 2021, but 2020 and 2021 values were both greater than the lower confidence limit indicating the values were close to the standard (Figure 10-22). Improved MIBI values at the middle North Fork location, ECU-2, and the upstream and middle Main stem locations, ECU-7A and ECU-7B, in 2021 resulted in values greater than the lower confidence limits indicating the 2021 values were close to the standard (Figure 2022). The 2020 and 2021 MIBI values at the upstream North Fork location, ECU-1A-1 and upstream and downstream South Fork locations, ECU-3A and ECU-5A, were below the applicable MPCA standards and lower confidence limits during both years (Figure 10-22).

The biological stressors identified by the *Nine Mile Creek Biological Stressor Identification* (November 2010) likely contributed to the low 2021 MIBI scores which were below the MPCA's MIBI standard for all but the downstream North Fork location. Biological stressors identified in the study included:

- South Fork of Nine Mile Creek - low dissolved oxygen was the most prominent of the stressors, followed by excess sediment, low baseflow, and ionic strength due to excess chlorides.

- North Fork of Nine Mile Creek - low dissolved oxygen and excess sediment followed by ionic strength due to excess chlorides.

- Main Stem of Nine Mile Creek - low dissolved oxygen and excess sediment followed by ionic strength due to excess chlorides.

The 2021 Nine Mile Creek data (Appendix A) documented:

- Low dissolved oxygen at North Fork ECU-2, South Fork N2 and ECU-5A, and Main Stem ECU- 7A/N1
- High specific conductance at all sample locations except the most upstream South Fork location, ECU-3A. The high specific conductance values indicate ionic strength from excess chlorides was likely stressing the biological community.

- Low baseflow at all South Fork locations including October discharge values of 0.1 cfs at ECU-3A (immediately upstream of the Highway 62 crossing and the Bryant Lake Park Reserve and downstream from Bren Road in Minnetonka), 0.4 cfs at N2 (at West 78th Street in Bloomington), and 0.1 cfs at ECU-5A (in Corridor Park immediately downstream from Interstate 494 in Bloomington and west of East Bush Lake Road).

10.3 Stream Monitoring Conclusions

Table 10-2 summarizes stream monitoring data from 2021.

Table 10-2 2021 Stream Data Summary

Station	Specific Conductance		Dissolved Oxygen		pH	Temperature	Turbidity		Fish IBI	Macroinvertebrate IBI
	Exceeded Standard (# of monthly events)		Exceeded Standard (# of monthly events)		Exceeded Standards	Exceeded Standards	Exceeded 25 NTU[1]			
ECU-1A-1	8/8	March - Oct					1/8	March	did not meet	did not meet
ECU-2	4/8	April, May, June, October	4/8	June, July, Sept, Oct			1/8	March	did not meet	met lower confidence limit
ECU-2A	4/8	April, May, June, October					1/8	March	met standard	met standard
ECU-3A									did not meet	did not meet
ECU-5A	3/8	March, April, May	2/8	Aug, Oct					met standard	did not meet
ECU-7A	3/8	March, April, May	2/8	Aug, Sept					met lower confidence limit	met lower confidence limit
ECU-7B	3/8	March, April, May							did not meet	met lower confidence limit
ECU-7C	3/8	March, April, May							met standard	met lower confidence limit

[1]Turbidity was a State standard (25 NTU) from the 1960's through 2014 when it was replaced with total suspended solids. Although turbidity is not currently a State standard, it is a useful surrogate indicator of total suspended solids.

All Nine Mile Creek temperature and pH measurements, 88 percent of the dissolved oxygen measurements, and 55 percent of the specific conductance measurements met MPCA standards in 2021 (Table 10-2). As in previous years, the North Fork locations met the MPCA standard for specific conductance less frequently in 2021 than other sampling locations (Table 10-2).

The downstream North Fork (ECU-2A), South Fork (ECU-5A), and Main Stem (ECU-7C) locations met the State Fish IBI standard (Table 10-2). The upstream Main Stem location (ECU-7A) did not meet the State Fish IBI standard, but met the lower confidence limit indicating it was close to the standard (Table 10-2).

The downstream North Fork location (ECU-2A) met the State Macroinvertebrate IBI standard (Table 10-2). The middle North Fork (ECU-2) and all three Main Stem locations (ECU-7A, ECU-7B, and ECU-7C) did not meet the State Macroinvertebrate IBI, but met the lower confidence limit, indicating the scores were close to the standard (Table 10-2).

10.4 Stream Recommendations

Nine Mile Creek was first listed on the MPCA's 303(d) list of impaired waters for chlorides in 2004. The *Nine Mile Creek Watershed Chloride Total Maximum Daily Load Report* (September 2010) addressed the impairment. Despite efforts to address the impairment, the 2021 data documented high specific conductance measurements (a surrogate for chlorides) at all North Fork locations, the downstream South Fork location (ECU-5A), and all Main Stem locations in 2021, an indication of high chloride concentrations in the stream. It is recommended that the District continue implementation of the strategies identified in the chloride TMDL study to reduce chloride concentrations in the stream, which included:

- Pilot-Scale Chloride Loading Study—Determine the sources and potential improvement measures for chloride load reductions from representative sources in a smaller portion of the Nine Mile Creek watershed
- Education and Training—Partner on public education and training/information exchange for MS4 staff and private/commercial salt applicators
- Cost-Sharing Initiative—Develop [and implement] cost-sharing program for retrofitting and upgrading equipment

Specific conductance is a measure of the conductive ions in water from dissolved and inorganic materials such as alkalis, chlorides, sulfides, and carbonate compounds, and is often used as a surrogate for measuring chloride levels. In 2021, high specific conductance measurements were observed in the fall at all North Fork locations and at South Fork location N2 (West 78th Street in Bloomington), which differs from a typical pattern of high chloride concentrations in the spring from winter deicing. It is recommended that the District further evaluate potential sources of the high fall chloride concentrations, including potential sources such as fall fertilization practices within the watershed, groundwater containing chlorides from winter deicing, and/or turn-over of stormwater ponds with high bottom chloride concentrations.

A portion of Nine Mile Creek was first listed on MPCA's 303(d) list of impaired waters for fish in 2004. In 2010, a biological stressor identification study was conducted by Barr Engineering Co. on behalf of the MPCA to evaluate probable causes of impairment based on existing biological, chemical, physical, and land-use data (*Nine Mile*

Creek Biological Stressor Identification, November 2010). In 2018, the MPCA added the Fish IBI and Macroinvertebrate IBI to the State's 7050 Rules as metrics to assess attainment of water quality standards. Following this, several portions of Nine Mile Creek were added to the MPCA's 303(d) impaired waters list for both fish and macroinvertebrates. Data from 2021 and other recent years indicate several locations along the North Fork, South Fork, and Main Stem are not meeting the State's fish IBI and/or macroinvertebrate IBI standards. Given this, it is recommended that the District consider updating the biological stressor analysis to determine the probable causes of the biological impairment(s) in the stream and management recommendations to improve the fish and macroinvertebrate communities in Nine Mile Creek. Updating the biological stressor analysis will allow for inclusion of more recent data to help evaluate benefits of recent District projects.

Continuation of water quality and biological monitoring is recommended in upcoming years to assess stream water quality and its biological community. The MPCA is scheduled to conduct stream monitoring in the Lower Minnesota River watershed in 2025 to assess attainment of State water quality standards. The District should consider contacting MPCA staff ahead of this monitoring to discuss ongoing District monitoring efforts and results and seek guidance on stressor evaluation updates.

11 Lake Level Monitoring

11.1 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 2021, 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 on 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 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 11-1 summarizes the net change in lake levels between the beginning of 2021 and end of 2021, as well as the historic high and low water elevations. Graphs showing measured lake levels from January 2000 through December 2021 are included in Appendix L.

During 2021, 19 of the monitored lake levels decreased and 8 of the monitored lake levels increased from the beginning to the end of the year, with exception of Smetana Lake, which showed no net change. The lowered lake levels reflect that 2021 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 many groundwater levels in the region were also declining in 2021. The most notable net drop in lake level was Birch Island Lake in Eden Prairie, which dropped 4.4 feet from January 2021 to December 2021.

Table 11-1. Summary of 2021 Monthly Observed Lake Levels

Lake	Measured Lake Level-January 2021 (1/6/2021)	Measured Lake Level-December 2021 (12/28/2021)	Net Change in Measured Lake Levels (1/6/2021 - 12/28/2021)	Historical High Water Elevation		Historical Low Water Elevation	
	[feet MSL]	[feet MSL]	[feet]	[feet MSL]	Date	[feet MSL]	Date
NW Anderson	839.1	838.3	-0.8	841.8	7/24/1987	833	1/5/2009
SE Anderson	839.0	836.7	-2.3	841.8	7/24/1987	833.1	2/28/2013
SW Anderson	839.1	838.4	-0.7	841.8	7/24/1987	835.1	12/8/1964
Arrowhead[1]	874.9	873.4	-1.5	878.6	7/24/1987	871.4	2/18/1981
Birch Island[3]	884.1	879.7	-4.4	891.2	3/24/1969	875.1	2/28/2013
Bryant	851.0	851.3	0.3	854.8	7/24/1987	849.3	1/14/1977
Bush[2]	832.0	830.8	-1.2	836.9*	6/11/1999*	826	8/8/1964
N Cornelia	859.0	859.3	0.3	864.1	7/24/1987	858.1	12/8/1967
S Cornelia	859.0	859.2	0.2	864.1	7/24/1987	858.1	12/8/1967
Edina	821.1	821.1	0.0	825.4	7/24/1987	817.8	2/9/1982
N Garrison	864.1	864.2	0.1	864.8	4/10/1965	860.7	2/28/2012
Glen	903.4	901.8	-1.6	905	8/6/1965	898.2	7/30/2010
Hawkes[2]	884.9	885.3	0.4	892.2	7/24/1987	881.6	1/14/1977
Indianhead[1]	863.6	862.5	-1.1	865.2	5/31/2019	861.0	2/28/2013
Lone[1]	900.4	898.8	-1.6	901.6	10/25/2019	895.4	2/6/1990
Minnetoga	896.4	896.2	-0.1	899.1	7/24/1987	894.1	2/6/1990
Mirror[2]	907.2	906.3	-0.9	912.1	7/24/1987	901.8	1/14/1977
Nancy (formerly S. Garrison)	862.9	863.0	0.1	863.3	4/10/1965	860.7	12/30/2011
Normandale	808.3	808.3	0.0	815.8	7/24/1987	-	-
Oxboro	803.5	802.0	-1.5	813.3	7/24/1987	797.9	1/15/1991
Pauly's Pond	816.0	816.0	0.0	821.2	7/24/1987	811.8	7/29/1988
Penn (Lower)	807.5	807.3	-0.2	816.6	7/24/1987	802.3	2/28/2013
Rose	924.9	922.7	-2.3	928.4	4/4/1966	919.6	1/8/1990
Shady Oak[1]	903.2	901.8	-1.4	905.6	5/31/2019	897.8	1/29/1990
Skriebakken	803.4	803.1	-0.3	811.3	7/24/1987	801.2	1/22/1977
Smetana	835.2	835.2	0.0	840.6	7/24/1987	830.2	11/8/1976
Swimming Pool Pond (formerly Valley View)	862.4	862.7	0.4	865.4	7/24/1987	860.1	2/28/2012
Wanda Miller	820.2	819.9	-0.2	826.7	7/24/1987	814.8	2/28/2013
Wing	938.8	938.0	-0.8	941.5	7/24/1987	933.5	1/31/1989

[1] Land-locked lakes

[2] Pumped outlet

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

12 Groundwater Well Monitoring

12.1 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, 16 groundwater monitoring wells were in operation. In 1999, 12 wells were active. In 2021, only 6 of the groundwater observation wells remain active. The active groundwater observation wells are shown in Figure 1-1.

Table 12-1 summarizes the groundwater level observations from 2021. The table includes measured groundwater observations from the beginning of 2021 (1/5/2021) and end of 2021 (12/26/2021), as well as the corresponding net change in groundwater levels during that time period. In 2021, the net change in groundwater elevation ranged from a 0.1 foot increase in Well 26 (east of Lake Edina in Edina) to a 2.3 foot drop in Well 41 (northeast of Hawkes Lake in Edina). Table 12-1 also lists the maximum fluctuation of each well during 2021. The maximum fluctuation observed throughout 2021 ranged from an approximately 0.2 foot drop at Well 26 (east of Lake Edina in Edina) to a 3.6 foot drop at Well 7 (northeast of Bredesen Park in Edina), with an average maximum fluctuation of 1.7 feet.

Table 12-1 also summarizes the highest and lowest readings of the water table at each well and the date of occurrence.

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

Table 12-1. Summary of 2021 Monthly Groundwater Levels

Well ID	Measured Groundwater Level- January 2021 (1/5/2021)	Measured Groundwater Level- December 2021 (12/26/2021)	Net Change in Measured Groundwater Levels (1/5/2021 - 12/26/2021)	Maximum 2021 Fluctuation	Historical High Water Elevation		Historical Low Water Elevation	
	[feet MSL]	[feet MSL]	[feet]	[feet]	[feet MSL]	Date	[feet MSL]	Date
7	852.4	851.8	-0.6	3.6	894.9	3/25/2004	857.2	10/17/1989
22	800.2	798.3	-1.9	1.9	802.3	5/3/1966	791.0	5/31/1990
26	820.9	821.0	0.1	0.2	827.9	4/29/2003	813.4	12/1/1964
35	842.4	841.5	-1.0	1.0	848.7	3/15/2005	834.1	1/1/1964
41	883.7	881.5	-2.3	2.3	885.8	8/26/2019	871.0	8/10/1977
52	852.4	851.8	-0.6	1.0	855.0	3/17/2003	849.1	9/15/1994

Appendices

available as separate PDFs