Watershed assessment and trends update

Thief River Watershed

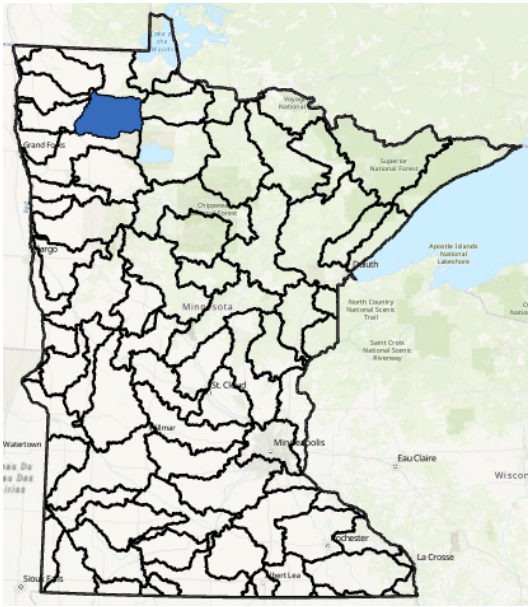
Red River Basin

Summary

The Minnesota Pollution Control Agency (MPCA), Minnesota Department of Natural Resources (MNDNR), and partners have completed a study of the Thief River Watershed, which includes ditch networks, natural streams and several large impoundments such as Agassiz National Wildlife Refuge, Thief Lake Wildlife Management Area, and the Moose River impoundment. The flow of water in the Thief River Watershed is largely controlled by impoundments, which regulate flow in the Thief River, along with major tributaries such as the Moose and Mud Rivers and large ditch networks. The Thief River Watershed provides a unique challenge to watershed partners due to the very high proportion of channelized systems in the watershed (97%). Water quality issues are often difficult to resolve, and even more so when issues are exacerbated by widespread hydrologic alteration. Seven stream segments were added to the impaired waters list, while two biological impairments were removed from the impaired waters list. All reaches of the Thief River mainstem that have been sampled for biology are impaired for aquatic life.

Instead of relying on chemical testing of the water alone, scientists reached their conclusions by studying the variety of fish and bugs living in the water. Doing so offers a more comprehensive understanding of the watershed's health over time. Volunteer water quality monitors contributed to this assessment, which is funded by Minnesota's Clean Water Land and Legacy Amendment. Details in this report will shape decisions on watershed management and pollution reduction measures for years to come.

Figure 1. The Thief River is in Northwest Minnesota, near Thief River Falls.



Watershed study

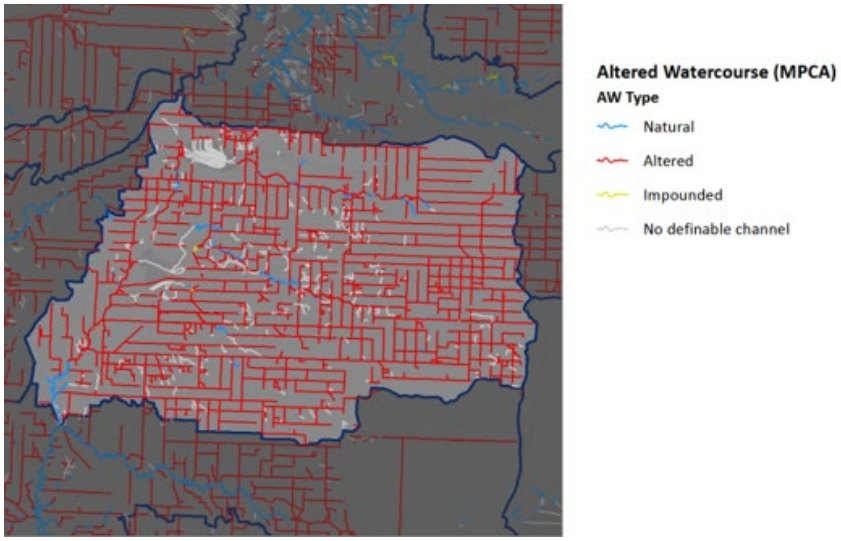
In 1970 the Red Lake Watershed District was established to work on projects to protect and improve water quality in five watersheds including the Thief River Watershed. The MPCA and partners monitored water quality conditions in 2011-2012 (cycle I) and 2022-2023 (cycle II). Chemistry data collected by local partners between 2013 and 2023 were used for assessment. The data used to assess the condition of Minnesota waterbodies, focuses on whether or not they meet water quality standards for aquatic life, recreation, and consumption. The overall goal of these assessments is to determine which waters are healthy and in need of protection or are polluted and require restoration.

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 MPCA and local partners conduct an intensive examination 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. Local partners can then use

this data to see which waters are healthy and in need of protection or are polluted and require restoration. Waters are considered impaired if they fail to meet water quality standards.

Changes in water quality

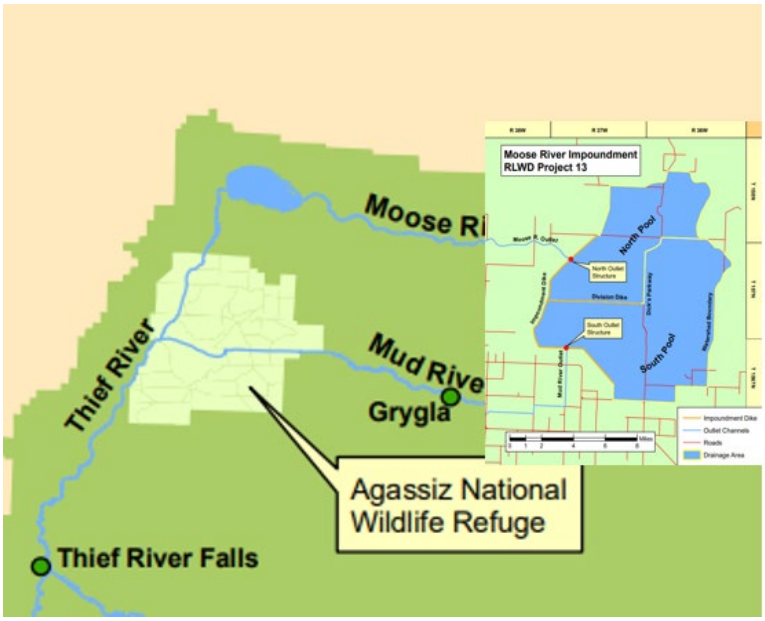
To detect any changes in water quality, this study looks at fish and macroinvertebrate communities as well as water chemistry. Scientists use a tool called the Index of Biological Integrity (IBI) to assess the health of biological communities in lakes, rivers, streams, and wetlands. High IBI scores indicate a healthy aquatic community, which can only be attained when water quality, habitat, and hydrology are minimally disturbed by human activities. Low IBI scores indicate impairment and highlight areas where restoration activities can be targeted to improve water quality. Water quality standards are established to create realistic expectations for both natural and ditched systems.



A map of watercourse designations within the Thief River watershed. Just over 3% of the Thief River Watershed is comprised of natural stream channels.

Over the past decade, scientists observed several changes in water quality in the Thief River Watershed. Positive changes include improved macroinvertebrate communities along the Mud River, resulting in two impairments being removed from stretches of the Mud River near Grygla. Also, Total suspended sediment (TSS) concentrations on a watershed wide scale have seen a slight reduction based on watershed pollutant load monitoring data collected near the pour point of the Thief River Watershed from 2008-2022. Negative changes in the watershed include 10 new impairments that were identified in cycle II at 7 stream reaches. Impaired parameters include fish (3), macroinvertebrates (3), dissolved oxygen (2), and TSS (2).

Continued problems include excess sediment (turbidity) and low dissolved oxygen levels which are exacerbated by water management activities and ditching in this watershed. Extensive ditch networks increase peak flows and regulated impoundments and eliminate stable baseflow conditions in most streams and ditches in this watershed.



The Thief River Watersheds main watercourses are all controlled by impoundments. The Moose and Mud Rivers come out of the Moose River impoundment, while the Thief River is regulated at the outlet of Thief Lake Wildlife Management Area and within Agassiz National Wildlife Refuge.

Local partners such as Soil and Water Conservation Districts (SWCDs), and the Red Lake Watershed District, have utilized data from Cycle I to develop the Thief River Watershed Comprehensive Watershed Management Plan, approved in March 2020. This planning effort is dynamic in its ability to incorporate updated scientific data as it becomes available to adjust priority areas based on recent assessment decisions. This plan offers valuable information and a reliable funding source for local groups to identify and prioritize further opportunities for installing best management practices (BMPs) to improve water quality. In collaboration with local

landowners, numerous BMPs have been implemented to enhance water quality in the Thief River Watershed. However, additional efforts are necessary, as it takes time for these practices to yield observable results.

Highlights of monitoring

- Several fish passage issues and corresponding impairments were identified through this study including fish passage through Agassiz National Wildlife Refuge. At the biological monitoring station downstream from the refuge, fish species such as Walleye, Shorthead Redhorse, Quillback, and several Shiner species are present. These species have not been documented at any of the three biological monitoring stations between the upstream extent of the refuge and the Thief Lake Wildlife Management Area. Agassiz National Wildlife Refuge and the Thief Lake Wildlife Management Area are primarily managed for waterfowl production and the flow of the river is disrupted as water is diverted into pools to maintain water levels.
- A series of impoundments largely controls flow in the Thief River Watershed. The mainstem of the Thief River is controlled at the outlet of Thief Lake, as well as several pools utilized by Agassiz National Wildlife Refuge. The Moose River impoundment, managed by the Red Lake Watershed District, controls major tributaries such as the Moose and Mud Rivers. This impoundment is managed to reduce peak flows on downstream waters and provides habitat for wildlife. This system has two outlets. The North outlet feeds directly into the Moose River, while the South outlet supplies water for the Mud River.
- Across the watershed, there is no statistically significant change in stream biological condition over the last 10 years for fish and macroinvertebrate communities. There were several site-specific changes observed, including 2 impairments removed from the impaired waters list (macroinvertebrates on 2 sections of the Mud River near Grygla). There were also 6 new biological impairments on the Thief River mainstem, County Ditch 32, JD 11/Branch 200, and County Ditch 20.
- Water levels remained high throughout the early summer of 2022, pushing biological monitoring to the second half of the summer. As a result, samples were also collected in 2023 where needed.
- Four new water chemistry impairments were identified during cycle II assessments. Judicial Ditch 11 was listed as impaired for TSS, while the stretch of the Thief River between Thief Lake and the upper boundary of Agassiz was listed for both dissolved oxygen and TSS. Ditch 200 was listed as impaired for dissolved oxygen. These impairments corroborate existing aquatic life impairments for biology on this section of the Thief River and in Ditch 200.

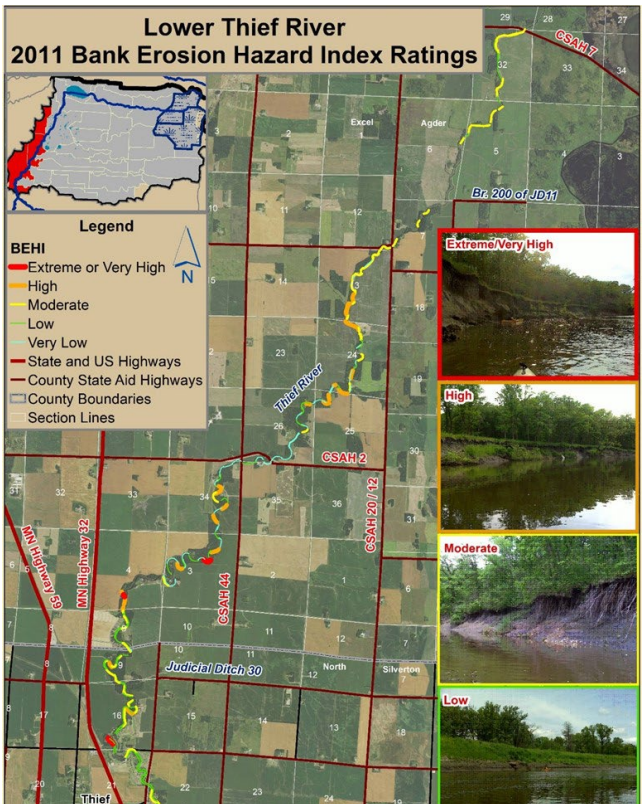
Success story

In 2020, the Thief River Comprehensive Watershed Management Plan (One Watershed One Plan) was completed. This plan informs watershed goals and priorities, one of which was to stabilize the streambank in the lower Thief River Sub-watershed.

Bank erosion hazard index (BEHI) ratings from geomorphology studies highlight priority areas for streambank stabilization. Roughly 5,000 linear feet of streambank along the Thief River were stabilized between 2021 and 2024 at 11 locations. These projects have resulted in a reduction of ~1400 tons of sediment loading.

In addition to streambank stabilization along the Thief River, side water inlet and gully stabilization projects have been completed. These smaller projects have resulted in a reduction of 290 tons of sediment per year.

Future efforts are planned for 2025-2026 to further reduce sediment loading in the lower Thief River. This work will continue to improve sediment issues in the Thief River and is directly related to addressing a longstanding turbidity impairment on the lowest section of the Thief River.



Results of Thief River BEHI surveys in the lower Thief River Sub-watershed.

This series of stabilization projects, and many other best management practices in the Thief River Watershed have been spearheaded by the Red Lake Watershed District and local soil and water conservation districts. More information about the Red Lake Watershed District and their work is available on their website: https://redlakewatershed.org/.

In addition to streambank stabilization efforts, it is worth noting that the Minnesota buffer law came into effect between monitoring cycles. This law requires a 50-foot buffer of perennial vegetation along lakes, rivers, and streams, and 16.5 feet along ditches. These buffers are designed to naturally filter out chemical pollutants such as phosphorus, nitrogen, and sediment, reducing pollutant loading to water resources across the state.

Watershed assessment results

Streams and rivers

Overall, about one-fourth of assessed watercourses support aquatic life uses (Figure 2) in the Thief River Watershed. While sections of the Moose and Mud Rivers have fish and macroinvertebrate communities that are in good condition, most streams, particularly in the lower two-thirds of the watershed, have biological communities that are severely degraded (Figure 3). In general, fish and macroinvertebrate communities in the watershed exhibit signs of degradation characterized by a dominance of pollution-tolerant species. All sites monitored in both cycle I and cycle II on the Thief River mainstem exhibited a decline in F-IBI performance (Figure 7). Six new biological impairments were added to the impaired waters list in cycle II (3 fish, 3 macroinvertebrates). Four stream reaches were also designated as vulnerable, all of these reaches were on the Moose and Mud Rivers. Vulnerable status is a way of identifying waters that are nearly or barely impaired. Vulnerable waters are highlighted to identify areas where smaller scale projects will have a more

pronounced affect on water quality. As a result, these are often the most cost-effective areas to restore and protect.

Stream water chemistry monitoring identified four new impairments for elevated levels of total suspended sediments (TSS) and low dissolved oxygen levels. Streams with new impairments include the Thief River, Ditch 200, and Judicial Ditch 11 (Figure 3). Several impairments were re-affirmed including existing E. coli impairments on the Mud River. No water chemistry impairments were removed from the impaired waters list as part of cycle II monitoring. The most common water chemistry impairments in the watershed are for TSS and dissolved oxygen. Many of the problematic areas in the watershed are affected by the management of water in impoundments. Stagnant conditions often occur when water is being held back, and sediment is often flushed through these systems when impoundments are opened. Improvements in water management activities could reduce peak flows and sediment loading, while also creating more consistent baseflow conditions for aquatic organisms. Finding management solutions to meet impoundment management goals while simultaneously improving conditions in receiving waterways would improve conditions for both water chemistry and aquatic communities.

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

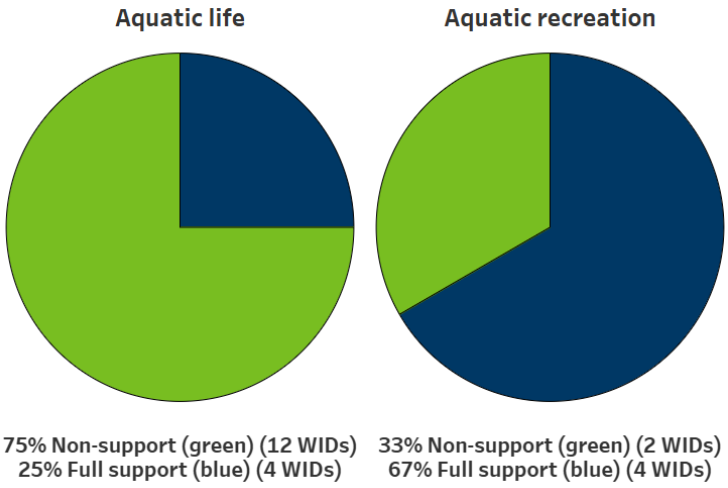
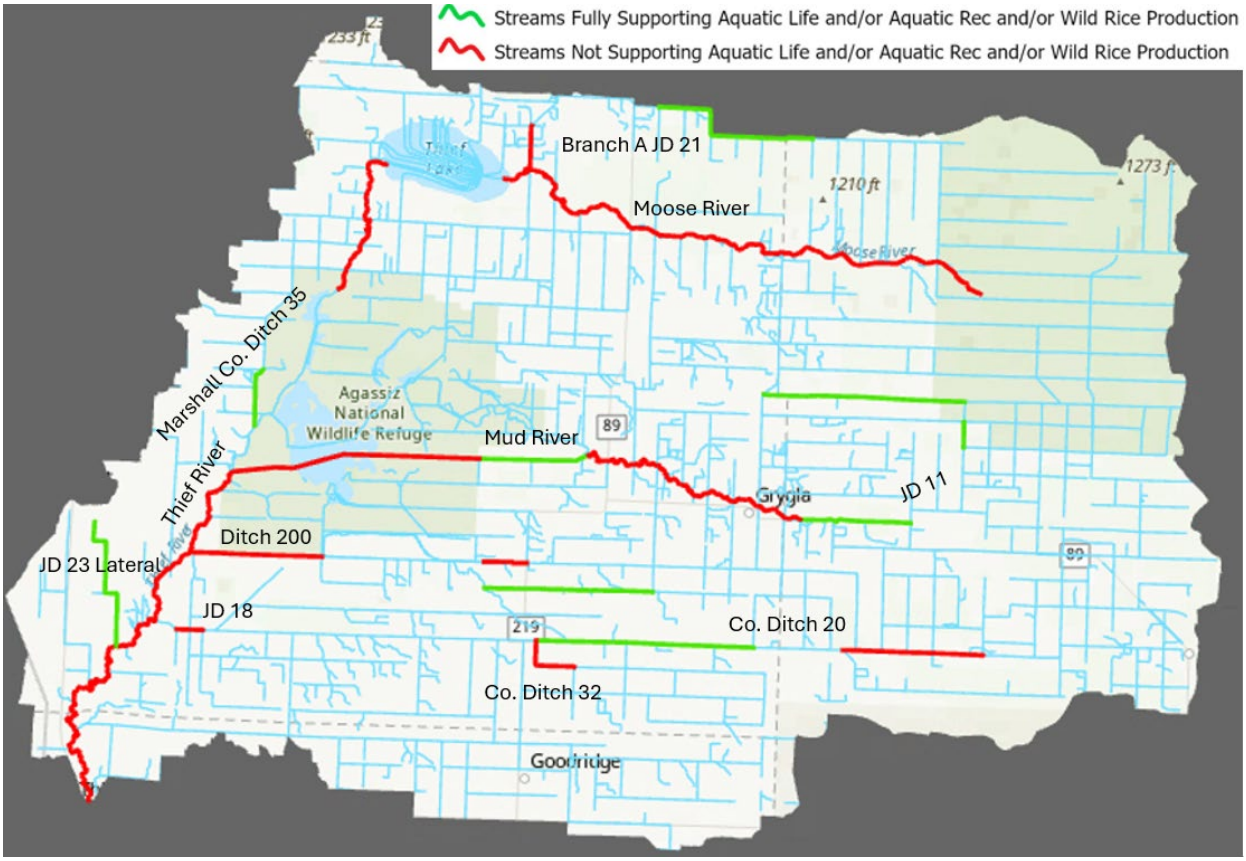


Figure 3. Assessment results for aquatic life and aquatic recreation on rivers and streams in the Thief River Watershed.



Lakes

There are very few lakes in the Thief River Watershed, and no lakes had sufficient water chemistry data to assess for aquatic recreation. Thief Lake was assessed as fully supporting aquatic recreation in cycle I, but no new data was collected in cycle II. Similarly, there were no lakes sampled by the Minnesota Department of Natural Resources Lake IBI program and no lakes had sufficient data for lake clarity trends.

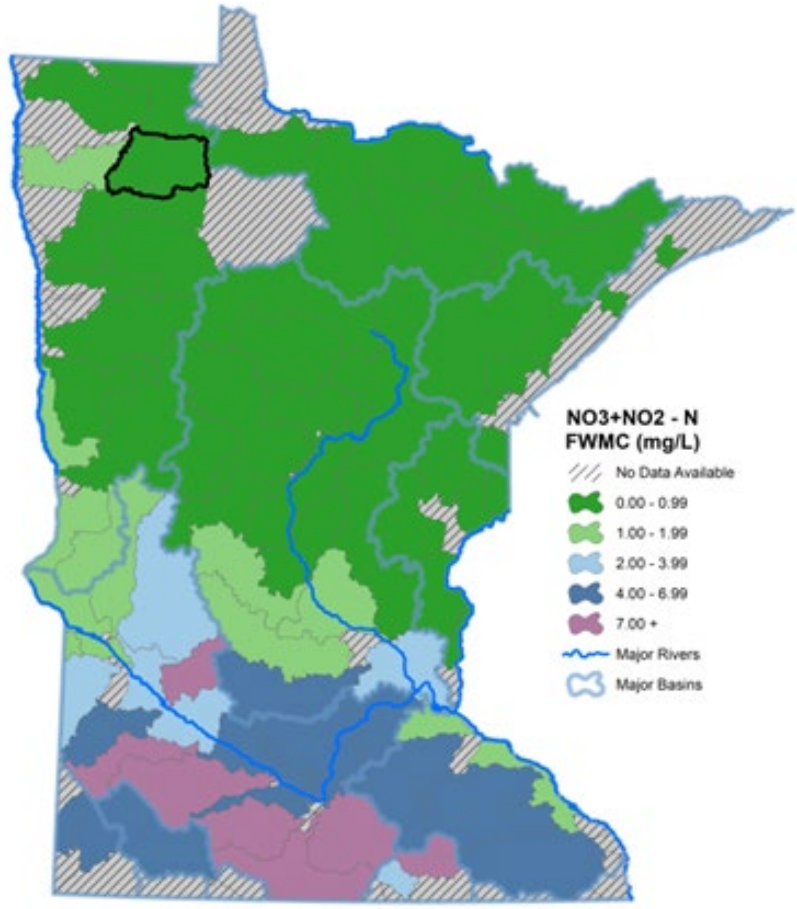
Trends

A key objective of the 2022 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 Thief River Watershed:

1) Streamflow, total suspended solids (TSS), total phosphorus (TP), and nitrate + nitrite nitrogen (NOX)
2) Biological communities
3) Climate

Figure 4. Flow weighted mean concentrations (FWMC) for nitrate + nitrite nitrogen in the Thief River Watershed.



Streamflow and pollutant concentrations

In addition to the intensive monitoring completed every ten years, approximately 200 Watershed Pollutant Load Monitoring Network (WPLMN) sites are operational year-round across Minnesota. These sites are sampled intensively across a range of flow conditions for parameters that are known to affect water quality. There are currently three WPLMN sites located in the Thief River Watershed. Two on the Thief River (near Thief River Falls and Holt) and a third site on the Mud River, near Grygla. More information about the WPLMN program can be found at https://www.pca.state.mn.us/air-water-land-climate/watershed-pollutant-load-monitoring.

Annual streamflow (discharge) data is available for the Thief River Watershed since 1909. There is an increasing trend in flow on the Thief River (Figure 5).

Increasing flow in the Thief River Watershed may increase stream bank erosion and pollutant loading because even if pollutant concentrations are stable, the increased flows would result in higher pollutant loads. Pollutant loads represent the total amount of a pollutant moving through a system, this way of measuring water quality is important for downstream resources such as the Red River, where these pollutants may accumulate.

Overall, pollutant concentrations analyzed for the Thief River Watershed are low or below average when compared to the rest of the state (Figure 4).

Within the watershed, concentrations generally increase from the headwaters toward the outlet. An exception can be found when looking at Nitrate+Nitrite Nitrogen for the Mud River near Grygla which has concentrations that are much higher than those found lower in the watershed (Figure 6). A plausible explanation could be denitrification occurring within Agassiz National Wildlife Refuge pools. Refuge staff have indicated nitrogen levels are higher on the upstream side of the refuge when compared to the downstream end.

A Seasonal Kendall trend test on total suspended solids (TSS), total phosphorus (TP), and nitrate + nitrite-nitrogen concentrations at the Thief River outlet was used to determine if

Figure 5. The percent deviation from normal flow over time for the Thief River at Thief River Falls.

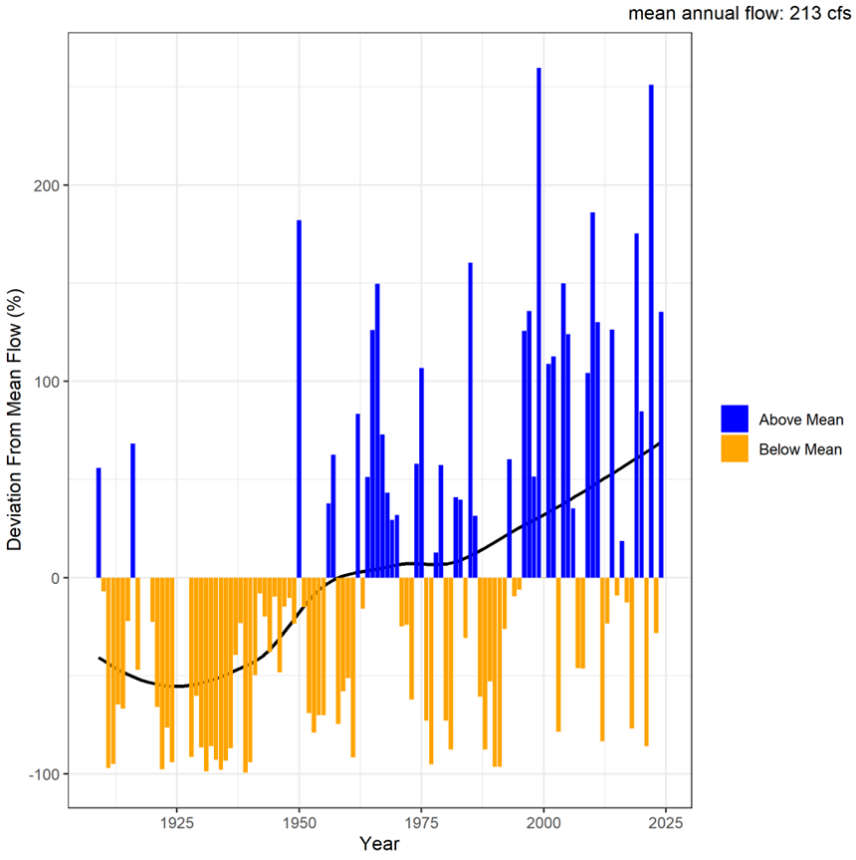
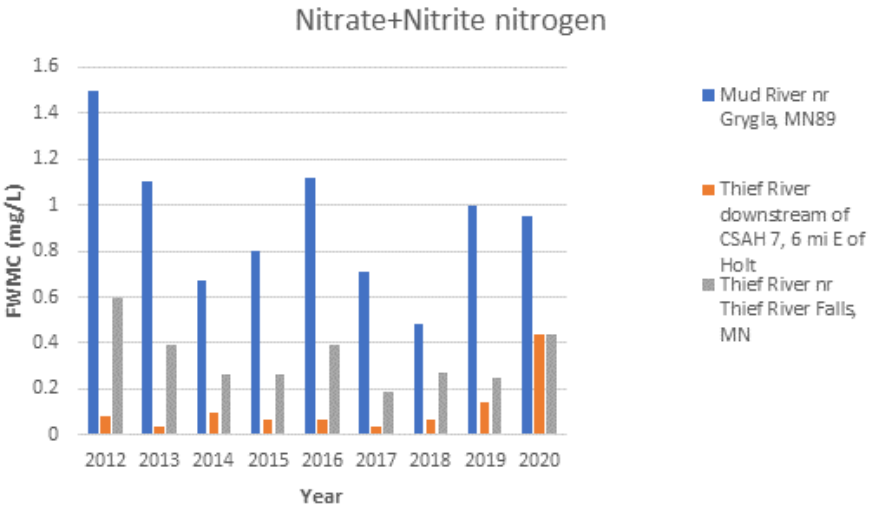


Figure 6. Nitrogen readings from the WPLMN stations in the Thief River watershed.

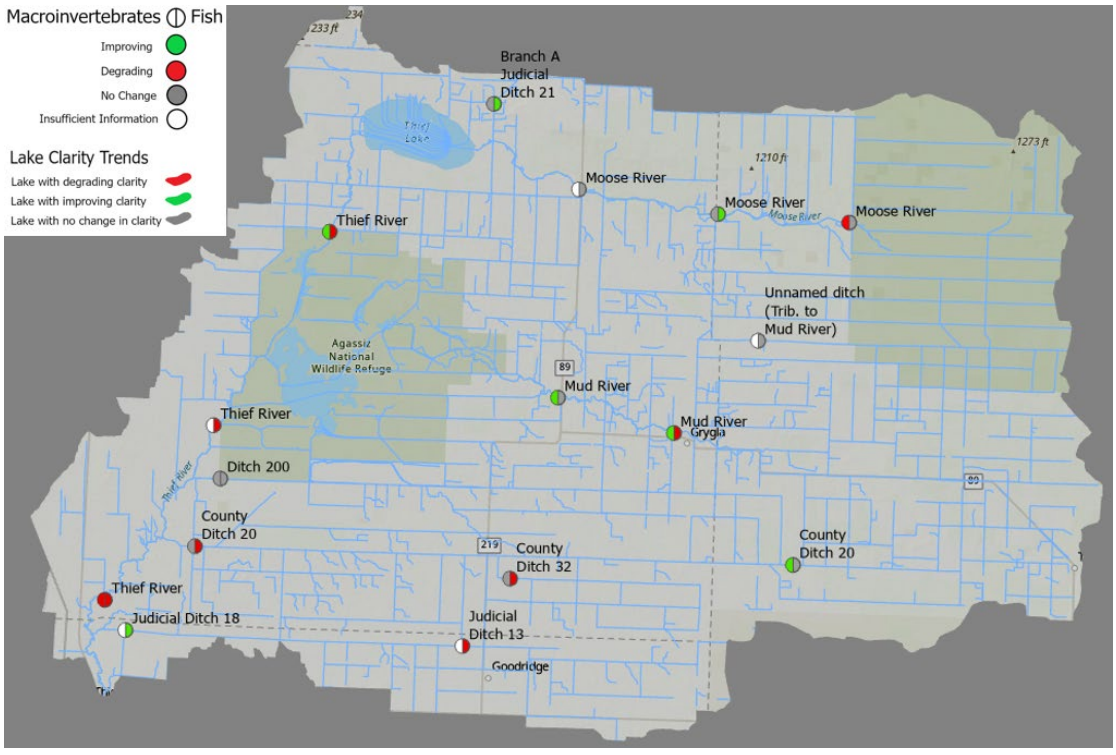


there were any statistically significant trends in concentrations. Only TSS showed a statistically significant change, decreasing 4.78% each year, or about 0.24mg/L between 2008-2022.

Biological communities

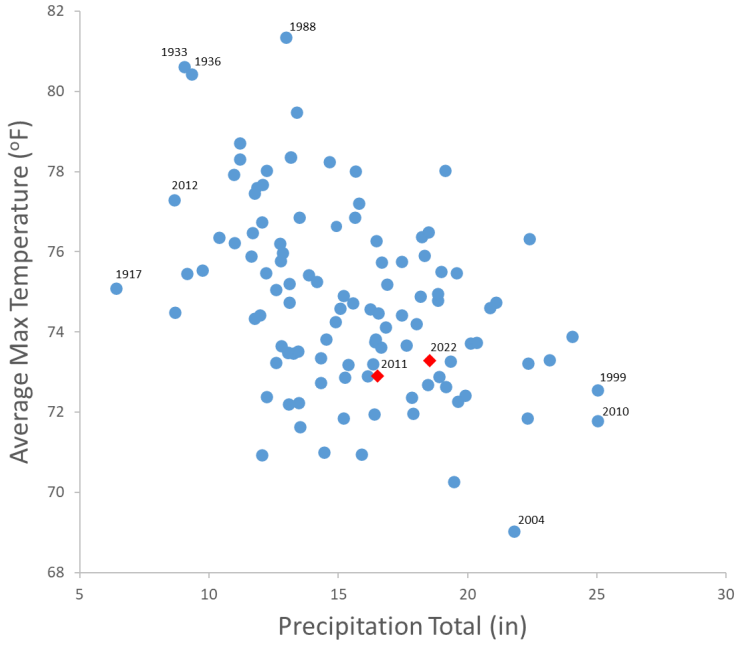
To evaluate if biological condition changed on a watershed wide scale between cycle I and cycle II, a change analysis was conducted utilizing paired t-tests of fish and macroinvertebrate IBI scores. Independent tests were performed on each community with 11 sites evaluated for macroinvertebrates and 16 sites evaluated for fish (i.e., sites that were sampled in both cycles). The average macroinvertebrate IBI score for the watershed increased by 4.9 points between 2011 and 2022; however, this does not represent a statistically significant change. Macroinvertebrates appeared to improve between cycle I and cycle II along the Mud River system, resulting in two delistings of historic macroinvertebrate impairments. Fish IBI scores across the Thief River Watershed decreased by 4.6 points, which was also not statistically significant. This decrease is likely driven by a decline in fish IBI performance along the mainstem of the Thief River. Common Carp, which are highly tolerant of degraded conditions dominated fish communities at many sites in cycle II but were not observed in the watershed during cycle I monitoring. While the overall health of fish and macroinvertebrate communities on a watershed scale did not change between cycles the condition of fish and macroinvertebrate communities at individual stream sites may have improved or degraded (± 10 IBI points) (Figure7).

Figure 7. Change in fish and macroinvertebrate IBI scores in the Thief River Watershed.



Context for the change analysis of biological communities is provided by a characterization of the conditions under which biological monitoring occurred in cycle I and cycle II. In 2011, the Thief River Watershed experienced near normal rainfall (0.4 inches above normal) and was abnormally cool (-1.3 °F below normal) during the May to September time period (Figure 8). In comparison, the watershed also had near normal rainfall (+1.6 in) and was abnormally cool (-1.0 °F) in 2022 over that same timeframe. Given the relatively similar conditions present during the summer months of each biological monitoring year, there is a low probability that observed changes in biological condition at either the watershed or individual site scale are due to differences in climatic conditions between the two periods. It is worth noting that while summer averages were comparable, the spring of 2022 had severe flooding, and monitoring was slightly delayed during the summer of 2022 as water levels returned to normal.

Figure 8. Characterization of air temperature and rainfall conditions for May-September period across historical record for the Thief River Watershed. Biological monitoring years for the watershed highlighted in red.



Climate

The Thief River Watershed now receives on average 1.8 additional inches of rain from the historical average (1895-2018). Furthermore, climate scientists suggest that precipitation events are becoming more intense. In addition, temperatures in the watershed have increased by about one degree in spring and fall over this 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's. Increased streamflow's 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. The Thief River watershed has recently experienced harmful algal blooms, which haven't previously been documented in any systems across the watershed. These changes will complicate efforts to protect and restore the watershed. For more information, please see Climate Summary for Watersheds, Thief River.

For more information

This study of the Thief 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. Assessment decisions can be viewed on Minnesota's impaired waters list while data utilized in these decisions can be accessed through MPCA's surface water data web application. The watershed 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 Thief 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 Thief River webpage, or search for "Thief River" on the MPCA website.

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