Watershed assessment and trends update

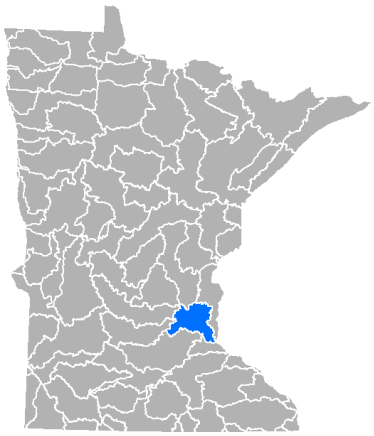
Mississippi River – Twin Cities Watershed

Upper Mississippi River Basin

Key characteristics

The Mississippi River – Twin Cities Watershed occupies an area of approximately 1,007 square miles in east central Minnesota and is drained by several streams and rivers that flow directly into the Mississippi River through the Twin Cities area. The rivers, lakes, and streams in this metropolitan area provide important ecosystem services and excellent recreational opportunities for more than 1.9 million residents as well as millions of annual visitors. The watershed contains Minnesota's largest two cities Minneapolis and St. Paul and is comprised of six counties as well as numerous watershed districts and management organizations.

Figure 1: Minnesota's 80 major river drainages. Mississippi River – Twin Cities Watershed is highlighted in blue.



Water monitoring is essential to determine whether lakes and streams meet water quality standards designed to ensure that waters are fishable and swimmable. The Minnesota Pollution Control Agency (MPCA), Minnesota Department of Natural Resources (MNDNR), and local partners conduct an intensive analysis of major lakes and streams in each of the state's 80 major watersheds every 10 years to detect changes in water quality. Water monitoring in this watershed is truly a collaboration between state agencies, watershed districts, watershed management organizations, and Met Council Environmental Services. The 10-year long effort produced the most complete picture of watershed condition in the state, including water quality and biological data on hundreds of lakes, rivers, and streams. The wealth of data collected and analyzed in the 2010 effort to assess the condition of water quality in the Mississippi River – Twin Cities Watershed provided a baseline for comparison with extensive chemical and biological sampling conducted in 2020 and 2021. In both cycles of monitoring, scientists examined levels of chemical pollutants, bacteria, and water clarity, as well as the biological condition of two aquatic communities (fish and aquatic macroinvertebrates) to determine if waters are healthy or in need of restoration. A comparison between the two sampling efforts provides a powerful mechanism for determining if water quality is improving or declining. Assessment using fish surveys in lakes was first utilized in 2013, therefore, this is the first cycle of monitoring within this watershed where scientists have examined the biological condition of fish communities in lakes. Partners use this information to develop or refine protection strategies for waters that are healthy and prioritize restoration plans for waters that are degraded or impaired.

Changes in water quality

To detect any changes in water quality, this recurring exam looks at fish and macroinvertebrate communities as well as water chemistry. Scientists use a tool called the Index of Biological Integrity (IBI) to assess the health of biological communities in lakes, rivers, streams, and wetlands. High IBI scores indicate a healthy aquatic community, which can only be attained when water quality, habitat, and hydrology are minimally disturbed by human activities.

Over the past decade, scientists observed some positive changes in water quality in the Mississippi River – Twin Cities Watershed. Several lakes with previous nutrient impairments have been restored to swimmable quality and will be removed from the state's Impaired Waters List (IWL). Stream fish communities show an overall improvement between the sampling that occurred in 2010 and 2021, but few stream sections have improved enough to propose a removal from the IWL. Changes to fish communities in lakes cannot be compared, since there had not been any assessable fish community surveys for the previous assessment cycle. The baseline for lake fish communities will be set during this 2020 cycle. Compared to 2010 results, average IBI scores for macroinvertebrates (i.e., small animals that can be seen with the naked eye and have no backbone such as aquatic insects, crayfish, and snails) remained virtually unchanged in 2020 across the watershed. Continued problems identified in some streams include elevated bacteria levels, low dissolved oxygen levels, high chloride levels, and increased land use development.

The most recent monitoring efforts indicate that restoration efforts and land management best practices have helped improve water quality in several water bodies throughout the watershed, while other waters show evidence of declining water quality:

- Twenty-five lakes have been approved for nutrient delistings since 2012, with a handful of others close to a restored status.
- 5 new lakes are being listed for new nutrient impairments (Rebecca, Lost (in Plymouth), Thies, Academy Pond, and Fish Lake (in Woodbury), and 16 others are vulnerable to impairment of aquatic recreation.
- For the 168 lakes with long-term monitoring data, nearly 40% are improving in water clarity suggesting water quality is also improving over time, and another 58% are showing no change.
- Increasing chloride concentrations are potentially threatening aquatic life cycles in 8 newly impaired lakes, a nearly 33% increase in chloride impairments from the previous round of chloride assessments in 2013.
- Stream water clarity is improving in 17 stream segments and declining in 15 stream segments within the watershed.
- Across the watershed, stream IBI scores for fish improved by an average of nearly 8 points while there is no significant change for macroinvertebrate community condition compared to 2010 monitoring results.

Highlights of monitoring

- The commitment local government units have shown toward monitoring water quality is exemplified by dozens of complete 10-year chemistry datasets.
- The watershed at large has one of the highest participation rates of the MPCA's Volunteer Monitoring Program.
- Twenty-four lakes including Tanners, Phalen, Crystal, Wirth, Johanna, McCarrons, Harriet, Bde Maka Ska, and Medicine are monitored every fall as part of a long-term chloride study to track increasing concentrations around the metro area.
- White Bear Lake and Lake Minnetonka have two of the highest fish IBI scores within the Mississippi River – Twin Cities Watershed. This is likely, in part, due to the complexity of habitat for hosting a higher diversity of fish species.
- A total of 50 fish species were collected in 39 lakes during the watershed monitoring period. Of these, one species is considered threatened (Pugnose shiner), and one is a species of concern (Least darter). Both species are State Species of Greatest Conservation Need that rely on high quality vegetated habitat.
- A total of 40 fish species were collected in 30 stream segments during the watershed monitoring period. Of these species, 20% are considered sensitive and 35% are considered tolerant.

Fish species sampled by MNDNR and MPCA biologists as part of lake and stream IBI surveys. From left to right, muskellunge and hybrid sunfish.

Success stories

- Twenty-five lakes have been removed from the impaired waters list since lakes were assessed following the 2010 monitoring. These delistings have been the result of both in lake and on land watershed management practices.
- Sand Creek – This stream flowing into Coon Creek has undergone an intense restoration and re-meandering project led by the Coon Creek Watershed District. Although this stream segment is still considered impaired for both fish and macroinvertebrates, the sampling was conducted shortly after the restoration work was completed and future monitoring will better reflect the work that has been done. Perched culverts continue to limit connectivity and migration on many streams in the watershed including Sand Creek but future work to remove these barriers is currently planned. Additional information can be found here.

An extensive habitat improvement project has been completed on Sand Creek helping to improve the creek's water quality along with fish and bug populations.

Watershed assessment results

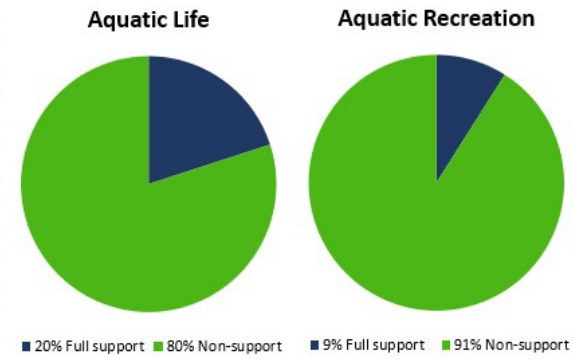
The MPCA and local partners monitored water quality conditions in the Mississippi River – Twin Cities Watershed between 2010 and 2021 for the 2022 surface water assessment process. The data used to assess the condition of Minnesota waterbodies focus on whether or not they are meeting water quality standards for aquatic life, recreation, and consumption. This was accomplished by comparing individual measurements of parameters such as total suspended solids (TSS), dissolved oxygen, and IBI scores to established water quality standards. The primary outcome of these assessments is to ultimately determine which waters are healthy and in need of protection or are polluted and require restoration.

Streams and rivers

Fish and macroinvertebrate communities are a direct measure of aquatic life in rivers and streams. Between the 2010 and 2021 cycles of biological monitoring in the Mississippi River – Twin Cities Watershed, the MPCA adopted new rules to assess aquatic life in channelized streams and ditches. This new framework, Tiered Aquatic Life Use (TALU), allowed channelized streams in the watershed—not assessed in 2010—to be assessed against reasonable aquatic life goals if they were legally altered prior to the advent of the Clean Water Act and currently demonstrate habitat-limiting conditions for fish or macroinvertebrate communities. Streams with these characteristics are classified as modified aquatic life, which have lower biological condition expectations than general aquatic life use streams. This framework also allowed the designation of streams that exhibit exceptional aquatic communities or a much higher quality than would be expected for supporting general aquatic life use goals. None of the stream reaches in the Mississippi River – Twin Cities Watershed meet the standards for exceptional aquatic life use potential.

Biological communities in streams as a whole have either improved or remained similar over the last 10 years while human population and development within the watershed has increased. Overall, about 20% of the stream reaches assessed in the Mississippi River – Twin Cities Watershed support both healthy fish and macroinvertebrate communities (Full Support). The remaining 80% of stream reaches exhibit impairments to either or both communities. Four new stream sections were found to have impaired macroinvertebrate communities in 2020, bringing the total number of macroinvertebrate impairments in the watershed to 26. There was one new stream section that was found to have an impaired fish community in 2021. This brings the total number of stream sections impaired for fish to 19. Aquatic life was determined to be fully supported on two new sections of stream in 2020, increasing the total for the watershed to 11.

Figure 2: Watershed assessment results for aquatic life use and aquatic recreation support in streams.



The most recent assessments also resulted in 22 new stream segments added to the IWL for chemical pollutants. The most common pollutants in the Mississippi River – Twin Cities Watershed are chloride, E. coli bacteria, dissolved oxygen, and total suspended solids (The MPCA's first watershed assessment in 2012 yielded 46 stream segments impaired for the same conventional pollutants). Given the robust monitoring datasets coupled with large amounts of developed land in this predominantly urban landscape, the high percentage of impaired waters is not surprising. Chloride is often high in area streams in the springtime and is difficult to manage, given the balance between public road safety and protecting water quality; the MPCA and many local partners have developed a chloride management plan. Work outlined local watershed restoration and protection plans are actively underway throughout the watershed. A specific example includes improving trends in stream clarity for 17 stream segments within the watershed, including several sites on Rice Creek. This is likely influenced by several water quality improvement projects within the Rice Creek Watershed.

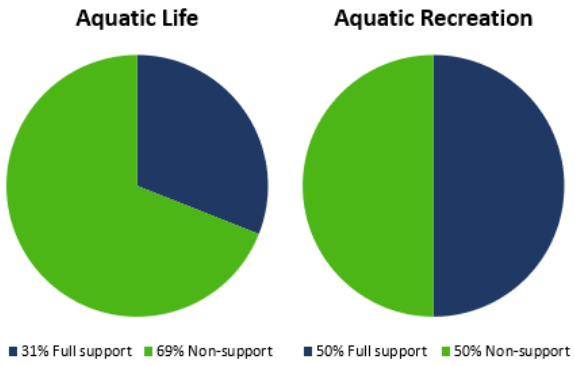
Lakes

More than 200 lakes had assessable datasets collected within the previous 10 years and many of those data covered the entire 10-year assessment window, a feat not often accomplished anywhere in the state. Twenty-five lakes have been delisted since the 2012 assessment cycle with most being part of nutrient reduction TMDLs and work by local partners. Ninety-five lakes are fully supporting recreational uses, whereas 67 are listed as impaired and 16 other lakes are nearly impaired, while two lakes are barely impaired.

High percentages of watershed disturbance and shoreline development are likely culprits of historical stressors to lake water quality, as well as fish communities. In areas where development has reached its maximum potential, water quality trends have mostly stabilized or started to improve following implementation of TMDL management plans.

New to this assessment cycle are aquatic life assessments based on fish communities in lakes. The combination of a biological assemblage plus the same chemical parameters that were analyzed in previous assessments provides a broader basis for examining water quality and its impacts to aquatic life. Several lakes with new aquatic life use impairments due to stressed fish populations also exhibit improved water quality and are approved to have their aquatic recreation impairments for excess nutrients removed. Fish communities may respond slowly to these improvements or may be adversely impacted by other stressors such as habitat loss, aquatic invasive species, and shoreline alterations.

Figure 3: Watershed assessment results for aquatic life use and aquatic recreation support in lakes.



Aquatic life assessments based on fish IBI data were completed for 35 lakes in the Mississippi River-Twin Cities Watershed, while four lakes sampled were not assessable. Approximately 31% of assessed lakes were fully supporting for aquatic life uses, while around half were found to have impaired fish communities. Three lakes were considered vulnerable to future impairment (i.e., Piersons, Weaver, and Phalen). Stressors that are likely influencing these fish communities include excess nutrient inputs from urban land uses, degraded and/or overly developed shorelines, and contamination from chloride and other pollutants.

Trends

A key objective of the 2020 and 2021 monitoring effort was to evaluate whether water quality has changed since 2010 (Figure 9). If water quality has improved, it is important to understand to what extent strategy development, planning, and implementation, based on the initial work and combined with actions that were already underway, may be responsible for those improvements. It is equally important to understand if water quality does not appear to be changing or is declining. Either way, the knowledge will help inform future planning and monitoring activities.

Trends in four different aspects of water quality were analyzed to provide as robust a picture as possible of what is happening in the Mississippi River – Twin Cities Watershed:

1) Streamflow, sediment (total suspended solids), total phosphorus (TP), and nitrogen (nitrate)
2) Biological communities
3) Clarity of lakes
4) Climate

Streamflow and pollutant concentrations

While much of the content in this report focuses on the lakes and streams within the Mississippi River – Twin Cities Watershed, this watershed also has the Mississippi River itself entering on the northwest side and exiting on the southeast side. In the next few years, a "large river" report on the Mississippi River will be published. However, since this watershed contributes to and influences the Mississippi River, a brief discussion of flow and pollutant trends are included here.

Figure 4: Average annual stream flow at the Mississippi River at Prescott, WI (USGS 05344500)

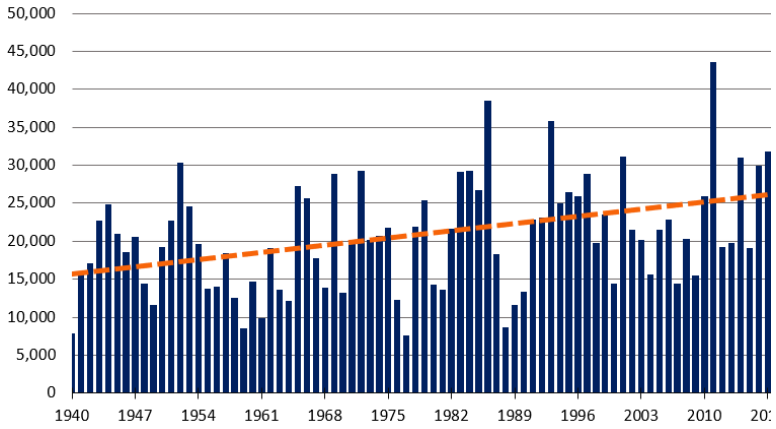


Figure 4 displays the increase of the average annual stream flow over 75 years at the Mississippi River at Prescott, WI (USGS 05344500). This long-term gage is located just outside of the Mississippi River-Twin Cities HUC-8 watershed boundary and after the Minnesota and St. Croix Rivers enter. Stream flow is a measure of the volume of water. As shown, there is great variability between years, but overall, the amount of water has increased over time. This is a result of many factors including increased precipitation and additional drainage from nonpoint sources. The increasing trend is also seen at the long-term USGS gage sites on the northern edge of the Mississippi River-Twin Cities Watershed.

Metropolitan Council's Environmental Services (MCES) has led efforts to understand the water quality dynamics and trends with data originating back to 1976. A recent report (*Regional Assessment of River Water Quality in the Twin Cities Metropolitan Area 1976-2015: Minnesota, Mississippi, St. Croix Rivers*) discusses the status of the river locations in the 7-county metro area by MCES and can be found here: https://metrocouncil.org/river-assessment.

Figure 5 summarizes the trends well. Sediment, phosphorus, and bacteria have all decreased mainly due to efforts of businesses, homeowners, wastewater treatment facilities, farmers, and cities. Unfortunately, nitrogen and chloride are both on the rise. Nitrogen increases are related to fertilizer application (urban and rural), livestock, and wastewater discharges. Chloride is primarily used as a deicer, synthetic fertilizer, and in water softeners. More recent data and analysis indicate nitrogen trends continue to increase at most sites. The Minnesota River at Fort Snelling is the exception for nitrogen which has shown a decreasing trend. This may be related to lag time as the Minnesota River near Jordan has an increasing trend. Newer data for phosphorus continues to show declining trends at most sites with the Rum River at Anoka showing no statistical trend for phosphorus (MPCA, 2020).

From a statewide perspective, nitrate, phosphorus, and suspended sediment flow weighted mean concentrations (FWMC) for stations monitoring by the Watershed Pollutant Loading Monitoring Network (WPLMN) show moderate values for all three parameters in the Mississippi River-Twin Cities Watershed. Figure 6 displays total phosphorus (TP) and highlights the transition zone between the higher water quality in northern Minnesota with the degraded quality in southern Minnesota which is also seen in the other parameters. More information can be found at: https://www.pca.state.mn.us/air-water-land-climate/watershed-pollutant-load-monitoring

Figure 5: Pollutant trends, METC, 2018.

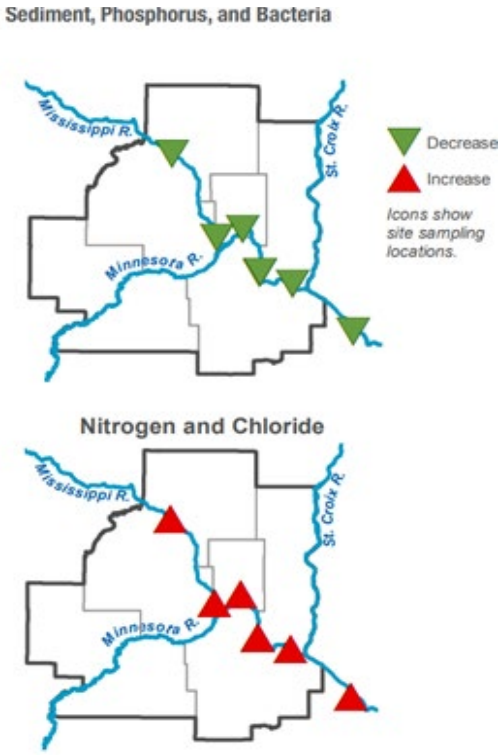
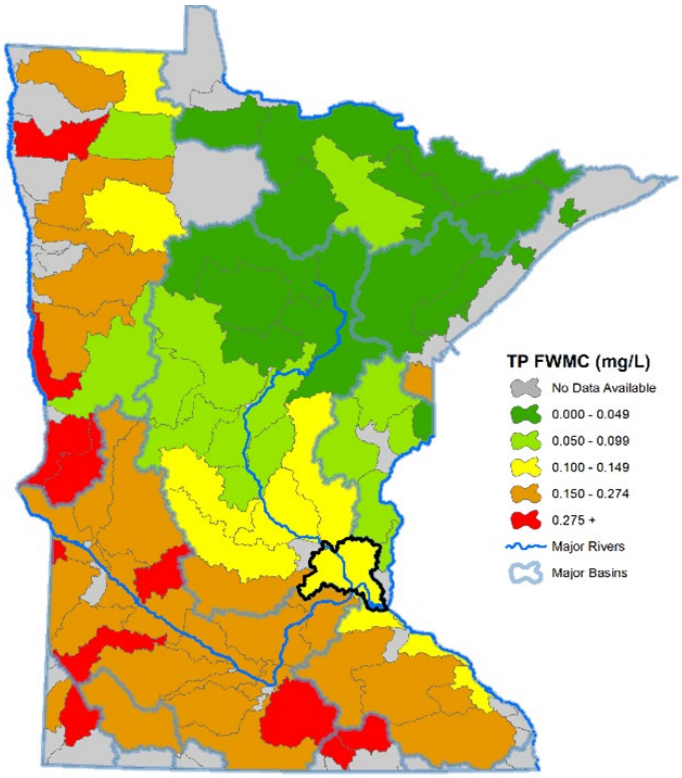


Figure 6: Phosphorus FWMC, 2007-2019



Biological communities

Fish and macroinvertebrate IBI scores were used to evaluate if biological condition of the watershed's rivers and streams has changed between time periods. Independent statistical tests, comparing data collected between 2010 and 2020/2021 were conducted on each community with 22 sites included in the macroinvertebrate analysis and 20 sites in the fish analysis. The average macroinvertebrate IBI score for the Mississippi River – Twin Cities Watershed increased by 2.4 points between 2010 and 2020, which does not represent a statistically significant change in biological condition. Fish IBI scores across the watershed increased by 7.6 points which represents a statistically significant increase in biological condition for the watershed. A similar change analysis was not completed for lakes because comparable fish community data had not been collected during the first time period. However, several sensitive fish species with historical records in certain lakes have not been found in the most recent sampling events. Some of these fish species include least darters and rock bass.

Context for the change analysis results is provided by a characterization of the conditions under which biological monitoring occurred in 2010 and 2020/2021. In 2010, the Mississippi River – Twin Cities Watershed experienced normal to high water levels during the May through September time period. In 2021, the watershed experienced low water levels and drought conditions during a large portion of the same sampling period (Figure 8). Low water levels during the 2021 sampling season could have worked to concentrate fish populations in the reaches that were sampled. Drought conditions in 2021 effectively ended fish monitoring at the end of July compared to a full sampling period which usually ends in September.

Clarity of lakes

Water transparency is typically a good indicator of overall lake water quality. As water clarity increases, there is a greater likelihood that water quality standards are being met. There are 168 lakes with some level of transparency data in this watershed, thanks in large part to volunteer monitoring programs at work. Of those lakes, 70 have enough data to estimate a long-term change in clarity. An improving trend was noted in 60 lakes, while only 10 show a decline (only 1 of those 10 currently has a nutrient impairment listing). Many of the high-use recreational lakes had improving water clarity trends (Bde Maka Ska, Wirth, Minnetonka, Phalen, White Bear). Watershed management or lake restoration projects, such as in lake alum treatments, or in some cases zebra mussel infestations all affect water clarity.

Climate

The Mississippi River – Twin Cities Watershed now receives on average 2.4 additional inches of rain above the historical annual average (1895-2018). Furthermore, climate scientists suggest that precipitation events are becoming more intense. In addition, the average annual temperature in the watershed has increased by about 1.3 degrees with winter temperatures increasing by 2.7 degrees over the same time period. Increased rainfall and temperature can worsen existing water quality problems. More precipitation and reduced snow cover can increase soil erosion, pollutant runoff, and streamflow. Increased streamflow in turn can lead to stream channel erosion and degraded habitat for fish and other aquatic life. Longer growing seasons with higher temperatures can lead to more algal blooms. These changes will complicate efforts to protect and restore the watershed. DNR climate summary for the Mississippi River – Twin Cities Watershed.

In 2010, the Mississippi River – Twin Cities Watershed experienced above normal rainfall (+4.4 in) and was abnormally hot (+1.1 oF) during the May to September time period. The watershed had near normal precipitation (-1.5 in) and temperature (+0.8 oF) in 2020 over the May to September time period. Additionally, in 2021 when fish were monitored in rivers and streams, the watershed experienced a severe rainfall deficit (-5.1 in) with extremely warm temperatures (+3.9 oF) during the summer months. Overall, comparing the relatively higher water levels present in 2010 to the near normal conditions in 2020 means there is a moderate likelihood that any observed changes in stream macroinvertebrate condition at either the watershed or individual site scale are partially due to differences in climatic conditions between the two periods. In contrast, there is a high likelihood, given the drastically different precipitation amounts and temperatures between 2010 and 2021 (Figure 8), that any observed changes in stream fish community condition are partially due to these observed climatic differences.

Figure 7: Average annual precipitation for the Mississippi River – Twin Cities Watershed (1895-2018).

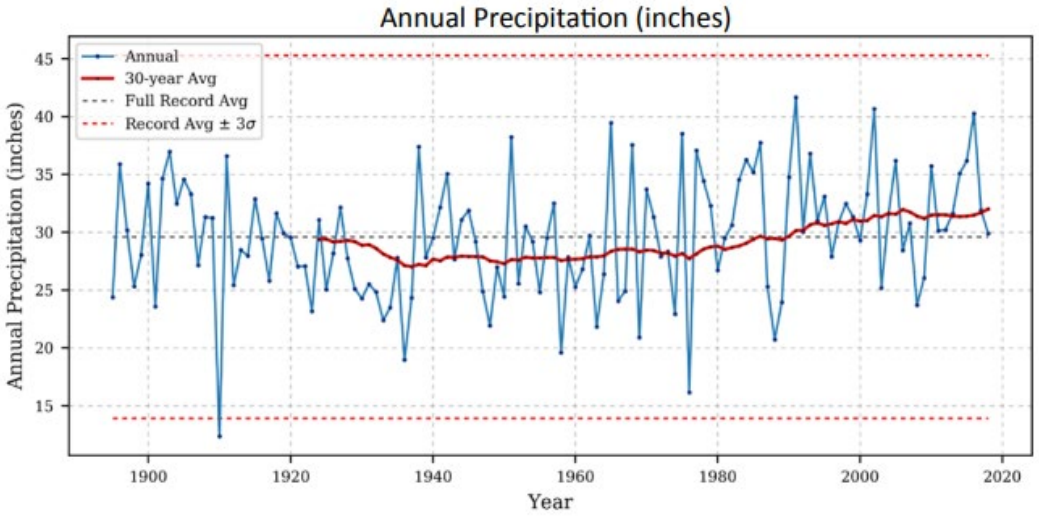


Figure 8: Characterization of air temperature and rainfall conditions for May-September period across the historical record (1938 – 2021) of climate data for the Mississippi River – Twin Cities Watershed. IWM years highlighted in red.

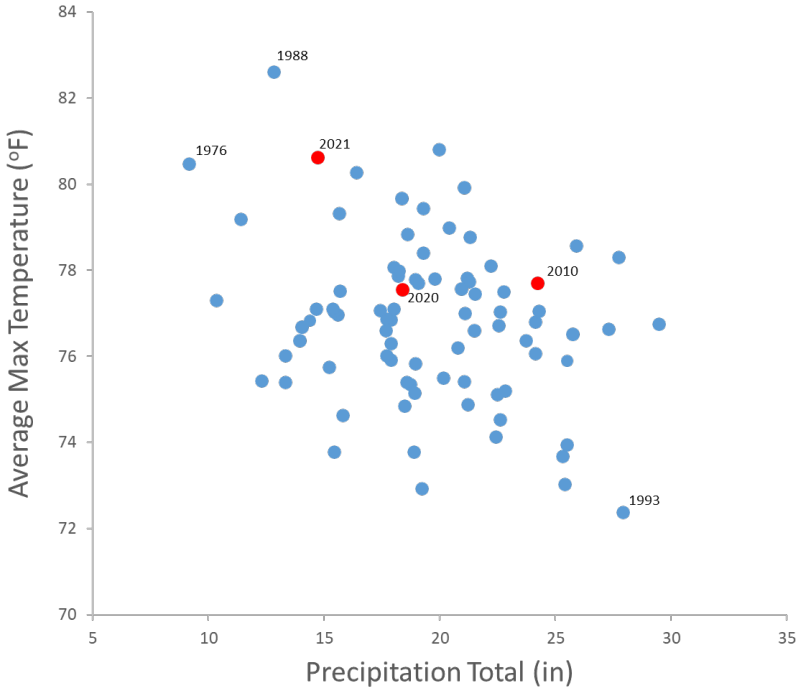


Figure 9: Changes in water quality in the Mississippi River – Twin Cities Watershed.

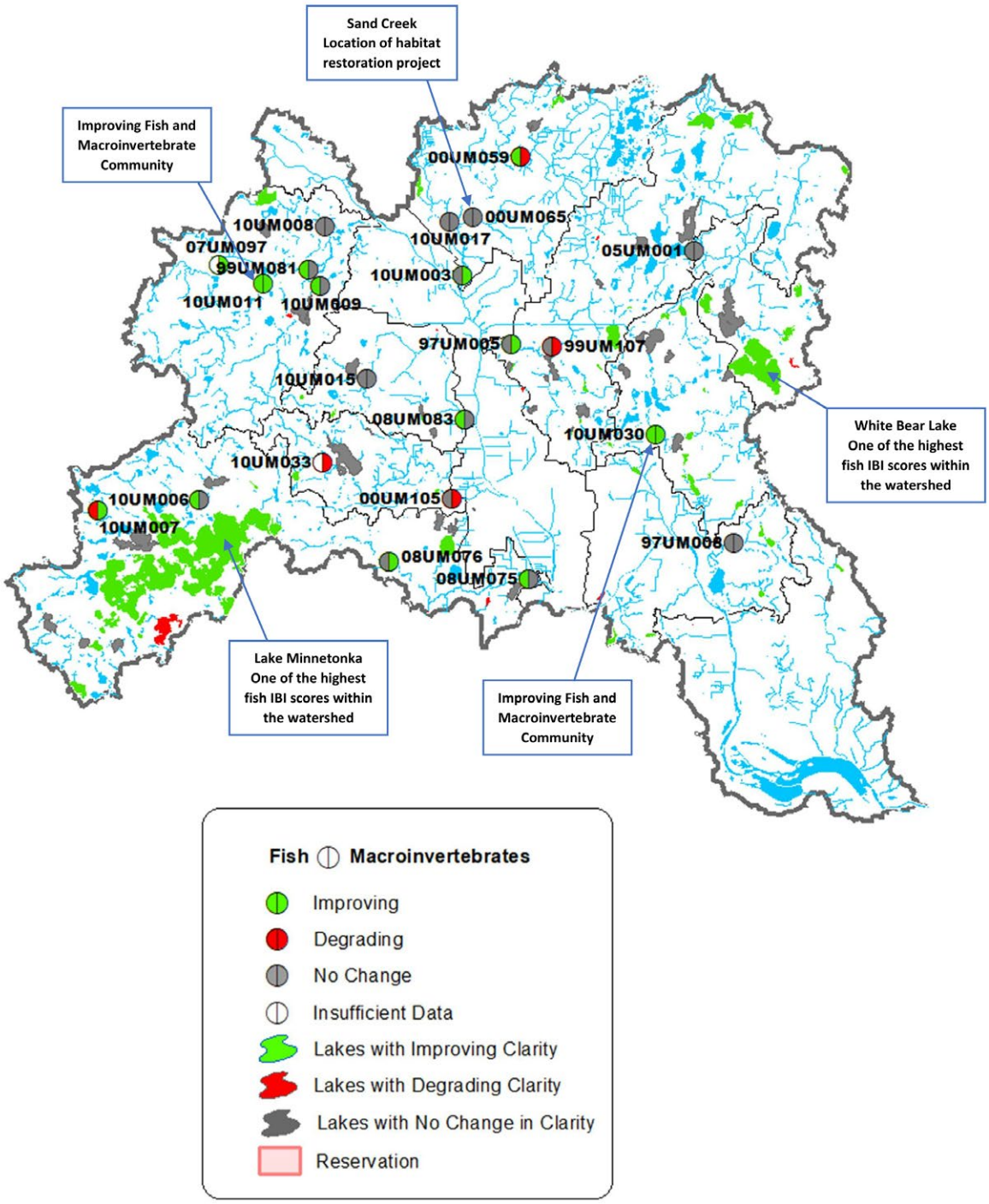
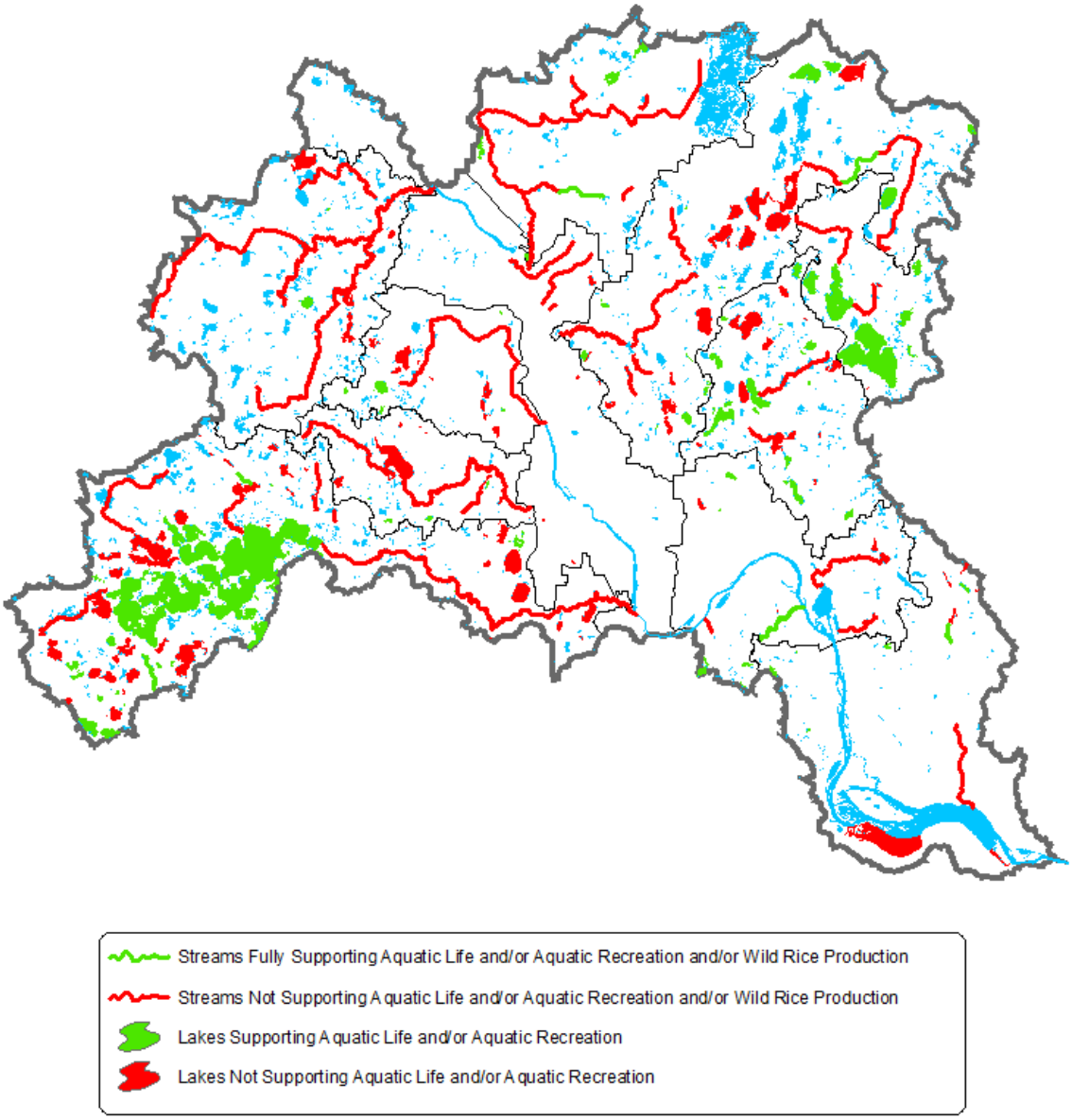


Figure 10: Aquatic life use and recreational use support/non-support in streams and lakes in the Mississippi River – Twin Cities Watershed.



For more information

This study of the Mississippi River – Twin Cities Watershed was conducted as part of Minnesota's Watershed Approach to restoring and protecting water quality. Efforts to monitor, assess, study, and restore impaired waters, and to protect healthy waters are funded by Minnesota's Clean Water, Land, and Legacy Amendment. Stressor identification for new impairments and updates to the Watershed Restoration and Protection Strategy follow the completion of monitoring and assessment. This approach allows for efficient and effective use of public resources in addressing water quality challenges across the state. The data and assessments produced by this study can inform local efforts to restore and protect waters in the Mississippi River – Twin Cities Watershed. For more information, go to the MPCA Mississippi River – Twin Cities webpage, or search for "Mississippi River – Twin Cities" on the MPCA website. For more specific assessment data, go to the Tableau workbook: https://public.tableau.com/app/profile/mpca.data.services/viz/WaterQualityAssessmentResultsDataViewer/HomePage.

Contact

Andrew Ching
Minnesota Pollution Control Agency
andrew.ching@state.mn.us
651-757-2750