Watershed assessment and trends update

Leech Lake River Watershed

Upper Mississippi River Basin

The Leech Lake River near its confluence with the Mississippi River

Summary

The Minnesota Pollution Control Agency (MPCA), Minnesota Department of Natural Resources (DNR), Leech Lake Band of Ojibwe (LLBO), and local partners have completed a study of surface water quality within the Leech Lake River Watershed (LLRW). Some of Minnesota's most valuable natural resources, including Leech Lake, the Woman Lake Chain, and Ten Mile Lake, along with numerous other lakes and wetlands, occur within this watershed. Healthy fish and macroinvertebrate (aquatic insect) communities were found throughout the watershed. Twenty-three lakes, including Woman Lake, have been identified as exceptional resources because they support such high-quality fish communities. Most lakes and streams met water quality standards designed to protect aquatic life and aquatic recreation.

Instead of relying on chemical testing of the water alone, scientists reached their conclusions through also 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.

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 Leech Lake River Watershed in 2012-2013 and again in 2023-2024. Any additional chemistry data collected by local partners between 2014 and 2022 were also 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. Per agency policy in 2025, waterbodies located wholly within the Leech Lake Reservation will not be formally assessed using state water quality standards. Water quality standards developed by the LLBO were approved by the U.S. Environmental Protection Agency (EPA) on December 20, 2024.

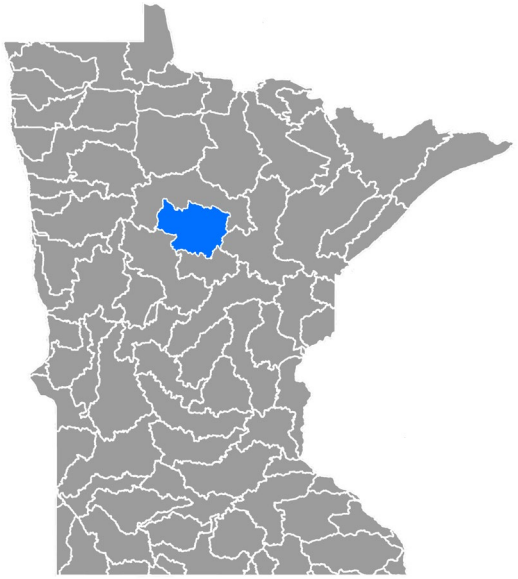
Changes in water quality

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 only 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 within the LLRW. Most waterbodies continued to exhibit excellent water quality that supports aquatic recreation and aquatic life. Numerous intolerant fish species reside in the lakes and streams throughout the watershed. These species are very sensitive to pollution and disturbances in their environment. Intolerant macroinvertebrate taxa were found in cold water streams, such as the Kabekona River and Bungashing Creek, as well as in warm water streams like the Leech Lake River. The numerous wetlands found throughout the watershed continue to influence dissolved oxygen (DO) concentrations in streams. They also play an important role in maintaining water quality. Overall, nutrient levels throughout the watershed remained low; however, excess nutrients (phosphorus) were still an issue on Hart Lake.

- During the last ten years, there hasn't been any significant change in the condition of fish and macroinvertebrate communities. Most fish and macroinvertebrate IBI (MIBI) scores are indicative of stable, minimally impacted conditions.
- Nutrient levels continue to exceed ecoregion standards on Hart Lake, confirming the existence of a previous aquatic recreation impairment.
- Most lakes contain excellent water quality necessary to support robust fisheries and provide aquatic recreational opportunities. Recent monitoring data indicate 38 lakes fully support aquatic recreation use. Thirty-five of the thirty-seven lakes assessed for aquatic life were found fully supporting; the two remaining lakes were either inconclusive or lacked sufficient data for assessment.
- Exceedances of the DO standard still occur on the Leech Lake River below Mud Lake Dam. Recent monitoring data confirm healthy fish and macroinvertebrate communities continue to thrive within this reach.

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



The Leech Lake River below Mud Lake Dam. Despite occassional low dissolved oxygen concentrations, healthy fish and macroinvertebrate communities thrive here.

Beavers continue to alter streams throughout the Leech Lake River Watershed. Some streams initially sampled in 2012 could not be sampled again in 2023 due to the presence of multiple impoundments created by beaver dams.

Highlights of monitoring

- A total of 50 fish species were collected in lakes during fish IBI (FIBI) sampling. Of these, 19 are considered intolerant species—susceptible to pollution and watershed disturbance. Least darter and northern sunfish are State Species of Concern and the pugnose shiner is State Threatened. Brook trout, burbot, cisco (tullibee), lake whitefish, and rainbow trout are considered cold water species, requiring cold, oxygenated water to survive.
- The LLRW includes 38 lakes identified as coldwater resources that support species such as cisco, lake whitefish, and stream trout and are managed using more protective water quality benchmarks. The DNR, MPCA, and LLBO collected Temperature and DO (TDO) profiles for three consecutive years during the period of maximum oxythermal stress (July 26 through August 24), along with eutrophication parameters (total phosphorus, chlorophyll-a, and Secchi depth), to guide management of these lakes.
- Ten Mile Lake (North of Hackensack) is one of twenty-five lakes that make up the DNR's Sentinel Lakes Program. This long-term lake ecosystem monitoring program was created to detect and understand the physical, chemical, and biological changes occurring in Minnesota's lakes. The data will be utilized to manage large-scale stressors such as climate change, land-use patterns, shoreline development, and invasive species. Metrics monitored for sentinel lakes include weather, water temperature, water levels, water quality, zooplankton, phytoplankton, aquatic plants, and fish. For more information about this program, please visit: https://www.dnr.state.mn.us/fisheries/slice/index.html
- Sixty-six percent of the 35 lakes assessed for aquatic life contained exceptional fish communities. These lakes feature less shoreline development when compared to other lakes in Minnesota. Forested lands within the watershed help sustain the clean water and healthy habitats that support exceptionally diverse fish communities and/or coldwater species found in many of the sampled lakes.
- Intolerant Leuciscid species (i.e. blackchin shiner, blacknose shiner, and pugnose shiner) were collected at 50% of the stream stations sampled in the LLRW. Intolerant species are very sensitive to watershed disturbances and their widespread distribution is an indicator of excellent water quality.
- Bungashing Creek and the Kabekona River are two high-quality, cold-water resources that contain brook trout, a cold water intolerant species. Intolerant, cold water obligate macroinvertebrate species were also found in these streams.
- The Leech Lake River produced high FIBI scores at both monitoring station locations. Diverse macroinvertebrate communities containing multiple intolerant taxa were also found at these locations.

The Leech Lake River Watershed supports numerous fish species that are intolerant to pollution, including the northern sunfish, a State Species of Concern.

This high gradient, rocky section of Gulch Creek represents a unique resource in the Leech Lake Watershed. This stream contained a high-quality macroinvertebrate community.

Bungashing Creek contained brook trout and a high-quality, cold water macroinvertebrate community. Two cold water obligate stonefly species were documented, in addition to the caddisfly *Glossossoma*, a genus infrequently observed in this region of the state.

Success story

From its headwaters to Kabekona Lake, the Kabekona River is a beautiful cold-water stream that supports a naturally reproducing population of brook trout. During the initial monitoring process in 2012, high concentrations of bacteria were found in this section of the river, resulting in an aquatic recreation impairment. Subsequent sampling conducted by Hubbard Soil and Water Conservation District (SWCD), including Escherichia coli (*E. coli)* DNA Source Tracing, indicated the bacteria were originating from a cattle pasture through which the Kabekona River flowed. The landowner, along with Hubbard SWCD, the Headwaters Chapter of Trout Unlimited, and numerous local partners came together to find (and fund) a solution that would restrict cattle access to the river yet still provide them with a water source. Fencing was installed to keep the cattle out of the river, and an alternative water source (troughs and well water) was created. The riparian area, damaged by cattle, was restored through the planting of native vegetation.

Monitoring data collected during 2023 and 2024 indicate *E. coli* levels are now meeting water quality standards. The Kabekona River is no longer considered impaired and will be delisted from the inventory of impaired waters. This restoration was the result of great collaboration between the landowner, local units of government, conservation organizations, and local businesses. Members of the Headwaters Chapter of Trout Unlimited volunteered their time to help restore the riparian area. The chapter also paid for the necessary permits for this project. Mantrap Power Co-op provided a grant to pay for any sample testing that exceeded costs already covered by the MPCA surface water assessment grant (SWAG). The Kabekona Lake Association, Howgs Gas & Service of Laporte, Lake Garfield Ice Racers, Hart Lake Township, Hendrickson Township, and Lakeport Township all donated money towards the completion of this project. Primary funding for the project was available through the Leech Lake River Comprehensive Watershed Management Plan.

The Kabekona River, upstream of CR 257 near Kabekona. This cold-water section of the river supports a naturally reproducing population of brook trout.

Cattle exclusion gate and fencing installed to prevent cattle from entering the river.

Alternative water source after completion.

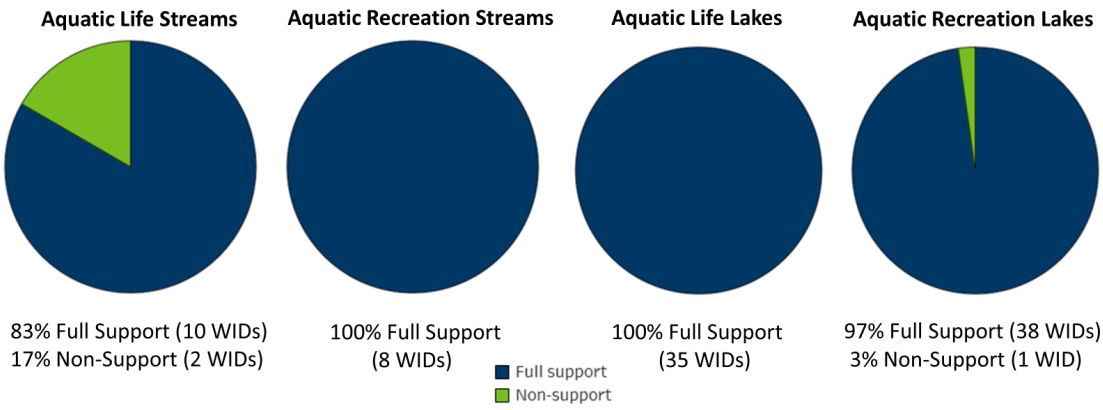
Trout Unlimited members restoring vegetation in stream riparian zone.

Watershed assessment results

Streams and rivers

Ten out of the twelve stream reaches that were assessed for aquatic life were fully supporting (Figure 2). Intolerant Leuciscid species, such as blackchin shiner and blacknose shiner, were collected at half of the stations sampled. Other intolerant species collected included logperch and burbot. These intolerants species, often insectivores, are very sensitive to watershed disturbances and are among the first to decline in abundance when exposed to environmental stressors. Their widespread distribution throughout the watershed is an indication of a healthy ecosystem. Intolerant taxa were also present in most macroinvertebrate samples. Some of the most sensitive taxa occurred in Bungashing Creek and the Kabekona River. The two stream reaches that failed to meet standards for aquatic life were already considered impaired due to natural phenomenon. Spring Creek was impaired due to poor fish and macroinvertebrate communities. This impairment was attributed to extensive beaver activity both within the sampling reach and further downstream. The Leech Lake River below Mud Lake was impaired for aquatic life due to exceedances of the DO standard. Despite occasional low DO, recent monitoring data indicate healthy aquatic communities reside within this reach. Good numbers of intolerant fish and macroinvertebrate species were sampled here.

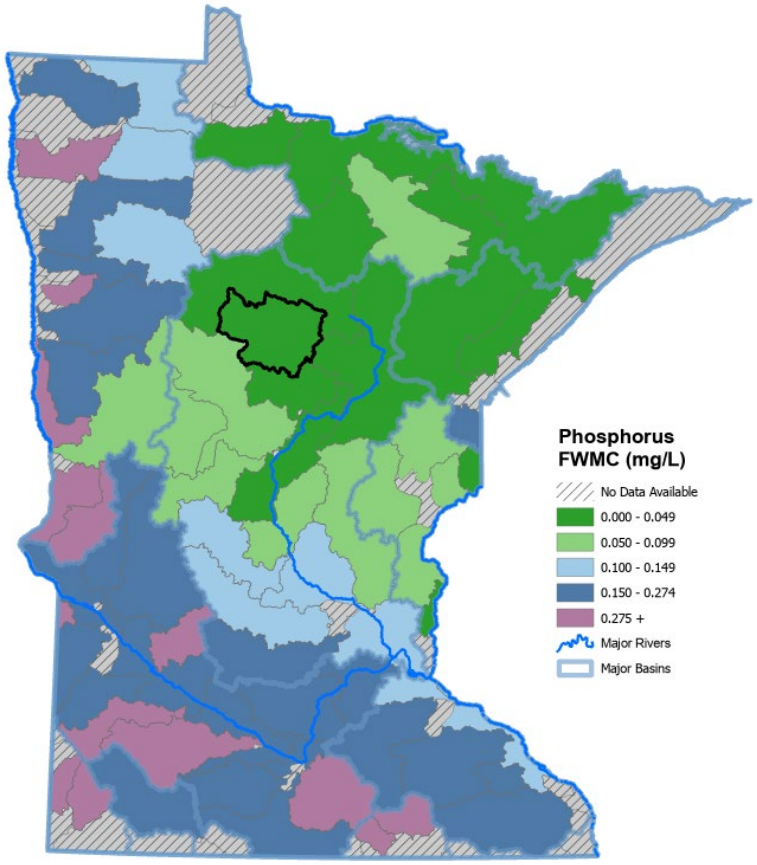
Figure 2. Watershed assessment results for aquatic life and aquatic recreation in streams and lakes.



All eight of the streams that were assessed for aquatic recreation were fully supporting (Figure 2). During the initial monitoring cycle, the Kabekona River was found to be impaired due to high *E.coli* concentrations that greatly exceeded the standard. Mitigation projects have resulted in reduced runoff and lower *E. coli* concentrations; the Kabekona River was removed from the impaired waters list during the 2025 assessment.

The Leech Lake River Watershed is located within an area of the state where the concentrations of pollutants (suspended solids, phosphorus, and nitrate nitrogen) are low, both within this watershed and surrounding watersheds (Figure 3). No significant pollutant concerns were found within the data collected within this watershed. However, investigations into potential beneficial water quality practices and implementation could aim to preserve the high water quality found within this watershed.

Figure 3. Comparison of TP concentrations (mg/L) within the Leech Lake River Watershed (outlined in black) and statewide.



Lakes

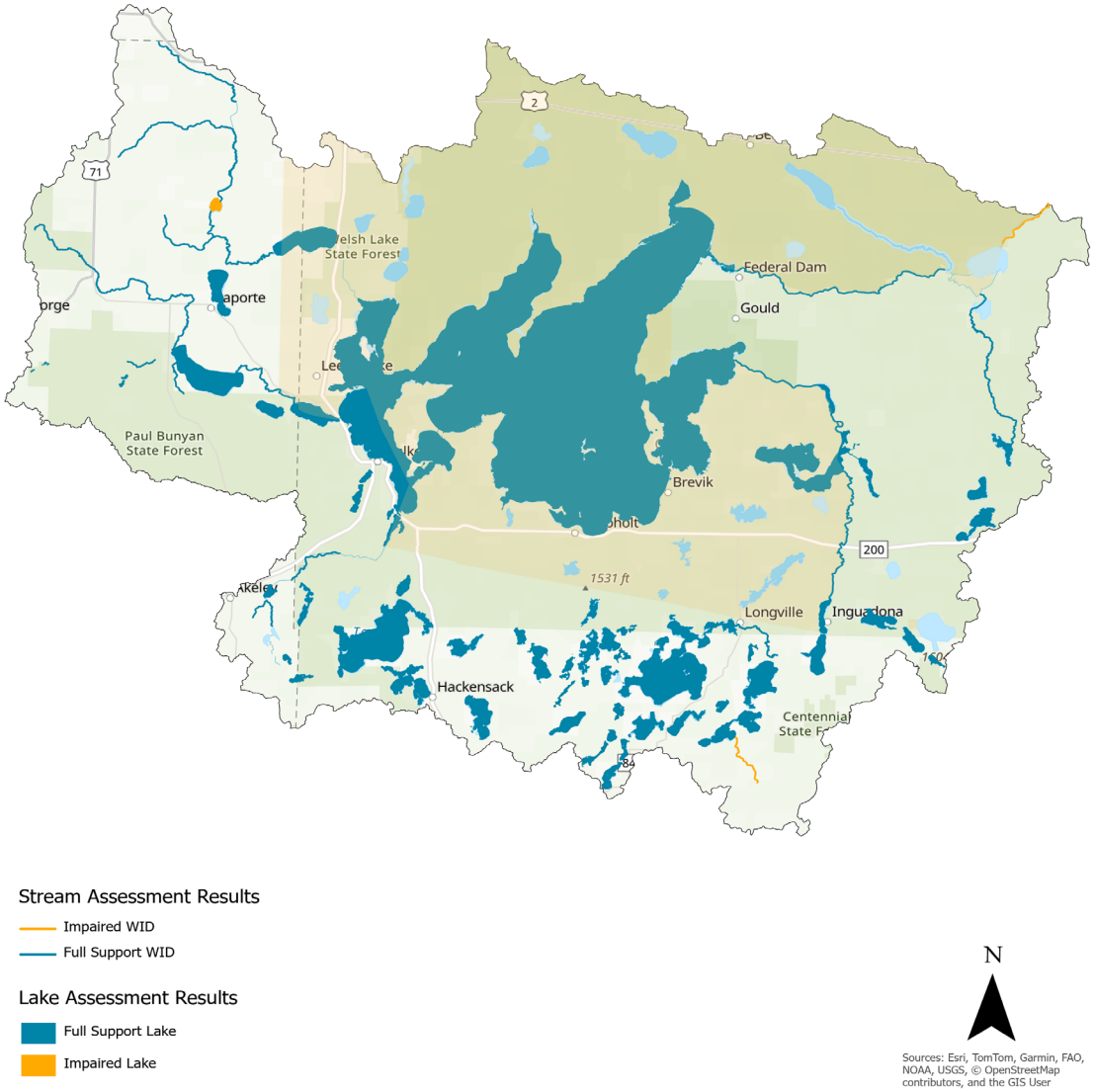
Within this watershed, 37 lakes (42 basins) were assessed for aquatic life for the first time using a fish-based IBI developed for Minnesota lakes, and nine additional lakes wholly within the Leech Lake Reservation were sampled in collaboration with the Leech Lake Band of Ojibwe (LLBO). Excluding two lakes with inconclusive or insufficient information, the remaining 35 that were assessed were found to fully support aquatic life, and a large percentage of those (i.e., 66%) contained exceptional fish communities, including Baby, Ten Mile, and Wabedo lakes as a few examples.

Similarly, temperature and DO profiles were collected in 15 lakes to evaluate the quality and quantity of cold, well-oxygenated habitat available to cold-water species such as Lake Whitefish and Cisco. Preliminary analysis indicates that all but one have sufficient habitat to support these species. Six additional lakes wholly within the Leech Lake Reservation were sampled in collaboration with LLBO. These six lakes may be considered for assessment by LLBO using their EPA approved cold-water criteria for Reservation lakes.

The upstream watersheds associated with the exceptional and cold-water lakes were generally forested and the shorelines were generally less developed than lakes statewide, although development pressure is occurring within the watershed. Efforts to protect the forested lands and undeveloped, natural shorelines associated with these lakes should continue into the future to ensure the water quality and habitat remains intact to support the diverse suite of species residing in these lakes. Additional information regarding protection of these lakes can be found in the LLRW Fish Community Stressor Protection Report for Lakes (DNR 2026).

Thirty-eight lakes fully support aquatic recreation use. Hart Lake (north of Laporte, Hubbard County) was again assessed as not supporting aquatic recreation due to continued exceedances of regional standards for phosphorus, chlorophyll-a, and Secchi readings. This waterbody receives considerable wetland influence (22% of drainage area) and is a flowage of the Necktie River. The Necktie River has been ditched and rerouted, resulting in large amounts of sediments flowing downstream into Hart Lake. This likely has a significant impact on the nutrient impairment in Hart Lake. The Hubbard SWCD is in the process of planning a restoration project on the Necktie River that will alleviate this issue.

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



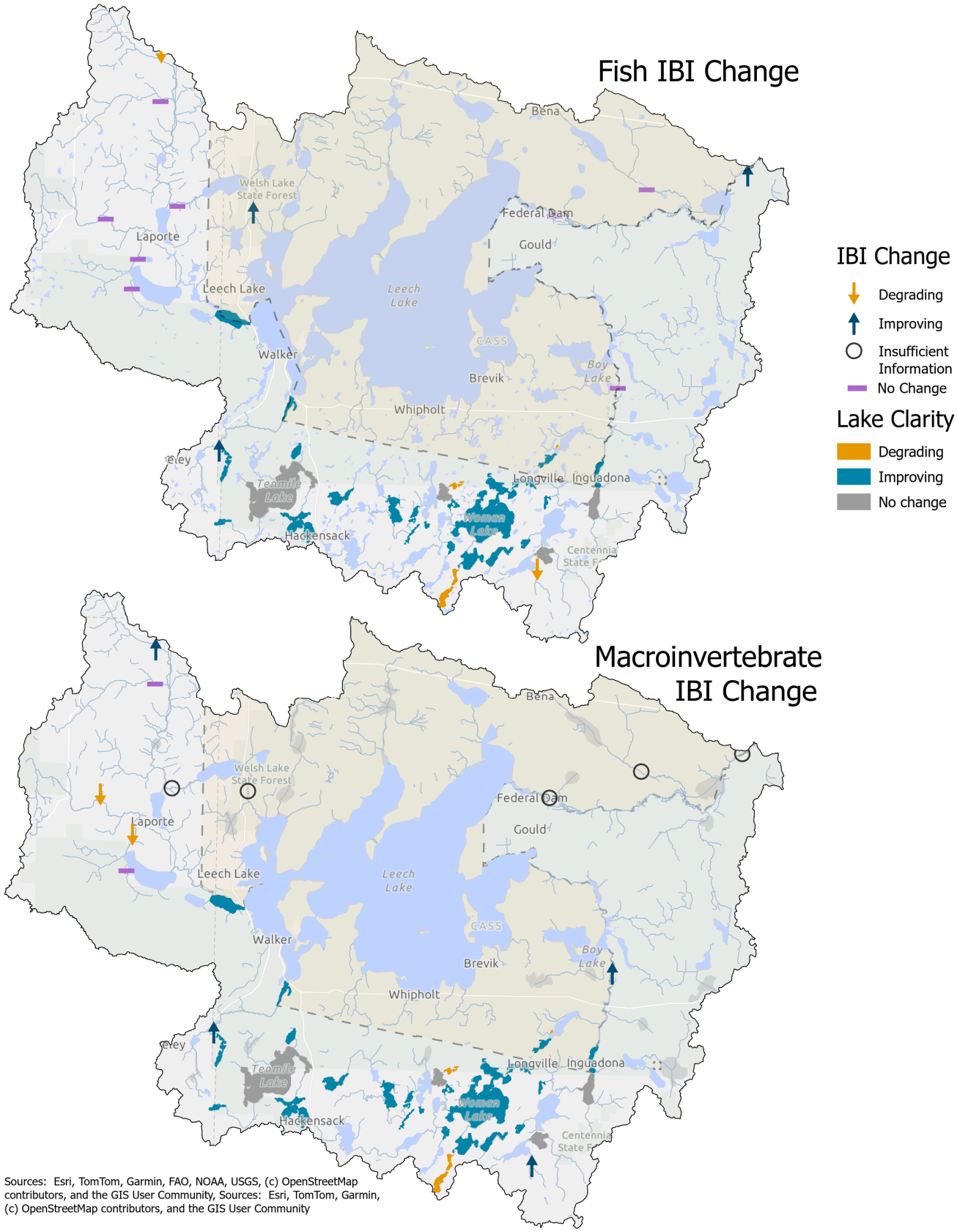
Trends

A key objective of the 2023-2024 monitoring effort was to evaluate if water quality has changed since 2012-2013 (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 LLRW:

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

Figure 5. Change in water quality in the Leech Lake River Watershed.



Streamflow and pollutant concentrations

Long-term water quality and stream flow monitoring occurs annually throughout Minnesota, with intensive sampling across a range of flow conditions. For more information about this sampling, please visit: https://www.pca.state.mn.us/wplmn

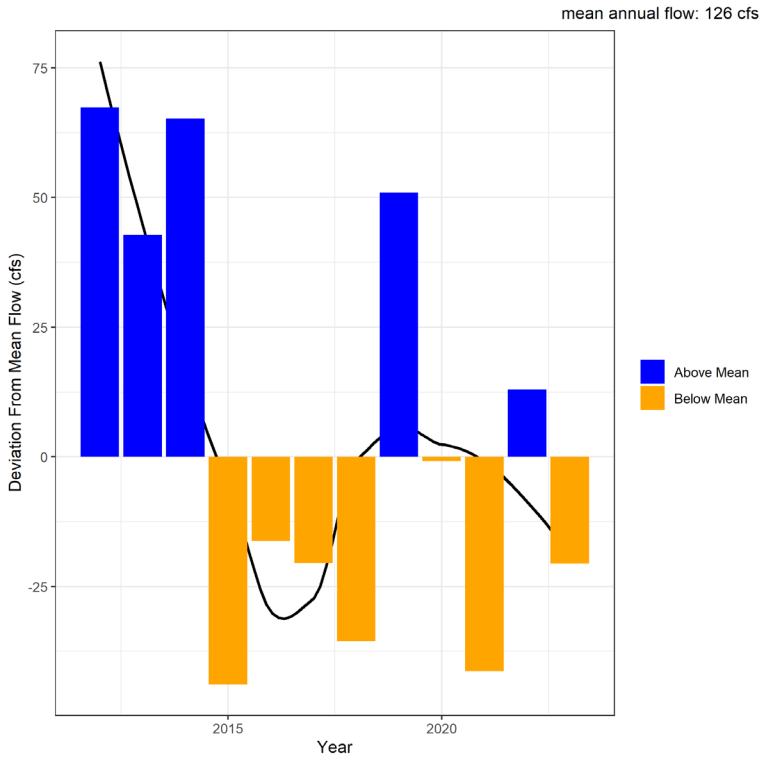
Annual streamflow (discharge) data for the LLRW is available since 2012 and water chemistry data available since 2015, both measured on the Boy River at CSAH 53, approximately two miles downstream of Boy Lake.

Although only sampled since 2015, which does not yet provide enough data for long-term statistical trend analysis, data were still looked at for patterns. General analysis were performed to analyze pollutant concentrations from 2015-2023. Analysis shows annual average flow weighted mean (FWMC) concentrations of nitrate-nitrogen increasing slightly each year, TP decreasing slightly and total suspended solids (TSS) remained roughly unchanged during the sampling period. The average yearly flow volume during this timeframe was 49,543 acre feet, gradually increasing over the nine-year sampling period.

Streamflow and water chemistry data was also previously available for a second site within this watershed, located on the Leech Lake River near Ball Club on CR139, roughly 17 river miles downstream of Leech Lake. This site, however, was only sampled from 2016-2019, with sampling being terminated after the 2019 season due to inability to record reliable flows, abundance of wetlands upstream and difficult sampling location. Although only sampled for four seasons, which does not provide enough data for statistical trend analysis, pollutant analysis shows low concentrations. In general, nitrate-nitrogen average concentrations remained constant, while TP and TSS concentrations decreased slightly over the sampling period. For reference, the average flow per year (2016-2019) at this station was 385,332 acre-feet, steadily increasing over the four-year sampling period.

Figure 6 shows the percent deviation from normal flow over time at the Boy River station. The changing yearly average flow (black line) is calculated using LOESS (locally estimated scatterplot smoothing) with the yellow and blue bars showing each years' deviation as above (blue) or below (yellow) the mean (126 cubic feet per second [cfs]). Significant increases in flow have negative 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. Loads represent the total amount of a pollutant moving through a system, providing important information for downstream resources such as the Mississippi Rivers, where these pollutants may accumulate.

Figure 6. Leech Lake River Watershed percent deviation from normal flow over time (CFS).

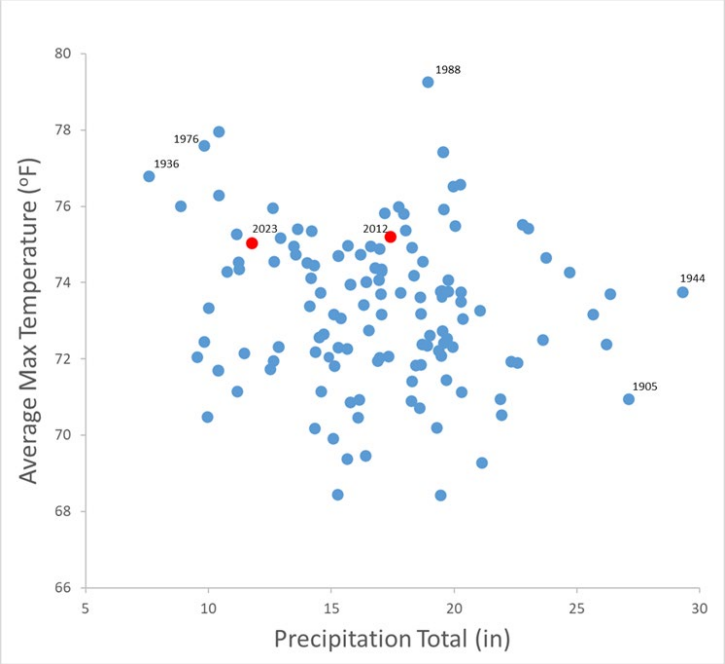


Biological communities

Paired t-tests (statistical analysis) 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. A similar change analysis was not completed for lakes because comparable fish community data had not been collected during the first time period. Independent tests were performed on each community with 8 sites evaluated for macroinvertebrates and 13 sites evaluated for fish (i.e., sites that were sampled in both cycles). Between 2012 and 2023/2024, the average MIBI score increased by 4.9 points and the average FIBI score decreased by 4.3 points. However, neither change was statistically significant. While individual stations demonstrated variability in IBI scores relative to 2012-2013, overall fish and macroinvertebrate communities in the LLRW remain stable.

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). Therefore, it is important to compare climatic conditions that occurred during each monitoring cycle to better understand and interpret the results (Figure 7).

Figure 7. Characterization of air temperature and rainfall conditions for May-September period across historical record for the Leech Lake River Watershed (1898-2024). Biological monitoring years for the watershed highlighted in red.



In 2012, the LLRW experienced a normal amount of precipitation and was abnormally warm (+2.2 °F) during the May to September time period. In comparison, the watershed had a severe rainfall deficit (-5.6 in) and was abnormally warm (+2.1 °F) in 2023 over the May to September time period, resulting in drought conditions for most of the summer (Figure 1). Overall, given the relatively normal conditions present in the watershed in 2012 compared to the drought conditions of 2023, 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

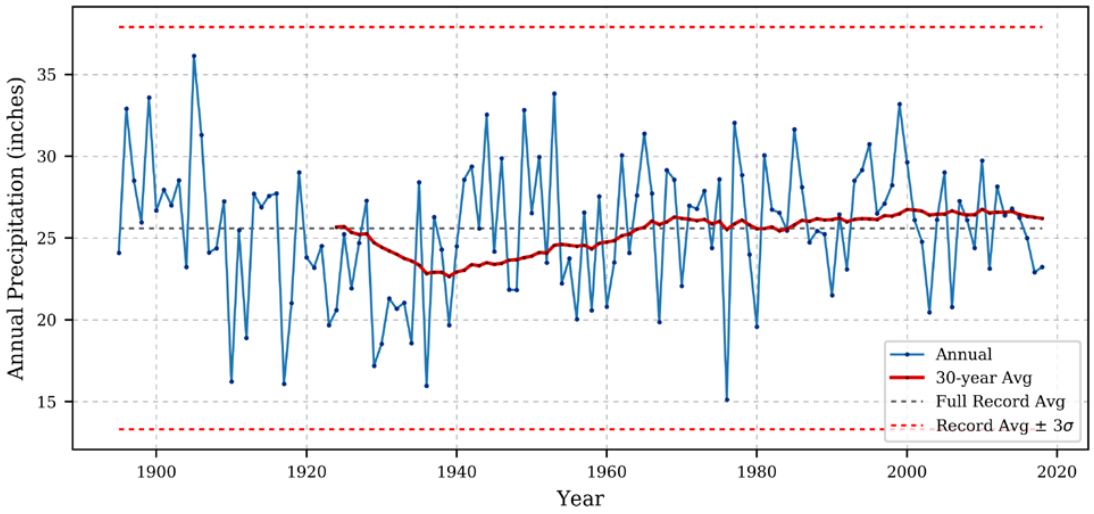
The LLRW has one hundred and nine lakes with transparency data. A trend analysis was conducted on sixty-nine lakes that met data requirements (eight years minimum, May-September data, and fifty or more observations). Of the sixty-nine lakes that had enough data to show a statistically significant trend, twenty-three were improving, four were degrading, and four lakes showed no change in trend.

Climate

The LLRW now receives an additional 0.6 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 (Leech Lake River Watershed Climate Summary MNDNR). 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.

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



For more information

This study of the LLRW 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 Leech Lake 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 Leech Lake River webpage, or search for "Leech Lake River" on the MPCA website.

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