Nine Mile Creek Photo by: R. Gottsleben

Nine Mile Creek Watershed District
2017 Annual Water Quality Monitoring Report

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Summary of 2017 Water Quality Monitoring Programs

The 2017 Nine Mile Creek Watershed District (NMCWD) water quality monitoring program included monitoring six lakes (Cornelia, Edina, Glen, Lone, Minnetoga, and Shady Oak) and Nine Mile Creek.

Lake Monitoring

The 2017 NMCWD lake water quality monitoring program included Lake Cornelia, Lake Edina, Glen Lake, Lone Lake, Minnetoga Lake, and Shady Oak Lake. Each lake was monitored on six occasions for selected parameters including: total phosphorus, soluble reactive phosphorus (ortho phosphorus), total nitrogen, total Kjeldahl nitrogen, nitrate plus nitrite nitrogen, pH, chlorophyll *a*, chloride, dissolved oxygen, temperature, specific conductance, turbidity, oxidation reduction potential (ORP), phytoplankton, and zooplankton. Aquatic plant (macrophyte) surveys were performed during June and August. Results of the 2017 lake monitoring program follow.

Lake Cornelia

Lake Cornelia is located in the north central portion of Edina. Lake Cornelia is comprised of North (North Lake Cornelia) and South (South Lake Cornelia) basins. The two basins are connected by an equalizing 12-inch culvert under 66th Street (invert elevation (I.E.) of 859.0 MSL) on the south side of North Lake Cornelia. Ultimately the water levels in North Lake Cornelia are controlled by the outlet structure at South Lake Cornelia. The outflow from South Lake Cornelia discharges over a 14-foot long weir structure with a control elevation of 859.1 MSL. Discharges from South Lake Cornelia are conveyed to Lake Edina through an extensive storm sewer network. Due to limited stormsewer capacity downstream of Lake Cornelia, stormwater runoff backs-up into the lake during large storm events, which provides temporary storage of the flood volumes.

Figure 1. In 2017, the water quality of North Lake Cornelia, pictured above, was poor

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

North Lake Cornelia

North Lake Cornelia (Figure 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.

North Lake Cornelia Water Quality—In 2017, North Lake Cornelia water quality was poor. The lake's summer average total phosphorus and chlorophyll *a* concentrations were 197 µg/L and 46 µg/L, respectively. The lake's summer average Secchi disc transparency was 0.4 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.

Poor water quality has been observed in North Lake Cornelia during the entire period of record. While summer average water quality in 2016 was generally better than previous years, summer average water quality in 2017 was poorer than 2016. Summer average total phosphorus concentration was 73 percent higher in 2017—197 µg/L in 2017 compared with 114 µg/L in 2016. Summer average chlorophyll *a* concentration was 28 percent higher in 2017—46 µg/L in 2017 compared with 36 µg/L in 2016. Summer average Secchi disc transparency was 50 percent lower in 2017 than 2016—0.4 meters in 2017 compared with 0.8 meters in 2016. Despite poorer water quality in 2017, the lake's summer average water quality was within the range observed during the period of record (Figure 2).

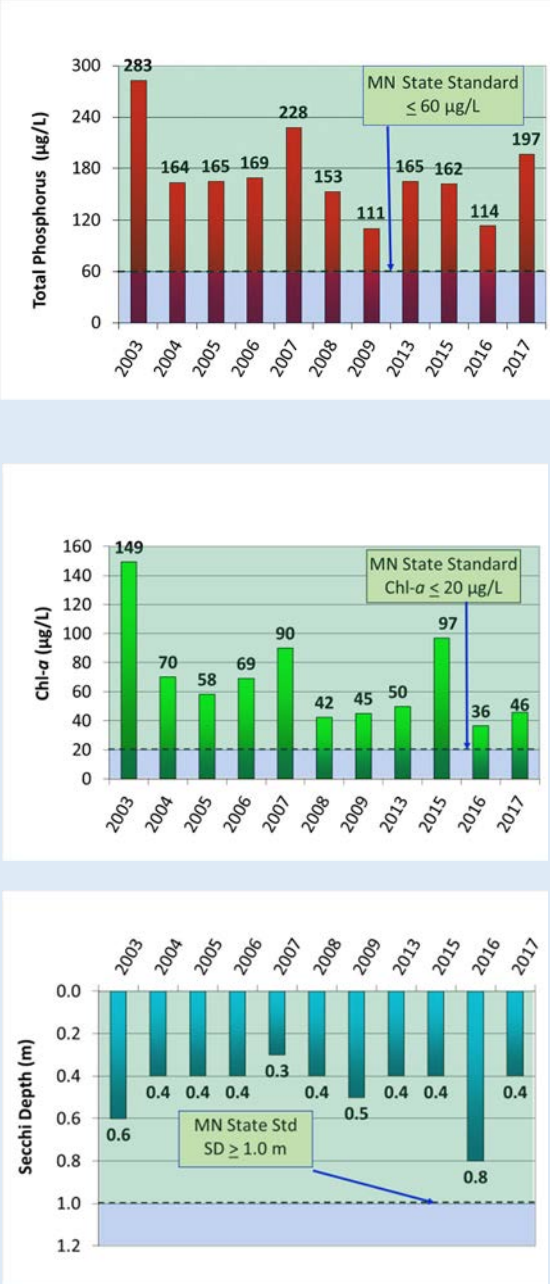


Figure 2. North Lake Cornelia summer average total phosphorus (top) , chlorophyll *a* (middle), and Secchi disc (bottom) values during 2003-2017

Figure 3. Algal scum in North Cornelia Lake on August 7

North Lake Cornelia Algae Toxins—In 2017, algal scum observed on North Lake Cornelia during August (Figure 3) and September was sampled and tested for algal toxins. Algal toxin levels for microcystins and anatoxin-a exceeded public health advisory levels on August 7. A microcystin concentration of 620 µg/L was observed compared with a public health advisory threshold of 6 µg/L. An anatoxin-a concentration of 6 µg/L was observed compared with a public health advisory threshold of 1 µg/L. Saxitoxin was present in the lake, but did not exceed the public health advisory level. A saxitoxin concentration of 0.05 µg/L was observed compared with a public health advisory threshold of 0.8 µg/L. The algal toxin level for anatoxin-a exceeded the public health advisory level on August 21 when a concentration of 4.6 µg/L was observed compared with a public health advisory threshold of 1 µg/L (Figure 4). The District alerted the City of Edina (City) and the public to the high algal toxins in the lake, advising no contact with the water until the lake's algal toxin levels declined below the public health advisory threshold. In September, the lake's algal toxin levels had declined below the public health advisory threshold and this was communicated to the City and the public.

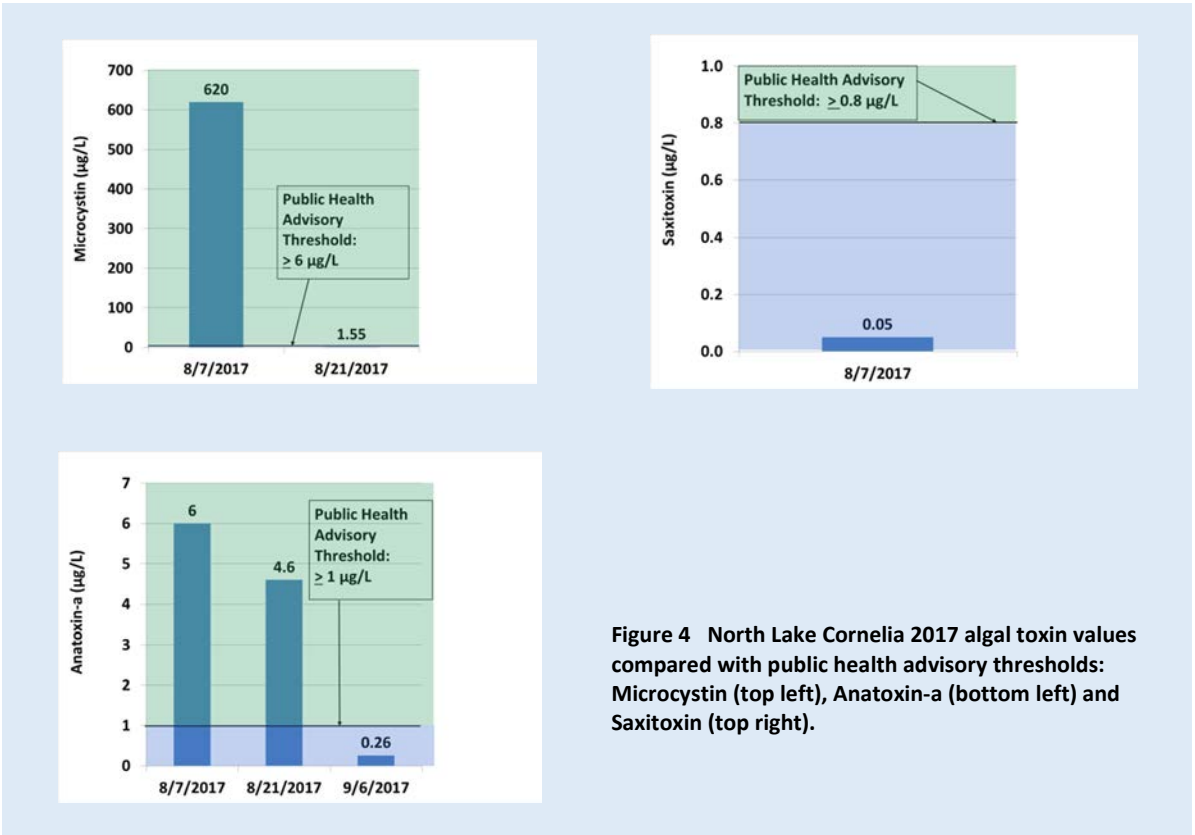


Figure 4 North Lake Cornelia 2017 algal toxin values compared with public health advisory thresholds: Microcystin (top left), Anatoxin-a (bottom left) and Saxitoxin (top right).

North Lake Cornelia Plants—Curly-leaf pondweed was problematic in North Lake Cornelia during 2015, 2016, and again in the early spring of 2017. An April 23rd plant survey completed by the City found curly-leaf pondweed forming a solid mat over the entire lake (Figure 6) with the exception of a few meters (about six feet) buffer near the immediate shoreline, usually over a pure sand substrate. The City completed a spring herbicide (endothall) treatment to manage the curly-leaf pondweed. During a June plant survey completed by the City, curly-leaf pondweed was not observed in North Lake Cornelia. Hence, the herbicide treatment effectively managed the lake's curly-leaf pondweed infestation.

However, senescence of the curly-leaf pondweed controlled by the herbicide added phosphorus to the lake. The phosphorus added appears to have fueled the algal blooms in the lake, which resulted in reduced Secchi disc transparency and the high algal toxins measured in August.

North Lake Cornelia plant survey data from 2004 through 2017 were assessed to determine plant Index of Biotic Integrity (IBI) values. Figure 5 shows the number of species and Floristic Quality Index (FQI) for that period compared to the MnDNR plant IBI proposed impairment thresholds.

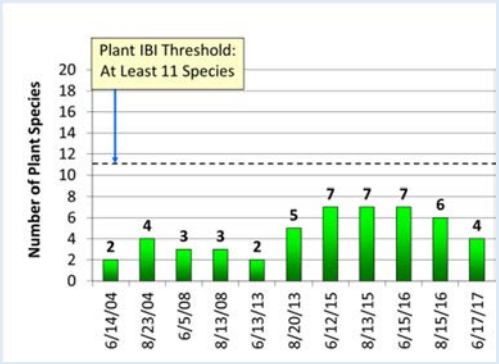


Figure 5A

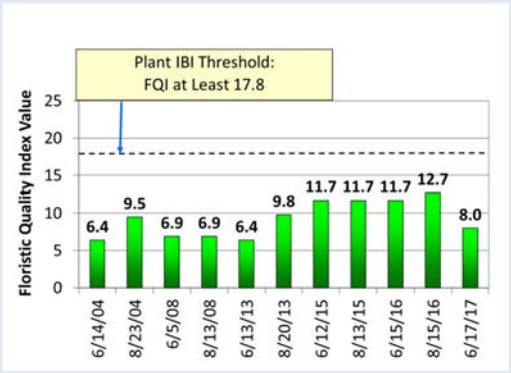


Figure 5B

Figure 5. 2004-2017 North Lake Cornelia Plant Index of Biotic Integrity (IBI) Threshold Values compared with Plant IBI Thresholds: Number of Plant Species (top) and Floristic Quality Index (FQI) Values (bottom). The City of Edina collected the 2017 plant survey data.

Figure 6. Curly-leaf pondweed grew densely in North Lake Cornelia forming a solid mat over the entire lake in April.

In 2017, the number of plant species (4) was lower than the number of species observed during 2013 through 2016 (5 to 7 —Figure 5A). Similarly, FQI was lower in 2017 (8.0) than 2013 through 2016 (9.8 to 12.7 —Figure 5B). From 2016 to 2017, the number of species declined from 7 species in June 2016 to 4 species in June 2017. In June 2017, 5 species were absent that had been observed in June 2016 while 2 duckweed species were present that had not been observed in June, 2016. The species that were not observed between June 2016 and June 2017 include curly-leaf pondweed, targeted by the herbicide treatment, three native pondweed species (*Potamogeton foliosus*, *Potamogeton nodosus*, and *Stuckenia pectinata*) and bulrush (*Schoenoplectus sp.*). Pondweed species and bulrush could have been removed by the 2017 endothall treatment to control curly-leaf pondweed. For future herbicide treatments to control curly-leaf pondweed, it is recommended that the herbicide be applied before the lake's average water column temperature reaches 60°F prior to the native plant growing season. Completing the herbicide

application prior to the start of the native plant growing season would protect the native plants from harm.

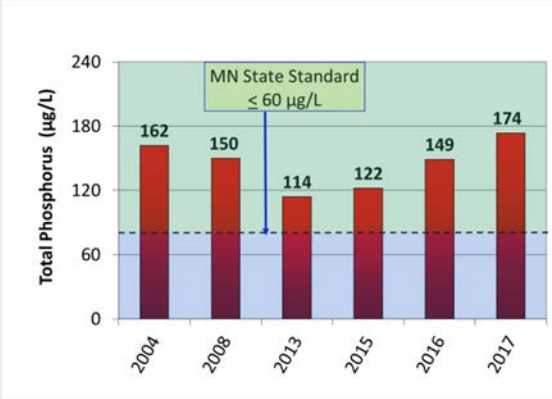
During 2004 through 2017, the number of plant species in North Lake Cornelia ranged from 2 to 7 compared with the proposed impairment threshold of at least 11 species for lakes shallower than 15 feet. FQI values during that period ranged from 6.4 to 12.7 compared with the proposed impairment threshold of at least 17.8 for lakes shallower than 15 feet. Because both the number of species in the lake and the FQI values were below the proposed impairment thresholds for the entire period of record, North Lake Cornelia would be considered impaired for plants. At this time, the plant IBI has not yet been used by the MPCA/MnDNR to determine impairment, however, it is expected to eventually be used to determine biological impairment.

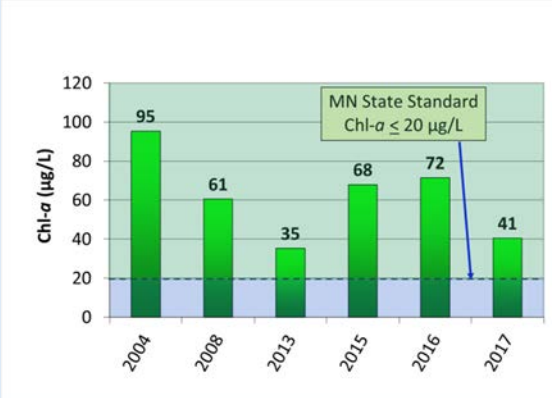
The City will complete an aquatic plant survey of North Lake Cornelia in the spring of 2018. If the survey results indicate herbicide treatment of the curly-leaf pondweed is needed, the City plans to apply for a DNR herbicide treatment permit and, after receiving the permit, complete a spring herbicide (endothall) treatment.

South Lake Cornelia

South Lake Cornelia (Figure 8) 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.

Figure 8. In 2017, the water quality of South Lake Cornelia, pictured above was poor





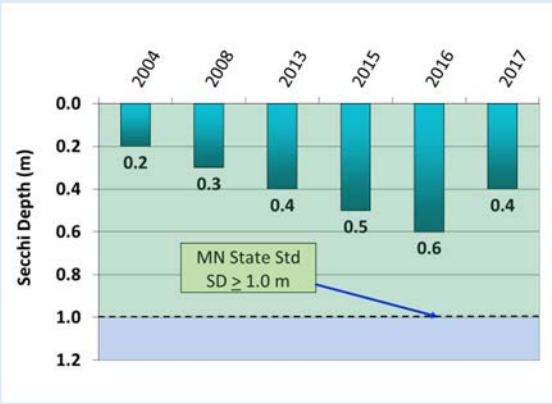


Figure 7. South Lake Cornelia summer average total phosphorus (top) , chlorophyll *a* (middle), and Secchi disc (bottom) values during 2004-2017

South Lake Cornelia Water Quality—In 2017, South Lake Cornelia water quality was poor. The lake's summer average total phosphorus and chlorophyll *a* concentrations were 174 µg/L and 41 µg/L, respectively. The lake's summer average Secchi disc transparency was 0.4 meters. All three summer averages failed to meet the Minnesota State water quality standards for shallow lakes in the North Central Hardwood Forest Ecoregion in 2017 which are ≤ 60 µg/L, ≤ 20 µg/L, and ≥ 1 meter, respectively.

The poor water quality observed in 2017 was typical of the water quality observed in previous years. However, the 2017 summer average total phosphorus concentration was higher than the summer averages observed previously—174 µg/L in 2017 compared with a range of 114 µg/L to 162 µg/L in previous years. The 2017 summer average chlorophyll *a* concentration (41 µg/L) was lower than 2015 (68 µg/L) and 2016 (72 µg/L) averages, but within the historic range (35 µg/L to 95 µg/L). The 2017

summer average Secchi disc transparency (0.4 meters) was lower than 2015 (0.5 meters) and 2016 (0.6 meters) averages, but within the historic range (0.2 to 0.6 meters) (Figure 7).

South Lake Cornelia Algae Toxins—In 2017, algal scum observed on South Lake Cornelia during August (Figure 9) was sampled and tested for algal toxins. The algal toxin level for microcystins (3.92 µg/L) was less than the public health advisory level (6 µg/L) and neither anatoxin-a nor saxitoxin were detected (Figure 10). The test results indicated the algal blooms did not cause a health risk to the public.

Figure 9. Algal scum in South Cornelia Lake on August 7

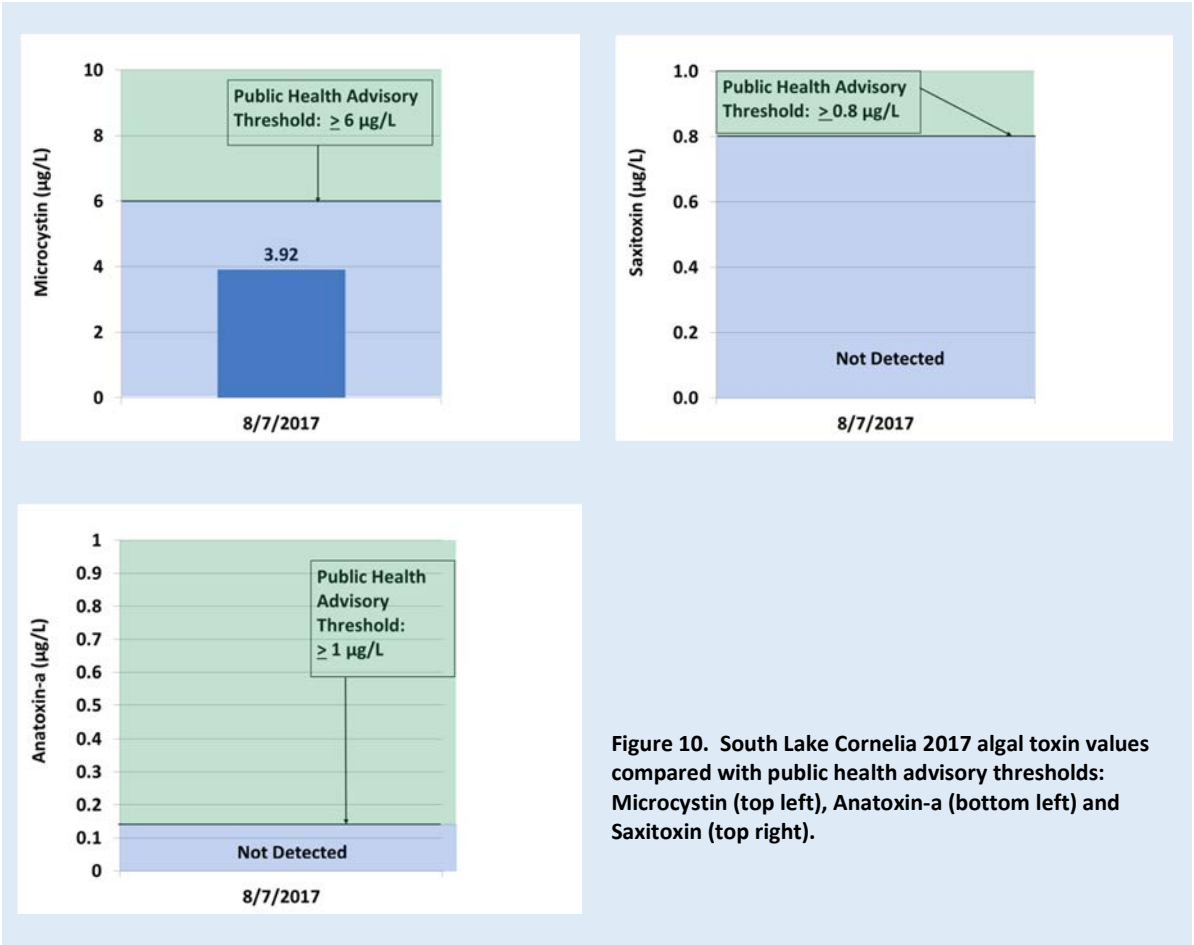


Figure 10. South Lake Cornelia 2017 algal toxin values compared with public health advisory thresholds: Microcystin (top left), Anatoxin-a (bottom left) and Saxitoxin (top right).

South Lake Cornelia Plants—Curly-leaf pondweed was problematic in South Lake Cornelia during 2015, 2016, and the early spring of 2017. A plant survey completed by the City on April 23 found curly-leaf pondweed forming a solid mat over the entire lake with the exception of a few meter buffer (about 6 feet) near the immediate shoreline, usually over a pure sand substrate. The City completed a spring herbicide (endothall) treatment to manage the curly-leaf pondweed. During a June plant survey completed by the City, curly-leaf pondweed was only observed at one location in the lake. Hence, the herbicide treatment effectively managed the lake's curly-leaf pondweed infestation. However, senescence of the curly-leaf pondweed controlled by the herbicide added phosphorus to the lake. The phosphorus added appears to have fueled the algal blooms in the lake which reduced Secchi disc transparency in 2017.

South Lake Cornelia plant survey data from 2004 through 2017 were assessed to determine plant IBI values. Figure 11 shows the number of species and FQI for that period compared to the MnDNR plant IBI proposed impairment thresholds.

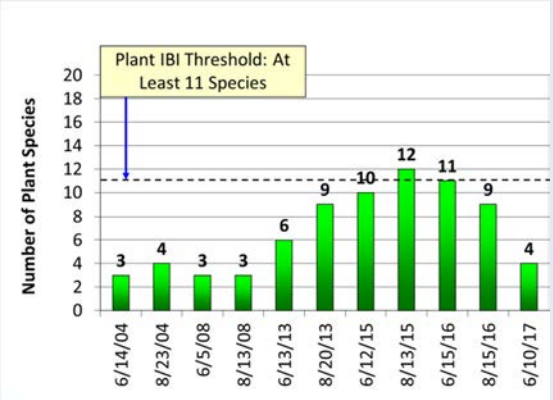


Figure 11A

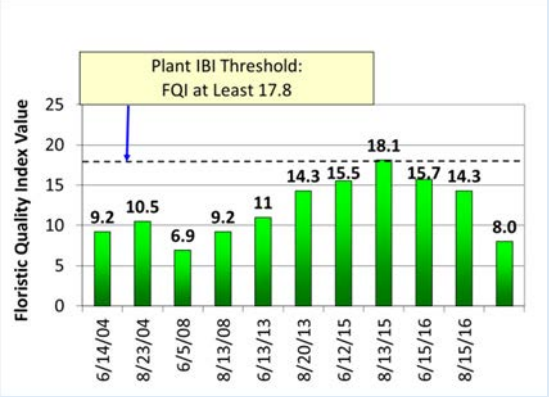


Figure 11B

Figure 11. 2004-2017 South Lake Cornelia Plant Index of Biotic Integrity (IBI) Threshold Values compared with Plant IBI Thresholds: Number of Plant Species (top) and Floristic Quality Index (FQI) Values (bottom).

In 2017, the number of plant species (4) was lower than the number of species observed during 2013 through 2016 (6 to 12 —Figure 11A). Similarly, FQI was lower in 2017 (8.0) than 2013 through 2016 (11.0 to 18.1—Figure 11B). From 2016 to 2017, the number of species declined from 11 species in June, 2016 to 4 species in June, 2017. In June, 2017, nine species were absent that had been observed in June, 2016 while two duckweed species were present that had not been observed in June, 2016. The species that were not observed between June, 2016 and June, 2017 include three native pondweed species (*Potamogeton foliosus*, *Potamogeton nodosus*, and *Stuckenia pectinata*) four bulrush species (*Bulboschoenus fluviatilis*, *Schoenoplectus acutus, Schoenoplectus tabernaemontani, and Schoenoplectus sp.*), muskgrass (*Chara sp.*), and coontail (*Ceratophyllum demersum*). Native plant species could have been removed by the 2017 endothall treatment of curly-leaf pondweed applied when the native plants began their growing season. As with North Lake Cornelia, for future herbicide treatments to control curly-leaf pondweed, the herbicide should be applied before the lake's average water column temperature reaches 60°F, prior to the start of the native plant growing season.

During 2004 through 2017, the number of plant species in South Lake Cornelia ranged from 3 to 12 compared with the proposed impairment threshold of at least 11 species for lakes shallower than 15 feet. FQI values during that period ranged from 6.9 to 18.1 compared with the proposed impairment threshold

of at least 17.8 for lakes shallower than 15 feet. Because both the number of species in the lake and the FQI values were below the proposed impairment thresholds for 9 of the 11 monitoring events during the period of record, including 2017, South Lake Cornelia would be considered impaired for plants. The plant IBI has not yet been used by the MPCA/MnDNR to determine impairment. As with North Lake Cornelia, it is expected to eventually be used to determine biological impairment.

The City will complete an aquatic plant survey of South Lake Cornelia in the spring of 2018. If the survey results indicate herbicide treatment of the curly-leaf pondweed is needed, the City plans to apply for a DNR herbicide treatment permit and, after receiving the permit, complete a spring herbicide (endothall) treatment.

Lake Cornelia Conclusion and Recommendations—The 2017 water quality data indicated both North Lake Cornelia and South Lake Cornelia had poor water quality that failed to meet the State's water quality standard. Algal toxin data documented high levels of algal toxins in North Lake Cornelia that exceeded the public health advisory threshold. Aquatic plant data indicated the plant community of both North Lake Cornelia and South Lake Cornelia had few species, was of poor quality, and failed to meet the MnDNR proposed plant IBI impairment thresholds.

To improve water quality, lower algal toxin levels, and improve the plant community in Lake Cornelia, the District should implement watershed and in-lake management measures. The Lake Cornelia UAA completed by the District recommended the following management measures: (1) a NURP Pond in NC-62a, (2) an alum treatment plant at the outlet of the swimming pool pond, and (3) an in-lake alum treatment. Currently, the MPCA is completing a Total Maximum Daily Load (TMDL) study of Lake Cornelia, using the District's UAA as a basis for the study. In 2018, the District will be updating the Lake Cornelia UAA, incorporating the results of the TMDL and identifying and further evaluating management measures to improve Lake Cornelia water quality, as necessary.

As noted previously, if needed, the City will complete an herbicide treatment of Lake Cornelia in 2018 to control curly-leaf pondweed. It is recommended that the District continue to support the City's efforts to manage curly-leaf pondweed in the lake. Whenever the City treats Lake Cornelia with endothall to control curly-leaf pondweed, it is recommended that the District complete a June post-treatment plant survey to assess impacts of the treatment on the native plant community. The assessment would determine whether native species were removed by the treatment.

When algal scum is observed on Lake Cornelia during the summer, algal toxin testing of the scum is recommended to determine whether or not algal toxin levels exceed the public health advisory threshold. If so, the District should alert the City and the public to the high algal toxins in the lake, advising no contact with the water until the lake's algal toxin levels decline below the public health advisory threshold.

To identify significant changes in the water quality of Lake Cornelia, a trend analysis of lake water quality data is recommended each year monitoring occurs. Beginning the next year in which Lake Cornelia is monitored by NMCWD, it is recommended that the software program WQ Stat be used to perform the Mann Kendall trend analysis on the average summer total phosphorus, chlorophyll *a*, and Secchi disc values for all historical data. The analysis would determine whether the changes in water quality over time

are due to natural occurring fluctuations or whether there is greater than a 95 percent chance that the changes are a significant trend. Identifying a significant trend toward degradation in water quality will alert the District to the need to determine the cause of the degradation so that management measures can be implemented to reverse the trend. Identifying significant water quality improvements can document positive changes in lake water quality due to District management efforts.

Lake Edina

Lake Edina is a small shallow lake with a surface area of 24 acres and a maximum depth of 1.2 meters (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).

Lake Edina Water Quality—In 2017, the water quality of Lake Edina was poor. The lake's average summer total phosphorus and chlorophyll *a* concentrations were 77 µg/L and 16 µg/L, respectively. The lake's average summer Secchi disc transparency was 0.8 meters (Figure 12). The lake's average summer total phosphorus concentration and Secchi disc transparency both failed to meet the Minnesota State Water Quality Standards for shallow lakes in the North Central Hardwood Forest Ecoregion which are ≤ 60 µg/L and ≥ 1 meter, respectively. However, the lake's average summer chlorophyll *a* value met the State Standard, which is, ≤ 20 µg/L. The MPCA considers a lake impaired when total phosphorus and at least one of the response variables (chlorophyll *a* or Secchi disc) fail to meet water quality standards. Lake Edina would therefore be considered impaired.

Although poor water quality was observed in 2017, water quality has improved since 2012. The total phosphorus and chlorophyll concentrations were lower (better) and the Secchi disc transparency was higher (better) or the same in both 2015 and 2017. 2008 and 2012 average summer total phosphorus concentrations ranged from 120 µg/L to 146 µg/L compared with 2015 and 2017 values of 77 µg/L to 85 µg/L. 2008 and 2012 summer chlorophyll *a* concentrations ranged from 40 µg/L to 48 µg/L compared with 2015 and 2017 values of 16 µg/L to 22 µg/L. 2008 and 2012 average summer Secchi disc transparencies ranged from 0.3 to 0.5 meters compared with 2015 and 2017 0.5 meters to 0.8 meters (Figure 12).

Figure 12. Lake Edina summer average total phosphorus (top) , chlorophyll *a* (middle), and Secchi disc (bottom) values during 2008-2017

Lake Edina Algal Mats—In 2017, algal mats were observed on Lake Edina during both the June 13 plant survey and the August 21 water quality monitoring event (Figure 13). Samples from the algal mats were collected and analyzed in the laboratory to determine whether they were harmful blue-greens or harmless greens—only blue-greens are capable of producing algal toxins which can be harmful to lake users. The algal species comprising the mats in the lake were green algal species—*Rhizoclonium* in June (Figure 14A) and *Spirogrya* in both June and August (Figure 14B).

Figure 13. Algal mats in Lake Edina during August

Blue-green algae were not found in the algal mats, but were present in the lake (Figure 15). Because of the lake's poor water quality and presence of blue-green algae, the numbers of blue-green algae in the lake were compared with World Health Organization criteria for assessing the risk posed to lake users by exposure to blue-green algae. The blue green algal numbers were low throughout 2017 and, according to World Health Organization (WHO) criteria, pose no risk to lake users—blue-green numbers were consistently in the "no risk of adverse health effects" category (Figure 16).

Figure 14A. Mats of *Rhizoclonium hieroglyphicum*,a green algae species pictured above, were found in Lake Edina during the June 13 plant survey.

Figure 14B. Mats of Spirogyra sp., a green algal species pictured above, were found in Lake Edina during the June 13 plant survey and the August 21 water quality monitoring event.

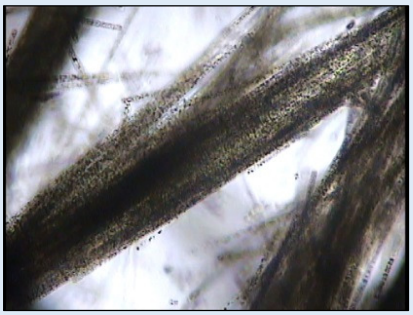


Figure 15. In 2017, blue-green algae, including Aphanizomenon flos-aquae, pictured above, were present in Lake Edina, but in such low numbers that they did not present a risk to public health.

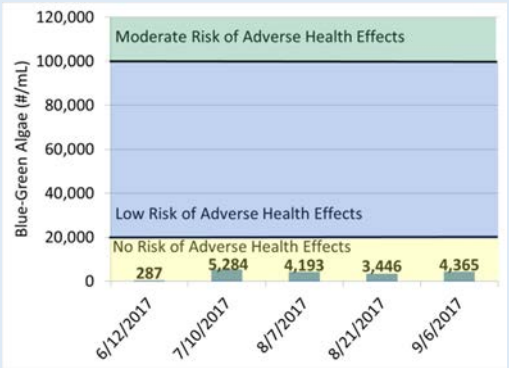


Figure 16. Lake Edina 2017 blue-green algae numbers compared with WHO guidelines for assessing the risk posed to the lake users by exposure to blue-green algae.

Lake Edina Plants—Lake Edina plant survey data from 2008 through 2017 were assessed to determine plant IBI values. Figure 17 shows the number of species and FQI for that period compared to the MnDNR plant IBI proposed impairment thresholds.

The 2017 plant community in Lake Edina was poor, but had improved from previous years. The number of plant species observed in 2017 was higher than the number of species observed during 2008 through 2015—6 to 8 in 2017 compared with 3 to 4 in previous years (Figure 17A). Similarly, FQI was higher (better) in 2017 than 2008 through 2015—11.1 through 13.4 in 2017 compared with 6.9 to 10.5 in previous years (Figure 17B).

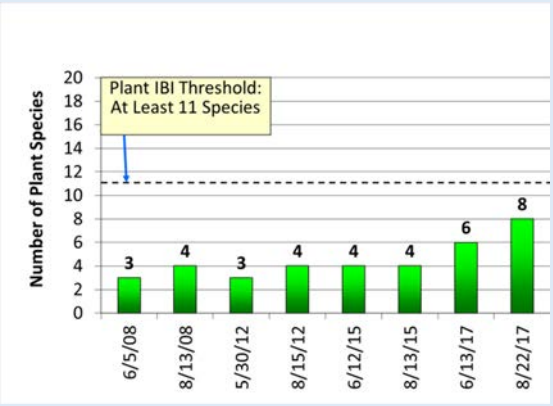


Figure 17A

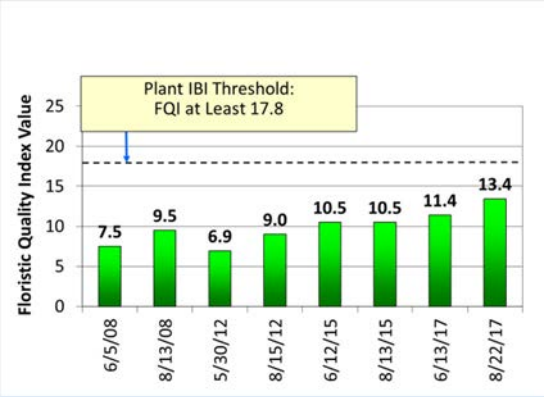


Figure 17B

Figure 17. 2008-2017 Lake Edina Plant Index of Biotic Integrity (IBI) Threshold Values compared with Plant IBI Thresholds: Number of Plant Species (top) and Floristic Quality Index (FQI) Values (bottom).

During 2008 through 2017, the number of plant species in Lake Edina ranged from 3 to 8 compared with the proposed impairment threshold of at least 11 species for lakes shallower than 15 feet. FQI values during that period ranged from 6.9 to 13.4 compared with the proposed impairment threshold of at least 17.8 for lakes shallower than 15 feet. Because both the number of species in the lake and the FQI values were below the proposed impairment thresholds during the entire period of record, Lake Edina would be considered impaired for plants. The plant IBI has not yet been used by the MPCA/MnDNR to determine impairment. However, it is expected to eventually be used to determine biological impairment.

Lake Edina Conclusion and Recommendations— The 2017 water quality data indicated Lake Edina had poor water quality that failed to meet the State's water quality standard. Aquatic plant data indicated the plant community had few species, was of poor quality, and failed to meet the MnDNR proposed plant IBI impairment thresholds.

Currently, the MPCA is completing a Total Maximum Daily Load (TMDL) study of Lake Edina. In 2018, the District will be developing a UAA for Lake Edina, incorporating the results of the TMDL and identifying watershed and/or in-lake management measures to improve the lake's water quality.

As noted previously, water quality since 2012 has improved. However, it is not known if the improvement is a significant trend or a natural fluctuation. To determine whether changes in lake water quality are significant, a trend analysis of lake water quality data is recommended each time monitoring occurs. It is recommended that the software program WQ Stat be used to perform the Mann Kendall trend analysis

on the average summer total phosphorus, chlorophyll *a*, and Secchi disc values for all historical data. As noted for Lake Cornelia, the analysis would determine whether the changes in water quality over time are due to natural occurring fluctuations or whether there is greater than a 95 percent chance that the changes are due to a significant trend.

Glen Lake

Glen Lake is located in the City of Minnetonka. The lake has a surface area of 104 acres, a maximum depth of 23 feet, and a mean depth of 7.8 feet.

Glen Lake Water Quality—In 2017, Glen Lake's water quality was good. The lake's summer average total phosphorus and chlorophyll *a* concentrations were 22 µg/L and 2 µg/L, respectively, and the lake's summer average Secchi disc transparency was 2.9 meters (approximately 9.5 feet). As shown on Figure 18, all three 2017 summer averages met the Minnesota State water quality standards for lakes in the North Central Hardwood Forest Ecoregion.

Glen Lake water quality has met the State's water quality standards throughout the period of record. The good water quality observed in 2017 was typical of the water quality observed in previous years. Previous summer average total phosphorus concentrations ranged from 14 µg/L to 38 µg/L compared with 22 µg/L in 2017. Previous summer average chlorophyll *a* concentrations ranged from 2 µg/L to 12 µg/L compared with 2 µg/L in 2017. Previous Secchi disc transparencies ranged from 1.8 meters to 3.9 meters compared with 2.9 meters in 2017. Summer averages for total phosphorus, chlorophyll *a*, and Secchi disc transparency met the Minnesota State water quality standard for lakes in the North Central Hardwood Forest Ecoregion during the entire period of record.

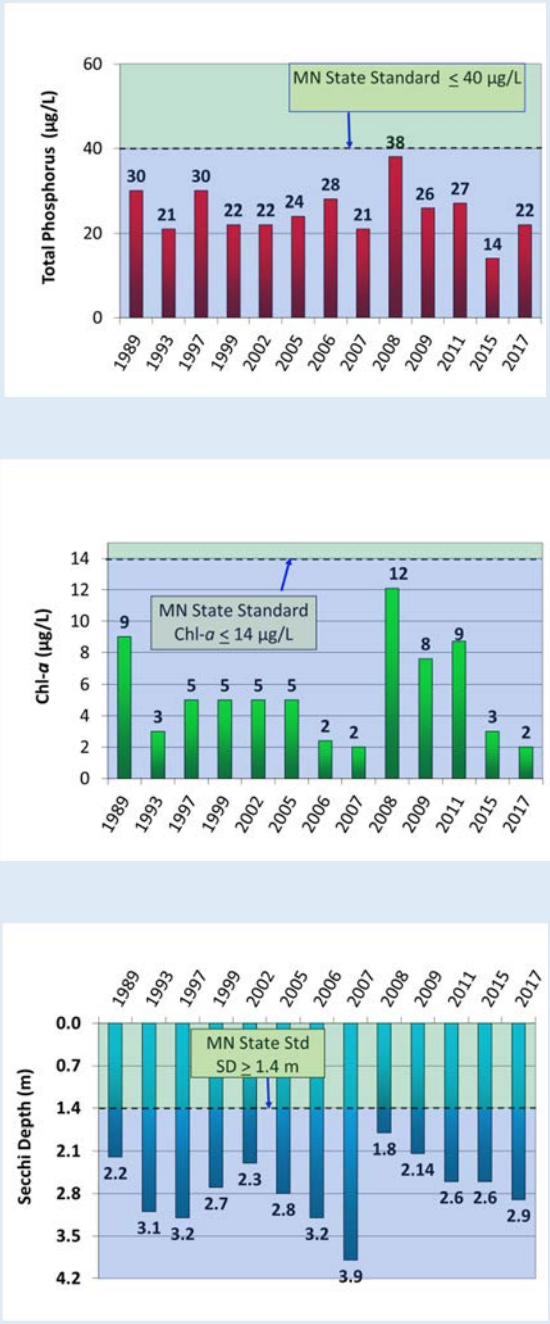


Figure 18. Glen Lake summer average total phosphorus, chlorophyll *a*, and Secchi disc values during 1989-2017.

Figure 19. A resident reported the presence of algal mats near shore in Glen Lake.

Glen Lake Algal Mats—In July, the District received a report that near shore algal mats were present in Glen Lake (Figure 19). The District investigated the algal bloom and samples were collected on August 7. The species causing the algal mats was identified as *Planktothrix Agardhii*, a blue-green species which can produce algal toxins. Given the presence of algal scum and the confirmation that the species observed in the algal scum has the potential to produce algal toxins, samples were submitted for algal toxin testing. Testing results are shown in Figure 20. The levels of all algal toxins measured in Glen Lake were below public health advisory levels.

A possible cause of the algal bloom is that nutrients added to the lake by watershed runoff from above average precipitation were used up by near-shore algae. As noted previously, lake water quality samples collected from the mid-lake location in 2017 indicated water quality in Glen Lake was good and similar to previous years, despite the increased precipitation and associated increase in nutrient loading from watershed runoff in 2017.

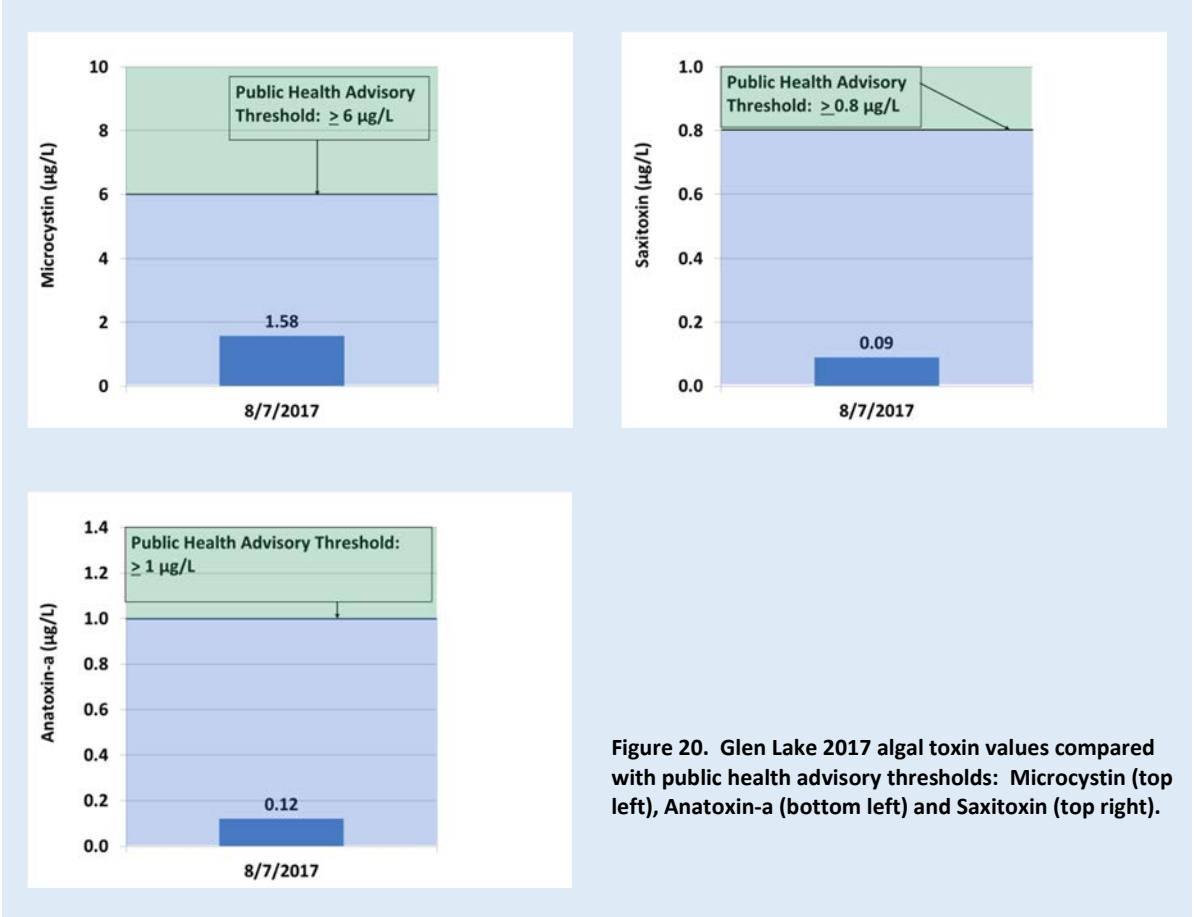


Figure 20. Glen Lake 2017 algal toxin values compared with public health advisory thresholds: Microcystin (top left), Anatoxin-a (bottom left) and Saxitoxin (top right).

Glen Lake Plants—Glen Lake plant survey data from 1997, 2006, 2009, and 2017 were assessed to determine plant IBI values. Figure 21 shows the number of species and FQI for that period compared to the MnDNR plant IBI proposed impairment thresholds.

During 1997 through 2017, the number of plant species in Glen Lake ranged from 12 to 18 compared with the proposed impairment threshold of at least 12 species for lakes at least 15-feet deep (Figure 21A). FQI values during that period ranged from 19.3 to 26.2 compared with the proposed impairment threshold of at least 18.6 for lakes at least 15-feet deep (Figure 21B). Both the number of species in the lake and the FQI values met the proposed impairment thresholds during the entire period of record, therefore, Glen Lake would not be considered impaired for plants. The plant IBI has not yet been used by the MPCA/MnDNR to determine impairment. However, it is expected to eventually be used to determine biological impairment.

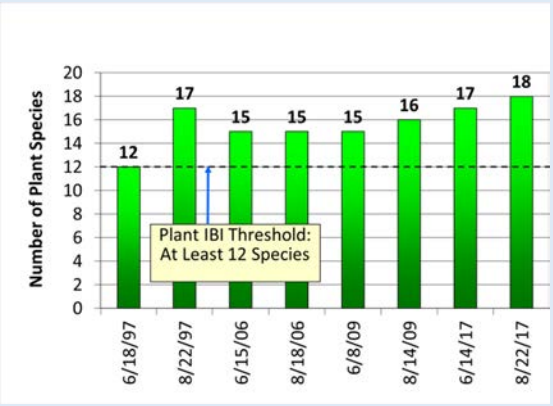


Figure 21A

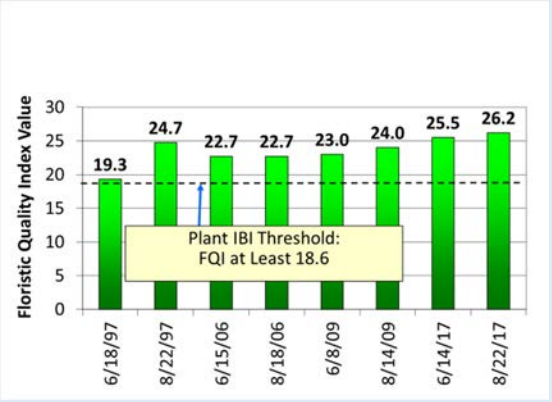


Figure 21B

Figure 21. 1997-2017 Glen Lake Plant Index of Biotic Integrity (IBI) Threshold Values compared with Plant IBI Thresholds: Number of Plant Species (top) and Floristic Quality Index (FQI) Values (bottom).

Figure 22. Glen Lake during the August 22 monitoring event.

Glen Lake Conclusion and Recommendations— The 2017 water quality data indicated Glen Lake has good water quality that met the State's water quality standards. The plant data indicated the lake has a healthy plant community that met the MnDNR's proposed plant IBI thresholds.

The City of Minnetonka monitors the quality of Glen Lake on a rotating three-year cycle and conducts trend analyses to detect significant degradation or improvement. The most recent trend analysis performed by the city on the historic water quality data for Glen Lake (through 2015) indicates that there are no statistically significant trends, suggesting the water quality is stable (neither improving nor declining). It is recommended that the District continue to coordinate water quality monitoring with the city, including analysis for water quality trends. In addition, the District may want to consider conducting more frequent aquatic communities monitoring (aquatic plants, phytoplankton, and zooplankton). The

aquatic communities monitoring is included as part of the NMCWD's typical rotating lake monitoring program, but not part of the City of Minnetonka's monitoring program.

Lone Lake

Lone Lake is located in the City of Minnetonka. The lake has a surface area of 17.3 acres, an approximate maximum depth of 28 feet, and a mean depth of 7.1 feet. Lone Lake has two relatively deep portions (23- and 28-feet deep according to the 1964 MnDNR lake map) and a large littoral (shallow) area. Lone Lake is "landlocked" meaning the lake does not have a low level piped outlet.

Lone Lake Water Quality—In 2017, Lone Lake water quality was good. The lake's summer average total phosphorus and chlorophyll *a* concentrations were 21 µg/L and 6 µg/L, respectively, and the lake's summer average Secchi disc transparency was 2.4 meters (approximately 8 feet). As shown on Figure 23, all three 2017 summer averages met the Minnesota State water quality standards for lakes in the North Central Hardwood Forest Ecoregion.

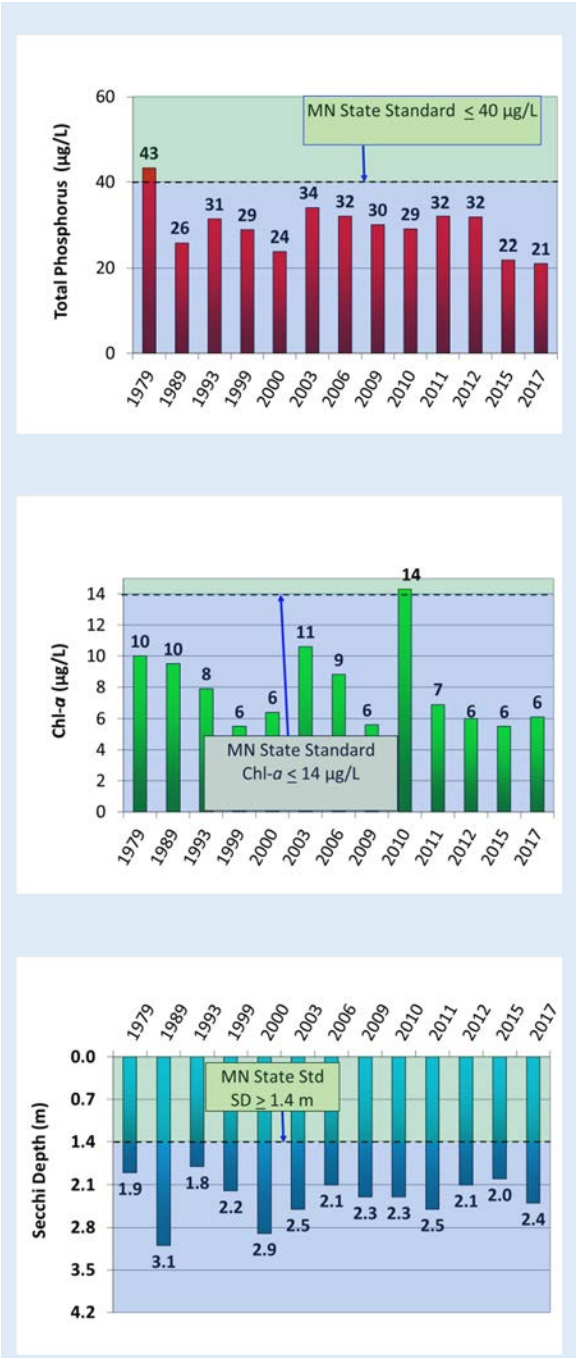


Figure 23. Lone Lake summer average total phosphorus, chlorophyll *a*, and Secchi disc values during 1979-2017.

Lone Lake water quality has generally met the State's water quality standards during the period of record. Values not meeting the State's water quality standards include a total phosphorus concentration of 43 µg/L in 1979 and a chlorophyll *a* concentration of 14.3 µg/L in 2010. All other values measured during the period of record met the State's water quality standards. The good water quality observed in 2017 was typical of the water quality that has generally been observed in previous years. The 2017 summer average total phosphorus concentration was lower than previous values. Previous summer average total phosphorus concentrations ranged from 22 µg/L to 43 µg/L compared with 21 µg/L in 2017. Chlorophyll *a* and Secchi disc transparency values were within the range observed in previous years. Previous summer average chlorophyll *a* concentrations ranged from 6 µg/L to 14 µg/L compared with 6 µg/L in 2017. Previous Secchi disc transparencies ranged from 1.8 meters to 3.1 meters compared with 2.4 meters in 2017.

Lone Lake Plants—Lone Lake plant survey data from 1999 and 2017 were assessed to determine plant IBI values. Figure 24 shows the number of species and FQI for that period compared to the MnDNR plant IBI proposed impairment thresholds.

During 1999 and 2017, the number of plant species in Lone Lake ranged from 9 to 13 species compared with the proposed impairment threshold of at least 12 species for lakes at least 15-feet deep (Figure 24A). FQI values during that period ranged from 18.0 to 22.2 compared with the proposed impairment threshold of at least 18.6 for lakes at least 15-feet deep (Figure 24B). Both the number of species in the lake and the FQI values failed to meet the impairment threshold in 1999 and both met the proposed impairment thresholds during 2017. The data indicate improvement in the plant community between 1999 and 2017. Because the number of species and FQI values in 2017 met the MnDNR proposed plant IBI impairment thresholds, Lone Lake would not be considered impaired for plants. The plant IBI has not yet been used by the MPCA/MnDNR to determine impairment. However, it is expected to eventually be used to determine biological impairment.

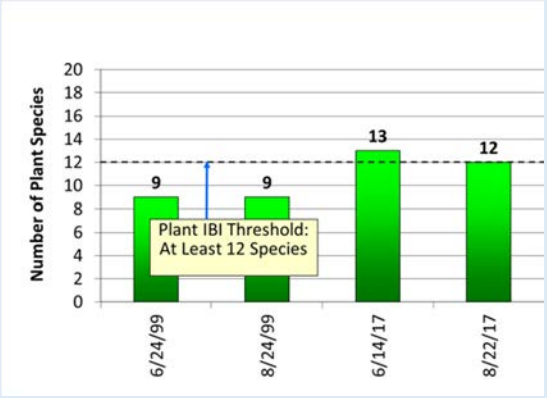


Figure 24A

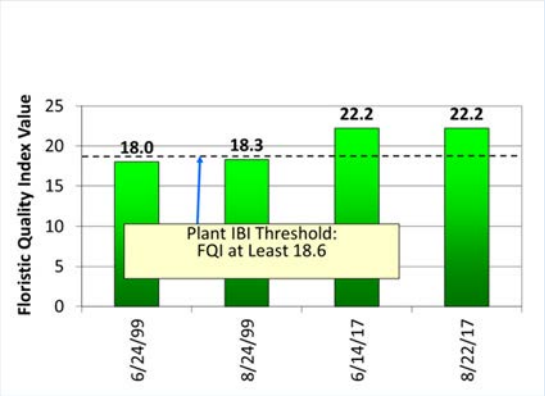


Figure 24B

Figure 24. 1999 and 2017 Lone Lake Plant Index of Biotic Integrity (IBI) Threshold Values compared with Plant IBI Thresholds: Number of Plant Species (top) and Floristic Quality Index (FQI) Values (bottom).

Lone Lake Conclusion and Recommendations— The 2017 water quality data indicated Lone Lake has good water quality that met the State's water quality standards. The plant data indicated the lake has a healthy plant community that met the MnDNR's proposed plant IBI thresholds.

Figure 25. Lone Lake

The City of Minnetonka monitors the quality of Lone Lake on a rotating three-year cycle and conducts trend analyses to detect significant degradation or improvement. The most recent trend analysis performed by the city on the historic water quality data for Lone Lake (through 2015) indicates that there are no statistically significant trends, suggesting the water quality is stable (neither improving nor declining). It is recommended that the District continue to coordinate water quality monitoring with the city, including analysis for water quality trends. In addition, the District may want to consider conducting more frequent aquatic communities monitoring (aquatic plants, phytoplankton, and

zooplankton). The aquatic communities monitoring is included as part of the NMCWD's typical rotating lake monitoring program, but not part of the City of Minnetonka's monitoring program.

Lake Minnetoga

Lake Minnetoga is located in the City of Minnetonka. The lake has a surface area of 15 acres, an approximate maximum depth of 27 feet, and a mean depth of 12.8 feet.

Figure 26. Lake Minnetoga in August 2017

Lake Minnetoga water quality—In 2017, Lake Minnetoga water quality was good. The lake's summer average total phosphorus and chlorophyll *a* concentrations were 29 µg/L and 6 µg/L, respectively, and the lake's summer average Secchi disc transparency was 2.1 meters (approximately 7 feet). As shown on Figure 27, all three 2017 summer averages met the Minnesota State water quality standards for lakes in the North Central Hardwood Forest Ecoregion.

Lake Minnetoga water quality has generally met the Minnesota State water quality standards during the period of record. Values not meeting Minnesota State water quality standards include:

- Total phosphorus concentrations of 41 µg/L in 1993 and 44 µg/L in 1999;
- Chlorophyll a concentrations of 17 µg/L in 2002, 20 µg/L in 2011, and 23 µg/L in 2013;
- Secchi disc transparencies of 1.1 meters in 1999 and 2002.

All other values measured during the period of record met the Minnesota State water quality standards.

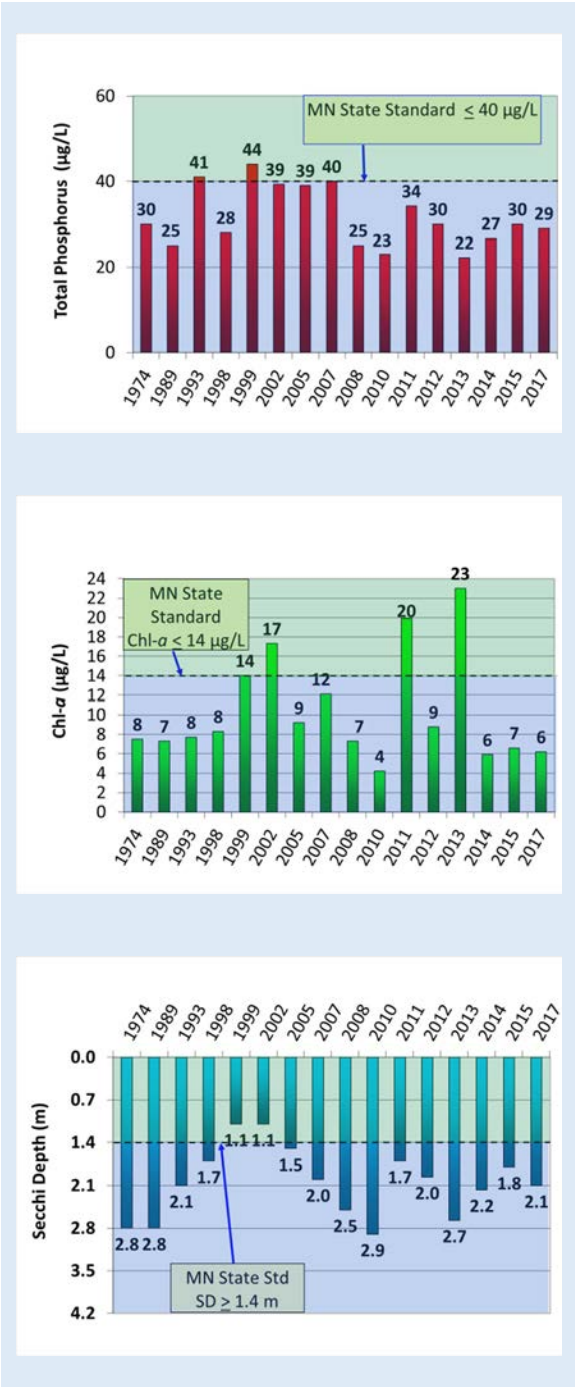


Figure 27. Lake Minnetoga summer average total phosphorus, chlorophyll *a*, and Secchi disc values during 1974-2017.

The good water quality observed in 2017 was typical of the good water quality that has generally been observed in previous years. The 2017 summer average total phosphorus concentration was 29 µg/L compared with summer averages of 22 µg/L to 44 µg/L in previous years. The 2017 summer average chlorophyll *a* concentration was 6 µg/L compared with summer averages of 4 µg/L to 23 µg/L in previous years. The 2017 Secchi disc summer average was 2.1 meters compared with summer averages of 1.1 meters to 2.9 meters in previous years.

Lake Minnetoga Plants—Lake Minnetoga plant survey data from 1998 and 2017 were assessed to determine plant IBI values. Figure 28 shows the number of species and FQI for that period compared to the MnDNR plant IBI proposed impairment thresholds.

The number of plant species in Lake Minnetoga increased from 11 in June 1998 to 12 in August 1998 to 13 in both June and August 2017. The MnDNR proposed impairment threshold is at least 12 species for lakes at least 15-feet deep. Lake Minnetoga met the proposed impairment threshold in August 1998 and during both June and August 2017 (Figure 28A). FQI values during 1998 ranged from 19.0 to 20.2 compared to 20.3 in 2017. All FQI values from 1998 and 2017 met the proposed impairment threshold of at least 18.6 for lakes at least 15-feet deep (Figure 28B). Since both the number of species in the lake and the FQI values met the proposed impairment thresholds during 2017, Lake Minnetoga would not be considered impaired for plants. The plant IBI has not yet been used by the MPCA/MnDNR to determine impairment. However, it is expected to eventually be used to determine biological impairment.

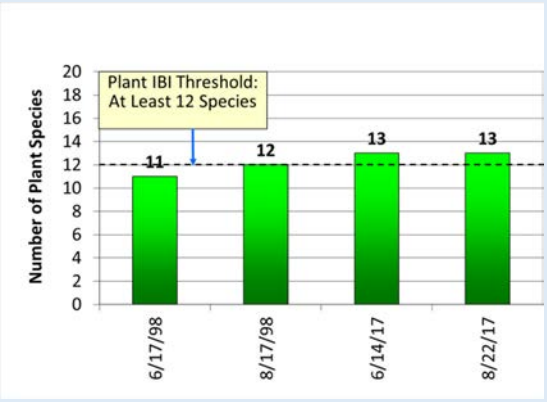


Figure 28A

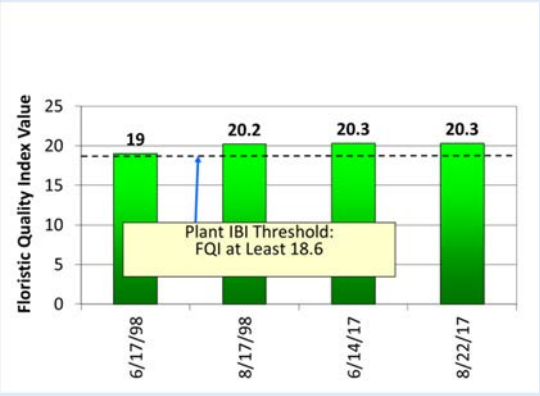


Figure 28B

Figure 28. 1998 and 2017 Lake Minnetoga Plant Index of Biotic Integrity (IBI) Threshold Values compared with Plant IBI Thresholds: Number of Plant Species (top) and Floristic Quality Index (FQI) Values (bottom).

Lake Minnetoga Conclusion and Recommendations— The 2017 water quality data indicated Lake Minnetoga has good water quality that met the State's water quality standards. The plant data indicated the lake has a healthy plant community that met the MnDNR's proposed plant IBI thresholds.

The City of Minnetonka monitors the quality of Lake Minnetoga on a rotating three-year cycle and conducts trend analyses to detect significant degradation or improvement. The most recent trend analysis performed by the city on the historic water quality data for Lake Minnetoga (through 2015) indicates that there are no statistically significant trends, suggesting the water quality is stable (neither improving nor declining). It is recommended that the District continue to coordinate water quality monitoring with the

city, including analysis for water quality trends. In addition, the District may want to consider conducting more frequent aquatic communities monitoring (aquatic plants, phytoplankton, and zooplankton). The aquatic communities monitoring is included as part of the NMCWD's typical rotating lake monitoring program, but not part of the City of Minnetonka's monitoring program.

Shady Oak Lake

Shady Oak Lake is located in the City of Minnetonka. The lake has a surface area of 85 acres, a maximum depth of 35 feet, and a mean depth of 11.3 feet.

Shady Oak Water Quality—In 2017, Shady Oak Lake water quality was good. The lake's summer average total phosphorus and chlorophyll *a* concentrations were 16 µg/L and 4 µg/L, respectively, and the lake's summer average Secchi disc transparency was 3.2 meters (approximately 10.5 feet). As shown on Figure 29, all three 2017 summer averages met the Minnesota State water quality standards for lakes in the North Central Hardwood Forest Ecoregion.

Shady Oak Lake water quality has met the State's water quality standards throughout the period of record. The good water quality observed in 2017 was typical of the water quality observed in previous years. Previous summer average total phosphorus concentrations ranged from 11 µg/L to 30 µg/L compared with 16 µg/L in 2017. Previous summer average chlorophyll *a* concentrations ranged from 3 µg/L to 5 µg/L compared with 4 µg/L in 2017. Previous Secchi disc transparencies ranged from 2.7 meters to 5.3 meters compared with 3.2 meters in 2017. Summer averages for total phosphorus, chlorophyll *a*, and Secchi disc transparency met the State's water quality standard for lakes in the North Central Hardwood Forest Ecoregion during the entire period of record.

Figure 30. Shady Oak Lake in August 2017

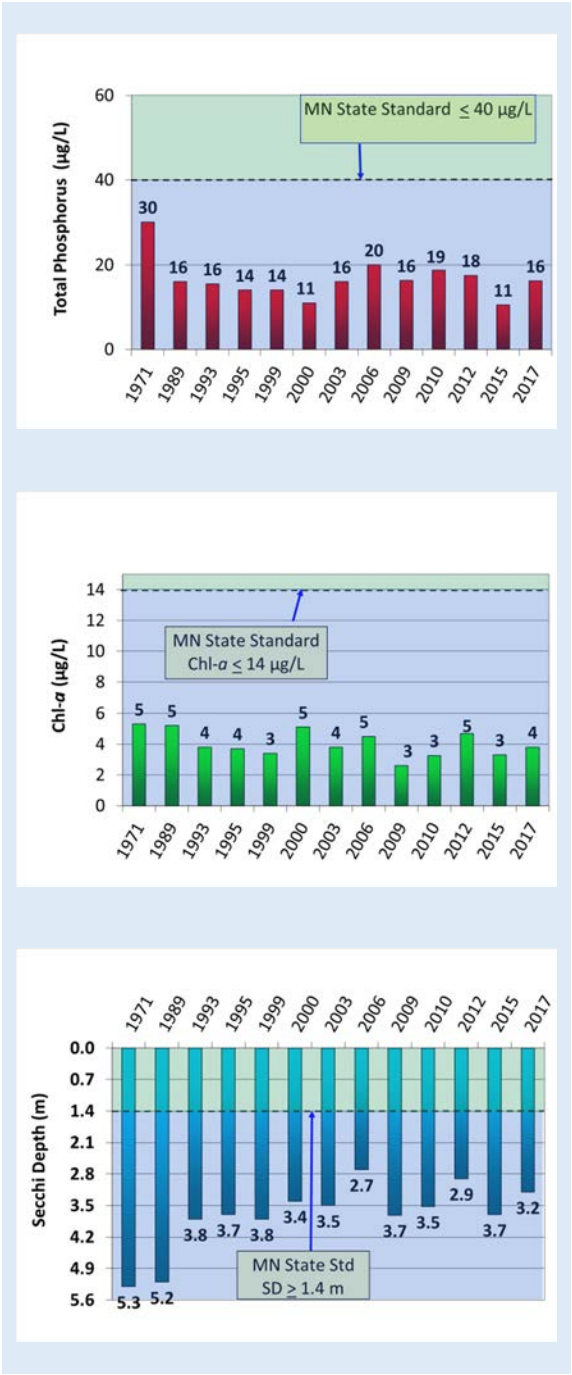


Figure 29. Shady Oak Lake summer average total phosphorus, chlorophyll *a*, and Secchi disc values during 1971-2017.

Shady Oak Lake Plants—Shady Oak Lake plant survey data from 1995, 1999, and 2017 were assessed to determine plant IBI values. Figure 31 shows the number of species and FQI for that period compared to the MnDNR plant IBI proposed impairment thresholds.

During 1995, 1999, and 2017, the number of plant species in Shady Oak Lake ranged from 15 to 22 compared with the proposed impairment threshold of at least 12 species for lakes at least 15-feet deep (Figure 31A). FQI values during that period ranged from 20.9 to 27.9 compared with the proposed impairment threshold of at least 18.6 for lakes at least 15-feet deep (Figure 31B). Both the number of species in the lake and the FQI values met the proposed impairment thresholds during the entire period of record. Shady Oak Lake would therefore not be considered impaired for plants. The plant IBI has not yet been used by the MPCA/MnDNR to determine impairment. However, it is expected to eventually be used to determine biological impairment.

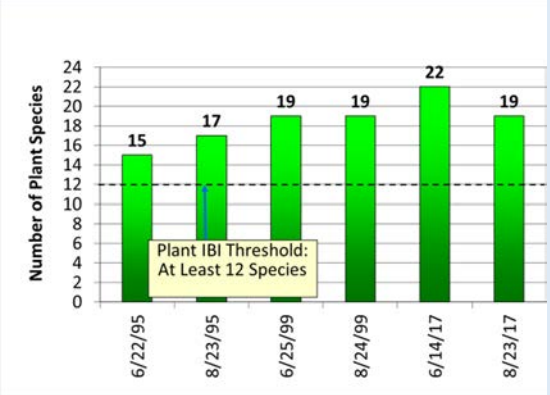


Figure 31A

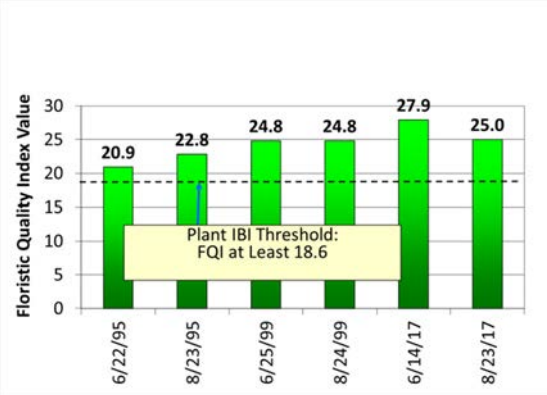


Figure 31B

Figure 31. 1995, 1999, and 2017 Shady Oak Lake Plant Index of Biotic Integrity (IBI) Threshold Values compared with Plant IBI Thresholds: Number of Plant Species (top) and Floristic Quality Index (FQI) Values (bottom).

Shady Oak Lake Conclusion and Recommendations— The 2017 water quality data indicated Shady Oak Lake has good water quality that met the State's water quality standards. The plant data indicated the lake has a healthy plant community that met the MnDNR's proposed plant IBI thresholds.

The City of Minnetonka monitors the quality of Shady Oak Lake on a rotating three-year cycle and conducts trend analyses to detect significant degradation or improvement. The most recent trend analysis performed by the city on the historic water quality data for Shady Oak Lake (through 2015) indicates that there are no statistically significant trends, suggesting the water quality is stable (neither improving nor declining). It is recommended that the District continue to coordinate water quality monitoring with the city, including analysis for water quality trends. In addition, the District may want to consider conducting more frequent aquatic communities monitoring (aquatic plants, phytoplankton, and zooplankton). The aquatic communities monitoring is included as part of the NMCWD's typical rotating lake monitoring program, but not part of the City of Minnetonka's monitoring program.

Nine Mile Creek

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 32). The 2017 Nine Mile Creek monitoring program included:

Figure 32. 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 the Main Stem of Nine Mile Creek at Station ECU-7C, pictured above

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

Monitoring locations are shown on Figure 33.

Data collected during 2017 were evaluated to determine whether:

- Specific conductance, dissolved oxygen, pH, temperature, and turbidity levels met Minnesota Pollution Control Agency (MPCA) standards for Class 2B waters published in Minnesota Rules 7050.
- Flow and water quality data were consistent with historical values.
- 2017 fish and aquatic life communities were consistent with the stream's ecological use determined from assessments completed in 1997 and 2003.
- The 2017 fish community met the MPCA Fish Index of Biological Integrity (IBI) standard for Nine Mile Creek.
- 2017 macroinvertebrate communities, assessed by biological indices, were consistent with historical data.

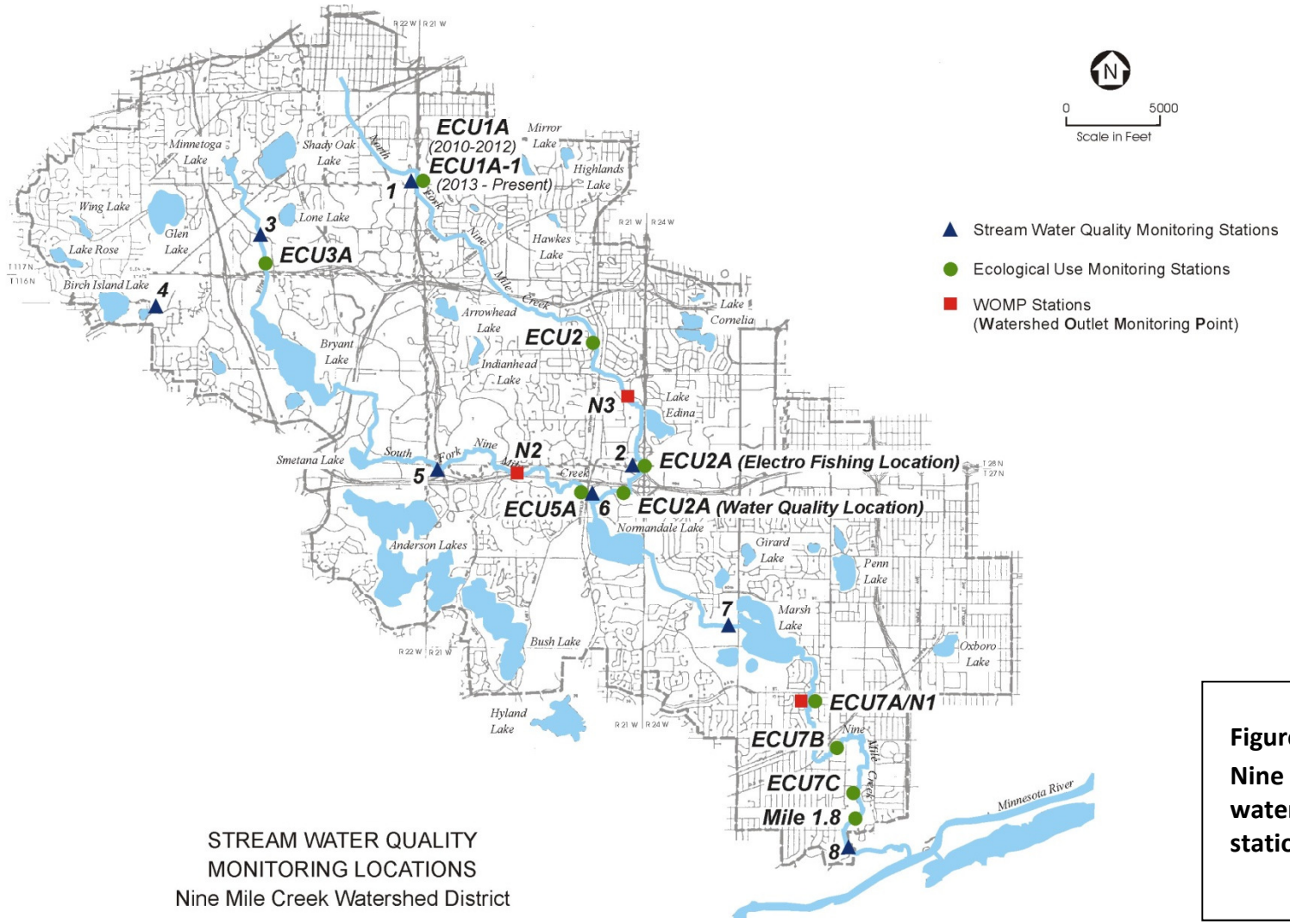


Figure 33.
Nine Mile Creek stream water quality monitoring stations

Nine Mile Creek Water Quality—In 2017, the levels of specific conductance, dissolved oxygen, pH, temperature, and turbidity in Nine Mile Creek generally met MPCA standards for Minnesota Class 2B waters (MPCA Standard). Overall, the 2017 values were within MPCA standards 91 percent of the time. The South Fork met MPCA standards most frequently (96 percent) followed by the Main Stem (94 percent) and North Fork (81 percent).

In 2017, the specific conductance criterion was met less frequently than other MPCA standards. All Nine Mile Creek temperature and pH measurements, 96 percent of the dissolved oxygen measurements, and 64 percent of the specific conductance measurements met MPCA standards. As in previous years, the North Fork locations met the MPCA standard for specific conductance less frequently than other sampling locations (e.g., 38 percent of the North Fork measurements met the MPCA specific conductance standard in 2017 compared with 75 percent of Main Stem and 88 percent of South Fork measurements).

Figure 34. In 2017, a tolerant forage fish assemblage, an indicator of average to poor water quality, was observed at the most upstream North Fork location, ECU-1A/1A-1, pictured above.

The North Fork of Nine Mile Creek met the MPCA dissolved oxygen standard for Minnesota Class 2B waters more frequently than the Main Stem and South Fork locations in 2017 – 100 percent of North Fork dissolved oxygen measurements met the MPCA standard compared with 96 percent of South Fork and 92 percent of Main Stem measurements.

Water quality data collected from Nine Mile Creek in 2017 indicate the stream's water quality generally remained stable and almost all values (99 percent) were within the range of historical values.

Figure 35. In 2017, a tolerant forage fish assemblage, an indicator of average to poor water quality, was observed at the most downstream North Fork location, ECU-2A, pictured above.

Ecological use—Ecological use is a term used to describe the fish assemblage/aquatic life use that the stream has the capacity to support per the stream's flow, water quality, and habitat characteristics. The 2017 fish data indicate Nine Mile Creek is currently supporting the ecological use determined from past assessments completed during 1997 and 2003. In 2017, a tolerant forage (grazing) fish assemblage (e.g., creek chub—an indicator of average to poorer water quality) was found at half of sample locations—ECU-1A/1A-1 (Figure 34), ECU-2 (Figure 46), and ECU-2A (Figure 35) on the North Fork and the most upstream Main Stem location, ECU-7A/N1 (Figure 36). An intolerant forage fish assemblage (e.g., western blacknose dace–

an indicator of better water quality) was found at both South Fork locations—ECU-3A (Figure 44) and ECU-5A (Figure 37) and the middle Main Stem location, ECU-7B (Figure 38). A warm water sport fish assemblage (e.g., green sunfish, largemouth bass) was found at the most downstream Main Stem location, ECU-7C (Figure 36).

A comparison of 2017 data with historical data indicates the current fish assemblage is generally similar to or better than the stream's average long-term fish assemblage. Main Stem monitoring location ECU-7B and both South Fork locations (ECU-3A and ECU-5A) observed a higher quality fish assemblage in 2017 than had, on average, been observed at these locations historically. A tolerant forage fish community has historically been observed at these locations compared to an intolerant forage fish community observed in 2017. An intolerant forage fish community is of better quality than a tolerant forage fish community. Intolerant forage fish require better water quality, flow, and habitat conditions than tolerant forage fish. The change from a tolerant forage fish community to an intolerant forage fish community at these locations is a positive change for the stream.

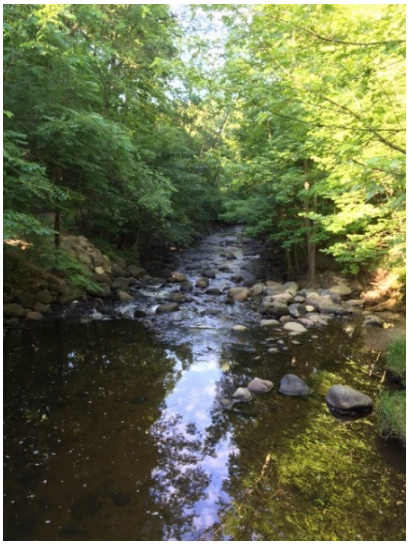


Figure 36. In 2017, four of the six Nine Mile Creek monitoring locations with a watershed area greater than 5 miles met the MPCA biological standard for fish, including the most downstream Main Stem location, ECU-7C (left) and the most upstream Main Stem location, ECU-7A/N1 (right).

The most downstream Main Stem location, ECU-7C, also observed a higher quality fish assemblage in 2017 than had, on average, been observed at this location historically. An intolerant forage fish community has historically been observed at ECU-7C compared to a warm water sport fish community observed in 2017. A warm water sport fish community is of better quality than an intolerant forage fish community. Sport fish require better water quality, flow, and habitat conditions than forage fish. Hence, the change to a sport fish community is a positive change for the stream.

The 2017 fish assemblage found at the North Fork locations in 2017 was similar to its long-term fish assemblage. A tolerant forage fish community has historically been observed at ECU-1A-1, ECU-2, and ECU-2A and was again observed in 2017.

Fish IBI—Fish collected from Nine Mile Creek in 2017 were assessed to determine whether the stream met the MPCA biological standard for fish. In 2017, biological impairment for fish in streams tributary to the Minnesota River, including Nine Mile Creek, is defined as failing to meet the Minnesota River

Assessment Project (MRAP) Index of Biotic Integrity (IBI) impairment threshold score of 30 or greater out of a possible score of 60. Only streams with a watershed area of at least 5 square miles were obligated to comply with the IBI impairment threshold.

In 2017, four of the six Nine Mile Creek monitoring locations with a watershed area greater than 5 square miles met the MPCA biological standard for fish –the South Fork location ECU-5A (Figure 37) and all Main Stem locations ECU-7A (Figure 36), ECU-7B (Figure 38), and ECU-7C (Figure 36). Both North Fork locations with a watershed area greater than 5 square miles (ECU-2 and ECU-2A) failed to meet the MPCA fish biological standard in 2017 (Figure 39).

The most downstream location of Nine Mile Creek, ECU-7C, has met the MPCA biological standard for fish annually during 2003 through 2017. All other locations have fluctuated between meeting or sometimes failing the standard during this time period. In 2006 and 2012, all Nine Mile Creek locations met the MPCA biological standard for fish. During the 15 years of monitoring, 2003 through 2017:

- Upstream North Fork location, ECU-2, met the standard 53 percent of the time
- Downstream North Fork location, ECU-2A, met the standard 60 percent of the time
- Downstream South Fork location, ECU-5A, met the standard 33 percent of the time
- Upstream Main Stem location, ECU-7A, met the standard 60 percent of the time
- Middle Main Stem location, ECU-7B, met the standard 53 percent of the time
- Downstream Main Stem location, ECU-7C, met the standard 100 percent of the time.

Figure 37. During 2003 through 2017, the most downstream South Fork location, ECU-5A, pictured above, met the Fish IBI standard 33 percent of the time.

Figure 38. During 2003 through 2017, the middle Main Stem location, ECU-7B, pictured above, met the Fish IBI standard 53 percent of the time.

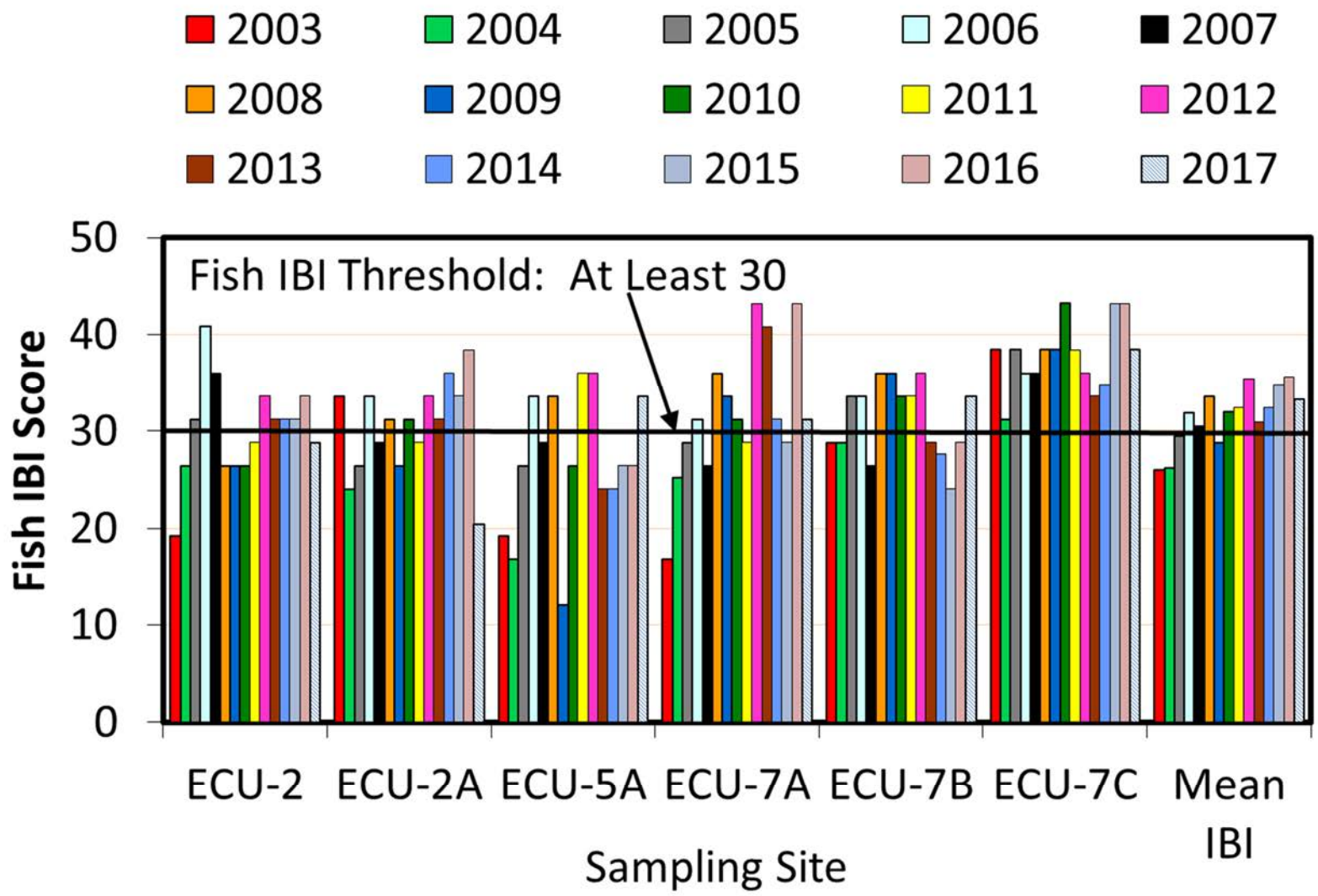


Figure 39. 2003-2017 Nine Mile Creek Fish IBI Scores

Habitat and water quality improvements from the North Fork stream stabilization project (Hopkins) have improved fish IBI scores at North Fork location ECU-1A/1A-1. The pre-project Fish IBI score from ECU-1A/1A-1 was 26.4, which did not meet the MPCA standard of at least 30. Following completion of the North Fork stream stabilization project, Fish IBI scores from ECU-1A/1A-1 have consistently met the MPCA standard even though not required since the tributary watershed to this reach is less than 5 square miles. Scores continue to improve annually—from 33.6 in 2014 to 36.0 in 2015 to 38.4 in 2016 to 40.8 in 2017 (Figure 40).

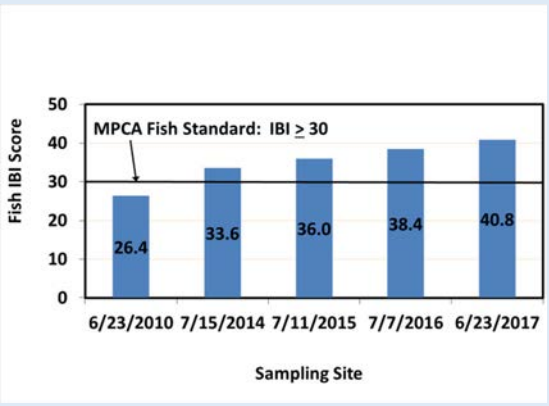


Figure 40. Fish IBI Scores for Nine Mile Creek Station ECU-1A/1A-a during 2010 and 2014-2017

Since 2011, ECU-3A, the most upstream location on the South Fork, has annually met the MPCA biological standard for fish. Fish IBI scores from ECU-3A have ranged from 31.2 to 55.2 during the 2011 through 2017 period (Figure 41). Prior to 2011, this location met the standard only 38 percent of the time. However, since the watershed tributary to ECU-3A is less than 5 square miles, the MPCA biological standard is not required to be met.

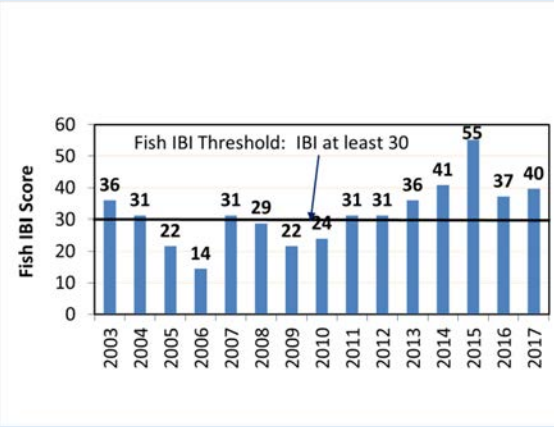


Figure 41. Fish IBI Scores for Nine Mile Creek Station ECU-3A during 2003-2017

Macroinvertebrates—Nine Mile Creek macroinvertebrates (bugs that can be seen with the naked eye) were assessed using two biotic indices to evaluate the water quality of Nine Mile Creek. The Hilsenhoff Biotic Index (HBI) was used to assess the long-term oxygen content of the stream. HBI assesses stream oxygen by determining the average tolerance of the macroinvertebrate community to low oxygen conditions. A second index, the Invertebrate Community Index (ICI), provides a broader view of the stream's water quality than the HBI, determining the average tolerance of the macroinvertebrate community to a wide range of pollutants.

In 2017, the HBI and ICI values from the two downstream locations on the Main Stem of Nine Mile Creek (ECU-7B and ECU-7C), the most upstream North Fork Location (ECU-1A/1A-1), and the most downstream South Fork location (ECU-5A) were similar to past values, indicating stream water quality, including oxygen conditions, have remained stable.

The HBI and ICI values from the most upstream location on the Main Stem of Nine Mile Creek (ECU-7A) indicated a significant improvement in 2017. This improvement was preceded by a significant decline in 2016. Frequent fluctuations in both HBI and ICI values have occurred at this location during the period of record (Figure 42 and Figure 43). This fluctuation is primarily due to the influence of Marsh Lake on the oxygen concentrations of downstream waters. Oxygen levels within Marsh Lake fluctuate due to biological activity within the marsh – plant photosynthesis during the day raises oxygen levels and at night plant respiration lowers oxygen levels. Water exiting the marsh may have either lower or higher oxygen levels than downstream locations, depending upon biological processes occurring within the marsh. The fluctuations in stream oxygen levels downstream from Marsh Lake cause changes in the macroinvertebrate assemblage, reflected by fluctuating HBI and ICI values.

Figure 42. 1976-2017 Nine Mile Creek HBI: Main Stem Station ECU-7A/N1

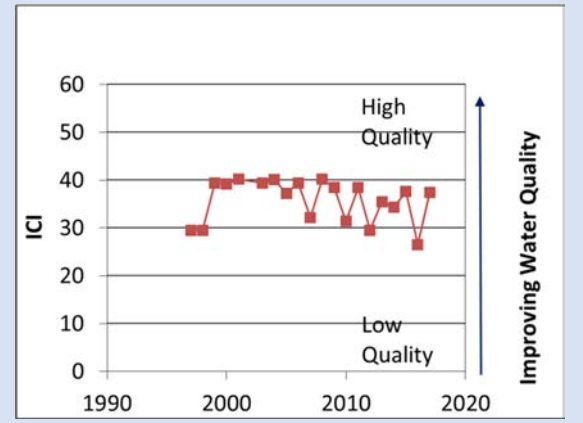


Figure 43. 1997-2017 Nine Mile Creek ICI: Main Stem Station ECU-7A/N1

Figure 44. In 2017, ECU-3A, pictured above, continued a trend toward improving fish IBI scores.

A rapid decline in caddisflies at North Fork locations ECU-2 (upstream) and ECU-2A (downstream) in 2013 resulted in the poorest biological index (i.e., HBI and ICI) values since monitoring began. The decline is likely due to sediment in the stream. Increases in caddisflies since 2013 have improved both HBI and ICI values. In 2017, the number of caddisflies at North Fork locations increased by more than three-fold at the upstream location—from 552 in 2016 to 1,840 in 2017 and nearly seven fold at the downstream location—from 368 in 2016 to 2,544 at 2017 at ECU-2A. The caddisfly recovery indicates the District's completed and on-going stream stabilization projects have reduced sediment levels in the stream. The numbers of caddisflies (Tricoptera) collected during 1975 through 2017 are shown in Figure 45.

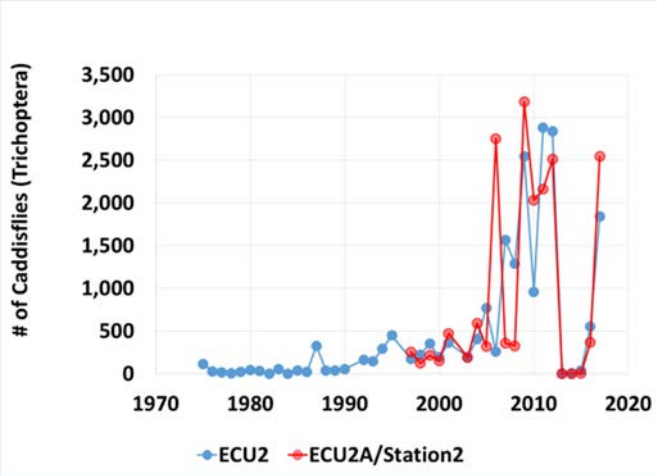


Figure 45. Number of Caddisflies at North Fork Stations ECU-2 and ECU-2A during 1975 through 2017

Figure 46. In 2017, North Fork location ECU-2, pictured above, continued a trend toward increasing numbers of caddisflies.

In 2017, the most downstream Main Stem location, ECU-7C continued a trend toward increasing oxygen levels (lower HBI scores) that began in 2015 (Figure 47). Lower HBI scores indicate the macroinvertebrate community is comprised of species that require higher concentrations of oxygen to survive, an indication of improving water quality. In 2017, the HBI score at ECU-7C was lower than all previous HBI scores - 3.95 in 2017 compared with HBI scores of 4.15 to 6.14 during 1976 through 2016. The lower score is an indication of increased oxygen levels and improved water quality at this location.

Nine Mile Creek Conclusion and Recommendations—The 2017 water quality, fish, and macroinvertebrate data indicate that despite urbanization impacts, water quality conditions in Nine Mile Creek during 1968 through 2017 have generally remained relatively stable over time. The continued stream stabilization projects completed and currently on-going have contributed to the improvements of fish numbers, quality of the fish community, and intolerant macroinvertebrates found in the creek.

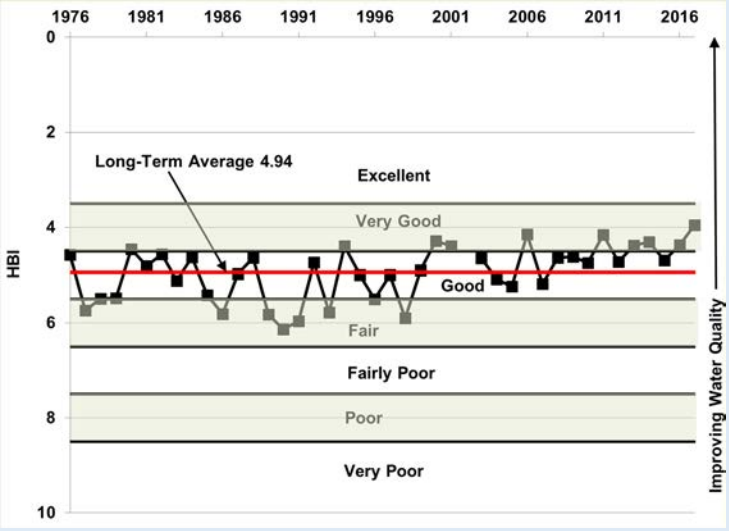


Figure 47. 1976-2017 Nine Mile Creek HBI: Main Stem Station ECU-7C

Continued monitoring at the annual stream monitoring stations is recommended to maintain this long-term record of water quality and biota in Nine Mile Creek and to assess the biological community to determine changes in stream habitat or water quality that warrant further investigation or management measures.

Minnesota has adopted changes to its water quality standards that establish biological water quality standards for all Minnesota streams and rivers, including Nine Mile Creek. Although the MPCA has assessed streams for biological impairment in the past, the MPCA water quality standards (Minn. Rule Chapters 7050 and 7052) did not previously contain biological standards. The fish IBI selected for the biological water quality standards is different from the fish IBI that was previously used to assess Nine Mile Creek for biological impairment. In addition, the MPCA has added a macroinvertebrate IBI to its biological water quality standards. The changes to MPCA standards became effective October 23, 2017. Beginning in 2018, it is recommended that the NMCWD apply the MPCA fish IBI and macroinvertebrate IBI to the biological data collected from the stream to determine whether or not the stream is biologically impaired for fish and/or macroinvertebrates. It is further recommended that the fish IBI and macroinvertebrate IBI be applied to past fish and macroinvertebrate data from Nine Mile Creek to determine whether or not the stream has met the standards over time. In addition, the IBI values will help identify long-term trends in the biological community and may help the NMCWD with its continued efforts to delist the stream from Minnesota's list of impaired waters.