Watershed assessment and trends update

Big Fork River Watershed

Rainy River Basin

Summary

The Minnesota Pollution Control Agency (MPCA), Minnesota Department of Natural Resources (MNDNR), Leech Lake Band of Ojibwe (LLBO), and local partners have completed a study of the Big Fork River Watershed. Instead of relying on chemical testing of the water alone, scientists reached their conclusions through studying the variety of fish and aquatic insects living in these waters. Doing so offers a more comprehensive understanding of the watershed's health over time. Volunteer water quality monitors contributed to the assessment, which is funded by Minnesota's Clean Water Land and Legacy Amendment. Details in the full report will shape decisions on watershed management and pollution reduction measures for years to come.

The Big Fork River originates from Dora Lake and flows 165 miles before emptying into the Rainy River. The watershed contains over 100 tributary streams and 98 lakes greater than 100 acres in size. These pristine, often remote waters are an important resource used for recreational activities such as fishing, swimming, boating, and hunting. Some of these waters are within the Leech Lake and Bois Forte Reservations.

Healthy fish and macroinvertebrate (aquatic insect) communities were found throughout the watershed. Most lakes and streams met water quality standards designed to protect aquatic life. Large stretches of the Big Fork River, the headwaters of the Rice River, and eight lakes have been identified as exceptional resources because they support such high-quality aquatic communities. High levels of turbidity and total suspended solids were found on some sections of the Big Fork River; however, healthy fish and macroinvertebrates were still found in these reaches.

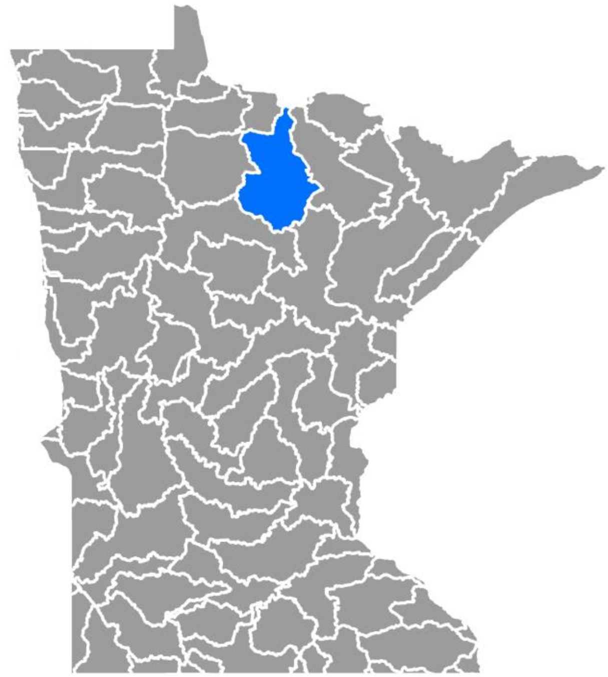
Most lakes and streams met water quality standards designed to protect aquatic recreation (i.e., swimming). High amounts of bacteria were found in the Bowstring River and Bear River; additional monitoring will be conducted to determine the source. Six lakes failed to meet regional standards for nutrients, chlorophyll-A, and/or transparency. Five of these were previously known impairments that were confirmed by recent monitoring data. Dunbar Lake was the only waterbody newly listed for an aquatic recreation impairment. Several of the lakes that are impaired for aquatic recreation are within the Leech Lake Reservation and under the jurisdiction of the Leech Lake Band of Ojibwe. The LLBO Division of Resource Management (DRM) is currently conducting a paleolimnological study to develop specific standards for these water bodies. The development of restoration and protection strategies for this watershed are crucial for protecting such an incredible resource.

Watershed study

Water quality monitoring is essential to determine whether lakes and streams meet water quality standards designed to ensure that waters are fishable and swimmable. 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 (Figure 1). This intensive monitoring looks at fish and macroinvertebrate communities as well as water chemistry to gauge water quality. The data are used to determine which waters are healthy and need protection and which are impaired and need restoration. Waters are considered impaired if they fail to meet water quality standards.

The MPCA and partners monitored water quality conditions within the Big Fork River Watershed in 2010-2011 and again in 2021-2022. Chemistry data collected by local partners between 2012 and 2021 were used for assessment. The data were used to assess the condition of waterbodies, with a focus on whether they are meeting water quality standards for aquatic life, recreation, and consumption. The overall goal of these assessments is to ultimately determine which waters are healthy and in need of protection or are polluted and require restoration.

Figure 1. The Big Fork River Watershed (highlighted in blue) is one of 80 major watersheds within Minnesota.



Changes in water quality

Over the past decade, scientists observed little change in water quality within the Big Fork River Watershed. Most waterbodies continued to exhibit excellent water quality that supports aquatic recreation and aquatic life. In fact, between 2010 and 2021 the condition of macroinvertebrate communities in the watershed improved slightly. Large tracts of forested land, combined with numerous wetlands and little development, have helped maintain these high-quality aquatic resources. Overall, sediment and nutrient levels throughout the watershed remained low; however, excess nutrients (phosphorus) were still an issue in lakes with previous known impairments.

- During the last ten years, there has been a significant improvement in the condition of the macroinvertebrate community. These changes were most evident at sites located on the Big Fork River.
- The recent monitoring data confirmed the existence of previous known aquatic recreation impairments on the following lakes: Bowstring, Shallow Pond, Jessie, Island, and Round.
- For the 46 lakes with long-term trends in water clarity, 11 (24%) are seeing improvements in water clarity, 5 (11%) are degrading, and 30 (65%) are showing no change.
- Some reaches of the Big Fork River experienced high levels of suspended sediment, especially after large rain events or ice out. However, these periods of high turbidity did not appear to have adverse effects on aquatic life, as the fish and macroinvertebrate communities in these reaches were exceptional.

MPCA scientists monitored the fish and macroinvertebrates, along with several water quality parameters, in the Big Fork River Watershed as part of the statewide effort to gauge the health of major lakes and rivers.

Ice out on the Big Fork River, at Big Falls. High levels of suspended sediment occur in some sections of the Big Fork River during ice out. Photo by Koochiching SWCD.

Highlights of monitoring

- A total of 38 fish species were collected in lakes during the fish community surveys. Of these, 13 are considered intolerant species, meaning they're more susceptible to pollution and watershed disturbance. Burbot and Cisco (Tullibee) are considered coldwater species, requiring cold, oxygenated water to survive. Least Darter and Northern Sunfish are considered State Species of Concern and the Pugnose Shiner is State Threatened.
- The Big Fork River continues to support high-quality fish and macroinvertebrate communities. Fish species found here include lake sturgeon, muskellunge, smallmouth bass, burbot, and river darters – all species that are intolerant to pollution.
- A severe drought during 2021 resulted in very low water levels, with many tributary streams becoming intermittent. As a result, some biological surveys on streams and rivers were postponed until 2022.
- Exceptional fish communities were found in 12 of the 39 fish samples (31%) collected from streams and rivers. The highest FIBI scores were from the Big Fork River, Rice River, Sturgeon River, and Turtle River.
- Exceptional macroinvertebrate communities were found in 22 of the 41 macroinvertebrate samples (54%) collected from streams and rivers. Sixteen (73%) of the highest MIBI scores came from the Big Fork River. The Rice River and Reilly Creek also had high MIBI scores.
- A rare mayfly taxa, *Neoephemera bicolor,* was collected from the Big Fork River. Only six records of this taxa exist in the MPCA dataset – 3 of the records are from the Big Fork River and 3 are from the Little Fork River. The presence of this taxa in north central Minnesota is well outside of its normal range.

The Sturgeon River, a major tributary to the Big Fork River, during August of 2021. Many tributary streams became intermittent during extreme drought conditions in 2021.

The Big Fork River supports numerous fish species that are intolerant to pollution, including this young lake sturgeon that was captured in the Big Fork River near the confluence of the Sturgeon River.

Success story

One hundred and twenty-two miles of the Big Fork River (74% of the entire 165-mile flow length) have been designated as exceptional. Exceptional waters contain biological assemblages that are similar to what may have been present in pre-settlement times. These types of systems have watersheds that are often forested and have little human disturbance. Other waterbodies that have exceptional aquatic communities include a section of the Rice River and the following eight lakes: Mirror, Clubhouse, North Star, Burns, Turtle, Big Too Much, Sand, and Grave Lake.

Since these waters have demonstrated exceptional conditions through the biological communities they support, they are protected by higher biological standards. Pristine, expansive ecosystems like the Big Fork River and the other exceptional waterbodies within this watershed are a scarce resource deserving protection from degradation.

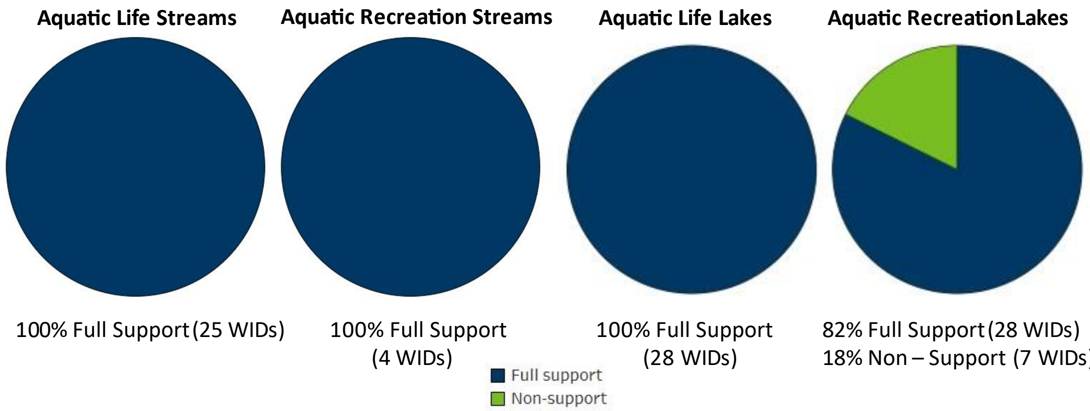
The Big Fork River, downstream of CR 40 near Craigville.
This section of river supports exceptional fish and macroinvertebrate communities.

Watershed assessment results

Streams and rivers

All 25 stream reaches that were assessed for aquatic life were fully supporting (Figure 2). The middle and lower reaches of the Big Fork River contained exceptional fish and macroinvertebrate communities. The diverse fish communities sampled from these locations often contained good numbers of non-tolerant, insectivorous species as well as several intolerant species. Various sensitive dragonfly, mayfly, caddisfly, and stonefly taxa were often present within the macroinvertebrate samples that were collected from these reaches. The macroinvertebrate IBI scores were uniformly good regardless of the size of the stream. In contrast, fish samples collected from smaller streams often exhibited lower IBI scores. They contained less sensitive, insectivorous taxa and more tolerant, generalist taxa. Drought conditions in 2021 followed by extensive flooding and prolonged high flows in 2022 may have hindered the recolonization efforts of some fish species prior to sampling.

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



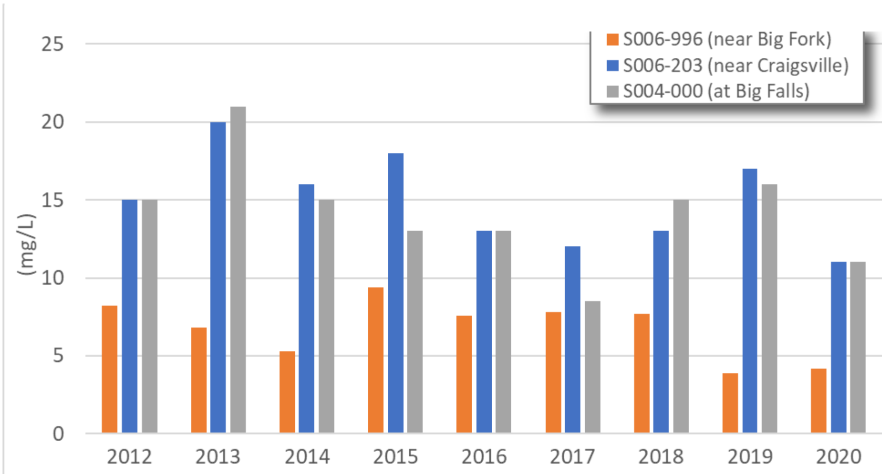
Bacteria levels were generally low in streams throughout the Big Fork River Watershed. Some exceedances of the monthly mean *E.coli* standard occurred on the Bowstring River and Bear River. Additional monitoring will be conducted on these streams to determine if an aquatic recreation impairment is warranted.

High levels of total suspended solids (sediment) occurred on two reaches of the Big Fork River (09030006-503, Reilly Brook to Sturgeon River and 09030006-504 Deer Creek to Caldwell Brook). These exceedances appear to be driven by spring snow melt and large precipitation events. The high TSS does not appear to be negatively impacting aquatic life – both reaches continue to support exceptional biological communities.

In a statewide comparison of pollutants (suspended solids, phosphorus, and nitrate nitrogen), the Big Fork watershed has low values compared to other parts of Minnesota. Within the watershed, there are three long-term monitoring stations. When comparing the water quality of the sites, there is a stark change between the headwaters station (S006-996) and the two downstream locations. Figure A shows that in most years the suspended sediment flow weighted mean concentration (FWMC) doubles between S006-996 and S006-203. This is not the case for phosphorus and nitrogen where both pollutants are very low, and no noticeable change occurs between stations.

As shown in Figure 3, in most years, all three sites' FWMC are at or below 21 mg/L, indicating very good water quality. It should be noted that when assessing waters, individual samples are used in the analysis, not FMWC. Generally, a FWMC can be a good indicator of the water quality.

Figure 3. Suspended sediment flow weighted mean concentration (FWMC mg/L) from three monitoring stations located on the Big Fork River.

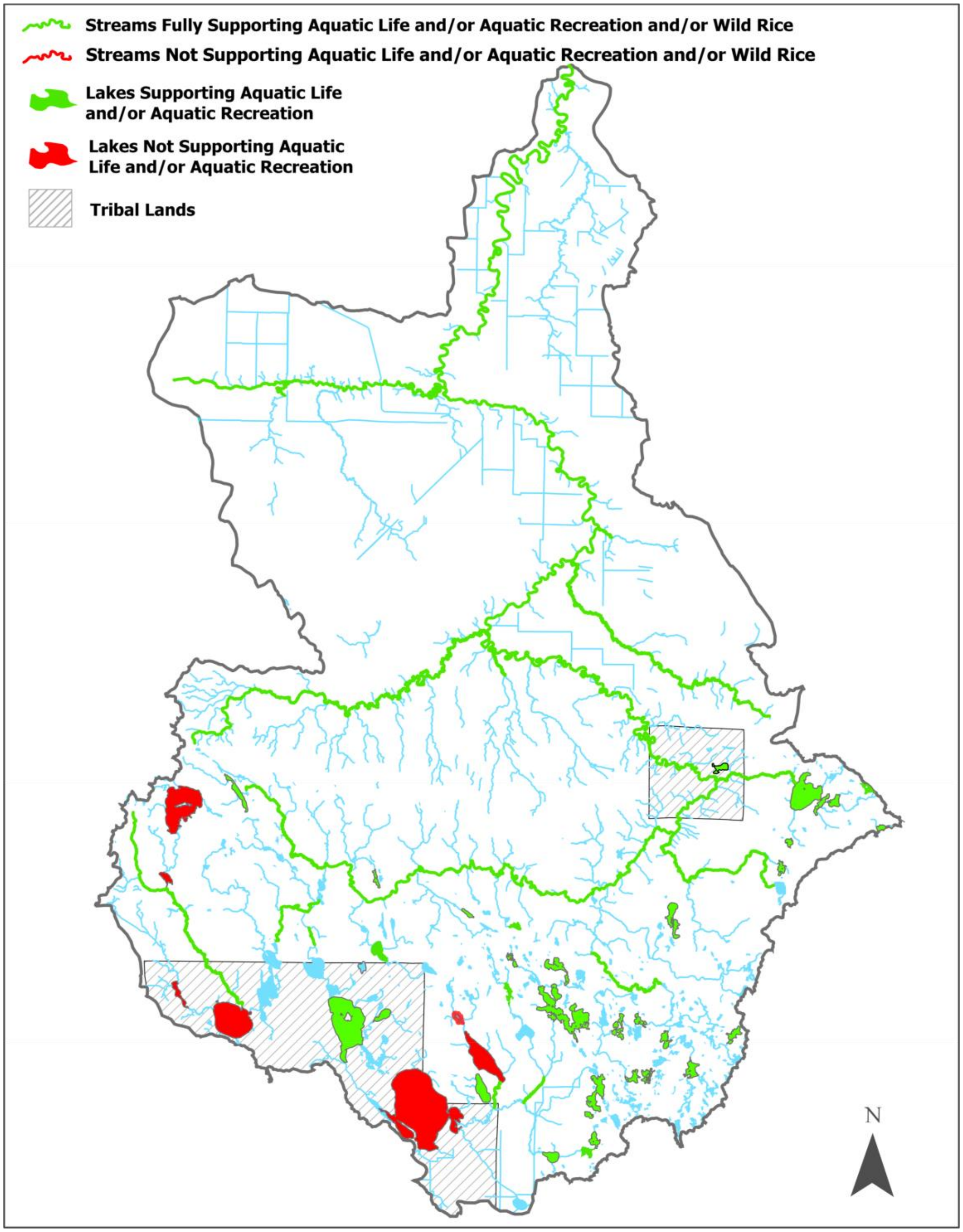


Lakes

Thirty-one lakes within this watershed were assessed for aquatic life for the first time using a fish-based index of biotic integrity (IBI) developed for Minnesota lakes. The vast majority (i.e., 81%) of lakes fully supported aquatic life, and a large percentage of them (i.e., 23%) contained exceptional fish communities (Mirror, Clubhouse, North Star, Burns, Turtle, Big Too Much, Grave, and Sand lakes). The upstream watersheds of these lakes were generally forested, and their shorelines were less developed than lakes statewide, although more development pressure is occurring within the watershed. Efforts to protect the forested lands and undeveloped, natural shorelines around these lakes should be emphasized to ensure that water quality and habitat remains intact to support the diverse suite of species residing in these lakes.

Round Lake was the only lake determined to be vulnerable to aquatic life impairment based on the fish IBI results. Excess nutrients are a likely stressor influencing the fish community. Round Lake was first listed as impaired for aquatic recreation due to excess nutrients in 2008; recent monitoring data confirm this impairment still exists. Bowstring and Dunbar lakes are also impaired for aquatic recreation. All three of these lakes lie within the Leech Lake Reservation and are under the jurisdiction of the Leech Lake Band of Ojibwe. Any restoration efforts or TMDL studies on these waterbodies would be in partnership and at the discretion of the LLBO. The LLBO DRM is currently conducting a paleolimnological study to develop water quality standards for Bowstring and Round lake. Other impaired lakes in the watershed include Shallow Pond Lake, Jessie Lake, Little Spring Lake, and Island Lake. Overall, chlorophyll A and phosphorus concentrations have declined in Island Lake; however, exceedances still occur especially during August.

Figure 4. Assessment results for aquatic life and aquatic recreation on rivers, streams, and lakes.



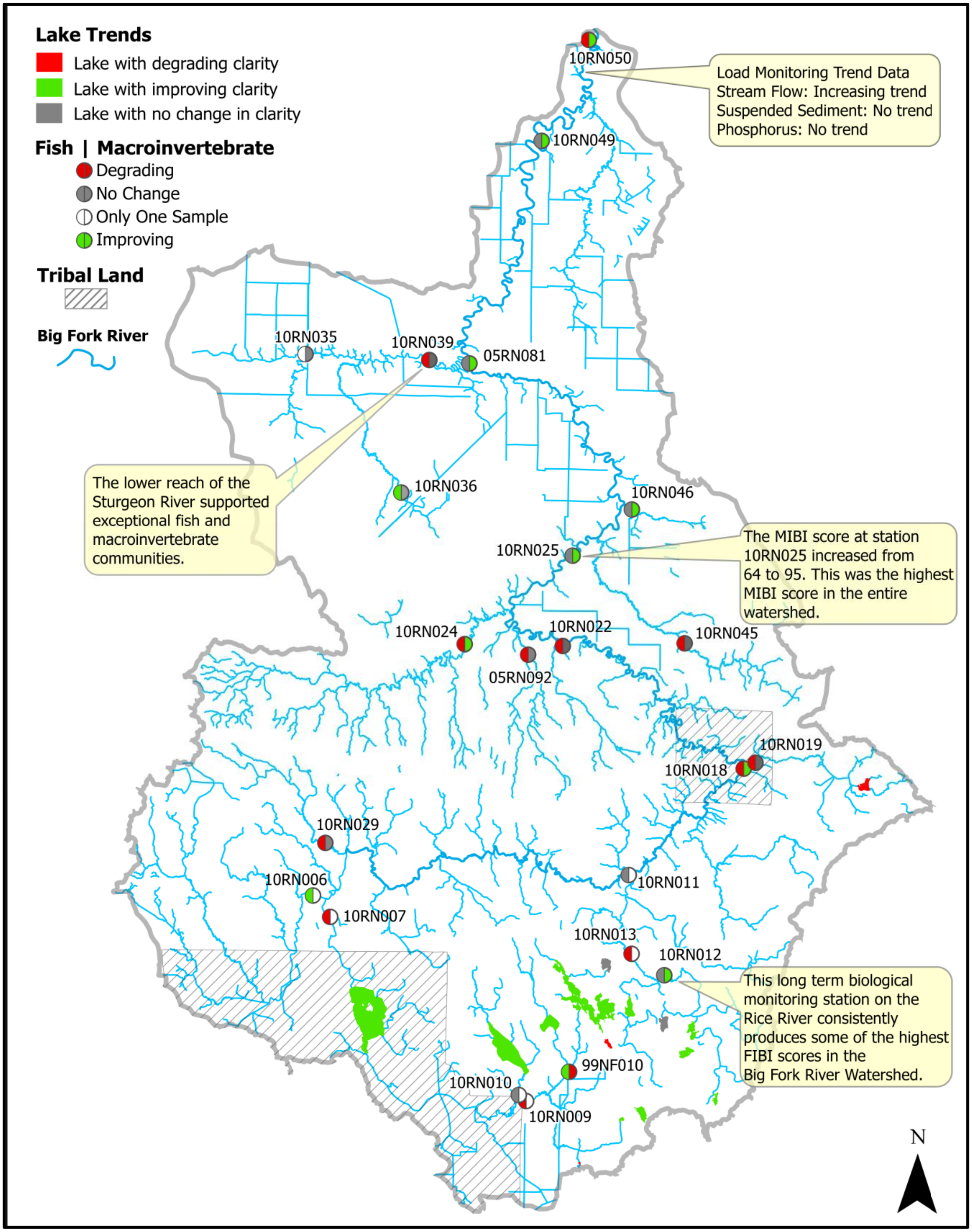
Trends

A key objective of the 2021 monitoring effort was to evaluate if water quality has changed since 2010 (Figure 5). If water quality has improved, it is important to understand to what extent strategy development, planning, and implementation, based on the initial work and combined with actions that were already underway, may be responsible. 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 four different aspects of water quality were analyzed to provide as robust a picture as possible of what is happening in the Big Fork River Watershed:

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

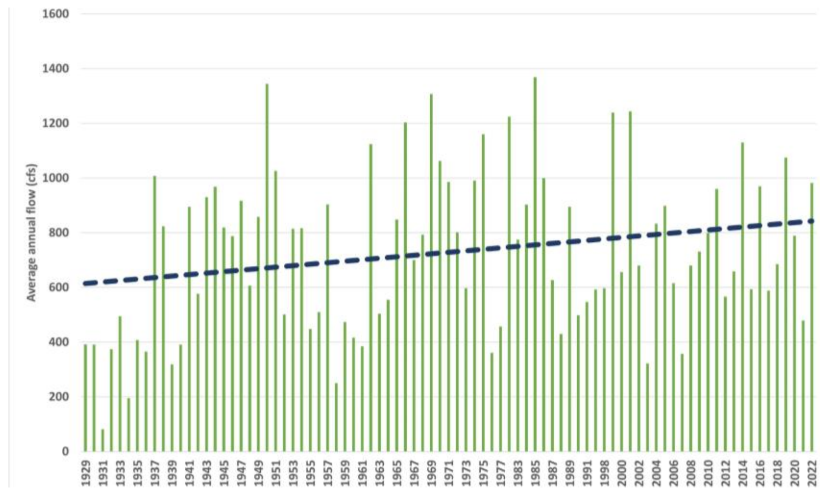
Figure 5. Change in water quality in the Big Fork River Watershed.



Streamflow and pollutant concentrations

Since 1929, stream flow information has been collected in the Big Fork River Watershed at the USGS station (Big Fork River at Big Falls, MN – 05132000). Figure 6 shows an increasing trend in flows over the 93-year record. Interestingly, removing the data during the Dust Bowl (1929-1935) shifts the trend to *no trend* which typically is not the case for many long-term stream stations in Minnesota. An increasing trend 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 a pollutant moving through a system, this way of measuring water quality is important for understanding the impacts to the Rainy River, where these pollutants may accumulate.

Figure 6. Big Fork River at Big Falls, MN average annual flow (1929-2022).



In the cycle 1 report, trend work completed at a monitoring station near the confluence with the Rainy River found an overall decreasing trend from 1971-2010 for suspended sediment, phosphorus, ammonia, and biochemical oxygen demand. No trend was detected for chloride or nitrogen.

Currently, trend information is not available for nitrogen but the data suggest there is *no significant trend* for suspended sediment or phosphorus at the Big Fork River near Big Falls long-term monitoring station. Data were used from 2008-2020 and corrected for flow. Please note: the long-term monitoring station for the Big Fork River is now located further upstream of the Rainy River confluence and the previous trend work was not incorporated into the current trend work due to the change in monitoring location.

Biological communities

Climate and extreme weather events can influence the condition of waterbodies and obscure changes that result from restoration/protection efforts, changes in land use, and hydrologic alteration (i.e., changes related to policies, regulations, and management activities). Specifically, climate can affect stream aquatic life by altering the flow regime and connectivity, water quality (e.g. dissolved oxygen, temperature), and habitat. However, the actual stream response may vary based 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). While in larger streams that retain flow during a drought, biological condition may be unaffected or possibly somewhat inflated as organisms become concentrated in pools and are more easily captured with the sampling gear. Nonetheless, it is important to attempt to compare and contrast the climatic conditions that occurred during each sampling event to better understand and interpret the results.

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 17 sites evaluated for macroinvertebrates and 22 sites evaluated for fish (i.e., sites that were sampled in both time periods). The average macroinvertebrate

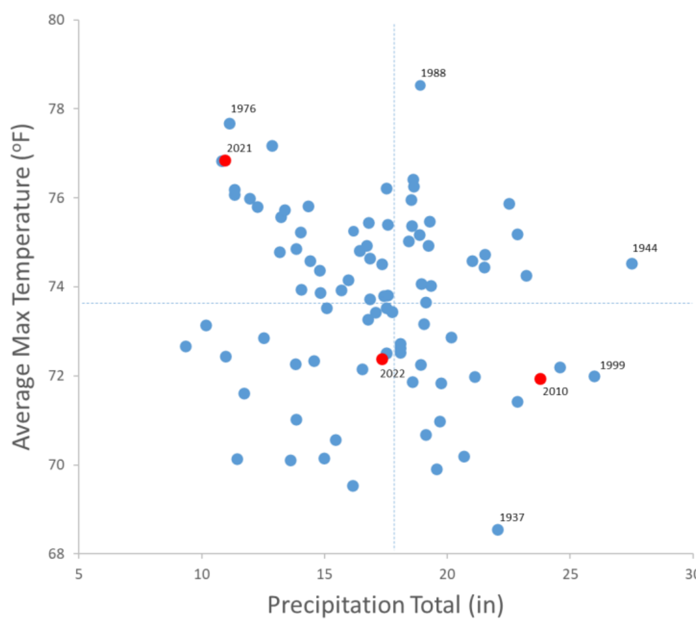
IBI score for the watershed increased by 10.3 points between 2010 and 2021/2022, a change that was statistically significant. Fish IBI scores across the watershed decreased by 3.6 points; however, this change was not statistically significant.

In 2010, the Big Fork River watershed experienced an extremely wet summer (+5.9 in) and was abnormally cool (-1.6 °F) during the index period (May to September). In contrast, the watershed suffered extreme drought conditions (-6.9 in rainfall deficit, +3.3 °F above normal) during the summer of 2021, forcing many biological monitoring sites to be sampled or re-sampled the following year (Figure 7). The summer of 2022 was relatively normal with the watershed having near normal precipitation (-0.5 in) and slightly cool temperatures (-1.2 °F). Overall, given the extremely wet conditions of 2010 and the drought or near normal conditions (depending on the year) present in cycle 2, 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 periods.

Clarity of lakes

The Big Fork River Watershed has 328 lakes with transparency data. Trend analysis was conducted on 46 lakes that met data requirements (50 Secchi measurements, eight years of data). Thirty lakes showed no trend. Clarity increased in 11 lakes including Gunn, Clubhouse, Three Island, Caribou, Boy, Johnson, Turtle, Hatch Little Turtle, Jessie, and Sand. Water clarity declined on 5 lakes – Battle, Jack The Horse (north and south), Ranier, and Maki.

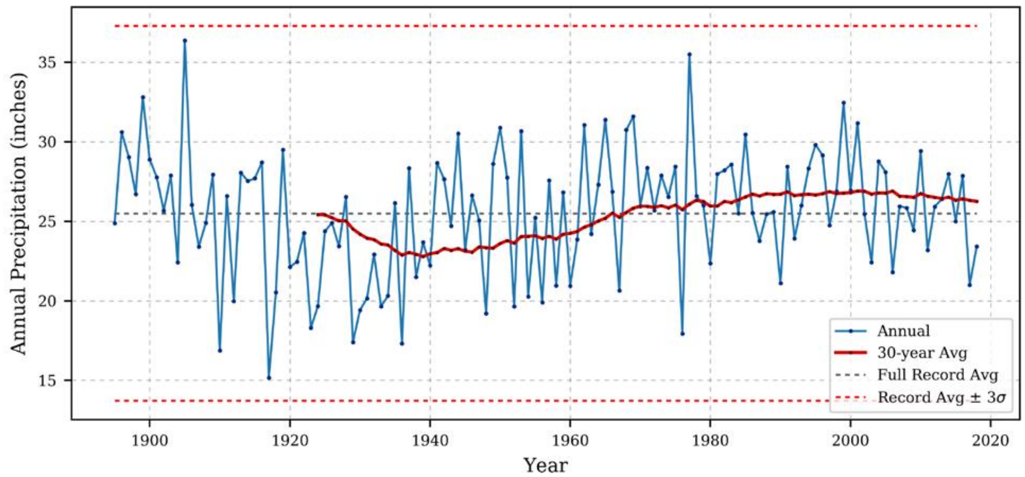
Figure 7. Characterization of air temperature and rainfall conditions for May-September period across historical record for the Big Fork River Watershed. Biological monitoring years for the watershed highlighted in red. The blue lines represent the estimated normal for May-Sept precipitation total and average daily max air temperature, based on data from 1981-2010.



Climate

The Big Fork River Watershed now receives an additional 0.7 inches of rain compared to the historical average (1895-2018, Figure 8). Furthermore, climate scientists suggest that precipitation events are becoming more intense. Temperatures over this period have also increased by about 1.2 degrees during spring and fall, and 3.1 degrees during the winter. Increased rainfall and temperature can worsen existing water quality problems. More precipitation and reduced snow cover can increase soil erosion, pollutant runoff, and streamflow. Increased streamflow in turn can lead to stream channel erosion and degraded habitat for fish and other aquatic life. Longer growing seasons with higher temperatures can lead to more algal blooms. These changes will complicate efforts to protect and restore the watershed. [Big Fork River Watershed Climate Summary MNDNR]

Figure 8: Average annual precipitation for the Big Fork River Watershed (1989-2018).



For more information

This study of the Big Fork 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 Big Fork 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 Big Fork River Watershed webpage, or search for "Big Fork River" on the MPCA website.

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