Watershed assessment and trends update

Mustinka River Watershed

Red River of the North Basin

Summary

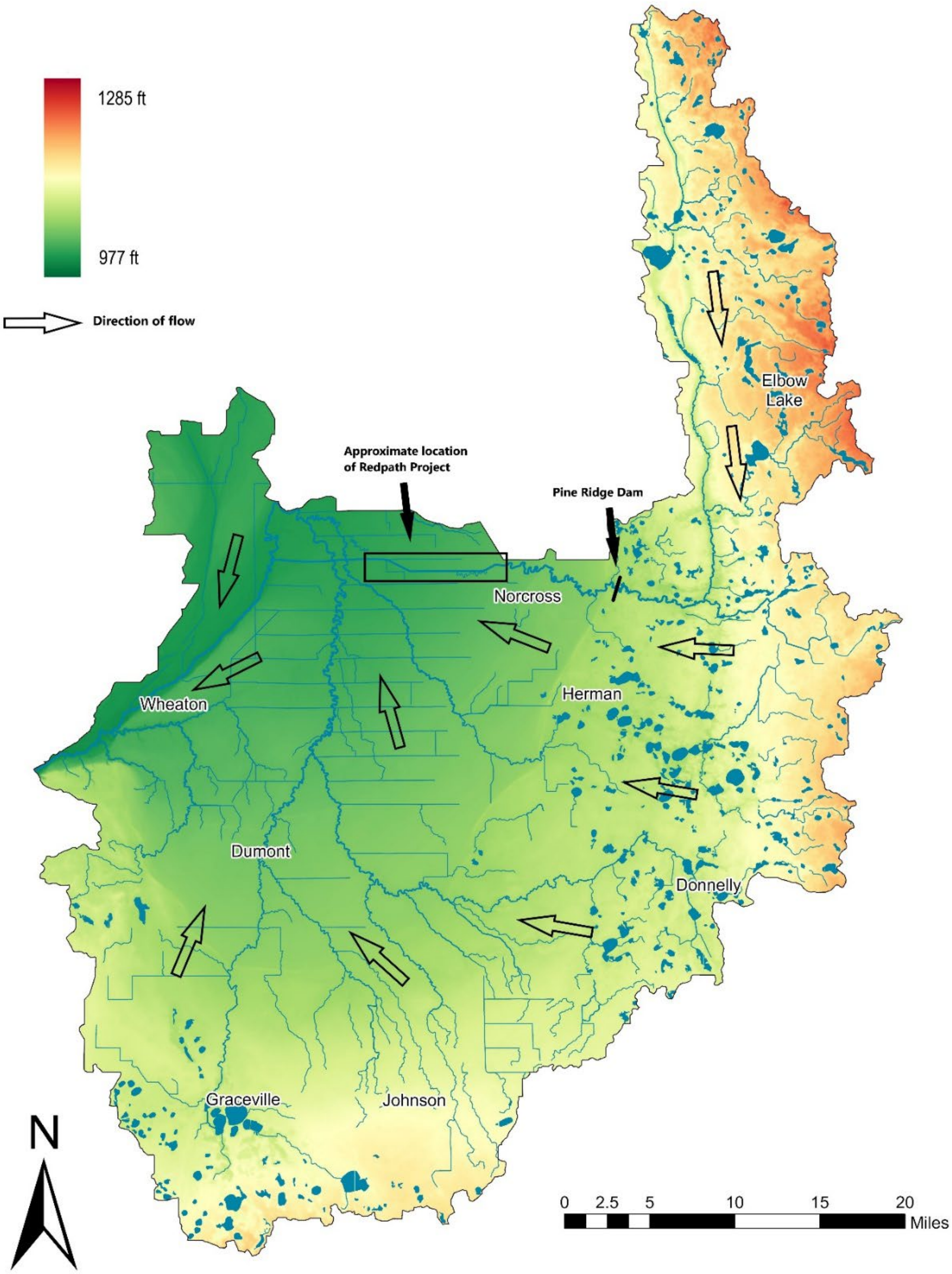
The Minnesota Pollution Control Agency (MPCA), Minnesota Department of Natural Resources (MNDNR), and partners have completed a study of the Mustinka River Watershed, which includes over 1,200 miles of watercourses (streams, rivers, and ditches) along with 188 lakes and 150 wetlands greater than ten acres in size within Big Stone, Grant, Otter Tail, Stevens, and Traverse Counties.

The headwaters of the Mustinka River are split between the North Central Hardwoods, Northern Glaciated Plains, and the eastern edge of the Lake Agassiz Plain Ecoregion where moraine deposits form gently rolling hills. Most of the watershed's lakes and wetlands are concentrated in this region. From its headwaters, the Mustinka River flows south and then abruptly west as it descends through a series of beach ridges into the Lake Agassiz Plain (Figure 1). The Mustinka River has been extensively straightened and channelized in the section of the watershed. East of Wheaton, the Mustinka River meets Twelvemile Creek and begins to flow the southwest where it meets Lake Traverse.

The Mustinka Watershed contains some of the most agriculturally productive land in the world, but due to the extremely flat topography of the Lake Agassiz Plain much of the watershed is prone to extensive flooding, particularly during spring snowmelt events. Since the arrival of white settlers to the area in the area in the mid to late 1800's, there have been a series of efforts to manage the landscape for agricultural production and mitigate flood risk. In 1883, the Minnesota legislature authorized county commissioners to construct public drainage ditches and an extensive campaign of ditching was undertaken in this watershed during the first half of the 1900's. More recently, subsurface tiling has become widespread in the watershed. Presently, 88% of the watercourses within this watershed are ditched/channelized and 84% of the land area has been developed for agricultural use. While this extensive alteration of the watershed's hydrology has reduced flood risk, and allowed for greater agricultural development, it has a dramatic impact on water quality. Nearly all the waterbodies assessed for aquatic life and/or aquatic recreation use in this study were found to be impaired with no improving or declining trend at the watershed scale.

This study relies on both chemical testing of the water and surveys of fish and macroinvertebrate (bug) communities living in the water. These multiple lines of evidence offer a more comprehensive understanding of the watershed's health over time. The assessment, which is funded by Minnesota's Clean Water Land and Legacy Amendment, also uses data collected by volunteer water quality monitors. Details in this report will shape decisions on watershed management and pollution reduction measures for years to come.

Figure 1. Flow in the Mustinka River Watershed proceeds from the elevated moraine deposits at its periphery, towards the flat Lake Agassiz Plain pictured in green.

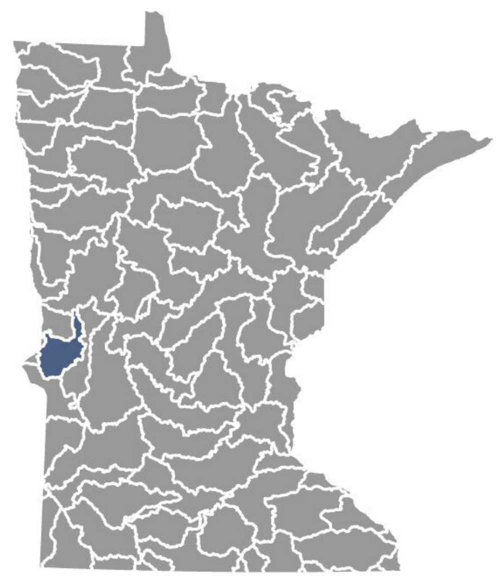


Watershed study

Water monitoring is essential to determining whether waterbodies (lakes, streams, and ditches) meet water quality standards. While local partners and state agencies monitor water quality on an ongoing basis, the MPCA and local partners conduct an intensive survey of lakes and streams in each of the state's 80 watersheds every ten years to detect any changes in water quality. In the Mustinka Watershed, the MPCA and local partners conducted this intensive monitoring in 2010-2011. The second round of intensive monitoring took place in 2021-2022, with biological sampling delayed in 2020 due to the COVID-19 pandemic and further delayed in 2021 due to severe drought conditions. Chemistry data collected by local partners between 2014 and 2023 were also used for assessment. The monitoring strategy focused on whether waterbodies met water quality standards that support aquatic life, recreation, and/or consumption use. Waters which fail to meet these use standards and were assessed as not supporting aquatic life, recreation, and/or consumption are considered impaired. The overall goal of these assessments is to determine which waters are healthy and may need protection or are polluted and require restoration. For more information on the MPCA's approach to water quality monitoring see the following links: Watershed Approach to Water Quality Minnesota's water quality Monitoring Strategy 2021 to 2031

Changes in water quality

Figure 2. The Mustinka River Watershed is one of 80 major watersheds within Minnesota.



Over the past decade, scientists observed little change in water quality in the Mustinka River Watershed. While the biological condition of individual streams may have improved or declined between 2010 and 2022, the biological condition of assessed fish and macroinvertebrate communities on a watershed scale did not change over this period. Continued water quality findings include excess bacteria levels, excess 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 there is some routine water monitoring in the Mustinka River Watershed that occurs every year, the MPCA and local partners conduct an intensive survey of lakes and streams in the watershed every ten years.

To detect changes in water quality, this intensive survey looks at fish and macroinvertebrate communities as well as water chemistry. The MPCA uses the data to determine which waters are healthy and may need protection, and which are polluted and need restoration.

- There was no significant change detected in the in the health of assessed fish and macroinvertebrate communities on a watershed-wide scale.
- Fish index of biological integrity (IBI) scores improved by an average of 11 points on reaches of the Mustinka River that were monitored in both in 2010 and in 2021-22 (Figure 7).
- Water clarity is declining at all three locations where clarity datasets were collected upstream of Norcross. The entire length of the Mustinka River below Lightning Lake is assessed as impaired for aquatic life use due to excess turbidity.

- East Toqua Lake, Lannon Lake, and Lightning Lake were assessed as impaired for aquatic recreation use in 2014 due to a combination of excess phosphorus, and the exceedance of a eutrophication response parameter (low water clarity via Secchi disk or high chlorophyll-a concentration). Limited samples collected from these lakes since 2014, continue to support the existing aquatic recreation use impairment.

Highlights of monitoring

- Nearly all the waterbodies assessed for aquatic life or aquatic recreation use within the watershed were found to be impaired (Figure 6).
- 16 waterbodies have been monitored for macroinvertebrates in the Mustinka River Watershed, 14 of which are assessed as impaired for aquatic life use due to low macroinvertebrate index of biological integrity (IBI) scores.
- The entirety of the Mustinka River from its headwaters to the dam at Pine Ridge Park is assessed as impaired for aquatic life use due to low dissolved oxygen.
- Twelvemile Creek produced the highest average dissolved orthophosphate phosphorus and the second highest normalized total phosphorus flow-weighted mean concentrations of any WPLMN station within the MPCA's statewide watershed pollutant load monitoring network.
- The dam on the Mustinka River at Pine Ridge Park is a barrier to fish passage from the Lower Mustinka River to its headwaters. Below the dam, the MPCA observed 31 species of fish, while above the dam, the only 15 species were observed (Table 1).
- The Mustinka River below the dam at Pine Ridge Park continues to support diverse and relatively healthy fish communities. Several species of game fish have consistently been collected from the lower reaches of the Mustinka River including Bluegill, Channel Catfish, Largemouth Bass, Northern Pike, Walleye, White Bass, White Crappie, and Yellow Perch.

MPCA Biologists surveyed the fish population within Traverse County Ditch 42 and found several large Channel Catfish within the 26–30-inch range.

- The MPCA collected numerous Channel Catfish, ranging from 26 to 30 inches long from Traverse County Ditch 42 (TCD 42). These large-bodied fish require adequate fish passage to freely migrate between tributaries and the deeper water found downstream in the Mustinka River and Lake Traverse. The MPCA also collected Hornyhead Chub and Rock Bass from TCD 42. These fish are considered intolerant of pollution and environmental stress due to their specific habitat requirements (e.g., clean gravel substrates, low turbidity, availability of cover). Presence of these species is indicative of healthy fish community.
- The MNDNR collected a total of ten fish species in Cottonwood Lake during fish IBI sampling. Most of the species collected are tolerant of degraded conditions and indicative of a fish community vulnerable to impairment (e.g., Black Bullhead and Fathead Minnow).
- The Bois de Sioux River Watershed District has replaced a failing outlet structure on Lightning Lake with a series of rock riffles and two new box culverts. These improvements will reduce flood risk, reduce erosion, and improve fish passage to and from the Mustinka River.


Aerial photo of the paired box culvert and riffle improvements on the outlet of Lightning Lake 11/10/2023

Success story

In the early 20th century, a 46-mile stretch of the Mustinka River just west of Norcross was legally ditched with the goal of reducing the frequency of overland flooding to the Rabbit River drainage. This ditched section of the Mustinka, now known as Judicial Ditch 14 (JD 14), cut the length of the Mustinka River by 18 miles, failed to reduce flooding, and destabilized the river channel.

In the spring of 2022, The Bois de Sioux River Watershed District and Moore Engineering began construction of the Redpath Flood Impoundment & Mustinka River Rehabilitation Project. The Redpath project aims to re-meander a five-mile stretch of JD 14 just west of Norcross while creating 23,000-acre feet of storage to reduce overland flooding and decrease peak flows to Lake Traverse and the Red River of the North. The re-meandered section of the Mustinka River will parallel the old JD 14 channel which will be utilized as a spillover channel in times of high flow. Ten miles of perimeter levees are being constructed around both JD 14 and the newly re-meandered channel. Within the bounds of the levees, a 300-foot-wide wildlife corridor will parallel the remaindered channel. Outside of the wildlife corridor, farmlands within the impoundment will be leased for agriculture and will help to pay for the cost of maintenance/operation of the project.

The Redpath Project is also designed to benefit aquatic life in the Mustinka River. Within the re-meandered channel, banks have been armored with imbedded wood to reduce erosion. Rock features have also been added to improve depth variability and add habitat complexity beneficial to both fish and macroinvertebrate communities. At the outlet of the levee system, openings will allow for fish to pass in and out of the re-meandered channel.

The Mustinka River is currently impaired for aquatic life use (low macroinvertebrate IBI scores, low dissolved oxygen, high turbidity levels), and aquatic recreation use (excess *E. coli* levels) both within and below boundaries of the Redpath Project. The MPCA will continue to track water quality progress related to this ongoing work. Construction on the Redpath Project is set to be completed in 2026, but is dependent on state funding.

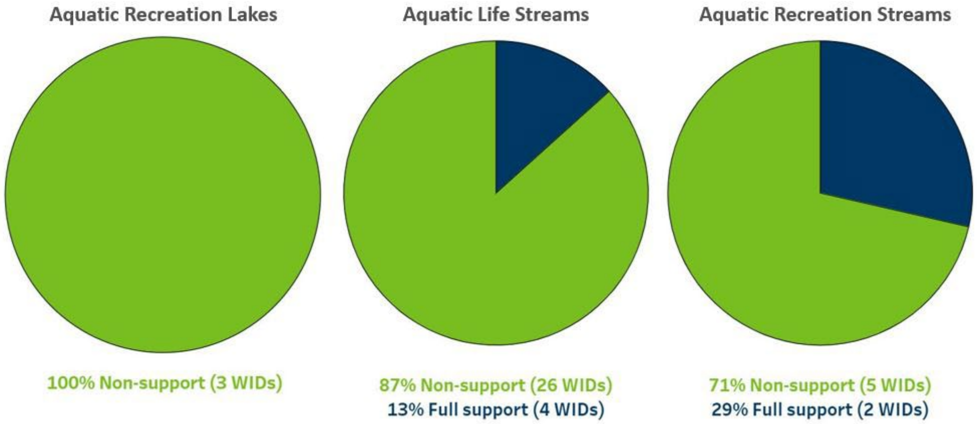
Redpath Impoundment groundbreaking ceremony in September of 2023. The re-meandered channel is visible on the left and the JD14 channel is visible on the right.

Watershed assessment results

Streams and rivers

Of the stream reaches in the Mustinka River Watershed that were assessed for aquatic life use, 87% are impaired. High turbidity levels, low dissolved oxygen, and excess nutrient levels are common across the watershed and fish and macroinvertebrate communities are significantly degraded, with a few exceptions. Five of the seven stream reaches assessed for aquatic recreation use are impaired due to excess *E. coli* levels.

Figure 3. Mustinka River Watershed assessment results for aquatic life use in streams and aquatic recreation use in streams and lakes. Aquatic life use was assessed in one lake within this watershed but was found to be inconclusive.



Compared to the rest of the watershed, the headwaters of the Mustinka River have been less intensively developed for agriculture. Many of the lakes and wetlands in the watershed are located within its headwaters and much of the Mustinka River in this region retains its natural sinuosity. Despite this more natural condition, agricultural development is still the predominant land use. The implementation of subsurface tiling has increased substantially in the last 15-20 years throughout the Red River Basin. Tiling is designed to remove water from saturated agricultural land and, when implemented at scale, can increased peak flows in the streams and ditches where it discharges and contribute to the destabilization of stream/ditch channels. The Mustinka River watershed also receives on average an additional 1.9 inches of rain per year when compared with the historical average (1895-2018), further exacerbating the impacts of agricultural development. The headwaters of the Mustinka River are also stressed by natural factors, as soils are naturally high in nutrients, and streams are subjected to low dissolved oxygen conditions, partially due to the influence of this region’s many wetlands and relatively low gradient. The combination of these natural and anthropogenic factors has resulted in impairments for both aquatic life use (low dissolved oxygen, low fish and macroinvertebrate IBI scores) and aquatic recreation use (excess E. coli) above Lightning Lake. Below Lighting Lake, the Mustinka River is also impaired aquatic life (Low dissolved oxygen, excess turbidity, low fish, and macroinvertebrate IBI scores) and aquatic recreation (excess E. coli).

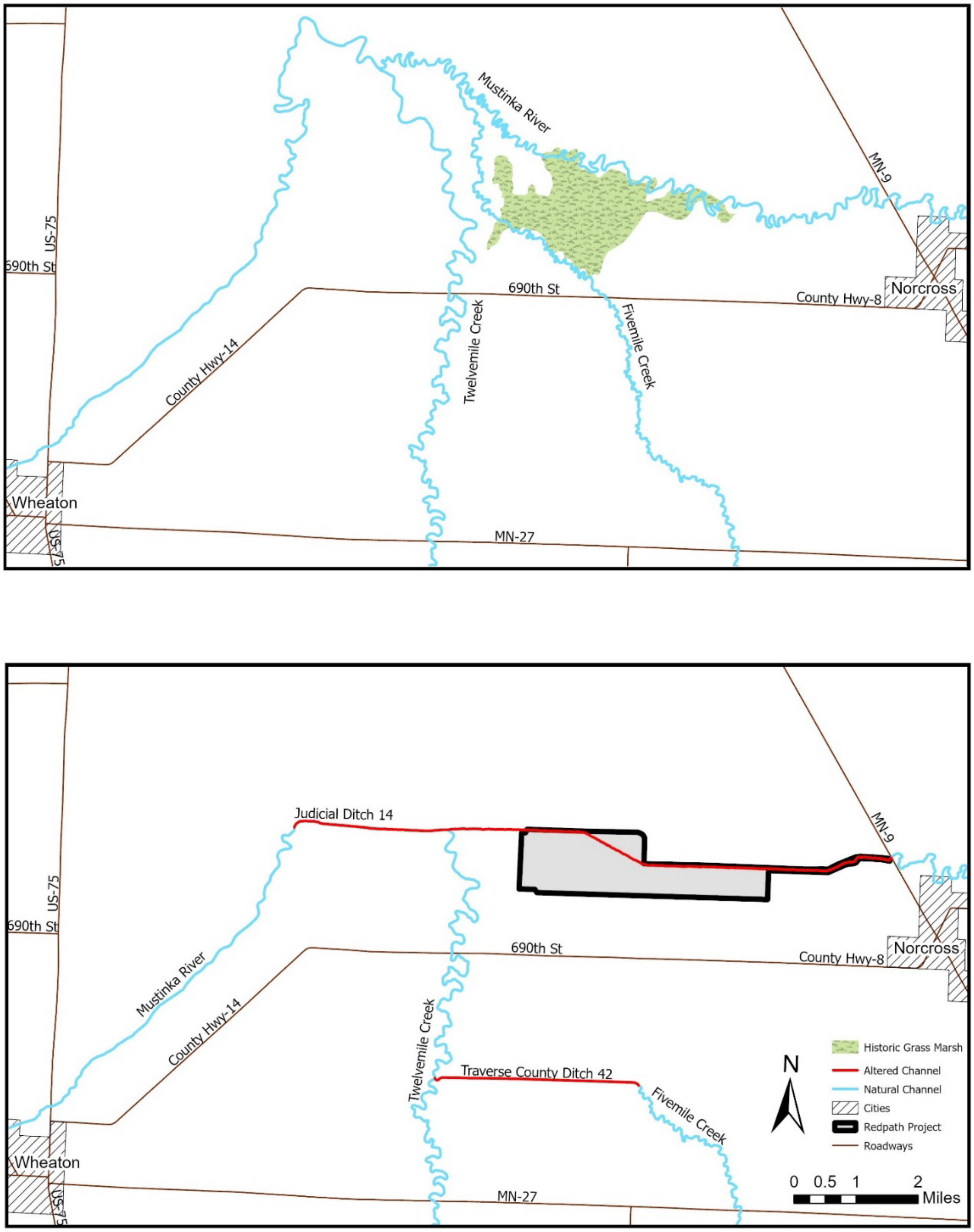
Further downstream, the Mustinka River abruptly turns west and increases in gradient as it drops towards the heart of the Lake Agassiz floodplain. Water clarity in this section of the Mustinka River is declining and fish and macroinvertebrate communities are in degraded condition. At Pine Ridge Park, the Mustinka River is dammed to create an impoundment. This dam presents a major barrier to fish passage from the lower Mustinka River to its headwaters. The MPCA observed 31 species of fish below the dam, but only 15 species of fish have been observed above the dam, all of which were observed below the dam as well (Table 1). Of the 15 species of fish observed above the dam, Bluegill, Largemouth Bass, White Crappie, and Yellow Perch were not collected in MPCA streams surveys and have only been observed in lakes. A loss of diversity of this magnitude is detrimental not only to the fish communities themselves, but to the richness and integrity of the entire ecosystem within the headwaters of the Mustinka River.

Table 1. Comparison of the fish diversity observed above and below the Pine Ridge Dam. Underlined species have not been recorded in the Mustinka River above the Pine Ridge Dam but have been collected within connected lakes.

Species observed only below the Pine Ridge Dam (16)	Species observed both above and below the Pine Ridge Dam (15)
Bigmouth Buffalo, Carmine Shiner, Channel Catfish, Common Shiner, Emerald Shiner, Freshwater Drum, Golden Redhorse, Hornyhead Chub, Johnny Darter, Orangespotted Sunfish, Quillback, Rock Bass, Sand Shiner, Shorthead Redhorse, Smallmouth Bass, White Bass	Black Bullhead, Black Crappie, Bluegill, Brook Stickleback, Common Carp, Fathead Minnow, Green Sunfish, Iowa Darter, Largemouth Bass, Northern Pike, Walleye, White Crappie, White Sucker, Yellow Bullhead, Yellow Perch

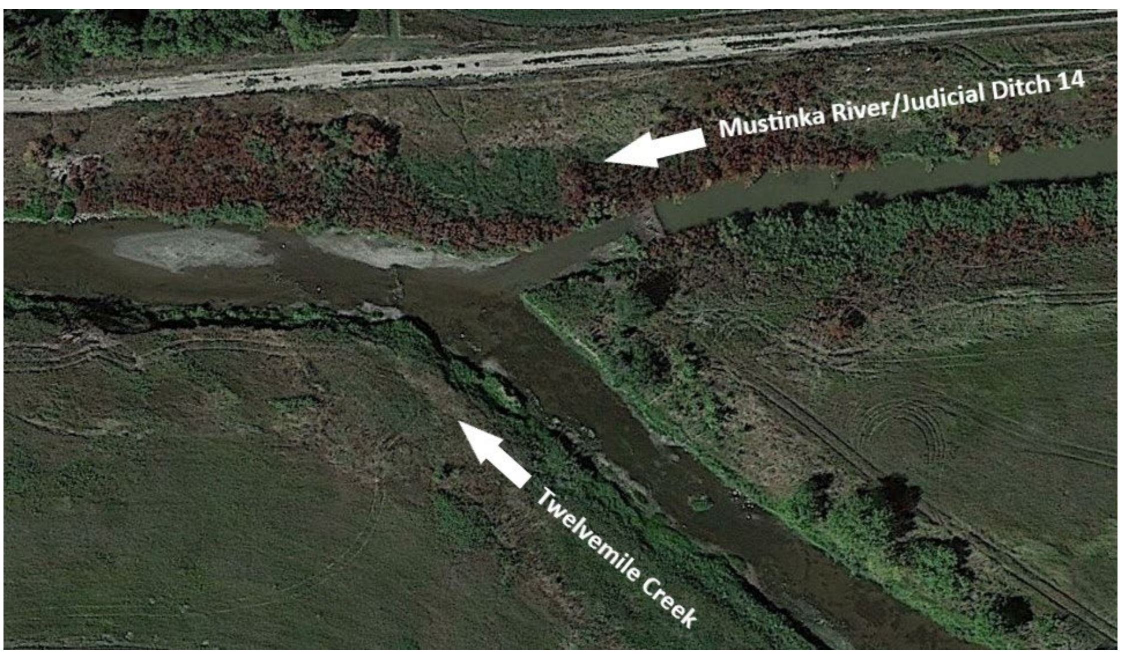
Downstream of the Pine Ridge Dam, overland flooding from the Mustinka River is a major threat to life, property, agricultural productivity, and water quality. To reduce the intensity of these floods and increase agricultural production, a 46-mile stretch of the Mustinka River just west of Norcross was legally ditched during the first half of the 20th century. This ditched section of the Mustinka, now known as Judicial Ditch 14 (JD 14), cut the length of the Mustinka River by 18 miles, but failed to reduce flooding, and further destabilized the river channel. In 2022, the Bois de Sioux River Watershed District began construction of the Redpath Flood Impoundment and Mustinka River Rehabilitation Project to address channel instability concerns in this stretch of river while creating significant flood storage capacity.

Figure 4. Comparison of the channels of the Mustinka River, Fivemile Creek, and Twelvemile Creek before and after ditching during the first half of the 20th century. Historically, a nearly six square mile grass marsh occupied the area where Fivemile Creek and the Mustinka River meet. This area is now largely occupied by the Redpath Project.



Historically, much of the area within the Redpath Impoundment was occupied by a nearly six square mile grassy marsh where the Mustinka River's two largest tributaries, Twelvemile and Fivemile Creek, joined the Mustinka River. These tributaries joined the Mustinka within 1.2 miles of each other, and given access to their floodplains, would have flooded the marsh during high flow events. The creation of Traverse County Ditch 42 (TCD 42) disconnected Fivemile Creek from the Mustinka River, shortening its length by 11.5 miles and connecting it with Twelvemile Creek eight miles upstream of its confluence with JD 14 (Figure 4). Twelvemile Creek, downstream of its confluence with TCD 42, now receives water from an additional 100 square miles of land which once drained through Fivemile Creek to the Mustinka River and at its confluence with the Mustinka River, the Twelvemile Creek contributing watershed (521 square miles) is now more than two times the size of the Mustinka River Watershed (200 square miles). As a result, the lower eight miles of Twelvemile Creek are experiencing severe erosion and bank instability (Figure 5). This stretch of Twelvemile Creek is impaired for aquatic life use (excess nutrients and turbidity, and low fish and macroinvertebrate IBI scores) and aquatic recreation use (excess *E. coli*). Total phosphorus measurements, were modeled at over 300% higher than the established aquatic life use standard at this location. Paired with dissolved oxygen flux exceedances observed in 2020 and 2022, these excessive levels of phosphorus represent a particularly significant source of stress to aquatic life in this stretch of Twelvemile Creek. Of the ten watercourses assessed for aquatic life use in the Twelvemile Creek drainage, only TCD 42 remains unimpaired.

Figure 5. The confluence between the Mustinka River/Judicial Ditch 14 and Twelvemile Creek is pictured in August of 2022. Bank sloughing and mid channel bars indicate very poor channel stability. At their confluence, Twelvemile Creek has a contributing drainage of 521 square miles, while the Mustinka River has a contributing drainage of 200 miles.



Near its confluence with the Lake Traverse, the Mustinka River is impaired for aquatic life use due to low dissolved oxygen, excess turbidity, and low macroinvertebrate IBI scores. Despite these stressors, fish communities in the lower reaches of the Mustinka River remain in good condition. A variety of game fish are found in this stretch of Mustinka River including Bluegill, Channel Catfish, Largemouth Bass, Northern Pike, Walleye, White Bass, White Crappie, and Yellow Perch. Anglers frequent this lower stretch of the Mustinka and value its diverse fish community.

Lakes

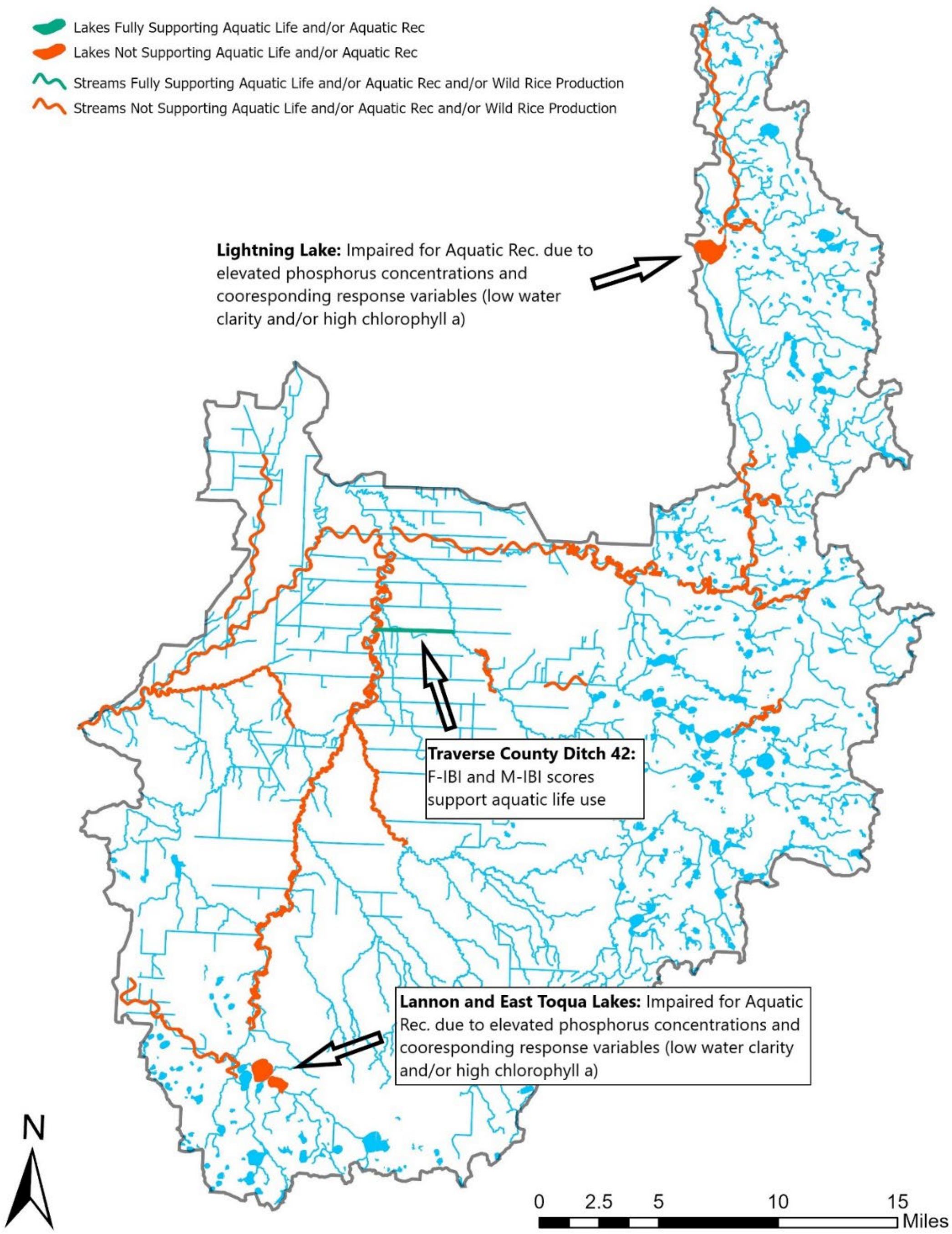
Excess algal growth or a related loss of water clarity may impair the recreational suitability of a lake. For this reason, the MPCA relies on an ecoregion-based eutrophication standard to determine whether a lake meets its aquatic recreation use. Excessive nutrient concentrations, in particular total phosphorus (TP), may lead to increased algae blooms under certain conditions (i.e., sunlight, warm weather). If nutrient concentrations exceed parameter-level standards, the MPCA utilizes water clarity data (Secchi disk), and/or algal growth data (chlorophyll-a) to determine if excess nutrients have resulted in a eutrophication response sufficient to trigger an aquatic recreation impairment.

Most lakes in this watershed area are naturally shallow and high in nutrients. Disturbances in the form of shoreline development, additional nutrient inputs from agriculture, or loss of connectivity can quickly create eutrophic conditions. Three lakes - East Toqua Lake, Lannon Lake, and Lightning Lake – are currently impaired for aquatic recreation use due to excess total phosphorus levels and either diminished water clarity measured using secchi disk readings (East Toqua and Lannon Lake) or elevated chlorophyll-a concentration (Lightning Lake). Total phosphorus, Secchi disk, and chlorophyll-a data collected in 2017 corroborates the existing aquatic recreation use impairment on Lightning Lake.

Cottonwood Lake is the only lake in the Mustinka River Watershed that was assessed for aquatic life use. A total of ten fish species were collected during fish IBI sampling in 2018, most of which are tolerant of degraded conditions and indicative of an impaired fish community. High nutrient levels, low water clarity, and a lack of submerged plant community are identified as major stressors. Despite this evidence of stress, Cottonwood Lake is assessed as inconclusive for aquatic life. The inconclusive assessment is an acknowledgement that, while F-IBI performance indicates impairment, the fish community likely does not adequately represent the biological potential of the lake. In October of 1996, Cottonwood Lake was treated rotenone and subsequently stocked with Walleye and Northern Pike fry, adult Largemouth Bass and Black Crappie in the spring of 1997. The outlet is being managed as a migration barrier for Common Carp, as such limiting recolonization of other species from the downstream watershed. Additionally, a barrier was constructed at the inlet to prevent gamefish from moving upstream of the lake.

The Bois de Sioux River Watershed District has replaced a failing outlet structure on Lightning Lake with a series of rock riffles and two new box culverts. These improvements will reduce flood risk, reduce erosion, and improve fish passage to and from the Mustinka River.

Figure 6. Assessment results for aquatic life and aquatic recreation use within the Mustinka River Watershed.



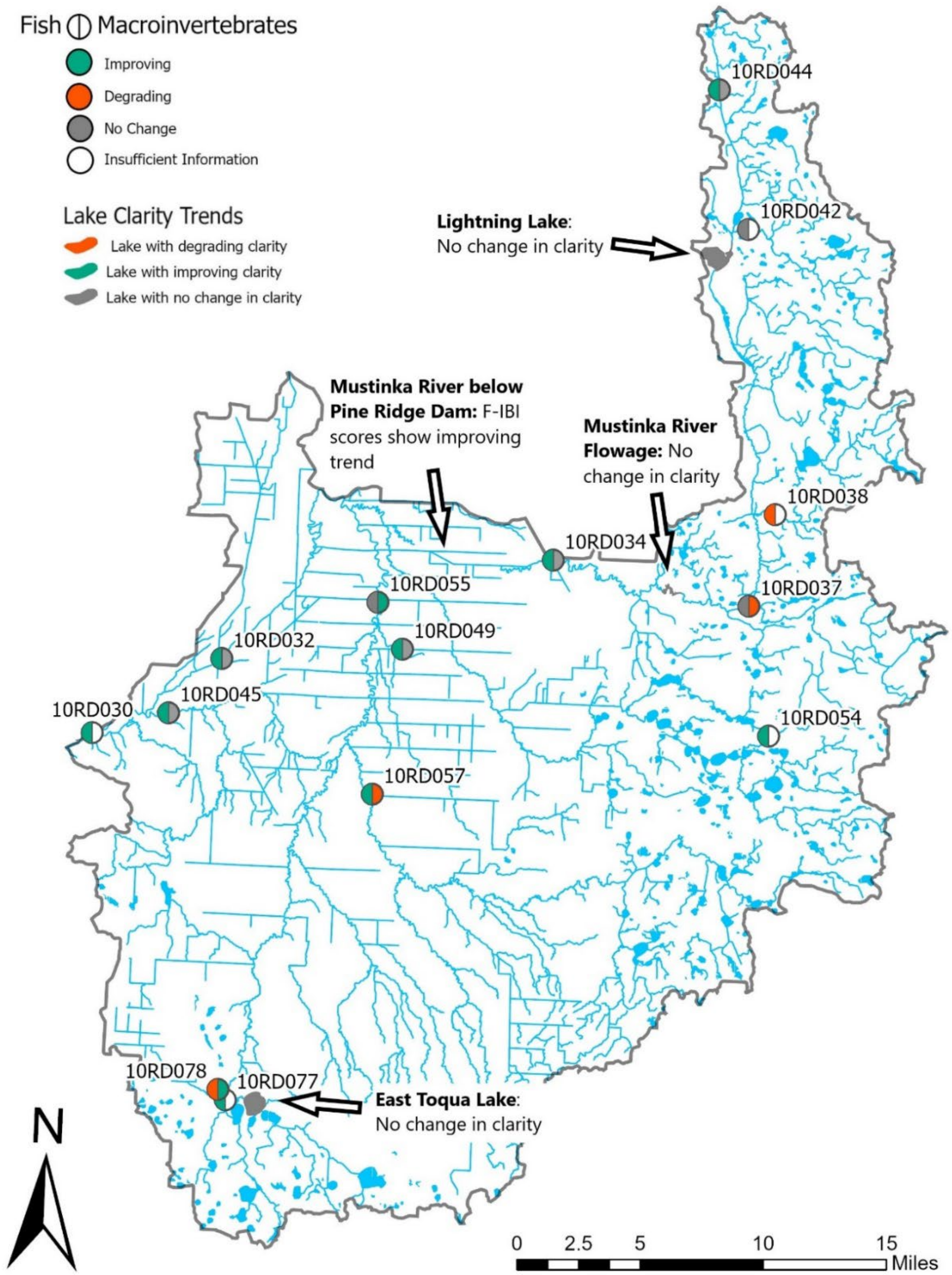
Trends

A key objective of the 2021-2022 monitoring effort was to evaluate if and how water quality has changed since 2010 (Figure 7). 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 any improvement. It is equally important to understand if there is no change or a declining trend in water quality. Either way, the knowledge will help inform future water quality management activities.

Trends in four different aspects of water quality were analyzed to determine if environmental conditions are changing in the Mustinka River Watershed:

1) Streamflow and pollutant concentrations
2) Biological communities
3) Clarity of lakes
4) Climate

Figure 7. Water quality parameter trends in the Mustinka River Watershed. The right half of the symbols represent macroinvertebrate IBI trend, and the left half of the symbols represent fish IBI trend.



Streamflow and pollutant concentrations

In addition to the intensive monitoring completed every ten years, approximately 200 Watershed Pollution Load Monitoring Network (WPLMN) sites are operational year-round across Minnesota. At these sites, streamflow data collected in collaboration with the United States Geological Survey (USGS) and the MNDNR is paired with water chemistry data collected by state and federal agencies, Metropolitan Council Environmental Services, state universities, and local partners. This combination of regular streamflow and pollutant monitoring is crucial for conducting trend analysis, assessing year-over-year variations, and identifying pollutant sources and their contributions. Three WPLMN sites are currently established in the Mustinka River Watershed (Table 2).

Table 2. WPLMN sites within the Mustinka River Watershed. Samples are collected by a local partner, the International Water Institute (IWI). Lab parameters are total suspended solids (TSS), total phosphorus (TP), nitrate+ nitrite nitrogen (NOX), total Kjeldahl nitrogen (TKN), and dissolved orthophosphate phosphorus (DOP). *DOP was collected at other sites in the past but is currently only collected at Mustinka River near Wheaton.

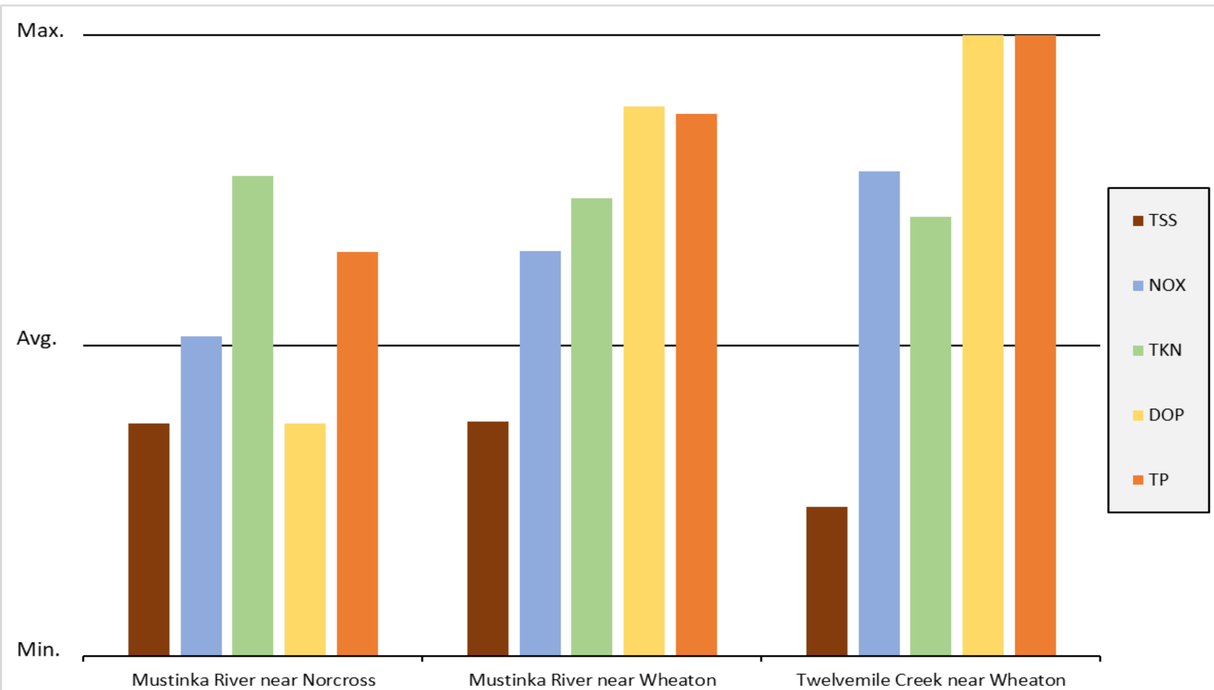
Site name (WISKI_ID)	Streamflow data available	Pollutant concentration data available	Sample collection	Lab parameters
Mustinka River near Norcross (H55044003)	2012-current (MNDNR)	2013-current	20-25 samples collected per year from ice out to Oct 31 by IWI.	TSS, TP, NOX, TKN
Twelvemile Creek near Wheaton (H55065001)	2014-current (MNDNR)	2014-current	20-25 samples collected per year from ice out to Oct 31 by IWI.	TSS, TP, NOX, TKN
Mustinka River near Wheaton (H55064003)	2011-current (MNDNR)	2011-current	28-35 samples collected year-round by IWI.	TSS, TP, NOX, TKN, DOP*

The length of streamflow data in the Mustinka River Watershed is relatively short and limits trend analysis. However, streamflow at the White Rock Dam, located directly downstream of Lake Traverse on the Bois de Sioux River, does show a statistically significant increasing streamflow trend. As most of the flow contributed to the Bois de Sioux River comes from the Mustinka River Watershed, it is likely that the increasing streamflow trend observed at the White Rock Dam is also present in the Mustinka River Watershed. A likely increase in streamflow in the Mustinka River and its tributaries 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.

Water samples collected at WPLMN sites are analyzed for pollutants that are known to have an impact on water quality (Table 2). Combining sampled pollutant concentrations with streamflow data allows for the calculation of a flow-weighted mean concentration (FWMC) and total pollutant load. Loads represent the total amount of a pollutant moving through a system. FWMCs are important when considering the impact of pollutants on downstream resources such as Lake Traverse, the Red River of the North and Lake Winnipeg where these pollutants may accumulate. These statistics can also be used to determine what the water quality is like on average, allowing for the equal comparison between watersheds differing in size or streamflow volume.

Compared to other WPLMN sites in the Red River Basin, most of the FWMCs in the Mustinka River Watershed are above the basin average (Figure 8). TSS is the only parameter that is below the basin average for all Mustinka River Watershed WPLMN sites. On a statewide scale, FWMCs are varied among the parameters. TSS and NOX are among the lowest FWMCs in the state while TKN, TP, and DOP are among the highest. Twelvemile Creek appears to contribute higher FWMCs of NOX, TP, and DOP when compared the Mustinka River. It also has the highest DOP and second highest TP FWMC when compared to all other WPLMN sites in the Red River Basin and the rest of the state. Less than five miles downstream after the confluence, the Mustinka River near Wheaton has noticeably higher concentrations compared to the upstream site at Norcross, possibly due to the contributions of Twelvemile Creek.

Figure 8. The graph compares normalized FWMC data from the 43 total WPLMN sites in the Red River Basin to the sites in the Mustinka River Watershed. The y-axis is scaled in terms of maximum, average, and minimum for each lab parameter in the basin. For example, a maximum value would indicate that site has the highest FWMC in the Red River basin.



To determine if sample pollutant concentrations experienced statistically significant changes over time, a seasonal Mann-Kendall trend test was applied to TSS, TP, and NOX data at the furthest downstream WPLMN station in the watershed (Mustinka River near Wheaton). This site did not show a statistically significant change for any of the sample pollutant concentrations or didn't meet the data requirements to perform the test. More information regarding the WPLMN program can be found at: https://www.pca.state.mn.us/water/watershed-pollutant-load-monitoring

Biological communities

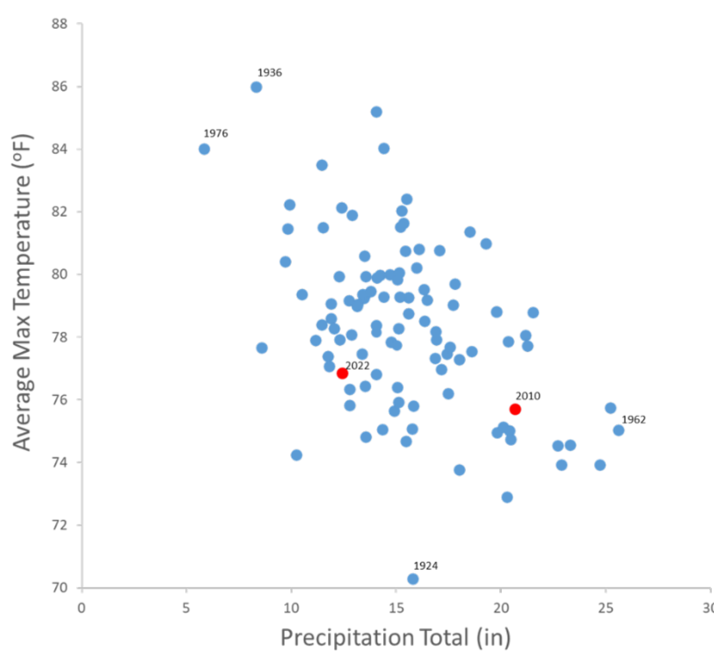
Paired t-tests of fish and macroinvertebrate IBI scores were used to evaluate if the biological condition of the watershed's assessed rivers and streams has changed between sampling in 2010 and 2021-22. Independent tests were performed on each community with nine sites evaluated for macroinvertebrates and 14 sites evaluated for fish (sites that were sampled in both time periods). The average macroinvertebrate IBI score for the watershed decreased by 1.5 points between 2010 and 2021-22, this however does not represent a statistically significant change. Fish IBI scores in the Mustinka River Watershed increased by 5.6 points, which was also not statistically significant.

Despite a lack of statistically significant watershed IBI trend, Twelvemile Creek above its West Branch and the Mustinka River just above the Pine Ridge Dam showed a significant decline in macroinvertebrate IBI score between 2010 and 2021-22. Scores at these sites declined by 14 and 18 IBI points respectively, which corroborates existing aquatic life use impairments at both locations. Judicial Ditch 4 and Twelvemile Creek, below its confluence with TDC 42, both showed statistically significant improvement in macroinvertebrate IBI score. Scores at these sites improved by 11 and 20 IBI points respectively.

Fish IBI scores improved at 12 of the 15 sites sampled in both 2010 and 2021-22. Substantial improvements (over ten IBI points) were observed at nine of these sites including four on the Mustinka River, and one of each on Eighteenmile Creek, Traverse County Ditch 42, Tributary to Niemackl Lakes, Judicial Ditch 4 B6, and Twelvemile Creek. None of these improvements resulted in the delisting/correction of an existing aquatic life impairment. As there appears to be little change in other water quality parameters (e.g., dissolved oxygen, nutrients, and turbidity largely continue to indicate impaired aquatic life use), it is possible that fish and macroinvertebrate communities are responding to seasonal/annual variations in flow.

In 2010, the Mustinka River Watershed experienced above normal rainfall (+4.5 in) with abnormally cool temperatures (-2.6°F) during the time that the biological surveys were being conducted (May to September). In comparison, the watershed was in a moderate to severe drought for the majority of the summer in 2021 (-3.5 in), forcing biological monitoring activities to be suspended until the following summer. Stream flows during the summer of 2022 returned to near normal conditions primarily because of above normal winter precipitation, lessening the impacts of another summer with below normal rainfall. Overall, given the wet/cool conditions affecting the watershed in 2010 and the drought conditions present during monitoring in 2021-22, there is a high likelihood that 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 periods.

Figure 9. Characterization of air temperature and rainfall conditions for May-September period across historical record for the Mustinka River Watershed. Biological monitoring years for the watershed highlighted in red.



Clarity of lakes

Three lakes in the Mustinka River Watershed meet the data requirements for a water clarity trend analysis (50 Secchi measurements, eight years of data). Lightning Lake, East Toqua Lake, and the Mustinka River Flowage show no significant trends in water clarity within the last ten years. However, while the Mustinka River Flowage shows no trend in water clarity, the Mustinka River itself is impaired for turbidity and water clarity is declining at all three locations where clarity datasets were collected upstream of Norcross.

Climate

The Mustinka River Watershed now receives on average 1.9 additional inches of rain from the historical average (1895-2018). Furthermore, climate scientists suggest that precipitation events are becoming more intense. In addition, air temperatures in the watershed have increased by about 1.1° F 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 streamflows. 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. These changes will complicate efforts to protect and restore the watershed. MNDNR climate summary for the Mustinka River Watershed

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For more information

This study of the Mustinka 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 Mustinka 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 on assessment decisions and reports, go to the MPCA Mustinka River webpage, or search for "Mustinka River" on the MPCA website.

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