RAMSEY-WASHINGTON
METRO WATERSHED DISTRICT

2022 WATER MONITORING ANNUAL REPORT

Prepared
April 2023

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TERMS

Best management practices (BMPs): Practices that protect water quality.

Chloride: Small amounts of chlorides are required for normal cell functions in plant and animal life, but chloride from de-icing and water-softener salt that gets into lakes and streams can be toxic to some aquatic life. The standard for chloride in Minnesota lakes and streams is 230 mg/l for chronic levels. That is the standard level used in this report.

Chlorophyll *a*: Chlorophyll *a* measures the amount of algae in a lake. Large amounts of algae, which cause green scum and odors, are a symptom of degraded water quality.

Eutrophication: Eutrophication describes a situation where a lake or other body of water has excessive nutrients and minerals, frequently due to polluted runoff. Nutrient excess can lead to dense plant growth and cause stress to animal life due to lack of oxygen.

Orthophosphorus: The form of phosphorus that is readily available for use by algae and other aquatic plants for growth.

PFAS (perfluoroalkyl substances): Polluting substances used in a variety of industrial, agricultural, military, and commercial product applications.

Phosphorus: Phosphorus is a nutrient that is essential for plant life, but excessive phosphorus degrades water quality. Common sources of phosphorus in lakes are fertilizers and organic wastes from runoff and soil erosion.

Secchi disc: The clarity or transparency of water is measured by lowering a "Secchi disc" (usually black and white) into the water until it is no longer visible from the surface. The greater the "Secchi depth," the more transparent the water.

Tiered Aquatic Life Uses (TALU): The Minnesota Pollution Control Agency's TALU framework is a significant revision to the aquatic life use classification in the state's water quality standards and is built on existing water quality standards to improve how water quality in streams and rivers are monitored and managed.

Measuring water clarity with a Secchi disc

Total suspended solids: Particulate matter, including soils, metals, organic materials, and debris suspended in a moving body of water.

STATE STANDARDS

The following information on how Minnesota standards for water quality are determined is taken from the Minnesota Pollution Control Agency's *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 305(b) Report and 303(d) List.*

- **Total phosphorus and chlorophyll *a* in lakes:** Data used for phosphorus and chlorophyll *a* calculations are limited to those collected from the upper most 3 meters of the water column (surface). If more than one sample is collected in a lake per day, these values are averaged to yield a daily average value. Following this step, all June to September data for the 10-year assessment window are averaged to determine mean summer values for TP, corrected chlorophyll *a*, and Secchi depth. These values are then compared to the standards and the assessment is made.

- **Conventional pollutants (total suspended solids [TSS]):** A stream is considered to exceed the standard for TSS if (1) the standard is exceeded more than 10% of the days of the assessment season (April through September) as determined from a data set that gives an unbiased representation of conditions over the assessment season, and (2) there are at least three such measurements exceeding the standard.

- **Aquatic life toxicity-based standards (chlorides):** Aquatic life toxicity-based chronic water quality standards are written as 4-day average concentrations. In some cases, pollutant concentrations can be quite variable over such periods, depending on factors such as the type and size of the water body, weather and flow conditions, and the source and nature of the pollutant. For example, chloride concentrations in lakes, streams, and wetlands are relatively stable during low-flow conditions over a 4-day period, while pesticide concentrations during storm events in small streams can vary greatly in that same amount of time. The chloride values presented in this report represent average water column concentrations.

1. INTRODUCTION

This report presents annual and historical monitoring data, providing an overall water quality assessment of lakes and streams located within the Ramsey-Washington Metro Watershed District (RWMWD or the District). It includes an assessment of 15 lakes and ponds and five streams or conveyances, with a primary focus on total phosphorus, ortho-phosphorus, chlorophyll a, Secchi disk depth (lakes only), total suspended solids, and chloride. Nitrogen is also included for streams as there are many shallow lakes in the District, and nitrogen loads contributed by streams may have an influence on the ecological status of aquatic plant-dominated shallow lakes. Chloride is also a pollutant of increasing concern as road/sidewalk salt use has the potential to lead to high chloride concentrations in ponds, lakes, and streams, particularly during winter and spring months.

Also included as a separate section, as well as intermixed with the lake and stream assessment sections, is an assessment or accounting of BMPs that have been constructed at various locations in the watershed. Unlike ponds, which settle phosphorus attached to particles, these BMPs are designed to remove both particulate and dissolved phosphorus. While ponds are still a dominant feature in the District and remove most of the particulate pollutants, their phosphorus-removal performance is limited. For this reason, one of the primary types of BMPs installed to meet TMDL requirements is filtration-type BMPs. Many of the filtration-type BMPs with media designed to bind dissolved and unsettleable phosphorus are still considered somewhat experimental; hence, an assessment of the lifespan, performance, and effectiveness of these systems is warranted. This section will also cover other unique BMPs within the District, such as an alum treatment plant and a pond that received an iron filing application.

The report is organized by resource type or subject.

- Chapter 3 includes the most recent and historical lake data, water quality trends, a discussion of in-lake management actions and actions in the tributary watershed, and an overall assessment.
- Chapter 4 includes recent and historical monitoring data for streams and conveyances, an overall assessment, a discussion of water quality trends, and a description of relevant management actions.
- Chapter 5 provides a brief assessment of a potentially emerging issue for the District: PFAS (perfluoroalkyl substances).
- Chapter 6 provides the results of a 2021 and 2022 winter chloride study to better understand the sources of chloride in District waters.
- Chapter 7 provides the results of various monitored BMPs throughout the District.

2. CONCLUSIONS AND RECOMMENDATIONS

Overall, there is a long-term trend of improving water quality for eutrophication parameters for District lakes. A qualitative review of the figures in Section 3 suggests that in 2022 water quality improved in Battle Creek Lake and Gervais Lake, while water quality was worse for Casey Lake and Kohlman Lake. For monitored streams (Battle Creek, Fish Creek, Kohlman Creek, Beltline Interceptor, and Gervais Creek) and eutrophication parameters, there is also a long-term trend of improving water quality; however, those improvements appear to have plateaued and are potentially starting to decrease again over the last 10 years. In contrast, and although the period of record for many of these water bodies is short, it appears that chloride concentrations are either increasing or stable in District lakes and streams rather than decreasing.

Long-term water quality improvements in District lakes and streams suggest that the implementation of numerous best-management practices (BMPs) has been successful, though changes in precipitation may have also contributed to changes in the water quality of District water bodies. A next generation of BMPs has been implemented over the past decade to begin to remove dissolved phosphorus in addition to particulate phosphorus. A summarized assessment of these BMPs is provided below:

- The Beam Avenue filter, an iron-enhanced sand filter, was first monitored in 2009, with total phosphorus removal ranging from around 75 to 90% and ortho-phosphorus removal ranging from 10 to 80% from 2009 to 2018. Performance slightly improved in 2021 and 2022, but that may have been due to two drought years and a media closest to the inlet being replaced in 2022. Continued monitoring is planned for 2023, and this will provide valuable information regarding the expected longevity of iron-enhanced sand filters in Minnesota.

- The Woodlyn Avenue iron-enhanced sand-type vegetative filter was monitored from 2012 to 2018, and during that period, total phosphorus removal ranged from 22 to 75 percent, with the most recent removal in 2018 being 75 percent. Ortho-phosphorus removal during the monitoring period was as high as 90%, but in 2018 the percent removal was 0. In 2022, the BMP was monitored again and had over 90% removal for total phosphorus, orthophosphate, and total suspended solids. One potential explanation is that 2022 was a drought year with small rain events, so the potential for phosphorus release was low. Monitoring is planned to be on a rotational basis. After the next monitoring period, it will be important to evaluate if the media should be replaced.

- Three spent-lime media filtration type BMPs have been constructed in the District. It is instructive to compare the performance of these systems to the iron-enhanced sand filters and critically evaluate them both as it is still not clear which type of media performs best, as each has positive and negative attributes. The Wakefield Experimental Filter (Wakefield cell) was monitored from 2012 to 2016 and had annual average total phosphorus removal ranging from 41 to 80%, ortho phosphate removal ranging from 67 to 86%, and total suspended solids removal from 0 to 77%. The Frost Kennard Filter had a decrease in total phosphorus, orthophosphate, and total suspended solids removal from 2018 to 2019. In 2022, the filter had its best removal performance, with 78% total phosphorus removal, 65% orthophosphate removal, and 93% total suspended solids removal. The other spent-lime BMP, Willow Pond, is new and is just beginning to be monitored. Monitoring of Frost Kennard Filter will continue in 2023, and additional "start-up" monitoring will be conducted for Willow Pond in 2023.

- The Wakefield experimental filter (Wakefield cell) had the spent-lime media replaced with iron and granite sand media in 2022. The performance of the filter for phosphorus and orthophosphate was mixed with an average removal of 9% and 19%, respectively. Total suspended solids performance improved over the year, but the filter still had minimal removals, with two events releasing suspended solids. One potential reason for this is if the new media was not washed properly and contained additional solids at the time of installation. Monitoring is planned for 2023 to see if the performance improves.

- The Tanners Lake alum treatment facility deserves some mention as it has performed very reliably and is likely the primary reason that Tanners Lake has been taken off the impaired waters list and also why Battle Creek Lake water quality has improved notably. Since the beginning of operation in 1998, the average annual total phosphorus removal has ranged from 48 to 91%, with the removals from 2015 to 2019 ranging from 78-89%. Total phosphorus removal declined in the past 2 years at 72% in 2021 and 48% in 2022; therefore, it will be important to monitor to determine if the trend persists.
- The Shoreview Commons Pond is a pond that has a history of internal loading. In February 2021, an iron filing application was applied to the frozen lake. The application of iron on frozen ice allows the iron filings to be equally distributed as the ice melts. The pond was monitored from 2019 to 2021 to evaluate the impacts of the iron-filing application. Similarly, orthophosphate and total suspended solids removal were similar pre- and post-filing. Given similar removals pre- and post-filing application, a small data set in 2021, and the installation of an aerator in 2021, it is hard to make a statement regarding the impact of iron filings. It is recommended to sample more frequently for an entire year to determine the impacts of iron-filings.

The following include monitoring recommendations as well as some recommendations for future annual reports.

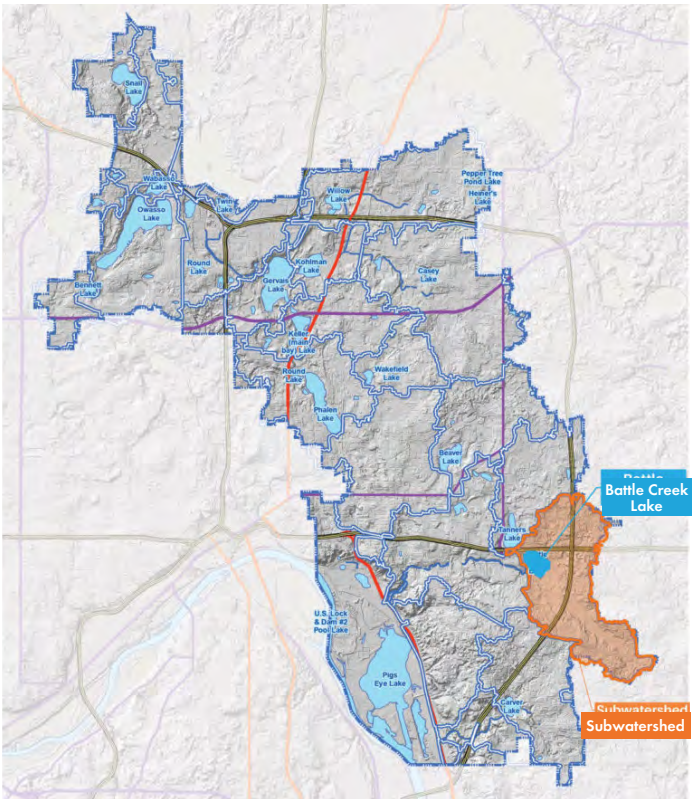
1. **Chloride**
    a. Continue to incorporate chloride monitoring into all routine water quality monitoring.
    b. On a rotating basis, continue annual monitoring of water bodies, including ponds, ditches, and creeks, to better understand where the chloride hotspots are located within the RWMWD. In 2022, chloride monitoring was continued (see Chapter 6) in water bodies downstream of approximately 40% of the District watershed area. Monitoring in water bodies is planned to continue in 2023.
    c. Measure specific conductance when measuring chloride to develop a relationship between chloride and specific conductance. In the future, specific conductance may be used as a surrogate for chloride by developing a regression between the two parameters.
2. **Streams**
    a. Continue monitoring water quality of streams (at a minimum total phosphorus, total dissolved phosphorus, ortho-phosphorus, total Kjeldahl nitrogen, nitrate plus nitrite, total suspended solids, chloride, and chlorophyll *a*). Monitoring will have value even if flow cannot be monitored.
3. **BMPs**
    a. A rotating monitoring schedule for the filtration-type BMPs has been developed to document the performance of BMPs constructed in the District. A rotating schedule will allow for a more widespread monitoring effort when new BMPs come online. It is important to reevaluate the BMP monitoring schedule annually.
    b. The media of the following BMPs needs further evaluation in 2023 or a latter year (another year of monitoring may be appropriate to confirm whether these filters are performing as designed):
        i. Beam Avenue iron-enhanced sand filter
        ii. Woodlyn Avenue iron-enhanced sand filter
        iii. Wakefield Lake experiemental iron and granite sand filter
    c. A recommendation of the 2020 report was to monitor high-priority ponds (flow and water quality) to determine whether ponds are releasing phosphorus and if performance can be improved by various treatments. A study is currently ongoing to evaluate internal loading in Markham Pond, Bennett Lake, Gervais Mill Pond, and Marham Pond to identify the potential benefit of aerating ponds and shallow lakes to reduce internal loading. The outcome of this study will be highlighted in the 2023 report.
4. **For future reports, it is recommended that other non-water-quality activities be documented to keep track of how watershed and waterbody health is being improved in the watershed. These activities may include the following:**
    a. Carp management
    b. Aquatic plant management
    c. Shoreline restoration
    d. Wetland reclamation
    e. Macroinvertebrate and fisheries monitoring (relative to TALU)

3. LAKE WATER QUALITY

BATTLE CREEK LAKE

Minnesota Pollution Control Agency (MPCA) designations	Shallow lake; "non-support" of aqutic life (chloride)
Tributary area	2,638 acres
Surface area	103 acres
Average/maximum depth	4 feet/15 feet
RWMWD nutrient classification[1]	At risk
Accountable municipalities	Landfall, Oakdale, Woodbury, Washington County
Downstream water body	Battle Creek

[1]RWMWD nutrient classifications are based on the relationship between the historical average water quality (based on phosphorus concentration alone) and the MPCA water quality (phosphorus) standards.



Battle Creek Lake is a shallow lake in Washington County that receives flows from Tanners Lake and outlets to Battle Creek. The lake is used for a variety of recreational purposes, including motor boating, canoeing, fishing, picnicking, and aesthetic viewing. A public boat access is located at the lake's southeast corner in Shawnee Park.

Battle Creek Lake is on the MPCA's impairment list for mercury (aquatic consumption) and chloride (aquatic life). A statewide mercury TMDL was completed in 2007, and the Twin Cities Metro Area Chloride TMDL was completed in 2016. The lake was removed from the MPCA's Impaired Waters List for excess nutrients in 2014.

Battle Creek Lake has been monitored annually for phosphorus, chlorophyll *a*, and Secchi disc depth from 1997 to 2022; it has been monitored annually for chloride since 2015. In 2022, the lake met Minnesota state standards for summer averages of all parameters but chloride (see table and graphs at right). The 10-year data shows a statistically significant trend of increasing Secchi disc transparency.

According to the 2017 *Ramsey Washington Metro Watershed District Watershed Restoration and Protection Strategies Report*, 68% of the phosphorus in Battle Creek Lake comes from stormwater. Strategies to address stormwater management include implementing water-quality projects that reduce external loading to the lake and BMP cost-share programs. Plans to address chloride include improving road salt management by promoting and adopting strategies outlined in the *Twin Cities Metro Area Chloride Management Plan*.

Since first establishing water quality goals for Battle Creek Lake, RWMWD has completed several projects that have contributed to improvements in water quality. Recent projects include:

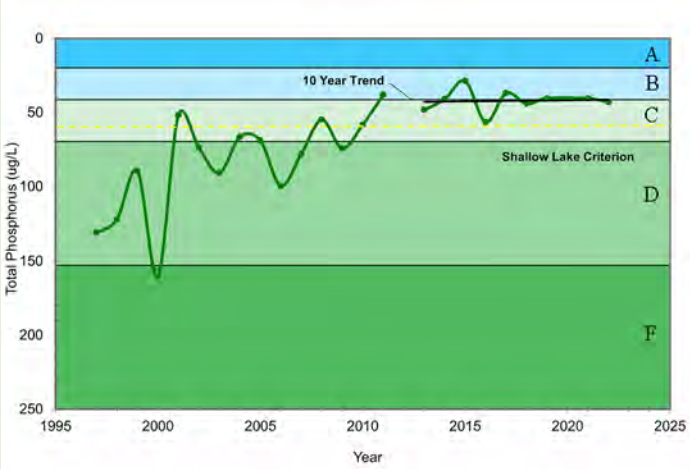
- Woodbury Elementary and Middle School rain gardens (2017): This was one of six school rain garden projects funded, in part, by a $150,000 Clean Water Fund grant. Two gardens were planted at the site, providing needed pollinator habitat and reducing the volume of polluted runoff that drains to Battle Creek Lake.
- Trinity Presbyterian Church (2017): Two rain gardens were installed at this site to manage runoff from the church's parking lot. This reduces the volume of polluted rainwater draining to Battle Creek Lake.

Parameter	State Standard	2022 Battle Creek Lake	10-Year Average[1]	10-Year Trend
Phosphorus	≤ 60 µg/l	43.0 µg/l	42 µg/l	None
Chlorophyll a	≤ 20 µg/l	9.6 µg/l	7.6 µg/l	None
Secchi disc transparency	> 1 meter	2.9 meters	2.4 meters	Increasing
Chloride	≤ 230 mg/l[2]	233 mg/l	N/A	N/A

[1] A minimum of 10 years of data were analyzed. If a year was missing within the most recent 10-year period, the period of record was extended.

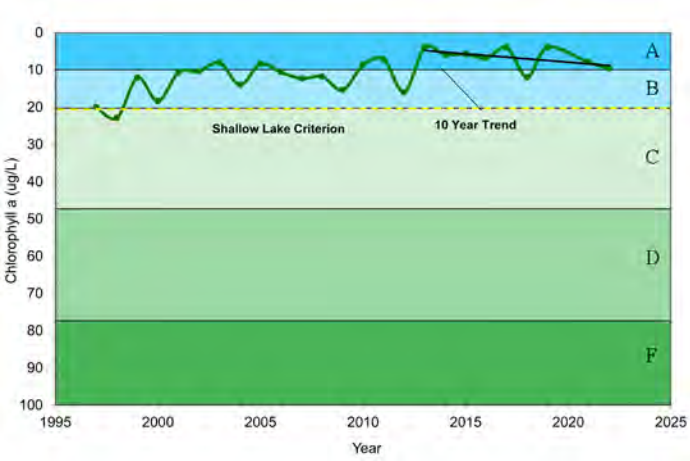
[2] State standard for chronic chloride exposure.

Total phosphorus (µg/l)

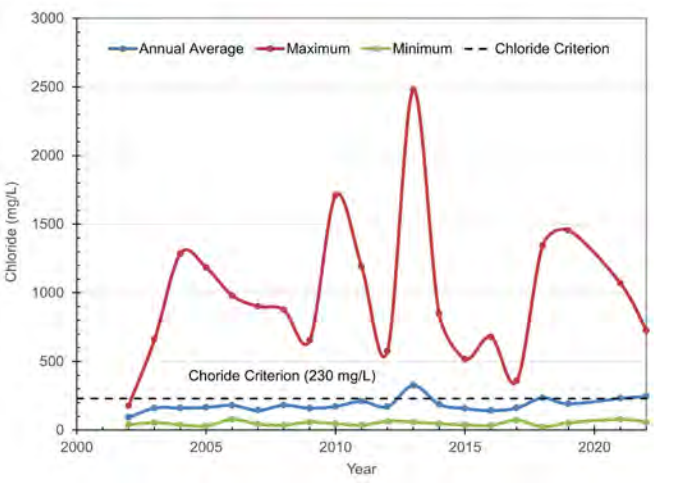


Secchi transparency (m)

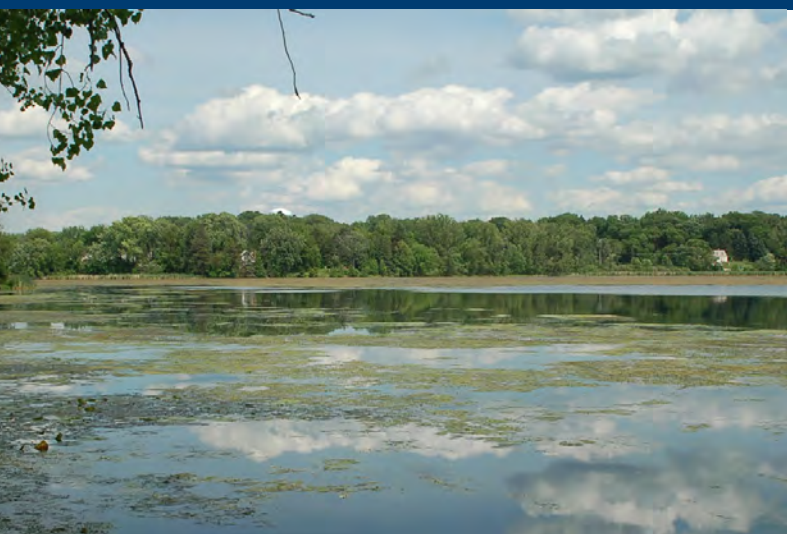
Chlorophyll *a* (µg/l)



Chloride (mg/l)

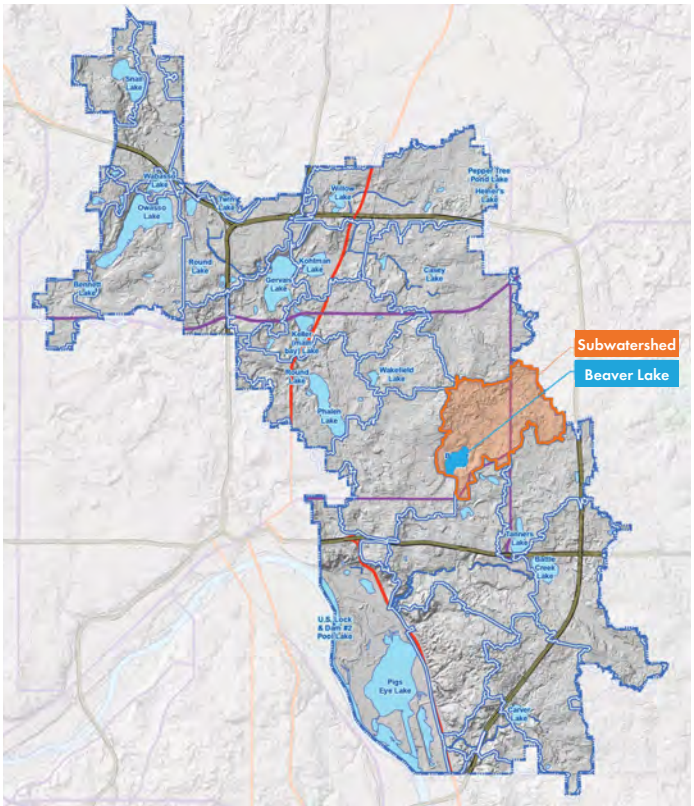


BEAVER LAKE



MPCA designation	Shallow
Tributary area	1,935 acres
Surface area	87 acres
Average/maximum depth	4/11 feet
RWMWD nutrient classification[1]	At risk
Accountable municipalities	Maplewood, St. Paul, Ramsey County, Washington County
Downstream water body	Beltline Storm Sewer and Mississippi River

[1]RWMWD nutrient classifications are based on the relationship between the historical average water quality (based on phosphorus concentration alone) and the MPCA water quality (phosphorus) standards.



Beaver Lake is a small, shallow lake in Maplewood that drains to the Beltline storm sewer and on to the Mississippi River. A Ramsey County park occupies most of the north and west shoreline. The lake has some wildlife habitat and is primarily used for canoeing, fishing, picnicking, and aesthetic viewing. It is impaired for mercury (aquatic consumption), at risk for chlorides, and listed by the Minnesota DNR as infested with Eurasian watermilfoil. In 2012 the lake was removed from the MPCA's Impaired Waters List for excess nutrients.

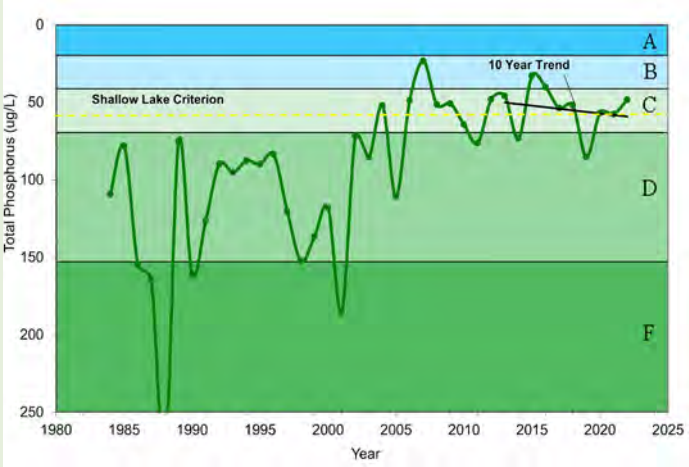
Beaver Lake has been monitored annually for phosphorus, chlorophyll *a*, and Secchi disc depth since 1984; chloride monitoring started in 2015. In 2022, the lake met summer-average state standards for all four parameters (see table and graphs at right). The 10-year data shows no statistically significant change for any parameter.

According to the *2017 Ramsey Washington Metro Watershed District Watershed Restoration and Protection Strategies Report*, 51% of the phosphorus in Beaver Lake comes from stormwater, and 47% comes from internal loading. Strategies to address stormwater management include implementing water-quality projects to reduce the total phosphorus load to the lake and BMP cost-share programs. Plans to reduce in-lake loading include assessing options for the inactivation of sediment release of phosphorus.

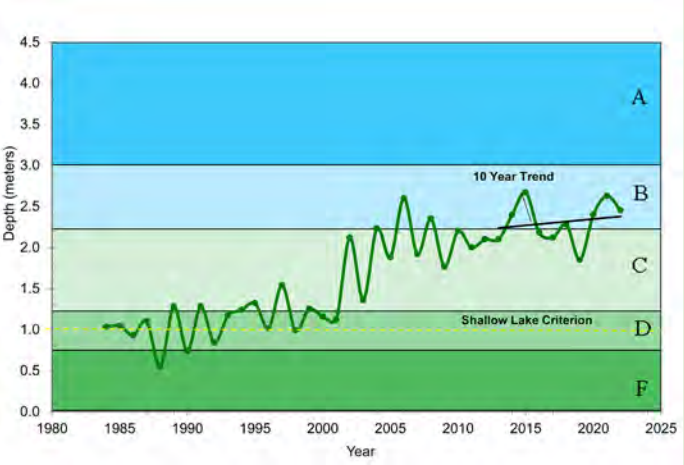
Parameter	State Standard	2022 Beaver Lake	10-Year Average[1]	10-Year Trend
Phosphorus	≤ 60 µg/l	48.5 µg/l	54 µg/l	None
Chlorophyll a	≤ 20 µg/l	18.1 µg/l	14 µg/l	None
Secchi disc transparency	> 1 meter	2.45 meters	2.3 meters	None
Chloride	≤ 230 mg/l[2]	116 mg/l	N/A	N/A

[1] A minimum of 10 years of data were analyzed. If a year was missing within the most recent 10-year period, the period of record was extended.
[2] State standard for chronic chloride exposure.

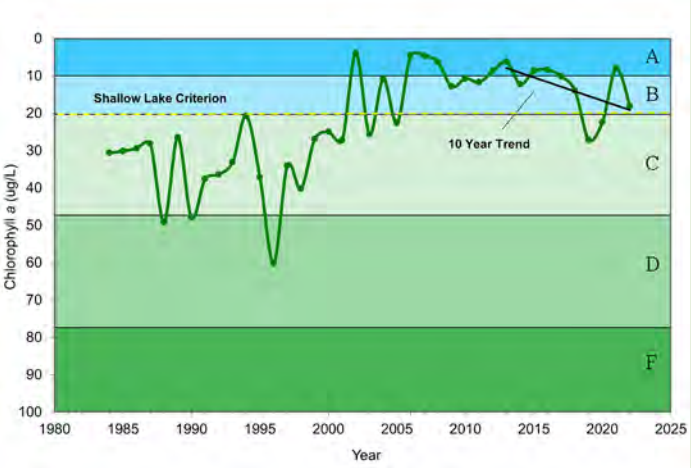
Total phosphorus (µg/l)



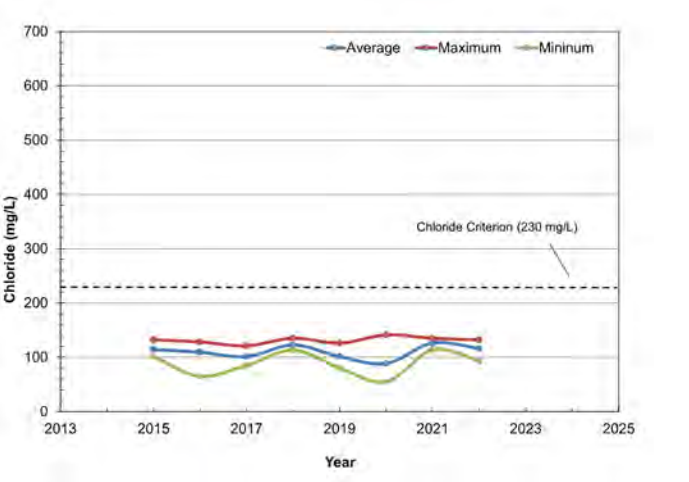
Secchi transparency (m)



Chlorophyll *a* (µg/l)



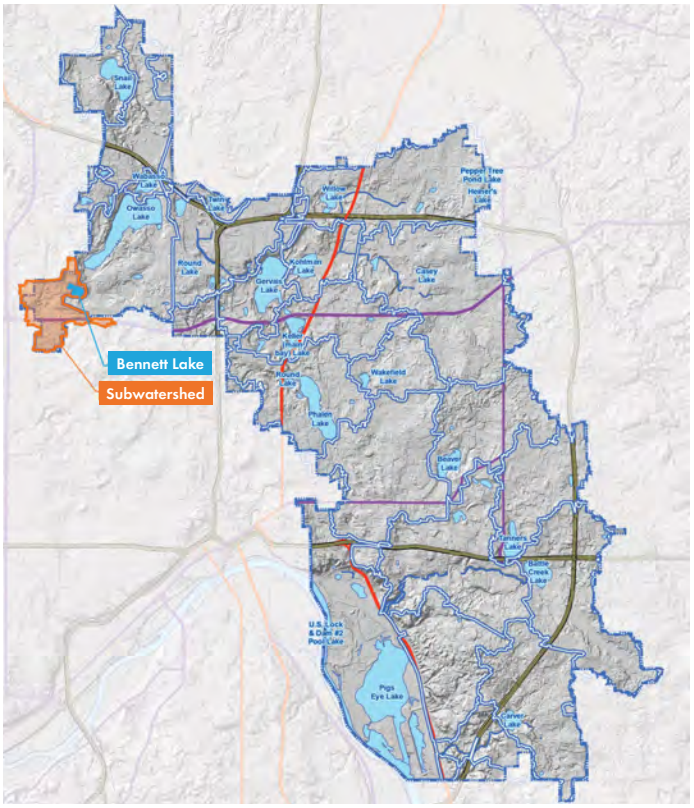
Chloride (mg/l)



BENNETT LAKE

MPCA designation	Shallow
Tributary area	721 acres
Surface area	25 acres
Average/maximum depth	9 feet
RWMWD nutrient classification[1]	Impaired
Accountable municipalities	Roseville, Ramsey County
Downstream water body	Lake Owasso

[1]RWMWD nutrient classifications are based on the relationship between the historical average water quality (based on phosphorus concentration alone) and the MPCA water quality (phosphorus) standards.



Bennett Lake is the start of a chain of lakes that ultimately drains to Grass Lake. The City of Roseville's Central Park surrounds the lake, which has a fishing pier and provides canoeing opportunities. The Minnesota Department of Natural Resources uses Bennett Lake as a fish nursery.

Bennett Lake is considered by the MPCA to be impaired for mercury (aquatic consumption) and excess nutrients. A statewide mercury TMDL was completed in 2007, and a nutrient TMDL was completed in 2017.

Bennett Lake has been monitored annually for chlorophyll *a* from 1984 to 2022 and for phosphorus and Secchi disc depth from 2003 to 2022. Annual chloride monitoring began in 2015. In 2022, the lake met summer-average state standards for chlorophyll *a*, Secchi disc transparency, and chloride but failed to meet the phosphorus standard (see table and graphs at right). The 10-year data shows a statistically significant trend of decreasing chlorophyll *a* levels.

According to the *2017 Ramsey Washington Metro Watershed District Watershed Restoration and Protection Strategies Report*, 56% of the phosphorus in Bennett Lake comes from internal loading, and 43% comes from stormwater. In 2022, a shallow lake aeration study began. The study consists of monthly monitoring for water quality and sediment coring, as well as continuous dissolved oxygen monitoring. The objective of the study is to determine if shallow aeration could reduce phosphorus loading and improve dissolved oxygen throughout the lake.

RWMWD has completed three recent projects that have contributed to the improving water quality of this lake:

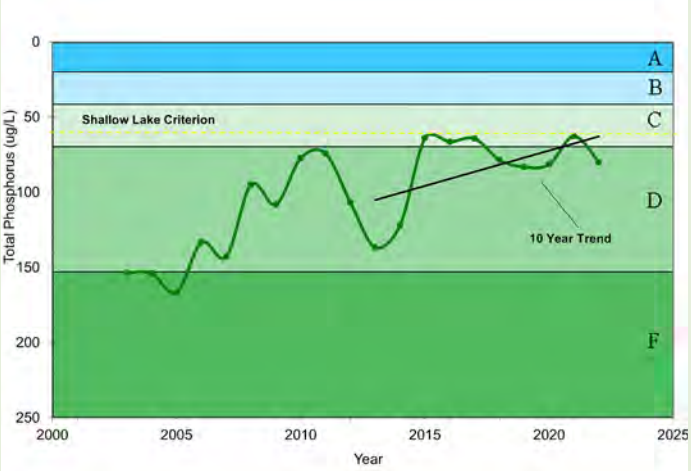
- Grace Church retrofit (2015): This project involved the installation of two rain gardens and three native planting areas to intercept and filter runoff from the Grace Church parking lot, reducing the volume of polluted rainwater draining to Bennett Lake.
- Willow Pond Spent Lime Filter (2018): This project involved the installation of a spent lime filter that draws water above the pond's outlet elevation off of Willow Pond. The pipe that draws water from Willow Pond can be opened and closed automatically to control the volume of water in the filter and the length of time between filling events.
- Carp management (ongoing since 2017): Carp management in the Lake Owasso system of lakes (Owasso, Wabasso, Bennet, and Grass) is helping control phosphorus loading in these waters. Foraging carp stir up nutrient-rich sediment on the lake bottom, which, in turn, contributes to turbid water and algae blooms. Management efforts include counting carp to understand the extent of the population, tracking them with radio tags to allow efficient harvesting and identification of carp nurseries, and installing barriers.

Parameter	State Standard	2022 Bennett Lake	10-Year Average[1]	10-Year Trend
Phosphorus	≤ 60 µg/l	80.1 µg/l	84 µg/l	None
Chlorophyll *a*	≤ 20 µg/l	6.7 µg/l	17.5 µg/l	Decreasing
Secchi disc transparency	> 1 meter	2.05 meters	1. 6 meters	None
Chloride	≤ 230 mg/l[2]	142 mg/l	N/A	N/A

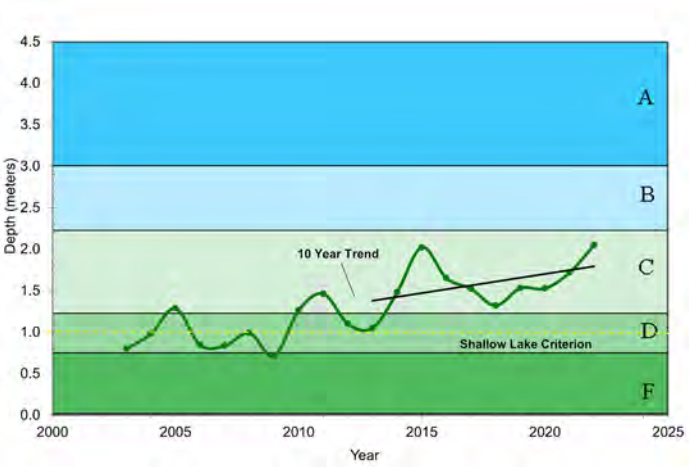
[1] A minimum of 10 years of data were analyzed. If a year was missing within the most recent 10-year period, the period of record was extended.

[2] State standard for chronic chloride exposure.

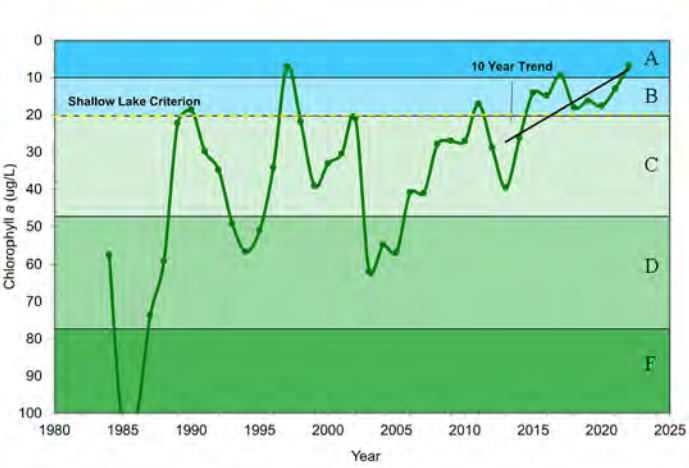
Total phosphorus (µg/l)



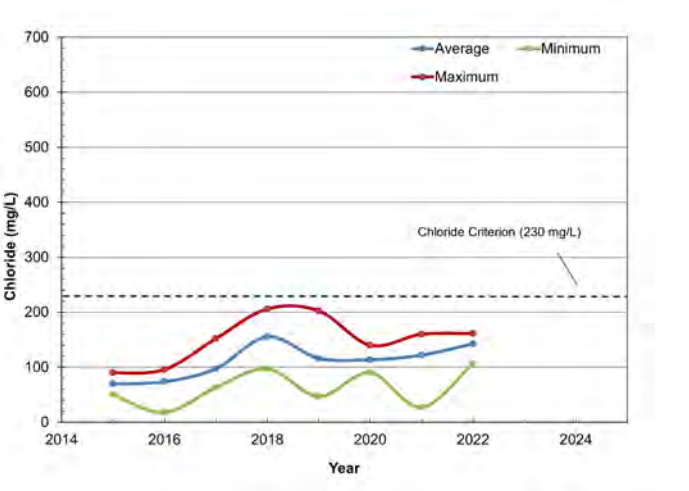
Secchi transparency (m)



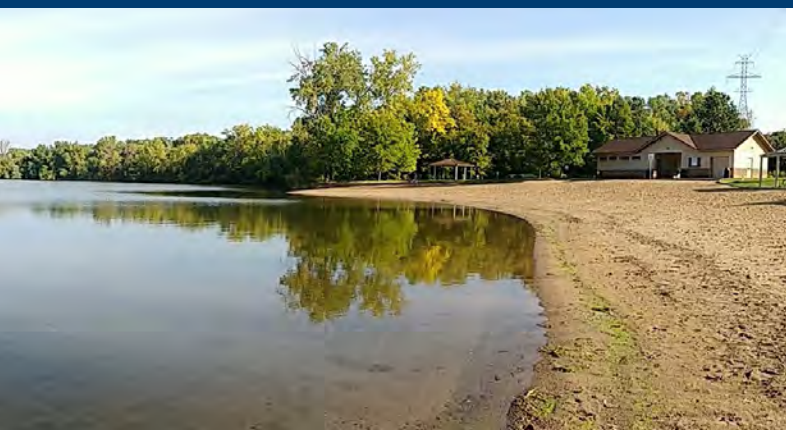
Chlorophyll *a* (µg/l)



Chloride (mg/l)

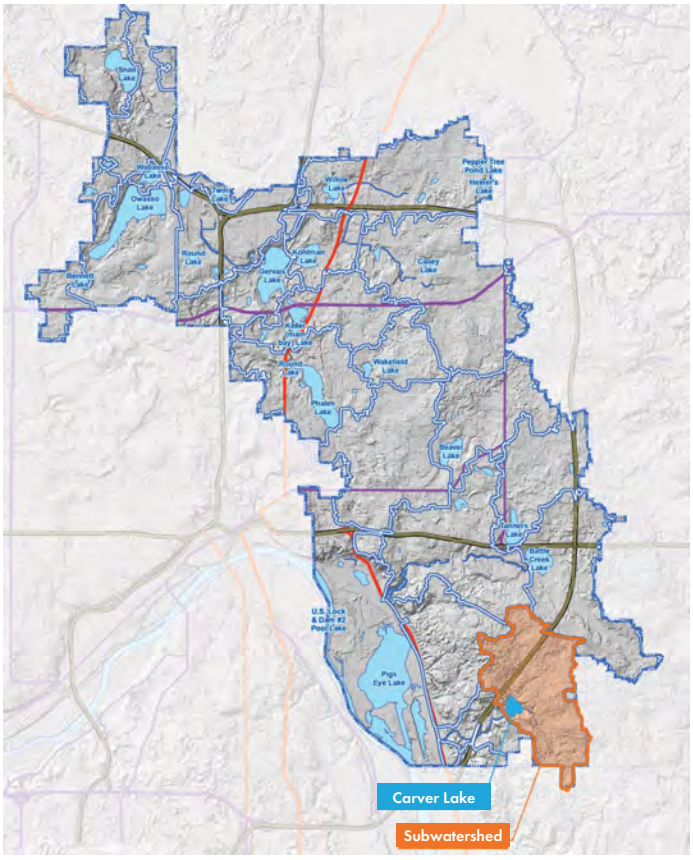


CARVER LAKE



MPCA designations	Deep lake; "non-support" of aquatic life (chloride)
Tributary area	2,274 acres
Surface area	49 acres
Average/maximum depth	16/36 feet
RWMWD nutrient classification[1]	At risk
Accountable municipalities	Maplewood, Woodbury, Ramsey County, Washington County
Downstream water body	Fish Creek

[1]RWMWD nutrient classifications are based on the relationship between the historical average water quality (based on phosphorus concentration alone) and the MPCA water quality (phosphorus) standards.



Carver Lake, which borders the popular Carver Lake Park, is used primarily for swimming and canoeing. There is a public beach located on the southeast side, along with a canoe access.

Carver Lake was removed from the MPCA's impaired list for nutrients in 2012. However, it is still considered by to be impaired for mercury (aquatic consumption) and chloride (aquatic life). A statewide mercury TMDL was completed in 2007, and the Twin Cities Metro Area Chloride TMDL was completed in 2016.

Carver Lake has been monitored annually for phosphorus, chlorophyll *a*, and Secchi disc depth from 1997 to 2021. Annual chloride monitoring began in 2016. In 2022, the lake met MPCA summer-average state standards for phosphorus, chlorophyll *a*, and Secchi disc transparency. However, chloride levels were notably over the state standard. The 10-year trend shows a statistically significant improvement in Secchi disc transparency (see table and graphs at right).

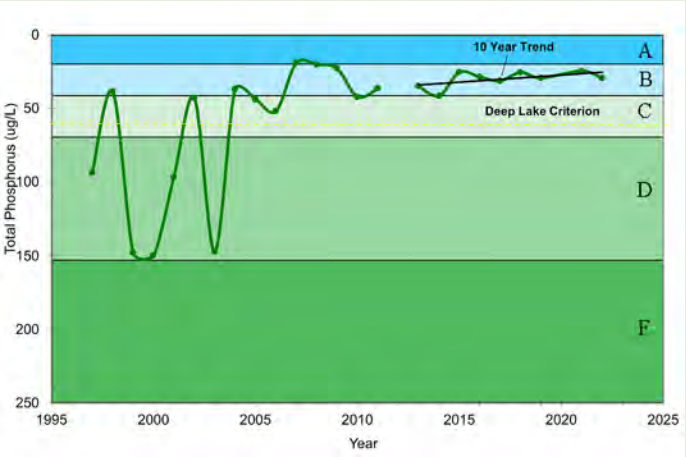
According to the *2017 Ramsey Washington Metro Watershed District Watershed Restoration and Protection Strategies Report*, 79% of the phosphorus in Carver Lake comes from stormwater, and 19% comes from internal loading. Goals for the lake include improving stormwater management by implementing a BMP cost-share program and water quality projects that decrease the phosphorus load to Carver Lake.

Parameter	State Standard	2021 Carver Lake	10-Year Average[1]	10-Year Trend
Phosphorus	≤ 40 µg/l	29.5 µg/l	30 µg/l	None
Chlorophyll *a*	≤ 14 µg/l	9.8 µg/l	13 µg/l	None
Secchi disc transparency	> 1.4 meters	3.07 meters	2.4 meters	Increasing
Chloride	≤ 230 mg/l[2]	317 mg/l	N/A	N/A

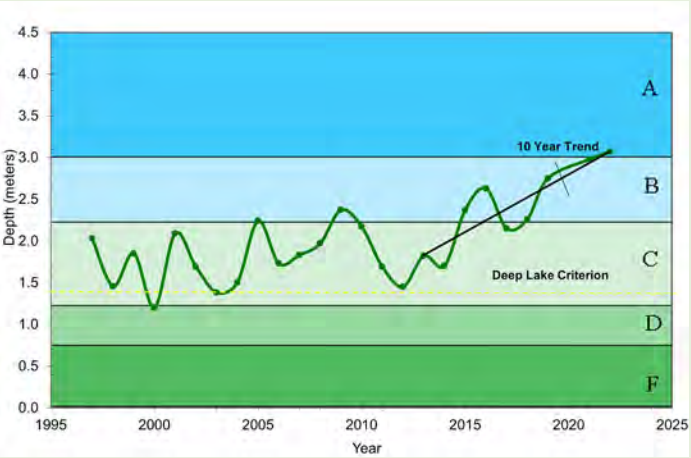
[1] A minimum of 10 years of data were analyzed. If a year was missing within the most recent 10-year period, the period of record was extended.

[2] State standard for chronic chloride exposure.

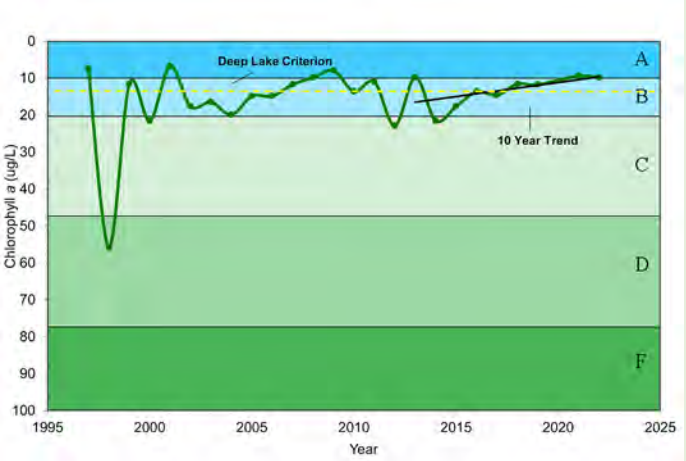
Total phosphorus (µg/l)



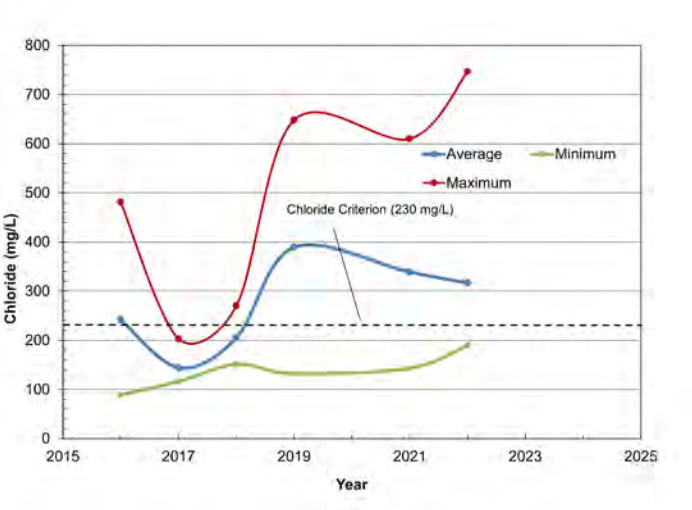
Secchi transparency (m)



Chlorophyll *a* (µg/l)



Chloride (mg/l)



CASEY LAKE

Casey Lake is actually a large wetland. Located in North St. Paul, it is the headwaters of Kohlman Creek.

Casey Lake has been monitored annually for phosphorus, chlorophyll a, and Secchi disc depth since 2008; however, as a wetland, state eutrophication standards do not apply. The 10-year data shows a statistically significant increase in Secchi disc depths and chlorophyll *a* concentrations.

In the winter of 2012–2013, a draw-down of Casey Lake was done to kill invasive carp, which used the lake as a nursery. Foraging carp stir up nutrient-rich sediment on the lake bottom, which, in turn, contributes to turbid water and algae blooms. The draw-down dramatically improved the lake's water clarity (from 0.26 meters to 0.88 meters). In the spring of 2013, the DNR stocked bluegills and bass in Casey Lake to keep carp levels low.

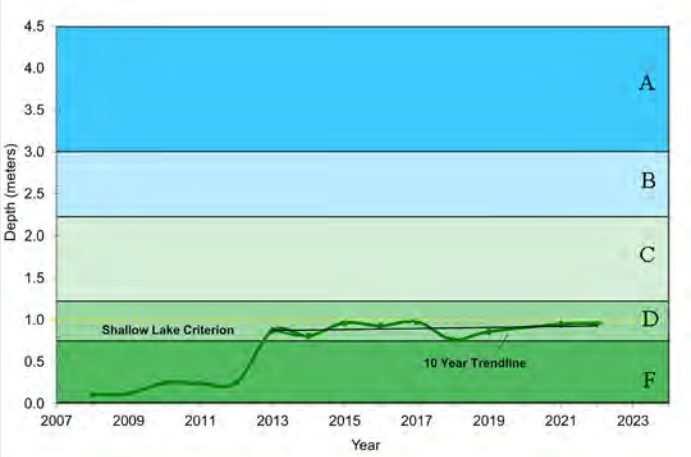
Parameter	State Standard	2022 Casey Lake	10-Year Average[1]	10-Year Trend
Phosphorus	N/A	133.2 µg/l	106 µg/l	None
Chlorophyll *a*	N/A	15.6 µg/l	17 µg/l	Increasing
Secchi disc transparency	N/A	0.96 meter	0.9 meters	Increasing
Chloride	N/A	74.6 mg/l	N/A	N/A

[1] A minimum of 10 years of data were analyzed. If a year was missing within the most recent 10-year period, the period of record was extended.

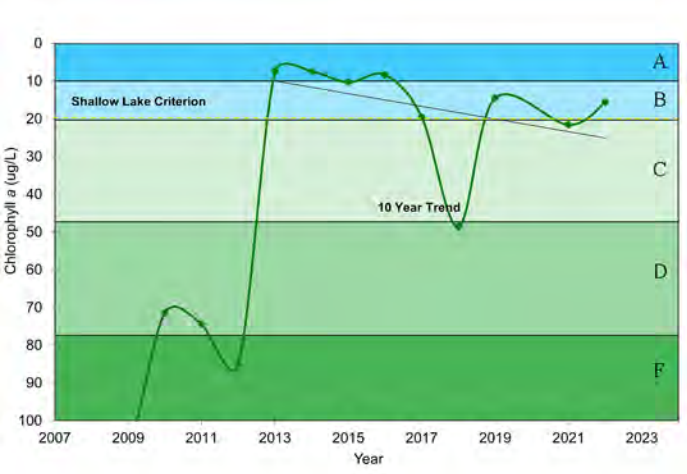
[2] Chloride value is average water-column concentration.

Total phosphorus (µg/l)

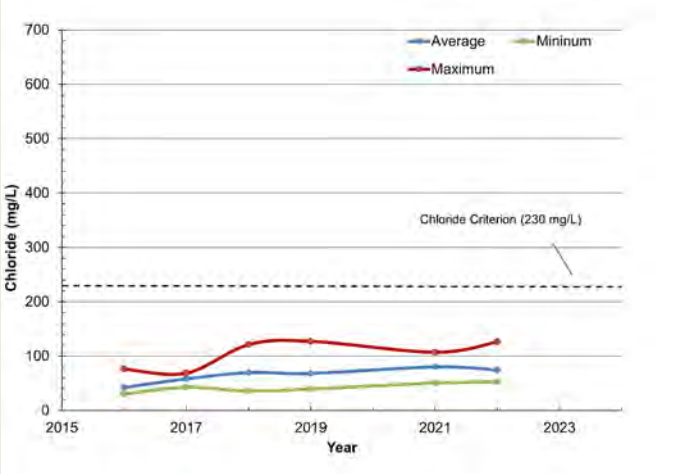
Secchi transparency (m)



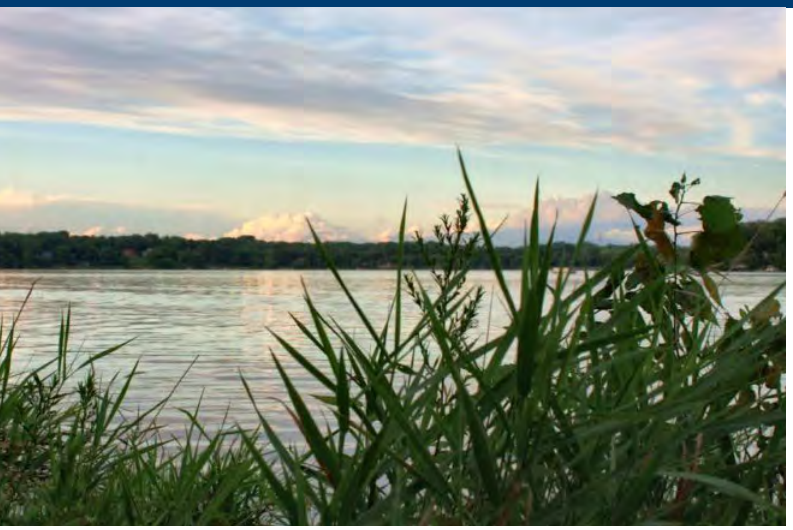
Chlorophyll *a* (µg/l)



Chloride (mg/l)

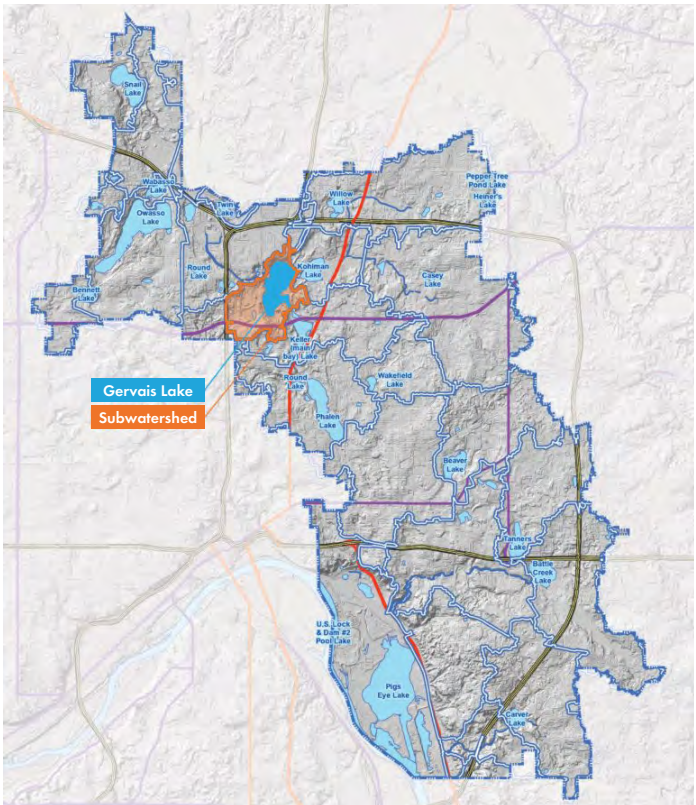


GERVAIS LAKE



MPCA designations	Deep; "non-support of aquatic life (fish and chloride)
Tributary area	893 acres
Surface area	234 acres
Average/maximum depth	22/41 feet
RWMWD nutrient classification[1]	Stable
Accountable municipalities	Little Canada, Maplewood, Ramsey County
Downstream water body	Keller Lake

[1]RWMWD nutrient classifications are based on the relationship between the historical average water quality (based on phosphorus concentration alone) and the MPCA water quality (phosphorus) standards.



Gervais Lake is the second and largest lake in the Phalen Chain of Lakes. It is used primarily for swimming, skiing, and boating. There is a public boat access from Spoon Lake and a Ramsey County swimming beach and park adjacent to the lake. The lake receives flows from Gervais Creek, Kohlman Lake, and runoff from its direct tributary area.

Gervais Lake is on the MPCA's impaired waters list as impaired for mercury (aquatic consumption) and is considered to be at risk for chloride. The lake is also listed by the Minnesota DNR as infested with Eurasian watermilfoil. A statewide mercury TMDL was completed in 2007.

Annual monitoring for phosphorus, chlorophyll *a*, and Secchi disc depth started in 1981. Annual monitoring for chloride began in 1998. In 2022, the lake met summer-average state standards for all parameters but chlorophyll *a*. The 10-year data shows no statistically significant change for any parameter.

According to the *2017 Ramsey Washington Metro Watershed District Watershed Restoration and Protection Strategies Report*, 24% of the phosphorus in Gervais Lake comes from stormwater, and 76% comes from upstream water bodies. Plans to address these conditions include implementing a BMP cost-share program and water-quality projects that decrease the total phosphorus load to the lake.

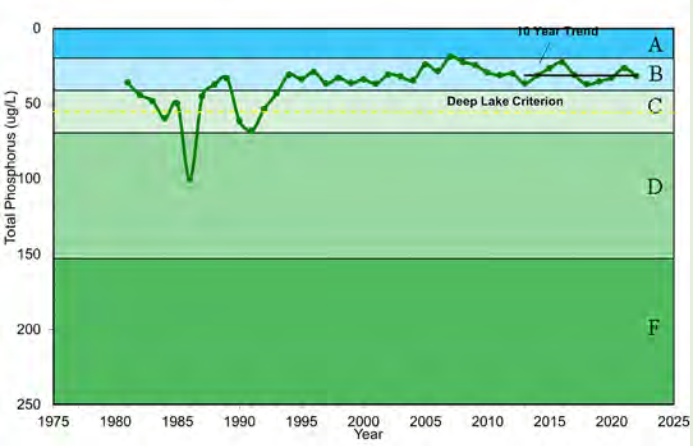
One project that helps control phosphorus loading in the Phalen Chain of Lakes (Gervais, Lake Phalen, Lake Keller, Kohlman Lake) is carp management (ongoing since 2009). Foraging carp stir up nutrient-rich sediment on the lake bottom, which, in turn, contributes to turbid water and algae blooms. Management efforts include counting carp to understand the extent of the population, tracking them with radio tags to allow efficient harvesting and identification of nurseries, and installing barriers. Efforts have reduced carp in the Phalen Chain by over 60%.

Parameter	State Standard	2022 Gervais Lake	10-Year Average[1]	10-Year Trend
Phosphorus	≤ 40 µg/l	31.9 µg/l	31 µg/l	None
Chlorophyll *a*	≤ 14 µg/l	21.6 µg/l	13 µg/l	None
Secchi disc transparency	> 1.4 meter	2.52 meters	2.3 meters	None
Chloride	≤ 230 mg/l[2]	196 mg/l	N/A	N/A

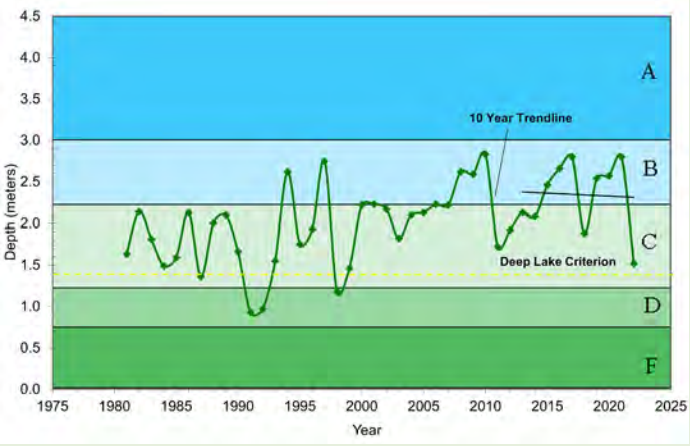
[1] A minimum of 10 years of data were analyzed. If a year was missing within the most recent 10-year period, the period of record was extended.

[2] State standard for chronic chloride exposure.

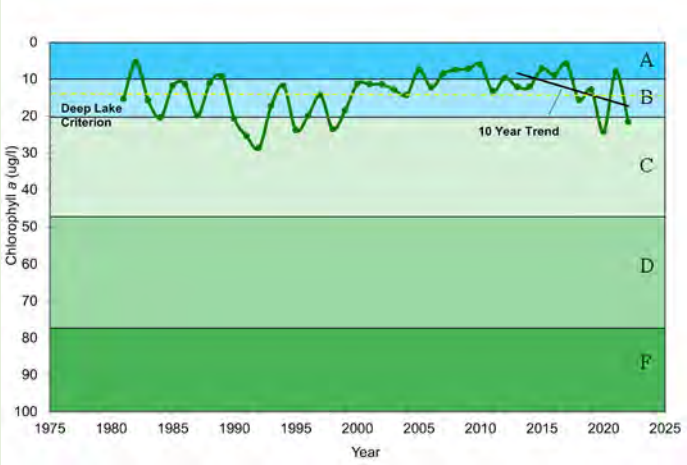
Total phosphorus (µg/l)



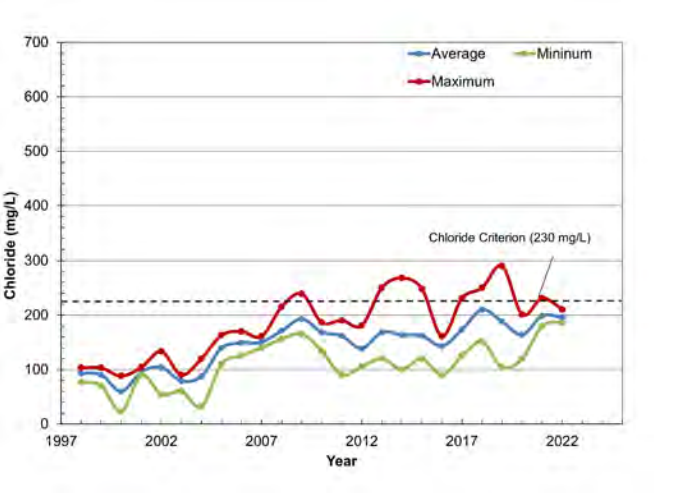
Secchi transparency (m)



Chlorophyll *a* (µg/l)



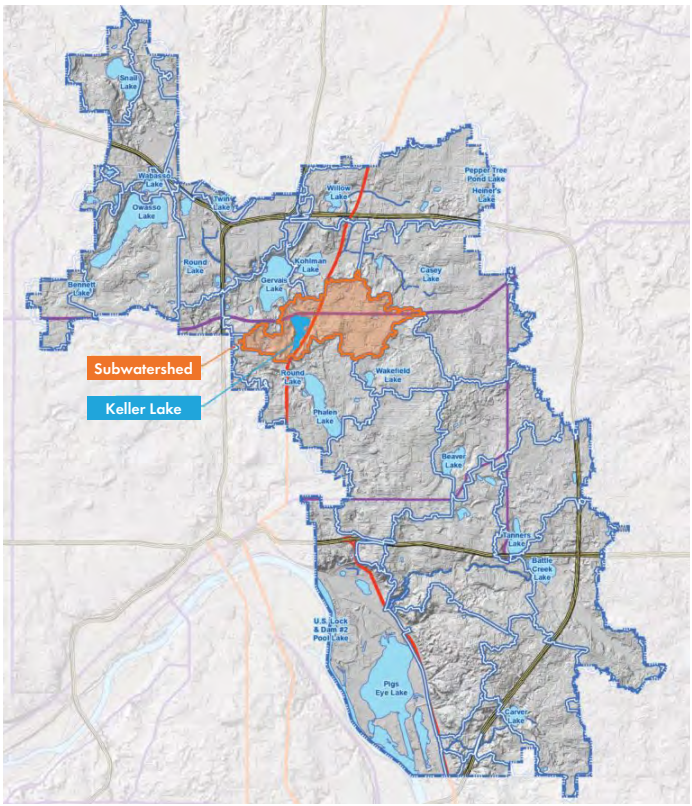
Chloride (mg/l)



KELLER LAKE

MPCA designation	Shallow
Tributary area	1,577 acres
Surface area	72 acres
Average/maximum depth	4/8 feet
RWMWD nutrient classification[1]	Stable
Accountable municipalities	Little Canada, Maplewood, Ramsey County
Downstream water body	Lake Phalen

[1]RWMWD nutrient classifications are based on the relationship between the historical average water quality (based on phosphorus concentration alone) and the MPCA water quality (phosphorus) standards.



Keller Lake is the third lake in the Phalen Chain of Lakes and is used for motor-boating, canoeing, fishing, picnicking, and aesthetic viewing. There is a Ramsey County Park on the lake's east shoreline. Flows to the lake are received from Gervais Lake (through Spoon Lake) and runoff from its direct tributary area.

Keller Lake was listed as impaired for excess nutrients in 2002 but was removed from the list in 2012 after meeting state standards (for shallow lakes). The lake is still at risk of impairment for chlorides. In addition, Keller Lake is listed by the Minnesota DNR as infested with Eurasian watermilfoil.

Annual monitoring for phosphorus, chlorophyll *a*, and Secchi disc depth began in 1981; monitoring for chlorides started in 2015. In 2022, Keller Lake did not meet summer-average state standards for any parameter except chloride concentration (see table and graphs at right). The 10-year data shows no statistically significant change for any parameter.

According to the *2017 Ramsey Washington Metro Watershed District Watershed Restoration and Protection Strategies Report*, 42% of the phosphorus in Keller Lake comes from stormwater, 8% comes from internal loading, and 49% comes from upstream water bodies. Strategies to address stormwater pollution include implementing a BMP cost-share program and water-quality projects that decrease the total phosphorus load to the lake. Internal loading is being addressed by managing carp.

Several recent projects have helped Keller Lake water quality. These include:

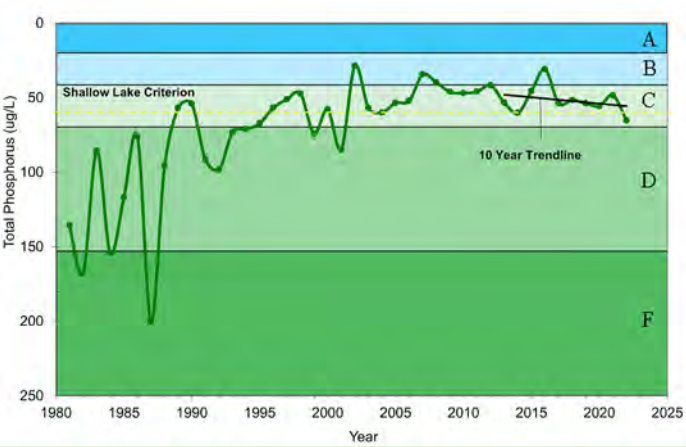
- Weaver Elementary School (2016) is one of six school rain garden projects to manage polluted runoff at schools in priority areas of the watershed. This project also provides needed pollinator habitat.
- The Highway 36/61 project (2014): This project was constructed as part of the overall Trunk Highway 36 and English Street interchange effort. It included the installation of a stormwater treatment system to prevent polluted stormwater runoff from entering Keller Lake and downstream Lake Phalen. The project treats stormwater from approximately 70 acres of commercial, residential, and highway areas by channeling it through an enhanced sand filter cell and two wetland treatment basins designed to remove phosphorus-rich sediment and other contaminants.
- Lakeview Lutheran (2013) is one of 12 projects to manage rainwater runoff at churches with large amounts of impervious surface. Three rain gardens were installed, as well as a native planting area that provides pollinator habitat. The gardens and planting area filter runoff from the church parking lot.

Parameter	State Standard	2022 Keller Lake	10-Year Average[1]	10-Year Trend
Phosphorus	≤ 60 µg/l	65.3 µg/l	52 µg/l	None
Chlorophyll *a*	≤ 20 µg/l	38.8 µg/l	14 µg/l	None
Secchi disc transparency	> 1 meter	0.78 meters	1.6 meters	None
Chloride	≤ 230 mg/l[2]	192 mg/l	N/A	N/A

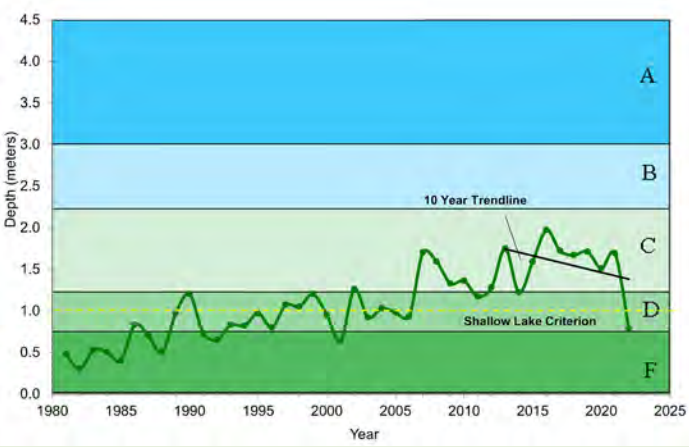
[1] A minimum of 10 years of data were analyzed. If a year was missing within the most recent 10-year period, the period of record was extended.

[2] State standard for chronic chloride exposure.

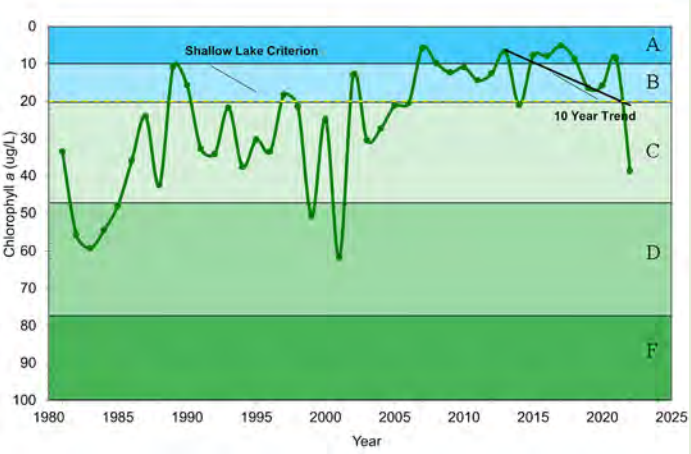
Total phosphorus (µg/l)



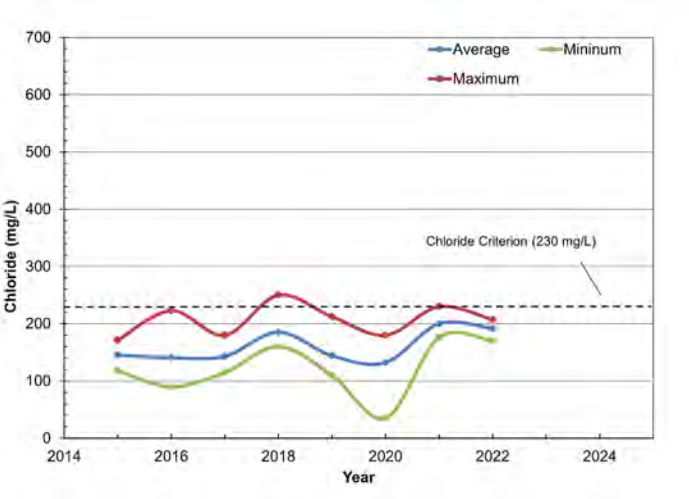
Secchi transparency (m)



Chlorophyll *a* (µg/l)



Chloride (mg/l)

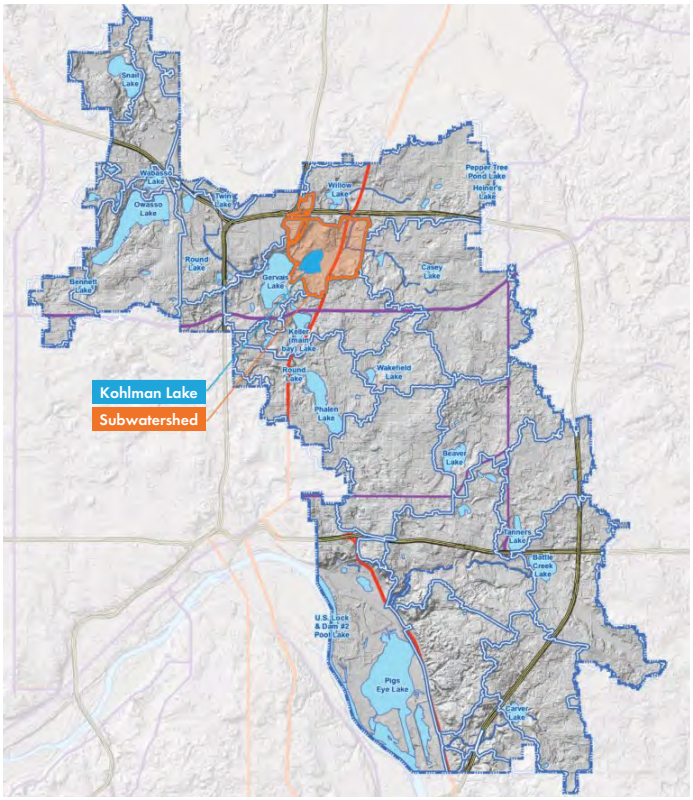


- Keller Lake Shoreline (2012): This ecological restoration project treated over 2,000 feet of shoreline, helping to reduce the volume of polluted stormwater that reaches the lake. The restoration areas now support more than 75 species of native plants.
- Carp management (ongoing since 2009): Carp management helps control phosphorus loading in the Phalen Chain of Lakes (Keller Lake, Gervais Lake, Lake Phalen, and Kohlman Lake). Foraging carp stir up nutrient-rich sediment on the lake bottom, which, in turn, contributes to turbid water and algae blooms. Management efforts include counting carp to understand the extent of the population, tracking them with radio tags to allow efficient harvesting and identification of nurseries, and installing barriers. Efforts have reduced carp in the Phalen Chain by over 60%.

Kohlman Lake

MPCA designations	Shallow; "non-support" of aquatic life (chloride)
Tributary area	1,009 acres
Surface area	84 acres
Average/maximum depth	4/12 feet
RWMWD nutrient classification[1]	At-risk (changed from "impaired" in 2022 MPCA assessment)
Accountable municipalities	Little Canada, Maplewood, Vadnais Heights, Ramsey County
Downstream water body	Gervais Lake

[1]RWMWD nutrient classifications are based on the relationship between the historical average water quality (based on phosphorus concentration alone) and the MPCA water quality (phosphorus) standards.



Kohlman Lake is the first lake in the Phalen Chain of Lakes. It is used for a variety of recreational purposes, including motor-boating, canoeing, fishing, picnicking, and aesthetic viewing. While the drainage area that directly reaches the lake is just over 1,000 acres, the total area connected to the lake through Kohlman and Willow Creeks is about 7,500 acres. There is no direct public boat access to Kohlman Lake, but it can be accessed from Gervais Lake.

Kohlman Lake was listed as impaired for excess nutrients in 2002 and is impaired for chloride (aquatic life). In addition, Kohlman is listed by the Minnesota DNR as infested with Eurasian watermilfoil. A nutrient TMDL was completed in 2010, and the Twin Cities Metro Area Chloride TMDL was completed in 2016.

Annual monitoring for phosphorus, chlorophyll *a*, and Secchi disc depth has occurred since 1981. Annual monitoring for chlorides began in 2021. In 2022, only chloride met summer-average state standards. The 10-year trend shows a statistically significant increase in total phosphorus and chlorophyll *a* concentration, while Secchi disc depth is decreasing.

According to the *2017 Ramsey Washington Metro Watershed District Watershed Restoration and Protection Strategies Report*, 76% of the phosphorus in Kohlman Lake comes from stormwater, and 23% comes from internal loading. Strategies to address stormwater pollution include implementing a BMP cost-share program and water-quality projects that decrease the total phosphorus load to the lake. Internal loading will be addressed by managing carp and curlyleaf pondweed, as needed. An initial alum treatment has been completed on the lake; treatment will be continued if needed, and other options will be assessed.

A few projects have helped improve water quality in Kohlman Lake:

- Maplewood Mall (2012): With 35 acres of asphalt pavement and concrete surfaces surrounding it, Maplewood Mall was a major source of phosphorus runoff to Kohlman Lake. But, over 4 years, the RWMWD installed a variety of stormwater management features that capture and filter 67 percent of rainwater at the mall—up from just 3 percent before the project. These features include innovative tree trenches, rain gardens, permeable pavers, and a 5,700-gallon cistern that receives runoff from the mall roof. Interpretive signage educates the public about these improvements, and a large watershed map in the entry vestibule shows how water travels from the mall all the way to the Mississippi River.

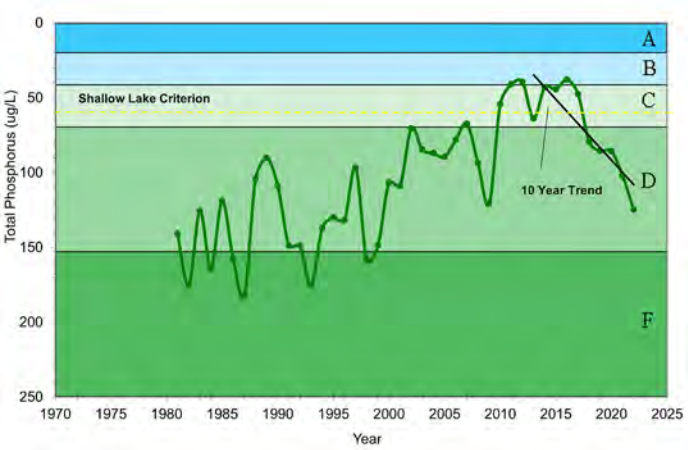
- Beam Avenue Iron-Enhanced Sand Filter (2009): During construction of the new Country View Lane

Parameter	State Standard	2022 Kohlman Lake	10-Year Average[1]	10-Year Trend
Phosphorus	≤ 60 µg/l	124.8 µg/l	71 µg/l	Increasing
Chlorophyll *a*	≤ 20 µg/l	54.4 µg/l	15 µg/	Increasing
Secchi disc transparency	> 1 meter	0.98 meters	1.6 meters	Decreasing
Chloride	≤ 230 mg/l[2]	168 mg/l	N/A	N/A

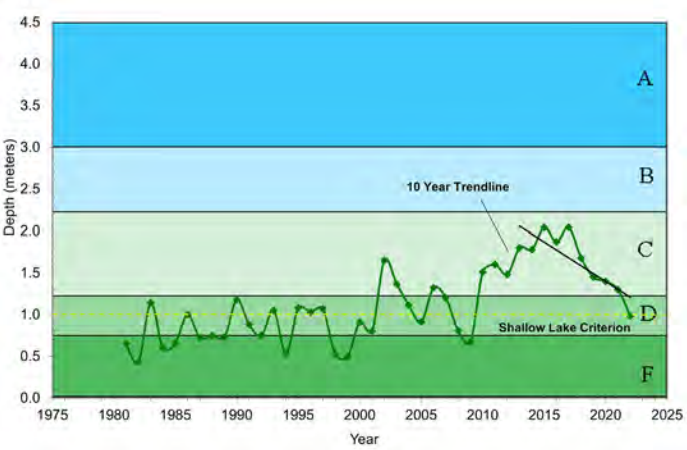
[1] A minimum of 10 years of data were analyzed. If a year was missing within the most recent 10-year period, the period of record was extended.

[2] State standard for chronic chloride exposure; chloride value is average water-column concentration.

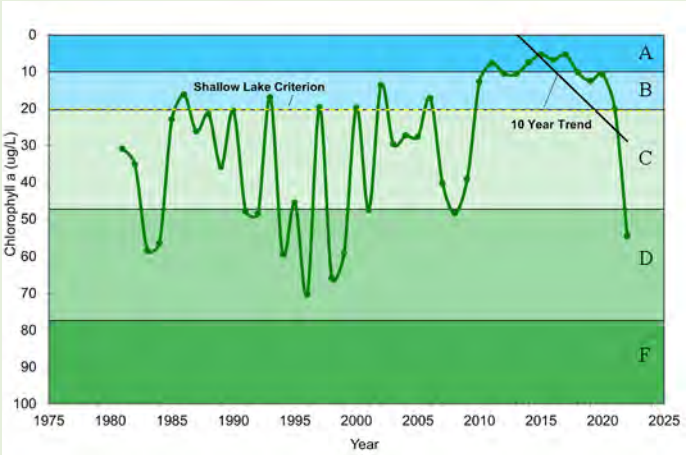
Total phosphorus (µg/l)



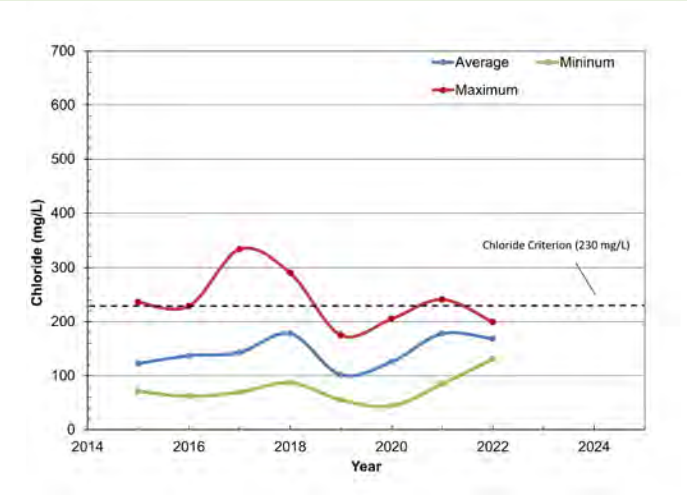
Secchi transparency (m)



Chlorophyll *a* (µg/l)



Chloride (mg/l)



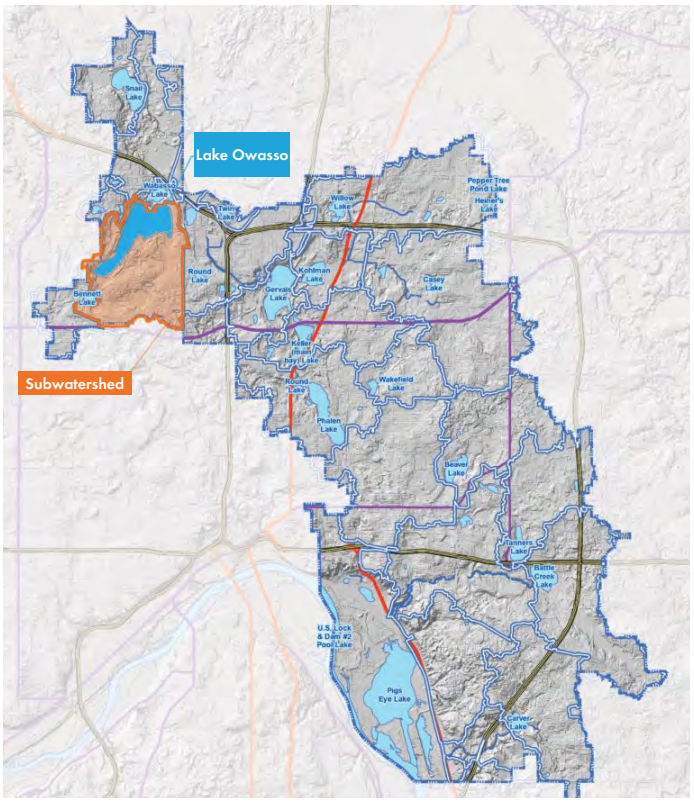
in Maplewood, RWMWD constructed a sand filter to remove dissolved phosphorus from stormwater. Sand filters have been used for years to remove solids and some pollutants from stormwater, but elemental iron (often called zero-valent iron) was added to the sand to remove dissolved phosphorus by forming iron-phosphate complexes. RWMWD monitoring indicates this practice is effectively removing about 90 percent of dissolved phosphorus in the tributary stormwater. This filter is evaluated in Section 7.

- Carp management (ongoing since 2009): Carp management helps control phosphorus loading in the Phalen Chain of Lakes (Kohlman Lake, Lake Phalen, Gervais Lake, Lake Keller). Foraging carp stir up nutrient-rich sediment on the lake bottom, which, in turn, contributes to turbid water and algae blooms. Management efforts include counting carp to understand the extent of the population, tracking them with radio tags to allow efficient harvesting and identification of nurseries, and installing barriers. These efforts have reduced carp in the Phalen Chain by over 60%.

LAKE OWASSO

MPCA designation	Deep
Tributary area	2,175 acres
Surface area	375 acres
Average/maximum depth	11/37 feet
RWMWD nutrient classification[1]	At risk
Accountable municipalities	Roseville, Shoreview, Ramsey County
Downstream waterbody	Lake Wabasso

[1]RWMWD nutrient classifications are based on the relationship between the historical average water quality (based on phosphorus concentration alone) and the MPCA water quality (phosphorus) standards.



Lake Owasso is the largest lake in the RWMWD and a major regional recreational resource for fishing, boating, waterskiing, and swimming. Roseville's Central Park North (along the south shore of the lake) and Owasso County Park in the city of Shoreview (on the north side) provide two public access points, including a boat launch and a public swimming beach. Lake Owasso receives water from Bennett Lake and Lake Emily.

Lake Owasso is impaired for mercury (aquatic consumption) and is also listed by the Minnesota DNR as infested with Eurasian watermilfoil. A statewide mercury TMDL was completed in 2007.

Phosphorus and Secchi disc depth have been monitored annually at Lake Owasso from 2003 to 2022. Chlorophyll *a* has been monitored annually since 1984, and chlorides have been monitored since 2015. 2022 monitoring shows that the lake meets summer-average state standards for all four parameters. The 10-year data shows a statistically significant decrease in phosphorus and chlorophyll *a* levels.

According to the 2017 Ramsey Washington Metro Watershed District Watershed Restoration and Protection Strategies Report, 31% of the phosphorus in Lake Owasso comes from stormwater, and 63% comes from internal loading. Plans to address stormwater pollution include implementing a BMP cost-share program and water-quality projects that decrease the total phosphorus load to the lake. Internal loading will be addressed by managing carp as needed. Options for the inactivation of sediment release of phosphorus will also be assessed.

Several projects have been completed to improve water quality in Lake Owasso:

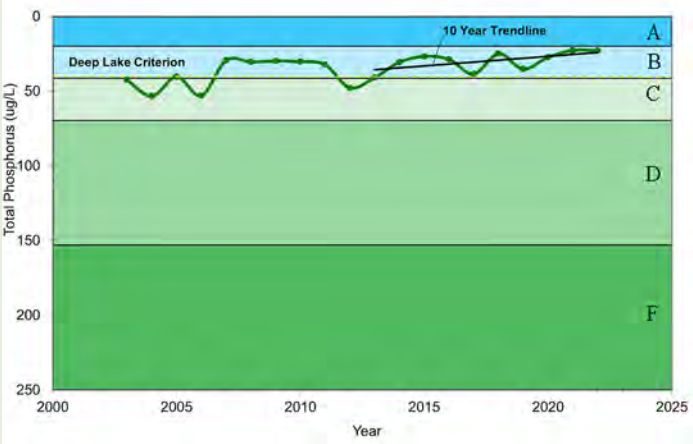
- Central Park Elementary (2017) is one of six school rain garden projects providing needed pollinator habitat and reducing the volume of polluted runoff. RWMWD's goal was to manage rainwater runoff at schools in priority areas of the watershed while engaging local communities in a shared learning experience.
- Prince of Peace Lutheran Church (2015) and North Heights Christian Academy (2017) are two of 12 projects to manage rainwater runoff at churches with large impervious surfaces. The goal of these projects was to install rain gardens to intercept and filter polluted runoff from the church parking lots.
- Carp management (ongoing since 2017): With four interconnected lakes (Owasso, Wabasso, Bennett, and Grass) and 12 shallow ponds, the Lake Owasso system offers prime habitat for carp to potentially out-compete native game fish. As carp root for food along the lake bottom, they stir up nutrient-rich sediment, which, in turn, contributes to turbid water and algae blooms. Management efforts include counting carp to understand the extent of the population, tracking them with radio tags to allow efficient harvesting and identification of nurseries, and installing barriers.

Parameter	State Standard	2022 Lake Owasso	10-Year Average[1]	10-Year Trend
Phosphorus	≤ 40 µg/l	22.9 µg/l	30 µg/l	Decreasing
Chlorophyll *a*	≤ 14 µg/l	9.2 µg/l	14 µg/l	Decreasing
Secchi disc transparency	> 1.4 meter	2.25 meters	2.0 meters	None
Chloride	≤ 230 mg/l[2]	70.3 mg/l	N/A	N/A

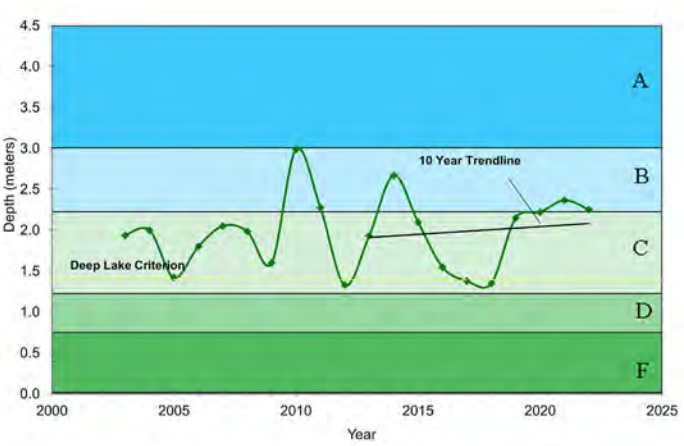
[1] A minimum of 10 years of data were analyzed. If a year was missing within the most recent 10-year period, the period of record was extended.

[2] State standard for chronic chloride exposure.

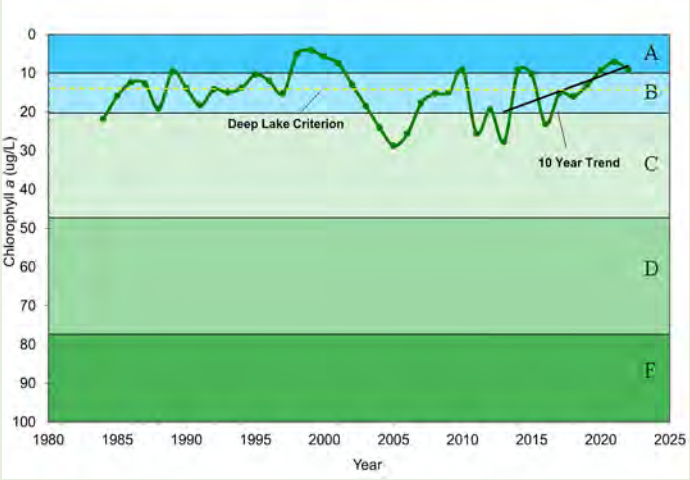
Total phosphorus (µg/l)



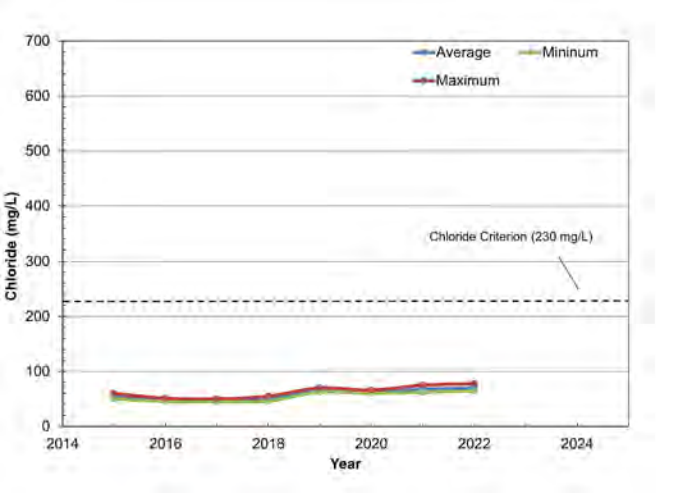
Secchi transparency (m)



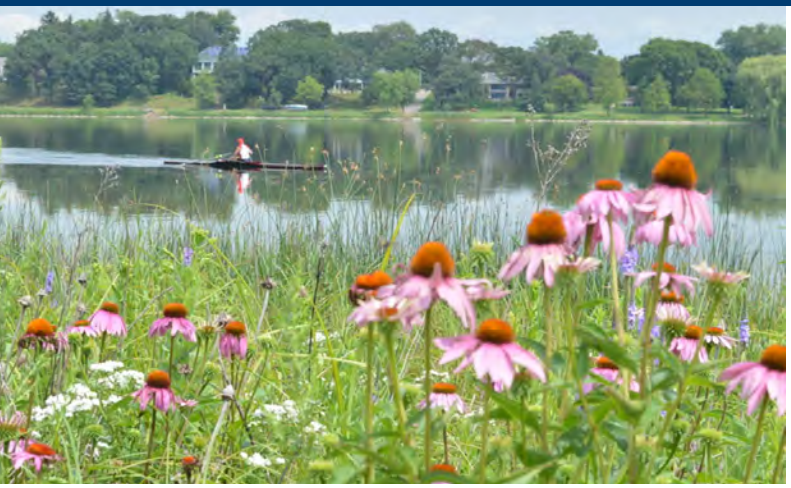
Chlorophyll *a* (µg/l)



Chloride (mg/l)

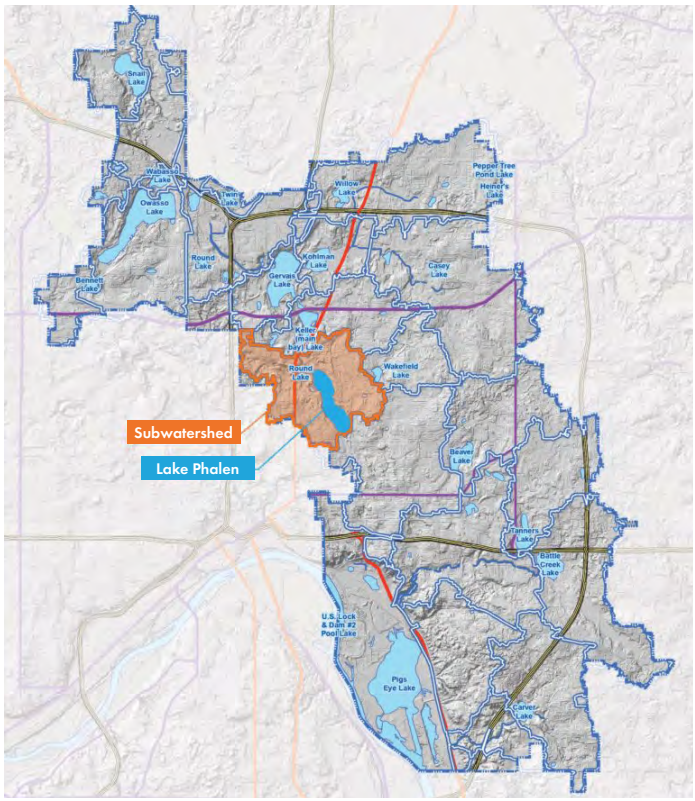


LAKE PHALEN



MPCA designation	Deep
Tributary area	1,995 acres
Surface area	200 acres
Average/maximum depth	22/95 feet
RWMWD nutrient classification[1]	Stable
Accountable municipalities	Maplewood, St. Paul, Ramsey County
Downstream water body	Mississippi River via the Beltline Interceptor storm sewer

[1]RWMWD nutrient classifications are based on the relationship between the historical average water quality (based on phosphorus concentration alone) and the MPCA water quality (phosphorus) standards.



Lake Phalen, the downstream-most lake in the Phalen Chain of Lakes, is surrounded by park land that has 2 miles of restored shoreline. The lake is used primarily for swimming, fishing, paddling, picnicking, and aesthetic viewing. It has public boating access and a swimming beach. While the direct tributary area to the lake is close to 2,000 acres, the total land area that ultimately drains through Lake Phalen is closer to 15,000 acres, including the Keller Lake and Wakefield Lake subwatersheds.

Lake Phalen is impaired for mercury (aquatic consumption) and is listed by the Minnesota DNR as infested with Eurasian watermilfoil. A statewide mercury TMDL was completed in 2007.

Phosphorus, chlorophyll *a*, and Secchi disc depth have been monitored annually since 1981. Annual chloride monitoring began in 2015. In 2022, all four parameters met summer-average state standards. The 10-year data shows no statistically significant trends for any tested parameters.

According to the *2017 Ramsey Washington Metro Watershed District Watershed Restoration and Protection Strategies Report*, 68% of the phosphorus in Lake Phalen comes from stormwater, and 32% comes from internal loading. Plans to address stormwater pollution include implementing a BMP cost-share program and water-quality projects that decrease the total phosphorus load to the lake.

Projects that have improved water quality in Lake Phalen include:

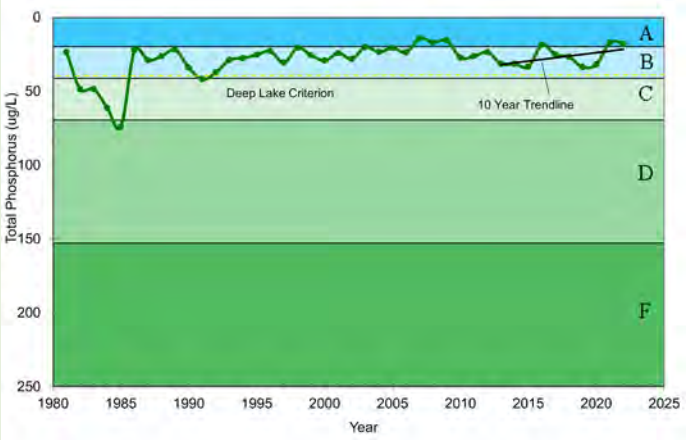
- Keller Creek Buffer (2018): The Keller Creek restoration effort restored native plant communities, removed invasive vegetation, reduced erosion, and brought significant improvements to wildlife habitat and recreation along nearly a mile of the creek.
- Keller Golf Course (2014): Keller is a beautiful public course located just east of Lake Keller. The no-play areas on this course comprise part of the Phalen Chain of Lakes natural areas corridor, providing critical wildlife habitat and improving infiltration. This improvement project restored more than seven acres of no-play area.
- Phalen Shoreline Restoration (2010): This project has become one of the largest lakeshore restoration efforts in Minnesota. The long-term effort involved restoring deep-rooted native plants to filter stormwater, prevent erosion, and create needed urban wildlife habitat. More than 100 native plant species have become established along the shore.

Parameter	State Standard	2022 Lake Phalen	10-Year Average[1]	10-Year Trend
Phosphorus	≤ 40 µg/l	17.8 µg/l	27 µg/l	None
Chlorophyll *a*	≤ 14 µg/l	7.9 µg/l	7.5 µg/l	None
Secchi disc transparency	> 1.4 meters	3.25 meters	3.0 meters	None
Chloride	≤ 230 mg/l[2]	171 mg/l	N/A	N/A

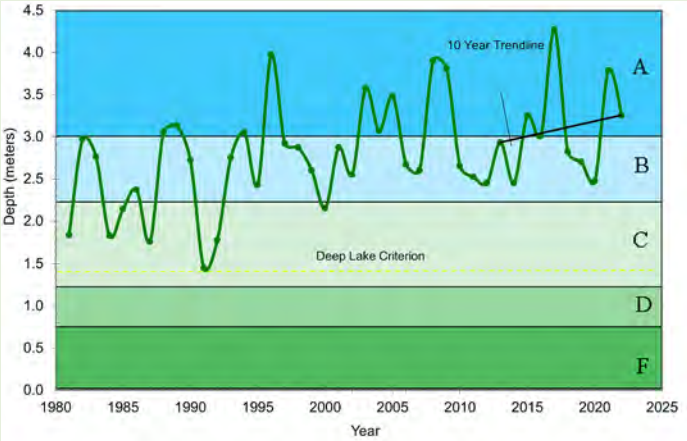
[1] A minimum of 10 years of data were analyzed. If a year was missing within the most recent 10-year period, the period of record was extended.

[2] State standard for chronic chloride exposure.

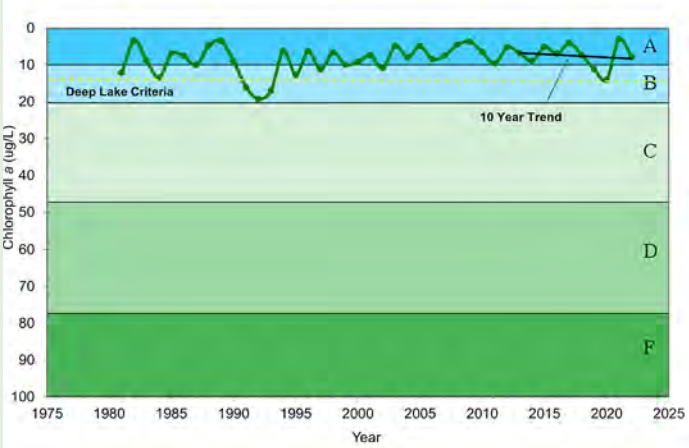
Total phosphorus (µg/l)



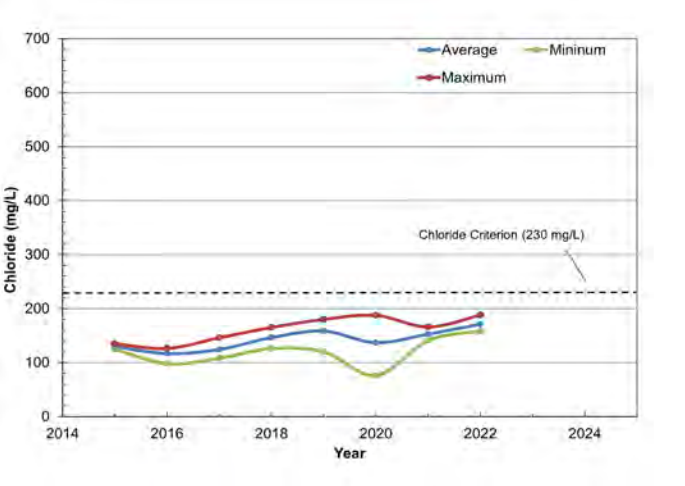
Secchi transparency (m)



Chlorophyll *a* (µg/l)

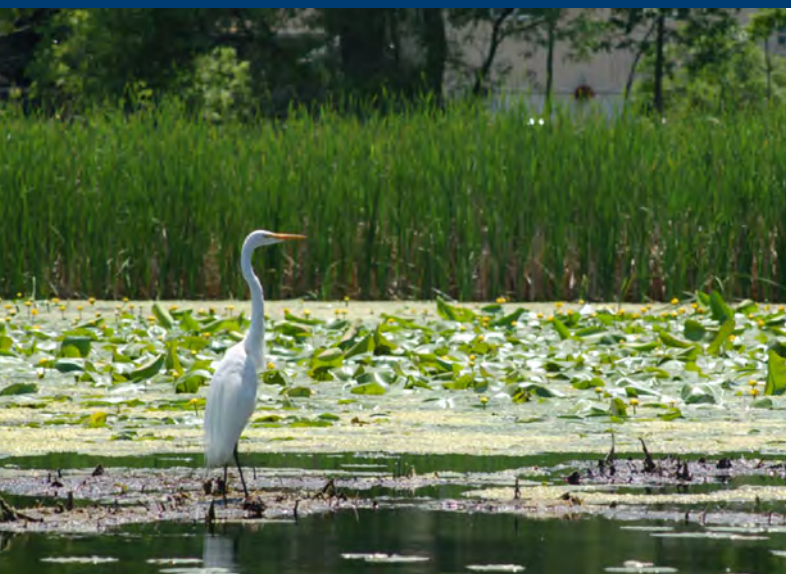


Chloride (mg/l)



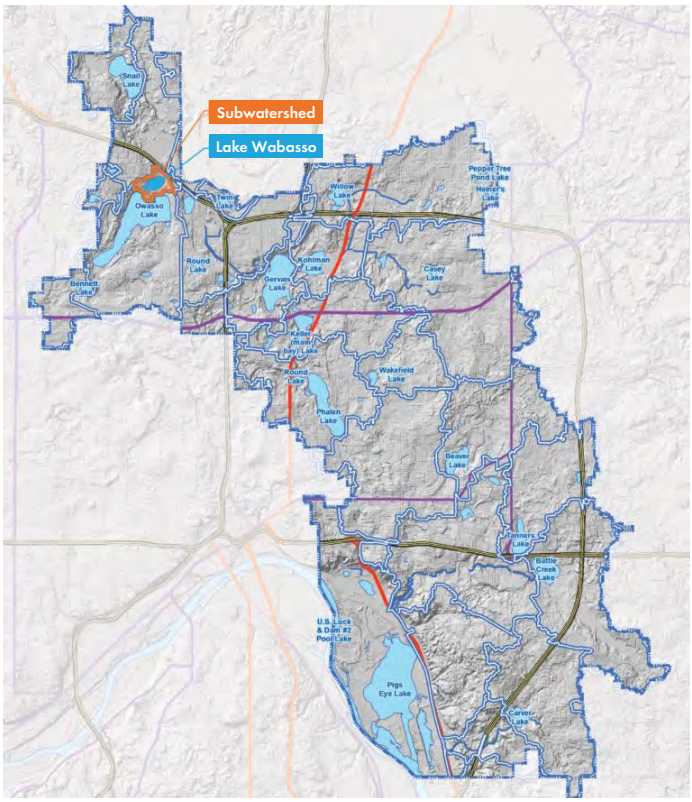
- Carp management (ongoing since 2009): Carp management helps control phosphorus loading in the Phalen Chain of Lakes (Lake Phalen, Gervais Lake, Lake Keller, Kohlman Lake). Foraging carp stir up nutrient-rich sediment on the lake bottom, which, in turn, contributes to turbid water and algae blooms. Management efforts include counting carp to understand the extent of the population, tracking them with radio tags to allow efficient harvesting and identification of nurseries, and installing barriers. These efforts have reduced carp in the Phalen Chain by over 60%.

LAKE WABASSO



MPCA designation	Deep
Tributary area	147 acres
Surface area	52 acres
Average/maximum depth	16/66 feet
RWMWD nutrient classification[1]	Stable
Accountable municipalities	Shoreview, Ramsey County
Downstream waterbody	Grass Lake

[1]RWMWD nutrient classifications are based on the relationship between the historical average water quality (based on phosphorus concentration alone) and the MPCA water quality (phosphorus) standards.



Lake Wabasso is a deep lake in Shoreview that supports a healthy fish population. In addition to fishing, it is used for boating and swimming. Boat access is provided in Lake Owasso County Park on the south side. The lake is at risk of impairment for chloride; however, 2019 data suggest it may not be at risk. It is also listed by the Minnesota DNR as infested with Eurasian watermilfoil.

Chlorophyll *a* has been monitored annually at Lake Wabasso since 1984. Phosphorus and Secchi disc depths have been monitored annually since 2003. Annual chloride monitoring began in 2015. In 2022, Lake Wabasso met summer-average state standards for all four parameters. The 10-year data shows no statistically significant trend for the tested parameters.

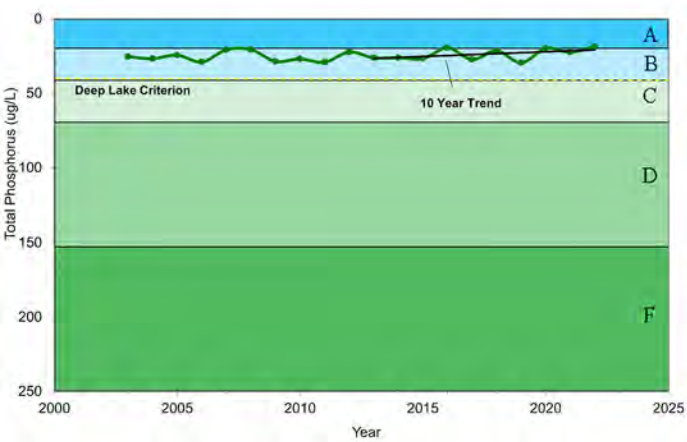
According to the *2017 Ramsey Washington Metro Watershed District Watershed Restoration and Protection Strategies Report*, 13% of the phosphorus in Lake Wabasso comes from stormwater, 62% comes from internal loading, and 22% comes from atmospheric deposition. Plans to address stormwater pollution include implementing a BMP cost-share program and water-quality projects that decrease the total phosphorus load to the lake.

Parameter	State Standard	2022 Lake Wabasso	10-Year Average[1]	10-Year Trend
Phosphorus	≤ 40 µg/l	18.6 µg/l	24 µg/	None
Chlorophyll *a*	≤ 14 µg/l	6.5 µg/L	6.5 µg/	None
Secchi disc transparency	> 1.4 meters	3.57 meters	3.2 meters	None
Chloride	≤ 230 mg/l[2]	65.6 mg/l	N/A	N/A

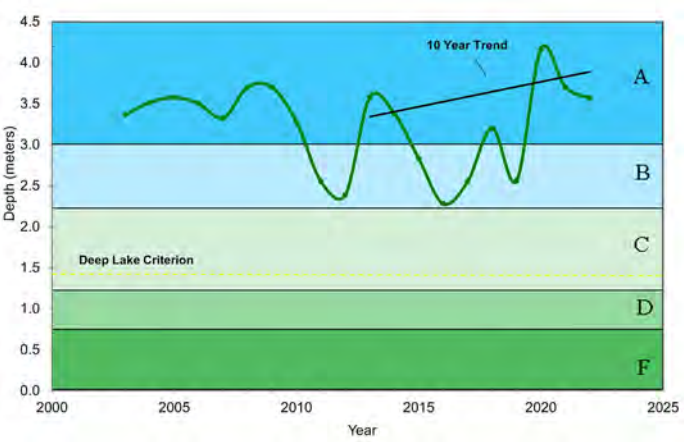
[1] A minimum of 10 years of data were analyzed. If a year was missing within the most recent 10-year period, the period of record was extended.

[2] State standard for chronic chloride exposure.

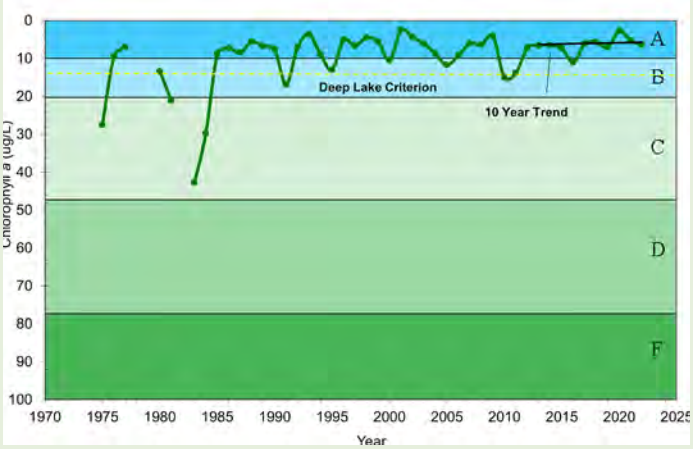
Total phosphorus (µg/l)



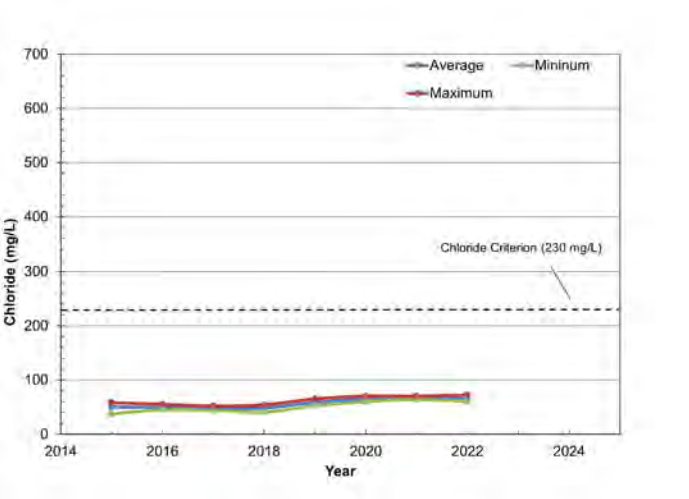
Secchi transparency (m)



Chlorophyll *a* (µg/l)



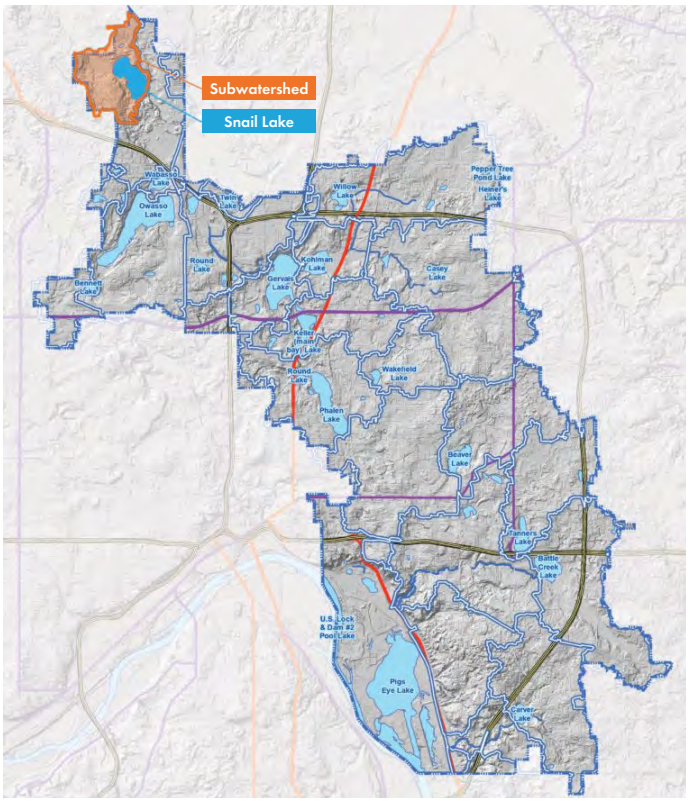
Chloride (mg/l)



SNAIL LAKE

MPCA designation	Deep
Tributary area	961 acres
Surface area	190 acres
Average/maximum depth	28 feet
RWMWD nutrient classification[1]	Stable
Accountable municipalities	Shoreview, Ramsey County
Downstream waterbody	Landlocked

[1]RWMWD nutrient classifications are based on the relationship between the historical average water quality (based on phosphorus concentration alone) and the MPCA water quality (phosphorus) standards.



Snail Lake is a 190-acre landlocked lake in the city of Shoreview; a 35 acre wetland can be found on the northwest side of the lake. The lake, used for fishing, boating, and swimming, is bordered by Snail Lake Regional Park to the south. The park includes public access and a swimming beach.

Snail Lake is impaired for mercury (aquatic consumption); a statewide mercury TMDL was completed in 2007. The lake is also listed by the Minnesota DNR as infested with Eurasian watermilfoil.

Phosphorus, chlorophyll *a*, and Secchi disc depth have been monitored annually since 2005. Annual monitoring of chloride began in 2015. In 2022, the lake met all four water-quality parameters. The 10-year data shows no statistically significant trends.

According to the *2017 Ramsey Washington Metro Watershed District Watershed Restoration and Protection Strategies Report*, 30% of the phosphorus in Snail Lake comes from stormwater, 11% comes from internal loading, and 51% from upstream water bodies. Strategies to address stormwater pollution include implementing a BMP cost-share program and water-quality projects that decrease the total phosphorus load to the lake.

One project that has improved water quality in Snail Lake is:

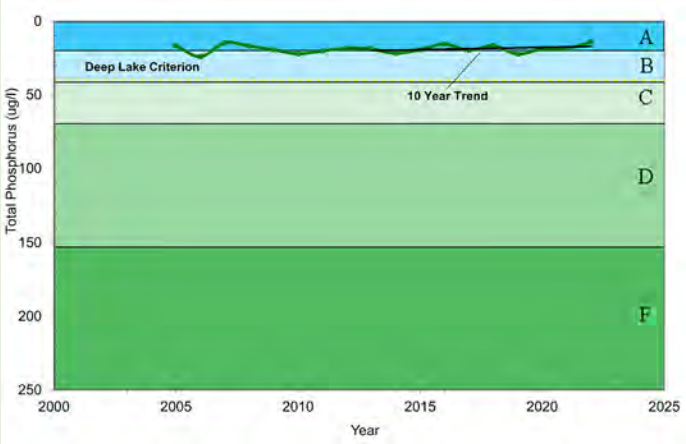
- Wetland A Ecological Restoration (2020 and 2021): RWMWD partnered with Ramsey County and other organizations to conduct a 3-year ecological restoration project in the area. Between 2020 and 2021, RWMWD staff and volunteers restored 4.8 acres of shoreline that stretched approximately 4,500 feet long. Over 80 species of native plants were installed as natural buffers in place of invasive species like common buckthorn.

Parameter	State Standard	2022 Snail Lake	10-Year Average[1]	10-Year Trend
Phosphorus	≤ 40 µg/l	14.1 µg/l	19 µg/l	None
Chlorophyll *a*	≤ 14 µg/l	3.3 µg/l	4.5 µg/l	None
Secchi disc transparency	> 1.4 meters	3.93 meters	3.5 meters	None
Chloride	≤ 230 mg/l[2]	109.4 mg/l	N/A	N/A

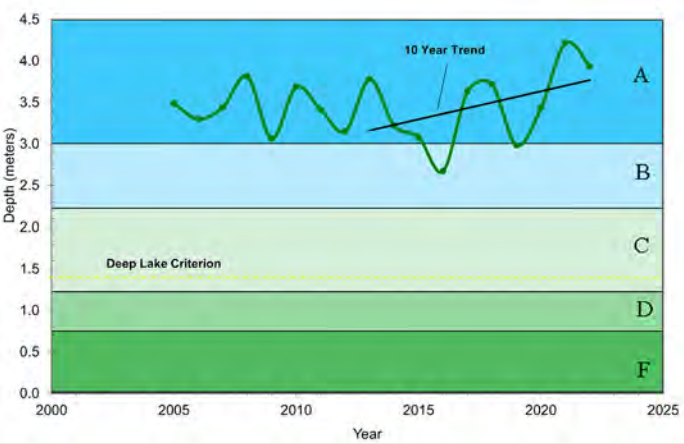
[1] A minimum of 10 years of data were analyzed. If a year was missing within the most recent 10-year period, the period of record was extended.

[2] State standard for chronic chloride exposure.

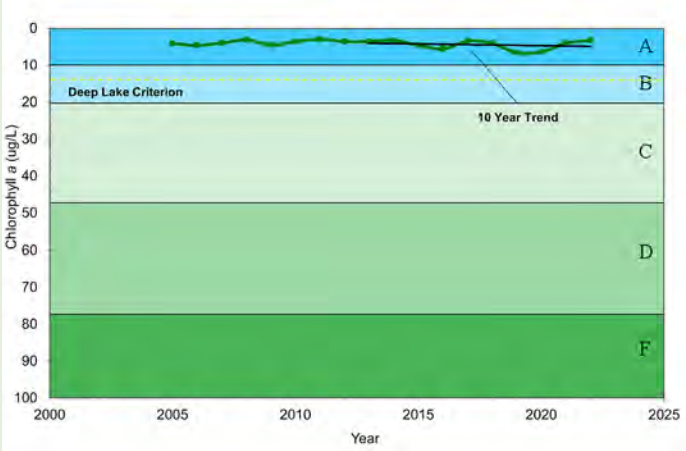
Total phosphorus (µg/l)



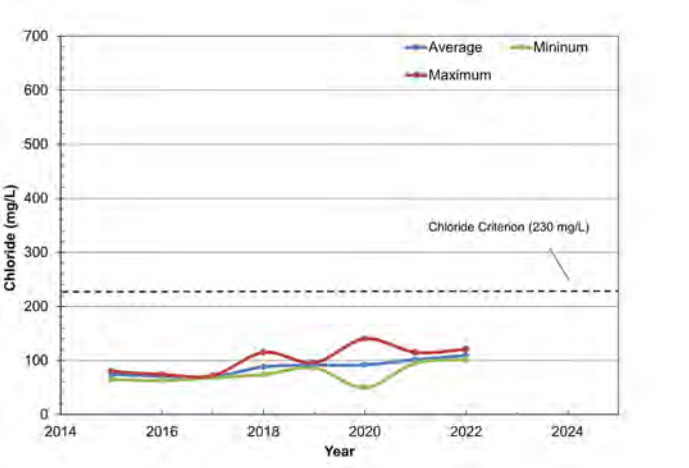
Secchi transparency (m)



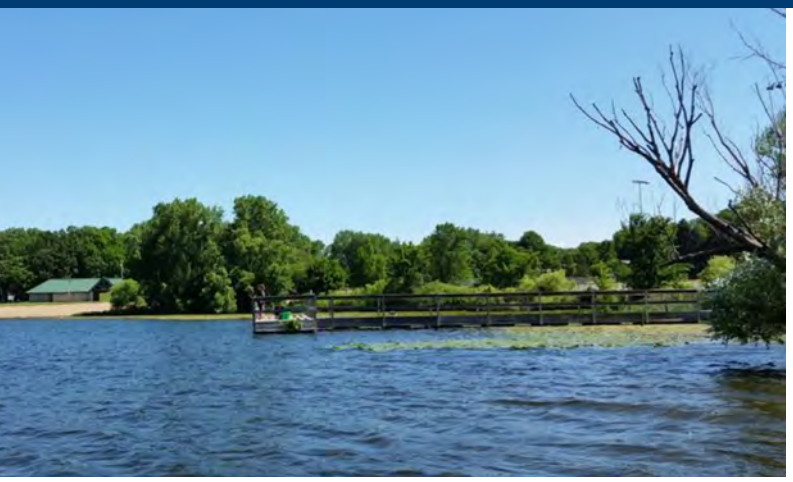
Chlorophyll *a* (µg/l)



Chloride (mg/l)

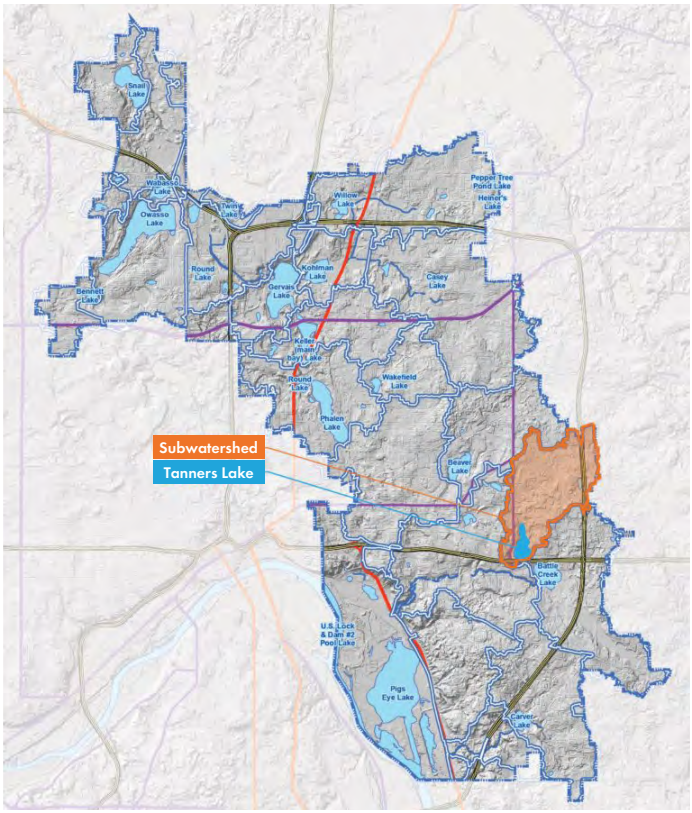


TANNERS LAKE



MPCA designations	Deep; "non-support" of aquatic life (chloride)
Tributary area	1,707 acres
Surface area	74 acres
Average/maximum depth	20/46 feet
RWMWD nutrient classification[1]	Stable
Accountable municipalities	Landfall, Maplewood, Oakdale, Woodbury, Ramsey County, Washington County
Downstream water body	Battle Creek Lake

[1]RWMWD nutrient classifications are based on the relationship between the historical average water quality (based on phosphorus concentration alone) and the MPCA water quality (phosphorus) standards.



Located almost entirely within the cities of Oakdale and Landfall, Tanners Lake discharges into the headwaters of Battle Creek—a tributary of the Mississippi River. The lake is used primarily for swimming, skiing, motor boating, fishing, canoeing, picnicking, and aesthetic viewing. Tanners Lake Park, which includes a beach for swimming and boat access for fishing, is located on the east shore of the lake. Facilities are also present for softball and volleyball.

Tanners Lake was listed as impaired for excess nutrients in 2002, but after meeting state standards was removed from the impaired waters list in 2004. It is currently impaired for mercury (aquatic consumption) and chloride (aquatic life). A statewide mercury TMDL was completed in 2007, and the Twin Cities Metro Area Chloride TMDL was completed in 2016.

RWMWD currently operates an aluminum sulfate (alum) treatment facility on the north end of Tanners Lake that treats a significant portion of watershed runoff before it enters the lake. Alum is injected into the stormwater runoff, which causes phosphorus to precipitate out and settle into a sedimentation pond.

Phosphorus, chlorophyll *a*, and Secchi disc depth have been monitored annually since 1993. Annual chloride monitoring began in 2017. In 2022, the lake met summer-average state standards for all parameters. The 10-year data shows no statistically significant trends.

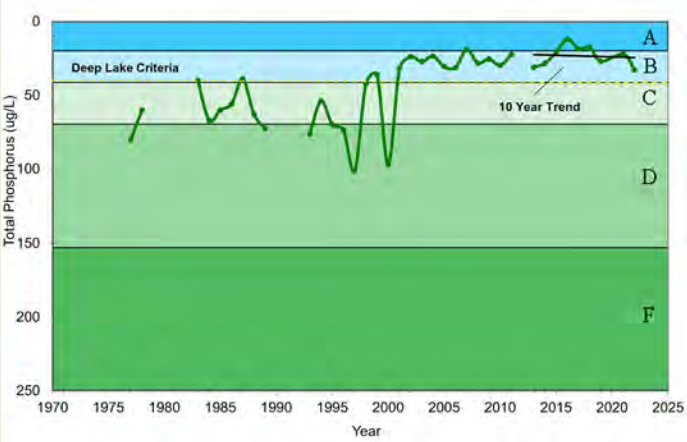
Strategies to address stormwater pollution include implementing the BMP cost-share program and water-quality projects that decrease the total phosphorus load to the lake. Plans to address chloride include improving road salt management by promoting and adopting strategies in the Twin Cities Metro Area Chloride Management Plan.

Parameter	State Standard	2022 Tanners Lake	10-Year Average[1]	10-Year Trend
Phosphorus	≤ 40 µg/l	32.9 µg/l	23 µg/l	None
Chlorophyll *a*	≤ 14 µg/l	13.02 µg/l	8.6 µg/l	None
Secchi disc transparency	> 1.4 meters	2.28 meters	2.9 meters	None
Chloride	≤ 230 mg/l[2]	177.3 mg/l	N/A	N/A

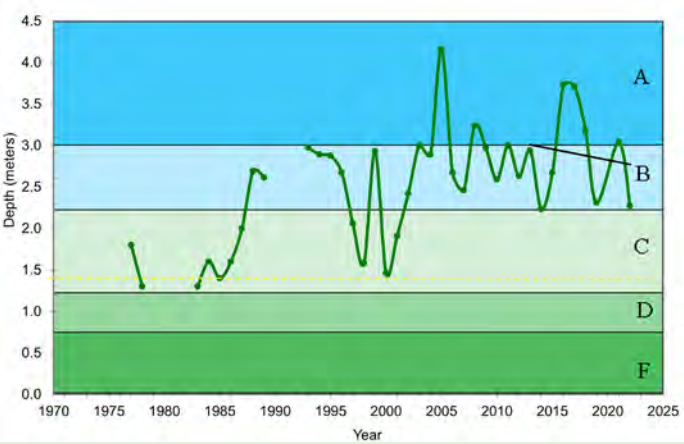
[1] A minimum of 10 years of data were analyzed. If a year was missing within the most recent 10-year period, the period of record was extended.

[2] State standard for chronic chloride exposure.

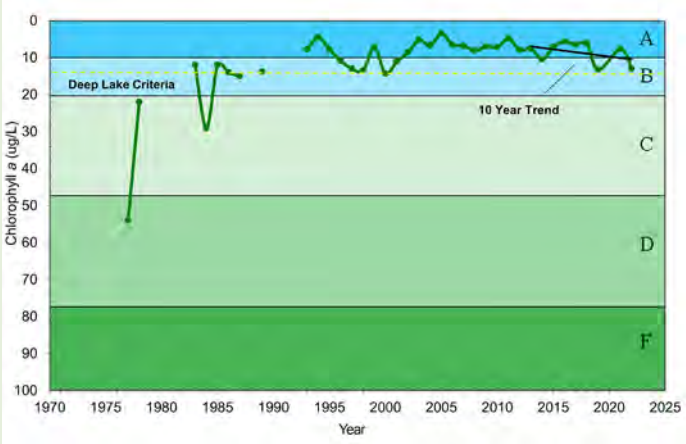
Total phosphorus (µg/l)



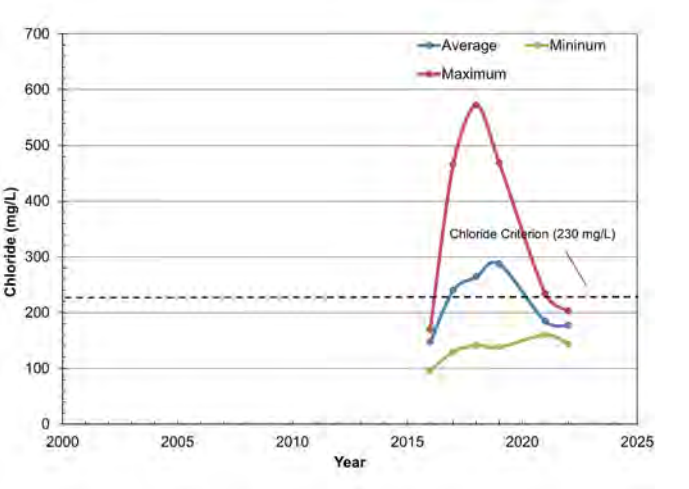
Secchi transparency (m)



Chlorophyll *a* (µg/l)



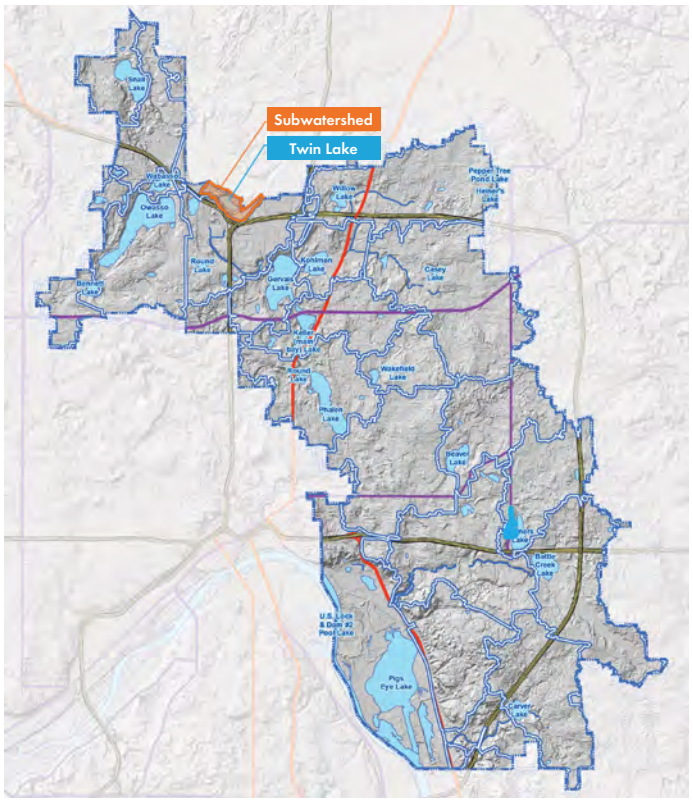
Chloride (mg/l)



TWIN LAKE

MPCA designation	Deep
Tributary area	192 acres
Surface area	35.5 acres
Average/maximum depth	33 feet
RWMWD nutrient classification[1]	Stable
Accountable municipalities	Little Canada, Vadnais Heights, Ramsey County
Downstream waterbody	Gervais Creek

[1]RWMWD nutrient classifications are based on the relationship between the historical average water quality (based on phosphorus concentration alone) and the MPCA water quality (phosphorus) standards.



Twin Lake lies in Little Canada and Vadnais Heights. It is a small and relatively deep lake, mainly surrounded by homes. Formerly landlocked, an outlet was installed in the lake in 2020 to allow water to discharge to Gervais Creek during high water periods. Twin Lake has some wildlife habitat and is primarily used for canoeing, aesthetic viewing, fishing, and occasional jet skiing; there is no public access. The lake is not impaired.

With the exception of 2007, phosphorus, chlorophyll *a*, and Secchi disc depth have been monitored annually on Twin Lake since 1996. Annual monitoring of chloride began in 2015. In 2022, the lake met all four summer-average state standards. The 10-year data shows no statistically significant change for any parameter.

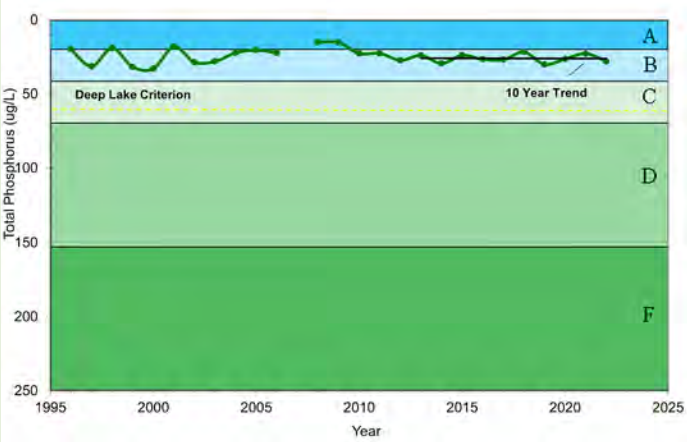
Strategies to address stormwater pollution include implementing a BMP cost-share program and water-quality projects that decrease the total phosphorus load to the lake.

Parameter	State Standard	2022 Twin Lake	10-Year Average[1]	10-Year Trend
Phosphorus	≤ 40 µg/l	28.0 µg/l	26 µg/l	None
Chlorophyll *a*	≤ 14 µg/l	11.7 µg/l	9.4 µg/l	None
Secchi disc transparency	> 1.4 meters	2.16 meters	2.5 meters	None
Chloride	≤ 230 mg/l[2]	56.5 mg/l	N/A	N/A

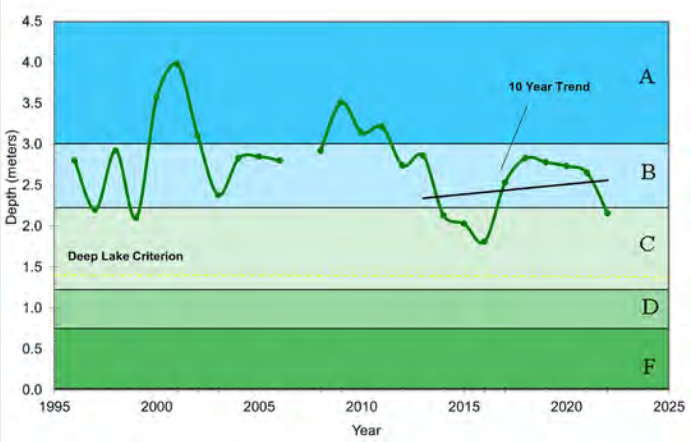
[1] A minimum of 10 years of data were analyzed. If a year was missing within the most recent 10-year period, the period of record was extended.

[2] State standard for chronic chloride exposure.

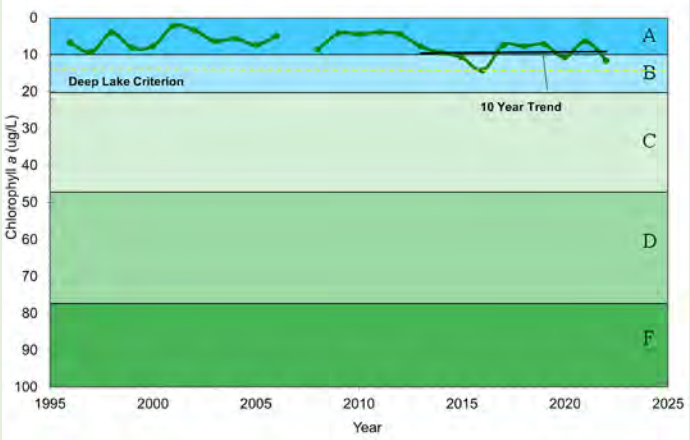
Total phosphorus (µg/l)



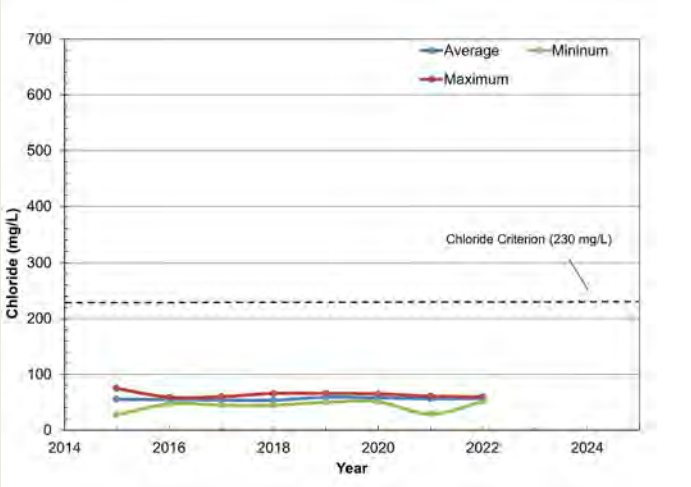
Secchi transparency (m)



Chlorophyll *a* (µg/l)



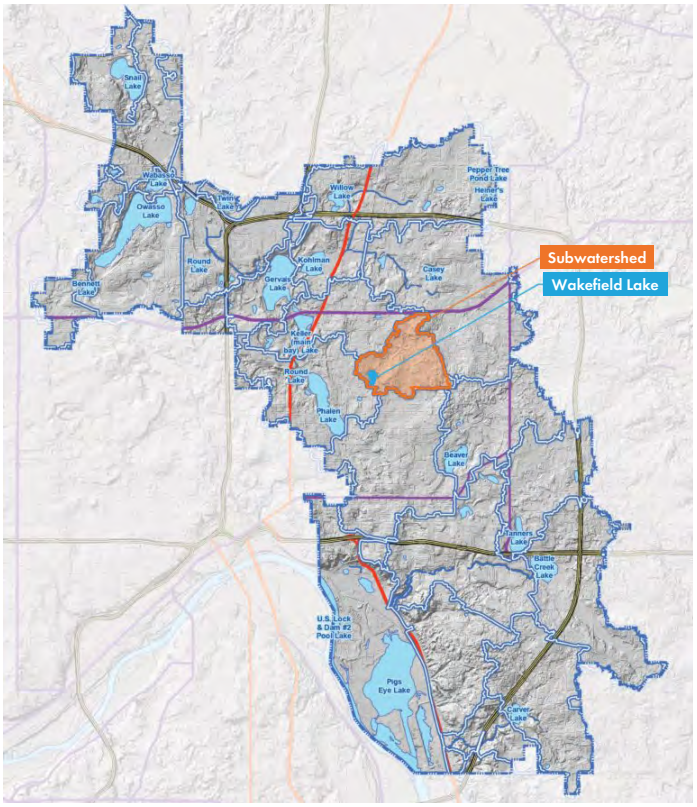
Chloride (mg/l)



WAKEFIELD LAKE

MPCA designation	Shallow
Tributary area	948 acres
Surface area	23 acres
Average/maximum depth	4.6/9 feet
RWMWD nutrient classification[1]	Impaired
Accountable municipalities	Maplewood, North St. Paul, St. Paul, Ramsey County
Downstream water body	Lake Phalen

[1]RWMWD nutrient classifications are based on the relationship between the historical average water quality (based on phosphorus concentration alone) and the MPCA water quality (phosphorus) standards.



Wakefield Lake is located in Maplewood and is primarily used for shoreline fishing, picnicking, and aesthetic viewing. It is bordered by park land on the north and east sides of the lake. Public access is available in Wakefield Park, although there is no boat launch.

Wakefield Lake was added to the MPCA's impaired waters list for excess nutrients in 2002; a nutrient TMDL was completed in 2017. Wakefield is also at risk for chloride impairment.

Phosphorus, chlorophyll *a*, and Secchi disc depth have been monitored annually since 1984. Chloride has been measured annually since 1992. In 2022, Wakefield Lake only met summer-average state standards for Secchi disc and chloride concentration. The 10-year data shows no statistically significant trends for the tested parameters.

Strategies to address stormwater pollution include implementing a BMP cost-share program and water-quality projects that decrease the total phosphorus load to the lake. Plans to reduce in-lake loading by 80% include developing a plan for macrophyte management (including curlyleaf pondweed) and assessing options for the inactivation of sediment release of phosphorus.

Recent projects to improve the water quality of Wakefield Lake are:

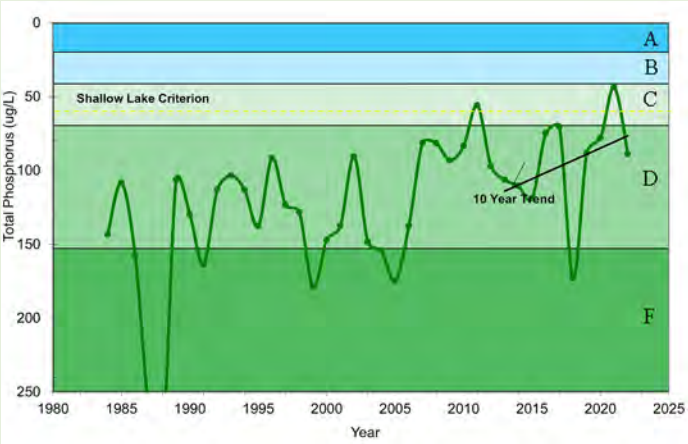
- Mounds Park Academy (2022): The goal of this project was to remove a section of unused parking lot to build a rain garden to treat runoff before it enters the school's pond. The school is interested in funding the creation of an outdoor learning space alongside the rain garden.
- Wakefield Park Stormwater Improvements (2020): The goal of this project was to install two large rain gardens that intercept and filter rainwater runoff from the streets. This reduces the volume of rainwater runoff and increases the quality of runoff that drains into Wakefield Lake. This project was completed in conjunction with a City of Maplewood project to narrow Frost Avenue, which also improves the quality of runoff going into Wakefield Lake.
- Aldrich Ice Arena (2020): The goal of this project was to remove the asphalt parking lot and install 15 rain gardens. The rain gardens reduce the volume of stormwater runoff and remove pollutants from the runoff before reaching Wakefield Lake.
- The Wakefield Spent Lime Filter (2018): This project involves piping stormwater from a large portion of the 944-acre Wakefield Lake subwatershed into a large underground chamber where it interacts with spent lime. The lime material is a repurposed byproduct of municipal drinking water treatment, and it binds to phosphorus in the stormwater. Water leaving the spent lime chamber was projected to contain about

Parameter	State Standard	2022 Wakefield Lake	10-Year Average[1]	10-YearTrend
Phosphorus	≤ 60 µg/l	88.6 µg/l	95 µg/l	None
Chlorophyll *a*	≤ 20 µg/l	37.2 µg/l	31 µg/l	None
Secchi disc transparency	> 1 meter	1.4 meters	1.4 meters	None
Chloride	≤ 230 mg/l[2]	132.3 mg/l	N/A	N/A

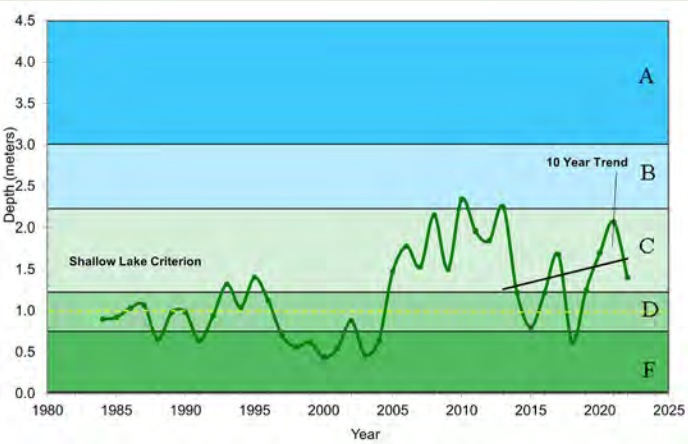
[1] A minimum of 10 years of data were analyzed. If a year was missing within the most recent 10-year period, the period of record was extended.

[2] State standard for chronic chloride exposure.

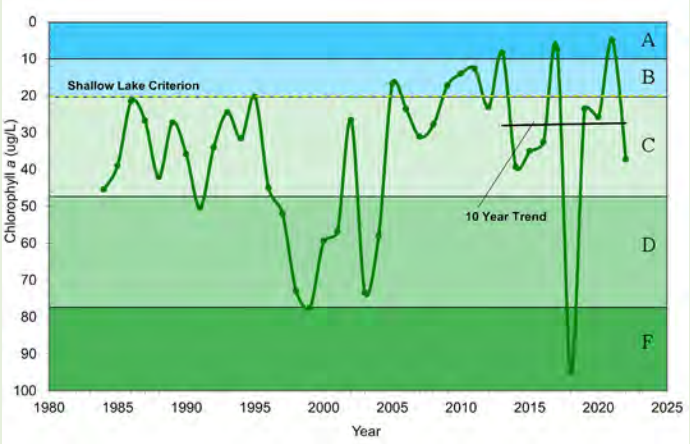
Total phosphorus (µg/l)



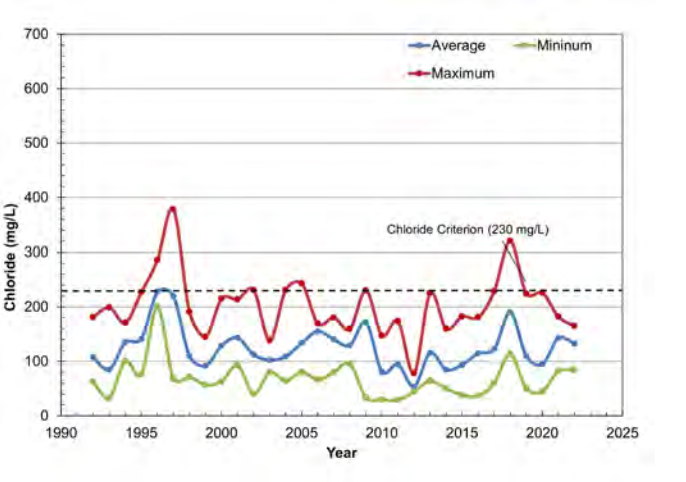
Secchi transparency (m)



Chlorophyll *a* (µg/l)



Chloride (mg/l)

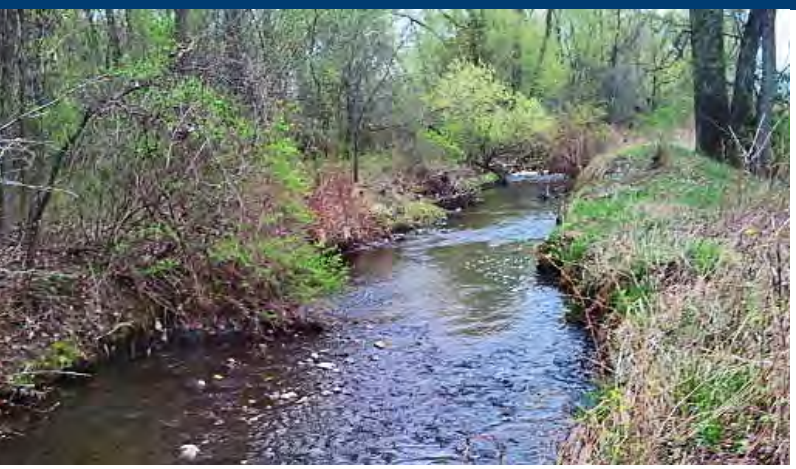


70 percent less dissolved phosphorus than when it entered. (This treatment system, during the first year of operation, is evaluated in Section 7).

- Presentation Catholic Church (2015) is one of 12 projects managing rainwater runoff at churches with large amounts of impervious surfaces. The goal was to install six rain gardens and one infiltration trench that intercept and filter runoff from the church parking lot. This reduces the volume of polluted rainwater draining to Wakefield Lake.

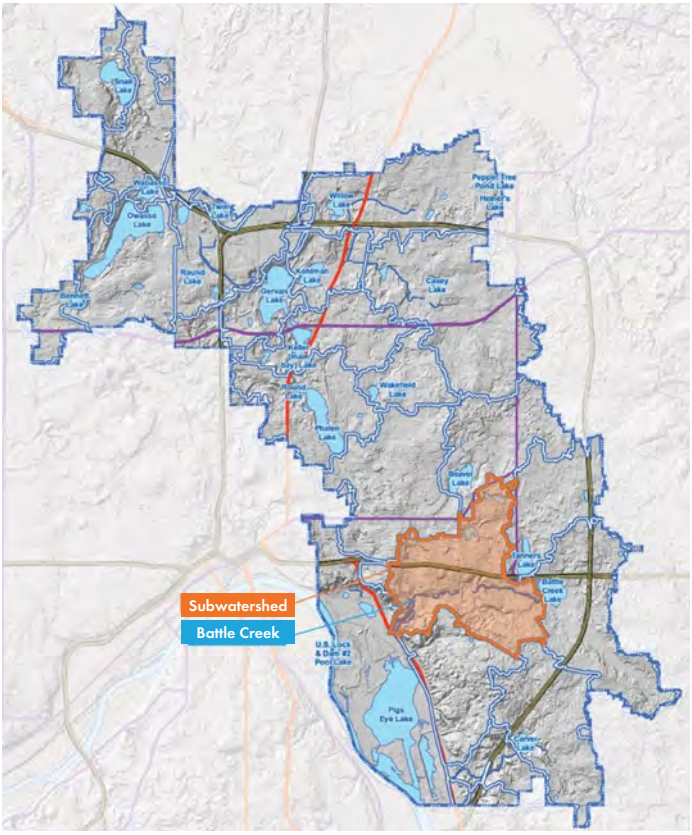
4. STREAMS

BATTLE CREEK



Tributary area	2,972 acres
Creek length	3.8 miles
Downstream waterbody	Mississippi River
MPCA designations	Impaired for "non-support" of aquatic life (chloride, fish, macroinvertebrates)
Accountable municipalities	Maplewood, St. Paul, Woodbury, Ramsey County, Washington County
RWMWD nutrient classification	Impaired (TSS)

[1]RWMWD nutrient classifications are based on the relationship between the historical average water quality (based on phosphorus concentration alone) and the MPCA water quality (phosphorus) standards.



Battle Creek is a perennial, urban stream that originates at the outlet from Battle Creek Lake in Woodbury. The creek then flows west and ultimately discharges to Pigs Eye Lake and the Mississippi River. A well-maintained regional park with trails for hiking, cross-country skiing, and cycling is situated along the creek in St. Paul.

Historically, Battle Creek has been plagued by frequent and devastating floods that caused loss of life, substantial property damage, and heavy stream erosion. The District completed a significant restoration project in 1982 and continues to conduct maintenance on the creek to sustain that project.

Battle Creek has been monitored annually for phosphorus and total suspended solids since 1996. Annual monitoring for nitrate began in 2000 and for chloride in 2002. The creek is currently impaired for chloride and was also listed in 2014 as impaired for degraded fish and macroinvertebrate biological community health. A stressor identification report was completed in 2015 and found that chloride and total suspended solids (TSS) are the primary stressors to the fish and macroinvertebrates in the creek. The study identified total phosphorus as a probable secondary stressor. For that reason, the District has assigned Battle Creek a RWMWD nutrient water quality classification of "Impaired. "

As seen in the chart at right, the creek failed to meet state standards for phosphorus, total suspended solids, and chloride in 2022. The 10-year data shows no statistically significant trend for any parameter.

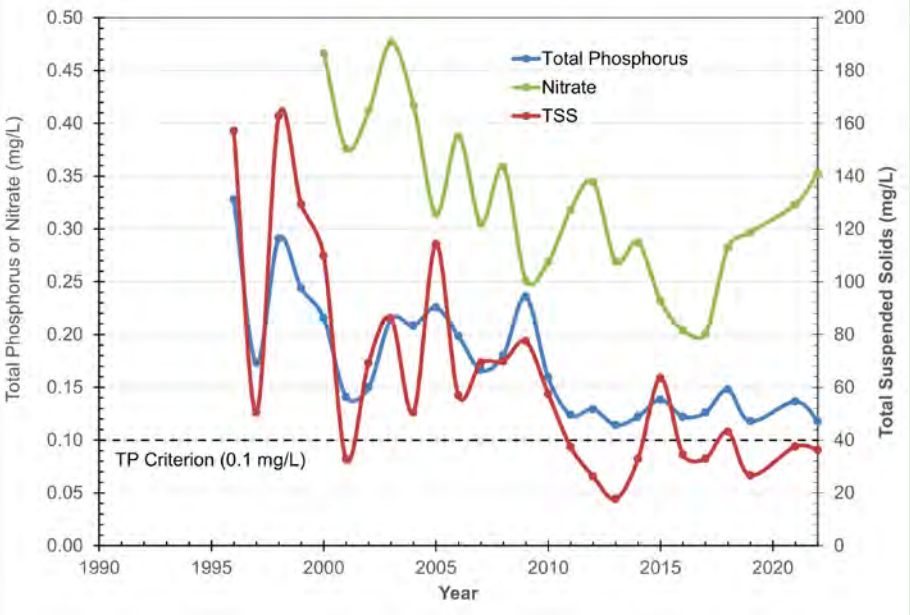
Recent projects to improve the water quality of Battle Creek include:

- St. Pascal Baylon Church (2022): The project included retrofitting the existing parking lot to maintain the existing grading and adding a tree trench and small rain garden. The tree trench and rain garden will remove phosphorus and sediment from stormwater that travels to Battle Creek.
- Target—Suburban Avenue (2020): The project included the removal of impervious parking lot to install seven rain gardens and a linear tree trench. The installed best management practices can reduce the volume of polluted runoff that drains to Battle Creek, as well as remove pollutants such as total suspended solids and total phosphorus.
- Christ United Methodist Church (2016): Two rain gardens were installed to intercept and filter runoff from the church's parking lot—reducing the volume of polluted runoff that drains to Battle Creek.
- Slumberland Clearance Outlet Store (2016): A native planting area replacing 20,000 square feet of parking lot surface provides pollinator habitat and filters rainwater runoff before it drains to Battle Creek.

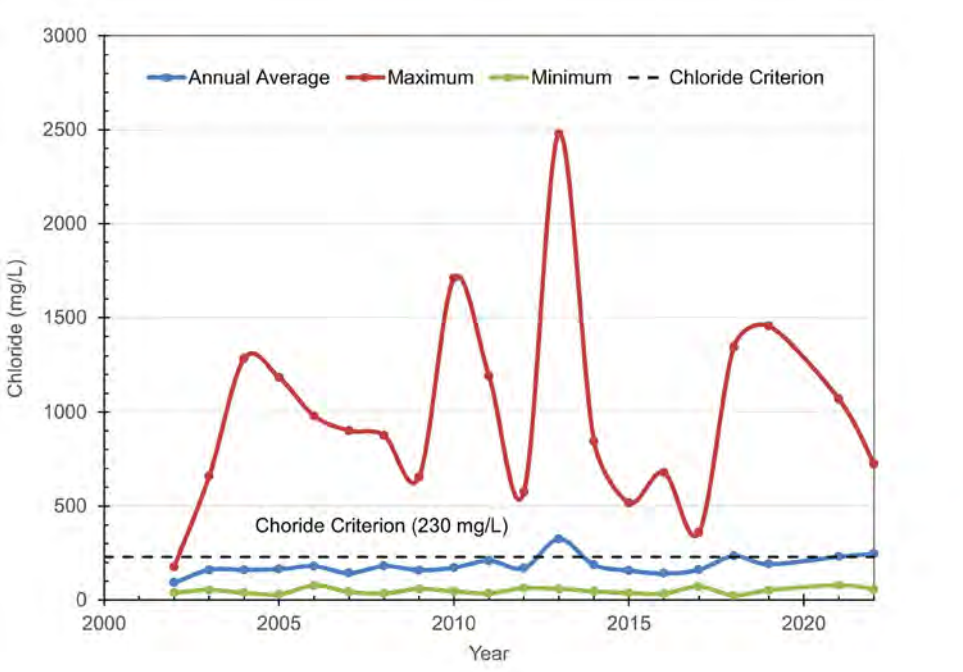
Parameter	State Standard	2022 Battle Creek	10-Year Average	10-Year Trend
Phosphorus	≤ 100 µg/l	118 µg/l	127 µg/l	None
Total suspended solids	<15 mg/l	36 mg/l	36 mg/l	None
Nitrate	N/A	0.35 mg/l	0.27 mg/l	None
Chloride	≤ 230 mg/l[1]	246 mg/l	208 mg/l	None

[1] State standard for chronic chloride exposure.

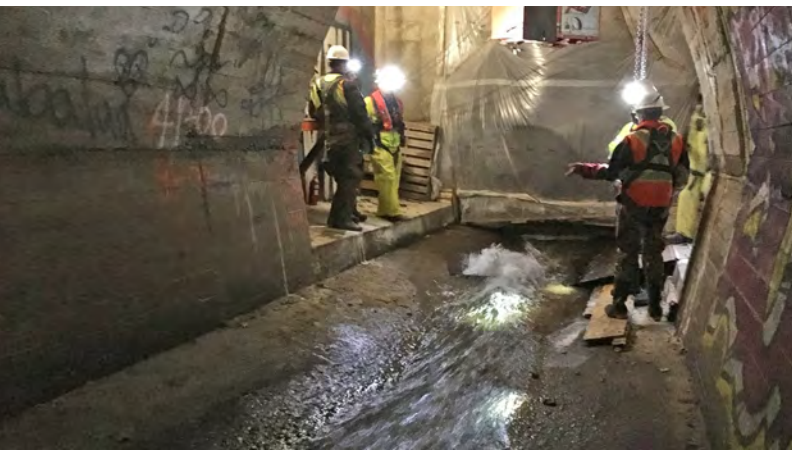
Nutrients and solids (mg/l)

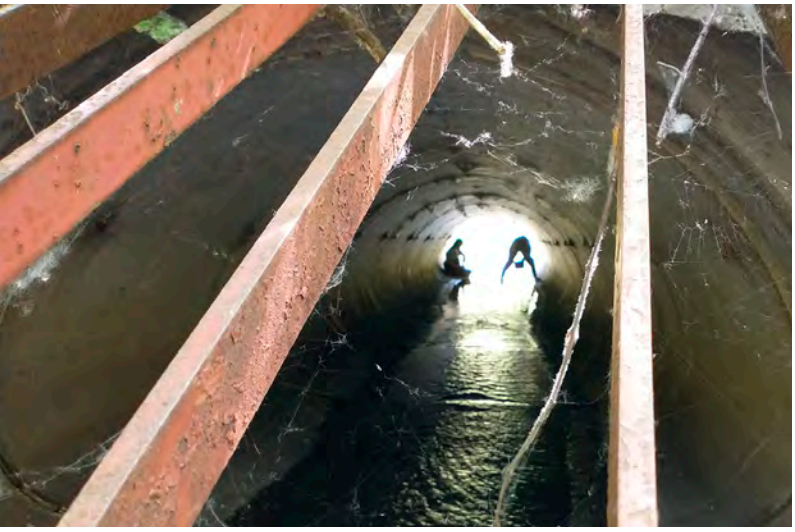


Chlorides (mg/l)



BELTLINE INTERCEPTOR





The Beltline Interceptor is a large storm sewer pipe system constructed in 1920 and maintained by the RWMWD. The system is approximately 5 miles long, extending from the outlets of Lake Phalen and Beaver Lake to the Mississippi River. It collects a large percentage of stormwater runoff from St. Paul's east side and also conveys runoff from the entire Phalen Chain of Lakes subwatershed and the Beaver Lake subwatershed to the Mississippi River. The total drainage area to the Beltline Interceptor is 27. 8 square miles—over half of the District's water.

The Beltline Interceptor has been monitored annually for phosphorus and total suspended solids since 1995. Annual monitoring for nitrates began in 2000 and for chloride in 2002. As seen in the chart at right, the Beltline Interceptor met state standards for only chlorides in 2022. At 59 mg/L, the decrease in total suspended solids has been dramatic since reaching its peak in 1997 (349 mg/L). The 10-year data shows no statistically significant trend for any parameterr.

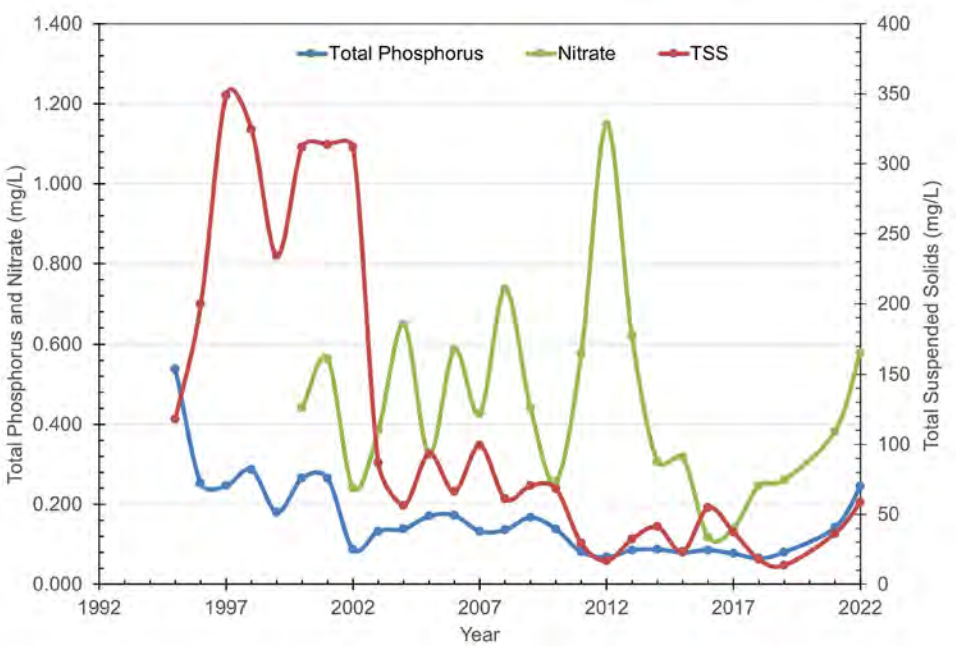
Recent projects to improve the water quality of Beltline Interceptor include:

- Saint Paul Urban Tennis Center (2020): A new infiltration basin was installed to reduce the volume of runoff to the Beltline interceptor and remove pollutants from stormwater runoff.

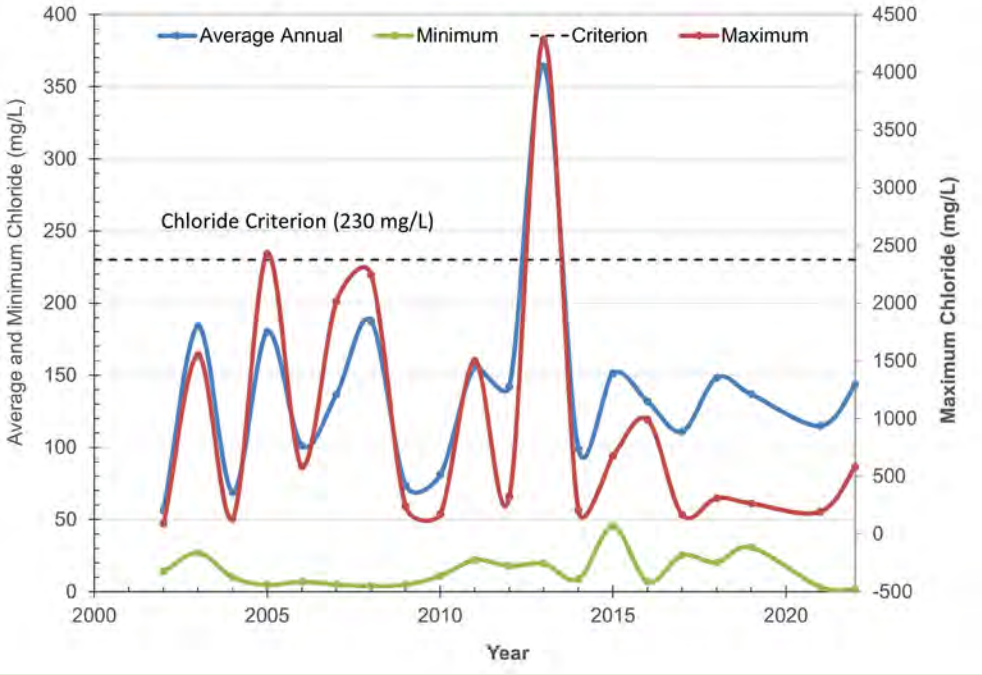
Parameter	State Standard	2022 Beltline Interceptor	10-Year Average	10-Year Trend
Phosphorus	≤ 100 µg/l	245 µg/l	105 µg/l	None
Total suspended solids	<15 mg/l	59 mg/l	35 mg/l	None
Nitrate	N/A	0.58 mg/l	0.33 mg/l	None
Chloride	≤ 230 mg/l[1]	143 mg/l	156 mg/l	None

[1] State standard for chronic chloride exposure; chloride value is average water-column concentration

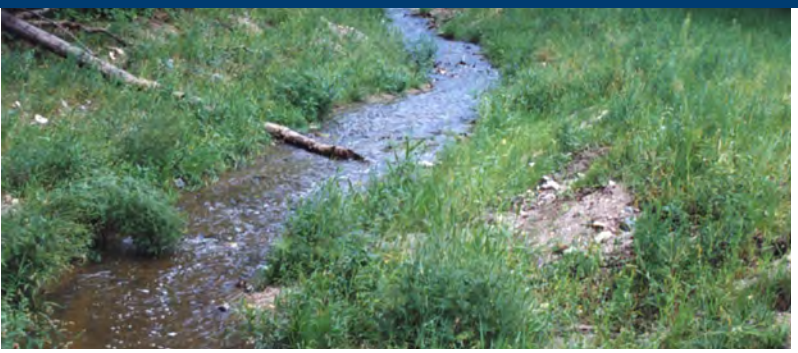
Nutrients and solids (mg/l)



Chlorides (mg/l)

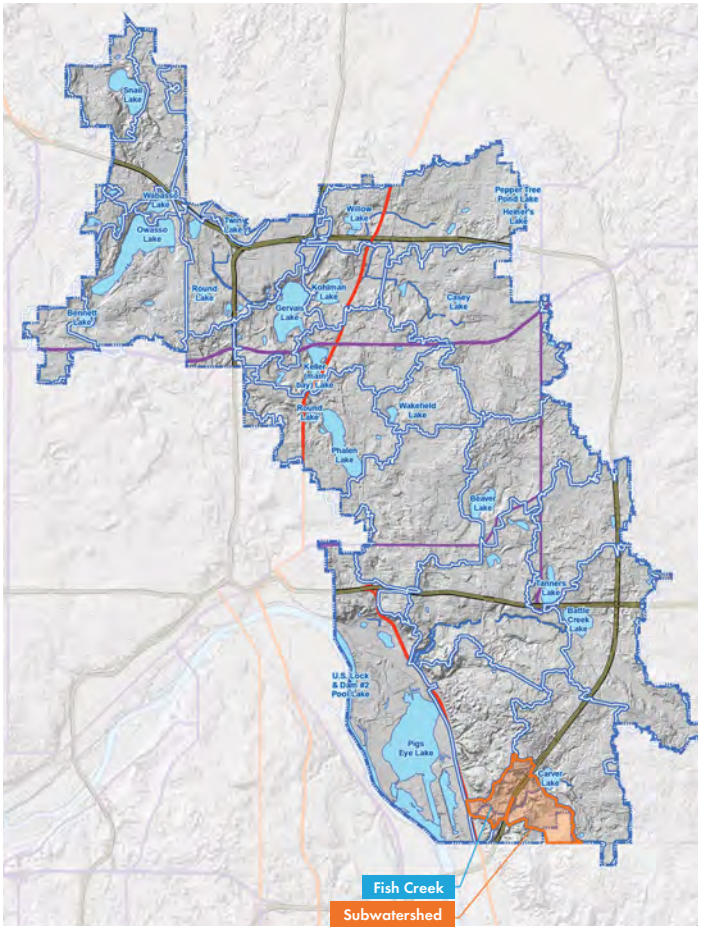


FISH CREEK



Tributary area	783 acres
Creek length	1.8 miles
Downstream waterbody	Eagle Lake
MPCA designations	"Non-support of aquatic life (benthic macroinvertebrates); at risk for chloride; "non-support of aquatic recreation (*E. coli*; and total suspended solids)
Accountable municipalities	Maplewood, St. Paul, Woodbury, Ramsey County, Washington County
RWMWD nutrient classification	Impaired (TSS)

[1]RWMWD nutrient classifications are based on the relationship between the historical average water quality (based on phosphorus concentration alone) and the MPCA water quality (phosphorus) standards.



Fish Creek is a perennial, urban stream that originates at Carver Lake and ultimately discharges to Eagle Lake and the Mississippi River. The majority of the Fish Creek subwatershed is located in Ramsey County and the southeastern portion of Washington County.

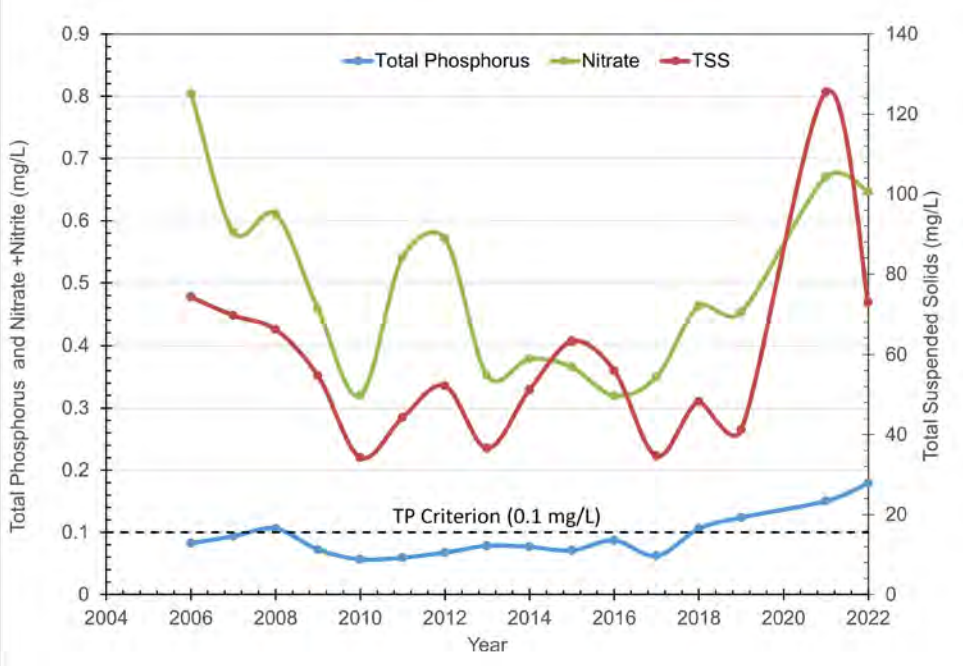
Fish Creek was placed on the 2014 303(d) impaired waters list due to elevated levels of E. coli bacteria. E. coli is used in water quality monitoring as an indicator of water that is contaminated with human or animal waste and accompanying disease-causing organisms. Bacterial abundance in excess of the water quality standards can pose a risk to human health.

Fish Creek has been monitored annually for phosphorus and total suspended solids since 1995. Annual monitoring for nitrates began in 2000 and for chlorides in 2002. In 2022, Fish Creek failed to meet state standards for phosphorus and total suspended solids, but the average annual chloride concentration met the chloride standard (see chart below). The 10-year data shows a statistically significant increase in total phosphorus, nitrate, and chloride concentrations.

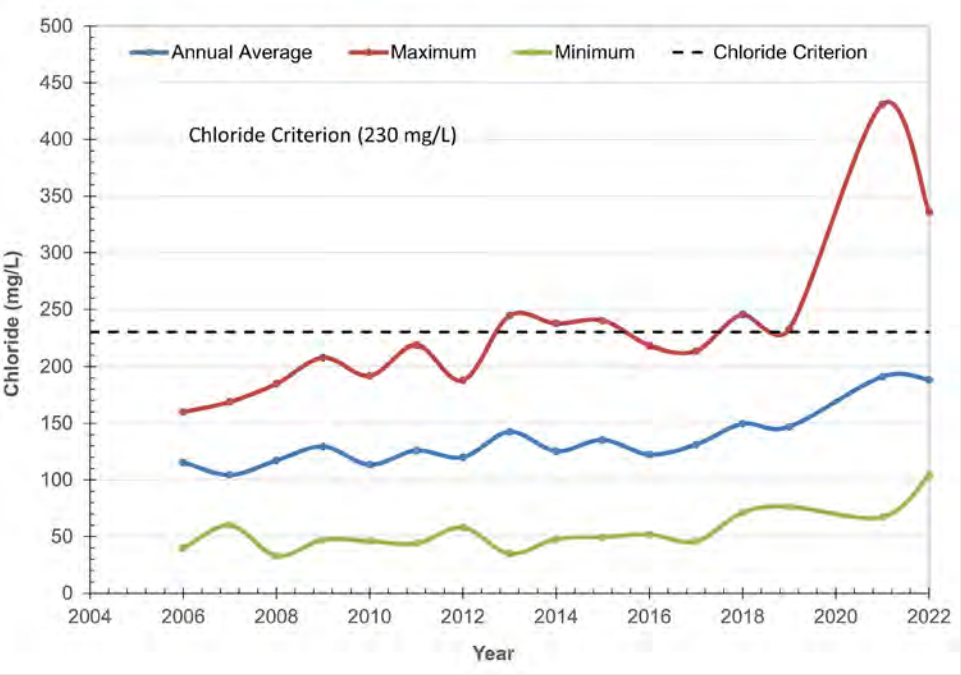
Parameter	State Standard	2022 Fish Creek	10-Year Average	10-Year Trend
Phosphorus	≤ 100 µg/l	179 µg/l	104 µg/L	Increasing
Total suspended solids	<15 mg/l	73 mg/l	59 mg/l	None
Nitrate	N/A	0.65 mg/l	0.44 mg/l	Increasing
Chloride	≤ 230 mg/l[1]	188 mg/l	148 mg/l	Increasing

[1] State standard for chronic chloride exposure; chloride value is average water-column concentration.

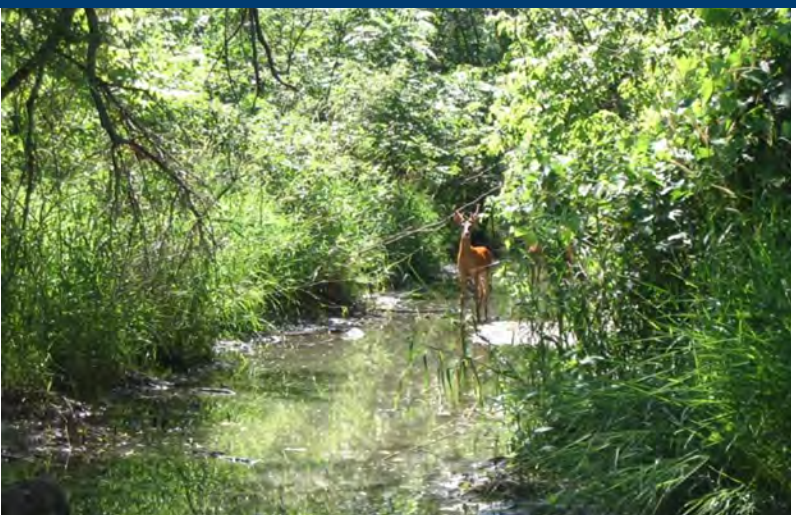
Nutrients and solids (mgl/l)



Chlorides (mg/l)



GERVAIS CREEK

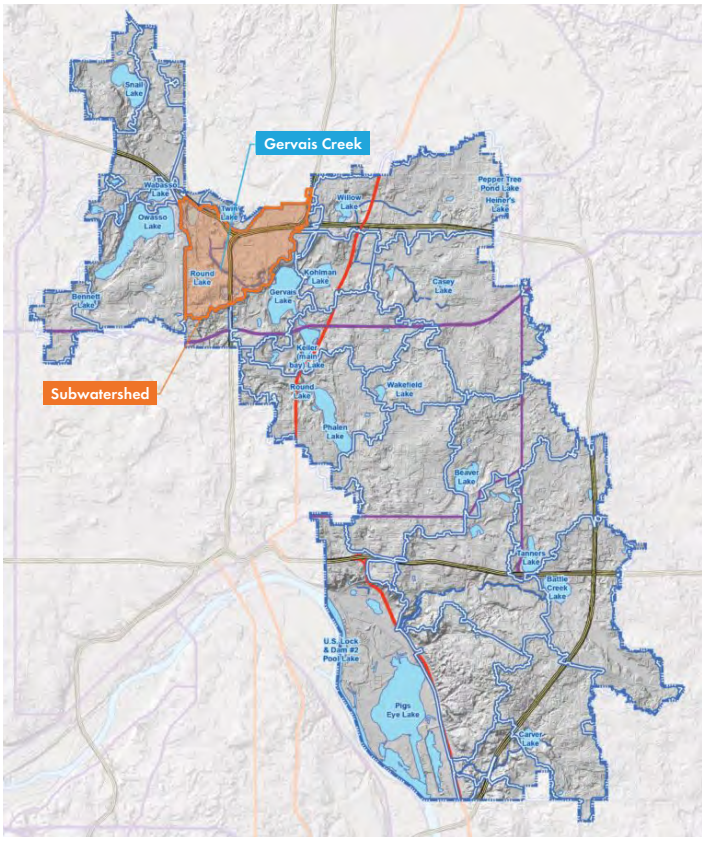


Gervais Creek is an intermittent stream that was previously managed as a county ditch (County Ditch 16). It is managed by the RWMWD as a stormwater system.

Gervais Creek has been monitored annually for phosphorus and total suspended solids since 2010. Annual monitoring for chlorides began in 2010 and for nitrates in 2016. In 2022 the creek exceeded the state standard for phosphorus but met the standard for total suspended solids. The average annual chloride concentration met the chloride standard, but the maximum concentration did not. The 10-year data shows no statistically significant trend for any parameter.

Tributary area	1,847 acres
Creek length	2.2 miles
Downstream waterbody	Gervais Lake
MPCA designations	"Non-support" of aquatic life (benthic macroinvertebrates)
Accountable municipalities	Little Canada, Vadnais Heights, Ramsey County
RWMWD nutrient classification	At risk

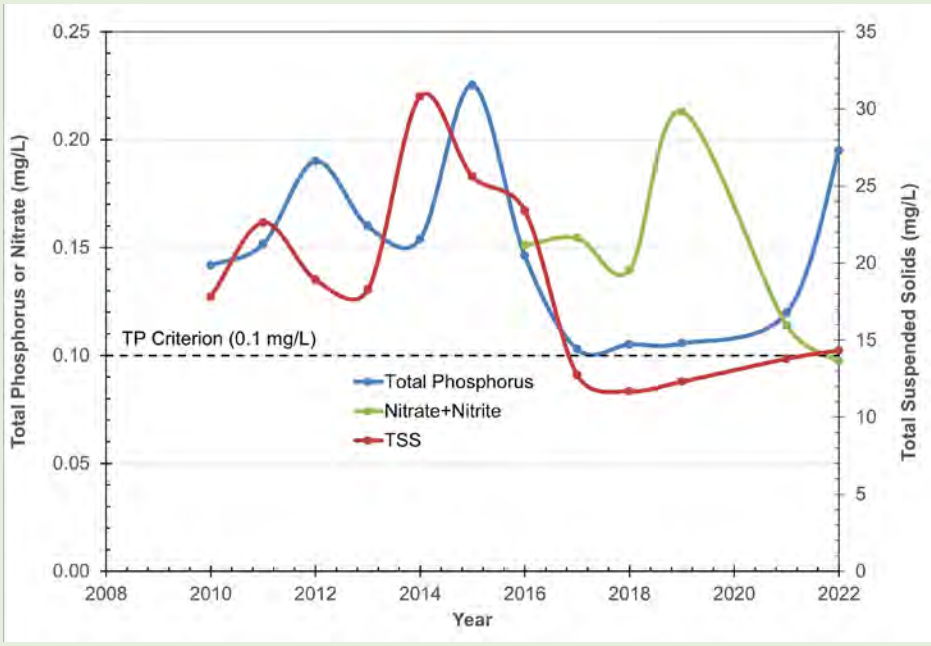
[1]RWMWD nutrient classifications are based on the relationship between the historical average water quality (based on phosphorus concentration alone) and the MPCA water quality (phosphorus) standards.



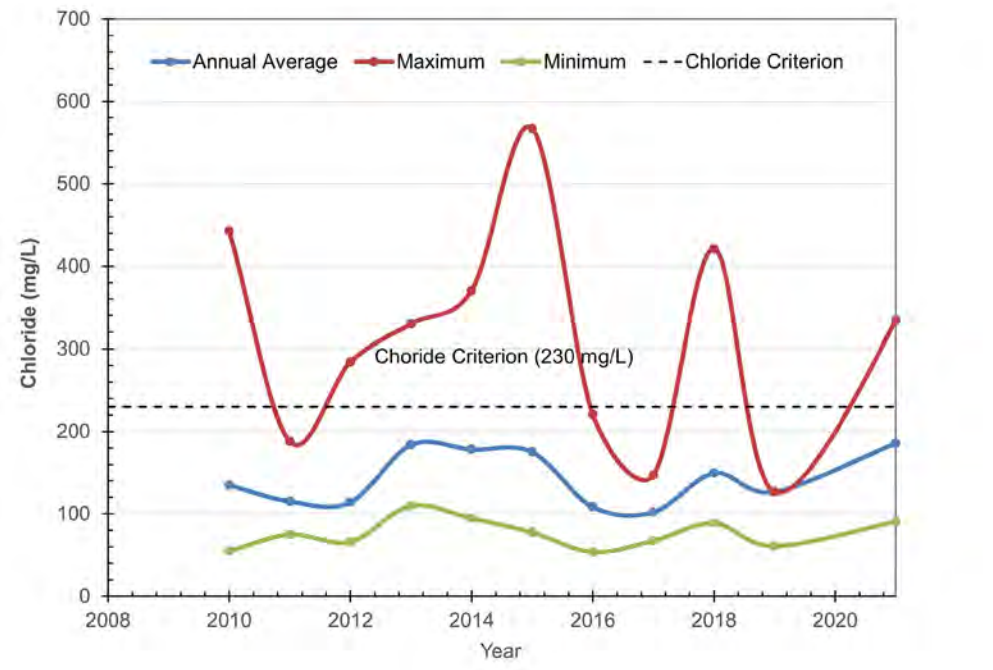
Parameter	State Standard	2022 Gervais Creek	Average	10-Year Trend
Phosphorus	≤ 100 µg/l	195 µg/l	146 µg/l (10-year average)	None
Total suspended solids	<15 mg/l	14 mg/l	18.1 mg/l (10-year average)	None
Nitrate	N/A	0.10 mg/l	0.15 mg/l (6-year average)	N/A
Chloride	≤ 230 mg/l[1]	208 mg/l	157 mg/l (10-year average)	None

[1] State standard for chronic chloride exposure.

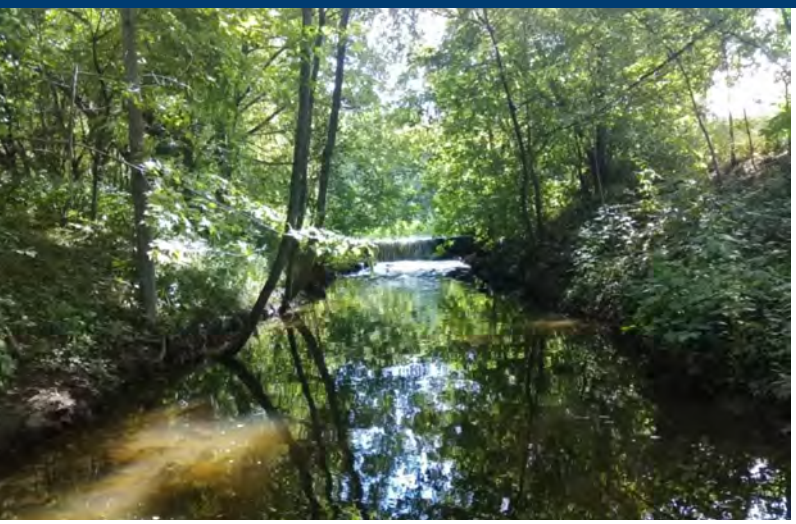
Nutrients and solids (mg/l)



Chlorides (mg/l)

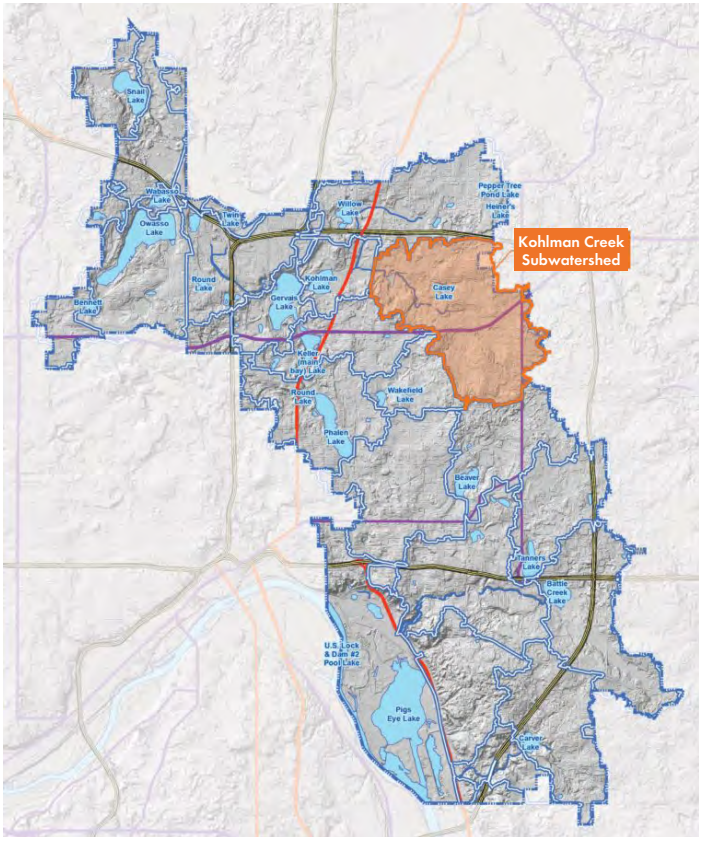


KOHLMAN CREEK



Tributary area	3,653 acres
Creek length	2.8 miles
Downstream waterbody	Kohlman Lake
Accountable municipalities	Maplewood, North St. Paul, Oakdale, Ramsey County, Washington County
RWMWD nutrient classification	At risk

[1]RWMWD nutrient classifications are based on the relationship between the historical average water quality (based on phosphorus concentration alone) and the MPCA water quality (phosphorus) standards.



Kohlman Creek is an intermittent stream that was previously considered a county ditch (County Ditch 18 South). The stream generally flows from southeast to northwest and eventually discharges to the Kohlman Basin in the Kohlman Lake subwatershed. The creek has been managed by the District as a stormwater conveyance system. Most of the creek remains in its natural state.

Kohlman Creek has been monitored annually for phosphorus, total suspended solids, and chlorides since 2008. Annual monitoring for chlorides began in 2015. In 2022, Kohlman Creek failed to meet the state standard for chloride. The 10-year data show statistically significant decreases in levels of phosphorus but an increase in chloride.

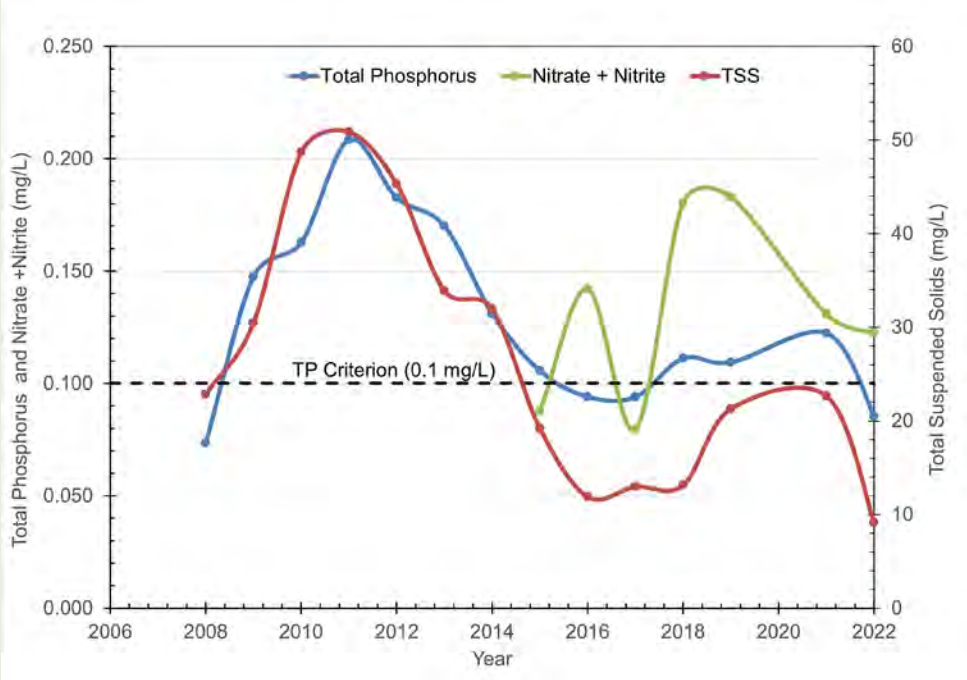
Recent projects to improve the water quality in Kohlman Creek include:

- Target—North Saint Paul (2021): The project included the removal of an impervious parking lot to install 4 rain gardens and 2 linear tree trenches. The installed best management practices can reduce the volume of polluted runoff that drains to Kohlman Creek, as well as remove pollutants such as total suspended solids and total phosphorus.
- North Presbyterian Church (2017): This rain garden intercepts and filters runoff from the church parking lot, reducing the volume of polluted rainwater draining to Kohlman Creek.
- Harmony Learning Center and Maplewood Middle School (2016): These school rain garden projects provide pollinator habitat and reduce the volume of polluted runoff that drains to Kohlman Creek.
- Maplewood Mall (2012): With 35 acres of asphalt pavement and concrete surfaces surrounding it, Maplewood Mall was a major source of phosphorus runoff to Kohlman Lake and Kohlman Creek. But, over 4 years, the RWMWD installed a variety of stormwater management features that capture and filter 67 percent of rainwater at the mall—up from just 3 percent before the project. These features include innovative tree trenches, rain gardens, permeable pavers, and a 5,700-gallon cistern that receives runoff from the mall roof. Interpretive signage educates the public about these improvements, and a large watershed map in the entry vestibule shows how water travels from the mall all the way to the Mississippi River.

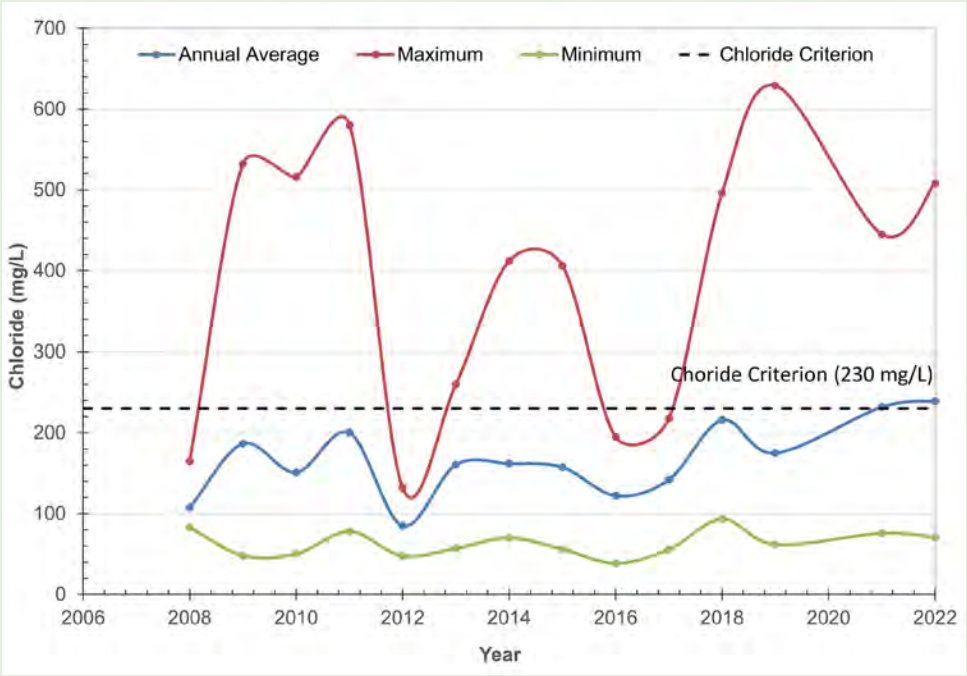
Parameter	State Standard	2022 Kohlman Creek	Average	10-Year Trend
Phosphorus	≤ 100 µg/l	85 µg/l	114 µg/l (10-year average)	Decreasing
Total suspended solids	<15 mg/l	9.1 mg/l	20 mg/l (10-year average)	None
Nitrate	N/A	0.12 mg/l	0.13 mg/l (6-year average)	N/A
Chloride	≤ 230 mg/l[1]	239 mg/l	178 mg/l (10-year average)	Increasing

[1] State standard for chronic chloride exposure.

Nutrients and solids (mg/l)



Chlorides (mg/l)



Perfluoroalkyl substances (PFAS) are also referred to as Perfluorochemicals (PFCs). PFAS are a family of manmade chemicals that have been widely used for decades. PFAS are extremely stable and do not breakdown in the environment. Common uses of PFAS include the following:

- Nonstick cookware, stain-resistant carpets and fabrics
- Coatings on some food packaging (especially microwave popcorn bags and fast food wrappers)
- Components of fire-fighting foam
- Many industrial applications

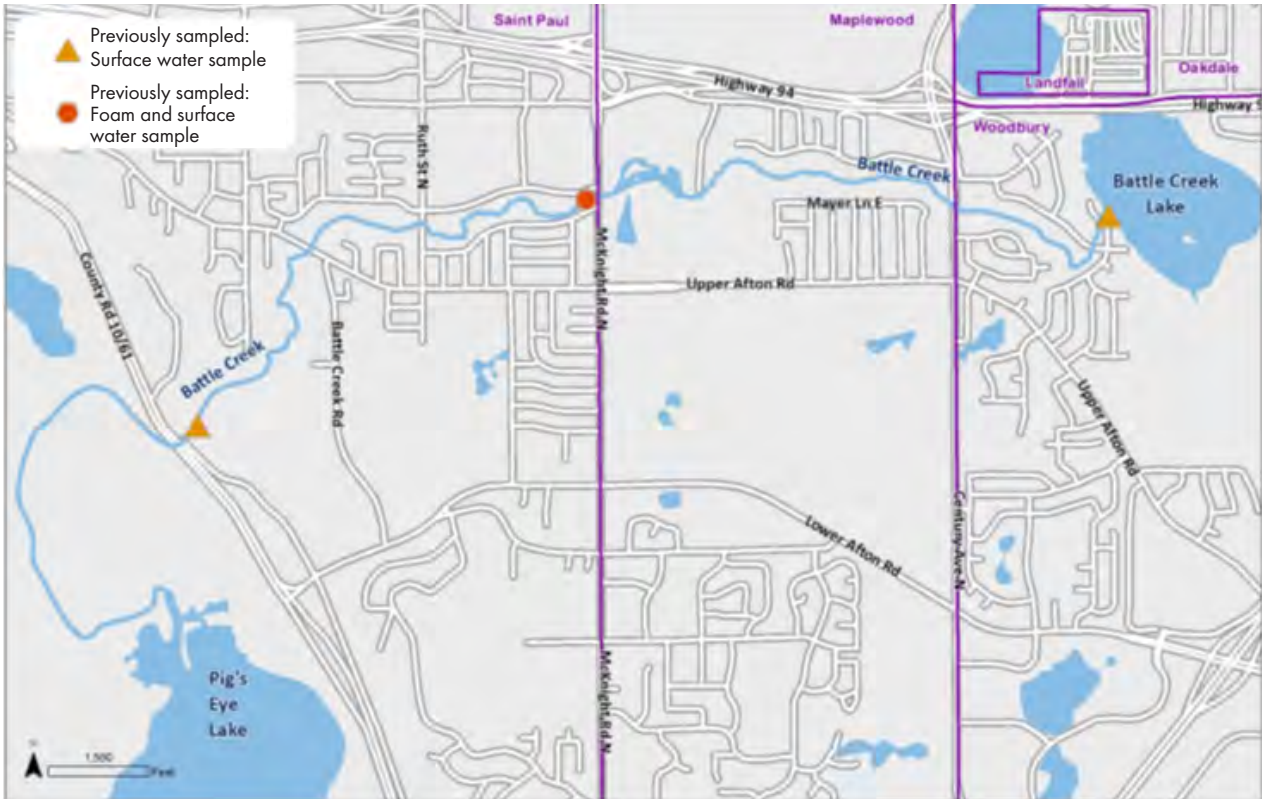
PFAS have been found in the groundwater in certain parts of Minnesota and are considered to be "emerging contaminants." Emerging contaminants are contaminants about which the MPCA has a new awareness or understanding of how they move in the environment or affect public health. PFAS, like other emerging contaminants, are the focus of active research and study, which means that new information is released occasionally.

Generally, surface water foam on natural water bodies is naturally occurring and does not contain PFAS. However, if PFAS-containing foam is found on surface water, MDH states that it does not pose a risk to human health if skin contact with the foam is minor and infrequent. Overall, with respect to contact with water bodies containing PFAS, MPCA recommends "when in doubt, stay out."

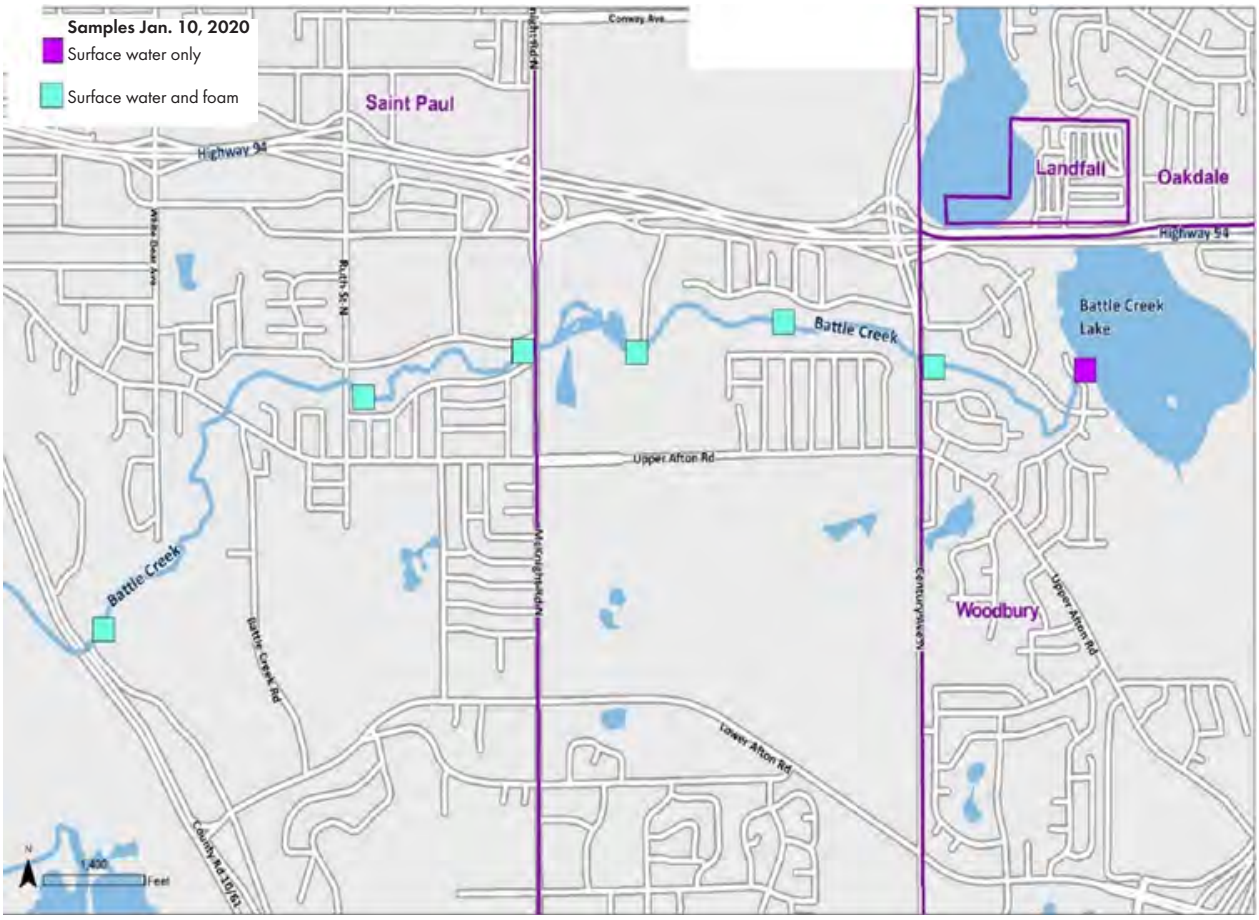
In 2019 and 2020, the Minnesota Department of Health (MDH) collected samples for PFAS analysis from Battle Creek (surface water and foam) and Battle Creek Lake (surface water) after discussions with the Minnesota Department of Transportation related to transit route planning in the area. All samples were analyzed for seven different PFAS compounds by the MDH Public Health Laboratory.

Various forms of PFAS (PFOS, PFOA, PFBA, PFPeA, PFPxA, PFBS, and PFHxS) were detected in surface water from both Battle Creek and Battle Creek Lake. Concentrations were low, especially in Battle Creek Lake. High concentrations of PFAS (PFOS, PFOA, PFBA, PFPeA, PFPxA, PFBS, and PFHxS) were detected in samples from the surface foam on Battle Creek.

This work is being conducted under MPCA's Superfund Site Assessment program. The objective of the program is to confirm earlier monitoring results and to develop lines of evidence for determining the potentially responsive party that can be brought into the Superfund program.



MPCA's 2019 PFAS sampling locations



MPCA's 2020 PFAS sampling locations

6. Chloride

The Minnesota Pollution Control Agency's chronic chloride criteria is 230 mg/L. Chloride is a component of total dissolved solids (or total dissolved salts), and chloride alone or in combination with other dissolved salts can be toxic to aquatic life. Most aquatic life criteria are based on testing with sensitive species; hence, the cumulative ecological impact of short-term or persistently high chloride is challenging to identify. Clearly, maintaining chloride below the 230 mg/L criteria will have ecological benefits by reducing overall stress on aquatic life. However, the potential ecological effect can be expected to be a function of the degree to which a given water sample exceeds criteria (e.g., how much greater than 230 mg/L), the frequency of the exceedance, and the persistence. The first step is to examine which water bodies have high chloride and consider if there are areas within the District that might be hot spots.

Chloride monitoring work prior to 2021 was focused on the routine annual sampling that occurs in lakes and streams, as presented in earlier sections of this report. In 2021, annual chloride sampling continued, but additional sampling took place from late March to early April. Late winter and early spring chloride sampling gives insight into worst-case chloride concentrations that are a result of road salt application.

The District sampled 36 water bodies in 15 subwatersheds for chloride concentrations. The goal of sampling 36 water bodies was to characterize runoff for as many of the District's drainage areas as possible to determine areas of high concentration ("hot spots"). In 2021, the majority of chloride samples were collected from the bottom of the water body (note that most of the water bodies sampled were shallow); however, some water bodies were sampled from the surface and/or the bottom. If a water body was sampled at more than one depth, then the surface sample was used in the mapping exercise. Chloride concentrations were mapped using drainage areas identified during the creation of the 2016 Management Plan. Figure 6-1 shows that runoff from approximately 40% of the District was included as part of the 2021 winter chloride monitoring program.

Figure 6-1 identifies chloride concentrations in monitored water bodies, and it also identifies the drainage areas that contribute runoff and chloride to the monitored water body. The lighter the shade of blue, the lower the chloride concentrations. Dark blue and black represent high concentrations that are above the MPCA chloride criteria. For the winter 2021 sampling program, 13 of the 15 major lake and stream subwatersheds had concentrations above the MPCA chloride criteria, while five of the 15 lake and stream subwatersheds had concentrations that were double the MPCA chloride criteria, including a sample in a Snail Lake subwatershed with a concentration of 1,520 mg/L.

Results in Figure 6-1 indicate that most subwatersheds have water bodies with elevated chloride concentrations, but the following subwatersheds are tentatively identified as hotspots, based on their high 2021 chloride concentrations in tributary drainage areas: Snail Lake, Gervais Creek, Battle Creek, Battle Creek Lake, and Carver Lake.

The winter monitoring program was continued in 2022. In April 2022, samples were collected from 22 sites. The sampling locations primarily comprise waterbodies with high (above the MPCA chloride criteria) chloride concentrations in 2021 (to confirm whether high concentrations were persistent) and/or waterbodies that were not included in the 2021 monitoring. Samples were either collected at the bottom of the waterbody or were composite samples that represented the entire water column. Results for the 2022 ice-out monitoring are shown in Figure 6-2. For the winter 2022 sampling program, seven of the 14 lake and stream subwatersheds had concentrations above the MPCA chloride criteria.

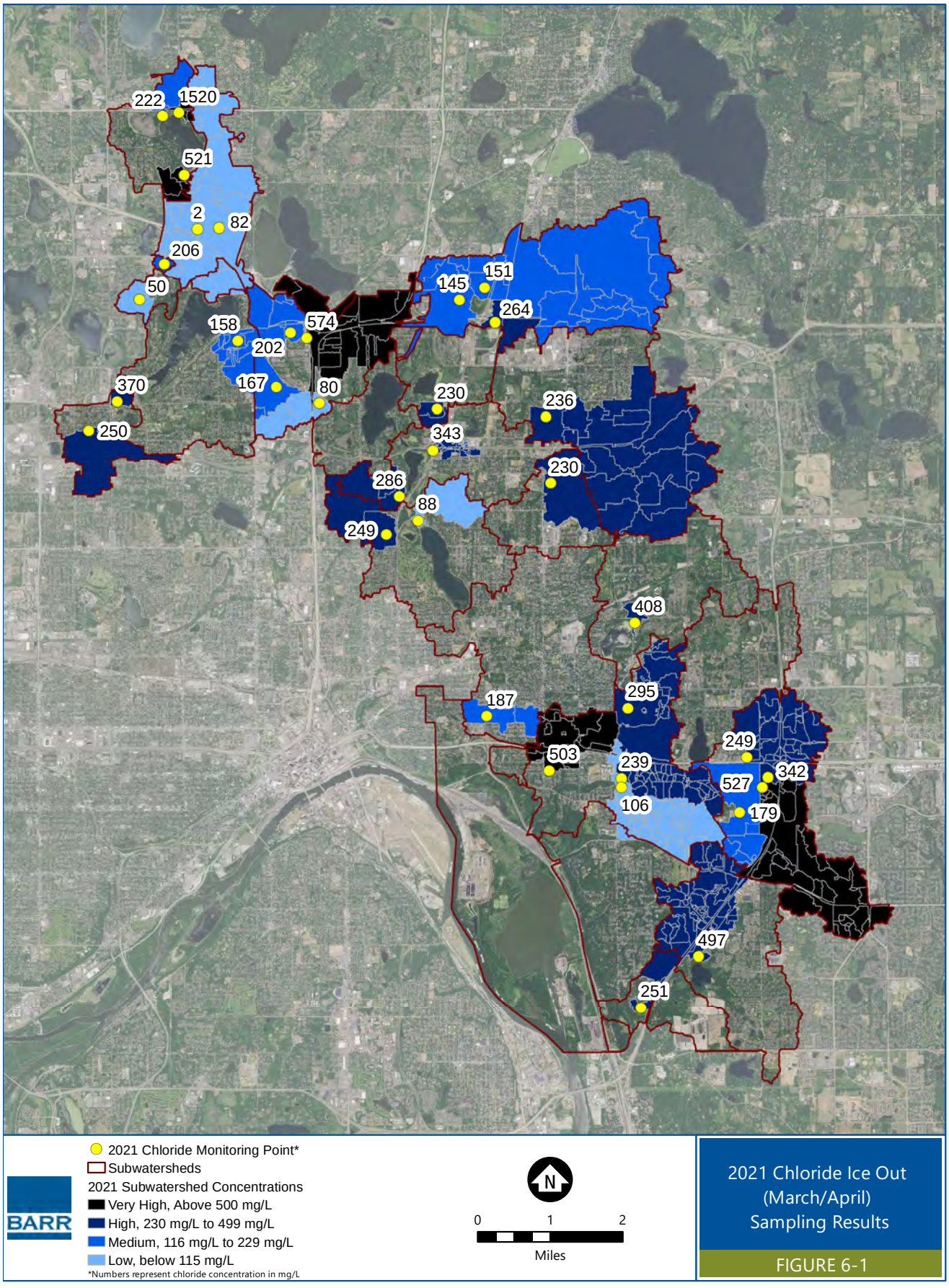


Figure 6-1 2021 chloride ice-out (March/April) sampling results

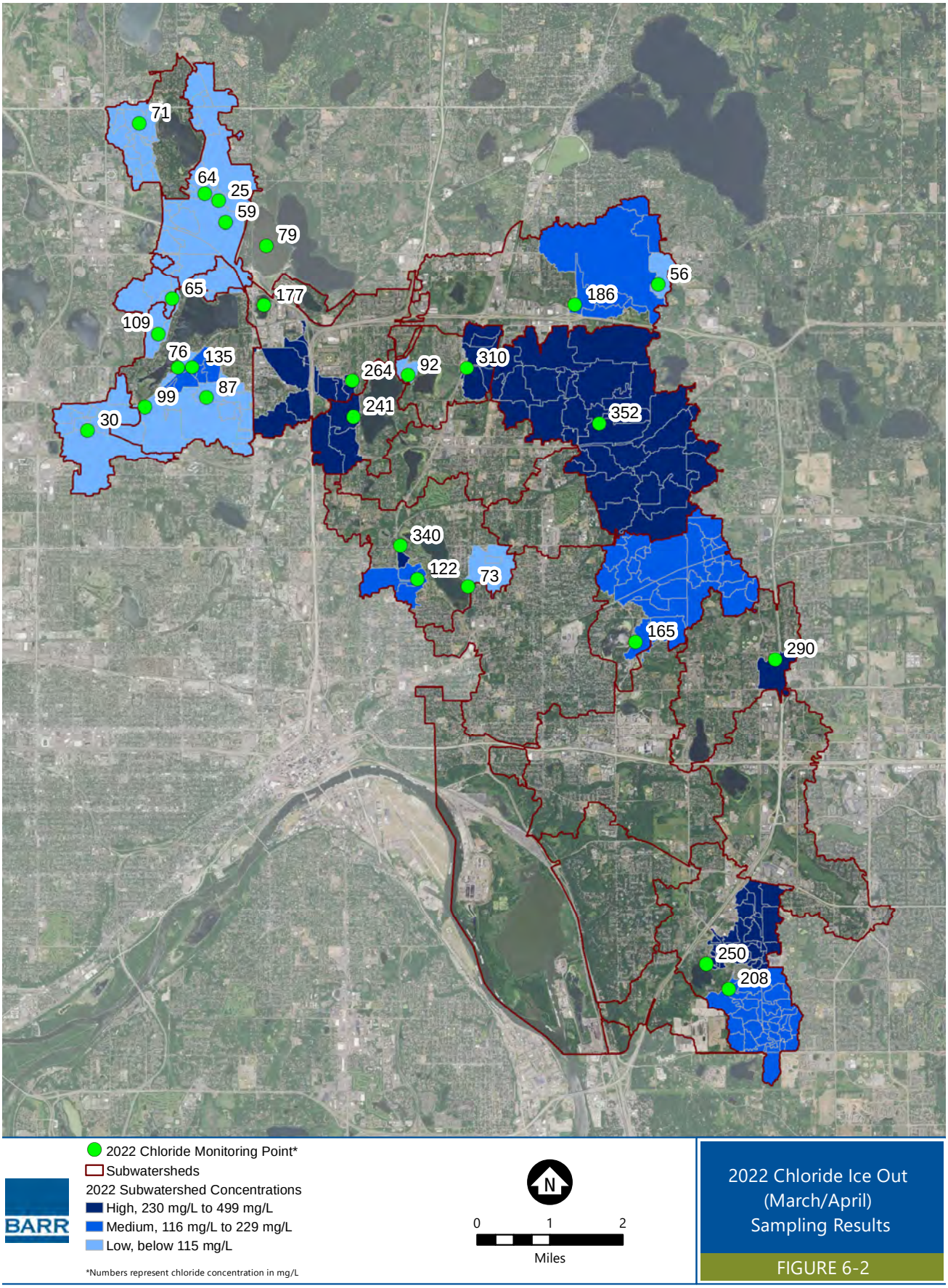


Figure 6-2 2022 chloride ice-out (March/April) sampling results

The results of the 2021 and 2022 monitoring period are superimposed in Figure 6-3. If a location was sampled in 2021 and 2022, the higher concentration is represented in the map. Overall, waterbodies receiving approximately 80% of the RWMWD's stormwater runoff (excluding those that drain to Pig's Eye Lake) have been sampled for chloride ice-out between 2021 and 2022. Results indicate that the majority of subwatersheds have either high or very high concentrations of chlorides after ice-out in late March and April, including but not limited to, Snail Lake, Carver Lake, Battle Creek Lake, Battle Creek, Keller Lake, and Gervais Creek. It is interesting to note was that there is no clear chloride correlation between years. Some waterbodies maintained similar concentrations; for example, one particular waterbody had a chloride concentration of 82 mg/L in 2021 and 59 mg/L in 2022. However, in a different location, another waterbody had a chloride concentration of 250 mg/L in 2021, and a concentration of 30 mg/L in 2022. These results reflect the need to annually repeat sampling to get a better understanding of year-to-year variation.

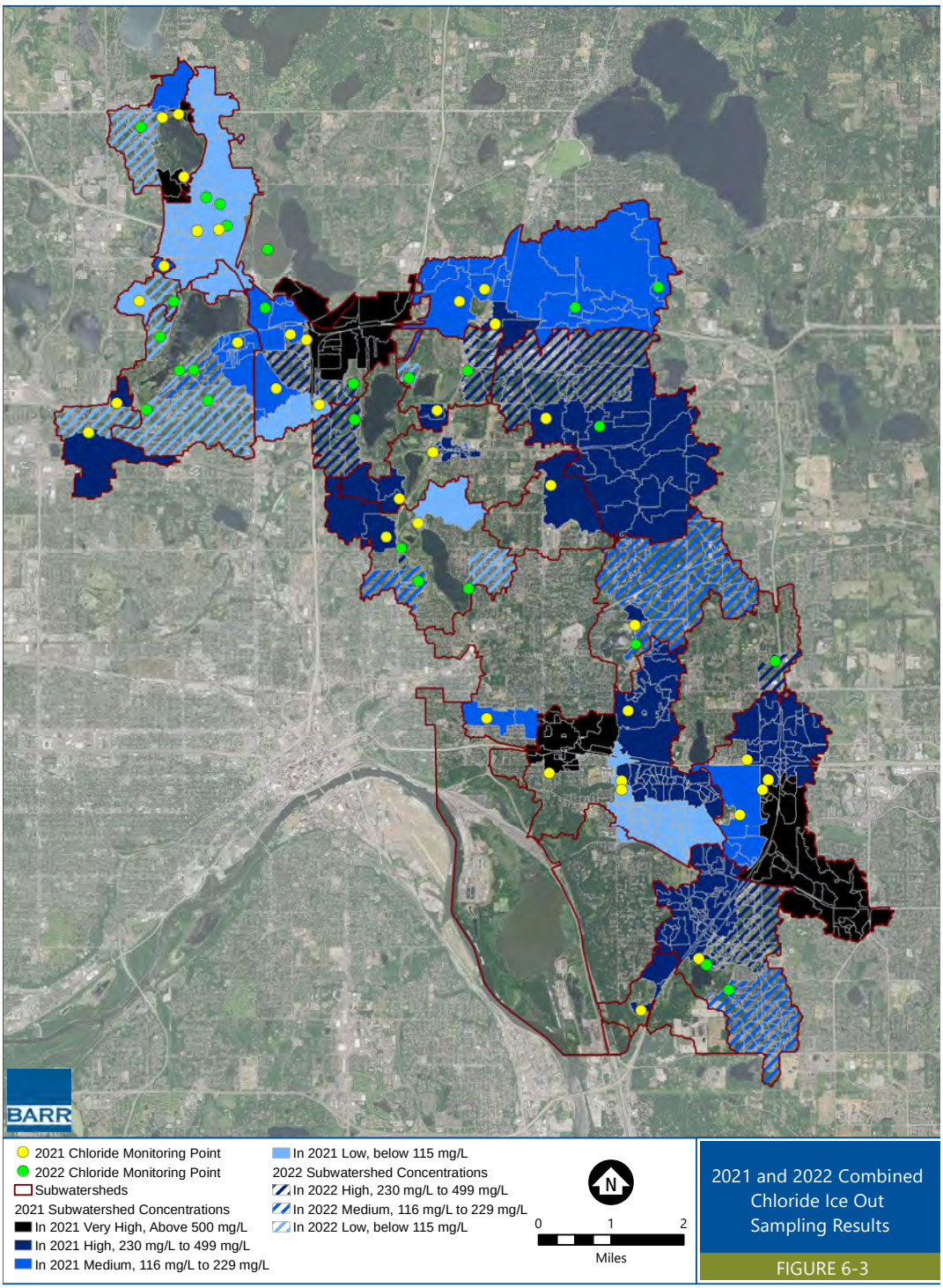


Figure 6-3 2021and 2022 combined chloride ice-out sampling results

Ice-out chloride monitoring is scheduled to continue in 2023. Using the results of 2021 and 2022 sampling, 30 locations have been selected (Figure 6-4). Half of the locations represent areas that were above the top 50th percentile for chloride concentrations in 2021 and/or 2022. The other half are locations in subwatersheds with lakes known to be impaired by high chloride concentrations: Tanners Lake, Carver Lake, Battle Creek Lake, and Kohlman Lake.

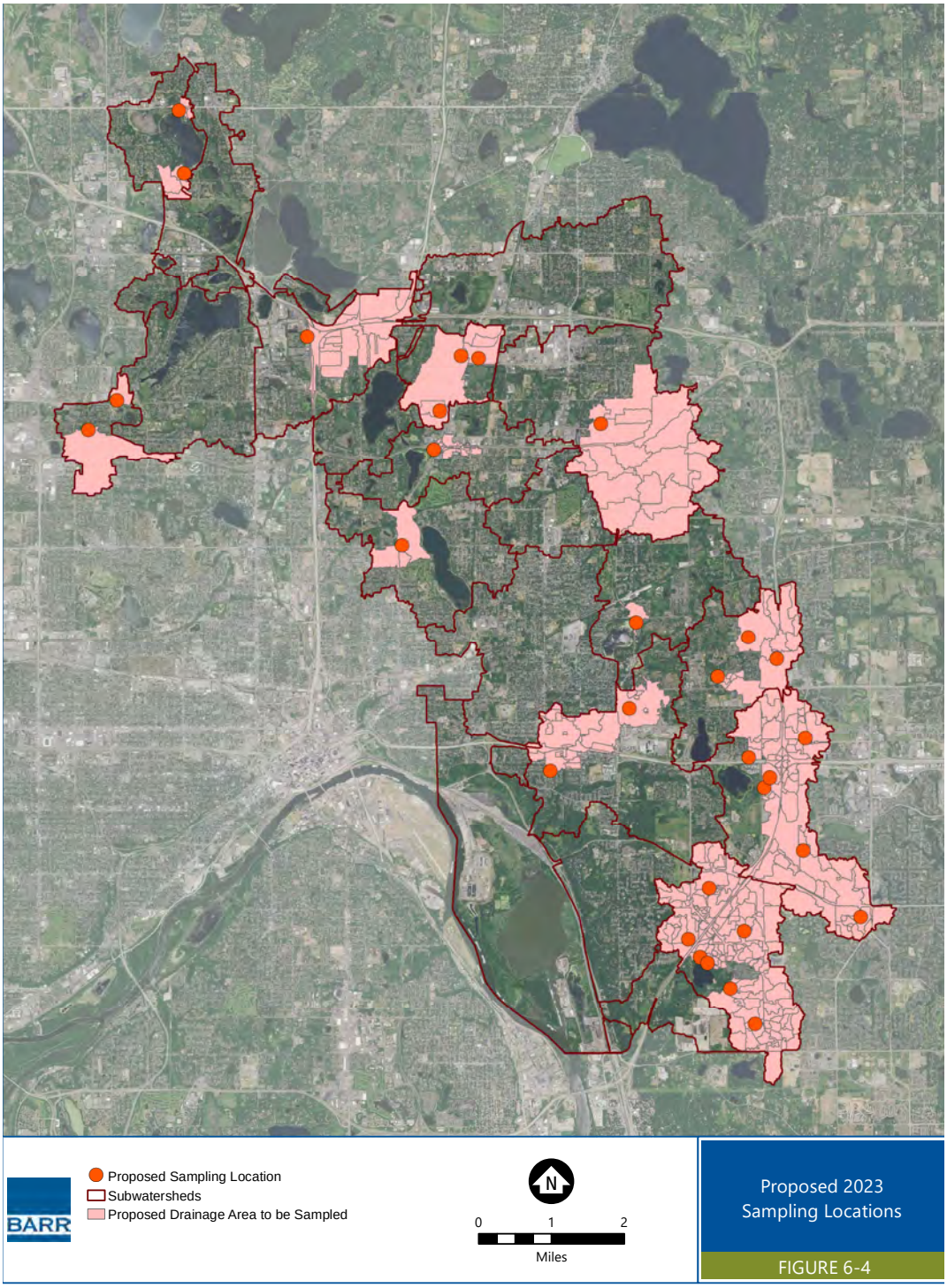


Figure 6-4 Proposed 2023 chloride sampling locations

7. Best Management Practices (BMPs)

SAND FILTERS

City	Maplewood
Subwatershed	Kohlman Creek
Completed	2009
Cost	$235,000
Funding Sources	District Levy Fund, Stormwater Impact Fund
Partners	City of Maplewood, University of Minnesota–St. Anthony Falls Laboratory

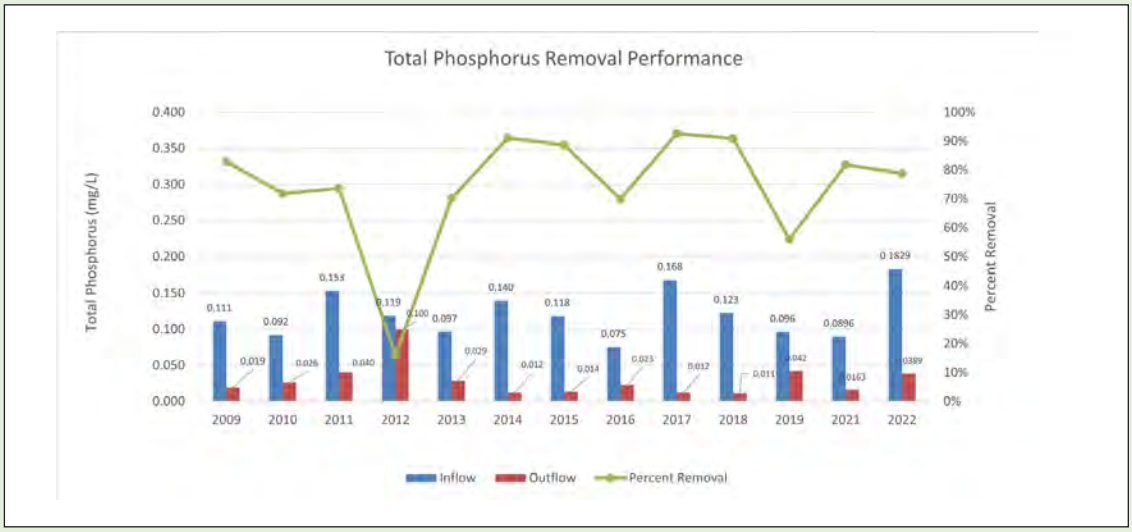
Beam Avenue Iron-Enhanced Sand Filter

RWMWD's iron-enhanced sand filter on Beam Avenue was installed in 2009 to improve the water quality of Kohlman Lake. It was the first filter of its kind in Minnesota.

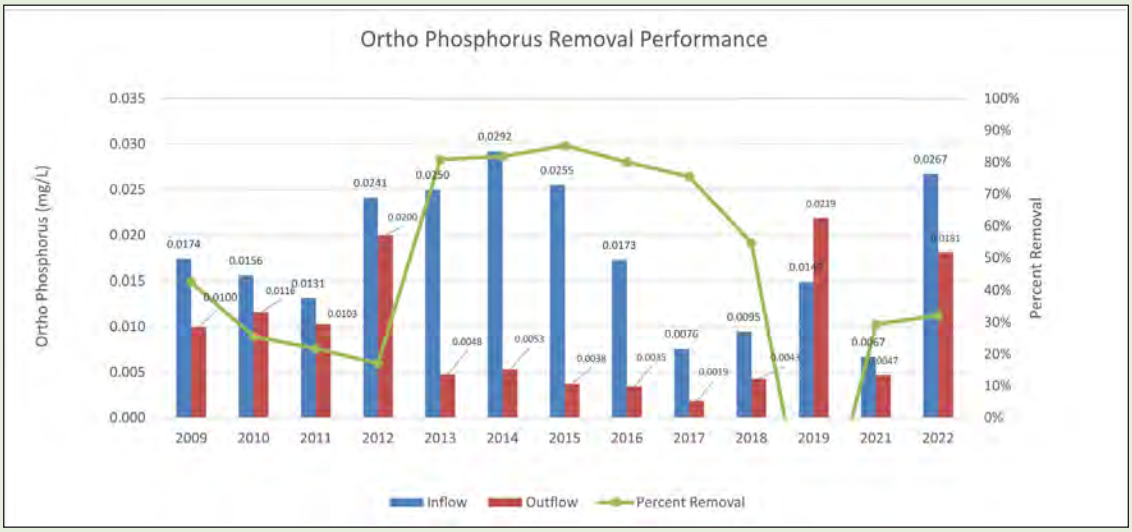
Sand filters have been used for years to remove solids and pollutants from stormwater. Newer, iron-enhanced sand filters (sand mixed with iron filings) are now being used as an efficient and cost-effective means of removing phosphorus. The filter works through a chemical process in which phosphorus molecules bind to the iron particles in the sand filter as water passes through.

The RWMWD has monitored its iron-enhanced sand filter since 2009. Between 2009–2018, total phosphorus removal ranged from 70–93%. But, in 2019, it declined significantly (56%). Since 2019, the TP removal has improved to 82% and 79% for 2021 and 2022, respectively. Removal of orthophosphate has declined, dropping from 70% removal in 2016 to -47% in 2019 (perhaps an indication that the filter is releasing dissolved phosphorus). In 2021 and 2022, orthophosphate removal rates increased slightly, but that could be due to 2021 and 2022 being drought years. Increased performance for total phosphorus and orthophosphate could also be attributed to the 2022 replacement of the media closest to the system's inlet. Removal of total suspended solids remains relatively steady, with average yearly removal consistently exceeding 85% for almost all monitored years. The average percent removal for the period of monitoring (2009–2022) is 74% for total phosphorus, 45% for orthophosphate, and 89% for total suspended solids.

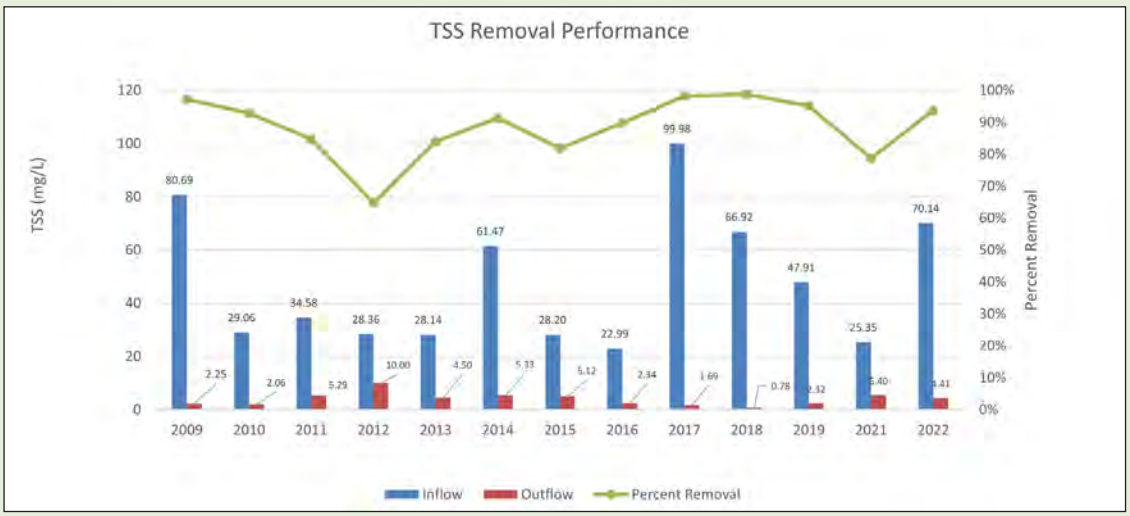
Total phosphorus removal performance



Orthophosphate removal performance



TSS removal performance



City	Maplewood
Subwatershed	Kohlman Lake
Completed	2009
Cost	$72,900
Funding Sources	District funds
Partner	Simon Property Group, Minnesota Pollution Control Agency (monitoring)

Woodlyn Rain Garden Iron-Enhanced Sand Filter

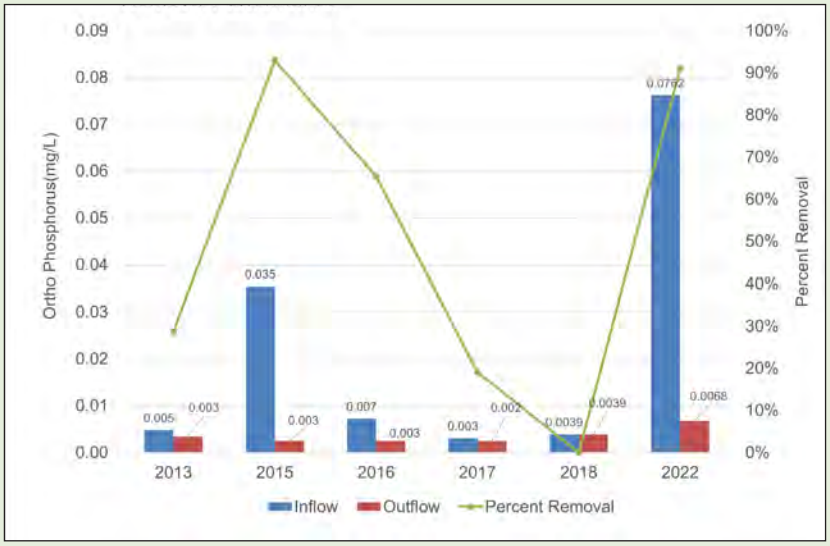
The Woodlyn iron-enhanced sand filter is part of the larger Maplewood Mall stormwater retrofit effort. The goal of that project—designed to capture and filter 67% of rainwater at the mall site—was to decrease the phosphorus runoff to nearby Kohlman Lake. Prior to the project, only 3% of the stormwater runoff from the mall was captured and filtered.

The Woodlyn iron-enhanced sand filter is a narrow strip of iron-enhanced sand beneath a rain garden. Runoff is intercepted from a parking lot and directed to the rain garden. There, the stormwater filters through the iron-enhanced sand for a period of time until it is treated. The average annual phosphorus removal with the filter has ranged from 3% during the first year of operation to 75% in 2018. The average annual removal of orthophosphate ranged from 0% in 2018 to 93% in 2015. The average removal for the period of monitoring (2012–2018) was 58% for total phosphorus, 73% for orthophosphate, and 94% for total suspended solids.

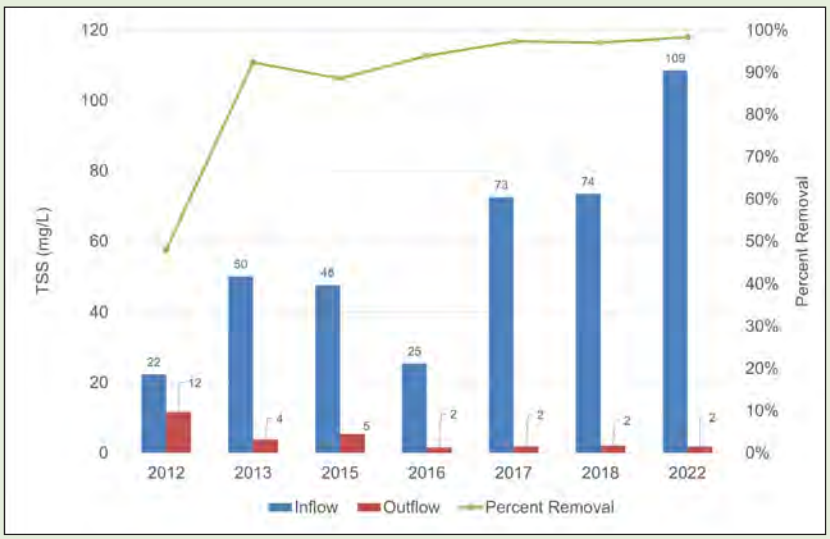
In 2022 total phosphorus, orthophosphate, and total suspended solids removal were all over 90%—the highest yearly removal rates since monitoring began. The infrequent and small rainfall events in 2022 may account for this increased performance, as the rain washed down impervious surfaces laden with atypically high levels of accumulated sediment. Due to the improved performance in 2022, it is recommended to monitor Woodlyn before deciding if filter media replacement is required.

Total phosphorus removal performance

Orthophosphate removal performance



TSS removal performance



City	Maplewood
Subwatershed	Wakefield Lake
Completed	Fall 2011; filter media changed in 2022
Cost	$40,000
Funding Source	MPCA 319 Grant
Partner	City of Maplewood

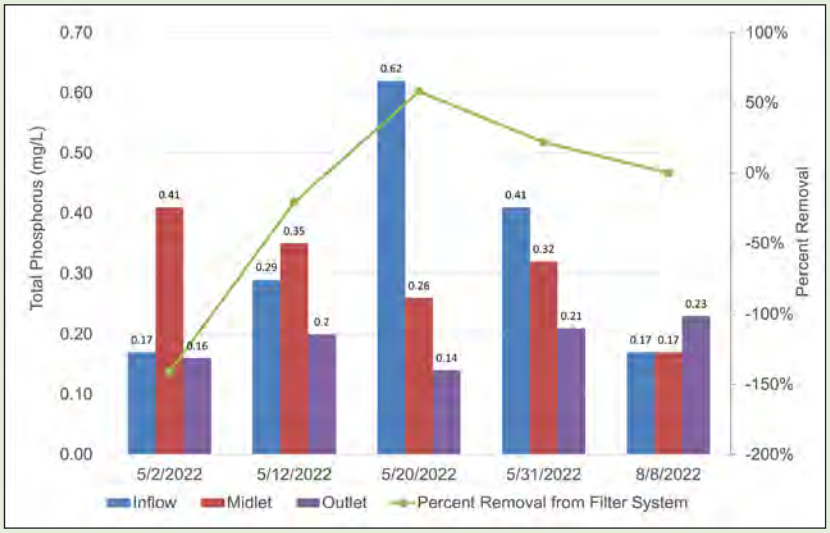
Wakefield Lake Experimental Iron and Granite Sand Filter

In 2022, the media in the Wakefield Lake Experimental Filter (see page 70) was replaced with iron and granite sand. Iron and granite sand was selected as replacement media due to granite sand's high infiltration rate and iron's capacity to remove dissolved phosphorus. The system was monitored in 2022 in three locations: inlet, "midlet," and outlet. The inlet is the inflow location, the "midlet" is where water leaves the filter media system, and the outlet is the outflow of the pond downstream of the filter (before Wakefield Lake).

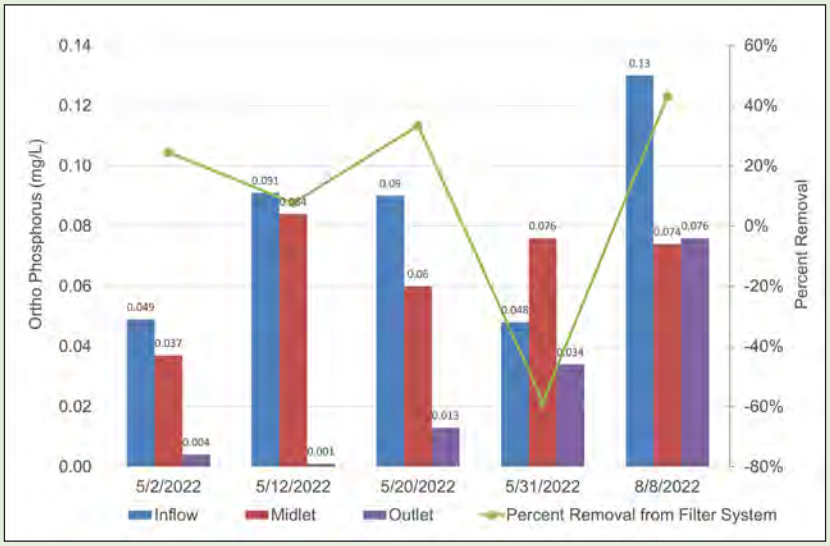
In 2022, the filter system had mixed total phosphorus removal performance—the filter removed phosphorus for some events, but released some phosphorus during others. From inlet to outlet, almost all events had a reduction in total phosphorus, but the majority of removals came from the downstream pond. The filter had an average total phosphorus removal (between the inlet and the "midlet") of 9%, while the pond's average removal (between the "midlet" and the outlet) was 38%. A similar trend was apparent for orthophosphate and total suspended solids. The average orthophosphate removal from the filter was 19%, while the average removal from the pond was 61%. The average total suspended solids removal from the filter was negative, while the pond was 91%.

The total suspended solids results stand out, especially when examining the outflow concentrations from the filter. The "midlet" concentrations decreased from 1,510 mg/L at the beginning of the year to 97.3 mg/L. One potential explanation for the high "midlet" concentration of total suspended solids on the first sampling date is that the granite sand was, perhaps, not washed well enough before being installed in the filter, resulting in a pulse of suspended solids getting washed off the new media. It will be important to continue monitoring the filter to see if the performance of all three parameters improves and performance stabilizes.

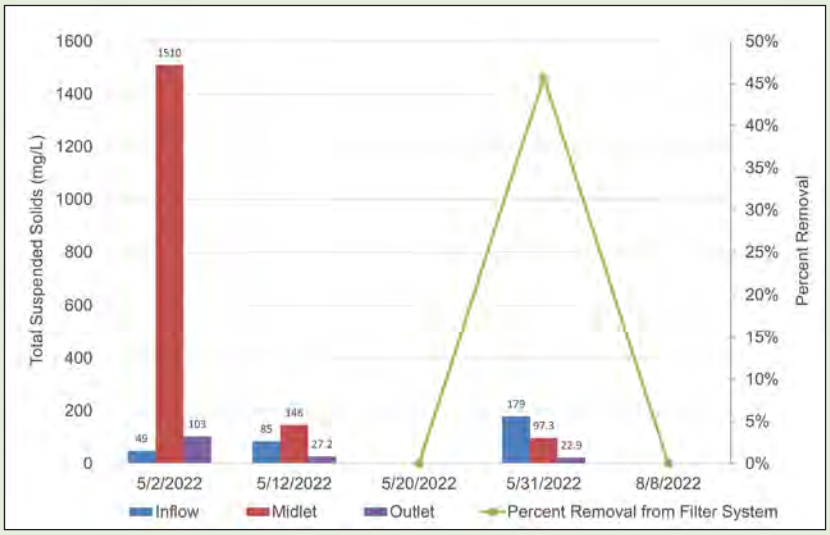
Total phosphorus removal performance



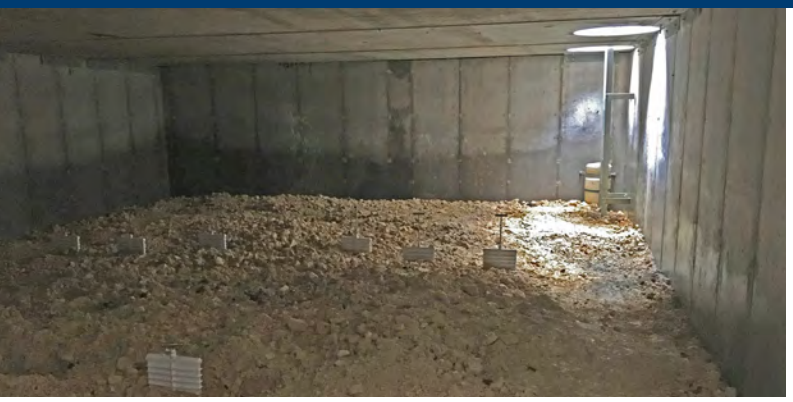
Orthophosphate removal performance



TSS removal performance



SPENT-LIME FILTERS



City	Maplewood
Subwatershed	Wakefield Lake
Completed	2018
Cost	$390,000
Funding Sources	Clean Water Fund ($300,000) and District funds
Partner	City of Maplewood

Frost and Kennard Spent-Lime Filter

This innovative stormwater filter is located at the corner of Frost Avenue and Kennard Street in Maplewood, a few blocks upstream from Wakefield Lake. It is designed to capture and filter stormwater runoff from a large portion of the lake's 944-acre subwatershed.

The filter intercepts water from the storm sewer and routes it into a 20- by 36-foot underground chamber. There, the water interacts with spent lime—a chalky clay-like material consisting of calcium carbonate, which is a waste product of municipal drinking water treatment. Phosphorus in the water binds to calcium in the spent lime material, decreasing the amount of phosphorus in the water leaving the chamber.

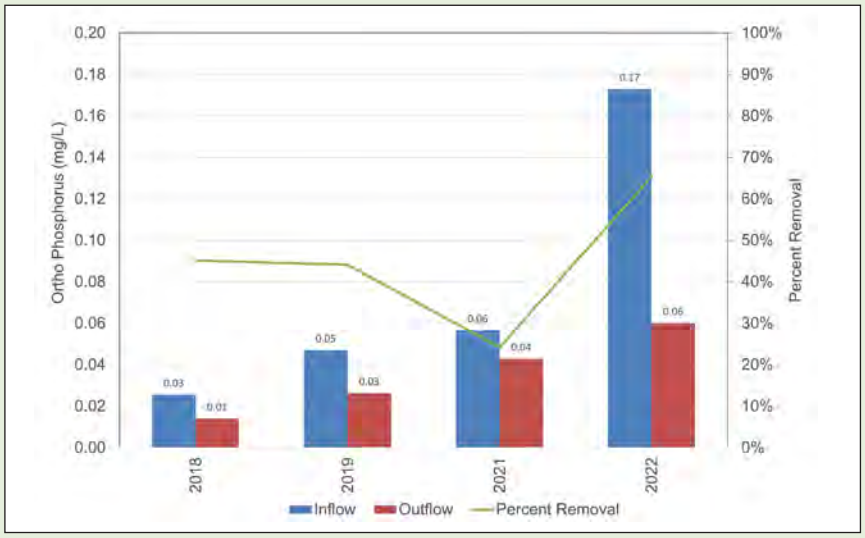
Spent lime is particularly effective in removing a form of phosphorus called orthophosphate, which is often found in stormwater runoff. While orthophosphate is a vital nutrient for bacteria and plants in surface waters, too much orthophosphate can promote algae growth and decrease water clarity.

Sampling equipment monitors phosphorus levels and total suspended solids as water enters and leaves the filter on its way to Wakefield Lake, which is impaired for phosphorus. The goal is to help the lake meet the state standard for phosphorus (60 micrograms per liter).

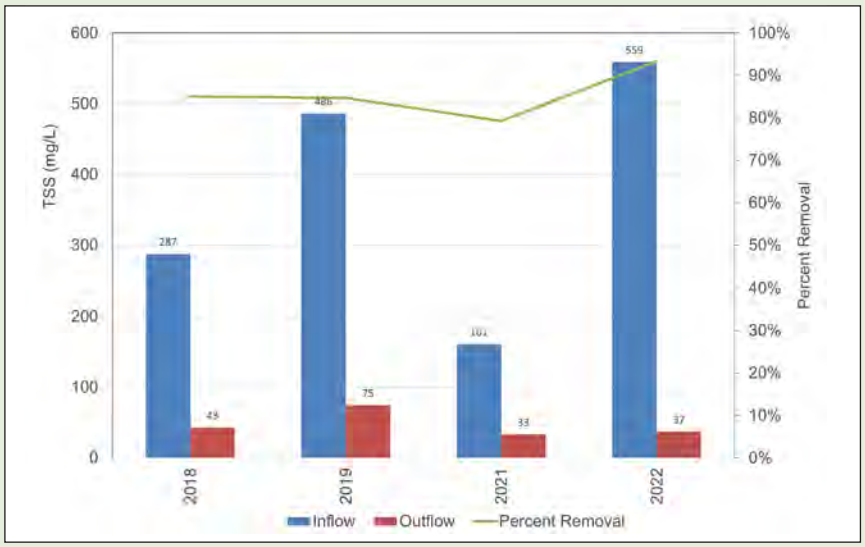
The removal performance for total phosphorus, orthophosphorus, and total suspended solids all show a similar pattern. From 2018 to 2021, there was a slight decrease in removal for all parameters. For example, total phosphorus performance was 68% in 2018, 61% in 2019, and 55% in 2021. This decreasing trend would indicate that the media may need to be replaced. However, in 2022, the filter had its best removal performance, with removals of 78% for total phosphorus, 65% for orthophosphate, and 93% for total suspended solids. One potential reason for the increased performance in 2022 could be that 2022 was a drought year with typically small rainfall events. It is important to continue monitoring the Frost Kennard filter to see if performance is improving or if the media is reaching the end of its lifespan, as the 2018–2021 data suggests.

Total phosphorus removal performance

Orthophosphate removal performance



TSS removal performance



City	Maplewood
Subwatershed	Wakefield Lake
Completed	Fall 2011
Cost	$40,000
Funding Source	MPCA 319 Grant
Partner	City of Maplewood

Wakefield Lake Experimental Spent-Lime Filter

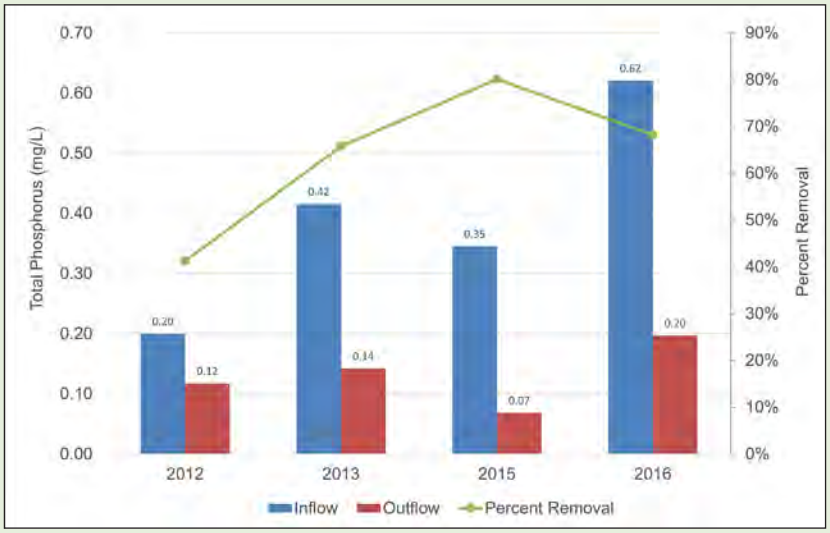
This stormwater filter is adjacent to Larpenteur Avenue and Prosperity Road. It is designed to capture and filter stormwater runoff from a large portion of the lake's 944-acre subwatershed.

The filter intercepts water from the storm sewer and routes it into an underground chamber. From 2011 to 2021 the filter media was spent lime. Spent lime is a chalky clay-like material consisting of calcium carbonate, which is a waste product of municipal drinking water treatment. Phosphorus in the water binds to calcium in the spent lime material, decreasing the amount of phosphorus in the water leaving the chamber.

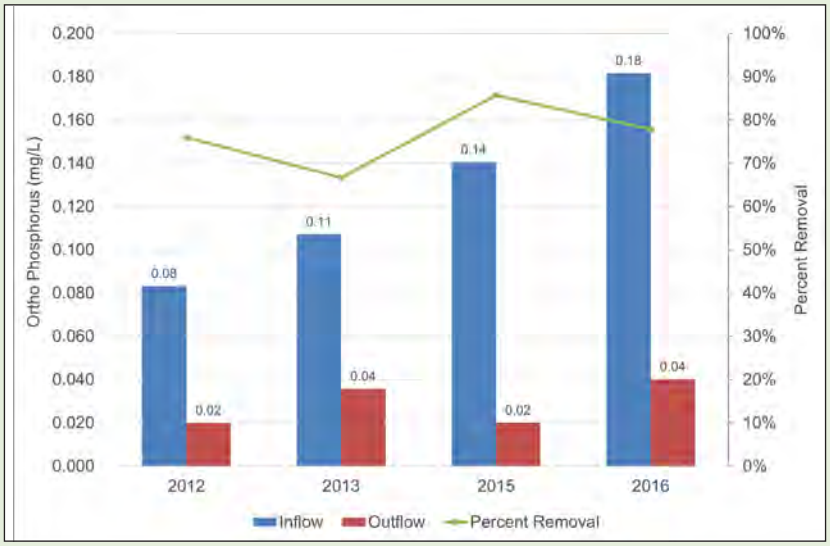
Spent lime is particularly effective in removing a form of phosphorus called orthophosphate, which is often found in stormwater runoff. While orthophosphate is a vital nutrient for bacteria and plants in surface waters, too much orthophosphate can promote algae growth and decrease water clarity. The goal of this filter is to decrease the amount of phosphorus and total suspended solids entering Wakefield Lake, which is impaired for phosphorus.

The graphs at right show the effectiveness of the spent-lime filter in reducing total phosphorus, orthophosphate, and total suspended solids in 2012, 2013, 2015, and 2016. Peak performance for total phosphorus and orthophosphate removal occurred in 2015 (73% and 77%). In 2016 performance dipped to 42% and 38%. Removal of total suspended solids improved substantially from 2012 (-19%) to 2016 (61%). Over the four years of monitoring, the average removal for the three parameters was 51% for total phosphorus, 55% for orthophosphate, and 37% for total suspended solids. It should be recognized that these averages include periods where performance changed due to structural changes in the media after placement. For example, total suspended solids removal of around 50% is probably more typical as the media broke down and filled in pore space, thereby improving the filtration effectiveness of the media.

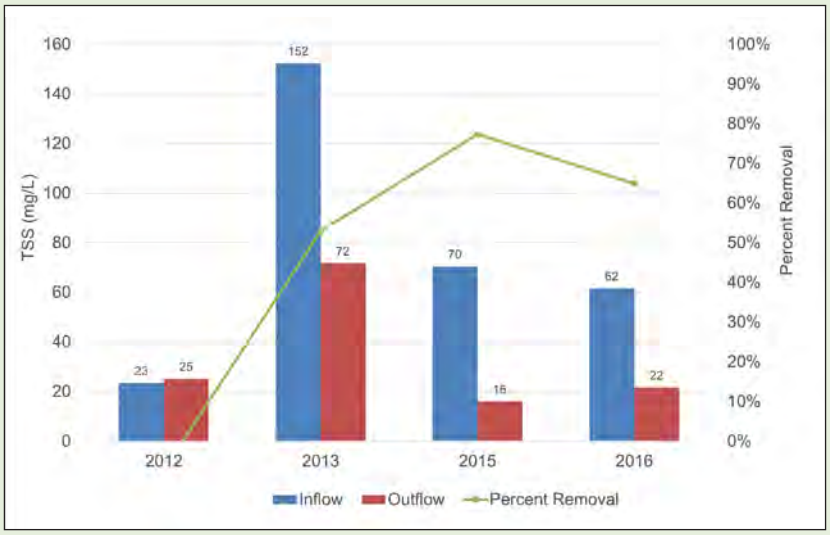
Total phosphorus removal performance



Orthophosphate removal performance



TSS removal performance



City	Shoreview
Subwatershed	Snail Lake
Completed	2021
Cost	$20,000
Funding Source	District funds
Partner	University of Minnesota

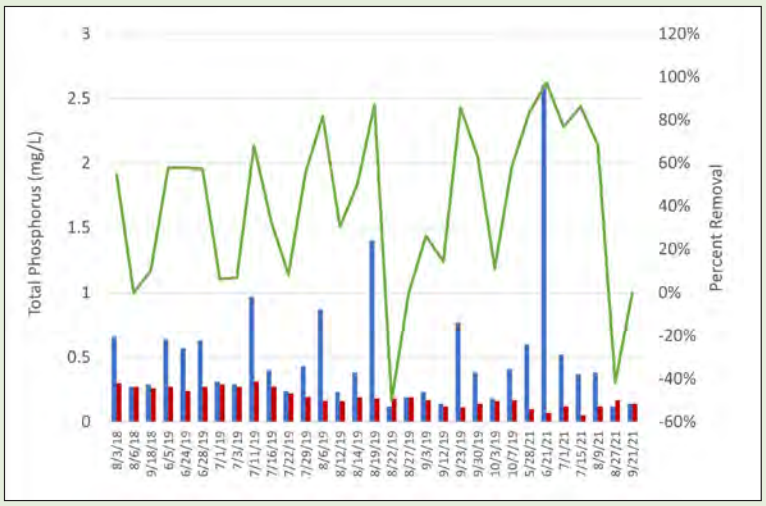
Shoreview Commons Pond

The Shoreview Commons Pond is located north of Highway 96 in the Shoreview Commons Park. The pond has a drainage area that is approximately 144 acres (35% impervious), primarily comprising residential, residential, and institutional land. The outflow of the pond travels to Snail Lake. Shoreview Commons Park Pond has a historical trend of odor problems, low water clarity, and significant duckweed growth.

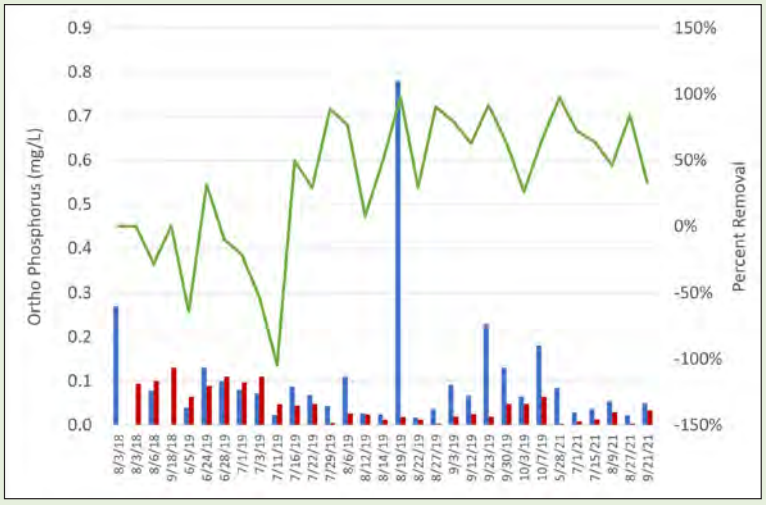
The pond was initially studied in 2018 with the use of sediment cores, laboratory mesocosms, and in-situ water quality sampling. The 2018 study was used to determine the baseline water quality for the pond and to develop an iron filings treatment plan and dose. St. Anthony Falls Laboratory researchers chose to add iron filings to the pond to reduce internal loading with the pond and to improve its water quality. In February 2021, Shoreview Commons Pond 12,000 pounds of iron filings were applied to the surface of the frozen pond. The application of iron on frozen ice allows the iron filings to be equally distributed as the ice melts, releasing the filings into the pond.

From 2018 to 2019 (pre-iron-filing application), the average total phosphorus removal in the pond was typically between 0 and 70%. In 2021, post-iron-filing application, the majority of events were over 65% total phosphorus removal and as high as 97% removal. However, toward the end of the season, there were two events with no total phosphorus removed. Therefore, , the impact of the iron filings on total phosphorus removal remains unclear. Similarly, it is difficult to understand the impacts of iron fillings on orthophosphate removal. Orthophosphate removals were the lowest in the 2018 pre-iron-filing application. However, 2019 (pre-iron filing) and 2021 (post-iron filing) had similarly low orthophosphate removal performance, although Lastly, it appears the iron-filing application did not impact total suspended solids performance, with all years typically having events with over 85% of total suspended solids removed. It is hard to predict the performance of the iron filing application due to limited data post-application. In addition, the pond had a fountain or aerator installed between October 2020 and August 2021 which may have interfered with the pond's water quality.. To understand the impacts of the filing, monitoring would need to continue and would need to be done more consistently, in a manner similar to the 2019 sampling period. However, given the 2021 results it may still be hard to draw conclusions.

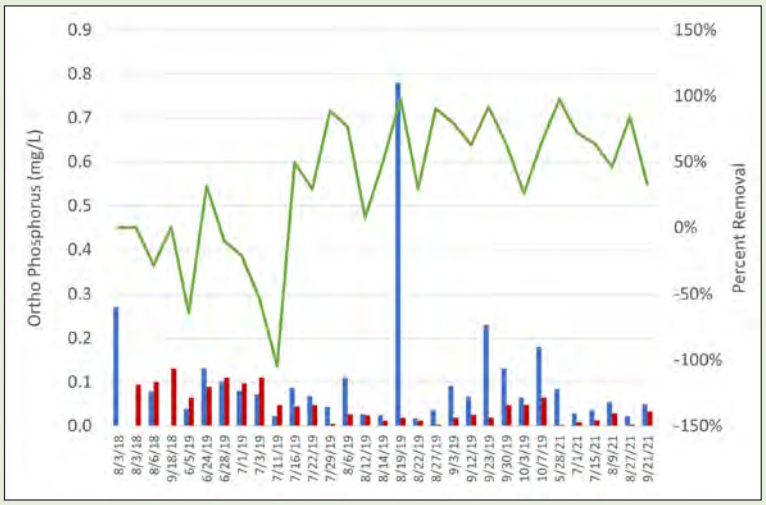
Phosphorus removal performance (mg/l)



Orthophosphate removal performance (mg/l)



Total suspended solids removal performance (mg/l)



ALUM TREATMENT SYSTEM

City	Oakdale
Subwatershed	Tanners Lake
Completed	1998
Cost	$1.9 million[1]
Funding Sources	District funds, Minnesota Pollution Control Agency State Revolving Fund Loan

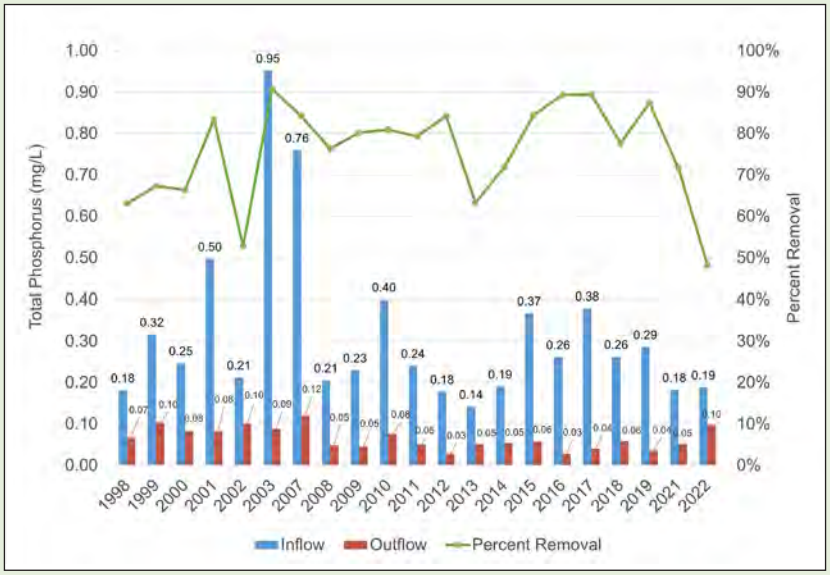
[1] This cost reflects the alum facility as well as other related water quality improvements: Tanners Lake 5th Street Basin, Tanners Lake Berm, Tanners Lake Tartan High School Pond

Tanners Lake Alum Treatment Facility

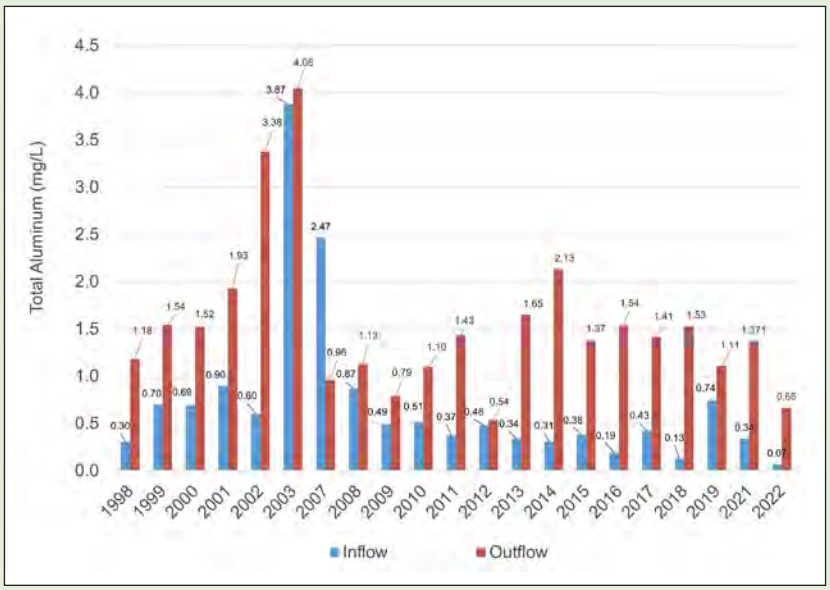
The Tanners Lake alum treatment facility was constructed in 1998 to reduce the amount of phosphorus reaching Tanners Lake. The facility receives stormwater runoff from a 1,246-acre watershed and injects it with aluminum sulfate (known as alum). The alum then binds with the phosphorus in the water and forms a floc that settles to the bottom of a pond upstream of Tanners Lake. The water that ultimately drains out of the pond to Tanners Lake has significantly lower phosphorus content.

The graphs at right show the effectiveness of the alum treatment system in reducing total phosphorus over the last 20-plus years of monitoring. Peak performance for phosphorus removal occurred in 2003 (91%) after improvements were made to the system in 2002. From 2004 to 2019, total phosphorus removal would consistently range from 72% to 89%. In 2021 and 2022, there was a slight downward trend in total phosphorus removal compared to years prior. It will be important to continue monitoring total phosphorus removal to determine if this trend persists.

Total phosphorus removal performance



Total aluminum



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