Watershed assessment and trends update

Minnesota River – Yellow Medicine River

Minnesota River Basin

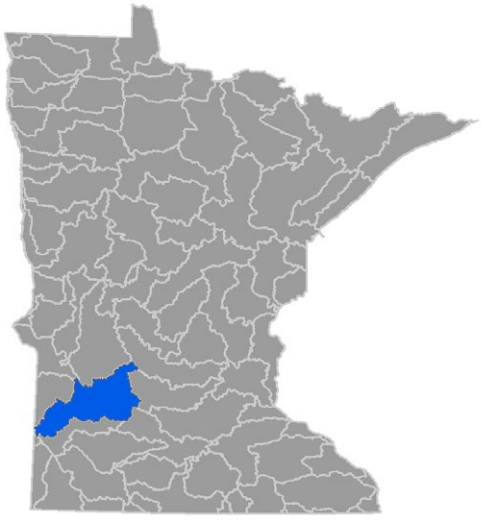
Summary

The Minnesota Pollution Control Agency (MPCA), Minnesota Department of Natural Resources (MNDNR), and partners have completed a study of the Minnesota River – Yellow Medicine Watershed in west central Minnesota (Figure 1). The Minnesota River – Yellow Medicine River Watershed (1,306,502 acres) is managed as one watershed, the Hawk Creek Watershed to the north of the Minnesota River and the Yellow Medicine River Watershed to the south. This watershed doesn't include the mainstem Minnesota River. Both waterways enter the Minnesota River downstream of Granite Falls. This includes not only the Yellow Medicine River and Hawk Creek but also many direct tributaries to the Minnesota River. In the heart of intensive agricultural land use, this watershed is at high risk to disturbance caused by human activity, however the study found several encouraging trends since the last assessment ten years ago.

Watershed study

Water monitoring is essential to determine if 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 a collaboration between state agencies, watershed districts, and watershed management organizations. The first cycle of this 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 Minnesota River - Yellow Medicine River Watershed provided a baseline for comparison with extensive chemical and biological sampling conducted in 2021 and 2022. 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. Comparing 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 used 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.

Figure 1: Minnesota's 80 major river drainages. Minnesota River – Yellow Medicine River Watershed is highlighted in blue.



Changes in water quality

To detect changes in water quality, this recurring exam looks at fish and macroinvertebrate communities as well as water chemistry. Scientists use the data to see which waters are healthy and need protection, and which are polluted and need restoration. To do this, they use a tool called the Index of Biological Integrity (IBI) to assess the health of biological communities in lakes, rivers, and streams. Wetlands are also assessed using a similar tool called Floristic Quality Assessment Index. 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.

MPCA scientists monitored the fish and bugs, along with several water quality parameters, in the Minnesota River – Yellow Medicine River Watershed as part of the statewide effort to gauge the health of major lakes and

Over the past decade, scientists observed little change in water quality in the Minnesota River – Yellow Medicine River Watershed. While the biological condition in individual streams may have improved or declined between 2010 and 2022, the overall health of biological communities increased over this period. Continued problems include elevated bacteria, excess sediment (turbidity) and low dissolved oxygen levels. Water monitoring is essential to determining whether lakes and streams meet water quality standards designed to ensure that waters are fishable and swimmable.

While local partners and state agencies monitor water quality on an ongoing basis, the Minnesota Pollution Control Agency (MPCA) and local partners conduct an intensive exam of major lakes and streams in each of the state's 80 watersheds every 10 years.

To detect any changes in water quality, this intensive exam looks at fish and macroinvertebrate communities as well as water chemistry. They use the data to see which waters are healthy and need protection, and which are polluted and need restoration.

- The Minnesota River -– Yellow Medicine River Watershed continues to support high-quality fish and bug communities. Some of these high-quality fish species include rainbow darters, smallmouth bass, and hornyhead chub. Intolerant invertebrate taxa found in the watershed, include winter stoneflies (Taeniopteryx), golden stoneflies (Acroneuria), blue-winged olive mayflies (Acerpenna), Hydatophylax caddisflies, and Helicopsyche caddisflies.
- Historic low flows hampered biological sampling efforts in 2021. No stations in the Yellow Medicine River section of the watershed (south of the Minnesota River) were sampled for fish and macroinvertebrates. Sampling at these locations was postponed until 2022 due to persistent low flow conditions.
- Macroinvertebrate and fish communities are generally improving in the upstream half of the Yellow Medicine River Watershed.
- Across the watershed, there is an increase in stream biological condition over the last 10 years for both fish and macroinvertebrates.

Landowners and local partners have installed hundreds of best management practices to improve water quality, but many more are needed. It takes time for these practices to show results.

Highlights of monitoring

- For lakes with long-term trends, 10% are seeing improvements in water quality, 20% are showing decreasing water quality, and 70% are seeing no change.
- Numerous lakes in the Hawk Creek – Yellow Medicine River Watershed have previously been assessed for aquatic consumption and aquatic recreation; however, IBIs had not been developed to assess aquatic life until after initial assessments had been made.
- Flows in the Yellow Medicine River and its tributaries are increasing as a result of both artificial drainage and increased precipitation. Increasing streamflow has negative implications for stream channel conditions and pollutant loading. This leads to more channel erosion and possibly more pollutant loading, even if pollutant concentrations are stable.
- Phosphorous concentrations showed a statistically significant change, decreasing on Hawk Creek.
- A total of 28 fish species were collected in lakes during fish IBI sampling. Of these, banded killifish, blacknose shiner, Iowa darter, and smallmouth bass are considered intolerant species—susceptible to pollution and watershed disturbance. Banded killifish, blacknose shiner, and smallmouth bass were only sampled from Eagle Lake. There are six lake fish species which are considered tolerant to shoreline and watershed stressors and the lakes contained between three and six of them.
- A total of 66 fish taxa were collected in streams during fish IBI sampling. Of these, 11 are considered sensitive species—susceptible to watershed disturbance. A total of 268 invertebrate taxa were collected in streams during invertebrate IBI sampling. Of these, 23 are considered intolerant of watershed disturbances.

Success story

Lake Shaokatan is a large shallow lake in Lincoln County, typical of the prairie-pothole region in southwest Minnesota. The lake's watershed forms the headwaters of the Yellow Medicine River. Lake Shaokatan has a long history of study and water quality concerns; however, it is one of the few lake water quality success stories in Minnesota's agricultural region. The lake was removed from the MPCA's Impaired Waters List in 2016, following significant water quality improvements through a Clean Water Partnership project sponsored by the Yellow Medicine Watershed District. The project included rehabilitation of feedlots that were draining to the lake, wetland restorations, and improvements in shoreline septic systems. This successful project included many partners including local citizens, farmers, and water quality authorities. Through the Sentinel Lakes program long-term lake sampling project, and the Clean Water Partnership, data has shown that Shaokatan has shifted from the undesirable turbid and algal dominated state in the 1990's, to a clearer water state dominated by aquatic macrophytes in recent years. The lake's decline in phosphorus and chlorophyll-a parallel the increasing aquatic macrophyte coverage.

Watershed assessment results

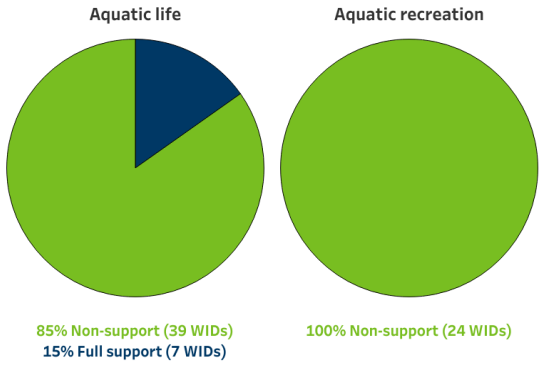
The MPCA and local partners monitored water quality conditions in the Minnesota River- – Yellow Medicine River Watershed between 2010 and 2022 for the 2023 surface water assessment process. The data used to assess the condition of Minnesota waterbodies focuses on whether they are meeting water quality 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 2022 cycles of biological monitoring in the Minnesota River- Yellow Medicine River 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 use, 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 of a much higher quality than would be expected for supporting general aquatic life use goals. None of the stream reaches in the Minnesota River – Yellow Medicine River Watershed meet the standards for exceptional aquatic life use potential.

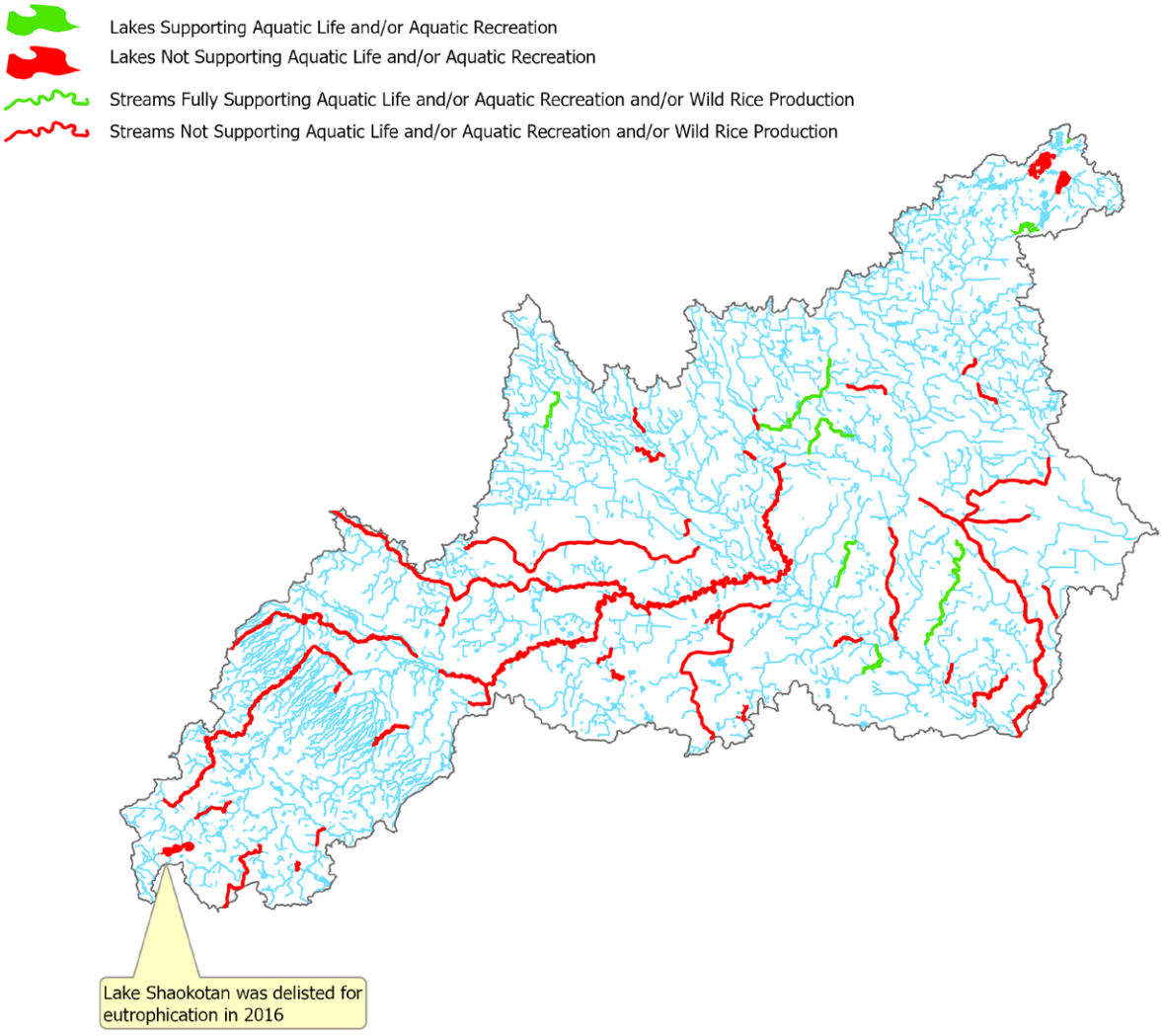
Biological IBI scores have improved over the last 12 years. Overall, about 25% of the stream reaches assessed in the Minnesota River – Yellow Medicine River Watershed support both healthy fish and macroinvertebrate communities (Full Support). After adding in water chemistry elements, such as dissolved oxygen, 15% of streams are supporting for aquatic life (figure 2). The remaining 85% of stream reaches exhibit impairments to either or both communities. Nine new stream sections were found to have impaired macroinvertebrate communities in 2023, bringing the total number of macroinvertebrate impairments in the watershed to 30. There are six new stream sections that were found to have an impaired fish community in 2023. This brings the total number of stream sections impaired for fish to 22. Aquatic life for fish and macroinvertebrates was determined to be fully supported on 12 sections of stream in 2023.

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



The most recent assessments also resulted in eight new stream segments added to the Impaired Waters List for conventional pollutants. The most common pollutants in the Minnesota River – Yellow Medicine River Watershed are E. coli bacteria, dissolved oxygen, and total suspended solids. The MPCA's previous assessments yielded 46 stream segments impaired for the same conventional pollutants. Given the robust monitoring datasets coupled with predominantly intensive agricultural land in this watershed, the high percentage of impaired waters are not surprising.

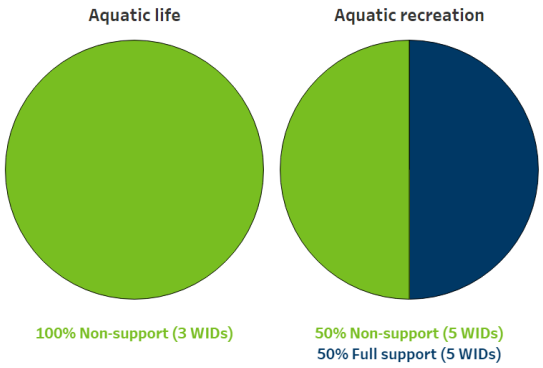
Figure 3: Change in water quality in the Minnesota River – Yellow Medicine River Watershed.



Lakes

More than 10 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. Five lakes are fully supporting recreational uses, whereas five are listed as impaired. Lake Shaokatan was delisted for lake eutrophication in 2016 between the sampling cycles.

Figure 4: Watershed assessment results for aquatic life use and aquatic recreation support in lakes.



Four lakes within this watershed were assessed for aquatic life for the first time using a fish-based IBI developed for Minnesota lakes. Three of lakes (Eagle, Long, and Shaokatan) were found to be not supporting the expected fish community and Perch was found to be inconclusive due to scores too close to the threshold to make a confident assessment. Overall, efforts to reduce the impacts of agriculture and urbanization in the lake catchments should be continued to improve the water quality and habitat to support a more balanced and diverse fish community. Although huge strides have been made to improve the water quality in some of these lakes, it may take several years for the fish community to respond to the improved water conditions.

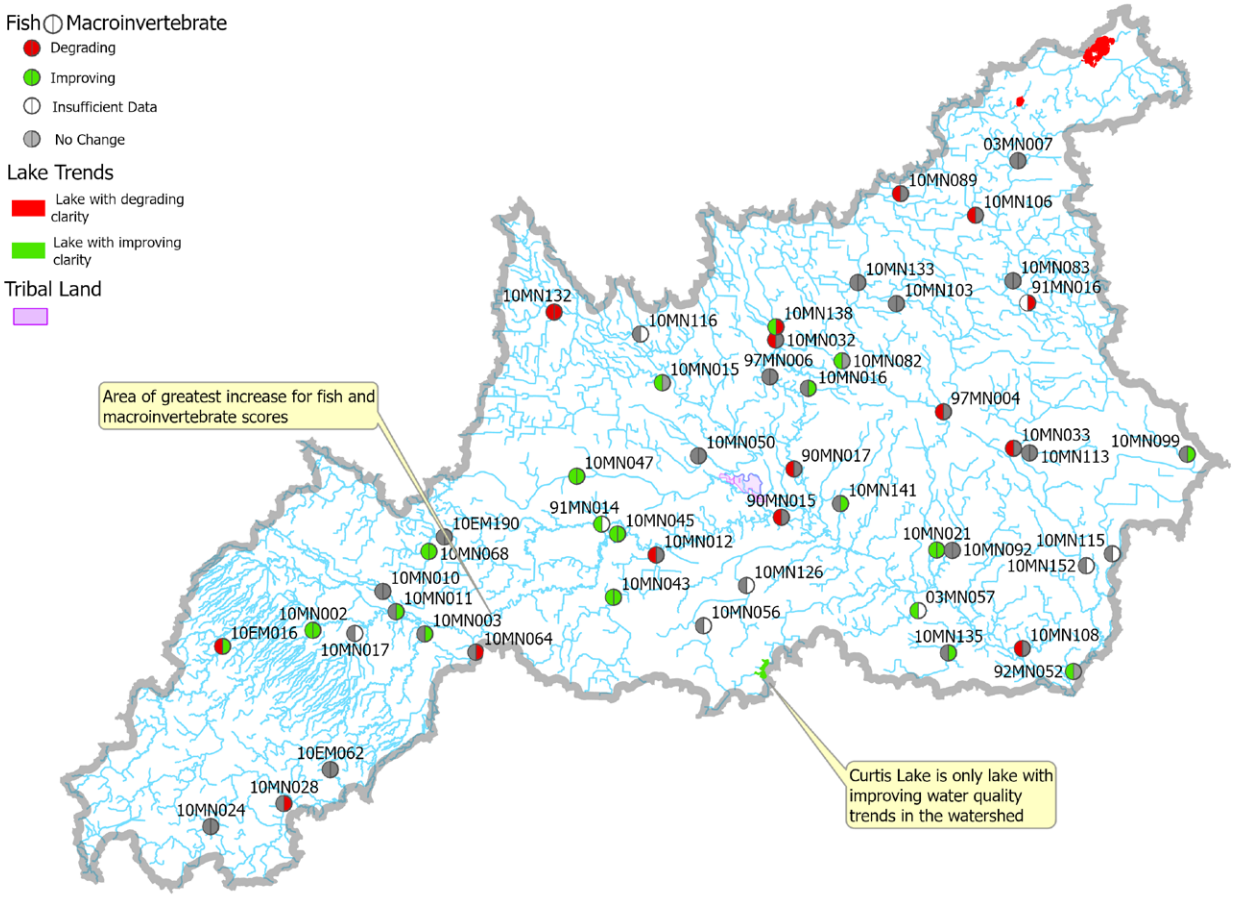
Perch Lake was assessed as vulnerable to impairment based on the fish community and fish IBI scores and efforts could be focused on protecting and improving the habitat and water quality in the surrounding watershed. Excess nutrients are a likely stressor resulting in the impaired and vulnerable fish communities in Lakes in the Minnesota River - Yellow Medicine River Watershed.

Trends

A key objective of the 2021 and 2022 monitoring effort was to evaluate if and how water quality has changed since 2010 (Figure 8). If water quality has improved, it is important to understand what may be responsible for those improvements, including strategy development, planning, and implementation, as well as initial work and work that was already underway prior to 2010. 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 Minnesota River – Yellow Medicine River Watershed:

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

Figure 5: Change in water quality in the Minnesota River – Yellow Medicine River Watershed.



Streamflow and pollutant concentrations

In a statewide comparison of pollutants (suspended solids, phosphorus, and nitrate nitrogen), the Minnesota River-Yellow Medicine River Watershed has high values compared to other parts of Minnesota, Figure 6. Within the watershed, there are six long-term monitoring stations; three on the north side of the Minnesota River (two on Hawk Creek, one on Beaver Creek) and three on the south side of the Minnesota River (two on the Yellow Medicine River and one on Spring Creek). Concentrations in the Hawk Creek and Beaver Creek Watersheds are similar to each other for most pollutants. The story is much the same within the Yellow Medicine River Watershed. However, when you compare Hawk Creek to the Yellow Medicine River you will see a stark difference. Figure 7 highlights the Total Suspended Solids (TSS) flow weighted mean concentrations (FWMC) calculated for each outlet station. In most years, the TSS FWMC is quite a bit higher in Hawk Creek than in the Yellow Medicine River. This pattern is similar for phosphorus and nitrate nitrogen, but not as drastic.

Winter water sampling on the Yellow Medicine River near Granite Falls.

Annual stream flow (discharge) data is available from USGS since 1936 for one stream in the Minnesota River- Granite Falls Watershed. Figure C shows an increasing trend in flow on the Yellow Medicine River near Granite Falls, MN (USGS station 07020004). Increasing streamflow has implications for stream channel conditions and pollutant loading. This could mean more channel erosion and possibly more pollutant loading, even if pollutant concentrations are stable. Because loads represent the total amount of pollutant moving through a system, this way of measuring water quality is important for downstream resources such as the lower Minnesota River, where these pollutants may accumulate.

Seasonal Kendall trend for 2008-2020 tests on suspended sediment, phosphorus, and nitrate-nitrogen concentrations at the Hawk Creek long-term monitoring station were used to determine if changes over time were statistically significant. Only phosphorus showed a statistically significant change, with the biggest decrease happening from 2008-2012. Suspended solids and nitrate (NO2+ NO3) concentrations are neither increasing nor decreasing according to the test.

Figure 6: Average TSS FWMC by major watershed.

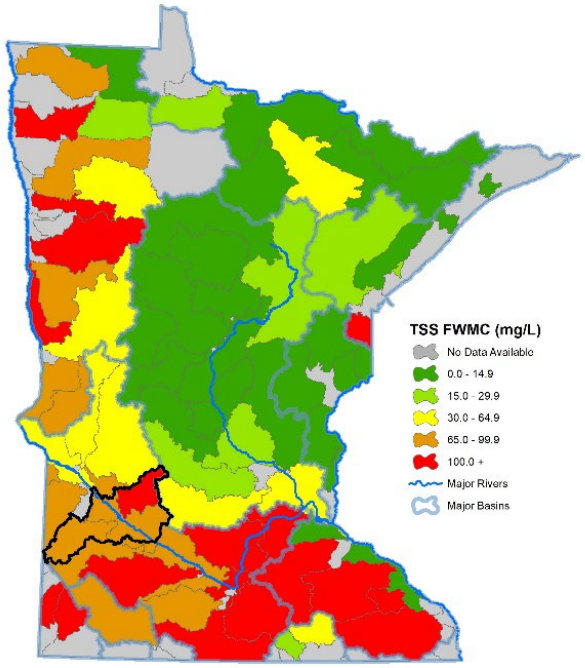


Figure 7: TSS FWMC (mg/L)

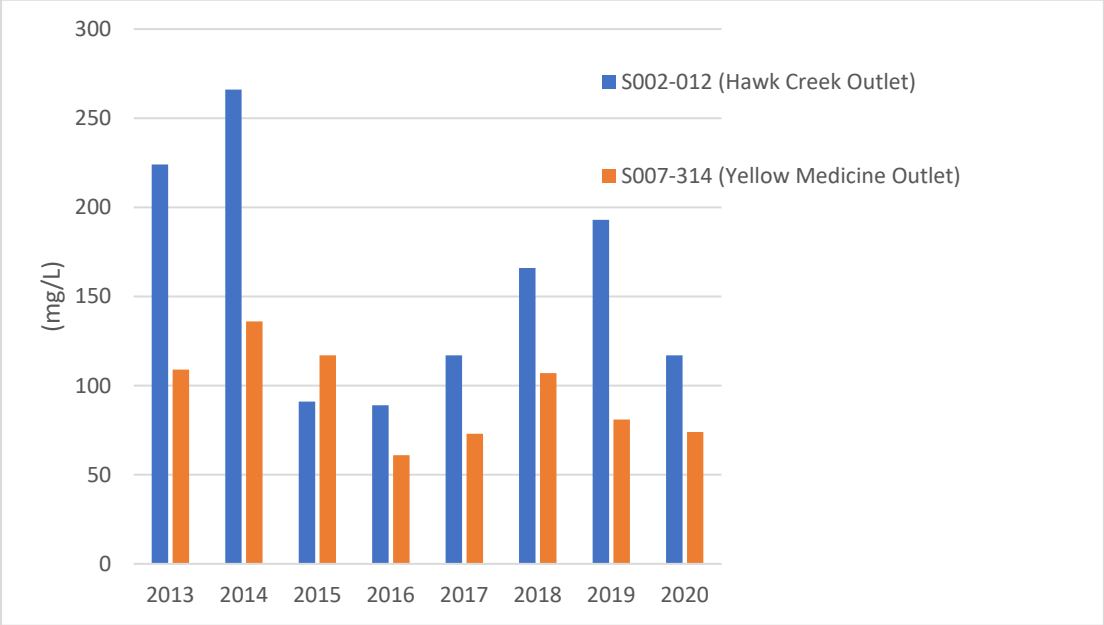
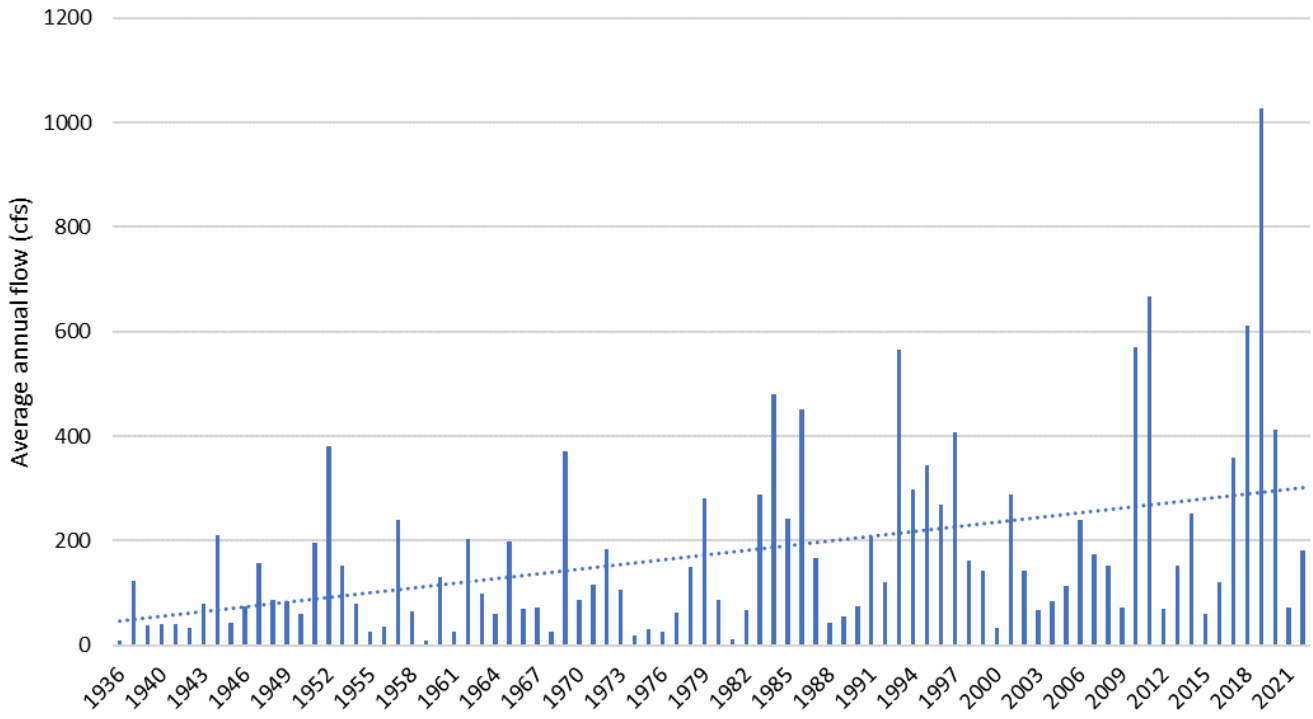


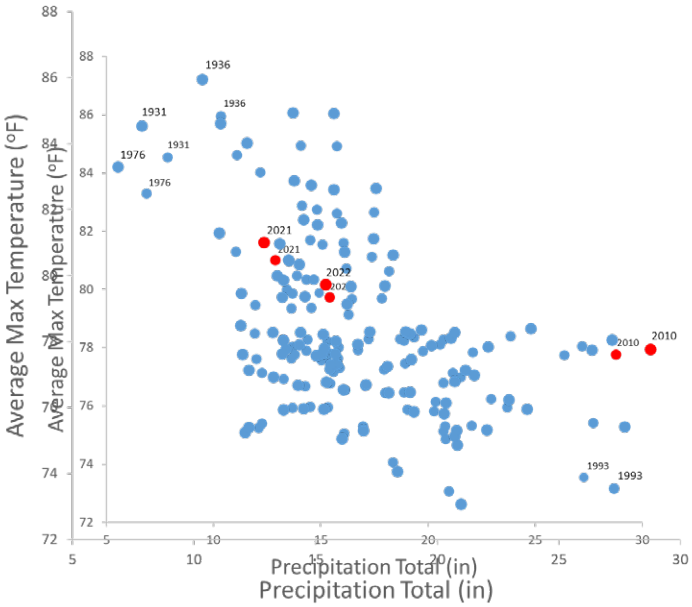
Figure 8: Yellow Medicine River near Granite Falls 07020004 average annual flow (1936-2022)



Biological communities

Paired t-tests of 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 tests were performed on each community with 42 sites evaluated for macroinvertebrates and 49 sites evaluated for fish (i.e., sites that were sampled in both time periods). The average macroinvertebrate IBI score for the watershed increased by 4.4 points between 2010 and 2022, this represents a statistically significant change. Fish IBI scores across the Minnesota River- Yellow Medicine River Watershed increased by 0.4 points, which is not statistically significant.

Figure 9: Characterization of air temperature and rainfall conditions for May-September period across the historical record of climate data for the Minnesota River – Yellow Medicine River Watershed (1926 – 2021).



Additional context for the change analysis results is provided by a characterization of the conditions under which biological monitoring occurred in 2010 and 2021/2022 In 2010, the Minnesota River - Yellow Medicine River Watershed experienced an extreme amount of precipitation (+11.5 inches above normal) and had near normal temps (+0.1 °F) during the May to September time period (Figure 1). However, it should be pointed out that a large contribution to the 2010 precipitation total occurred after biological monitoring had finished for the season, resulting in extreme flood events that impacted the watershed in early and late September. These events pushed an already above normal precipitation total for the summer of 2010 into the extreme category but did not impact the biological monitoring results obtained that year. In comparison, this watershed was in a severe drought (-4.4 in) with extreme heat (+3.4 °F) in 2021 over the May to September time period. In fact, drought conditions in 2021 led to a suspension of biological monitoring that summer, requiring roughly half of the stations to be monitored in the summer of 2022. The summer of 2022 was characterized by near normal rainfall (-1.8 in) and above normal temperatures (+2.1 °F). Overall, given the wetter than normal conditions affecting the watershed in 2010, the severe drought conditions of 2021, and the relatively normal conditions of 2022, there is a high likelihood that any observed changes in biological condition at either the watershed or individual site scale are at least partially due to differences in climatic conditions between the two years.

Clarity of lakes

The Minnesota River – Yellow Medicine River Watershed has 36 lakes with some level of transparency data. Trend analysis was conducted on 12 lakes that met data requirements (50 Secchi measurements, eight years of data). Similar to statewide results, most lakes do not exhibit a significant trend. One lake has increasing clarity (Curtis). Two lakes had declining clarity, Saint Johns and Long.

Climate

In an evaluation of whether conditions in the watershed are improving or degrading between intensive watershed monitoring cycles, climatic conditions and/or extreme weather events occurring before or during each cycle can dramatically obscure changes in condition that result from watershed scale factors such as restoration/protection efforts, changes in land use, and hydrologic alteration (i.e., changes relevant to policies, regulations, and management activities

within the state of Minnesota). Specifically, climatic conditions can affect stream aquatic life in a variety of ways such as altered flow, increased water temperatures, decreased dissolved oxygen, habitat degradation, and decreased connectivity. However, it is difficult to make predictions of the impact of climatic conditions/weather events on stream aquatic life due to the specificity of possible responses that are dependent on the timing, magnitude, frequency and duration of events, as well as the type of stream or biological community. For instance, a severe drought may negatively affect fish communities in headwater streams due to stressful conditions created by lack of flowing water (i.e., ↑temperature, ↓dissolved oxygen). Larger streams that retain flow during a drought, biological condition may be unaffected or possibly somewhat inflated during such conditions due to a "concentrating" effect of the fish community to this limited habitat in the watershed. Nonetheless, it is important to attempt to characterize the climatic conditions during each IWM cycle and compare these two periods to better interpret the causation of any observed changes (or lack thereof) in biological condition.

Across the historical record, watershed-wide rainfall totals were estimated for May-September based on the gridded precipitation data set (State Climatology Office). Temperature was summarized for the May-September period by calculating the average maximum temperature at a monitoring station centrally located in the watershed that had a period of record sufficient to determine a normal value (*source:* Western Regional Climate Center, https://wrcc.dri.edu/summary/mnF.html). Rainfall and temperature normal values were determined by averaging each statistic over a 30-year period (1981-2010). Departure from normal values were calculated and used to characterize climatic conditions for each IWM year using a matrix using departure of average maximum temperature and departure of normal precipitation. This information is used to estimate the likelihood (high, medium, or low) that climate/weather influenced biological condition in either IWM cycle. For instance, if both time periods fall within the bounds of near normal conditions then there would be a low likelihood that results in either time period are affected by climate/weather and thus any observed changes in condition are presumably driven by watershed scale factors.

For more information

This study of the Minnesota River – Yellow Medicine River 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 Minnesota River – Yellow Medicine River Watershed, such as the One Watershed One Plan document, a comprehensive watershed management plan that targets projects to protect and restore the watershed's most valuable resources. For more information, go to the MPCA Minnesota River – Yellow Medicine River Watershed webpage, or search for "Minnesota River – Yellow Medicine River" on the MPCA website.

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