Watershed assessment and trends update

Red Lake River and Grand Marais Creek

Summary

The Minnesota Pollution Control Agency (MPCA) and numerous partners have recently completed a follow-up water quality assessment and trends study of the Red Lake River and Grand Marais Creek watersheds. These watersheds are located adjacent to one another in northwestern Minnesota, and both regions are predominantly agricultural land use. Due to low sampling needs within the Grand Marais Creek Watershed, the proximity, and overlap with local partner activities, the MPCA decided to merge these reports into one for efficiency and clarity.

Instead of relying on chemical testing of the water alone, scientists reached their conclusions through studying the variety of fish and bugs living in the waters. Doing so offers a more comprehensive understanding of the watershed's health over time and has broadened the scope of this assessment beyond a simple snapshot. Assessing the important relationships and interplay between water chemistry and fish and bug species living in these watersheds allows for a better understanding of the water resource conditions and challenges the region faces. Numerous volunteers and local partners have contributed to this assessment, which is funded by Minnesota's Clean Water, Land, and Legacy Amendment. Data and outcomes from this assessment and report will help shape decision-making for watershed management strategies and pollution reduction methods for years to come.

Watershed study

Water monitoring is essential to determine 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 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 monitoring looks at fish and macroinvertebrate (bug) communities as well as water chemistry to gauge water quality. The partners use the data to see which waters are healthy and need protection and which are impaired and need restoration. Waterbodies are considered impaired if they fail to meet water quality standards. No lakes were sampled within the Red Lake River or Grand Marais Creek watersheds due to the unique regional hydrology in these areas. Very few natural lakes are present in the region.

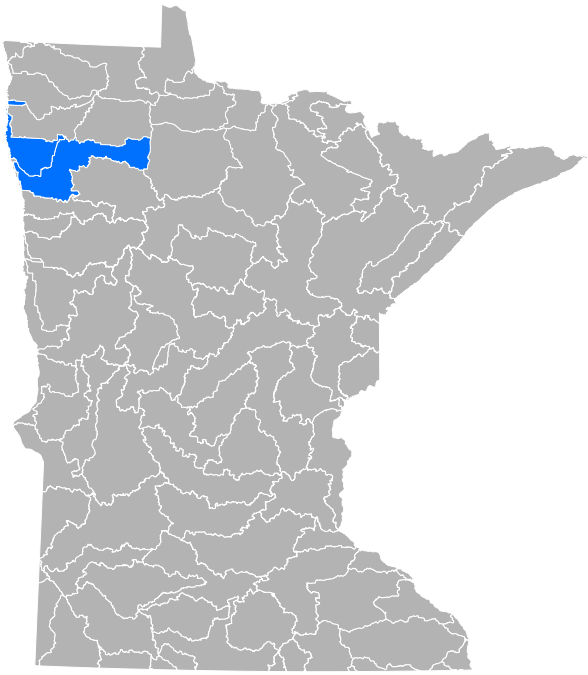
The MPCA and partners monitored water quality conditions in 2012-2013 and again in 2023-2024. Chemistry data collected by local partners between 2015 and 2024 were used for assessment. The data used to assess the condition of Minnesota waterbodies focus on whether or not they are meeting water quality standards for aquatic life, recreation, and consumption.

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 best be attained when water quality, habitat, and hydrology are minimally disturbed by human activities.

Over the past decade, scientists observed little change in water quality in the Red Lake River and Grand Marais Creek watersheds. While the biological condition in individual streams may have improved or declined between sampling cycles, the overall health of fish and macroinvertebrate communities did not change over this 10-year period. Continued problems within the watersheds include declining stream base flow, residence time, and increased flashiness (extreme highs and lows) in hydrological patterns following precipitation events. Many of these occurrences are plausibly correlated to increased drainage practices such as ditching and tiling. Other stressors within the watersheds include elevated bacteria and excess total suspended solids (TSS) concentrations.

Figure 1. Red Lake River and Grand Marais Creek watersheds in northwestern Minnesota



- The first years of both sampling periods (2012 and 2023) were within extreme drought conditions for both of the watersheds, requiring additional, more in-depth review of samples and assessment results.
- Across the watersheds, no significant changes in stream biological condition over the last 10 years for both fish and macroinvertebrates were observed, despite some significant positive or negative changes observed on individual reaches.

Highlights of monitoring

- In the Red Lake River Watershed, although some biological communities and tributary systems show declining water quality trends, the main stem of the Red Lake River is currently assessed as fully supporting both fish and macroinvertebrate biological communities.
- The main stem of the Red Lake River from Gentilly River confluence to County Ditch 99 confluence had near exceptional biological communities of both fish and macroinvertebrates.
- Slight declines were noted in fish IBI scores between years of monitoring for almost all of the highest scoring stations identified in the first cycle of monitoring.
- None of the streams sampled in the Grand Marais Creek Watershed were found to be fully supporting aquatic life communities.

Success story

Grand Marais Creek outlet restoration

In the early 1900s, a 1-mile drainage ditch was installed at the outlet of Grand Marais Creek to the Red River of the North in Polk County. This “cutoff” ditch diverted water from the approximately 6-mile natural outlet and instead directed it straight west into the Red River of the North. Since its inception, the cutoff ditch has experienced significant erosion which worsened over time, leading to more bank failures and loss of adjacent land. This contributed an estimated 700 tons of sediment to the Red River each year. To reverse nearly 100 years of damage, the Red Lake River Watershed District restored natural characteristics of the original 6-mile outlet and re-diverting outlet flow back into the natural channel. Houston Engineering worked with the Polk County Drainage Authority and Minnesota Department of Natural Resources to ensure the project design would provide an adequate outlet. Construction was completed in 2015 after nearly eight years of intense planning and design. The restored channel provides aquatic habitat for various biological communities and nearly 400 acres of wetland and prairie native vegetation, habitat for spawning and juvenile fish, as well as waterfowl.

Burnham Creek grade stabilization structure installations

Since 2017, several grade stabilization structures have been installed along tributary systems to Burnham Creek. The creek was identified as being an impaired reach for aquatic life use based on sampling that occurred in 2012 and 2013. Stressor identification and local partner staff identified side gully erosion and the resulting sediment as a potential contributor to the impairment. The Red Lake Watershed District and West Polk Soil and Water Conservation District installed structures to mitigate some of this side gully erosion.

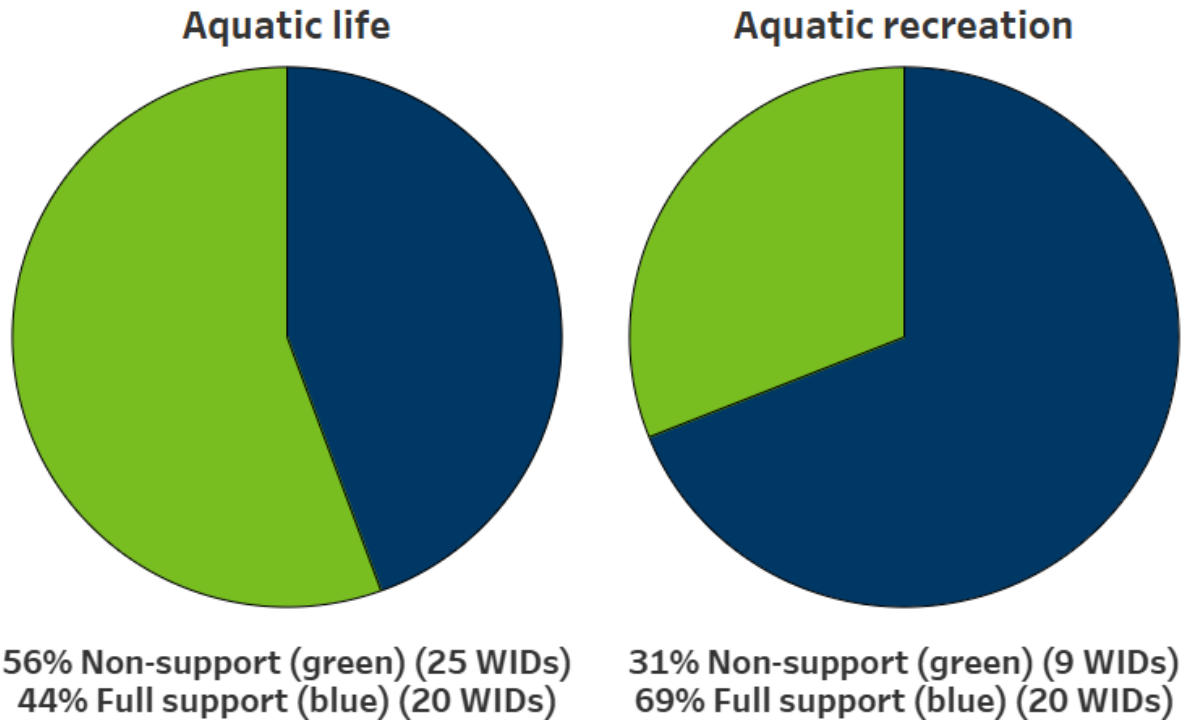
Figure 2. Recently installed side water inlet by Pennington Soil and Water Conservation District.

Watershed assessment results

Streams and rivers

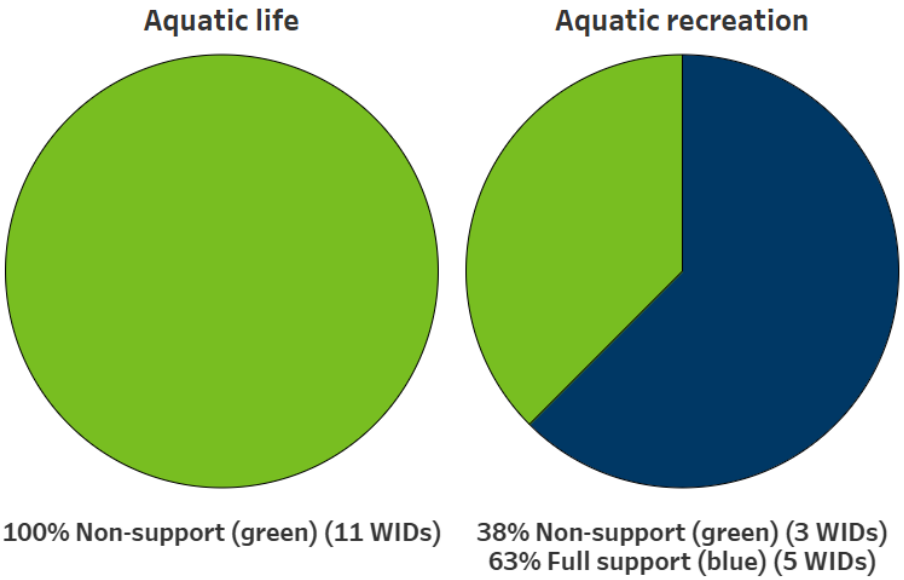
In the Red Lake River Watershed, scientists found almost half of the assessed stream reaches are fully supporting aquatic life uses (Figure 3), and just over two-thirds are fully supporting aquatic recreational uses. Despite these positive results, four of the assessed tributary systems to the Red Lake River are showing declining trends and are considered vulnerable to future impairments (Little Black River, Black River, County Ditch 2, and Heartsville Coulee). The main stem Red Lake River is proving resilient and continues to support aquatic life communities, with some sections maintaining exceptional fish and bug communities. Improvements in aquatic recreation use were seen, with reduced *E. coli* concentrations being observed in numerous stream reaches in the Red Lake River Watershed, and five assessable stream reaches being delisted for previous *E. coli* impairments. There are six new impairments of aquatic life use (dissolved oxygen, macroinvertebrates, and fish) and two new impairments related to aquatic recreation use (*E. coli*) in streams in the watershed.

Figure 3. Watershed assessment results for aquatic life use and aquatic recreational use in streams within the Red Lake River Watershed.



Within the Grand Marais Creek Watershed, all sampled reaches were found to be impaired for aquatic life (based on fish and macroinvertebrate IBIs). These findings were likely influenced by decreasing stream flows and less groundwater being replenished within the watershed. Reduced base flow conditions have become more common over the last few decades due to large increases in drainage practices, such as tiling and ditching, being installed within the watershed. Despite the impairment findings for aquatic life, roughly two-thirds of assessed stream reaches in Grand Marais Creek were found to be fully supporting aquatic recreation. Reduced streamflow in late summer led to a reduction in water quality samples being collected, as samples are analyzed only if water is flowing. Stagnant water is not assessed for water chemistry. These assessment results indicate that when water is flowing, aquatic recreation use is supported, yet due to the flashy hydrological flow patterns, many of the fish and bugs are unable to proliferate in these conditions.

Figure 4. Watershed assessment results for aquatic life use and aquatic recreational use in streams within the Grand Marais Creek Watershed



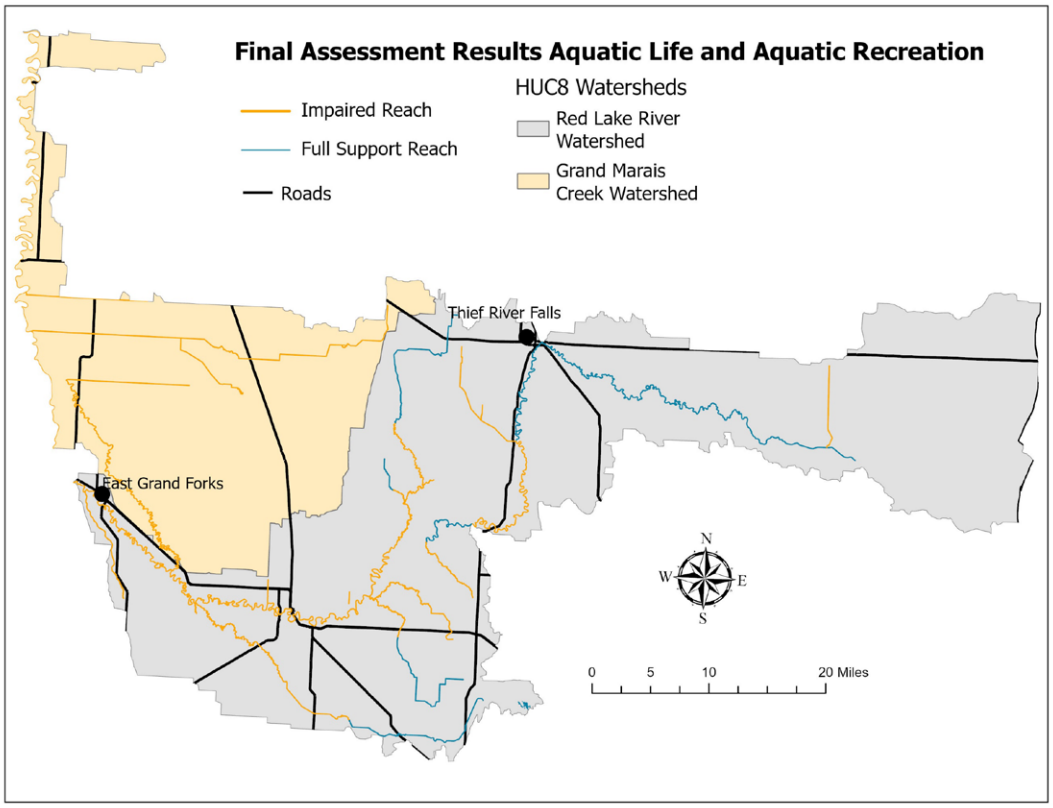
Evaluating the most recent fish communities, two new fish related impairments (one in each watershed) were identified. In addition, there are 13 existing fish-related impairments (nine in the Red Lake River Watershed and four in the Grand Marais Creek Watershed), and new data confirmed four of those impairments.

Within the Red Lake River Watershed, a new fish impairment was identified on Unnamed Trib. to Red Lake River (Polk County Ditch 100 (09020303-569), and an existing macroinvertebrate impairment on Burnham Creek was corrected. Existing impairments were confirmed with new data on Kripple Creek, Branch 5 of Pennington County Ditch 95, and Gentilly River. A near exceptional fish community was identified on the main stem of the Red Lake River from Gentilly River confluence to County Ditch 99 confluence.

For the Grand Marais Creek Watershed, a new fish and macroinvertebrate impairment was identified on County Ditch 44 and Grand Marais Creek from the old cutoff ditch to its confluence with the Red River of the North (09020306-530, formerly 513). Follow-up monitoring in subsequent years is strongly suggested at this location because sampling results were plausibly impacted by extreme drought events. Recent work in the area will hopefully lead to improved biological communities in the future. New data confirmed an existing impairment on County Ditch 2, and the existing impairment on County Ditch 43/JD 75 was noted as “now vulnerable” due to barely exceeding applicable standards for aquatic life of both fish and macroinvertebrate communities. No corrections or de-listings occurred in the Grand Marais Creek Watershed.

In the Red Lake River Watershed, new impairments were identified on the Black River and Judicial Ditch 60. Existing impairments were confirmed on Kripple Creek and Burnham Creek. There was also a correction to an existing macroinvertebrate impairment on Burnham Creek. It’s worth noting that the entire main stem of the Red Lake River continues to support aquatic life, based on fish and macroinvertebrate data.

Figure 5. Assessment results for aquatic life and aquatic recreation on rivers and streams in the Red Lake River and Grand Marais Creek watersheds.



Trends

A key objective of the 2023 monitoring effort was to evaluate if and how water quality has changed since the initial monitoring. If water quality has improved, it is important to understand to what extent human actions may be responsible for the change. 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 activities.

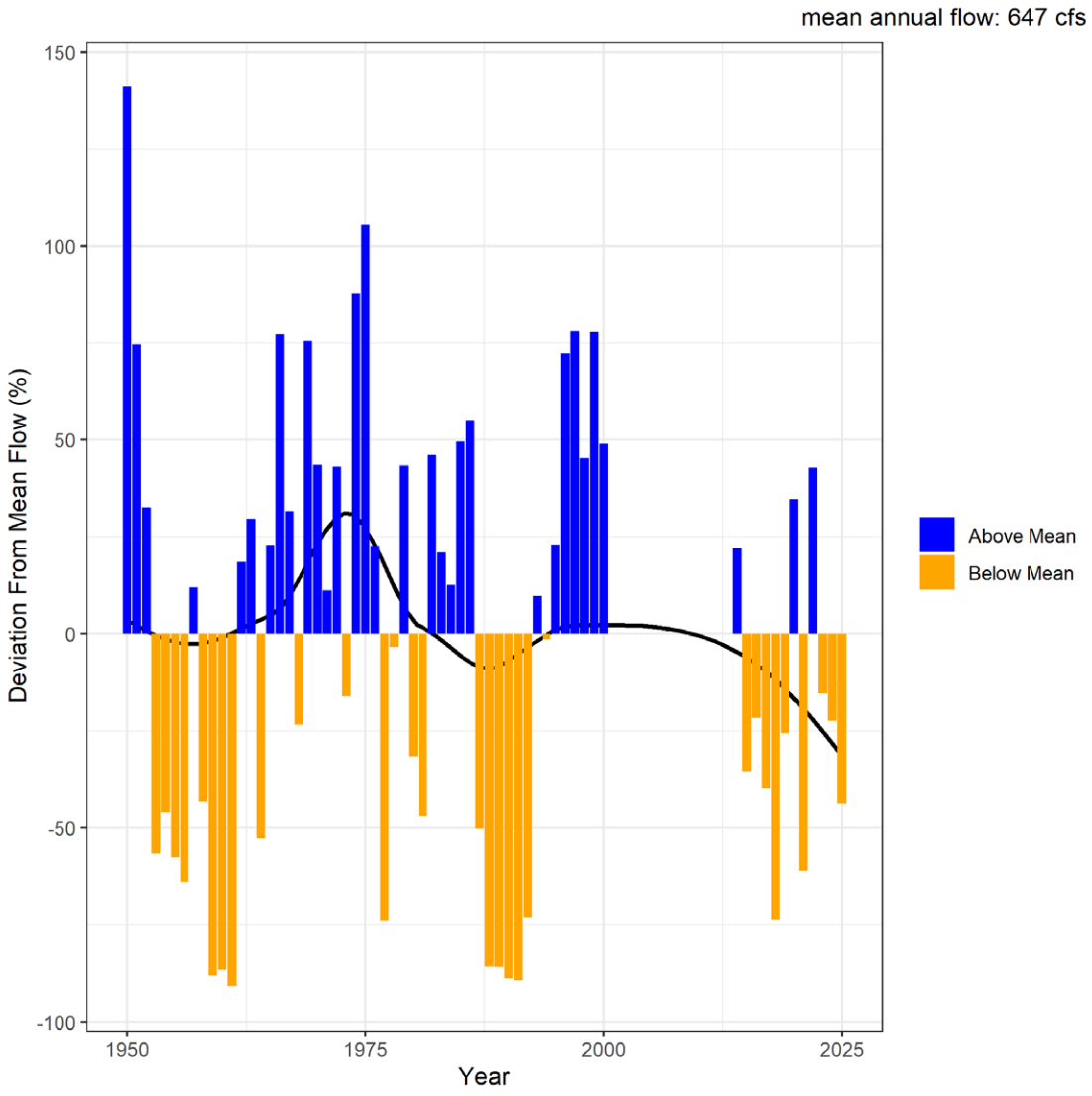
Trends in three different aspects of water quality were analyzed to provide as robust a picture as possible of what is happening in the Red Lake River and Grand Marais Creek watersheds:

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

Streamflow

Annual streamflow (discharge) data for the Red Lake River extend back to 1929, though interpretation of long-term trends is somewhat constrained by data gaps and the exclusion of the Dust Bowl era prior to 1950. Recent observations suggest a potential decreasing trend in flow (Figure 6), although the trend is not statistically conclusive. Streamflow influences channel conditions and pollutant transport; therefore, even stable pollutant concentrations can result in changing loads if flow conditions shift.

Figure 6. Percent deviation from normal flow over time for the Red Lake River near Goodridge, Minnesota. The black line represents a LOESS-smoothed annual average, while yellow and blue bars indicate each year's deviation above or below normal (647 cubic feet per second).



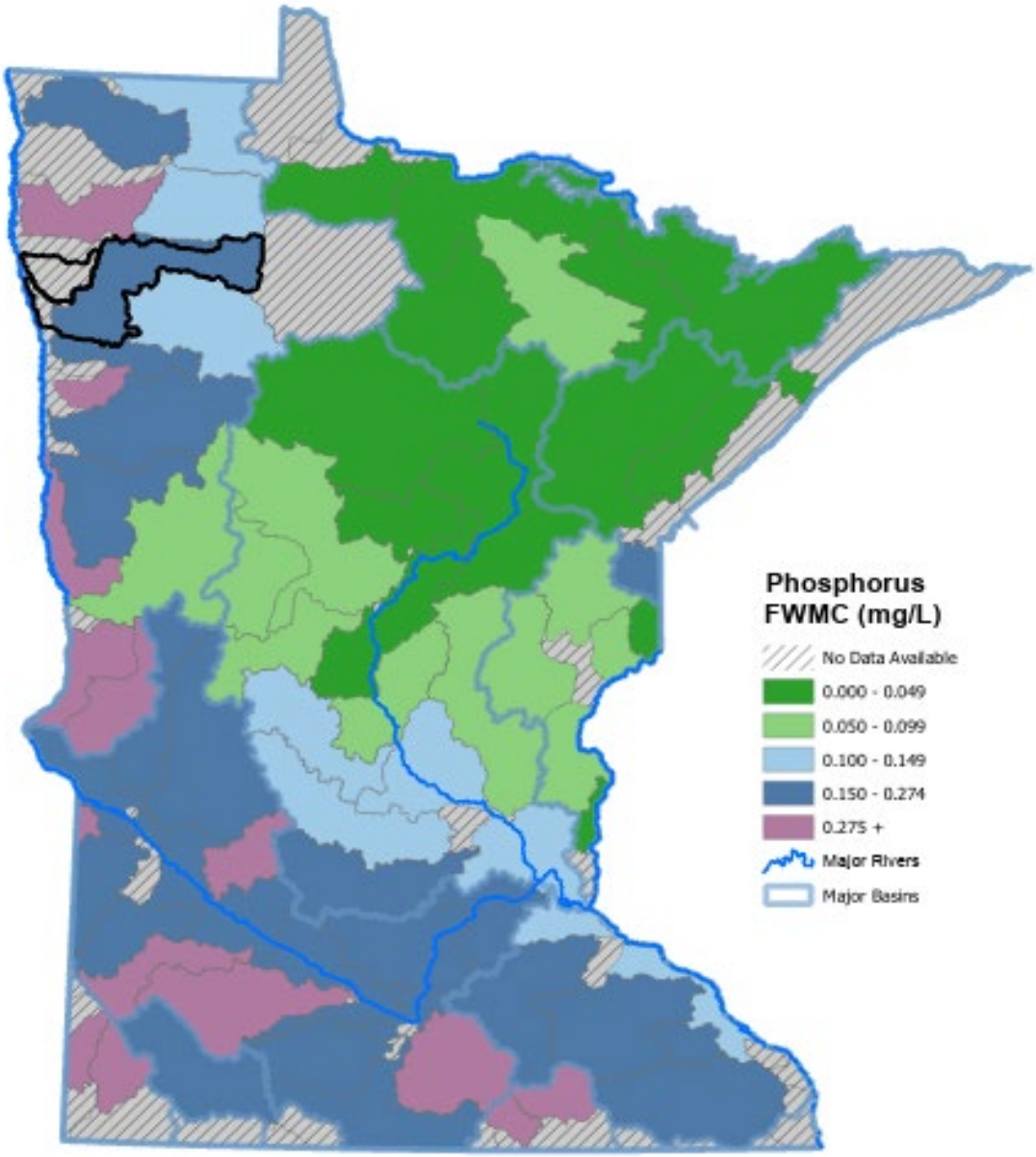
Pollutant concentrations

The Watershed Pollutant Load Monitoring Network (WPLMN) collects year-round data at approximately 200 long-term monitoring sites statewide, including three located on the Red Lake River main stem. There are no WPLMN sites within the Grand Marais Creek Watershed. Samples span a wide range of flow conditions and include parameters known to influence water quality, such as total suspended solids (TSS), total phosphorus (TP), dissolved orthophosphate (DOP), nitrate + nitrite nitrogen (NOX), and total Kjeldahl nitrogen (TKN).

When compared statewide, pollutant concentrations within the Red Lake River watershed display a distinct pattern:

- **TSS is high**, with concentrations at outlet site near Fisher at the 72nd percentile for the state. Broadly, all measured water quality indicators tend to increase in the downstream portions of a watershed. In particular, TSS increases downstream for the Red Lake River, reflecting the influence of a larger drainage area, tributary inputs, and land use.
- **TP and DOP are moderate,** generally falling in the lower half of statewide values (Figure 7)
- **NOX and TKN are consistently low**, with most stations falling well below the 50th percentile, including some as low as the 7th–15th percentile. Although nitrogen concentrations are low, downstream yields increase due to higher flow volumes in the lower main stem.

Figure 7. Flow-weighted mean concentrations (FWMC) for total phosphorus (TP) in the Red Lake River Watershed compared to other Minnesota watersheds.



Tributary influence and downstream implications

The Clearwater River is the most influential tributary to the lower Red Lake River, contributing substantial sediment and nutrient loads, particularly during higher flow conditions. Its TSS and nitrogen yields are often comparable to, or exceed, those observed at upstream main stem sites, making it a key driver of water-quality conditions in the lower watershed.

These tributary inputs, combined with increasing downstream drainage area and flow volume, result in high total annual loads at the Red Lake River outlet. Although nitrogen concentrations are relatively low compared to statewide values, the large flow volumes in the lower main stem produce significant nitrogen loads. TSS loads also remain a particular concern.

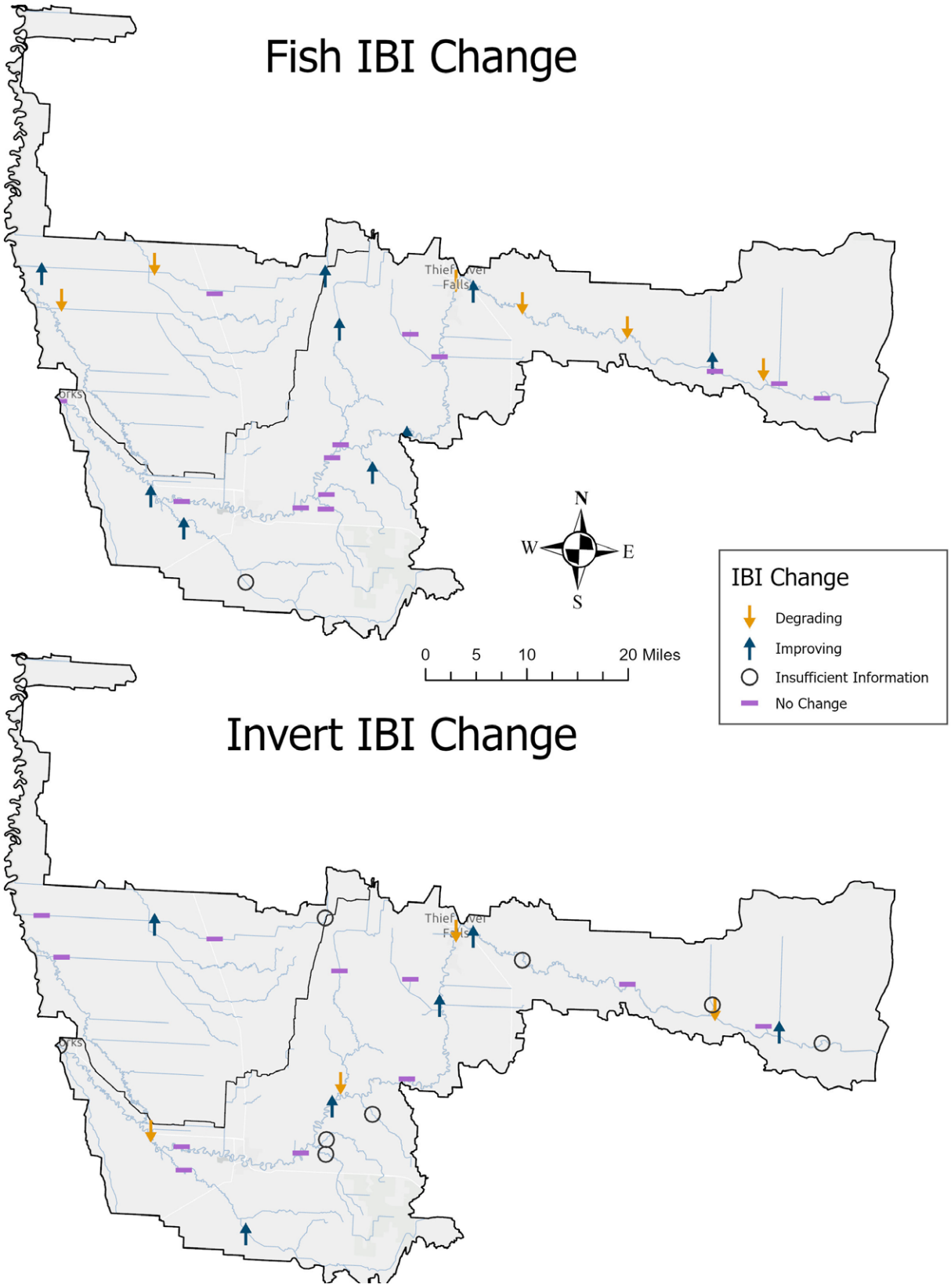
Trends in pollutant concentrations Pollutant Concentrations

Trend patterns help clarify where the watershed stands today. To understand whether conditions are improving, declining, or remaining stable, the next step is to examine how pollutant concentrations have changed over time. A Seasonal Kendall trend test was performed on long-term concentrations of TSS, TP, and NOX at the outlet. Results indicate no statistically significant concentration trends for any of the parameters evaluated. Existing data do not show evidence of increasing or decreasing TSS, TP, or NOX over time.

Understanding the relationship between lack of concentration trends and streamflow variability is important. If flows decline, loads may decrease even though concentrations remain unchanged; conversely, higher flows can increase loads despite stable concentrations.

Ultimately, the Red Lake River delivers substantial sediment and nutrient loads to the Red River of the North. Managing sediment and nutrient inputs will be critical for improving water quality not only within the watershed but also in downstream waters, including the Red River and Lake Winnipeg.

Figure 8. Change in water quality as it relates to Index of Biological Integrity (IBI) scores in the Red Lake River and Grand Marais Creek watersheds.



Biological communities

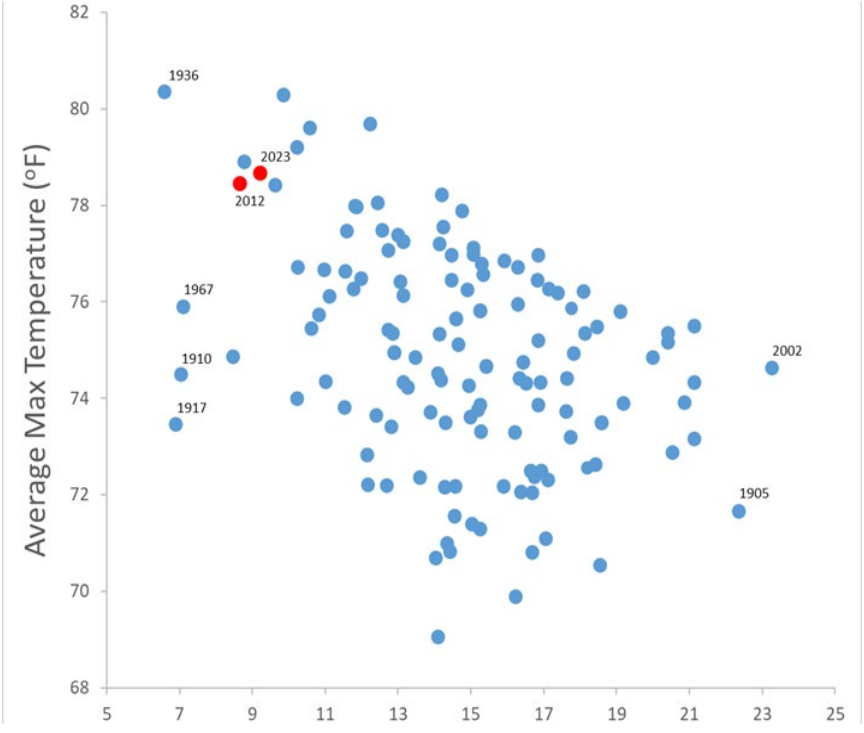
Paired t-tests of fish and macroinvertebrate IBI scores were used to evaluate if biological condition of the watershed's rivers and streams has changed between time periods. Independent tests were performed on each community with 21 sites evaluated for macroinvertebrates and 28 sites evaluated for fish (i.e., sites that were sampled in both time periods). The average macroinvertebrate IBI score increased by 1.5 points between 2012 and 2023, which does not represent a statistically significant change. Similarly, fish IBI scores increased by 3.9 points, which was also not statistically significant. While the overall health of fish and macroinvertebrate communities across the watersheds did not statistically change between time periods, biological conditions at individual stream sites may have improved or degraded (± 10 IBI points) (Figure 8).

Context for the change analysis results are provided by a look at the conditions under which biological monitoring occurred in time 1 and time 2. In 2012 and 2023, severe drought affected both the Red Lake River and Grand Marais Creek watersheds, and temperatures were abnormally high during the May to September time frame (Figure 9).

Climate

When evaluating whether conditions in the watershed are improving or degrading between intensive watershed monitoring (IWM) cycles, climatic conditions and extreme weather events before or during each cycle can dramatically obscure changes attributable to watershed-scale factors such as restoration and 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 temperatures, decreased dissolved oxygen, habitat degradation, and decreased connectivity. However, it is difficult to make predictions of the impact of climatic conditions and weather events on stream aquatic life. This is 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, severe drought may negatively affect fish communities in headwater streams due to stressful conditions created by lack of flowing water (i.e., higher temperature, lower dissolved oxygen). While in larger streams that retain flow during a drought, biological conditions 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.

Figure 9. Characterization of air temperature and rainfall conditions for May-September period across historical record for the Red Lake River and Grand Marais Creek watersheds. Biological monitoring years for the watershed highlighted in red.



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 (Table 1). This information was then used to estimate the likelihood (high, medium, or low) that climate/weather influenced biological conditions in either period of IWM. For instance, if both time periods fall within the bounds of near-normal conditions (i.e., lightest shade of gray in Table 1), then there would be a low likelihood that results in either time period is affected by climate/weather and thus any observed changes in condition are presumably driven by watershed-scale factors.

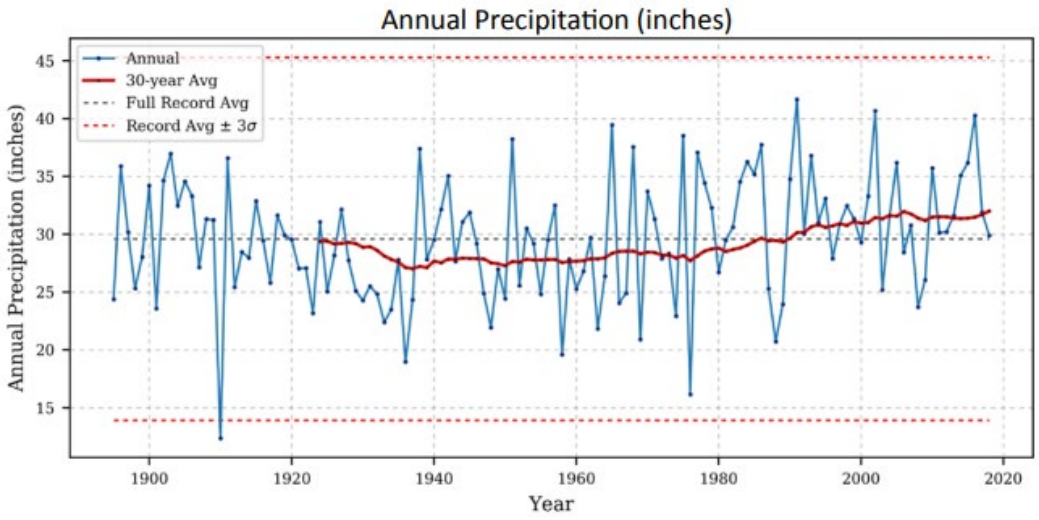
In 2012, both watersheds experienced an extreme rainfall deficit (-7.0 in) and was abnormally hot (+4.2 ^{o}F) during the May-September period, resulting in a severe drought for this region by mid-July of that year. Similarly, these watersheds had another extreme rainfall deficit (-6.4 in) and were abnormally hot (+4.4 ^{o}F) in 2023 over the May-September period. Once again, the region was in a severe drought by mid-July of 2023. To compensate for the extremely dry conditions experienced in 2012 and 2023, additional biological monitoring was conducted in each watershed the following year. Conditions were more favorable in 2013 and 2024, with slightly below or slightly above normal rainfall amounts, respectively. Overall, given the extremely hot and dry conditions affecting these watersheds in both 2012 and 2023, there is a low likelihood that observed changes in biological condition at either the watershed or individual scale are due to differences in climatic conditions between the two periods.

Table 1. Criteria used to characterize May-September rainfall and temperature conditions across the watershed. Likelihood of climate/weather influence on biological condition results: low; medium; high.

Departure from Normal Precipitation Total (in)

Departure from Avg. Maximum Temperature (°F)	< -6	< -2 to -6	-2 to +2	> +2 to +6	> +6
> +3	Extreme Drought Conditions	Moderate-Severe Rainfall Deficit & Extreme Heat	Near Normal Rainfall & Extreme Heat	Above Normal Rainfall & Extreme Heat	Extreme Flooding & Extreme Heat
> +1 to +3	Extreme Rainfall Deficit & Abnormally Hot	Moderate-Severe Rainfall Deficit & Abnormally Hot	Near Normal Rainfall & Abnormally Hot	Above Normal Rainfall & Abnormally Hot	Extreme Flooding & Abnormally Hot
-1 to +1	Extreme Rainfall Deficit & Normal Temps	Moderate-Severe Rainfall Deficit & Normal Temps	At or Near Normal Conditions	Above Normal Rainfall & Normal Temps	Extreme Flooding & Normal Temps
< -1 to -3	Extreme Rainfall Deficit & Abnormally Cool	Moderate-Severe Rainfall Deficit & Abnormally Cool	Near Normal Rainfall & Abnormally Cool	Above Normal Rainfall & Abnormally Cool	Extreme Flooding & Abnormally Cool
< -3	Extreme Rainfall Deficit & Cold	Moderate-Severe Rainfall Deficit & Cold	Near Normal Rainfall & Cold	Above Normal Rainfall & Cold	Extreme Flood Conditions

Figure 10: Average annual precipitation for the Red Lake River and Grand Marais Creek watersheds



For more information

This study of the Red Lake River and Grand Marais Creek watersheds 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 Red Lake River and Grand Marais Creek watersheds, 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 Red Lake River and Grand Marais Creek webpages, or search for "Red Lake River or Grand Marais Creek" on the MPCA website.

Contact

Karsten Klimek
Minnesota Pollution Control Agency
karsten.klimek@state.mn.us
218-316-3917

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