Watershed health

May 2019

Upper Mississippi River-Brainerd Watershed Monitoring and Assessment Report

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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List of acronyms

CI Confidence Interval

CLMP Citizen Lake Monitoring Program

CR County Road

CSAH County State Aid Highway

CSMP Citizen Stream Monitoring Program

CWA Clean Water Act

DNR Minnesota Department of Natural Resources

DOP Dissolved Orthophosphate

E Eutrophic

EPA U. S. Environmental Protection Agency

EQuIS Environmental Quality Information System

EXS Exceeds Criteria, Potential Severe Impairment

FS Full Support

FWMC Flow Weighted Mean Concentration

H Hypereutrophic

HUC Hydrologic Unit Code

IBI Index of Biotic Integrity

IF Insufficient Information

K Potassium

LRVW Limited Resource Value Water

MCES Metropolitan Council Environmental Services

MDA Minnesota Department of Agriculture

MDH Minnesota Department of Health

MPCA Minnesota Pollution Control Agency

MSHA Minnesota Stream Habitat Assessment

MTS Meets the Standard

N Nitrogen

NCHF Northern Central Hardwood Forest

Nitrate-N Nitrate Plus Nitrite Nitrogen

NA Not Assessed

NHD National Hydrologic Dataset

NH3 Ammonia

NLF Northern Lakes and Forest

IMP Not Supporting

OP Orthophosphate

PCB Poly Chlorinated Biphenyls

PWI Protected Waters Inventory

RNR River Nutrient Region

SWAG Surface Water Assessment Grant

SWCD Soil and Water Conservation District

TALU Tiered Aquatic Life Uses

TKN Total Kjeldahl Nitrogen

TMDL Total Maximum Daily Load

TP Total Phosphorous

TSS Total Suspended Solids

USGS United States Geological Survey

WID Waterbody Identification Number

WPLMN Watershed Pollutant Load Monitoring Network

Executive summary

The Upper Mississippi River-Brainerd Watershed (HUC 07010104), located within the Upper Mississippi River Basin, drains 1,682 square miles in north central Minnesota. This watershed borders nine other major watersheds and spans parts of Aitkin, Crow Wing, Morrison, and Todd counties. There are many lakes and streams in the watershed, offering exceptional fishing, boating, and other recreational opportunities. These water resources are used by seasonal cabin owners and resort patrons who contribute greatly to the local economy.

This report will focus on the tributaries to the Mississippi River including the Rice River, Ripple River, Little Willow River, Cedar Creek, Nokasippi River, Little Elk River, Swan River and Pike Creek and many small named and unnamed tributaries. A separate report completed in 2015 documented the assessment results on the Mississippi River mainstem from its headwaters to St. Anthony Falls in Minneapolis.

In 2016, the Minnesota Pollution Control Agency (MPCA) began an intensive watershed monitoring (IWM) effort of rivers, streams and lakes within the Upper Mississippi River-Brainerd Watershed. Then in 2018, many of these waterbodies were assessed to determine if they met standards that protect aquatic life, aquatic recreation, and aquatic consumption. Results from these assessments varied, although overall water quality within the watershed is generally good.

This watershed is rich with lakes, and most have good water quality. Water quality monitoring was conducted on 141 lakes, of those 92 had sufficient data to assess aquatic recreation (nutrients), and 61 had sufficient data to assess aquatic life (fish). Seventy-four lakes fully supported aquatic recreation and 18 did not support aquatic recreation. Fifty-seven lakes supported aquatic life and only four lakes (Elm Island, Crow Wing, Green Prairie Fish, and Moose) did not meet aquatic life standards.

Similar to lakes, the aquatic life in streams, as indicated by the fish and macroinvertebrate communities, were generally good. The Nokasippi River from Hay Creek to the Little Nokasippi River was designated as exceptional based on the composition of the fish and macroinvertebrate communities. This reach should be protected for its diverse biological community. Several streams are impaired for aquatic life based on poor fish and/or macroinvertebrate communities. These biological impairments are likely the result of low dissolved oxygen (DO), altered hydrology, and/or loss of stream connectivity with upstream resources.

Introduction

Water is one of Minnesota's most abundant and precious resources. The Minnesota Pollution Control Agency (MPCA) is charged under both federal and state law with the responsibility of protecting the water quality of Minnesota's water resources. MPCA's water management efforts are tied to the 1972 Federal Clean Water Act (CWA), which requires states to adopt water quality standards to protect their water resources and the designated uses of those waters, such as for drinking water, recreation, fish consumption and aquatic life. States are required to provide a summary of the status of their surface waters and develop a list of water bodies that do not meet established standards. Such waters are referred to as "impaired waters" and the state must make appropriate plans to restore these waters, including the development of total maximum daily loads (TMDLs). A TMDL is a comprehensive study determining the assimilative capacity of a waterbody, identifying all pollution sources causing or contributing to impairment, and an estimation of the reductions needed to restore a water body so that it can once again support its designated use.

The MPCA currently conducts a variety of surface water monitoring activities that support our overall mission of helping Minnesotans protect the environment. To successfully prevent and address problems, decision makers need good information regarding the status of the resources, potential and actual threats, options for addressing the threats and data on the effectiveness of management actions. The MPCA's monitoring efforts are focused on providing that critical information. Overall, the MPCA is striving to provide information to assess, and ultimately, to restore or protect the integrity of Minnesota's waters.

The passage of Minnesota's Clean Water Legacy Act in 2006 provided a policy framework and the initial resources for state and local governments to accelerate efforts to monitor, assess, restore and protect surface waters. This work is implemented on an on-going basis with funding from the Clean Water Fund created by the passage of the Clean Water Land, and Legacy Amendment to the state constitution. To facilitate the best use of agency and local resources, the MPCA has developed a watershed monitoring strategy, which uses an effective and efficient integration of agency and local water monitoring programs to assess the condition of Minnesota's surface waters, and to allow for coordinated development and implementation of water quality restoration and improvement projects.

The strategy behind the watershed monitoring approach is to intensively monitor streams and lakes within a major watershed to determine the overall health of water resources, identify impaired waters, and to identify waters in need of additional protection. The benefit of the approach is the opportunity to begin to address most, if not all, impairments through a coordinated TMDL process at the watershed scale, rather than the reach-by-reach and parameter-by-parameter approach often historically employed. The watershed approach will more effectively address multiple impairments resulting from the cumulative effects of point and non-point sources of pollution and further the CWA goal of protecting and restoring the quality of Minnesota's water resources.

This watershed-wide monitoring approach was implemented in the Upper Mississippi River-Brainerd Watershed beginning in the summer of 2016. This report provides a summary of all water quality assessment results in the Upper Mississippi River-Brainerd Watershed and incorporates all data available for the assessment process including watershed monitoring, volunteer monitoring and monitoring conducted by local government units.

The watershed monitoring approach

The watershed approach is a 10-year rotation for monitoring and assessing waters of the state on the level of Minnesota's 80 major watersheds. The major benefit of this approach is the integration of monitoring resources to provide a more complete and systematic assessment of water quality at a geographic scale useful for the development and implementation of effective TMDLs, project planning, effectiveness monitoring and protection strategies. The following paragraphs provide details on each of the four principal monitoring components of the watershed approach. For additional information see: Minnesota's Water Quality Monitoring Strategy 2011 to 2021 https://www.pca.state.mn.us/sites/default/files/p-gen1-10.pdf.

Watershed pollutant load monitoring

The Watershed Pollutant Load Monitoring Network (WPLMN) is a long-term statewide river monitoring network initiated in 2007 and designed to obtain pollutant load information from 199 river monitoring sites throughout Minnesota. Monitoring sites span three ranges of scale:

Basin – major river main stem sites along the Mississippi, Minnesota, Rainy, Red, Des Moines, Cedar and St. Croix rivers

Major Watershed – tributaries draining to major rivers with an average drainage area of 1,350 square miles (8-digit HUC scale)

Subwatershed – major branches or nodes within major watersheds with average drainage areas of approximately 300-500 square miles

The program utilizes state and federal agencies, universities, local partners, and MPCA staff to collect water quality and flow data to calculate nitrogen, phosphorus, and sediment pollutant loads.

Intensive watershed monitoring

The intensive watershed monitoring strategy utilizes a nested watershed design allowing the sampling of streams within watersheds from a coarse to a fine scale (Figure 1). Each watershed scale is defined by a hydrologic unit code (HUC). These HUCs define watershed boundaries for water bodies within a similar geographic and hydrologic extent. The foundation of this approach is the 80 major watersheds (8-HUC) within Minnesota. Using this approach, many of the smaller headwaters and tributaries to the main stem river are sampled in a systematic way so that a more holistic assessment of the watershed can be conducted and problem areas identified without monitoring every stream reach. Each major watershed is the focus of attention for at least one year within the 10-year cycle.

River/stream sites are selected near the outlet of each of three watershed scales, 8-HUC, aggregated 12-HUC and 14-HUC (Figure 1). Within each scale, different water uses are assessed based on the opportunity for that use (i.e., fishing, swimming, supporting aquatic life such as fish and insects). The major river watershed is represented by the 8-HUC scale. The outlet of the major 8-HUC watershed (purple dot in Figure 2) is sampled for biology (fish and macroinvertebrates), water chemistry and fish contaminants to allow for the assessment of aquatic life, aquatic recreation and aquatic consumption use support. The aggregated 12-HUC is the next smaller subwatershed scale, which generally consists of major tributary streams with drainage areas ranging from 75 to 150 mi2. Each aggregated 12-HUC outlet (green dots in Figure 2) is sampled for biology and water chemistry for the assessment of aquatic life and aquatic recreation use support. Within each aggregated 12-HUC, smaller watersheds (14 HUCs, typically 10-20 mi2), are sampled at each outlet that flows into the major aggregated 12-HUC tributaries. Each of these minor subwatershed outlets is sampled for biology to assess aquatic life use support (red dots in Figure 2).

Figure 1. The Intensive Watershed Monitoring Design.

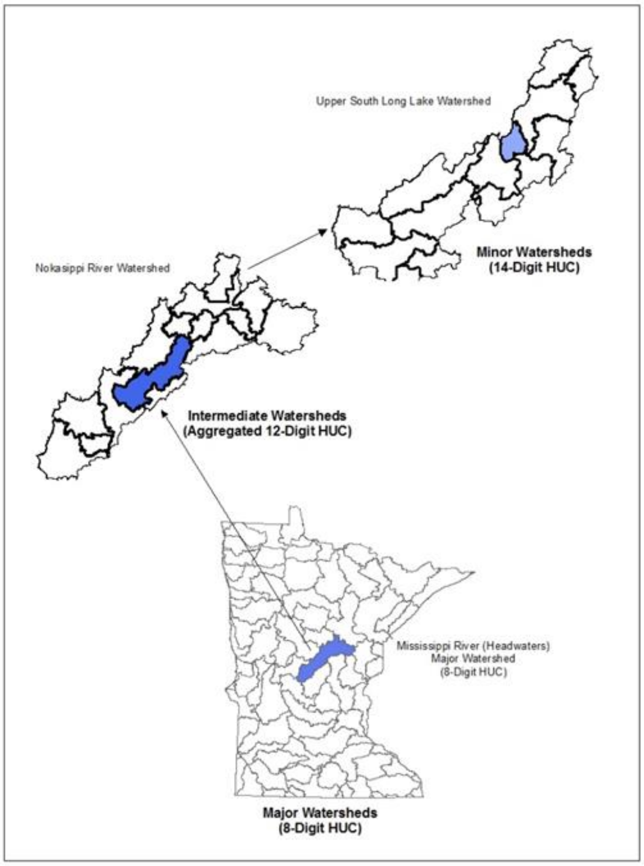
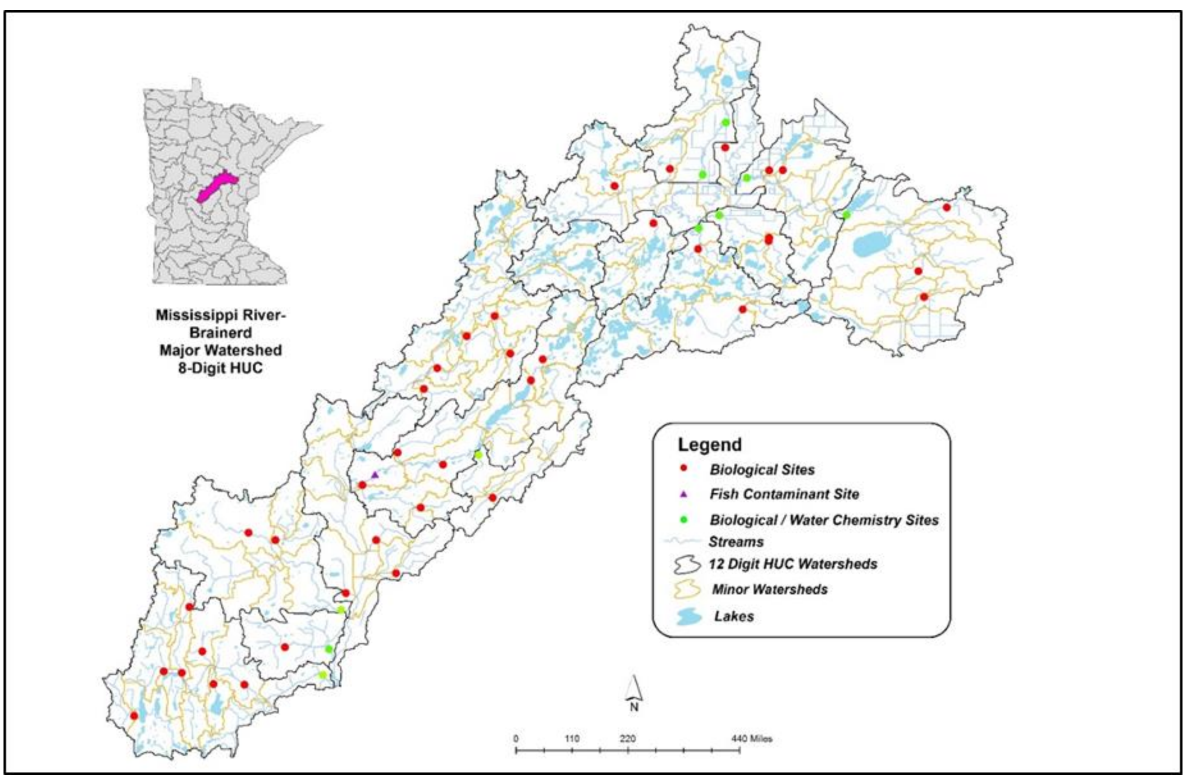


Figure 2. Intensive watershed monitoring sites for streams in the Upper Mississippi River-Brainerd Watershed.



Lake monitoring

Lakes most heavily used for recreation are monitored for water chemistry to determine if recreational uses, such as swimming and wading, are being supported and where applicable, where fish community health can be determined. Lakes are prioritized by size (greater than 100 acres), accessibility (can the public access the lakes), and presence of recreational use.

Specific locations for sites sampled as part of the intensive monitoring effort in the Upper Mississippi River-Brainerd Watershed are shown in Figure 2 and are listed in Appendices 2.1 and 2.2.

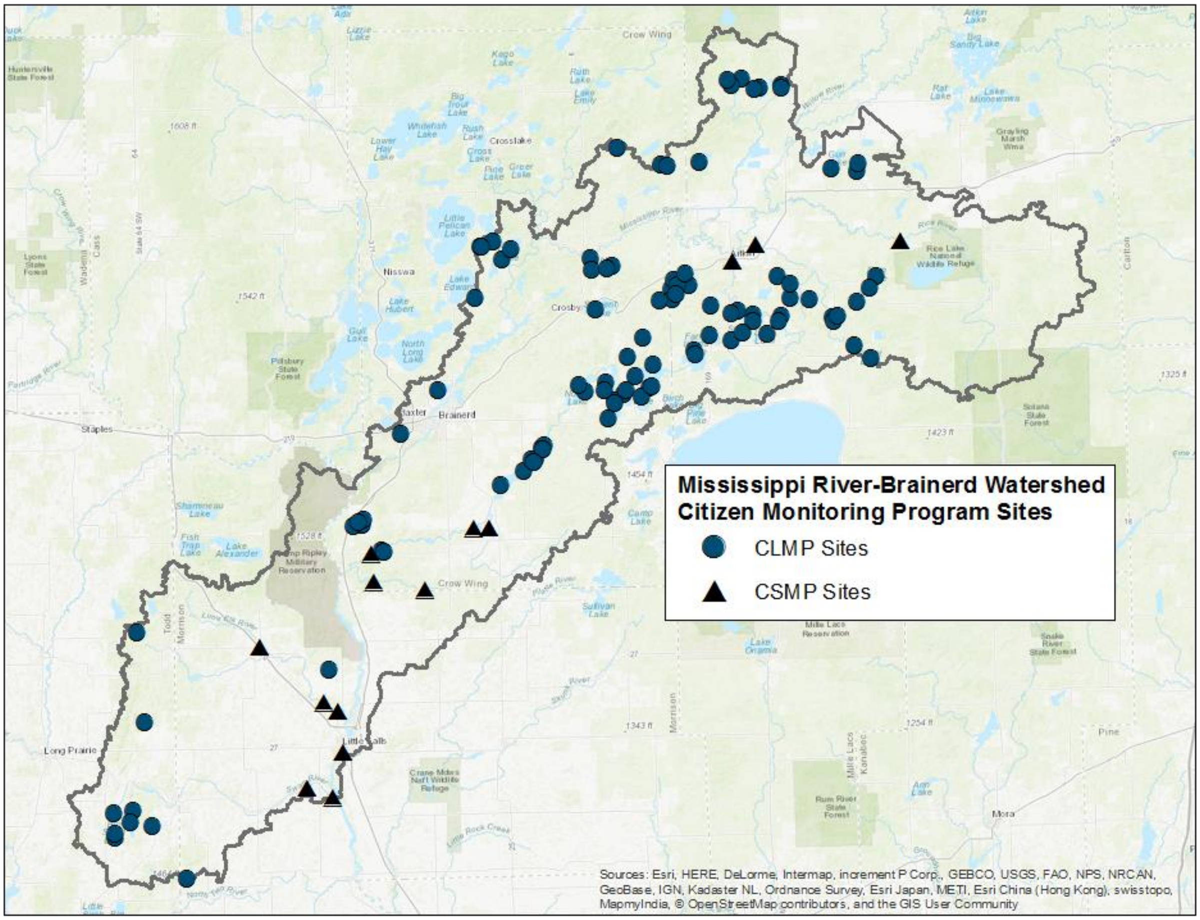
Citizen and local monitoring

Citizen and local monitoring is an important component of the watershed approach. The MPCA and its local partners jointly select the stream sites and lakes to be included in the intensive watershed monitoring process. Funding passes from MPCA through Surface Water Assessment Grants (SWAGs) to local groups such as counties, soil and water conservation districts (SWCDs), watershed districts, nonprofits and educational institutions to support lake and stream water chemistry monitoring. Local partners use the same monitoring protocols as the MPCA, and all monitoring data from SWAG projects are combined with the MPCA's to assess the condition of Minnesota lakes and streams. Preplanning and coordination of sampling with local citizens and governments helps focus monitoring where it will be most effective for assessment and observing long-term trends. This allows citizens/governments the ability to see how their efforts are used to inform water quality decisions and track how management efforts affect change. Many SWAG grantees invite citizen participation in their monitoring projects and their combined participation greatly expand our overall capacity to conduct sampling.

In addition to agency-funded efforts, considerable monitoring occurs at the local and private level in this watershed. Aitkin and Crow Wing counties have numerous lake associations with active monitoring programs. Local county environmental offices or soil and water conservation districts also support water quality monitoring in lakes across the region.

The MPCA coordinates two programs aimed at encouraging long term citizen surface water monitoring: the Citizen Lake Monitoring Program (CLMP) and the Citizen Stream Monitoring Program (CSMP). Like the permanent load monitoring network, having citizen volunteers monitor a given lake or stream site monthly and from year to year can provide the long-term picture needed to help evaluate current status and trends. Citizen monitoring is especially effective at helping to track water quality changes that occur in the years between intensive monitoring years. Figure 3 provides an illustration of the locations where citizen-monitoring data were used for assessment in the Upper Mississippi River-Brainerd Watershed.

Figure 3. Monitoring locations of local groups, citizens and the MPCA lake monitoring staff in the Upper Mississippi River-Brainerd Watershed.



Assessment methodology

The CWA requires states to report on the condition of the waters of the state every two years. This biennial report to Congress contains an updated list of surface waters that are determined to be supporting or non-supporting of their designated uses as evaluated by the comparison of monitoring data to criteria specified by Minnesota Water Quality Standards (Minn. R. ch. 7050 2008; https://www.revisor.leg.state.mn.us/rules/?id=7050). The assessment and listing process involves dozens of MPCA staff, other state agencies and local partners. The goal of this effort is to use the best data and best science available to assess the condition of Minnesota's water resources. For a thorough review of the assessment, methodologies see: *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment 305(b) Report and 303(d) List (MPCA 2012)*. https://www.pca.state.mn.us/sites/default/files/wq-iw1-04.pdf.

Water quality standards

Water quality standards are the fundamental benchmarks by which the quality of surface waters are measured and used to determine impairment. These standards can be numeric or narrative in nature and define the concentrations or conditions of surface waters that allow them to meet their designated beneficial uses, such as for fishing (aquatic life), swimming (aquatic recreation) or human consumption (aquatic consumption). All surface waters in Minnesota, including lakes, rivers, streams and wetlands are protected for aquatic life and recreation where these uses are attainable. Numeric water quality standards represent concentrations of specific pollutants in water that protect a specific designated use. Narrative standards are statements of conditions in and on the water, such as biological condition, that protect their designated uses.

Protection of aquatic recreation means the maintenance of conditions safe and suitable for swimming and other forms of water recreation. In streams, aquatic recreation is assessed by measuring the concentration of *E. coli* bacteria in the water. To determine if a lake supports aquatic recreational activities its trophic status is evaluated, using total phosphorus, Secchi depth and chlorophyll-a as indicators. Lakes that are enriched with nutrients and have abundant algal growth are eutrophic and do not support aquatic recreation.

Protection of consumption means protecting citizens who eat fish from Minnesota waters or receive their drinking water from waterbodies protected for this beneficial use. The concentrations of mercury and polychlorinated biphenyls (PCBs) in fish tissue are used to evaluate whether or not fish are safe to eat in a lake or stream and to issue recommendations regarding the frequency that fish from a particular water body can be safely consumed. For lakes, rivers and streams that are protected as a source of drinking water the MPCA primarily measures the concentration of nitrate in the water column to assess this designated use.

Protection of aquatic life means the maintenance of a healthy aquatic community, including fish, macroinvertebrates, and plants. Biological monitoring, the sampling of aquatic organisms, is a direct means to assess aquatic life use support, as the aquatic community tends to integrate the effects of all pollutants and stressors over time. To effectively use biological indicators, the MPCA employs the Index of Biotic Integrity (IBI). This index is a scientifically validated combination of measurements of the biological community (called metrics). An IBI is comprised of multiple metrics that measure different aspects of aquatic communities (e.g., dominance by pollution tolerant species, loss of habitat specialists). Metric scores are summed together and the resulting index score characterizes the biological integrity or "health" of a site. The MPCA has developed stream IBIs for (fish and macroinvertebrates) since these communities can respond differently to various types of pollution. The MPCA also uses a lake fish IBI developed by the Minnesota Department of Natural Resources (DNR) to determine if lakes are meeting aquatic life use. Because the lakes, rivers, and streams in Minnesota are physically, chemically, and biologically diverse, IBI's are developed separately for different stream classes and lake class groups to account for this natural variation. Further interpretation of biological community data is provided by an assessment threshold or biocriteria against which an IBI score can be compared within a given stream class. In general, an IBI score above this threshold is indicative of aquatic life use support, while a score below this threshold is indicative of non-support. Additionally, chemical parameters are measured and assessed against numeric standards developed to be protective of aquatic life. For streams, these include pH, dissolved oxygen, un-ionized ammonia nitrogen, chloride, total suspended solids, pesticides, and river eutrophication. For lakes, pesticides and chlorides contribute to the overall aquatic life use assessment.

Protection for aquatic life uses in streams and rivers are divided into three tiers: Exceptional, General, and Modified. Exceptional Use waters support fish and macroinvertebrate communities that have minimal changes in structure and function from the natural condition. General Use waters harbor "good" assemblages of fish and macroinvertebrates that can be characterized as having an overall balanced distribution of the assemblages and with the ecosystem functions largely maintained through redundant attributes. Modified Use waters have been extensively altered through legacy physical modifications, which limit the ability of the biological communities to attain the General Use. Currently the Modified Use is only applied to streams with channels that have been directly altered by humans (e.g., maintained for drainage). These tiered aquatic life uses are determined before assessment based on the attainment of the applicable biological criteria and/or an assessment of the habitat (MPCA 2015). For additional information, see: http://www.pca.state.mn.us/index.php/water/water-permits-and-rules/water-rulemaking/tiered-aquatic-life-use-talu-framework.html).

Table 1. Tiered aquatic life use standards.

Tiered aquatic life use	Acronym	Use class code	Description
Warm water General	WWg	2Bg	Warm water stream protected for aquatic life and recreation, capable of supporting and maintaining a balanced, integrated, adaptive community of warm or cool water aquatic organisms that meet or exceed the General Use biological criteria.
Warm water Modified	WWm	2Bm	Warm water stream protected for aquatic life and recreation, physically altered watercourses (e.g., channelized streams) capable of supporting and maintaining a balanced, integrated, adaptive community of warm or cool water aquatic organisms that meet or exceed the Modified Use biological criteria, but are incapable of meeting the General Use biological criteria as determined by a Use Attainability Analysis
Warm water Exceptional	WWe	2Be	Warm water stream protected for aquatic life and recreation, capable of supporting and maintaining an exceptional and balanced, integrated, adaptive community of warm or cool water aquatic organisms that meet or exceed the Exceptional Use biological criteria.
Coldwater General	CWg	2Ag	Coldwater stream protected for aquatic life and recreation, capable of supporting and maintaining a balanced, integrated, adaptive community of cold water aquatic organisms that meet or exceed the General Use biological criteria.
Coldwater Exceptional	CWe	2Ae	Coldwater stream protected for aquatic life and recreation, capable of supporting and maintaining an exceptional and balanced, integrated, adaptive community of cold water aquatic organisms that meet or exceed the Exceptional Use biological criteria.

A small percentage of stream miles in the state (~1% of 92,000 miles) have been individually evaluated and re-classified as a Class 7 Limited Resource Value Water (LRVW). These streams have previously demonstrated that the existing and potential aquatic community is severely limited and cannot achieve aquatic life standards either by: a) natural conditions as exhibited by poor water quality characteristics, lack of habitat or lack of water; b) the quality of the resource has been significantly altered by human activity and the effect is essentially irreversible; or c) there are limited recreational opportunities (such as fishing, swimming, wading or boating) in and on the water resource. While not being protective of aquatic life, LRVWs are still protected for industrial, agricultural, navigation and other uses. Class 7 waters are also protected for aesthetic qualities (e.g., odor), secondary body contact, and groundwater for use as a potable water supply. To protect these uses, Class 7 waters have standards for bacteria, pH, dissolved oxygen and toxic pollutants.

Assessment units

Assessments of use support in Minnesota are made for individual waterbodies. The waterbody unit used for river systems, lakes and wetlands is called the “assessment unit”. A stream or river assessment unit usually extends from one significant tributary stream to another or from the headwaters to the first tributary. A stream "reach" may be further divided into two or more assessment reaches when there is a change in use classification (as defined in Minn. R. ch. 7050) or when there is a significant morphological feature, such as a dam or lake, within the reach. Therefore, a stream or river is often segmented into multiple assessment units that are variable in length. The MPCA is using the 1:24,000 scale high resolution National Hydrologic Dataset (NHD) to define and index stream, lake and wetland assessment units. Each river or stream reach is identified by a unique waterbody identifier (known as its WID), comprised of the United States Geological Survey (USGS) eight-digit hydrologic unit code (8-HUC) plus a three-character code that is unique within each HUC. Lake and wetland identifiers are assigned by the DNR. The Protected Waters Inventory (PWI) provides the identification numbers for lake, reservoirs and wetlands. These identification numbers serve as the WID and are composed of an eight-digit number indicating county, lake and bay for each basin.

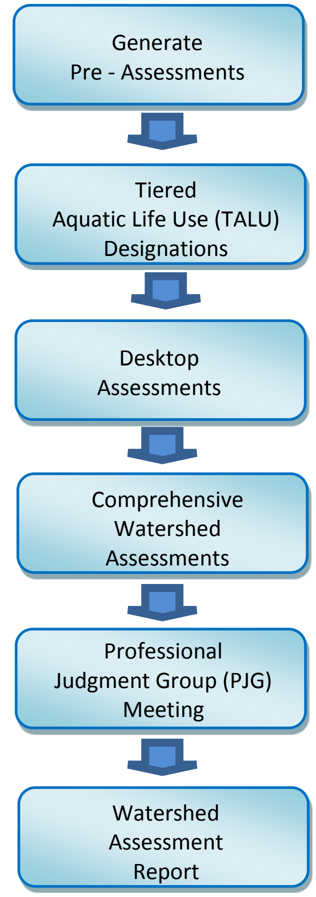
It is for these specific stream reaches or lakes that the data are evaluated for potential use impairment. Therefore, any assessment of use support would be limited to the individual assessment unit. The major exception to this is the listing of rivers for contaminants in fish tissue (aquatic consumption). Over the course of time it takes fish, particularly game fish, to grow to "catchable" size and accumulate unacceptable levels of pollutants, there is a good chance they have traveled a considerable distance. The impaired reach is defined by the location of significant barriers to fish movement such as dams upstream and downstream of the sampled reach and thus often includes several assessment units.

Determining use attainment

For beneficial uses related to human health, such as drinking water or aquatic recreation, the relationship is well understood and thus the assessment process is a relatively simple comparison of monitoring data to numeric standards. In contrast, assessing whether a waterbody supports a healthy aquatic community is not as straightforward and often requires multiple lines of evidence to make use attainment decisions with a high degree of certainty. Incorporating a multiple lines of evidence approach into MPCA's assessment process has been evolving over the past few years. The current process used to assess the aquatic life use of rivers and streams is outlined below and in Figure 4.

The first step in the aquatic life assessment process is largely an automated process performed by logic programmed into a database application where all data from the 10 year assessment window is gathered; the results are referred to as 'Pre-Assessments'. Data filtered into the "Pre-Assessment" process is then reviewed to insure that data is valid and appropriate for assessment purposes. Tiered aquatic life use designations are determined before data is assessed based on the attainment of the applicable biological criteria and/or an assessment of the habitat. Stream reaches are assigned the highest aquatic life use attained by both biological assemblages on or after November 28, 1975. Streams that do not attain the Exceptional or General Use for both assemblages undergo a Use Attainability Analysis (UAA) to determine if a lower use is appropriate. A Modified Use can be proposed if the UAA demonstrates that the General Use is not attainable as a result of legal human activities (e.g., drainage maintenance, channel stabilization) which are limiting the biological assemblages through altered habitat. Decisions to propose a new use are made through UAA workgroups, which include watershed project managers and biology leads. The final approval to change a designated use is through formal rulemaking.

Figure 4. Flowchart of aquatic life use assessment process.



The next step in the aquatic life assessment process is a comparison of the monitoring data to water quality standards. Pre-assessments are then reviewed by either a biologist or water quality professional, depending on whether the parameter is biological or chemical in nature. These reviews are conducted at the workstation of each reviewer (i.e., desktop) using computer applications to analyze the data for potential temporal or spatial trends as well as gain a better understanding of any extenuating circumstances that should be considered (e.g., flow, time/date of data collection, or habitat).

The next step in the process is a Comprehensive Watershed Assessment meeting where reviewers convene to discuss the results of their desktop assessments for each individual waterbody. Implementing a comprehensive approach to water quality assessment requires a means of organizing and evaluating information to formulate a conclusion utilizing multiple lines of evidence. Occasionally, the evidence stemming from individual parameters are not in agreement and would result in discrepant assessments if the parameters were evaluated independently. However, the overall assessment considers each piece of evidence to make a use attainment determination based on the preponderance of information available. See the *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment 305(b) Report and 303(d) List* (MPCA 2016) https://www.pca.state.mn.us/sites/default/files/wq-iw1-04j.pdf for guidelines and factors considered when making such determinations.

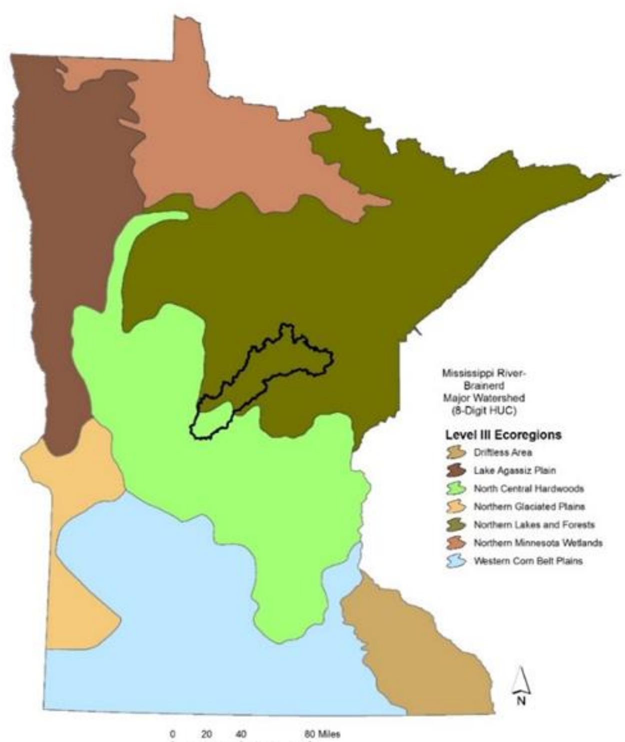
The last step in the assessment process is the Professional Judgment Group meeting. At this meeting, results are shared and discussed with entities outside of the MPCA that may have been involved in data collection or that might be responsible for local watershed reports and project planning. Information obtained during this meeting may be used to revise previous use attainment decisions (e.g., sampling events that may have been uncharacteristic due to annual climate or flow variation, local factors such as impoundments that do not represent the majority of conditions on the WID). Waterbodies that do not meet standards and therefore do not attain one or more of their designated uses are considered impaired waters and are placed on the draft 303(d) Impaired Waters List. Assessment results are also included in watershed monitoring and assessment reports.

Watershed overview

The Upper Mississippi River-Brainerd Watershed drains 1,682 square miles in north central Minnesota. From northeast to southwest, this watershed stretches 90 miles and encompasses parts of Aitkin, Crow Wing, Morrison and Todd counties. With approximately 2,100 river miles and over 200 lakes greater than 10 acres, this watershed is rich with water resources. Many of the lakes and rivers provide excellent recreational opportunities such as fishing, boating, and swimming.

This watershed lies in the northeastern portion of the Northern Central Hardwood Forest (NCHF) and southwestern portion of the Northern Lakes and Forest (NLF) ecoregions (Figure 5). The NCHF ecoregion is characterized by glacial till, lacustrine basins, outwash plains, and rolling to hilly moraines and beach ridges. The NCHF is nestled between the Northern Lakes and Forest ecoregion to the north and the more agricultural ecoregions to the south. The NLF is dominated by relatively nutrient-poor glacial soils, which support the growth of coniferous and northern hardwood forests. This heavily forested ecoregion is made-up of many steep, rolling hills, broad lacustrine basins, and extensive sandy outwash plains. Soils within this ecoregion are generally thicker than those to the north and lack the arability of soils in the adjacent ecoregions to the south. Lakes are numerous throughout the NLF ecoregions and are clearer and less productive than those that are located to the south. Throughout the NLF many Precambrian granitic bedrock outcropping exists between shallow-to-deep moraine deposits left by the last glacier retreat that dates back to 12,000 years ago (Omernik, 1988).

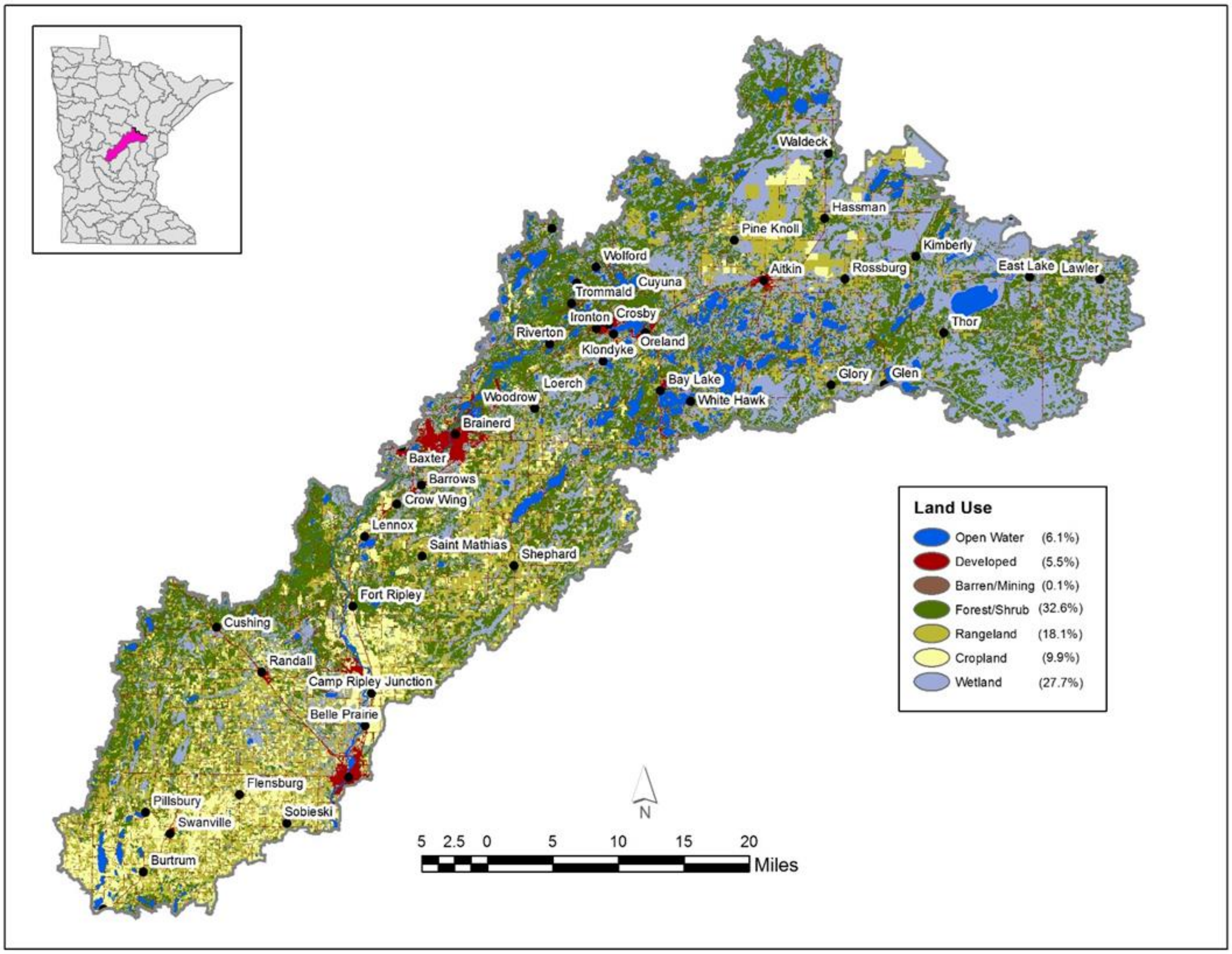
Figure 5. The Upper Mississippi River-Brainerd Watershed within the Northern Lakes and Forest and North Central Hardwoods ecoregions of central Minnesota.



Land use summary

Historically, much of the landscape within the watershed was dominated by old growth forest, swampland (wetlands), and open water. Today, the landscape resembles three distinct regions. The northeastern portion is predominately forest and wetlands. This area contains numerous wildlife management areas (WMAs) and protected lands, most notably the Rice Lake National Wildlife Refuge. The central portion is dominated by lakes with intermixed forest and range. The western portion gradually transitions into more rangeland, agriculture, and development, as the watershed nears its outlet. Land use totals for the watershed are: forest (32.7 %), wetland (27.7%), range (18.1%), cropland (9.9%), open water (6.1%), developed (5.5%), and mining (0.1%) (Figure 6). Development within the watershed is primarily concentrated around the towns of Aitkin, Baxter, Brainerd, Crosby, and Little Falls.

Figure 6. Land use in the Upper Mississippi River-Brainerd Watershed.



Surface water hydrology

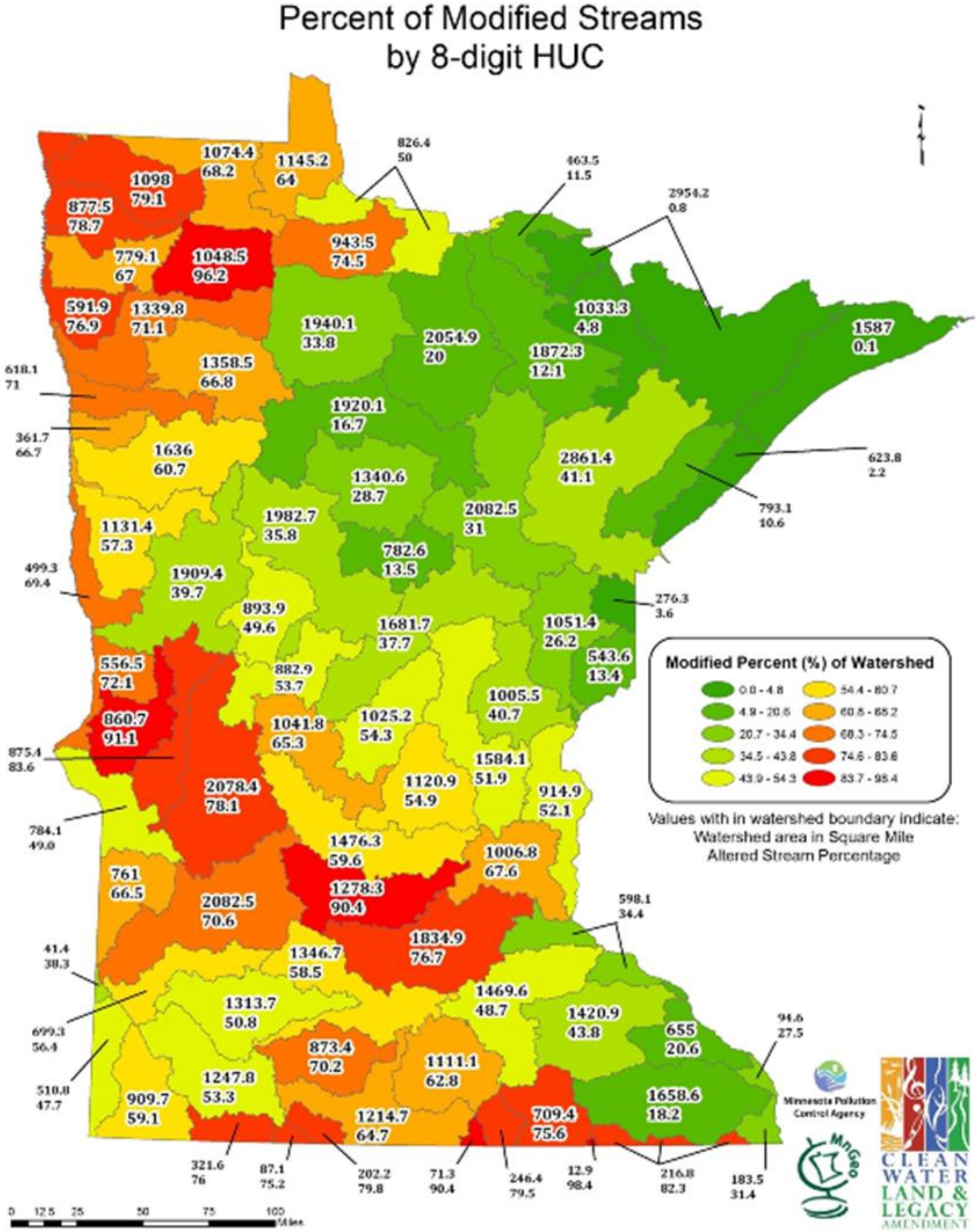
The Upper Mississippi River–Brainerd Watershed is comprised of 15 intermediate sized watersheds (aggregated 12 HUC), which contain a total of 2,100 river miles and more than 200 lakes >10 acres in size. The Mississippi River enters the watershed after its confluence with the Willow River, just north of Hassman, Minnesota; this confluence also marks the outlet of the Upper Mississippi River–Grand Rapids Watershed. After entering the watershed, the Mississippi River flows southwesterly approximately 119 miles to its confluence with the Swan River, which is the de-facto outlet of the Upper Mississippi River–Brainerd Watershed. Major tributary streams to the Mississippi River within the watershed include the Rice River, Ripple River, Little Willow River, Little Elk River, Nokasippi River, Swan River, and many other smaller tributaries.The hydrology of these streams will be covered in Section V: Individual aggregated 12-HUC subwatershed results.

Due to the relatively flat nature of the east-central portion of the watershed (i.e. Aitkin County), flooding is a concern. The city of Aitkin is located at the bottom of a large "U" turn along the Mississippi River, making it especially prone to flooding. Following a relatively severe flood in 1950, the U.S. Army Corps of Engineers designed a diversion which was cut across the top of the "U". The diversion channel is 6 ¼ miles long and cuts off 24 miles of river. The design is gravity fed, with a purpose to carry flood water away from the town of Aitkin. In its first 50 years of operation, it was estimated to save the town over 22 million dollars in flood related damages (Weeks III, 2006).

Many tributaries to the diversion channel have drop structures installed at their outlets. The purpose of these structures is to prevent high water in the diversion channel from backing up into the tributaries and flooding the surrounding landscape. While these structures likely help flood reduction, many of them act as fish barriers by limiting fish migration into upstream habitats.

According to the Altered Water Course Project (http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/streams-and-rivers/minnesota-statewide-altered-watercourse-project.html) conducted by the MPCA, the majority (55%) of the watershed is comprised of natural rivers and streams (the remaining stream miles are either altered or impounded (Figure 8). The majority of the altered streams occur north and east of Aitkin..

Figure 7. Map of percent altered streams by major watershed (8-HUC).



Climate and precipitation

Minnesota has a continental climate, marked by warm summers and cold winters. The mean annual temperature is 3.3˚C for northern Minnesota. The mean summer (June-August) temperature for the Upper Mississippi River-Brainerd Watershed is 18.9˚C and the mean winter (December-February) temperature is -10.6˚ C (DNR: Minnesota State Climatology Office, 2019).

Precipitation is an important source of water input to a watershed. Figure 8 displays two representations of precipitation for calendar year 2016. On the left is total precipitation, showing the typical pattern of increasing precipitation toward the southeastern portion of the state. According to this figure, the Upper Mississippi River-Brainerd Watershed area received 28 to 36 inches of precipitation in 2016. The display on the right shows the amount that precipitation levels departed from normal. The watershed area experienced precipitation that ranged from two to ten inches above normal in 2016.

Figure 8. Comparison of natural to altered streams in the Upper Mississippi River-Brainerd Watershed (percentages derived from the Statewide Altered Water Course project).

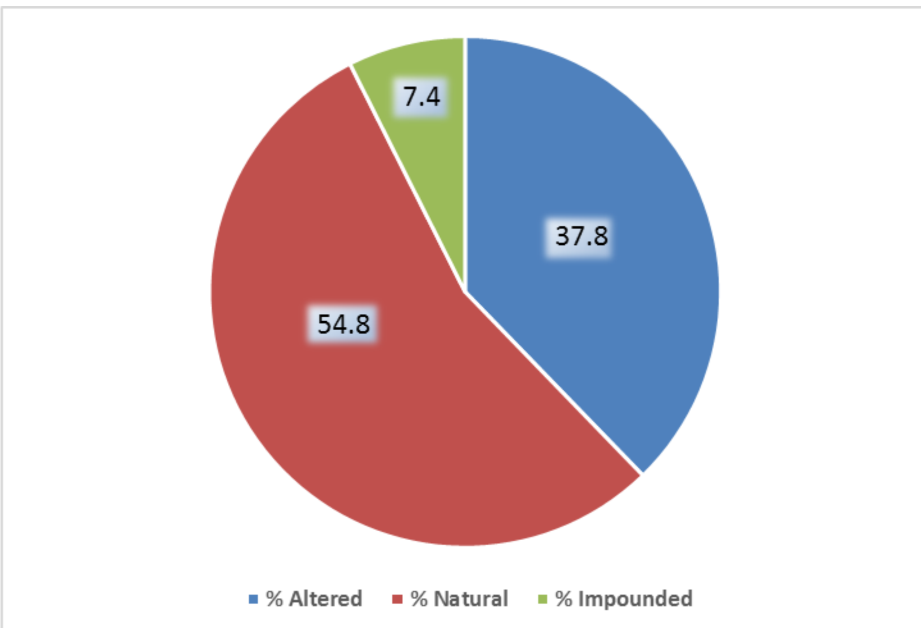
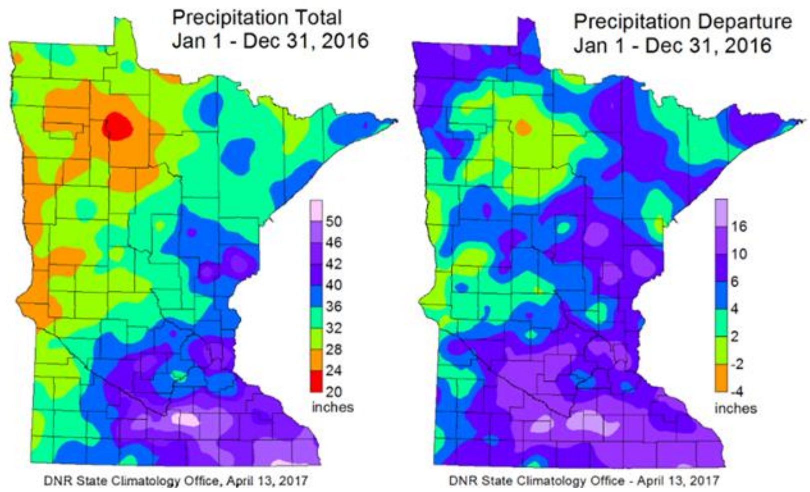


Figure 9. Statewide precipitation total (*left*) and precipitation departure (*right*) during 2016 (Source: DNR State Climatology Office, 2019)



The upper half of the Mississippi River-Brainerd Watershed is located in the East Central precipitation region and the lower half is located in the Central precipitation region. Figure 10 displays the areal average representation of precipitation in East Central Minnesota for 20 and 100 years, *left and right respectively*, while Figure 11 represents the Central region. Though rainfall can vary in intensity and time of year, rainfall totals in the East Central and Central regions display no significant trends over the last 20 years. However, precipitation in both regions exhibit a significant rising trend over the past 100 years ($p<0.001$). This is a strong trend and matches similar trends throughout Minnesota.

Figure 10. Precipitation trends in East Central Minnesota from 1997-2016 (left) and 1917-2016 (right) (Source: WRCC, 2018)

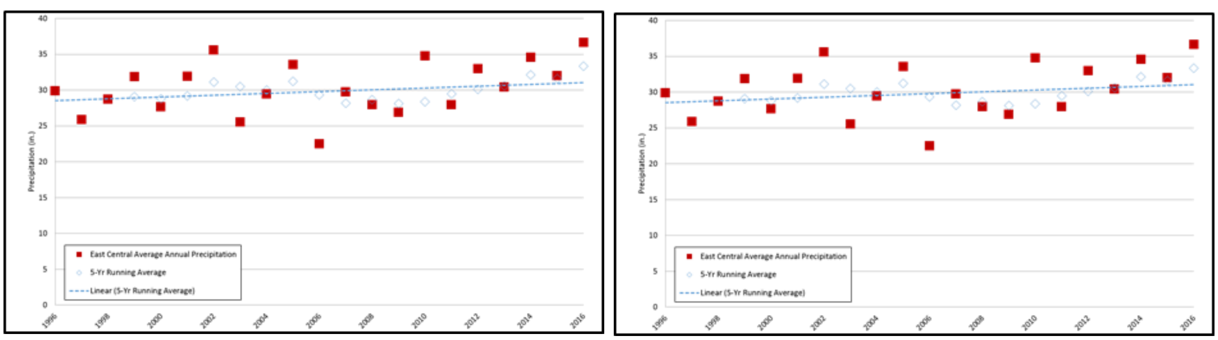
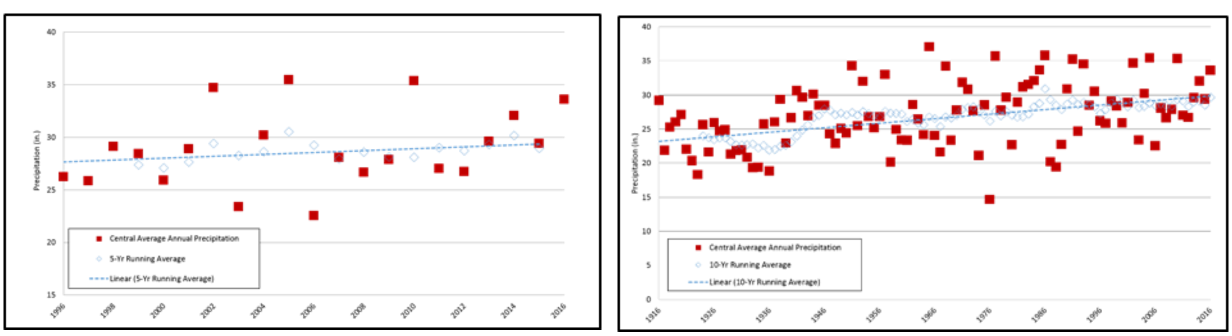


Figure 11. Precipitation trends in Central Minnesota from 1997-2016 (left) and 1917-2016 (right) (Source: WRCC, 2018)



Hydrogeology and groundwater quality

Hydrogeology

Hydrogeology is the study of the interaction, distribution and movement of groundwater through the rocks and soil of the earth. The geology of a region strongly influences the quantity of groundwater available, the quality of the water, the sensitivity of the water to pollution, and how quickly the water will be able to recharge and replenish the source aquifer. This branch of geology is important to understand as it indicates how to manage groundwater withdrawal and land use and can determine if mitigation is necessary.

Surficial and bedrock geology

Surficial geology is identified as the earth material located below the topsoil and overlying the bedrock. Glacial sediment is at the surface in much of the Mississippi River-Brainerd Watershed and is the parent material for the soils that have developed since glaciation. The depth to bedrock ranges from exposed at the surface to 430 feet and is buried by deposits of the various ice lobes that reached this watershed during the last glacial period, as well as during previous glaciations in the last 2.58 million years. The deposits at the surface are predominately associated with the Des Moines and Rainy ice lobes, and post-glacial alterations to that sediment, including soil formation and peat accumulation. The geomorphology includes glacial lake sediment, lake modified till, moraines (end and ground), mine workings, peat, outwash and alluvium.

Bedrock is the main mass of rocks that form the Earth, located underneath the surficial geology and can be seen in only a few places where weathering has exposed the bedrock. Precambrian bedrock lies under the extent of the Mississippi River-Brainerd Watershed. The main terrane groups include the Mille Lacs and Cuyuna North Range Groups, Animikie Group, and Little Falls Formation (Jirsa et al., 2011). The rock types that are found in the uppermost bedrock include arenite, claystone, conglomerate, diabase, felsic volcanic rock, gneiss, granite, iron formation, metasedimentary rock, metavolcanic rock, mudstone, pyroxenite, sandstone, schist, shale, and slate (Morey & Meints, 2000).

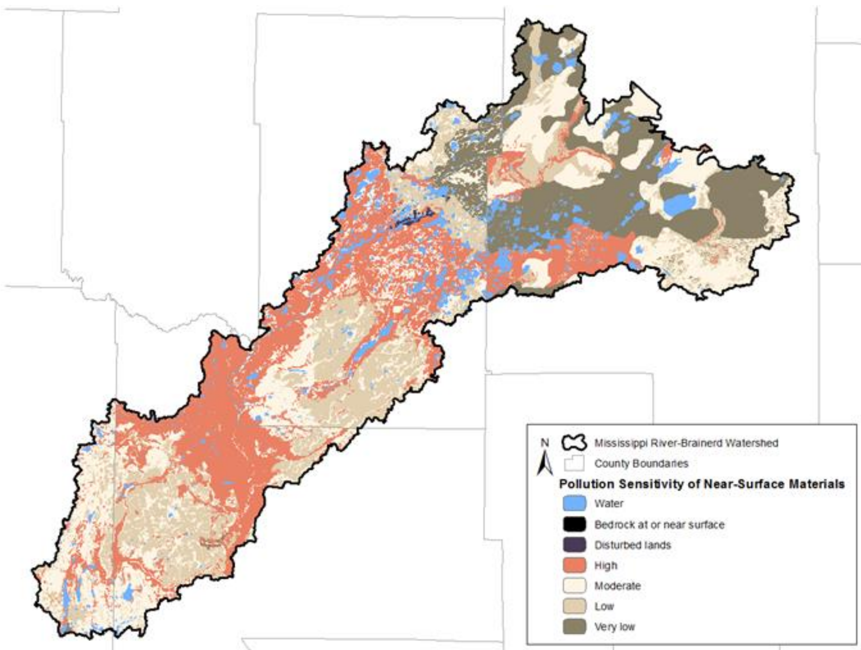
Aquifers

Groundwater aquifers are layers of water-bearing units that readily transmit water to wells and springs (USGS, 2016). As precipitation hits the surface, it infiltrates through the soil zone and into the void spaces within the geologic materials underneath the surface, saturating the material and becoming groundwater (Zhang, 1998). The water table is the uppermost portion of the saturated zone, where the pore-water pressure is equal to local atmospheric pressure. The geologic material determines the permeability and availability of water within the aquifer. The Mississippi River-Brainerd Watershed is almost completely within the Central Groundwater Province, with one minor area with Cretaceous bedrock present in the northeast region. The Central Province has sand aquifers in thick sandy and clayey glacial drift (DNR, 2001). The Cretaceous bedrock consists of layers of sandstone that are interbedded with thick layers of shale, located between older bedrock and glacial drift, and are often utilized as local water sources (DNR, 2001). The Central Province has good groundwater availability in the surficial sands, moderate availability in the buried sands, and limited availability within the bedrock (DNR, 2001; DNR, 2018a).

Groundwater pollution sensitivity

Bedrock aquifers are typically covered with thick till, which normally makes them better protected from contaminant releases at the land surface. It is also less likely that withdrawals from wells would have a direct and significant impact on local surface water bodies. In contrast, surficial aquifers are typically more likely to 1) be vulnerable to contamination, 2) have direct hydrologic connections to local surface water, and 3) influence the quality and quantity of local surface water. A 2016 statewide evaluation of pollution sensitivity of near-surface materials completed by the DNR is utilized to estimate pollution vulnerability up to 10 feet from the land surface. This display is not intended to be used on a local scale, but as a coarse-scale planning tool. According to this data, the Mississippi River-Brainerd Watershed is estimated to have very low to moderate pollution sensitivity with some high pollution sensitivity areas scattered throughout the watershed, most likely due to the presence of sand and gravel Quaternary geology (Figure 12) (DNR, 2016).

Figure 12. Pollution sensitivity of near-surface materials for the Mississippi River-Brainerd Watershed (GIS Source: DNR, 2016)

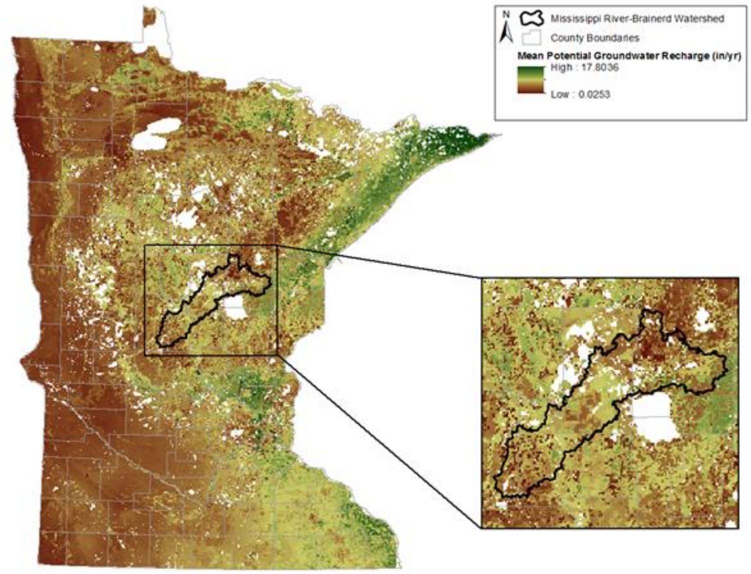


Groundwater potential recharge

Groundwater recharge is one of the most important parameters in the calculation of water budgets, which are used in general hydrologic assessments, aquifer recharge studies, groundwater models, and water quality protection. Recharge is a highly variable parameter, both spatially and temporally, making accurate estimates at a regional scale difficult to produce. The MPCA contracted the US Geological Survey to develop a statewide estimate of recharge using the SWB – Soil-Water-Balance Code. The result is a gridded data structure of spatially distributed recharge estimates that can be easily integrated into regional groundwater studies. The full report of the project as well as the gridded data files are available at: https://gisdata.mn.gov/dataset/geos-gw-recharge-1996-2010-mean.

Recharge of these aquifers is important and limited to areas located at topographic highs, those with surficial sand and gravel deposits, and those along the bedrock-surficial deposit interface (Figure 13). Typically, recharge rates in unconfined aquifers are estimated at 20% to 25% of precipitation received, but can be less than 10% of precipitation where glacial clays or till are present (USGS, 2007). For the Mississippi River-Brainerd Watershed, the average annual potential recharge rate to surficial materials ranges from 0.03 to 10.74 inches per year, with an average of 5.08 inches per year. The statewide average potential recharge is estimated to be four inches per year with 85% of all recharge ranging from three to eight inches per year. When compared to the statewide average potential recharge, the Mississippi River-Brainerd Watershed receives approximately an inch greater average potential recharge per year.

Figure 12. Average annual potential recharge rate to surficial materials in Mississippi River-Brainerd Watershed (1996-2010) (GIS Source: USGS, 2015)



Groundwater quality

Approximately 75% of Minnesota's population receives their drinking water from groundwater, undoubtedly indicating that clean groundwater is essential to the health of its residents. The Minnesota Pollution Control Agency's Ambient Groundwater Monitoring Program monitors trends in statewide groundwater quality by sampling for a comprehensive suite of chemicals including nutrients, metals, and volatile organic compounds. These ambient groundwater wells represent a mix of deeper domestic wells and shallow monitoring wells. The shallow wells interact with surface waters and exhibit impacts from human activities more rapidly. Available data from federal, state and local partners are used to supplement reviews of groundwater quality in the region.

There are currently 20 MPCA ambient groundwater monitoring wells within the Mississippi River-Brainerd Watershed (Figure 14). Data collection for the network ranges from 2004 to 2018 with 90% of the wells installed after 2011. The most commonly detected analytes within this watershed were sulfate (100%), phosphorus (99.3%), strontium (99.3%), sodium (98.6%), calcium (97.1%), chloride (93.1%) and potassium (91.4%). All of these analytes are naturally occurring and are released into the groundwater as the mineral dissolves over time. The majority were within water quality standards set by Minnesota Department of Health (MDH) and U. S. Environmental Protection Agency (EPA). There were 49 exceedances of a water quality standard. This included manganese (17.7%), perfluorooctane sulfonate (PFOS) (10.0%), iron (8.6%), aluminum (6.6%), perfluorohexane sulfonate (PFHxS) (5.0%), inorganic nitrogen (1.4%), and chloride (0.7%).

Manganese has a Health Based Value (HBV) of 100 µg/L. In 29.8% of the samples collected, it the HBV 17.7% of the time. Exceedances occurred in seven wells ranging from one to six occurrences per well. Manganese is naturally occurring and commonly found in groundwater across the state. High concentrations of manganese give water a black to brown color, a bitter metallic taste, and may be unsafe for human consumption when concentrations are over the HBV, especially for infants. At low levels, manganese is considered beneficial, but high exposures can cause harm to the nervous system and issues with memory, attention and motor skills (MDH, 2019). If drinking water exceeds the HBV, individuals are advised by the MDH to utilize a carbon filter or bottled water, especially with infants and nursing mothers (MDH, 2019).

Perfluorinated chemicals (PFCs) were sampled at 18 wells within the watershed. PFCs are general class of manmade chemicals that resist heat, oil, stains, grease and water. They are used in the manufacture of nonstick cookware, coatings on some food packaging, and fire-fighting foam. Exposure to elevated levels of PFCs may cause higher cholesterol, changes to liver function, reduced immune response, thyroid disease, and increased risk of kidney and testicular cancer (MDH, 2018). PFC samples were tested for 13 specific contaminants, such as perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), perfluorobutanoic acid (PFBA). There were detections in 16.5% of the samples. Specifically, there were three exceedances of PFOS and perfluorohexane sulfonate (PFHxS) in two wells in 2013. These wells were sampled again for PFCs in 2017 and all levels had decreased with no exceedances. If PFC levels exceed the drinking water standards, residents are recommended to install a whole house granular activated charcoal filter (MPCA, 2017).

Iron has a secondary maximum contaminant level (SMCL) of 300 µg/L, where exceedances can lead to noticeable nuisance affects (taste, color, odor), but are not considered to be a threat to human health (EPA, 2017). These effects may include rusty color, metallic taste, pipe clogging and staining clothes and appliances. Within this watershed, 23.7% of samples had detections of iron while 8.6% of samples exceeded the SMCL. Conventional treatments, such as coagulation, flocculation, filtration, aeration, and granular activated carbon filters, are effective ways of removing color and odor associated with secondary contaminants (EPA, 2017).

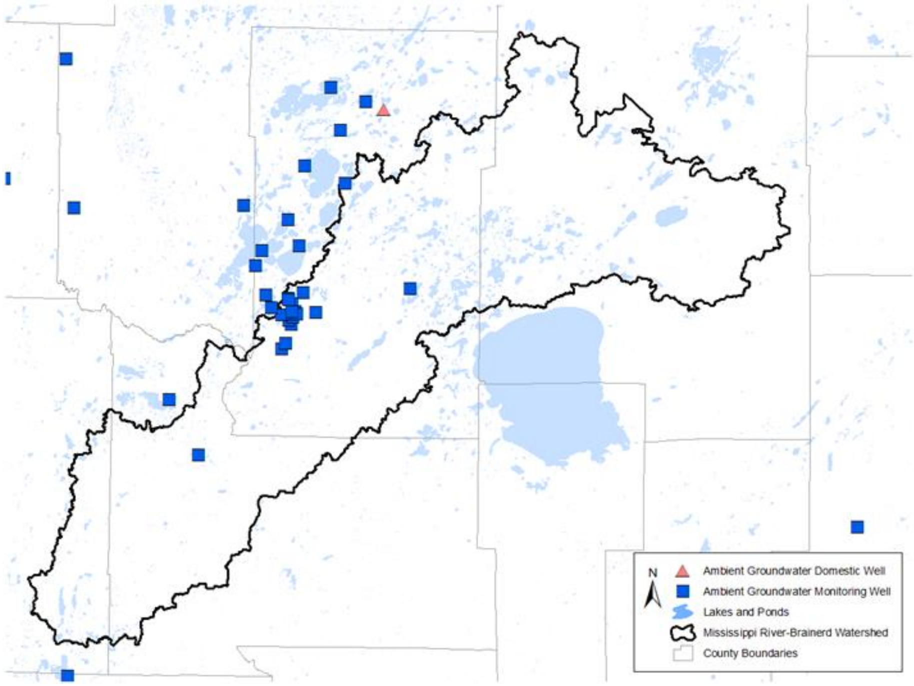
There was a 24.1% detection frequency of aluminum and a 6.6% exceedance frequency of the SMCL of 50 to 200 µg/L. Exceedances of aluminum can cause water to have a colored appearance and may be caused by dissolved organic material, inadequate treatment, high demand and possible excess by-products of disinfectant (EPA, 2017). Granular activated carbon filters are recommended to help remove contaminants that cause color, odors and foaming (EPA, 2017).

Inorganic nitrogen includes nitrate and nitrite that may contaminate water sources through excess fertilizer runoff, leakage from septic tanks and sewage, and erosion of natural deposits (EPA, 2018). The maximum contaminant level (MCL) is 10 mg/L for nitrate and 1 mg/L for nitrite. For this analysis, 10 mg/L was used as the exceedance benchmark, since nitrate is the dominant form typically found in groundwater. Nitrate levels that exceed the HRL are considered dangerous for infants younger than six months due to the risk of methemoglobinemia (blue-baby syndrome), which could potentially be life threatening if untreated. Although detections of inorganic nitrogen occurred at 87.4% of all samples, there were only two wells with an exceedance of this standard, which occurred in 2012 and have not exceeded the HRL since that time.

Chloride has become an increasing concern due to salt being used as a deicing agent. Elevated chloride concentrations can affect the taste of drinking water (Kroening & Ferrey, 2013). The EPA set a SMCL of 250 mg/L for chloride in drinking water to minimize taste issues. Chloride occurs naturally in groundwater and therefore has been commonly detected in this watershed (93.1%) but there was only one exceedance of the SMCL.

In addition to the annual ambient groundwater samples, MPCA staff collect 40 samples for contaminants of emerging concern (CECs). CECs are predominantly manmade chemicals, although some may be naturally occurring or endocrine active chemicals, and include pharmaceuticals, fire retardants, pesticides, personal-care products, hormones, and detergents (Erickson et al., 2014). These samples were collected at 19 of the wells with detections identified in eight of the wells at a 0.91% detection rate. The most commonly detected CEC was sulfamethoxazole with four detections. There were no exceedances to applicable water quality guidelines.

Figure 13. MPCA ambient groundwater monitoring well locations within the Mississippi River-Brainerd Watershed.



Groundwater quantity

The DNR permits all high capacity water withdrawals where the pumped volume exceeds 10,000 gallons per day or one million gallons per year. Permit holders are required to track water use and report back to the DNR annually. The changes in withdrawal volume are a representation of water use and demand in the watershed and are taken into consideration when the DNR issues permits for water withdrawals.

The three largest permitted consumers of water in the state are (in order) power generation, public water supply (municipals), and irrigation (DNR, 2018b). According to the most recent DNR Permitting and Reporting System (MPARS), in 2016 the withdrawals within the Mississippi River-Brainerd Watershed were utilized for agricultural irrigation (53.4%) followed by water supply (39.1%). The remaining withdrawals include non-crop irrigation (3.5%), water level maintenance (2.3%), industrial processing (1.2%), and special categories (0.4%). From 1997 to 2016, withdrawals associated with non-crop irrigation and water supply have decreased significantly. Withdrawals associated with special categories and industrial processing have increased, while agricultural irrigation and water level maintenance have remained steady during this time period.

Figure 15 displays total high capacity withdrawal locations within the watershed with active permit status in 2016. During 1997 to 2016, groundwater withdrawals within the Mississippi River-Brainerd Watershed appear to be increasing, but not at a significant rate (Figure 16, *left*), while surface water withdrawals exhibit a significant decreasing rate (Figure 16, *right*).

Figure 14. Locations of active status permitted high capacity withdrawals in 2016 within the Mississippi River-Brainerd Watershed

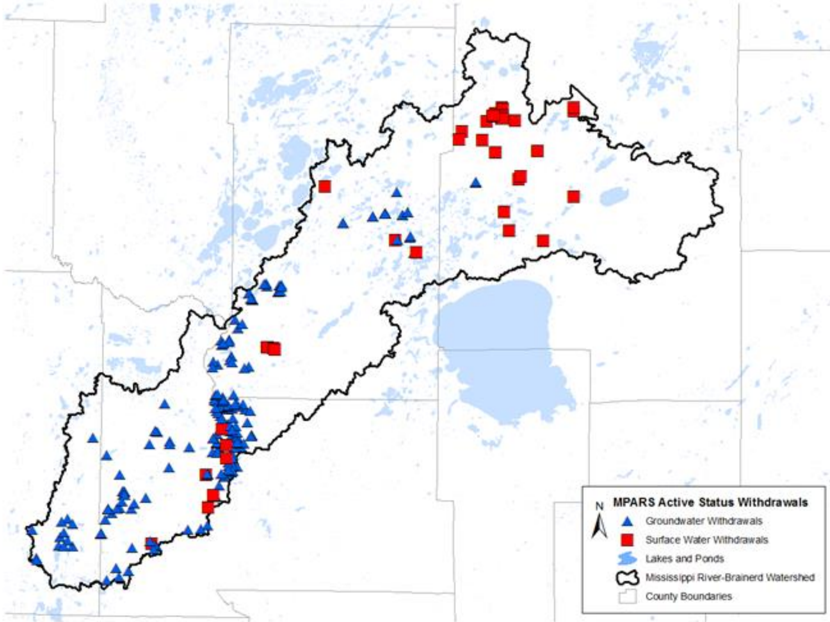
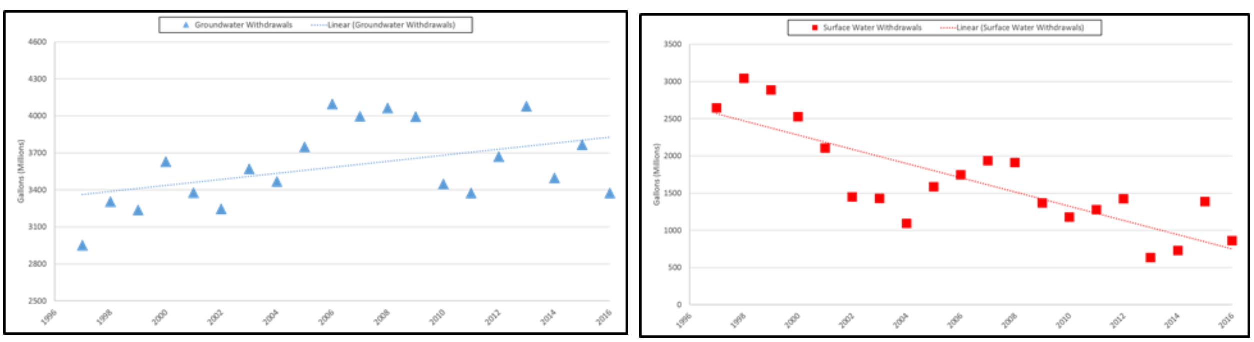


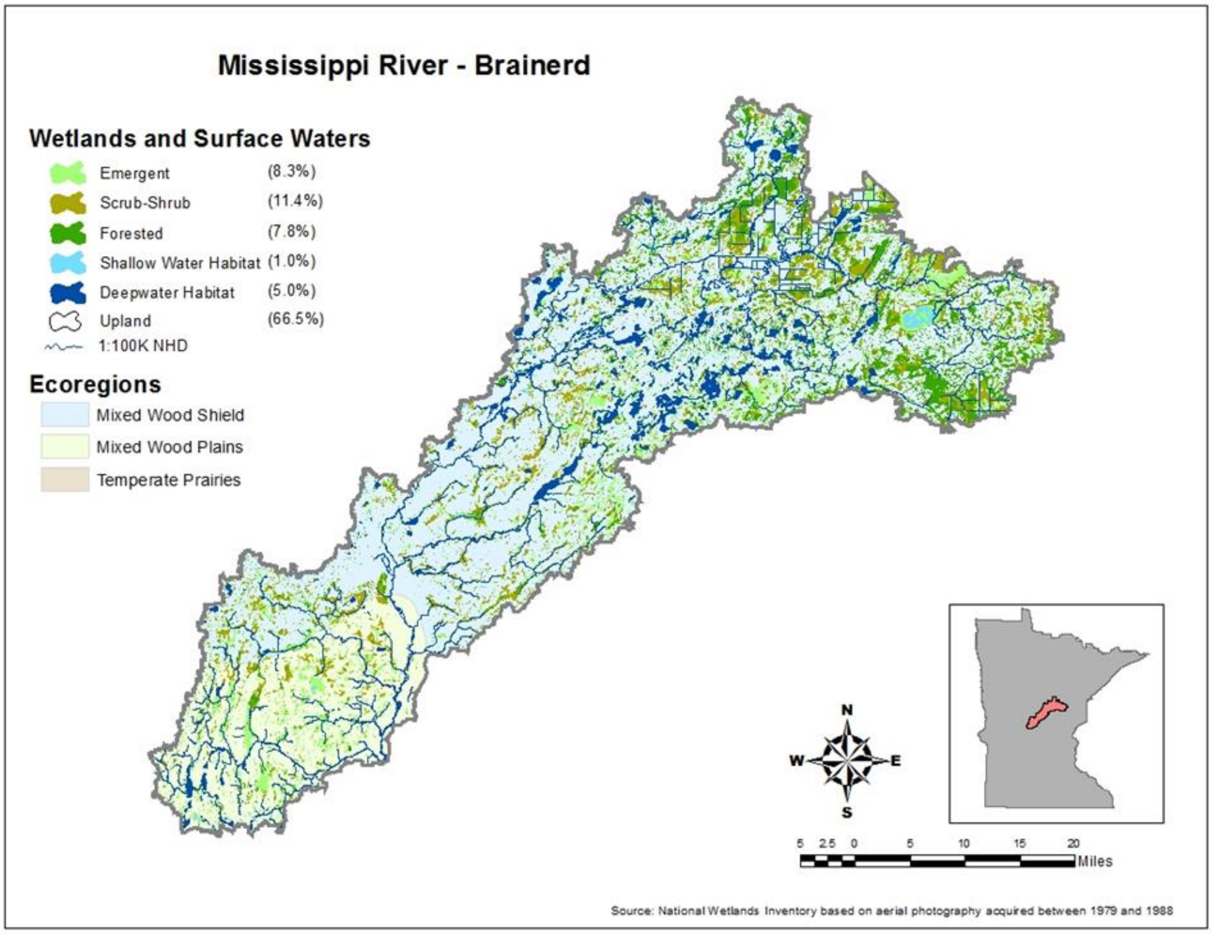
Figure 15. Total annual groundwater (left) and surface water (right) withdrawals in the Mississippi River-Brainerd Watershed (1997-2016).



Wetlands

Wetlands are prevalent in the Mississippi River–Brainerd Watershed. There are 306,609 wetland acres in the watershed according the National Wetlands Inventory (NWI), or 28% of the watershed (Figure 17). This coverage rate is greater than the statewide coverage rate of 19% but less than the Mixed Wood Shield ecoregion (which most of the watershed occurs in) rate of 34% (Kloiber and Norris 2013, Bourdaghs et al. 2015). Scrub-shrub wetlands (wetlands dominated by willows and alder or open bogs) are the predominant wetland type—occupying approximately 11% of the watershed and comprising roughly 40% of the wetlands in the watershed.

Figure 16. Wetlands and surface water in the Mississippi River–Brainerd Watershed. Wetland data are from the National Wetlands Inventory.



A variety of glacial landforms are present in the Mississippi River–Brainerd Watershed (MNGS 1997), contributing to a mixed wetland drainage history and contrasting hydrogeomorphic (HGM) wetland types that are present today. Glacial lake Aitkin once covered a portion of the northeast watershed and extensive peat forming wetlands known as organic flats (Smith et al. 1995) formed on the resulting lake plain. Precipitation and evapotranspiration are the predominant water pathways of organic flats, but they can also provide source waters to streams (often delivering waters with high dissolved organic matter, low pH, and low dissolved oxygen) as excess surface water slowly drains from the wetlands (Acerman and Holden 2013). A complex ditch network was established in the watershed throughout these lake plain organic flats to develop the land for agriculture. In many cases, the wetlands have been successfully drained and farmed, but in other cases, the drainage has been only partially effective or ineffective and wetlands remain. The watershed is also dissected by several sandy glacial outwash plains and valleys that formed during glacial melt (most notably running alongside the Mississippi river from Brainerd to Little Falls and south to the broader Anoka sandplain). Similar to lake plains, HGM flat wetlands are the predominant type in outwash landscapes. They can be large, but typically not as extensive as wetland complexes found in glacial lake landforms. The Mississippi River–Brainerd Watershed also includes areas of ground and end moraine typified by moderate to steep hilly terrain where flat and depressional HGM type wetlands form in the topographic depressions. Moraine landforms occur south and west of the City of Aitkin and throughout much of the southern half of the watershed. Depressional HGM type wetland hydrology may be dominated by surface flow, precipitation, and/or groundwater depending on the local setting and whether a basin has a surface water connection (Smith et al. 1995). Much of the southern portion of the watershed that corresponds with the Mixed Wood Plains ecoregion (Figure 17) and along the outwash valley adjacent to the Mississippi River extending north to Brainerd has been developed for agriculture and there appears have been some corresponding wetland drainage in both the moraine and outwash landform areas. Complete soil survey data, however, is not available to make historical wetland loss estimates. Wild rice is also widespread throughout much of the Mississippi River–Brainerd Watershed. Documented populations are concentrated mainly in the northeast two-thirds of the watershed with scattered populations southwards. Given how common wild rice is throughout this part of the state, there may be many more un-documented wild rice populations in the watershed.

Watershed-wide data collection methodology

Lake water sampling

Sixty-six lakes were sampled to assess their suitability to support aquatic recreation. A SWAG (Surface Water Assessment Grant) was awarded to Aitkin SWCD, Crow Wing SWCD and Todd SWCD to collect water samples at thirty of these stations. MPCA staff collected water chemistry at the remaining stations. There are currently 106 volunteers enrolled in the MPCA's CLMP that are conducting lake monitoring within the watershed. Sampling methods are similar among monitoring groups and are described in the document entitled "*MPCA Standard Operating Procedure for Lake Water Quality*" found at http://www.pca.state.mn.us/publications/wq-s1-16.pdf. The lake recreation use assessment requires eight observations/samples within a 10-year period (June to September) for phosphorus, chlorophyll-a and Secchi depth. Chloride, sulfate, and nitrates are sampled at a subset of waters that have been identified, as being impacted by chloride inputs, are designated wild rice waters, or have a designated drinking water use.

Stream water sampling

Eleven water chemistry stations were sampled from May through September in 2016, and again June through August of 2017, to provide sufficient water chemistry data to assess for aquatic life and recreation use support. Following the IWM design, water chemistry stations were placed at the outlet of each aggregated 12-HUC subwatershed (40 - 200 square miles) (blue, purple and green circles (Figure 2). A SWAG was awarded to Aitkin SWCD and Crow Wing SWCD to collect water samples at eight of these stations. MPCA staff collected water chemistry at the remaining stations. (See Appendix 2.1 for locations of stream water chemistry monitoring sites. See Appendix 1 for definitions of stream chemistry analytes monitored in this study.) There are currently 15 volunteers enrolled in the MPCA's CSMP that are conducting stream monitoring within the watershed.

Stream flow methodology

MPCA and the DNR joint stream water quantity and quality monitoring data for dozens of sites across the state on major rivers, at the mouths of most of the state's major watersheds, and at the mouths of some aggregated 12-HUC subwatersheds are available at the DNR/MPCA Cooperative Stream Gaging webpage at: http://www.dnr.state.mn.us/waters/csg/index.html.

Lake biological sampling

A total of 72 lakes were monitored for fish community health in the Upper Mississippi River-Brainerd Watershed. While data from the last 10 years contributed to the watershed assessments, the majority of data utilized for the 2018 assessment was collected in 2016 – 2017. Waterbody assessments to determine aquatic life use support were completed for 69 lakes.

To measure the health of aquatic life at each lake, a fish IBI was calculated based on monitoring data collected in the lake. A fish classification framework was developed to account for natural variation in community structure, which is attributed to area, maximum depth, alkalinity, shoreline complexity, and geographic location. As a result, an IBI is available for four different groups of lake classes (Schupp Lake Classification, DNR). Each IBI class uses a unique suite of metrics, scoring functions, impairment thresholds, and confidence intervals (CIs). IBI scores higher than the impairment threshold and upper CI indicate that the lake supports aquatic life. Scores below the impairment threshold and lower CI indicate that the lake does not support aquatic life. When an IBI score falls within the upper and lower confidence limits additional information may be considered when making the impairment decision such as the consideration of potential local and watershed stressors and additional monitoring information (e.g., water chemistry, physical habitat, plant surveys, and observations of local land use activities).

Stream biological sampling

The biological monitoring component of the IWM in the Upper Mississippi River-Brainerd Watershed was completed during the summer of 2016 and 2017. A total of 46 sites were newly established across the watershed and sampled. These sites were located near the outlets of most minor HUC-14 watersheds. In addition, four existing biological monitoring stations within the watershed were revisited in 2016. These monitoring stations were initially established as part of a random Upper Mississippi River basin wide survey in 1998 and 2000. While data from the last 10 years contributed to the watershed assessments, the majority of data utilized for the 2018 assessment was collected in 2016 and 2017. A total of 46 stream reaches (WIDs) were sampled for biology in the Upper Mississippi River-Brainerd Watershed. Waterbody assessments to determine aquatic life use support were conducted for 41 WIDs. Biological information that was not used in the assessment process will be crucial to the stressor identification process and will also be used as a basis for long-term trend results in subsequent reporting cycles.

To measure the health of aquatic life at each biological monitoring station, indices of biological integrity (IBIs), specifically fish IBI (FIBI) and macroinvertebrate IBI (MIBI), were calculated based on monitoring data collected for each of these communities. A fish and macroinvertebrate classification framework was developed to account for natural variation in community structure which is attributed to geographic region, watershed drainage area, water temperature and stream gradient. As a result, Minnesota's streams and rivers were divided into seven distinct warm water classes and two cold water classes, with each class having its own unique FIBI and MIBI. Each IBI class uses a unique suite of metrics, scoring functions, impairment thresholds, and confidence intervals (CIs) (For IBI classes, thresholds and CIs, see Appendix 3.1). IBI scores higher than the impairment threshold and upper CI indicate that the stream reach supports aquatic life. Contrarily, scores below the impairment threshold and lower CI indicate that the stream reach does not support aquatic life. When an IBI score falls within the upper and lower confidence limits additional information may be considered when making the impairment decision such as the consideration of potential local and watershed stressors and additional monitoring information (e.g., water chemistry, physical habitat, observations of local land use activities). For IBI results for each individual biological monitoring station, see Appendices 4.1 and 4.2.

Fish contaminants

The DNR fisheries staff collect most of the fish for the Fish Contaminant Monitoring Program. In addition, MPCA's biomonitoring staff collect up to five piscivorous (top predator) fish and five forage fish near the 8-HUC pour point, as part of the Intensive Watershed Monitoring. All fish collected by the MPCA are analyzed for mercury and the two largest individual fish of each species are analyzed for polychlorinated biphenyls (PCBs).

Captured fish were wrapped in aluminum foil and frozen until they were thawed, scaled (or skinned), filleted, and ground to a homogenized tissue sample. Homogenized fillets were placed in 60 mL glass jars with Teflon™ lids and frozen until thawed for lab analysis. The Minnesota Department of Agriculture Laboratory analyzed the samples for mercury and PCBs. If fish were tested for poly- and perfluoroalkyl substances (PFAS), whole fish were shipped to AXYS Analytical Laboratory, which analyzed the homogenized fish fillets for 13 PFAS. Of the measured PFAS, only perfluorooctane sulfonate (PFOS) is reported because it bioaccumulates in fish to levels that are potentially toxic and a reference dose has been developed.

From the fish contaminant analyses, MPCA determines which waters exceed impairment thresholds. The Impaired Waters List is prepared by the MPCA and submitted every even year to the EPA. MPCA has included waters impaired for contaminants in fish on the Impaired Waters List since 1998. Impairment assessment for PCBs (and PFOS when tested) in fish tissue is based on the fish consumption advisories prepared by the Minnesota Department of Health (MDH). If the consumption advice is to restrict consumption of a particular fish species to less than a meal per week the MPCA considers the lake or river impaired. The threshold concentration for impairment (consumption advice of one meal per month) is an average fillet concentration of 0.22 mg/kg for PCBs (and 0.200 mg/kg for PFOS).

Monitoring of fish contaminants in the 1970s and 1980s showed high concentrations of PCBs were primarily a concern downstream of large urban areas in large rivers, such as the Mississippi River, and in Lake Superior. Therefore, PCBs are now tested where high concentrations in fish were measured in the past and the major watersheds are screened for PCBs in the watershed monitoring collections.

Before 2006, mercury in fish tissue was assessed for water quality impairment based on MDH's fish consumption advisory, the same as PCBs. With the adoption of a water quality standard for mercury in edible fish tissue, a waterbody has been classified as impaired for mercury in fish tissue if 10% of the fish samples (measured as the 90^{th} percentile) exceed 0.2 mg/kg of mercury. At least five fish samples of the same species are required to make this assessment and only the last 10 years of data are used for the assessment. MPCA's Impaired Waters List includes waterways that were assessed as impaired prior to 2006 as well as more recent impairments.

Watershed pollutant load monitoring network

Intensive water quality sampling occurs at all WPLMN sites. Thirty-five samples per year are allocated for basin and major watershed sites and 25 samples per season (ice out through October 31) for subwatershed sites. Because concentrations typically rise with streamflow for many of the monitored pollutants, and because of the added influence elevated flows have on pollutant load estimates, sampling frequency is greatest during periods of moderate to high flow. All major snowmelt and rainfall events are sampled. Low flow periods are also sampled although sampling frequency is reduced, as pollutant concentrations are generally more stable when compared to periods of elevated flow.

Water sample results and daily average flow data are coupled in the $FLUX_{32}$ pollutant load model to estimate the transport (load) of nutrients and other water quality constituents past a sampling station over a given period of time. Loads and flow weighted mean concentrations (FWMCs) are calculated for total suspended solids (TSS), total phosphorus (TP), dissolved orthophosphate (DOP), nitrate plus nitrite nitrogen (NO_3+NO_2-N), and total Kjeldahl nitrogen (TKN).

More information can be found at the WPLMN website.

Groundwater monitoring

The MPCA maintains an ambient groundwater-monitoring network that monitors the aquifers that are most likely to be polluted with non-agricultural chemicals. This network primarily targets the shallow aquifers that underlie the urban parts of the state, due to the higher tendency of vulnerability to pollution. The MPCA's Ambient Groundwater Monitoring Network as of 2019, when this report was produced, consisted of approximately 270 wells that are primarily located in the sand and gravel and Prairie du Chien-Jordan aquifers.

Some wells in the MPCA's network are used to discern the effect of urban land use on groundwater quality and comprise an early warning network. Most wells in this early warning network contain water that was recently recharged into the groundwater, some even less than one year old. The wells in the early warning network are distributed among several different settings to determine the effect land use has on groundwater quality. These assessed land use settings are: 1) sewered residential, 2) residential areas that use subsurface sewage treatment systems (SSTS) for wastewater disposal, and 3) commercial or industrial, and 4) undeveloped. The data collected from the wells in the undeveloped areas provide a baseline to assess the extent of any pollution from all other land use settings.

Water samples from the MPCA's Ambient Groundwater Monitoring Network wells generally are collected annually by MPCA staff. This sampling frequency provides sufficient information to determine trends in groundwater quality. The water samples are analyzed to determine the concentrations of over 100 chemicals, including nitrate, chloride, and VOCs.

Information on groundwater monitoring methodology is taken from Kroening and Ferrey's report: The Condition of Minnesota's Groundwater, 2007-2011 (2013). To download ambient groundwater monitoring data, please refer to: https://www.pca.state.mn.us/data/groundwater-data.

Wetland monitoring

Wetland vegetation quality is high overall in Minnesota (Bourdaghs et al. 2015). This is driven by the large share of wetlands located in Mixed Wood Shield (i.e., northern forest) ecoregion where development and resulting stressors are much less widespread (and wetland condition is largely intact) compared to the rest of the state. Wetlands in exceptional or good vegetation condition have few (if any) changes in their expected native species composition or abundance distribution. Wetland vegetation quality is largely degraded in the remainder of the state, where non-native invasive plant species (most notably Reed canary grass and Narrow leaf or Hybrid cattail) have replaced native wetland plant communities over the majority of the remaining wetland extent (Bourdaghs et al. 2015). High abundance of non-native invasive plant species is associated with a broad spectrum of wetland stressors and may also occur in the absence of stressors.

As the majority of the Mississippi River–Brainerd Watershed lies within the Mixed Wood Shield ecoregion (Figure 17), wetland vegetation quality in the watershed is expected to be high overall. An estimated 84% of the wetland extent in the Mixed Wood Plains are in good to exceptional vegetation condition (Bourdaghs et al. 2015). In addition, wetland vegetation quality at monitoring sites in the Mixed Wood Plains ecoregion located near the Mixed Wood Shield border is often higher than the vegetation quality of wetlands for the ecoregion as a whole. Wetland quality impacts in the watershed are likely localized. Primary impacts to wetland vegetation quality include hydrology alterations and clearing associated to drainage ditches and farming and runoff from farm fields or directed stormwater in cities and towns.

Individual aggregated 12-HUC subwatershed results

Aggregated 12-HUC subwatersheds

Assessment results for aquatic life and recreation use are presented for each Aggregated HUC-12 subwatershed within the Upper Mississippi River-Brainerd Watershed. The primary objective is to portray all the full support and impairment listings within an aggregated 12-HUC subwatershed resulting from the complex and multi-step assessment and listing process. This scale provides a robust assessment of water quality condition at a practical size for the development, management, and implementation of effective TMDLs and protection strategies. The graphics presented for each of the aggregated HUC-12 subwatersheds contain the assessment results from the 2018 Assessment Cycle as well as any impairment listings from previous assessment cycles. Discussion of assessment results focuses primarily on the 2016-2017 intensive watershed monitoring effort, but also considers available data from the last ten years.

The proceeding pages provide an account of each aggregated HUC-12 subwatershed. Each account includes a brief description of the aggregated HUC-12 subwatershed, and summary tables of the results for each of the following: a) stream aquatic life and aquatic recreation assessments, and b) lake aquatic life and recreation assessments. Following the tables is a narrative summary of the assessment results and pertinent water quality projects completed or planned for the aggregated HUC-12 subwatershed. A brief description of each of the summary tables is provided below.

Stream assessments

A table is provided in each section summarizing aquatic life and aquatic recreation assessments of all assessable stream reaches within the aggregated HUC-12 subwatershed (i.e., where sufficient information was available to make an assessment). Primarily, these tables reflect the results of the 2018 assessment process (2020 EPA reporting cycle); however, impairments from previous assessment cycles are also included and are distinguished from new impairments via cell shading (see footnote section of each table). These tables also denote the results of comparing each individual aquatic life and aquatic recreation indicator to their respective criteria (i.e., standards); determinations made during the desktop phase of the assessment process (see Figure 4). Assessment of aquatic life is derived from the analysis of biological (FIBI and MIBI), dissolved oxygen, total suspended solids, chloride, pH, total phosphorus, chlorophyll-a, biochemical oxygen demand and un-ionized ammonia (NH_3) data, while the assessment of aquatic recreation in streams is based solely on bacteria (*Escherichia coli*) data. Included in each table is the specific aquatic life use classification for each stream reach: cold water community (2A) or cool or warm water community (2B). Where applicable and sufficient data exists, assessments of other designated uses (e.g., class 7, drinking water, aquatic consumption) are discussed in the summary section of each aggregated HUC-12 subwatershed as well as in the Watershed-wide results and discussion section.

Lake assessments

A summary of lake water quality is provided in the aggregated 12-HUC subwatershed sections where available data exists. This includes aquatic recreation (phosphorus, chlorophyll-a, and Secchi) and aquatic life, where available (chloride and fish IBI). Similar to streams, parameter level and over all use decisions are included in the table.

Lower Rice River Aggregated 12-HUC

HUC 0701010401-01

The Lower Rice River Subwatershed encompasses 99 square miles of Aitkin County. This subwatershed contains the lower section of the Rice River, as it flows 24.5 miles from Wakefield Brook to its outlet with the Mississippi River. Major tributaries to the Rice River include Wakefield Brook, Flemming Brook, and Dam Brook. Land use is predominately wetlands (46.1%) and forest (29.8%), with the remaining land comprised of range (11.8%), open water (6.0%), cropland (3.5%), and developed (2.8%). The water chemistry monitoring station for this subwatershed was established upstream of Hwy 210, 7 mi. NE of Aitkin.

Table 2. Aquatic life and recreation assessments on stream reaches: Lower River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

WID *Reach name,* *Reach description*	Biological Station ID	Reach length (miles)	Use class*	Aquatic life indicators: Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Eutrophication	Aquatic life	Aquatic rec. (Bacteria)
07010104-543 ***Unnamed ditch,*** *French Lk to Rice R*	16UM058	2.22	WWg	MTS	MTS	IF	IF	IF	--	IF	IF	IF	SUP	--
07010104-693 ***Rice River,*** *Wakefield Bk to Mississippi R*	16UM037	24.58	WWg	MTS	MTS	MTS	IF	IF	MTS	MTS	MTS	IF	SUP	SUP

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: = existing impairment, listed prior to 2018 reporting cycle; = new impairment; = full support of designated use; = insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 3. Lake assessments: Lower Rice River Aggregated 12-HUC.

Lake name	DNR ID	Area (acres)	Max depth (ft)	Assessment method	Ecoregion	Secchi Trend	Aquatic life indicators: Fish IBI	Aquatic life indicators: Chloride	Aquatic life indicators: Pesticides ***	Aquatic recreation indicators: Total phosphorus	Aquatic recreation indicators: Chlorophyll-a	Aquatic recreation indicators: Secchi	Aquatic life use	Aquatic recreation use
Portage	01-0069-00	363.50	18	Deep	NLF		MTS	MTS	--	EXS	EXS	EXS	SUP	IMP
Long	01-0089-00	434.04	117	Deep	NLF		IF	MTS	--	MTS	MTS	MTS	IF	SUP
Dam	01-0096-00	587.79	48	Deep	NLF		MTS	MTS	--	MTS	EXS	MTS	SUP	IF
Gun	01-0099-00	695.49	44	Deep	NLF		IF	MTS	--	MTS	IF	IF	IF	IMP
Wilkins	01-0102-00	344.45	39	Deep	NLF		MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
French	01-0104-00	141.08	37	Deep	NLF		IF	IF	--	MTS	MTS	MTS	IF	SUP
Fleming	01-0105-00	305.23	15	Shallow	NLF		MTS	MTS	--	EXS	EXS	EXS	SUP	IMP
Turner	01-0074-00	62.18	21	Deep	NLF		--	MTS	--	IF	EXS	NA	IF	IF
Newstrom	01-0097-00	66.24	2	Shallow	NLF		--	--	--	IF	--	IF	--	IF
Jenkins	01-0100-00	111.61	38	Deep	NLF		--	IF	--	IF	IF	IF	IF	IF

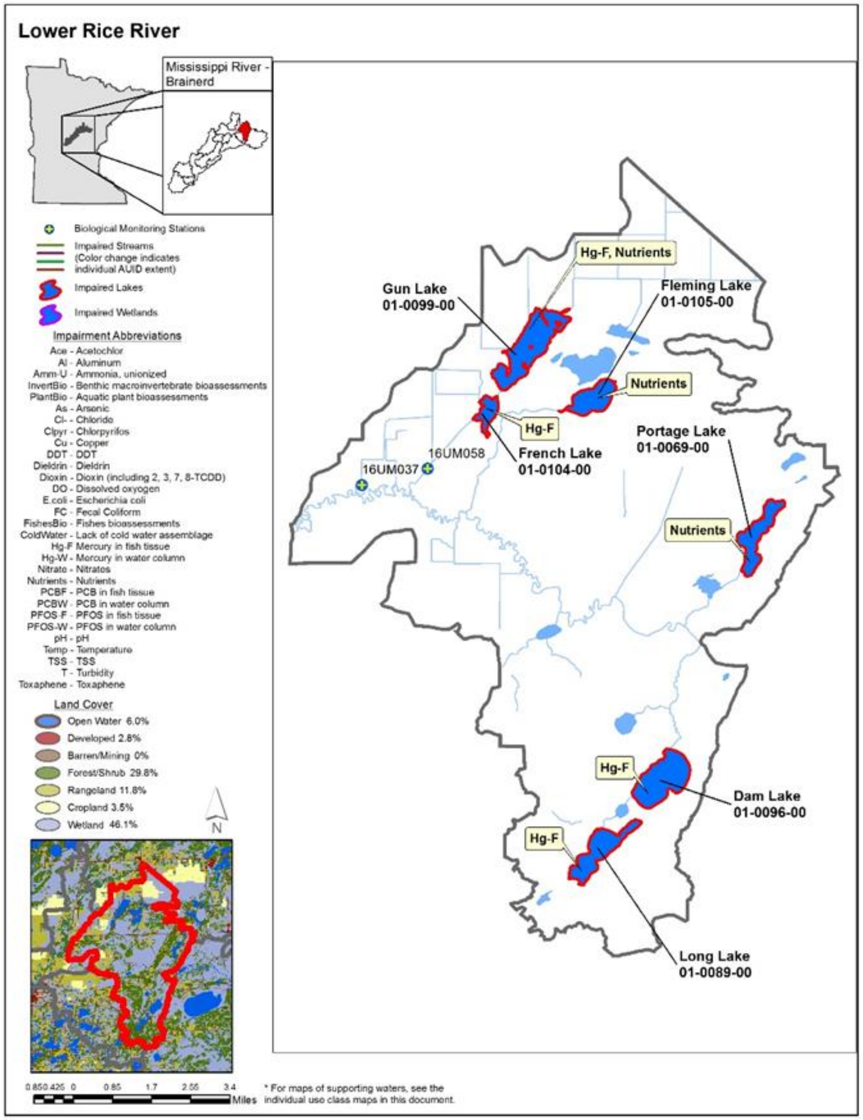
Abbreviations for Ecoregion: **DA** = Driftless Area, **NCHF** = North Central Hardwood Forest, **NGP** = Northern Glaciated Plains, **NLF** = Northern Lakes and Forests, **NMW** = Northern Minnesota Wetlands, **RRV** = Red River Valley, **WCBP** = Western Corn Belt Plains
Abbreviations for Secchi Trend: **D** = decreasing/declining trend, **I** = increasing/improving trend, **NT** = no detectable trend, **--** = not enough data
Abbreviations for Indicator Evaluations: **--** = No Data, **MTS** = Meets Standard; **EXS** = Exceeds Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Not Support (Impaired, exceeds standard)
Key for Cell Shading: ☐ = existing impairment, listed prior to 2018 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐= insufficient information.

Summary

Aquatic life indicators on rivers and streams within the Lower Rice River Subwatershed reflect very good water quality. The fish assemblage collected along the lower portion of the Rice River (Wakefield Brook to Mississippi River) was exceptional. Shorthead Redhorse dominated the fish assemblage. This species is generally indicative of healthy, well-connected riverine habitats. In addition, several other sensitive fish species that indicate healthy water quality conditions were collected, such as Walleye, Rock Bass, and Trout Perch. Nutrients, although elevated along this reach, did not trigger an impairment. Bacteria levels along the Rice River are low and indicate suitable conditions for aquatic recreation.

This subwatershed had ten lakes reviewed for aquatic recreation; seven of these were also reviewed for aquatic life. These lakes are small to medium sized and have low to moderate development. Portage, Fleming, and Gun Lakes were determined to be impaired for aquatic recreation. Fleming, listed for eutrophication in 2010, had TP, chl-a, and transparency values that were well in excess of aquatic recreation standards (average TP was 62 ug/L and chl-a was 35 ug/L). Portage also had elevated TP and chl-a and low transparency. Poor water quality and the shallow nature of Portage Lake led to a severe winterkill in the winter of 2018. Gun Lake was first listed for eutrophication in 2010 and should be considered a high priority for restoration as water quality has been improving since its previous assessment: chl-a is narrowly exceeding, Secchi transparency is right at the standard, and TP is just below the standard. Portage, Dam, Wilkins, and Fleming Lakes fully supported aquatic life based on the fish IBI. The fish IBI scores were positively influenced on Dam and Wilkins by the number of intolerant and small benthic species found. The species composition in gill nets drove the supporting fish IBI scores on Fleming and Portage lakes. An aquatic plant survey performed on these lakes found healthy plant communities.

Figure 17. Currently listed impaired waters by parameter and land use characteristics in the Lower Rice River Aggregated 12-HUC.



Upper Rice River Aggregated 12-HUC HUC 0701010401-02

The Upper Rice River Subwatershed drains 198 square miles of southeastern Aitkin County and is the largest of the subwatersheds in the Upper Mississippi River-Brainerd major watershed. As the name implies, this subwatershed contains the upper reaches of the Rice River, which begins in a remote wetland complex approximately 15 miles south of McGregor, and flows 21 miles to the north before its confluence with Wakefield Brook. Just upstream of its Wakefield Brook confluence, the Rice River indirectly receives flow from Rice Lake via an unnamed ditch; a dam is located at the outlet of this ditch to help control water levels within Rice Lake for wild rice production. A second dam is located approximately four miles downstream of the first dam, and its purpose is to control water levels on the river and the lake. Land use is dominated by wetlands (53%) and forest (35%), with the remaining land comprised of range (4.9%), open water (4.8%), and developed (1.6%). Rice Lake National Wildlife Refuge (RLNWR) is located in the northwestern portion of the subwatershed. The refuge is an important resource to the area, and is home to some of the most abundant fish and wildlife habitat in the Upper Mississippi River-Brainerd Watershed. The water chemistry monitoring station was established upstream of 362nd Ln, 2 mi. SE of Kimberly.

Table 4. Aquatic life and recreation assessments on stream reaches: Upper Rice River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

				Aquatic life indicators:										
WID ***Reach name,*** *Reach description*	**Biological Station ID**	**Reach length (miles)**	**Use class***	**Fish IBI**	**Invert IBI**	**Dissolved oxygen**	**TSS**	**Secchi Tube**	**Chloride**	**pH**	**Ammonia -NH_3**	**Eutrophication**	**Aquatic life**	**Aquatic rec. (Bacteria)**
07010104-505 ***Rice River,*** *Headwaters (Porcupine Lk 01-0066-00) to Section 5 Cr*	16UM036, 98NF143	13.27	WWg	EXS	--	EXS	MTS	NA	--	IF	IF	IF	IMP	SUP
07010104-536 ***Wakefield Brook,*** *Headwaters to Rice R*	16UM061	10.76	WWg	MTS	MTS	IF	IF	IF	--	IF	IF	IF	SUP	--
07010104-649 ***Rice River,*** *Section 5 Cr to Wakefield Bk*	10EM088	7.80	WWg	EXP	MTS	EXS	MTS	NA	--	MTS		IF	IMP	IMP

07010104-692 ***Rice River,*** *Wakefield Bk to Dam Bk*	00UM019	10.65	WWg	MTS	MTS	NA	MTS	NA	MTS	MTS	MTS	IF	SUP	SUP

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards) Key for Cell Shading: = existing impairment, listed prior to 2018 reporting cycle; = new impairment; = full support of designated use; = insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 5. Lake water aquatic recreation assessments Upper Rice River Aggregated 12-HUC.

Lake name	DNR ID	Area (acres)	Max depth (ft)	Assessment method	Ecoregion	Secchi trend	Aquatic life indicators:			Aquatic recreation indicators:			Aquatic life use	Aquatic recreation use
							Fish IBI	Chloride	Pesticides ***	Total phosphorus	Chlorophyll-a	Secchi		
Sugar	01-0087-00	416.77	45	Deep	NLF		MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
Sheriff	01-0027-00	90.23	80	Deep	NLF			IF	--	IF	IF	MTS	IF	IF
Swamp	01-0092-00	274.16	5.5	Shallow	NLF			MTS	--	IF	IF	NA	IF	IF

Abbreviations for Ecoregion: **DA** = Driftless Area, **NCHF** = North Central Hardwood Forest, **NGP** = Northern Glaciated Plains, **NLF** = Northern Lakes and Forests, **NMW** = Northern Minnesota Wetlands, **RRV** = Red River Valley, **WCBP** = Western Corn Belt Plains
Abbreviations for Secchi Trend: **D** = decreasing/declining trend, **I** = increasing/improving trend, **NT** = no detectable trend, **--** = not enough data
Abbreviations for Indicator Evaluations: **--** = No Data, **MTS** = Meets Standard; **EXS** = Exceeds Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Not Support (Impaired, exceeds standard)
Key for Cell Shading: = existing impairment, listed prior to 2018 reporting cycle; = new impairment; = full support of designated use; = insufficient information

Summary

Water quality indicators within the Upper Rice River Subwatershed show mixed results. The headwaters of the Rice River (headwaters to Section 5 Creek) was previously listed as impaired for aquatic life in 2002 due to a poor fish community. New fish data collected along this reach in 2016 corroborates the original listing. Fish communities on the next downstream reach are also poor with fish assemblages along both reaches being dominated by species which are very tolerant to low dissolved oxygen (DO) (ex. Central Mudminnow, Black Bullhead). Fish communities are better along the lower section of the Rice River (Wakefield Brook to the Dam Brook), with FIBI scores above the impairment threshold. Two riverine species (Silver Redhorse, Walleye) were captured along this lower reach, however were absent along the reach immediately upstream which indicates a possible connectivity issue along the Rice River.

Corresponding to the fish impairments in this subwatershed, DO was impaired on the same reaches of the Rice River: from its headwaters to Section 5 Creek and Section 5 Creek to Wakefield Brook. Low DO is a likely stressor to the biological communities, leading to the poor FIBI scores. Downstream of Wakefield Brook, low DO levels continued, likely due to the impact of surrounding wetlands.

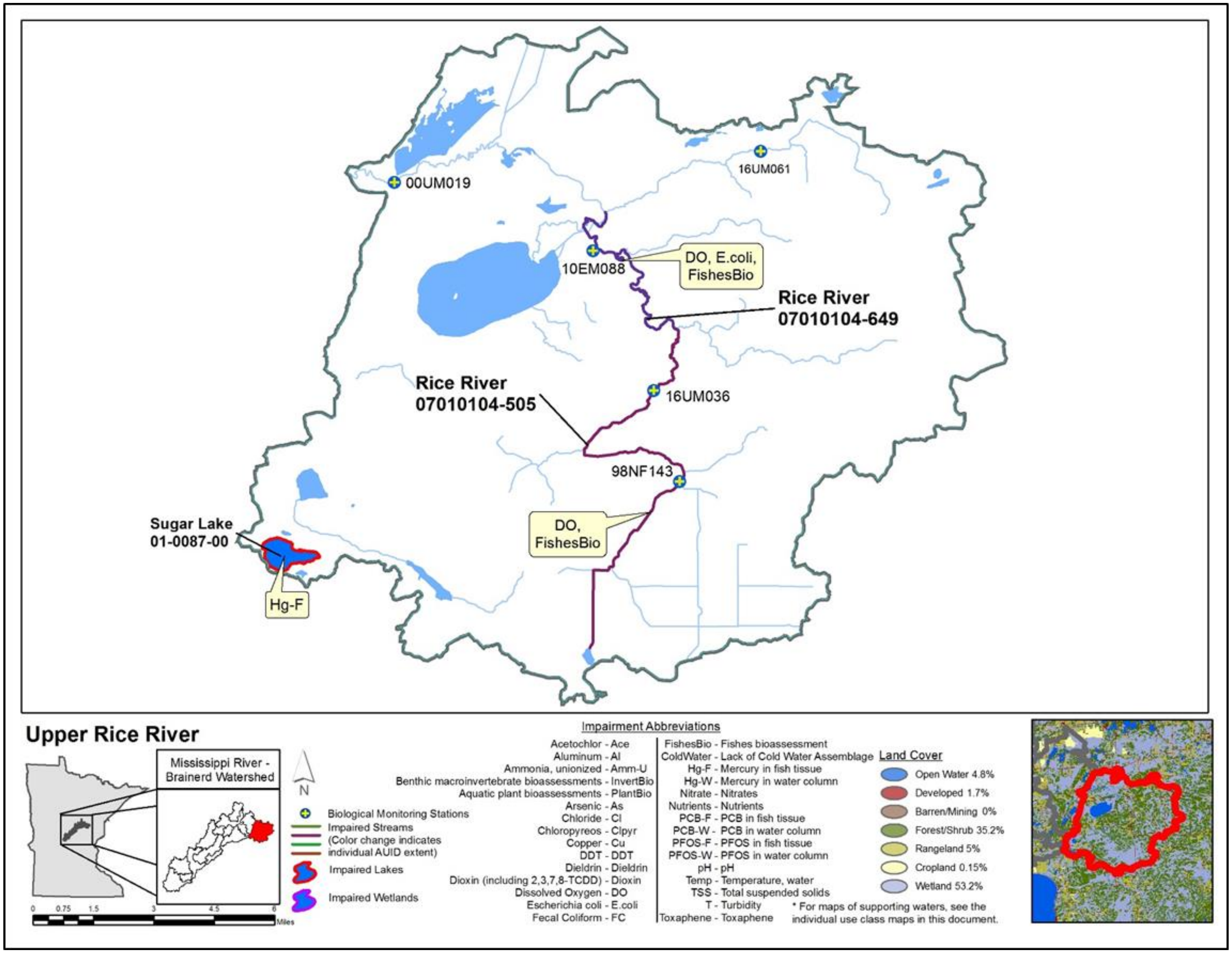
Wakefield Brook was the only tributary monitored in this subwatershed. Fish and macroinvertebrates were sampled in 2016; however, the samples were collected one month after a historic flooding event that occurred within the watershed in early July. Water levels along Wakefield Brook became extremely high (Figure 19), and due to its limited floodplain the channel became incised and straightened. Both FIBI and MIBI scores from 2016 fell well below their respective impairment thresholds. The fish assemblage only contained four species, all of which are tolerant to poor water quality. The macroinvertebrate community showed similar results. In 2017, the original station was re-sampled to determine if the poor biological communities found in 2016 were caused by the isolated flooding event. Both 2017 samples were collected under normal water levels (Figure 20), and FIBI and MIBI scores drastically improved and were indicative of very good water quality. The fish assemblage was very diverse and contained two sensitive taxa (Pearl Dace and Northern Redbelly Dace).

Figure 18. Wakefield Brook flooding - July 13, 2016

Figure 19. Wakefield Brook with normal flows - July 11, 2017

Three lakes were reviewed for aquatic recreation and one lake for aquatic life. These are small to medium sized lakes with small catchments. They are located in the headwater portions of the subwatershed with low development. The only lake with sufficient data for a full assessment was Sugar. This lake had great water quality and fully supports aquatic recreation. The good water quality is likely a reflection of its small contributing watershed area. Aquatic life use was fully supported based on fish surveys conducted in 2011 and 2016. The score was positively influenced by the number of intolerant, small benthic, and vegetation dwelling species. An aquatic plant survey performed on Sugar indicates a healthy plant community.

Figure 20. Currently listed impaired waters by parameter and land use characteristics in the Upper Rice River Aggregated 12-HUC.



Ripple River Aggregated 12-HUC HUC 0701010402-01

The Ripple River Subwatershed drains 127 square miles in Aitkin and Crow Wing counties. The Ripple River begins at Bay Lake, and flows 42 miles to its outlet at the Mississippi River in Aitkin. The Ripple River flows through a number of recreationally significant lakes, making it an important water resource to Aitkin and Crow Wing counties. The headwater sections of the river are short, low gradient segments that connect lakes. Just downstream of Spirit Lake, the river enters an extensive wetland complex within the Ripple River WMA. The river channel is ditched (dredged) for the next 10 miles before returning to its natural channel along its final 20 miles to the Mississippi River, just north of Aitkin. Land use is primarily wetland (36%), forest (30%), and open water (16%). Development makes up 5.4%, and is primarily concentrated around lakes and the city of Aitkin. The water chemistry monitoring station was established on the Ripple River, just upstream 1st Ave NE, in Aitkin.

Table 6. Aquatic life and recreation assessments on stream reaches: Ripple River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

				Aquatic life indicators:										
WID ***Reach name,*** *Reach description*	**Biological Station ID**	**Reach length (miles)**	**Use class***	**Fish IBI**	**Invert IBI**	**Dissolved oxygen**	**TSS**	**Secchi Tube**	**Chloride**	**pH**	**Ammonia -NH_3**	**Eutrophication**	**Aquatic life**	**Aquatic rec. (Bacteria)**
07010104-660 ***Ripple River,*** *Raspberry Cr to Mississippi R*	16UM041	5.90	WWg	MTS	MTS	NA	IF	MTS	MTS	MTS	MTS	IF	SUP	SUP
07010104-661 ***Ripple River,*** *Hanging Kettle Lk to Raspberry Cr*	16UM038	5.27	WWg	MTS	MTS	IF	IF	IF	--	IF	IF	IF	SUP	--
07010104-666 ***Ripple River,*** *Unnamed wetland (01-0394-00) to Lingroth Lk outlet*	16UM040	2.26	WWm	MTS	MTS	NA	IF	IF	--	IF	IF	IF	SUP	--

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Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: ☐ = existing impairment, listed prior to 2018 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐ = insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water

*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 7. Lake assessments: Ripper River Aggregated 12-HUC

							Aquatic life indicators:			Aquatic recreation indicators:				
Lake name	**DNR ID**	**Area (acres)**	**Max depth (ft)**	**Assessment method**	**Ecoregion**	**Secchi Trend**	**Fish IBI**	**Chloride**	**Pesticides *****	**Total phosphorus**	**Chlorophyll-a**	**Secchi**	**Aquatic life use**	**Aquatic recreation use**
Clear	01-0093-00	564.03	24	Deep	NLF		MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
Nord	01-0117-00	420.10	29	Deep	NLF		MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
Elm Island	01-0123-00	515.99	25	Deep	NLF		EXS	MTS	--	EXS	EXS	EXS	IMP	IMP
Lone	01-0125-00	428.06	60	Deep	NLF		MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
Ripple	01-0146-00	567.53	39	Deep	NLF		MTS	MTS	--	EXS	EXS	EXS	SUP	IMP
Mallard	01-0149-00	315.01	5	Shallow	NLF		--	--	--	IF	IF	IF	--	IF
Farm Island	01-0159-00	1960.67	56	Deep	NLF		MTS	MTS	--	MTS	IF	MTS	SUP	SUP
Hammal	01-0161-00	375.14	44	Deep	NLF		MTS	MTS	--	MTS	MTS	MTS	SUP	SUP

Hanging Kettle	01-0170-00	313.54	35	Deep	NLF		MTS	MTS	--	MTS	IF	MTS	SUP	IF
Diamond	01-0171-00	72.47	26	Deep	NLF		--	MTS	--	IF	EXS	EXS	IF	IF
Little Pine	01-0176-00	221.65	44	Deep	NLF		MTS	--	--	--	--	MTS	SUP	SUP
Spirit	01-0178-00	519.43	49	Deep	NLF		MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
Hickory	01-0179-00	205.12	32	Deep	NLF		MTS	--	--	MTS	MTS	MTS	SUP	SUP
Birch	01-0206-00	438.89	6	Shallow	NLF		--	--	--	IF	IF	IF	--	IF
Johnson	01-0232-00	12.26			NLF		--	--	--	IF	IF	IF	--	IF
Killroy	01-0238-00	12.67			NLF		--	--	--	IF	--	--	--	IF
Bay	18-0034-00	2279.20	74	Deep	NLF		MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
Knieff	18-0035-00	43.10	41	Deep	NLF		--	--	--	--	--	MTS	--	IF
CROOKED (SUGAR BAY)	18-0041-01	92.80	~30	Deep	NLF		--	--	--	MTS	MTS	MTS	--	SUP
CROOKED (MAIN BAY)	18-0041-02	357.33	72	Deep	NLF		MTS	--	--	MTS	MTS	MTS	SUP	SUP
Hanks	18-0044-00	161.35	45	Deep	NLF		MTS	--	--	MTS	MTS	MTS	SUP	SUP
Portage	18-0050-00	279.97	37	Deep	NLF		MTS	--	--	MTS	MTS	MTS	SUP	SUP
Rice	18-0053-00	158.83	8.5	Shallow	NLF		--	--	--	NA	NA	NA	IF	NA
Shirt	18-0072-00	217.57	38	Deep	NLF		--	--	--	MTS	MTS	MTS	--	SUP
Arbor	18-0080-00	102.35		Deep	NLF		--	--	--	MTS	MTS	MTS	--	SUP

Abbreviations for Ecoregion: **DA** = Driftless Area, **NCHF** = North Central Hardwood Forest, **NGP** = Northern Glaciated Plains, **NLF** = Northern Lakes and Forests, **NMW** = Northern Minnesota Wetlands, **RRV** = Red River Valley, **WCBP** = Western Corn Belt Plains

Abbreviations for Secchi Trend: **D** = decreasing/declining trend, **I** = increasing/improving trend, **NT** = no detectable trend, **--** = not enough data
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Key for Cell Shading: ☐ = existing impairment, listed prior to 2018 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐= insufficient information.

Summary

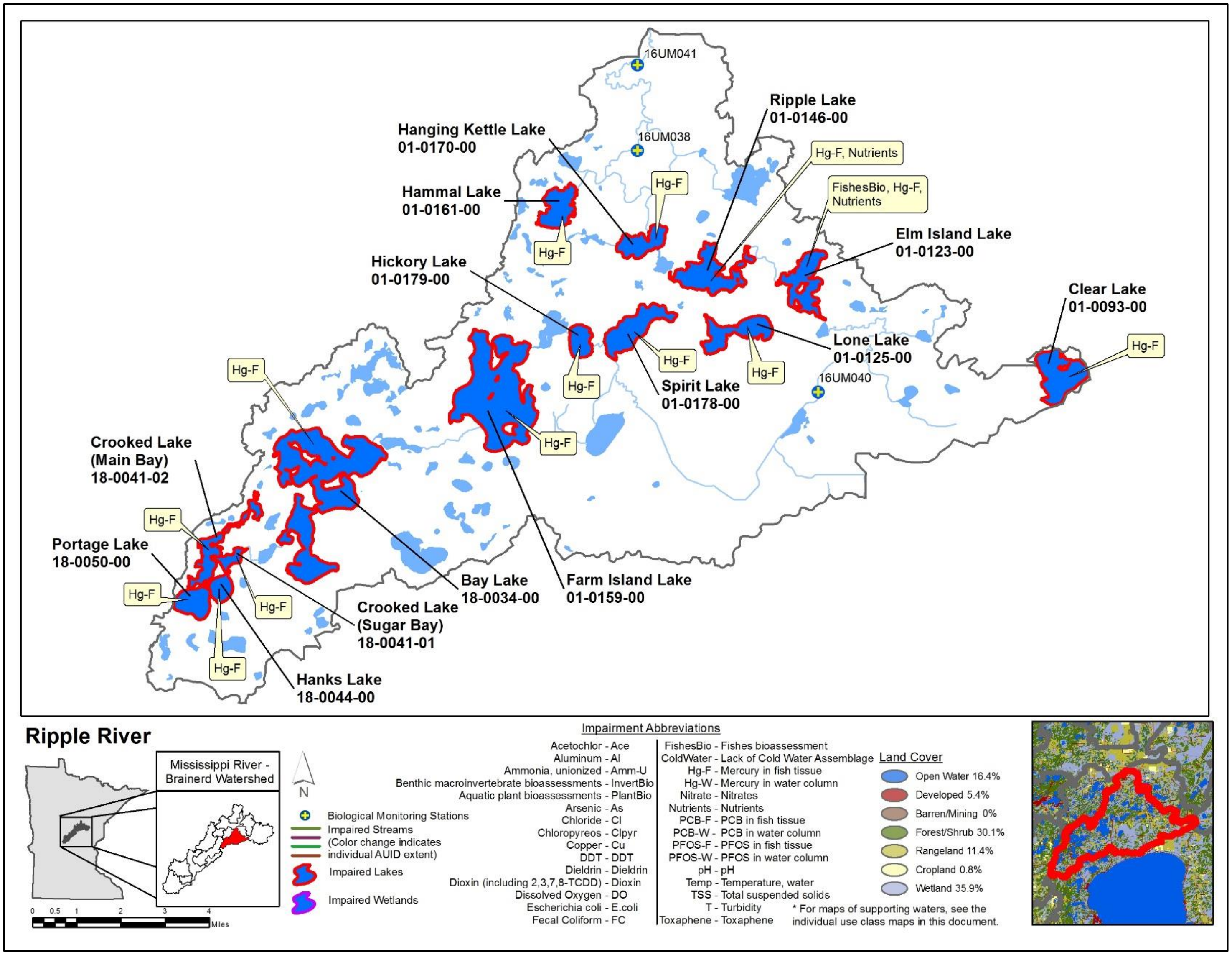
Aquatic life indicators along the Ripple River and its tributaries reflect very good water quality. The fish assemblage collected along the lower portion of the Ripple River (Raspberry Creek to Mississippi River) was exceptional. Several sensitive minnow and riverine species (ex. Longnose Dace and Walleye) were present. Longnose dace are very sensitive to disturbance. They prefer clean course substrates, and generally inhabit streams that have low levels of sediment and stable channel morphology. Bacteria levels along the Ripple River are also low, indicating good conditions for recreation.

In 2016, low DO was found on the lower section of the Ripple River. However, the low DO concentrations were attributed to storms that occurred during 2016, so the data was not assessed. Low DO was also found on the uppermost reach, upstream of Lingroth Lake. However, surrounding wetlands are likely naturally causing these conditions.

The Ripple River Subwatershed had 25 lakes reviewed for aquatic recreation, 15 of these were also reviewed for aquatic life. These lakes are small to large sized and have low to moderate development. Water quality was meeting aquatic recreation standards on 15 lakes. To note, Lone Lake had exceptional water quality: there was very low TP and chlorophyll-a concentrations and the Secchi depth averaged 6.6 m. Elm Island and Ripple were not meeting aquatic recreation standards. Elm Island was first listed for eutrophication in 2010 and data from this assessment period confirms the impairment. Ripple Lake had TP that was narrowly over the standard, but transparency and chlorophyll-a were well over the aquatic recreation standard – algal blooms were also observed in both 2016 and 2017.

On 14 of the 15 lakes, aquatic life use was found to be fully supporting. Elm Island was the lone lake that failed to meet aquatic life use standards. The fish IBI score was negatively influenced by the low number of intolerant species and composition of species sampled, for instance a high number of tolerant species (Black Bullhead) were sampled in trap nets.

Figure 21. Currently listed impaired waters by parameter and land use characteristics in the Ripple River Aggregated 12-HUC



Little Willow River Aggregated 12-HUC HUC 0701010403-01

The Little Willow River Subwatershed drains 99 square miles of Aitkin County. The Little Willow River begins at Esquagamah Lake, and then flows 16 miles to the south before its outlet at the Mississippi River. The upper 12 miles flow slowly through a natural channel, as the river winds through a low gradient, relatively undisturbed wetland landscape. Dense stands of wild rice and abundant aquatic macrophytes encompass the channel. Downstream of biomonitoring station 16UM022 (Figure 31), the river becomes ditched and splits into two channels; these channels were re-named as unnamed ditch (Little Willow River Diversion) to the east, and Little Willow River Old Channel to the west. Unnamed ditch (Little Willow River Diversion) takes roughly 60% of the flow to the south for four miles, before emptying into the Mississippi River. The Little Willow River Old Channel takes approximately 40% of the flow to the southwest for 9.5 miles, before empting into the Mississippi River Diversion Channel. The Little Willow River Old Channel functions more as an "overflow" for high flow events on the Little Willow River. Water in this channel becomes stagnant during low flows. Land use within this subwatershed is predominately wetlands (39.7%), forest (37.2%), and range (10%). Two water chemistry monitoring stations were established along the Little Willow River; one on the Little Willow River just upstream of 450th St., and a second on the Little Willow River Old Channel just upstream of the Mississippi River Diversion Channel.

Table 8. Aquatic life and recreation assessments on stream reaches: Little Willow River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

WID ***Reach name,*** *Reach description*	Biological Station ID	Reach length (miles)	Use class*	Aquatic life indicators: Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Eutrophication	Aquatic life	Aquatic rec. (Bacteria)
07010104-624 ***Unnamed creek,*** *Rice Lk to Little Willow R*	--	3.36	--	--	--	--	--	MTS	--	--	--	--	IF	--
07010104-689 ***Little Willow River,*** *Headwaters (Esquagamah Lk 01-0147-00) to Little Willow Diversion ditch*	16UM022	11.96	WWg	MTS	--	NA	IF	IF	MTS	MTS	MTS	IF	SUP	IF
07010104-697 ***Unnamed ditch,*** *Blind Lk to Mississippi R flood diversion channel*	16UM063	5.52	WWm	MTS	MTS	IF	IF	IF	--	IF	IF	IF	SUP	--

07010104-701 ***Little Willow River Old Channel,*** *Unnamed ditch to Flood Diversion Channel*	16UM020	5.66	WWm	EXS	MTS	IF	IF	IF	MTS	MTS	MTS	IF	IMP	IF
07010104-691 ***Unnamed ditch (Little Willow River Diversion),*** *Little Willow Ditch old channel to Mississippi R*	17UM200	3.96	WWm	MTS	EXS	--	--	--	--	--	--	--	IMP	--

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: ☐ = existing impairment, listed prior to 2018 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐ = insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 9. Lake assessments: Little Willow River Aggregated 12-HUC.

Lake name	DNR ID	Area (acres)	Max depth (ft)	Assessment method	Ecoregion	Secchi Trend	Aquatic life indicators:			Aquatic recreation indicators:			Aquatic life use	Aquatic recreation Use
							Fish IBI	Chloride	Pesticides ***	Total Phosphorus	Chlorophyll-a	Secchi		
Sitas	01-0134-00	58.77			NLF		--	--	--	IF	--	IF	--	IF
Waukenabo	01-0136-00	598.11	38	Deep	NLF		MTS	MTS	--	MTS	EXS	EXS	SUP	IMP
Round	01-0137-00	624.45	59	Deep	NLF		IF	MTS	--	MTS	MTS	MTS	IF	SUP
Esquagamah	01-0147-00	819.22	31	Deep	NLF		IF	MTS	--	EXS	EXS	EXS	IF	IMP
Blind	01-0188-00	308.46	17	Shallow	NLF		MTS	MTS	--	EXS	EXS	EXS	SUP	IMP
Unnamed	01-0285-00	10.61			NLF		--	--	--	IF	--	--	--	IF
West	01-0287-00	50.00			NLF		--	--	--	IF	--	IF	--	IF
Upper Blind	01-0331-00	6.68			NLF		--	--	--	IF	--	--	--	IF
Unnamed	01-0419-00	15.89			NLF		--	--	--	IF	--	IF	--	IF
Terry	18-0162-00	77.59			NLF		--	--	--	IF	--	IF	--	IF
Stark	18-0169-00	207.72	66	Deep	NLF		MTS	MTS	--	MTS	MTS	MTS	SUP	SUP

Abbreviations for Ecoregion: **DA** = Driftless Area, **NCHF** = North Central Hardwood Forest, **NGP** = Northern Glaciated Plains, **NLF** = Northern Lakes and Forests, **NMW** = Northern Minnesota Wetlands, **RRV** = Red River Valley, **WCBP** = Western Corn Belt Plains
Abbreviations for Secchi Trend: **D** = decreasing/declining trend, **I** = increasing/improving trend, **NT** = no detectable trend, **--** = not enough data
Abbreviations for Indicator Evaluations: **--** = No Data, **MTS** = Meets Standard; **EXS** = Exceeds Standard; **IF** = Insufficient Information
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Key for Cell Shading: ☐ = existing impairment, listed prior to 2018 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐= insufficient information.

Summary

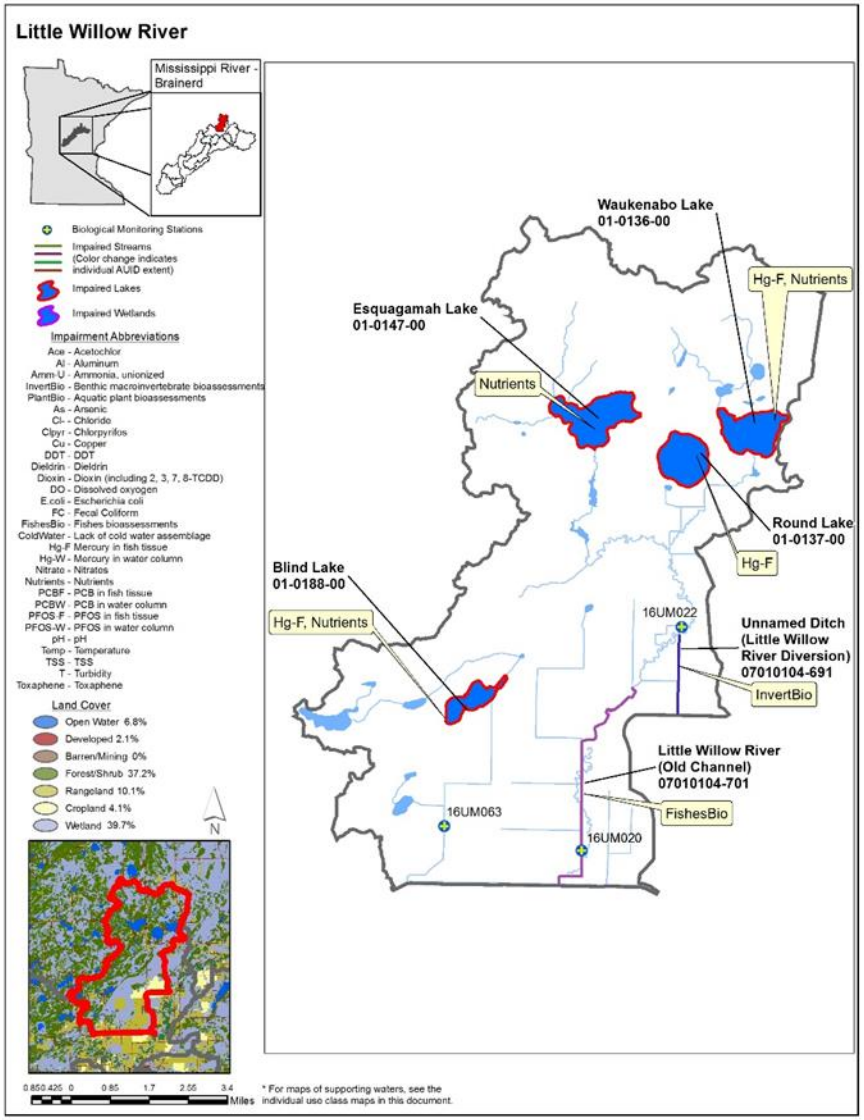
Aquatic life indicators along the Little Willow River and its tributaries indicate mixed results. The upper portion of the Little Willow River (07010104-689) is in good condition. This portion of the river is low gradient and flows slowly through a natural channel. The streambed contains primarily fine sediments, and the channel is comprised of dense stands of wild rice, which commonly grow across the entire river channel. Due to its very soft streambed and deep water, crews were unable to sample macroinvertebrates. Fish community data collected along this reach in 2016 indicatedgood water quality conditions, the FIBI score was above the impairment threshold.

As previously noted, the Little Willow River becomes ditched downstream of 350th St. and splits into two channels; these channels are the Little Willow River Old Channel (-701) and unnamed ditch (Little Willow River Diversion Channel) (-691). Unnamed ditch flows straight south, directly into the Mississippi River. The Little Willow River Old channel flows to the southwest into the Mississippi River Diversion Channel. During low flows, the Little Willow River Old Channel becomes mostly stagnant because much of the flow from the Little Willow River is directed into Unnamed Ditch. A fish impairment was found on the Little Willow River Old Chanel. This impairment is likely the result of a loss in stream connectivity to upstream habitats. A flood control structure is located at the outlet of the Little Willow River Old Channel, which acts as a fish barrier during normal, and low flows. A macroinvertebrate impairment was found on Unnamed Ditch.

Eleven lakes in this subwatershed were reviewed for aquatic recreation; five of these were also reviewed for aquatic life. These lakes are small to medium sized and have low development. Water quality met aquatic recreation standards on Round and Stark while Waukenabo, Esquagamah, and Blind did not meet aquatic recreation standards. All were previously listed for eutrophication in 2010 and data from this assessment period confirms those impairments. Of those impaired lakes, Waukenabo has shown the most water quality improvement since they were listed, with a drop in total phosphorus, but elevated algae concentrations still occur. The improving conditions suggest that this lake should be considered a high priority for restoration.

Aquatic life use was fully supported on Waukenabo, Blind and Stark lakes. The FIBI scores were positively influenced by the high proportion of top carnivores sampled in gill nets. Aquatic plant surveys performed on these lakes and were found to have healthy plant communities.

Figure 22. Currently listed impaired waters by parameter and land use characteristics in the Little Willow River Aggregated 12-HUC



City of Aitkin-Mississippi River Aggregated 12-HUC HUC 0701010404-01

The City of Aitkin-Mississippi River Subwatershed drains 120 square miles of Aitkin and Crow Wing counties and is a Mississippi River mainstem flow-through subwatershed. The Mississippi River enters this subwatershed at its confluence with the Willow River, then flows southwest 54 miles to its confluence with the Pine River. Four miles northeast of Aitkin, a diversion channel along the Mississippi River diverts flow straight west, helping reduce floodwater around the town of Aitkin. Dean Brook is the only major tributary to the Mississippi River within this subwatershed. Land use is dominated by forest (34.8%), wetland (34.8%), and range (19%) with a smaller percentage of open water (4.6%), row crop (3.6%), and developed land (3.1%). Most of the development is concentrated nearthe town of Aitkin, which is located along the south-central edge of the subwatershed. A water chemistry monitoring station was not established because the main stem Mississippi River is the primary river in this subwatershed. Water chemistry was previously sampled on the Mississippi River (WID 07010104-655) during the 2013-2014 large river monitoring effort.

Table 10. Aquatic life and recreation assessments on stream reaches: City of Aitkin-Mississippi River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

WID ***Reach name,*** *Reach description*	Biological Station ID	Reach length (miles)	Use class*	Aquatic life indicators: Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Eutrophication	Aquatic life	Aquatic rec. (Bacteria)
07010104-678 ***Dean Brook,*** *Dean Lk to Mississippi R*	16UM006	2.91	WWg	MTS	IF	IF	IF	IF	--	IF	IF	IF	SUP	--

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: = existing impairment, listed prior to 2018 reporting cycle; = new impairment; = full support of designated use; = insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 11. Lake assessments: City of Aitkin-Mississippi River Aggregated 12-HUC.

Lake name	DNR ID	Area (acres)	Max depth (ft)	Assessment method	Ecoregion	Secchi Trend	Aquatic life indicators:			Aquatic recreation indicators:			Aquatic life use	Aquatic recreation use
							Fish IBI	Chloride	Pesticides ***	Total phosphorus	Chlorophyll-a	Secchi		
Island	18-0129-00	112.10	36		NLF		--	IF	--	MTS	MTS	MTS	IF	SUP
Upper Dean	18-0170-00	248.62	24		NLF		MTS	IF	--	EXS	EXS	EXS	SUP	IMP
Lower Dean	18-0181-00	365.83	5.5		NLF		--	--	--	IF	IF	IF	--	IF
Rogers	18-0184-00	235.25	64		NLF		MTS	--	--	MTS	MTS	MTS	SUP	SUP

Abbreviations for Ecoregion: DA = Driftless Area, NCHF = North Central Hardwood Forest, NGP = Northern Glaciated Plains, NLF = Northern Lakes and Forests, NMW = Northern Minnesota Wetlands, RRV = Red River Valley, WCBP = Western Corn Belt Plains

Abbreviations for Secchi Trend: D = decreasing/declining trend, I = increasing/improving trend, NT = no detectable trend, -- = not enough data

Abbreviations for Indicator Evaluations: -- = No Data, **MTS** = Meets Standard; **EXS** = Exceeds Standard; **IF** = Insufficient Information

Abbreviations for Use Support Determinations: -- = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Not Support (Impaired, exceeds standard)

Key for Cell Shading: ☐ = existing impairment, listed prior to 2018 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐= insufficient information.

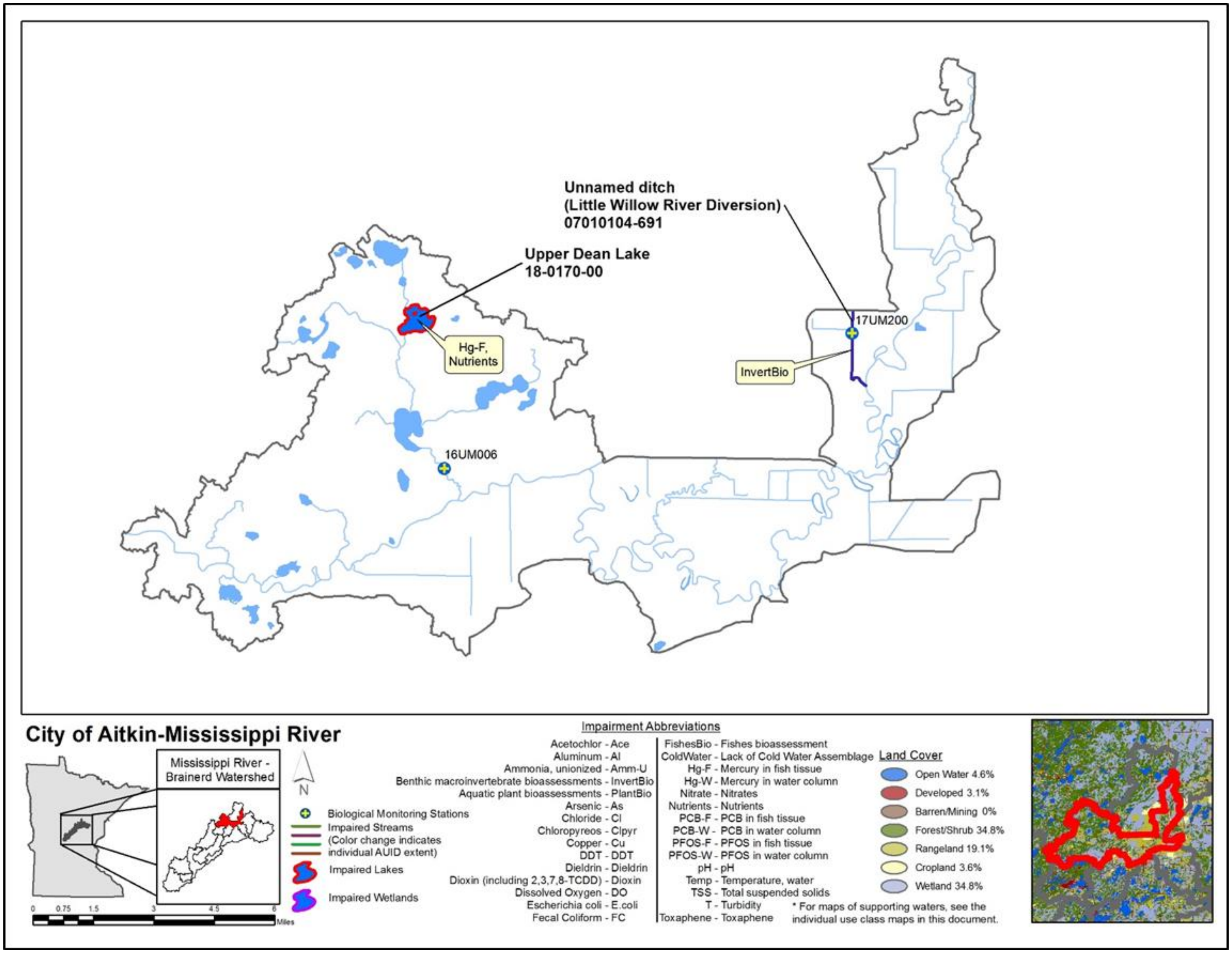
Summary

Aquatic life indicators within the City of Aitkin-Mississippi River Subwatershed generally reflect good water quality. Fish and macroinvertebrates were sampled from one station along Dean Brook in 2016. The FIBI score from this sample was good; however, the MIBI score failed to meet standards. The macroinvertebrate sample was collected following a historic flooding event, which occurred in 2016. This station was resampled for macroinvertebrates in 2017 and conditions drastically improved, although the MIBI still fell below the standard. A decision was made to make an aquatic life use assessment based only on the fish community data at this time.

Four lakes were reviewed for aquatic recreation; two of these were also reviewed for aquatic life. These lakes are medium sized and have low development. Water quality met aquatic recreation standards on Island Lake but not Upper Dean Lake. In Upper Dean Lake TP, chl-a and Secchi all easily exceeded the standards, leading to the eutrophication impairment.

Aquatic life use was fully supported on Upper Dean and Rogers lakes. The FIBI scores were positively influenced by the high biomass of top carnivores sampled on Upper Dean Lake. The absence of tolerant species in any sampling gear, the presence of intolerant species in the gill nets (Rock Bass), and a high proportion of insectivores (Bluegill) positively influenced the FIBI score in Rogers Lake. Aquatic plant surveys performed on these lakes indicated that they have healthy plant communities.

Figure 23. Currently listed impaired waters by parameter and land use characteristics in the City of Aitkin-Mississippi River Aggregated 12-HUC. AUID 07010104-691 is predominately (>50%) within the Little Willow River Aggregated 12-HUC and therefore this reach is discussed in that section.



Cedar Creek Aggregated 12-HUC

HUC 0701010404-02

The Cedar Creek Subwatershed drains 46 square miles in Aitkin and Crow Wing counties. Cedar Creek begins at Cedar Lake and flows approximately three miles to its confluence with the Mississippi River. Cedar Lake is the primary waterbody within this subwatershed, and is one of the larger and more recreationally significant lakes in the major watershed. Land use is primarily forest (34.3%), wetland (31.1%), open water (14%), and range (13.7%) with the remaining land cover being made up of developed (4.8%), row crop (2.0%), and baron (<1%). The water chemistry monitoring station was established one mi. upstream of Eagle St., four mi. NW of Aitkin

Table 12. Aquatic life and recreation assessments on stream reaches: Cedar Creek Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

WID ***Reach name,*** *Reach description*	Biological Station ID	Reach length (miles)	Use class*	Aquatic life indicators: Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Eutrophication	Aquatic life	Aquatic rec. (Bacteria)
07010104-639 ***Unnamed creek,*** *Ringhand Lk to Cedar Lk*	--	0.11	--	--	--	NA	NA	NA	--	NA	--	NA	NA	SUP
07010104-641 ***Cedar Creek,*** *Cedar Lk to Mississippi R*	16UM002	3.13	WWg	MTS	MTS	IF	IF	IF	--	IF	IF	IF	SUP	--
07010104-642 ***Cedar Brook,*** *Anderson Lk to Unnamed lk*	--	1.26	--	--	--	NA	NA	NA	--	NA	--	NA	NA	SUP

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
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Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 13. Lake assessments: Cedar Creek Aggregated 12-HUC.

Lake name	DNR ID	Area (acres)	Max depth (ft)	Assessment method	Ecoregion	Secchi Trend	Aquatic life indicators: Fish IBI	Chloride	Pesticides ***	Aquatic recreation indicators: Total phosphorus	Chlorophyll-a	Secchi	Aquatic life use	Aquatic recreation use
Blue	01-0181-00	51.51	106		NLF		--	MTS	--	MTS	MTS	MTS	IF	SUP
Pickerel	01-0182-00	91.82	34		NLF		--	IF	--	IF	IF	IF	IF	IF
Townline	01-0207-00	106.74	69		NLF		MTS	--	--	--	--	MTS	SUP	IF
Sunset	01-0208-00	219.54	43		NLF		MTS	--	--	--	--	--	SUP	IF
Cedar(Main Basin)	01-0209-01	1445.70	103		NLF		MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
Cedar(N.E. Arm)	01-0209-02	24.58	~20		NLF		--	--	--	--	--	MTS	--	IF
Cedar(West Bay)	01-0209-03	191.12	~50		NLF		--	MTS	--	MTS	MTS	MTS	IF	SUP
Black	18-0059-00	100.24	47		NLF		--	IF	--	MTS	MTS	MTS	IF	SUP
Portage	18-0069-00	129.19	57		NLF		--	--	--	--	--	MTS	--	IF
Hamlet	18-0070-00	292.02	88		NLF		--	--	--	--	--	MTS	--	IF
Placid	18-0076-00	183.75	37		NLF		--	--	--	--	--	MTS	--	SUP
Casey	18-0087-00	57.97	39.5		NLF		--	--	--	EXS	EXS	EXS	--	IMP

Abbreviations for Ecoregion: DA = Driftless Area, NCHF = North Central Hardwood Forest, NGP = Northern Glaciated Plains, NLF = Northern Lakes and Forests, NMW = Northern Minnesota Wetlands, RRV = Red River Valley, WCBP = Western Corn Belt Plains
Abbreviations for Secchi Trend: D = decreasing/declining trend, I = increasing/improving trend, NT = no detectable trend, -- = not enough data
Abbreviations for Indicator Evaluations: -- = No Data, **MTS** = Meets Standard; **EXS** = Exceeds Standard; **IF** = Insufficient Information
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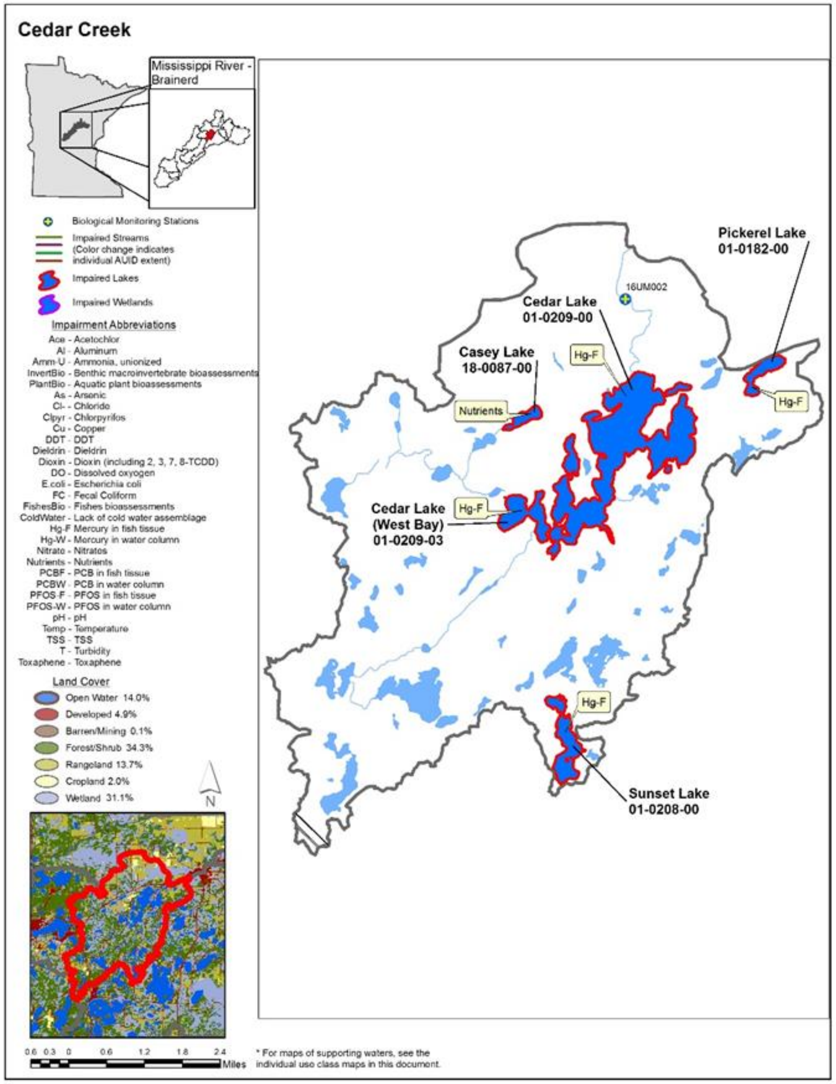
Summary

Aquatic life and recreation indicators for streams within the Cedar Creek Subwatershed reflect good water quality. Biological monitoring in the subwatershed was limited to one station (16UM002) on Cedar Creek. Habitat at this station was very poor, although the fish community data indicated very good water quality; the assemblage contained two sensitive taxa (Blackchin Shiner, Burbot) which are species that require clean, cool water. Bacteria samples were collected from two tributaries to Cedar Lake (Cedar Creek, and an unnamed creek) and indicate healthy conditions for aquatic recreation.

Twelve lakes were reviewed for aquatic recreation; three of these were also reviewed for aquatic life. These small to large lakes have low to moderate development. Water quality met aquatic recreation standards on Blue, Cedar (all basins), and Placid lakes. Water quality was very good on Blue Lake where TP averaged only 8 ug/L, chlorophyll-a was 3.2 ug/L and the Secchi depth averaged 4.1 m. Casey Lake was impaired for aquatic recreation. All of the eutrophication indicators were severely exceeded (means of 137 ug/L for TP, 57 for chlorophyll-a, and 0.6 m for Secchi). Shallow lakes do not have capacity for phosphorus inputs; internal cycling of phosphorus likely drives algal blooms on Casey Lake throughout the summer. Three lakes with fish data to assess aquatic life all fully met standards. The FIBI scores were positively influenced on Townline, Sunset and Cedar lakes by the lack of tolerant species. Aquatic plant surveys performed on Townline and Cedar lakes indicated that healthy plant communities were present.

Figure 24. Currently listed impaired waters by parameter and land use characteristics in the Cedar Creek Aggregated 12-HUC.



Sisabagamah Creek Aggregated 12-HUC HUC 0701010404-03

The Sisabagamah Creek Subwatershed drains 44.3 square miles of Aitkin County. Sisabagamah Creek originates at Sisabagamah Lake and flows 9.5 miles to its outlet at the Mississippi River. The lower two miles of Sisabagamah Creek are ditched, as the creek flows through the airport in Aitkin. Rabbitt Creek and several small, unnamed tributary streams contribute water to Sisabagmah Creek. The landscape contains primarily wetlands (39.1%), forest (25.8%), and range (20.6%) with a smaller percentage of open water (6.6%), developed land (4.5%), and row crop (3.4%). The water chemistry monitoring station was established downstream of CR 54 on Sisabagamah Creek, just northeast of Aitkin.

Table 14. Aquatic life and recreation assessments on stream reaches: Sisabagamah Creek Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

				Aquatic life indicators:										
WID ***Reach name,*** *Reach description*	**Biological Station ID**	**Reach length (miles)**	**Use class***	**Fish IBI**	**Invert IBI**	**Dissolved oxygen**	**TSS**	**Secchi Tube**	**Chloride**	**pH**	**Ammonia -NH_3**	**Eutrophication**	**Aquatic life**	**Aquatic rec. (Bacteria)**
07010104-659 ***Sisabagamah Creek,*** *Unnamed cr to Mississippi R*	16UM047, 16UM171	2.12	WWg	MTS	EXS	NA	IF	IF	MTS	MTS	MTS	IF	IMP	SUP
07010104-677 ***Sisabagamah Creek,*** *Sisabagamah Lk to Rabbit Cr*	16UM046	2.13	WWg	EXS	MTS	EXS	IF	IF	--	IF	IF	IF	IMP	--
07010104-688 ***Rabbit Creek,*** *Rabbit Lk to Sisabagamah Cr*	16UM032	6.04	WWg	EXP	MTS	--	--	--	--	--	--	--	IMP	--

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
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*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 15. Lake assessments: Sisabagmah Creek Aggregated 12-HUC.

Lake name	DNR ID	Area (acres)	Max depth (ft)	Assessment method	Ecoregion	Secchi trend	Aquatic life indicators:			Aquatic recreation indicators:			Aquatic life use	Aquatic recreation use
							Fish IBI	Chloride	Pesticides ***	Total phosphorus	Chlorophyll-a	Secchi		
Rabbit	01-0091-00	207.35	51	Deep	NLF		MTS	IF	--	MTS	MTS	MTS	SUP	SUP
Section Ten	01-0115-00	420.32	17	Shallow	NLF		MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
Section Twelve	01-0120-00	164.87	40	Deep	NLF		MTS	IF	--	MTS	MTS	MTS	SUP	SUP
Sisabagamah	01-0129-00	391.27	37	Deep	NLF		MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
Hanson	01-0132-00	136.23	42	Deep	NLF		MTS	MTS	--	MTS	IF	MTS	SUP	SUP

Abbreviations for Ecoregion: DA = Driftless Area, NCHF = North Central Hardwood Forest, NGP = Northern Glaciated Plains, NLF = Northern Lakes and Forests, NMW = Northern Minnesota Wetlands, RRV = Red River Valley, WCBP = Western Corn Belt Plains
Abbreviations for Secchi Trend: D = decreasing/declining trend, I = increasing/improving trend, NT = no detectable trend, -- = not enough data
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Key for Cell Shading: ☐ = existing impairment, listed prior to 2018 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐= insufficient information.

Summary

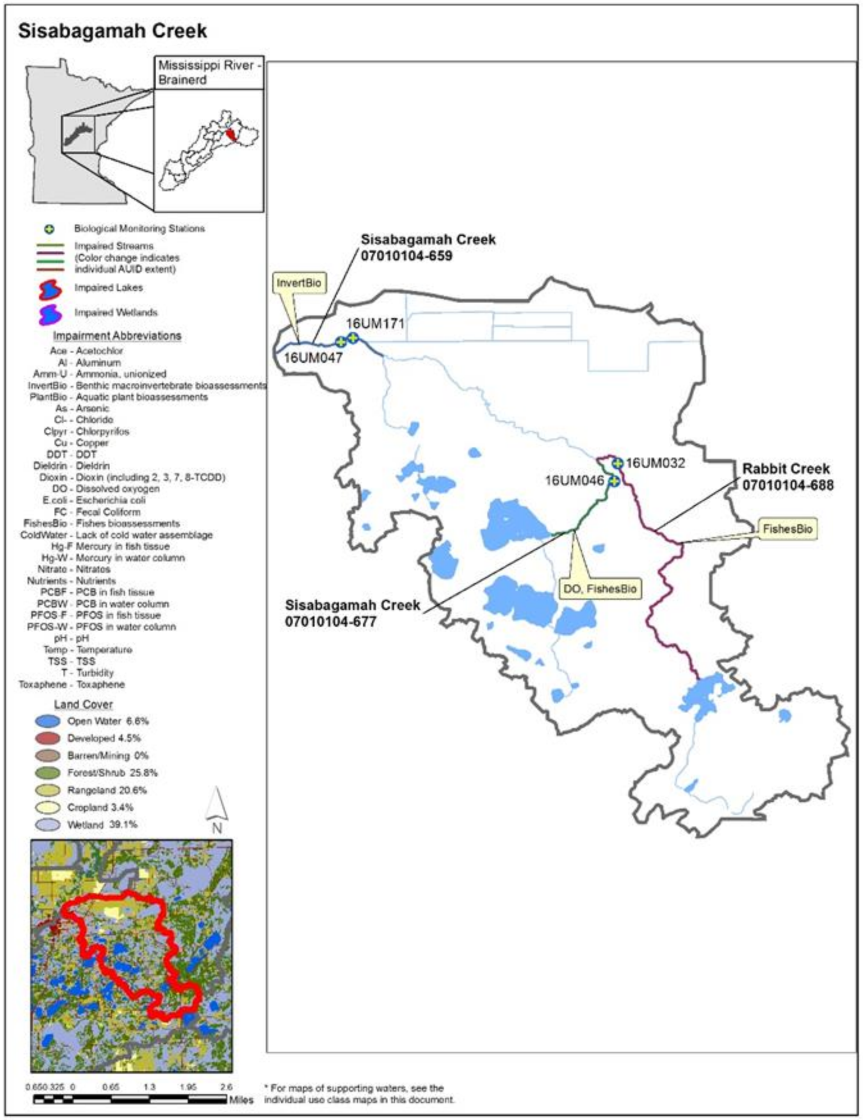
Water quality indicators in the Sissabagmah Creek Subwatershed indicate mixed results. Bacteria levels along Sissabagmah Creek are good, however biological samples throughout the subwatershed failed to meet aquatic life standards for fish, macroinvertebrates, or both indicators.

Rabbit Creek (-688) joins Sissaabagmah Creek (-677) just south of Hwy 47, 6.5 miles east of Aitkin (Figure 26). Both Rabbit Creek and Sissabogmah Creek were monitored for fish and macroinvertebrates in 2016. Data from both stations indicate that the macroinvertebrate communities are healthy while the fish communities are impaired. Both fish assemblages were comprised of species that are highly tolerant to low DO, which was noted in the water chemistry monitoring data. The upper portion of Sisagbagmah Creek (upstream of Rabbit Creek) had several low DO readings, resulting in a DO impairment. This, coupled with the presence of several large beaver impoundments downstream of HWY 47, could certainly be affecting the fish communities present in the stream.

Fish and macroinvertebrate samples were also collected along the lower section of Sissabagmah Creek, just upstream of the airport in Aitkin. The fish assemblage at this station met aquatic life standards and was much more diverse than upstream samples; however, a macroinvertebrate impairment is warranted due to a poor MIBI. Habitat along this reach is extremely poor, the course substrates and woody habitat is severely imbedded with sediment. Channel stability along this lower reach is extremely poor and should be addressed through the WRAPs process. Sampling crews noted extensive bank erosion and a very mobile streambed throughout the sampling reach.

Five lakes were reviewed for aquatic recreation and aquatic life. These are small to medium sized lakes with low development which all fully supported aquatic life and recreation. The FIBI scores were positively influenced on Sissabagamah, Section 12 and Section Ten Lakes by the number of intolerant species and/or small benthic species found. The species composition and number of top predators in gill nets drove the supporting FIBI scores on Hanson and Rabbit Lakes. Aquatic plant surveys conducted on all of the lakes found healthy plant communities.

Figure 25. Currently listed impaired waters by parameter and land use characteristics in the Sisabagamah Creek Aggregated 12-HUC



City of Brainerd-Mississippi River Aggregated 12-HUC HUC 0701010405-01

The City of Brainerd-Mississippi River Subwatershed drains 165 square miles in Crow Wing County. This is a Mississippi River mainstem flow-through subwatershed. The Mississippi River enters this subwatershed at its confluence with the Pine River, and then flows 33 miles southwest to its confluence with the Crow Wing River. This subwatershed contains both warmwater and cold water tributaries to the Mississippi River. The cities of Brainerd and Baxter make this one of the most highly populated areas in the entire major watershed. There are a number of recreationally significant lakes, most notably Perch, Gilbert, Upper and Lower Mission, and Rice. Land use is dominated by forest (39.8%); wetland (27.4%), with a smaller percentage of developed (8.9%), open water (8.2%) and row crop (4.6%). Tributaries in this watershed were not large enough to warrant a chemistry monitoring station.

Table 16. Aquatic life and recreation assessments on stream reaches: City of Brainerd-Mississippi River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

WID *Reach name,* *Reach description*	Biological Station ID	Reach length (miles)	Use class*	Aquatic life indicators: Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Eutrophication	Aquatic life	Aquatic rec. (Bacteria)
07010104-580 ***Sand Creek,*** *T45 R30W S13, south line to Mississippi R*	16UM043	5.80	WWg*	MTS	MTS	IF	IF	IF	--	IF	IF	IF	SUP	--
07010104-589 ***Whiteley Creek,*** *Headwaters to Rice Lk (18-0145-00)*	10UM146	3.05	CWg	MTS	IF	IF	IF	IF	--	IF	IF	IF	SUP	--
07010104-610 ***Buffalo Creek,*** *Unnamed cr to Unnamed cr*	16UM001	2.83	WWg	MTS	EXS	IF	IF	IF	--	IF	IF	IF	IMP	--
07010104-653 ***Unnamed creek (Whiskey Creek),*** *Headwaters to Mississippi R*	--	1.66	--	--	--	IF	IF	IF	MTS	IF	--	IF	IF	--

07010104-679, ***Unnamed creek,*** *Headwaters to Sand Cr*	16UM042	3.78	WWm	MTS	EXS	IF	IF	IF	--	IF	IF	IF	IMP	--
07010104-695 ***Buffalo Creek (Little Buffalo Creek),*** *Wright St to Mississippi R*	00UM015	2.43	WWg	EXS	EXS	IF	IF	IF	MTS	MTS	IF	IF	IMP	IMP

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: ☐ = existing impairment, listed prior to 2018 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐= insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water

*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 17. Lake assessments: City of Brainerd-Mississippi River Aggregated 12-HUC.

Lake name	DNR ID	Area (acres)	Max depth (ft)	Assessment method	Ecoregion	Secchi Trend	Aquatic life indicators:			Aquatic recreation indicators:			Aquatic life use	Aquatic recreation use
							Fish IBI	Chloride	Pesticides ***	Total phosphorus	Chlorophyll-a	Secchi		
Black Bear	18-0140-00	212.18	48	Deep	NLF		MTS	IF	--	MTS	MTS	MTS	SUP	SUP
Russell	18-0142-00	146.87			NLF		--	--	--	IF	--	IF	--	IF
Rice	18-0145-00	316.00	20	Deep	NLF		--	--	--	EXS	IF	MTS	--	IF
Silver	18-0239-00	185.08	18	Shallow	NLF		MTS	IF	--	MTS	MTS	MTS	SUP	SUP
Fawn	18-0240-00	115.23	20	Shallow	NLF		--	MTS	--	EXS	EXS	EXS	IF	IMP

Upper Mission	18-0242-00	855.66	36	Deep	NLF		MTS	--	--	MTS	IF	MTS	SUP	SUP
Lower Mission	18-0243-00	703.77	27	Deep	NLF		MTS	--	--	EXS	EXS	MTS	SUP	IMP
Little Bass	18-0254-00	91.23	49	Deep	NLF		--	IF	--	MTS	MTS	MTS	IF	SUP
Bass	18-0256-00	279.26	21	Deep	NLF		MTS	--	--	MTS	MTS	MTS	SUP	SUP
Bonnie	18-0259-00	71.37	42	Deep	NLF		--	--	--	MTS	MTS	MTS	--	SUP
Bass	18-0306-00	394.75	38	Deep	NLF		MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
GILBERT (EAST BAY)	18-0320-01	221.99	45	Deep	NLF		MTS	--	--	MTS	MTS	MTS	IF	SUP
GILBERT (WEST BAY)	18-0320-02	66.26	~25	Deep	NLF		--	--	--	--	--	MTS	--	IF
Gilbert (South Bay)	18-0320-03	74.69	~14	Shallow	NLF		--	--	--	--	--	--	NA	NA
Sorenson	18-0323-00	87.10	46	Deep	NLF		--	--	--	MTS	MTS	MTS	--	SUP
Perch	18-0371-00	265.67	42	Deep	NLF		MTS	--	--	MTS	MTS	MTS	SUP	SUP
Island	18-0383-00	36.63			NLF		--	--	--	IF	IF	IF	--	IF
Unnamed	18-0527-00	18.56			NLF		--	IF	--	IF	IF	IF	IF	IF

Abbreviations for Ecoregion: DA = Driftless Area, NCHF = North Central Hardwood Forest, NGP = Northern Glaciated Plains, NLF = Northern Lakes and Forests, NMW = Northern Minnesota Wetlands, RRV = Red River Valley, WCBP = Western Corn Belt Plains
Abbreviations for Secchi Trend: D = decreasing/declining trend, I = increasing/improving trend, NT = no detectable trend, -- = not enough data
Abbreviations for Indicator Evaluations: -- = No Data, **MTS** = Meets Standard; **EXS** = Exceeds Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Not Support (Impaired, exceeds standard)
Key for Cell Shading: = existing impairment, listed prior to 2018 reporting cycle; = new impairment; = full support of designated use; = insufficient information.

Summary

Aquatic life indicators for streams in the City of Brainerd-Mississippi River Subwatershed generally reflect poor water quality. Little Buffalo Creek is the most locally known and significant tributary stream in this subwatershed, originating southeast of Brainerd before flowing westerly 5.62 miles to its outlet at the Mississippi River. The creek went on the impaired waters list for FIBI in 2002 and MIBI in 2006. The original biomonitoring station (00UM015) was resampled in 2016 and the new data corroborates those impairments. Additionally, elevated levels of bacteria were found along the reach, which led to a new impairment for aquatic recreation. Land use around the stream is intensive, with residential and commercial buildings comprising much of the creeks surrounding land use. A large portion of the city of Brainerd's stormwater flows directly and/or indirectly into Little Buffalo Creek, causing flows to fluctuate rapidly. The DNR conducted a survey along the creek in 1995 (DNR, 1995) and highlighted the "flashy" water levels. They also noted bank erosion and a mobile bed load throughout the stream. The bank erosion is extremely problematic to some nearby property owners whose land is continuously eroded from flooding events. Fish and macroinvertebrate communities at station 00UM015 are poor based on the MIBI score; however, several very sensitive cold water macroinvertebrates were identified in the 2000 and 2016 samples ,notably *Diamesa*, *Heterotrissocladius*, *Odontomesa*, and *Prodiamesa*. Several of these organisms have not been found in any other stream in the major watershed.The DNR report from 1995 looked into Little Buffalo Creeks potential as a cold water trout stream. The report notes geomorphology issues, however also notes that the stream once contained a trout hatchery in the 1950's, and a "Gentleman by the name of Johnson" reportedly caught a Brook Trout in the stream during the 1960's (DNR, 1995).

Temperature data from the DNR shows the stream is very cold; however, temperatures rise above stressful levels for cold water organisms after most medium/large precipitation events. Shortly after water temperatures spike to stressful levels, they quickly rebound back into a suitable range for trout. MPCA installed a single temperature logger in 2017 downstream of S. 6th St. in Brainerd and obtained very similar results (Figure 27). Additionally, one-time water temperature readings from the fish and macroinvertebrate visits were extremely cold, and well within the temperature range suitable for cold water organisms. The temperature spikes associated with rain events were thought to be associated with stormwater runoff after moderately high precipitation events. During the summer of 2018, MPCA installed five temperature loggers along the creek just downstream of the major stormwater outlets; a sixth logger was deployed upstream of the stormwater outlets to be used as a reference site (Figure 28). The purpose of this monitoring was to gain a longitudinal understanding of the creeks thermal regime, and how the temperatures change after a precipitation event. This data will also help future MPCA decisions in determining the correct use class designation for this creek (i.e. 2A Coldwater vs 2B Warmwater).

Whitely Creek (-589) is one of the few streams in the watershed to support a fishable Brook Trout population. Brook Trout have been stocked annually since 1950, with Brown Trout occasionally stocked since 1976; the fish are generally stocked as yearling size. Brook Trout were not stocked in 2015. In 2016, MPCA sampled one station along the creek (10UM146) and collected Brook Trout of varying sizes, including multiple young of the year (YOY). The fact that Brook Trout had not been stocked for two years, yet YOY Brook Trout were present in the stream, indicatesthis was the first evidence of Brook Trout naturally reproducing in Whitley Creek. This stream does experience extensive beaver activity, and a large beaver dam has been historically problematic between Highway 210 and Johnson Rd. The WRAPs process should consider developing management strategies to protect this stream.

Figure 26. Temperature readings aligned with precipitation data at Little Buffalo Creek (June 3, 2016-August 12, 2017)

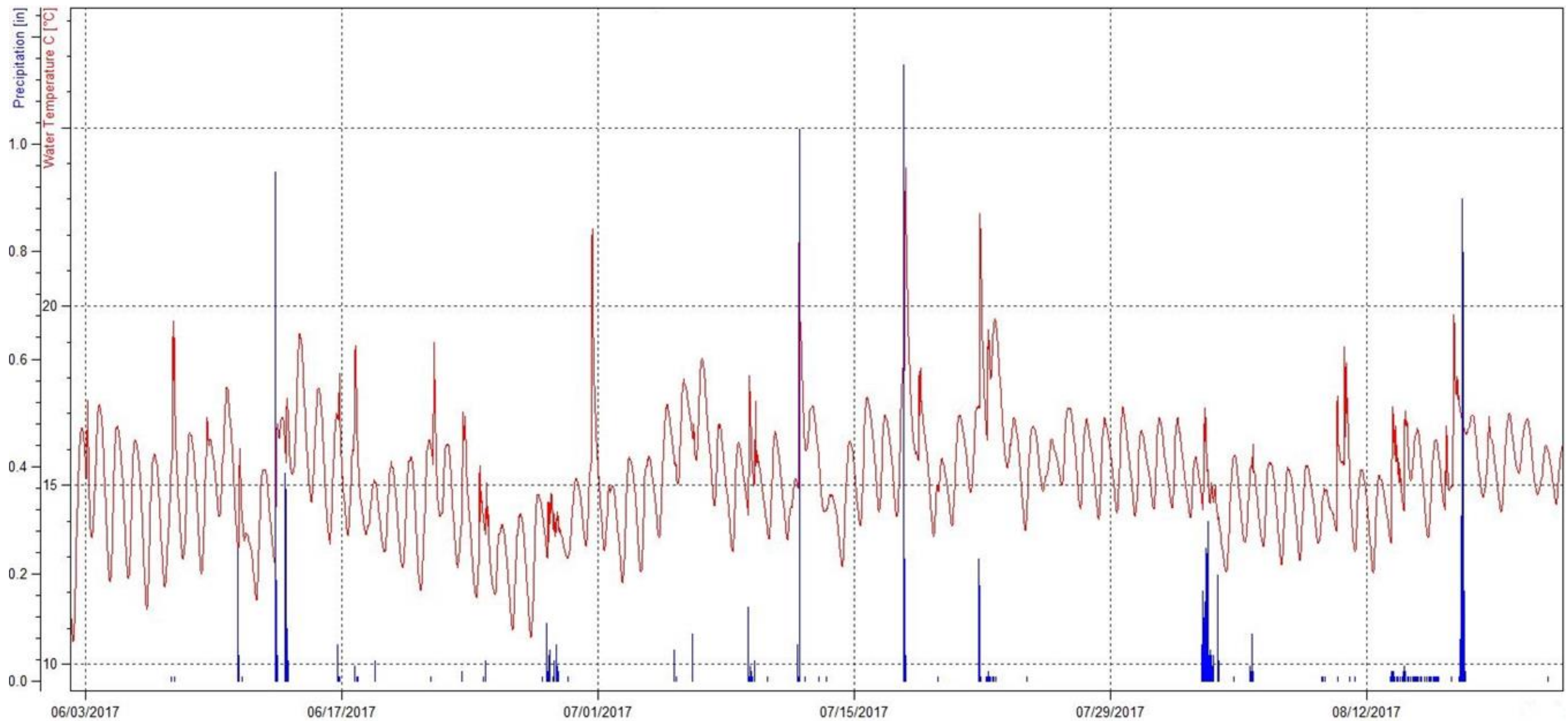
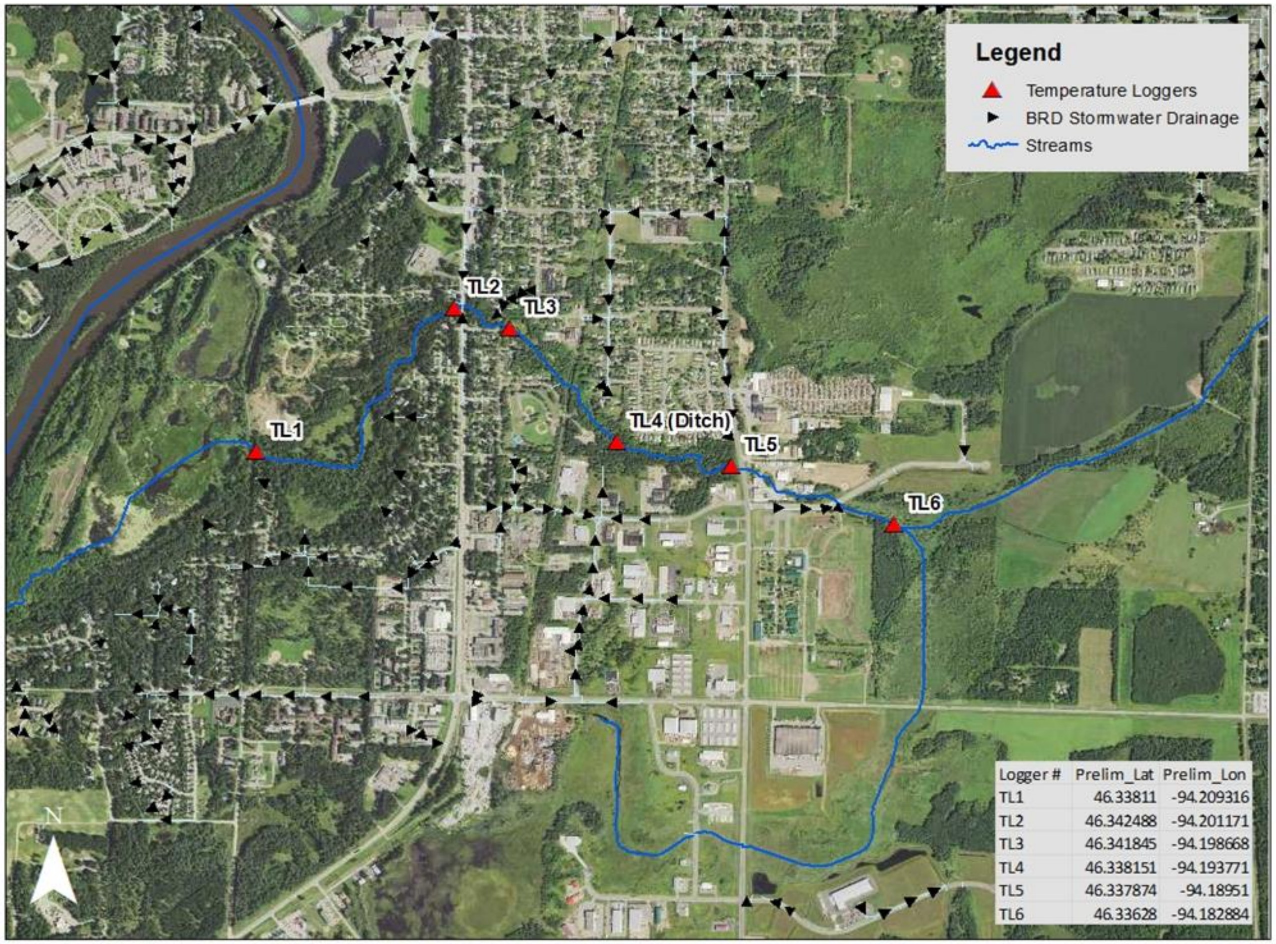


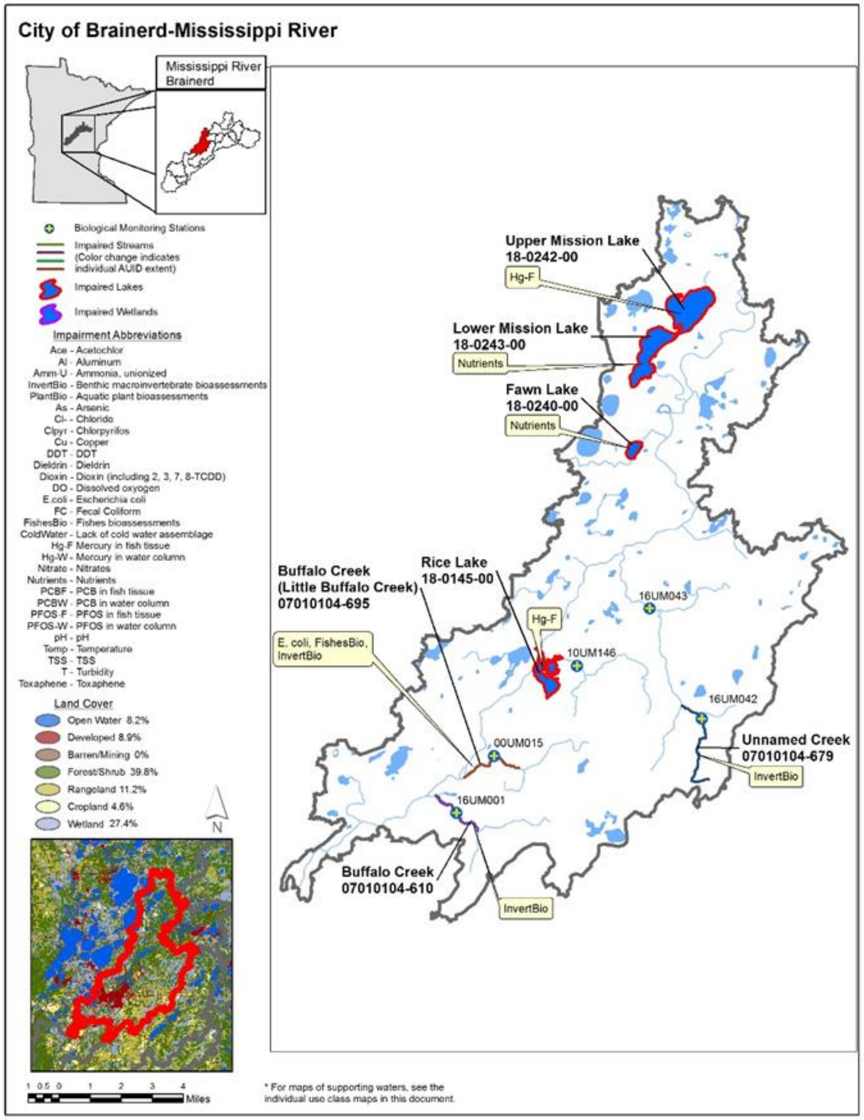
Figure 27. Temperature logger locations in Little Buffalo Creek during the summer of 2018



Eighteen lakes were reviewed for aquatic recreation and eight were reviewed for aquatic life. These small to medium sized lakes have little to heavy development. Water quality was meeting aquatic recreation standards on ten lakes. Fawn Lake was found to be impaired for aquatic recreation. All eutrophication indicators were well in excess of the standard (54 ug/L for TP, 41 ug/L for chl-*a*, and 0.7 m Secchi). Fawn Lake is shallow; these lakes have little capacity for additional phosphorus inputs. Internal cycling of nutrients will drive algal production across the summer months. Lower Mission Lake, a deep lake, was listed for eutrophication as well. TP and chl-a were both over the aquatic recreation standards. This lake has a history of highly productive seasons followed by lower algae summers; 2006, 2010, and 2014 were particularly high in algae production.

Seven lakes fully supported aquatic life. FIBI scores were positively influenced by the presence of intolerant species on Upper Mission, Lower Mission, Black Bear, and Perch. Bass (18-0256-00), Bass (18-0306-00), and Silver had few tolerant species and an adequate biomass of insectivores (Bluegill and other sunfish). Aquatic plant communities on Black Bear, Upper Mission, Lower Mission, Bass (18-0256-00) and Perch were healthy.

Figure 28. Currently listed impaired waters by parameter and land use characteristics in the City of Brainerd-Mississippi River Aggregated 12-HUC



Rabbit River Aggregated 12-HUC

HUC 0701010405-02

The Rabbit River Subwatershed drains 45 miles in Crow Wing County. Encompassing the Cuyuna Iron Range, this subwatershed comprises a number of mine pit lakes connected by short tributary streams; these streams include Rabbit, Serpent and Blackhoof Creeks. The subwatershed has the highest percentage of open water (18.4%) and developed land (10.8%) in the Upper Mississippi River-Brainerd Watershed. The remaining land use is a mixture of forest (44.7%) and range (9.4%). As a result of the extensive lake influence and lack of stream reaches in this subwatershed, no biological or stream chemistry-monitoring stations were established.

Table 18. Lake assessments: Rabbit River Aggregated 12-HUC.

Lake name	DNR ID	Area (acres)	Max depth (ft)	Assessment method	Ecoregion	Secchi Trend	Aquatic life indicators:			Aquatic Recreation Indicators:			Aquatic life use	Aquatic recreation use
							Fish IBI	Chloride	Pesticides ***	Total phosphorus	Chlorophyll-a	Secchi		
Agate	18-0060-00	183.39	25	Deep	NLF		--	IF	--	MTS	IF	MTS	IF	SUP
Cascade	18-0061-00	41.57	23	Deep	NLF		--	--	--	MTS	MTS	IF	--	SUP
Reno	18-0067-00	168.71	9	Shallow	NLF		--	IF	--	MTS	MTS	MTS	IF	SUP
Rice	18-0068-00	158.33	6.5	Shallow	NLF		--	--	--	IF	--	IF	--	IF
Serpent	18-0090-00	1099.88	62	Deep	NLF		MTS	--	--	MTS	MTS	MTS	SUP	SUP
Rabbit (East Portion)	18-0093-01	612.68	337	Deep	NLF		MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
Rabbit (West Portion)	18-0093-02	516.91	50	Deep	NLF		MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
Black Hoof	18-0117-00	194.94	29	Deep	NLF		MTS	IF	--	IF	EXS	MTS	SUP	IF
Little Black Hoof	18-0118-00	65.20	13	Shallow	NLF		--	--	--	--	--	IF	--	IF
East Mahnomen	18-0126-01	81.04	25	Wetland	NLF		--	--	--	NA	NA	NA	--	NA

Clinker	18-0131-00	80.58	35	Deep	NLF		--	IF	--	MTS	MTS	MTS	IF	SUP
Turner	18-0135-00	59.94	36	Deep	NLF		--	--	--	MTS	MTS	MTS	--	SUP
Little Rabbit	18-0139-00	173.80	33	Deep	NLF		NA	IF	--	MTS	MTS	MTS	NA	SUP
Unnamed	18-0433-00	15.07			NLF		--	--	--	EXS	EXS	IF	--	IF
Portsmouth Mine	18-0437-00	136.91	352	Deep	NLF		--	--	--	SUP	SUP	SUP	--	SUP
Pennington Mine	18-0439-00	47.88	259	Deep	NLF		--	IF	--	IF	IF	IF	IF	IF
Unnamed	18-0504-00	24.94	~6.9	Shallow	NLF		--	--	--	MTS	MTS	NA	--	SUP

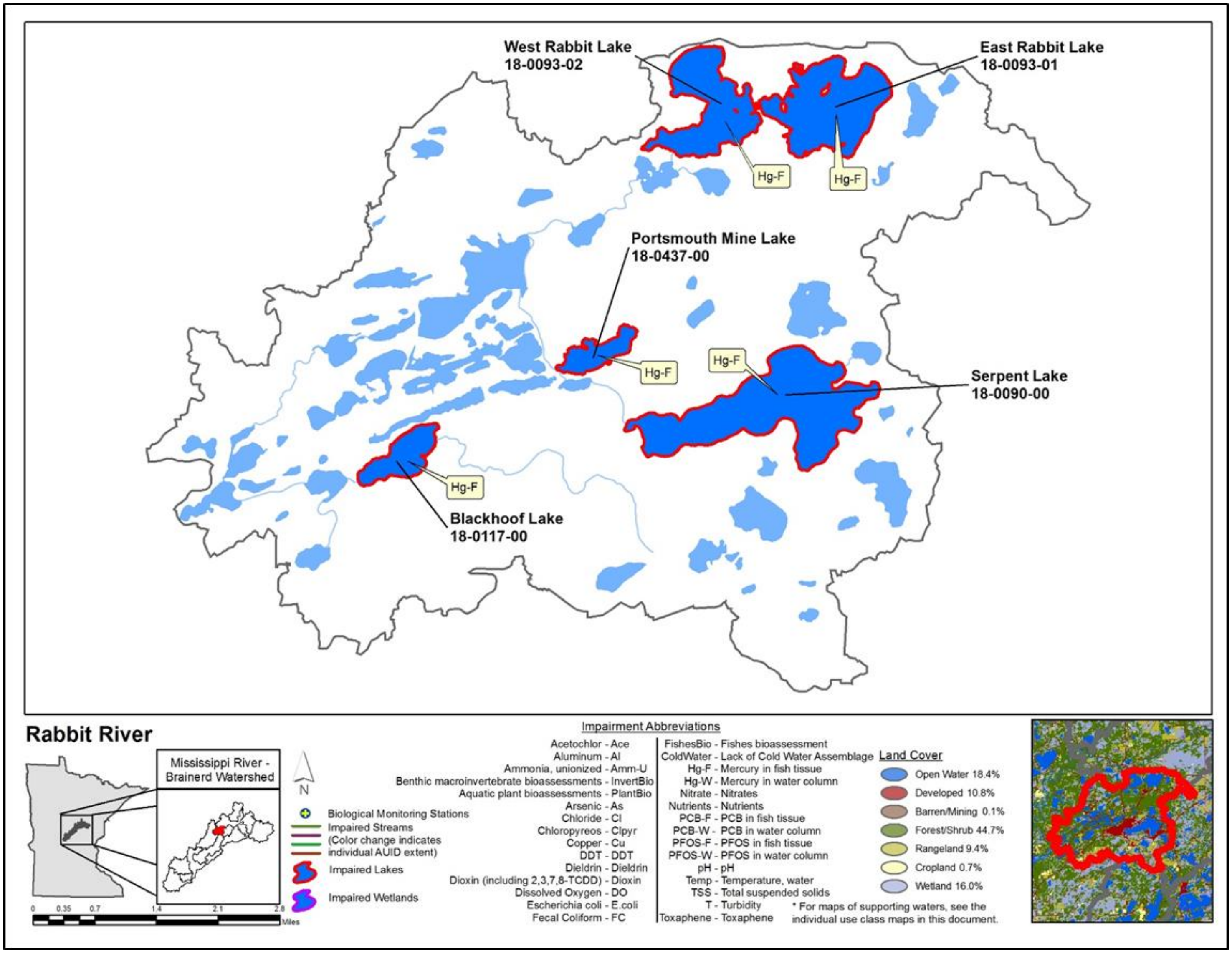
Abbreviations for Ecoregion: DA = Driftless Area, NCHF = North Central Hardwood Forest, NGP = Northern Glaciated Plains, NLF = Northern Lakes and Forests, NMW = Northern Minnesota Wetlands, RRV = Red River Valley, WCBP = Western Corn Belt Plains
Abbreviations for Secchi Trend: D = decreasing/declining trend, I = increasing/improving trend, NT = no detectable trend, -- = not enough data
Abbreviations for Indicator Evaluations: -- = No Data, **MTS** = Meets Standard; **EXS** = Exceeds Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Not Support (Impaired, exceeds standard)
Key for Cell Shading: ☐ = existing impairment, listed prior to 2018 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐= insufficient information.

Summary

Seventeen lakes were reviewed for aquatic recreation; five of these were also reviewed for aquatic life. These small to large lakes have little to high development. Land use surrounding Serpent Lake is highly developed, being nestled between the cities of Ironton, Crosby, and Deerwood. Water quality met aquatic recreation standards on 11 lakes. Former mine pits are among some of the lakes reviewed, such as Rabbit Lake (East Portion), Portsmouth Mine, and Pennington Mine. As custom for mine pits, these lakes have very low nutrients, algal growth, and excellent clarity.

Serpent, Rabbit (East & West Portions), and Black Hoof Lakes fully supported aquatic life. The FIBI scores were positively influenced by the presence of intolerant species and vegetation dwelling species. The absence of tolerant species in any gear, the presence of intolerant species in the gill nets (Rock Bass), and a high proportion of insectivores (Bluegill) positively influenced the FIBI score on Rogers. Aquatic plant communities on Black Hoof Lake were healthy.

Figure 29. Currently listed impaired waters by parameter and land use characteristics in the Rabbit River Aggregated 12-HUC



Nokasippi River Aggregated 12-HUC — HUC 0701010406-01

The Nokasippi River Subwatershed drains 174 miles of Crow Wing and Morrison counties, which makes it the second largest drainage within the Upper Mississippi River-Brainerd Watershed. The Nokasippi River begins at Clearwater Lake and flows 46 miles to its confluence with the Mississippi River. The upper reaches of the Nokasippi River are short connectors between a number of popular lakes. Following its confluence with Daggett Brook, the Nokasippi River flows through two miles of agricultural and range land before picking up gradient along its final 22 miles. A number of large tributaries, notably the Little Nokasippi River, Hay Creek, and Daggett Brook, contribute flow to the Nokasippi River. There are 62 lakes greater than ten acres in size, with the two most prominent and highly developed being Upper and Lower South Long Lakes. Land use is dominated by forest (37.6%), rangeland (24.8%), and wetland (20.1%) with the remaining land cover consisting of cropland (8.7%), open water (5.2%), and developed land (3.5%). The water chemistry monitoring station was established on the Nokasippi River, just upstream of CSAH 2, 3.5 mi. SE of Lennox.

Table 19. Aquatic life and recreation assessments on stream reaches: Nokasippi River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

WID *Reach name,* *Reach description*	Biological Station ID	Reach length (miles)	Use class*	Aquatic life indicators:									Aquatic life	Aquatic rec. (Bacteria)
				Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Eutrophication		
07010104-509 ***Nokasippi River,*** *Headwaters (Clearwater Lk 18-0038-00) to Daggett Bk*	16UM026, 16UM029	20.77	WWg	MTS	MTS	NA	NA	NA	--	NA	NA	NA	SUP	SUP
07010104-510 ***Nokasippi River,*** *Daggett Bk to Hay Cr*	16UM027	15.42	WWg	MTS	--	IF	IF	MTS	--	IF	--	IF	SUP	SUP
07010104-511 ***Nokasippi River,*** *Hay Cr to Little Nokasippi R*	16UM028	9.28	WWe	MTS	MTS	NA	MTS	MTS	MTS	MTS	MTS	IF	SUP	SUP
07010104-532 ***Little Nokasippi River,*** *Headwaters to Nokasippi R*	16UM017	13.80	WWg	MTS	MTS	IF	IF	IF	--	IF	IF	IF	SUP	IF

07010104-612 ***Unnamed creek,*** *Headwaters (Graves Lk 18-0110-00) to Nokasippi R*	--	0.45	--	--	--	NA	NA	NA	--	NA	--	NA	NA	SUP
07010104-645 ***Hay Creek,*** *Headwaters to Grave Lk*	--	5.58	--	--	--	IF	MTS	IF	--	MTS	--	--	IF	IMP
07010104-699 ***Hay Creek,*** *-94.253 46.244 to Nokasippi R*	16UM010	3.7000000 000000002	WWg	MTS	--	IF	IF	IF	--	IF	IF	IF	SUP	IF

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: = existing impairment, listed prior to 2018 reporting cycle; = new impairment; = full support of designated use; = insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 20. Lake assessments: Nokasippi River Aggregated 12-HUC.

Lake name	DNR ID	Area (acres)	Max depth (ft)	Assessment method	Ecoregion	Secchi Trend	Aquatic life indicators:			Aquatic recreation indicators:			Aquatic life use	Aquatic recreation use
							Fish IBI	Chloride	Pesticides ***	Total phosphorus	Chlorophyll-a	Secchi		
Clearwater	18-0038-00	888.63	53	Deep	NLF		MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
Upper South Long	18-0096-00	788.73	47	Deep	NLF		MTS	--	--	MTS	EXS	IF	SUP	IF
Eagle	18-0099-00	240.34	38	Deep	NLF		--	IF	--	MTS	MTS	MTS	IF	SUP

Unnamed	18-0102-00	30.51			NLF		--	--	--	--	--	MTS	--	IF
Nokay	18-0104-00	697.94	42	Deep	NLF		MTS	MTS	--	MTS	IF	MTS	SUP	SUP
Dog	18-0107-00	40.36			NLF		--	--	--	--	--	IF	--	IF
Grave	18-0110-00	169.13	13	Shallow	NLF		--	--	--	EXS	EXS	EXS	IF	IMP
Wolf	18-0112-00	188.84	4	Shallow	NLF		--	--	--	MTS	MTS	NA	--	SUP
Lookout	18-0123-00	232.92	16	Shallow	NLF		NA	--	--	--	--	IF	--	IF
South Long	18-0136-00	1283.76	47	Deep	NLF		MTS	--	--	MTS	EXS	MTS	SUP	IF
West Twin	18-0148-01	24.37			NLF		--	--	--	MTS	MTS	MTS	--	SUP
East Twin	18-0148-02	20.68			NLF		--	--	--	MTS	IF	MTS	--	SUP
Unnamed	18-0154-00	42.70			NLF		--	--	--	IF	--	IF	--	IF
Sebie	18-0161-00	176.57	27	Deep	NCHF		--	--	--	EXS	EXS	EXS	--	IMP

Abbreviations for Ecoregion: DA = Driftless Area, NCHF = North Central Hardwood Forest, NGP = Northern Glaciated Plains, NLF = Northern Lakes and Forests, NMW = Northern Minnesota Wetlands, RRV = Red River Valley, WCBP = Western Corn Belt Plains
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Key for Cell Shading: ☐ = existing impairment, listed prior to 2018 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐= insufficient information.

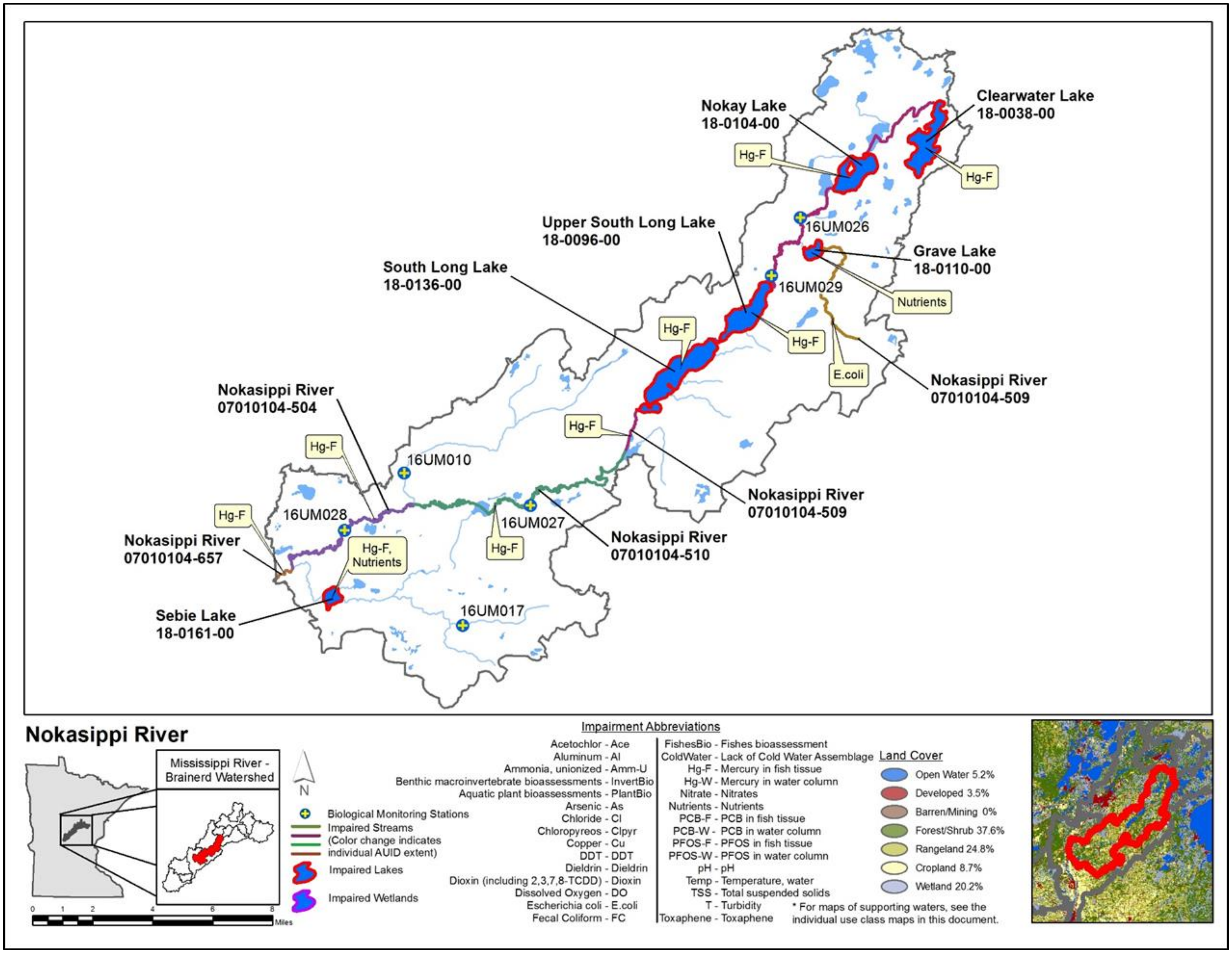
Summary

Aquatic life indicators along the Nokasippi River and its tributaries indicate very good water quality, with low levels of sediment and healthy fish and macroinvertebrate communities. The Nokasippi River from Hay Creek to the Little Nokasippi River met exceptional use standards based on the FIBI and MIBI scores. Protection strategies should be developed through the WRAPs process to help maintain this high quality resource. Elevated bacteria was found along the headwaters of the Nokasippi River (from its headwaters to Grave Lake), resulting in an impairment for aquatic recreation.

Fourteen lakes were reviewed for aquatic recreation and five lakes were reviewed for aquatic life. These small to large sized lakes have little development. Lakes in the western half of the subwatershed are surrounded by pasture and cropland. Water quality met aquatic recreation standards on six lakes. Grave Lake, a shallow lake, was found to be impaired for aquatic recreation; all parameters were well in excess of the standard. Shallow lakes have little capacity for inputs of phosphorus; internal cycling of nutrients will drive algal production throughout the summer. Sebie Lake, a flow-through lake, was listed for eutrophication in 2010 and current data corroborates the impairment. The lake drains a large watershed and is relatively shallow.

Clearwater, Upper South Long, Nokay, and South Long lakes all supported aquatic life. The FIBI scores were positively influenced by the presence of intolerant species and a high number of vegetation dwelling species surveyed. Aquatic plant communities on Clearwater, Upper South Long, Lookout, and South Long lakes were healthy.

Figure 30. Currently listed impaired waters by parameter and land use characteristics in the Nokasippi River Aggregated 12-HUC.



Daggett Brook Aggregated 12-HUC HUC 0701010406-02

The Daggett Brook Subwatershed drains 51 square miles of Crow Wing and Aitkin counties. Daggett Brook begins in a large wetland complex 12 miles southeast of Brainerd, then flows 22.5 miles to its outlet at the Nokasippi River. Multiple unnamed tributaries drain into Daggett Brook, with Coon Creek being the largest. The headwaters of this subwatershed is comprised of primarily forest (33.2%) and wetlands (22.4%), however a fair amount of rangeland (32.6%) make up the lower sections. The remaining land use is comprised of cropland (8.5%), developed land (3.0%), and open water (0.3%). The water chemistry monitoring station was established on the Daggett Brook, just upstream of Nokasippi River Rd, 8.5 mi. SE of Brainerd.

Table 21. Aquatic life and recreation assessments on stream reaches: Daggett Brook Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

WID *Reach name,* *Reach description*	Biological Station ID	Reach length (miles)	Use class*	Aquatic life indicators: Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Eutrophication	Aquatic life	Aquatic rec. (Bacteria)
07010104-534 ***Daggett Brook,*** *Headwaters to Nokasippi R*	16UM003, 16UM004	22.48	WWg	MTS	MTS	IF	IF	MTS	MTS	MTS	MTS	IF	SUP	SUP

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: = existing impairment, listed prior to 2018 reporting cycle; = new impairment; = full support of designated use; = insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 22. Lake assessments: Daggett Brook Aggregated 12-HUC.

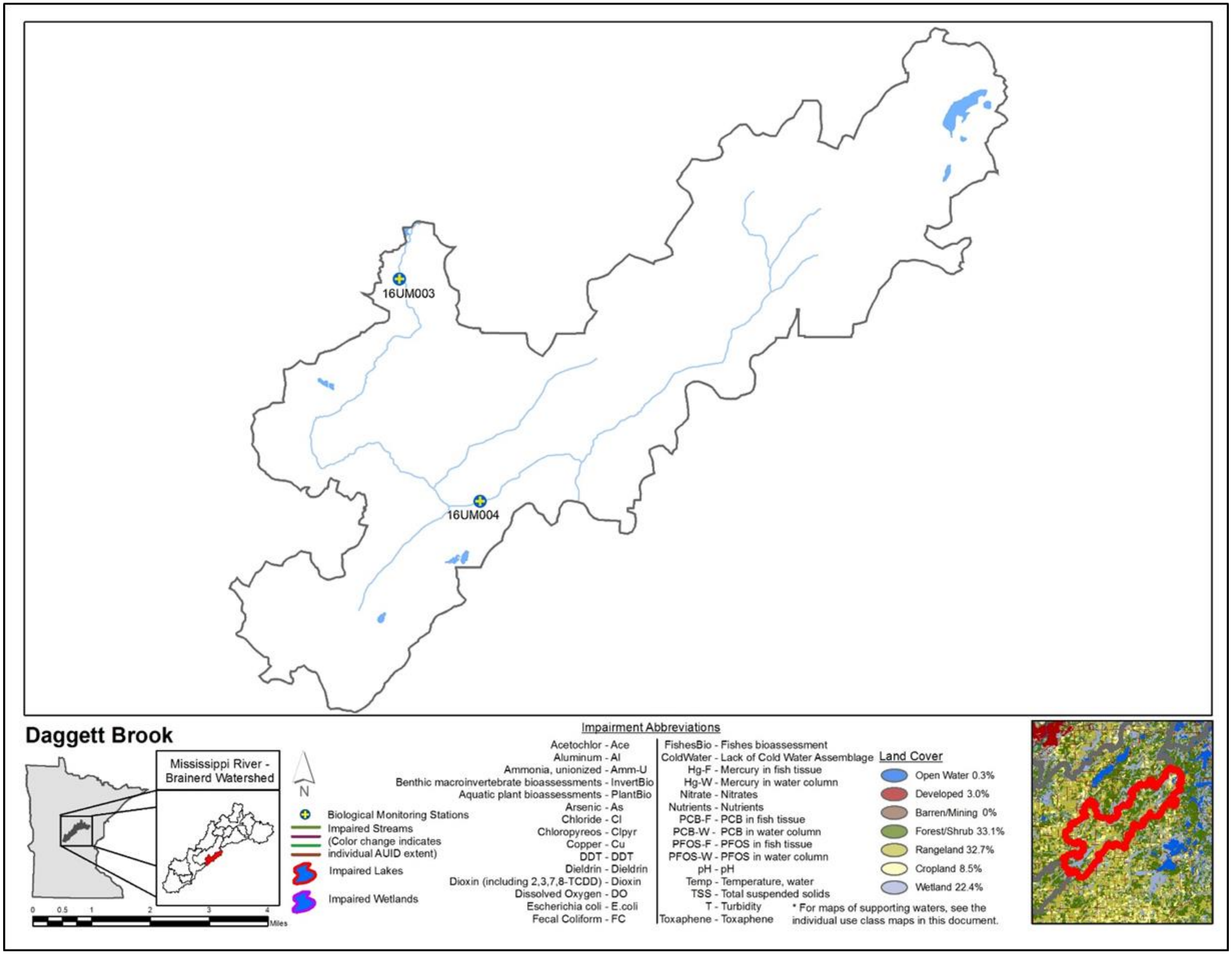
Lake name	DNR ID	Area (acres)	Max depth (ft)	Assessment method	Ecoregion	Secchi Trend	Aquatic life indicators:			Aquatic recreation indicators:			Aquatic life use	Aquatic recreation use
							Fish IBI	Chloride	Pesticides ***	Total phosphorus	Chlorophyll-a	Secchi		
Jack Pine	18-0023-00	83.40		Shallow	NLF		--	--	--	IF	--	IF	--	IF

Abbreviations for Ecoregion: DA = Driftless Area, NCHF = North Central Hardwood Forest, NGP = Northern Glaciated Plains, NLF = Northern Lakes and Forests, NMW = Northern Minnesota Wetlands, RRV = Red River Valley, WCBP = Western Corn Belt Plains
Abbreviations for Secchi Trend: D = decreasing/declining trend, I = increasing/improving trend, NT = no detectable trend, -- = not enough data
Abbreviations for Indicator Evaluations: -- = No Data, **MTS** = Meets Standard; **EXS** = Exceeds Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Not Support (Impaired, exceeds standard)
Key for Cell Shading: ☐ = existing impairment, listed prior to 2018 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐= insufficient information.

Summary

Aquatic life and recreation indicators within the Daggett Brook Subwatershed reflect good water quality, with FIBI and MIBI scores all well above their respective standards. The robust macroinvertebrate community found here is likely attributed to the excellent habitat that consists of clean course substrates, vegetation and woody debris. Chemistry data was reviewed on Daggett Brook from its headwaters to the Nokasippi River. Transparency, pH, chloride and unionized ammonia met standards for aquatic life. One lake in the subwatershed was reviewed, Jack Pine, had only a single measurement from 2009.

Figure 31. Currently listed impaired waters by parameter and land use characteristics in the Daggett Brook Aggregated 12-HUC.



Little Elk River Aggregated 12-HUC HUC 0701010407-01

The Little Elk River Subwatershed drains 148 square miles of Morrison and Todd counties. Originating in a small wetland seven miles northwest of Randall, the Little Elk River flows southeasterly approximately 13.5 miles before joining the Little Elk River, South Branch, in the town of Randall. From there, the Little Elk River flows 16 miles southeast to its outlet at the Mississippi River. Land use is primarily forest (37.8%), rangeland (24.5%), wetlands (19.2%) and cropland (12.6%), and developed land (4.2%).The water chemistry monitoring station was established upstream of County Road 13, 2 miles SW of Belle Prairie.

Table 23. Aquatic life and recreation assessments on stream reaches: Little Elk River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

WID ***Reach name,*** *Reach description*	Biological Station ID	Reach length (miles)	Use class*	Aquatic life indicators: Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Eutrophication	Aquatic life	Aquatic rec. (Bacteria)
07010104-521 ***Little Elk River,*** *T129 R30W S1, north line to Mississippi R*	16UM014	2.55	WWg	MTS	MTS	IF	IF	MTS	MTS	MTS	MTS	IF	SUP	IMP
07010104-529 ***Little Elk River,*** *Headwaters to S Br Little Elk R*	16UM013	13.48	WWg	MTS	MTS	IF	IF	IF	--	IF	IF	IF	SUP	--
07010104-530 ***Little Elk River,*** *S Br Little Elk R to T130 R30W S36, south line*	--	13.32	WWg	--	--	--	--	MTS	--	--	--	--	IF	--
07010104-682 ***Hay Creek,*** *Unnamed cr to Little Elk R*	16UM011	1.36	WWg	MTS	EXS	IF	IF	IF	--	IF	IF	IF	IMP	--
07010104-683 ***Unnamed creek,*** *Headwaters to Hay Cr*	16UM060	4.56	WWe	MTS	MTS	IF	IF	IF	--	IF	IF	IF	SUP	--

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: ☐ = existing impairment, listed prior to 2018 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐= insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 24. Lake assessments: Little Elk River Aggregated 12-HUC.

Lake name	DNR ID	Area (acres)	Max depth (ft)	Assessment method	Ecoregion	Secchi Trend	Aquatic life indicators:			Aquatic recreation indicators:			Aquatic life use	Aquatic recreation use
							Fish IBI	Chloride	Pesticides ***	Total phosphorus	Chlorophyll-a	Secchi		
Round	49-0056-00	124.25	18		NLF		MTS	--	--	MTS	MTS	MTS	SUP	SUP
Big	77-0063-00	319.60	21		NCHF		IF	MTS	--	MTS	IF	MTS	IF	SUP
Pine Island	77-0067-00	226.21	26		NLF		MTS	--	--	MTS	MTS	MTS	SUP	SUP
Kominek Pond	77-0378-00	30.29			NLF		--	--	--	IF	IF	--	--	IF

Abbreviations for Ecoregion: DA = Driftless Area, NCHF = North Central Hardwood Forest, NGP = Northern Glaciated Plains, NLF = Northern Lakes and Forests, NMW = Northern Minnesota Wetlands, RRV = Red River Valley, WCBP = Western Corn Belt Plains
Abbreviations for Secchi Trend: D = decreasing/declining trend, I = increasing/improving trend, NT = no detectable trend, -- = not enough data
Abbreviations for Indicator Evaluations: -- = No Data, **MTS** = Meets Standard; **EXS** = Exceeds Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: -- = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Not Support (Impaired, exceeds standard)
Key for Cell Shading: ☐ = existing impairment, listed prior to 2018 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐= insufficient information.

Summary

Aquatic Life indicators along the Little Elk River and its tributaries generally reflect good water quality. Fish and macroinvertebrate communities along the Little Elk River are very good with FIBI and MIBI scores all near, or above the upper confidence limits for their respective thresholds. The fish assemblage collected along the headwaters of the Little Elk River scored well above the exceptional use standard for the northern headwaters fish class. The community was very diverse, and contained several sensitive taxa (i.e. Mottled Sculpin, Burbot, and Pearl Dace); these taxa generally indicate cool, clean, well-oxygenated water.

Hay Creek was monitored at one station (16UM011) during the summer of 2016. The FIBI score from this sample was above the exceptional use standard; however, the MIBI score fell well below the lower confidence interval, indicating a severe impairment. The fish sample was collected in June and the water was crystal clear (Figure 34) however, at the time of the macroinvertebrate sample in August 2016, the stream was covered with iron floc (Figure 33). Dissolved oxygen measurements were collected throughout the summer of 2016 and the values were all well below the 5 mg/L warmwater standard. The low DO levels, coupled with the very orange, iron colored water, suggest that stream conditions allow iron to precipitate. A local landowner stopped at the time of the macroinvertebrate sampling and indicated that the stream turns this "brown color" every August.

Interestingly, an unnamed tributary to Hay Creek (unnamed creek, 07010104-683) was monitored and met the exceptional use standard for FIBI and MIBI. This small, headwater tributary flows through a generally undisturbed landscape and contains very good in-stream habitat. The fish assemblage was numerically dominated by Pearl Dace, along with other cool water sensitive species.

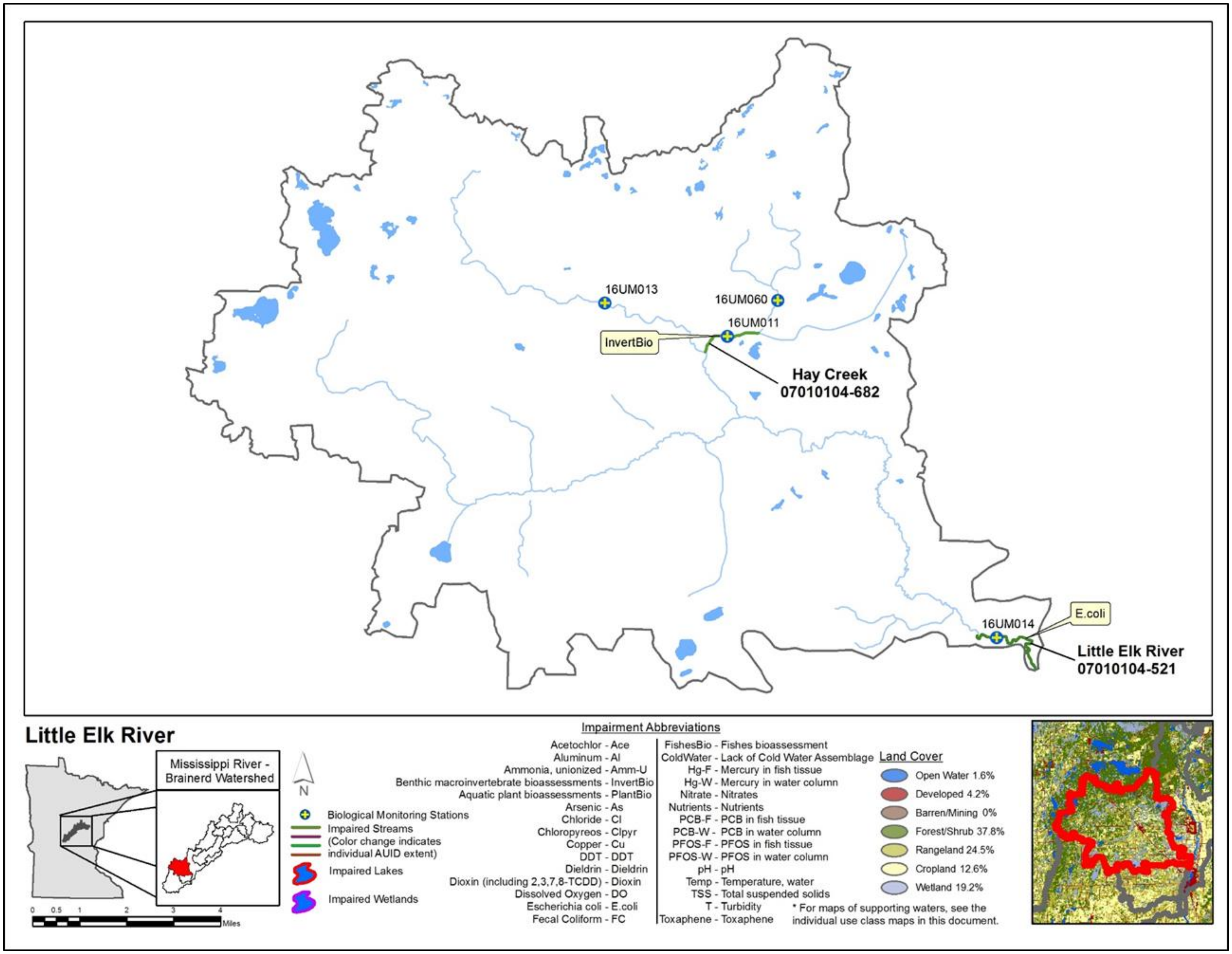
Chemistry data was reviewed for aquatic life on five reaches within the subwatershed, including Hay Creek and the Little Elk River. Most chemistry data available was on the 2.5 mi reach of the Little Elk River that ends at the Mississippi River. Aquatic life use standards were met for pH, chloride and unionized ammonia on that reach. Elevated bacteria was found on the Little Elk River resulting in an impairment for aquatic recreation.

Four lakes met the standards for aquatic recreation with low nutrient levels. Three of these lakes (Round, Big, and Pine Island) were also reviewed for aquatic life. The fish IBI scores on Round and Pine Island lakes indicated they are meeting aquatic life use standards. Round Lake's score was positively influenced by the absence of any tolerant or omnivore species, a high biomass of top carnivores (Northern Pike), and a high proportion of insectivores (sunfish). Pine Island had a relatively high proportion of insectivore biomass (Bluegill and Pumpkinseed), a relatively low proportion of omnivores, and a low number of omnivorous species surveyed.

Figure 32. Hay Creek on August 110, 2016 with high iron floc

Figure 33. Hay Creek on June 29, 2016 with clear water

Figure 34. Currently listed impaired waters by parameter and land use characteristics in the Little Elk River Aggregated 12-HUC



Swan River Aggregated 12-HUC

HUC 0701010408-01

The Swan River Subwatershed drains 180 square miles of Morrison and Todd counties. The Swan River flows easterly 37 miles from its headwaters at Big Swan Lake, to its outlet at the Mississippi River. Various named tributaries such as Little Swan River and Irish Creek contribute water to the Swan River. There are 62 lakes greater than ten acres, most notably Big Swan Lake. The landscape is primarily cropland (33.6%), rangeland (31.7%) and forest (20.5%); this is the highest percentage of cropland and second highest percentage of rangeland within the Upper Mississippi River-Brainerd Watershed. The remaining land use is a mixture of wetlands (6.2%), developed land (4.3%), and open water (3.6%). The water chemistry monitoring station was established upstream of Hwy 238, 3 mi. SW of Little Falls.

Table 25. Aquatic life and recreation assessments on stream reaches: Swan River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

				Aquatic life indicators:										
WID ***Reach name,*** *Reach description*	**Biological Station ID**	**Reach length (miles)**	**Use class***	**Fish IBI**	**Invert IBI**	**Dissolved oxygen**	**TSS**	**Secchi Tube**	**Chloride**	**pH**	**Ammonia -NH_3**	**Eutrophication**	**Aquatic life**	**Aquatic rec. (Bacteria)**
07010104-502 ***Swan River,*** *Headwaters (Big Swan Lk 77-0023-00) to Mississippi R*	16UM049, 16UM050, 16UM051	36.68	WWg	MTS	MTS	EXS	IF	MTS	MTS	MTS	MTS	IF	IMP	IMP
07010104-570 ***Little Swan River,*** *Spring Br to Swan R*	10EM118, 16UM018	6.21	WWg	EXP	MTS	IF	IF	IF	--	IF	IF	IF	IMP	--
07010104-626 ***Unnamed creek,*** *Headwaters to Big Swan Lk*	--	3.45	--	--	--	IF	MTS	--	MTS	MTS	MTS	IF	IF	IMP
07010104-627 ***Schwanke Creek,*** *Unnamed cr to Big Swan Lk*	16UM044	1.77	WWg	MTS	MTS	IF	MTS	IF	MTS	MTS	MTS	IF	SUP	IMP
07010104-628 ***Unnamed creek,***	--	0.79	--	--	--	IF	NA	--	NA	NA	NA	NA	NA	SUP

Lady Lk to Big Swan Lk														
07010104-629 ***Unnamed creek,*** *Long Lk (77-0027-00) to Big Swan Lk*	--	1.32	--	--	--	NA	NA	--	NA	NA	NA	NA	NA	IMP
07010104-685 ***Unnamed creek,*** *Big Marsh (49-0160-00) to -94.621, 45.915*	16UM007	1.88	WWm	MTS	MTS	NA	IF	IF	--	IF	IF	IF	SUP	--
07010104-687 ***Little Swan River,*** *335th Ave to Spring Branch*	16UM019	3.89	WWg	MTS	MTS	NA	IF	IF	--	IF	IF	IF	SUP	--

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: = existing impairment, listed prior to 2018 reporting cycle; = new impairment; = full support of designated use; = insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 26. Lake assessments: Swan River Aggregated 12-HUC.

Lake name	DNR ID	Area (acres)	Max depth (ft)	Assessment method	Ecoregion	Secchi Trend	Aquatic life indicators:			Aquatic recreation indicators:			Aquatic life use	Aquatic recreation use
							Fish IBI	Chloride	Pesticides ***	Total phosphorus	Chlorophyll-a	Secchi		
Pine	49-0081-00	182.69	59	Deep	NCHF		MTS	--	--	MTS	MTS	MTS	SUP	SUP
Long	49-0086-00	115.28	19	Shallow	NCHF		--	--	--	MTS	MTS	MTS	--	SUP
Mound	77-0007-00	263.36	57	Deep	NLF		MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
Trace	77-0009-00	250.63	6	Shallow	NCHF		--	IF	--	EXS	EXS	EXS	IF	IMP
Twin	77-0021-00	115.56	43	Deep	NCHF		--	IF	--	IF	IF	IF	IF	IF
Mons	77-0022-00	91.15	80	Deep	NCHF		MTS	--	--	MTS	MTS	MTS	SUP	SUP
Big Swan	77-0023-00	876.91	45	Deep	NCHF		MTS	MTS	--	IF	EXS	MTS	SUP	IMP
Bass	77-0024-00	124.72	78	Deep	NCHF		IF	--	--	MTS	MTS	MTS	IF	SUP
Pepin	77-0025-00	50.82	34	Deep	NCHF		NA	--	--	--	--	MTS	NA	IF
Moose	77-0026-00	129.37	26	Deep	NCHF		EXS	--	--	EXS	EXS	MTS	IMP	IMP
Long	77-0027-00	395.33	63	Deep	NCHF		MTS	--	--	MTS	MTS	MTS	SUP	SUP
Buck	77-0029-00	58.55	39	Deep	NCHF		--	--	--	MTS	MTS	MTS	--	SUP
Lady	77-0032-00	183.52	62	Deep	NCHF		MTS	IF	--	MTS	MTS	MTS	SUP	SUP
Little Swan	77-0034-00	170.46	67	Deep	NCHF		MTS	--	--	MTS	MTS	MTS	SUP	SUP
Beauty	77-0035-00	226.76	29	Deep	NCHF		MTS	--	--	MTS	MTS	MTS	SUP	SUP

Abbreviations for Ecoregion: DA = Driftless Area, NCHF = North Central Hardwood Forest, NGP = Northern Glaciated Plains, NLF = Northern Lakes and Forests, NMW = Northern Minnesota Wetlands, RRV = Red River Valley, WCBP = Western Corn Belt Plains
Abbreviations for Secchi Trend: D = decreasing/declining trend, I = increasing/improving trend, NT = no detectable trend, -- = not enough data
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Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Not Support (Impaired, exceeds standard)
Key for Cell Shading: = existing impairment, listed prior to 2016 reporting cycle; = new impairment; = full support of designated use; = insufficient information.

Summary

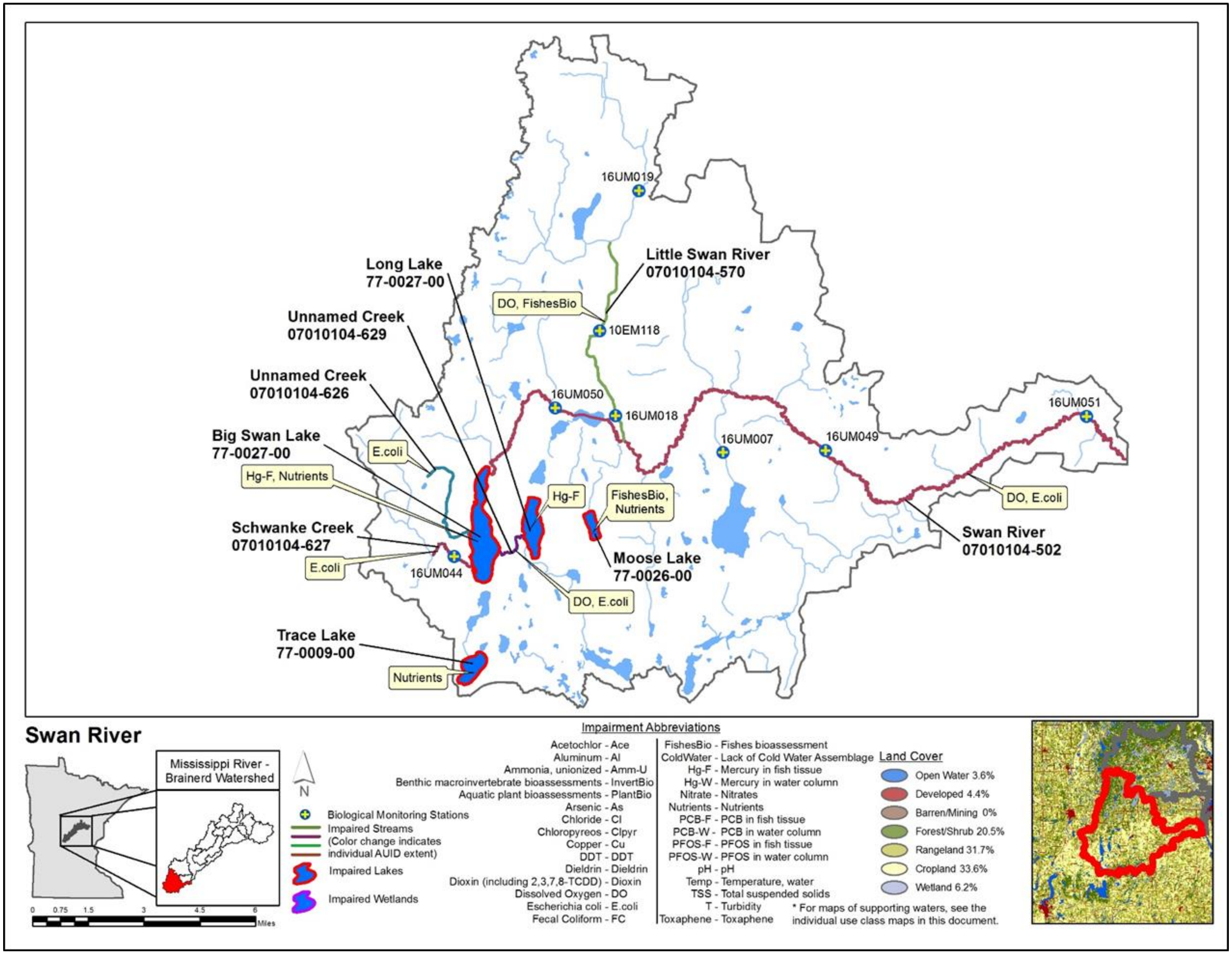
Aquatic life and recreation indicators within the Swan River Subwatershed generally reflect poor water quality. Schwanke Creek and unnamed creek were the only streams meeting Aquatic Life standards; however, Schwanke Creek will be impaired for aquatic recreation due to high levels of *E. coli* bacteria. Elevated *E. coli* concentrations were also found on the Swan River and three small tributaries to Big Swan Lake. The Big Swan Lake tributaries had particularly high bacteria levels.

Swan River is impaired for aquatic life. The impairment was the result of low DO and/or high turbidity. In addition, the lower section of the Little Swan River (Spring Brook to Swan River) was found to have a FIBI impairment. This reach had extremely low DO, which is likely stressing the biological community. Macroinvertebrate communities were very good throughout the subwatershed.

Fifteen lakes were reviewed for aquatic recreation, 11 of those were reviewed for aquatic life. Trace, Big Swan and Moose do not meet aquatic recreation standards. Trace Lake was listed as impaired for aquatic recreation in 2008. Lake eutrophication parameters are easily exceeding standards with means of 98 ug/L for TP, 36 ug/L for chl-*a* and 0.7 m Secchi transparency. A new eutrophication impairment will be attached to Moose Lake as TP, chl-*a* and Secchi were all exceeding. Both drain watersheds with disturbed land use, Trace Lake in particular is quite shallow and does not have capacity for additional inputs of phosphorus. Big Swan Lake was listed for aquatic recreation in 2010. The lake is a high priority for restoration since TP was right at the eutrophication standard with algal levels still exceeding the standard.

The FIBI scores on eight lakes all met aquatic life use standards. The FIBI scores were positively influenced by the presence of intolerant species (Cisco, Smallmouth Bass or Rock Bass) and/or a high proportion of insectivores (sunfish). Moose Lake was the lone lake in the subwatershed that will be listed as impaired for aquatic life. The low number of intolerant species, low biomass insectivores and high biomass of omnivores (Yellow Bullhead) were the primary IBI metrics that contributed to the impairment.

Figure 35. Currently listed impaired waters by parameter and land use characteristics in the Swan River Aggregated 12-HUC



City of Little Falls-Mississippi River Aggregated 12-HUC HUC 0701010409-01

The City of Little Falls-Mississippi River Subwatershed drains 149 square miles of Morrison and Crow Wing counties and is a Mississippi River mainstem flow-through subwatershed. The Mississippi River enters this subwatershed at its confluence with the Crow Wing River and flows southwest 30.7 miles to its confluence with the Swan River; this is the de-facto outlet of the Upper Mississippi River-Brainerd Watershed. Tributaries are limited to Fletcher Creek and a number of small, unnamed streams. Land use is a mixture of forest (33.3%), row crop (22.3%), rangeland (17.9%), wetland (14.5%), developed land (7.9%), and open water (4.1%). Crow Wing Lake is the only lake within the subwatershed boundaries. A water chemistry monitoring station was not established because the Mississippi River mainstem is the primary river in the watershed. Sampling occurred on the Mississippi River WID 07010104-631 as part of the 2013-2014 large river monitoring effort.

Table 27. Aquatic life and recreation assessments on stream reaches: City of Little Falls-Mississippi River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

WID ***Reach name,*** *Reach description*	Biological Station ID	Reach length (miles)	Use class*	Aquatic life indicators: Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Eutrophication	Aquatic life	Aquatic rec. (Bacteria)
07010104-681 ***Unnamed creek,*** *Unnamed ditch to Mississippi R*	16UM055	2.45	WWg	EXS	MTS	IF	IF	IF	--	IF	IF	IF	IMP	--
07010104-684 ***Unnamed creek,*** *Unnamed outlet to Mississippi R*	16UM056	2.77	WWm	MTS	EXS	EXS	IF	IF	--	IF	IF	IF	IMP	--

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
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Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 28. Lake assessments: City of Little Falls-Mississippi River Aggregated 12-HUC.

Lake name	DNR ID	Area (acres)	Max depth (ft)	Assessment method	Ecoregion	Secchi Trend	Aquatic life indicators: Fish IBI	Aquatic life indicators: Chloride	Aquatic life indicators: Pesticides ***	Aquatic recreation indicators: Total phosphorus	Aquatic recreation indicators: Chlorophyll-a	Aquatic recreation indicators: Secchi	Aquatic life use	Aquatic recreation use
Crow Wing	18-0155-00	370.85	26	Deep	NLF		EXS	MTS	--	EXS	EXS	EXS	IMP	IMP
Green Prairie Fish	49-0035-00	172.76	23	Deep	NCHF		EXS	--	--	MTS	MTS	MTS	IMP	SUP

Abbreviations for Ecoregion: DA = Driftless Area, NCHF = North Central Hardwood Forest, NGP = Northern Glaciated Plains, NLF = Northern Lakes and Forests, NMW = Northern Minnesota Wetlands, RRV = Red River Valley, WCBP = Western Corn Belt Plains
Abbreviations for Secchi Trend: D = decreasing/declining trend, I = increasing/improving trend, NT = no detectable trend, -- = not enough data
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Key for Cell Shading: ☐ = existing impairment, listed prior to 2018 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐= insufficient information.

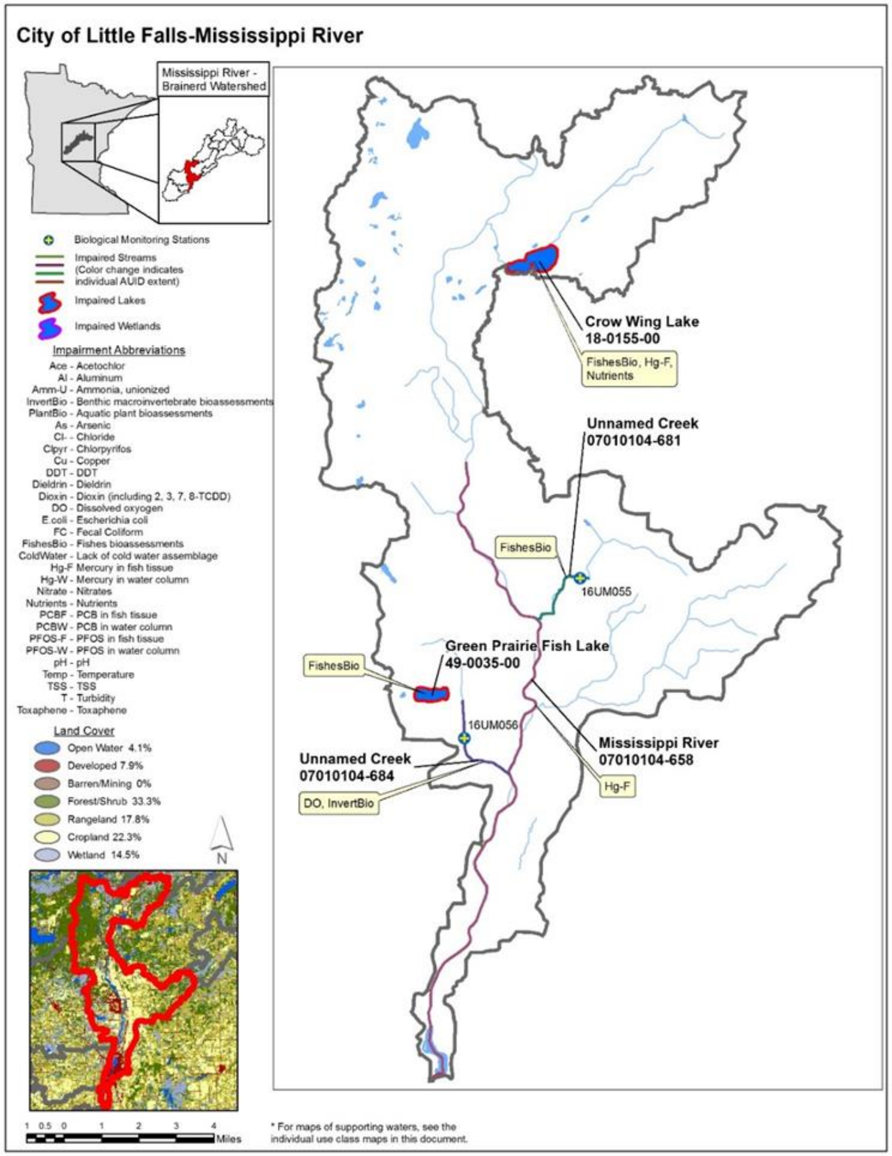
Summary

Aquatic life indicators in the City of Little Falls-Mississippi River Subwatershed reflect poor water quality. Fish and macroinvertebrates were collected from two unnamed tributaries in the summer 2016 and both samples yielded FIBI and/or MIBI scores below their respective standards, resulting in aquatic life impairments. A check dam is located at the outlet of the unnamed creek (07010104-681) where it meets the Mississippi River. It is unlikely that fish can move upstream of the dam, creating a likely fish barrier between the outlet and station 16UM055.

Chemistry data on streams was mostly limited to DO data from an unnamed creek (07010104-684). The DO data showed severe exceedances with concentrations as low as 0.12 mg/L, leading to a DO impairment. Tolerant invertebrate taxa along this reach also indicate low DO conditions.

Similar to streams, lake water quality is generally poor in the subwatershed. Crow Wing and Green Prairie Fish Lakes were assessed for aquatic recreation and aquatic life. These lakes are medium sized and are located within largely agricultural areas of the subwatershed. Crow Wing was listed for eutrophication in 2010, data from this assessment agrees with that decision. TP and Secchi are narrowly exceeding, but chl-*a* is well over the standard. Conditions are better in Green Prairie Fish Lake, with relatively low algal levels and average clarity of two meters. Both lakes are impaired for aquatic life according to the fish surveys. Crow Wing Lake had a low number of intolerant species, high number of omnivore species, and high biomass of omnivores (Yellow Bullhead). Green Prairie Fish Lakes FIBI scores were negatively impacted by the low number of intolerant species and vegetation dwelling species – high numbers of Yellow Bullhead were also sampled further negatively affecting the score.

Figure 36. Currently listed impaired waters by parameter and land use characteristics in the City of Little Falls-Mississippi River Aggregated 12-HUC



Pike Creek Aggregated 12-HUC HUC 0701010409-02

The Pike Creek Subwatershed encompasses 44 square miles of Morrison County, making it the smallest subwatershed in the Upper Mississippi River-Brainerd Watershed. The primary watercourse in this subwatershed is Pike Creek, which is a direct tributary to the Mississippi River. A large portion of the streams have been ditched. Over half of the watershed is comprised of rangeland (40.1%) and cropland (31.5%), with the remaining land use being a mixture of wetlands (12.4%), forest (9.6%), and developed land (6.2%). The water chemistry monitoring station was established upstream of Fountain Rd., one mi. SW of Little Falls.

Table 29. Aquatic life and recreation assessments on stream reaches: Pike Creek Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

WID ***Reach name,*** *Reach description*	Biological Station ID	Reach length (miles)	Use class*	Aquatic life indicators:									Aquatic life	Aquatic rec. (Bacteria)
				Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Eutrophication		
07010104-522 ***Pike Creek,*** *T129 R30W S21, west line to Mississippi R*	10EM026, 16UM031	6.99	WWg	MTS	MTS	EXS	MTS	EXS	MTS	MTS	MTS	IF	IMP	IMP

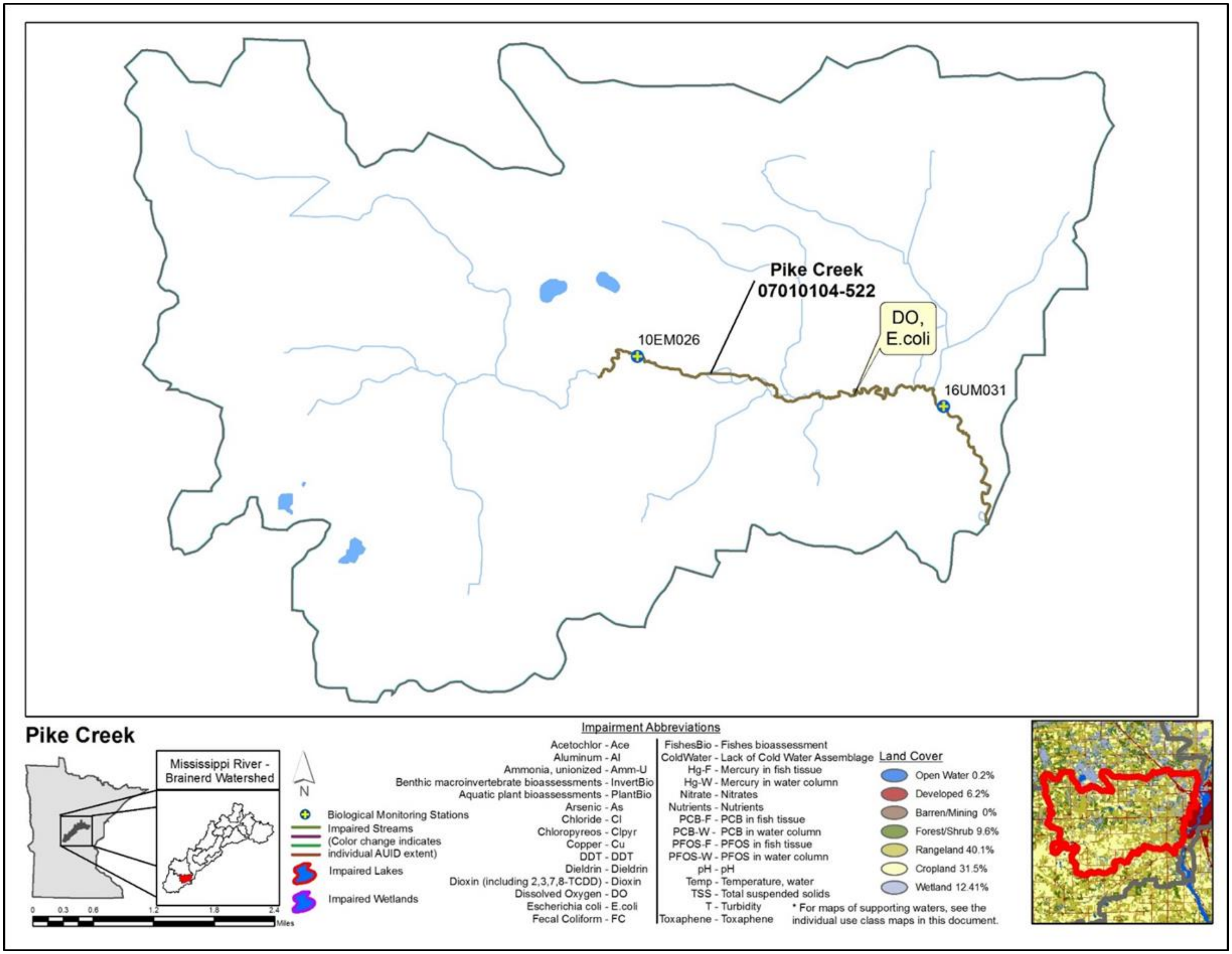
Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: = existing impairment, listed prior to 2018 reporting cycle; = new impairment; = full support of designated use; = insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Summary

Aquatic life indicators for streams within the Pike Creek Subwatershed show mixed results. Fish and macroinvertebrates communities along Pike Creek (07010104-522) indicate good water quality, however low DO has triggered an aquatic life impairment. Clarity issues were limited primarily to 2012 when intensive rains moved through the watershed. It is worth noting that several sensitive fish species were collected along Pike Creek, notably Mottled Sculpin at 16UM031.

An aquatic recreation impairment will also be attached to this reach as *E. coli* concentrations were elevated; both persistent conditions across months and for extremely high events (bacteria counts in excess of 2,400).

Figure 37. Currently listed impaired waters by parameter and land use characteristics in the Pike Creek Aggregated 12-HUC.



Watershed-wide results and discussion

Assessment results and data summaries are included below for the entire 8-HUC watershed unit of the Upper Mississippi River-Brainerd Watershed, grouped by sample type. Summaries are provided for lakes, streams, and rivers in the watershed for the following: aquatic life and recreation uses, aquatic consumption results, load monitoring data results, transparency trends, and remote sensed lake transparency. Waters identified as priorities for protection or restoration work were also identified. Additionally, groundwater and wetland monitoring results are included where applicable.

Following the results are a series of graphics that provide an overall summary of assessment results by designated use, impaired waters, and fully supporting waters within the entire Upper Mississippi River-Brainerd Watershed.

Stream water quality

Sixty-six of the 191 stream WIDs were assessed (Table 20). Of the assessed streams, 25 streams fully supported aquatic life and 13 streams fully supported aquatic recreation. One WID was classified as limited resource waters and assessed accordingly.

Throughout the subwatersheds, 16 WIDs did not support aquatic life and 9 streams did not support aquatic recreation.

Table 30. Assessment summary for stream water quality in the Upper Mississippi River-Brainerd Watershed River Watershed.

				Supporting		Non-supporting		Insufficient data		
Watershed	Area (acres)	# Total WIDs	# Assessed WIDs	# Aquatic life	# Aquatic recreation	# Aquatic life	# Aquatic recreation	# Aquatic life	# Aquatic recreation	Limited Resource Value
07010104	**1,076,301**		**66**	**25**	**13**	**16**	**9**	**15**	**9**	**1**
0701010401-02	126,788	6	4	2	2	2	1	0	0	0
0701010401-01	63,506	21	4	2	1	0	0	2	0	0
0701010404-03	28,371	4	3	0	1	3	0	0	0	0
0701010402-01	81,568	15	3	3	1	0	0	0	0	0
0701010404-02	29,387	7	3	1	2	0	0	0	0	0
0701010403-01	57,203	7	4	2	0	1	0	1	2	0
0701010404-01	77,142	10	2	1	0	1	0	0	0	0
0701010405-02	28,817	24	0	0	0	0	0	0	0	0
0701010406-02	32,765	3	1	1	1	0	0	0	0	0
0701010406-01	111,096	19	8	5	4	0	1	2	3	0
0701010405-01	105,560	24	9	2	0	3	1	4	0	0
0701010409-01	95,362	12	3	0	0	2	0	1	0	0
0701010407-01	95,061	10	5	3	0	1	1	1	0	0
0701010409-02	28,293	8	2	0	0	1	1	0	0	1
0701010408-01	115,382	31	15	3	1	2	4	4	4	0

Lake water quality

Sixty-one of the 90 lakes with available data for aquatic life use were assessed and 92 of the 138 lakes with available data were assessed for aquatic recreation use (Table 31). Of the assessed lakes, 57 lakes fully supported aquatic life and 74 lakes fully supported aquatic recreation.

Throughout the subwatersheds, 4 lakes did not support aquatic life and 18 lakes did not support aquatic recreation. These lakes tended to be shallow and/or in more highly disturbed watersheds.

Table 31. Assessment summary for lake water chemistry in the Upper Mississippi River-Brainerd Watershed River Watershed.

			Supporting		Non-supporting		Insufficient data	
Watershed	**Area (acres)**	**Lakes >10 acres**	**# Aquatic life**	**# Aquatic recreation**	**# Aquatic life**	**# Aquatic recreation**	**# Aquatic life**	**# Aquatic recreation**
07010104	**1,076,301**	**582**	**57**	**74**	**4**	**18**	**29**	**46**
0701010401-02	126,788	17	1	1	0	0	2	2
0701010401-01	63,506	18	4	3	0	3	5	4
0701010404-03	28,371	15	5	5	0	0	0	0
0701010402-01	81,568	92	14	15	1	2	2	7
0701010404-02	29,387	42	3	5	0	1	4	6
0701010403-01	57,203	16	3	2	0	3	2	6
0701010404-01	77,142	30	2	2	0	1	0	1
0701010405-02	28,817	55	4	11	0	0	4	5
0701010406-02	32,765	6	0	0	0	0	0	1
0701010406-01	111,096	62	4	6	0	2	2	6
0701010405-01	105,560	93	7	10	0	2	4	5
0701010409-01	95,362	27	0	1	2	1	0	0
0701010407-01	95,061	43	2	3	0	0	1	1
0701010409-02	28,293	4	0	0	0	0	0	0
0701010408-01	115,382	62	8	10	1	3	3	2

Fish contaminant results

Mercury and polychlorinated biphenyls (PCBs) have been analyzed in fish tissue samples collected from the Nokasippi River and 52 lakes in the watershed. Samples were collected by DNR fisheries staff from 1978 to 2017 and MPCA biomonitoring staff collected fish from the Nokasippi River in 2016.

Thirty-nine of the 52 tested lakes are on the 2018 Impaired Waters Inventory (IWI) for mercury in fish tissue (Table 32). Thirty-four of the lakes on the IWI qualified for inclusion in the Minnesota Statewide Mercury TMDL.

PCBs were tested in representative species from 13 lakes and the Nokasippi River. All PCB concentrations were mostly less than the reporting limits and all were less than the 0.2-ppm threshold for impairment.

Table 32. Fish contaminants: summary of fish length, mercury and PCBs by waterway-species-year.

							Length (in)			Mercury (mg/kg)			PCBs (mg/kg)			
WID	Waterway	Species	Year	Anatomy[1]	Total Fish	Number Samples	Mean	Min	Max	Mean	Min	Max	N	Mean	Max	< RL
07010104-504, -509, -510, -511	NOKASIPPI RIVER**	Walleye	2016	FILSK	6	6	12.5	11.5	15.2	0.322	0.152	0.806	2	0.025	0.025	Y
01-0087-00	SUGAR**	Black crappie	2011	FILSK	10	2	9.7	8.5	10.9	0.042	0.032	0.052				
		Bluegill sunfish	2011	FILSK	5	1	7.6	7.6	7.6	0.034	0.034	0.034				
		Northern pike	2011	FILSK	6	6	20.8	16.3	29.0	0.204	0.086	0.518				
		Walleye	2011	FILSK	7	7	19.2	11.5	24.5	0.306	0.115	0.677				
		Yellow bullhead	2011	FILET	5	1	10.8	10.8	10.8	0.160	0.160	0.160				
01-0089-00	LONG**	Black crappie	2014	FILSK	10	1	8.7	8.7	8.7	0.157	0.157	0.157				
		Bluegill sunfish	2014	FILSK	10	1	7.1	7.1	7.1	0.123	0.123	0.123				
		Cisco (Lake herring)	2014	FILSK	5	1	9.0	9.0	9.0	0.178	0.178	0.178				
		Northern pike	2014	FILSK	8	8	18.9	14.8	27.6	0.684	0.364	1.351				
		Walleye	2014	FILSK	5	5	16.8	12.7	24.0	0.894	0.507	1.952				
01-0091-00	RABBIT	Black crappie	2014	FILSK	8	1	7.7	7.7	7.7	0.088	0.088	0.088				
		Bluegill sunfish	2008	FILSK	13	2	8.5	7.7	9.3	0.154	0.138	0.169				
			2014	FILSK	9	1	7.0	7.0	7.0	0.121	0.121	0.121				
		Northern pike	2008	FILSK	4	4	23.7	19.7	27.6	0.560	0.268	0.840				
			2014	FILSK	6	6	21.7	19.1	25.5	0.448	0.320	0.878				
		Walleye	2008	FILSK	3	3	14.5	13.1	17.1	0.309	0.297	0.317				
			2014	FILSK	1	1	18.2	18.2	18.2	0.385	0.385	0.385				
		Yellow bullhead	2014	FILSK	3	1	11.7	11.7	11.7	0.371	0.371	0.371				

WID	Waterway	Species	Year	Anatomy[1]	Total Fish	Number Samples	Length (in) Mean	Length (in) Min	Length (in) Max	Mercury (mg/kg) Mean	Mercury (mg/kg) Min	Mercury (mg/kg) Max	PCBs (mg/kg) N	PCBs (mg/kg) Mean	PCBs (mg/kg) Max	PCBs (mg/kg) < RL
01-0093-00	CLEAR*	Black crappie	1991	FILSK	6	1	6.8	6.8	6.8	0.052	0.052	0.052				
		Bluegill sunfish	1991	FILSK	15	1	6.3	6.3	6.3	0.084	0.084	0.084				
		Northern pike	1991	FILSK	28	5	22.7	13.3	32.5	0.344	0.120	0.720				
			2014	FILSK	10	10	25.2	20.4	31.7	0.263	0.163	0.425				
		Walleye	1991	FILSK	18	4	19.5	12.8	26.8	0.478	0.130	0.990	1	0.01	0.01	Y
		White sucker	1991	FILSK	2	2	19.0	15.9	22.0	0.099	0.028	0.170	1	0.01	0.01	Y
		Yellow bullhead	1991	FILET	11	1	9.0	9.0	9.0	0.160	0.160	0.160				
01-0096-00	DAM*	Bigmouth buffalo	1990	FILSK	2	1	26.1	26.1	26.1	0.240	0.240	0.240	1	0.041	0.041	
		Black crappie	2012	FILSK	10	2	10.4	9.3	11.4	0.063	0.053	0.072				
		Bluegill sunfish	1990	FILSK	10	1	7.4	7.4	7.4	0.058	0.058	0.058	1	0.01	0.01	Y
			2012	FILSK	10	2	7.5	7.1	7.8	0.063	0.061	0.065				
		Northern pike	1990	FILSK	9	2	25.7	22.2	29.1	0.160	0.160	0.160	2	0.01	0.01	Y
			2012	FILSK	8	8	20.8	17.8	24.7	0.194	0.130	0.282				
		Walleye	1990	FILSK	19	3	19.0	13.0	26.6	0.510	0.180	1.100	3	0.01	0.01	Y
			2012	FILSK	7	7	14.6	11.2	20.6	0.243	0.136	0.563				
		White sucker	1990	FILSK	11	2	14.2	11.3	17.0	0.028	0.020	0.036	2	0.01	0.01	Y
		Yellow bullhead	2012	FILET	5	1	12.1	12.1	12.1	0.213	0.213	0.213				
01-0099-00	GUN*	Black crappie	2007	FILSK	8	1	7.7	7.7	7.7	0.010	0.010	0.010				
			2016	FILSK	10	1	8.9	8.9	8.9	0.107	0.107	0.107				
		Bluegill sunfish	2016	FILSK	10	1	7.4	7.4	7.4	0.087	0.087	0.087				
		Northern pike	1985	FILSK	8	2	19.3	18.3	20.2	0.160	0.100	0.220				
			2007	FILSK	7	7	19.7	13.3	24.0	0.182	0.014	0.410				
			2016	FILSK	8	8	22.7	18.4	27.0	0.355	0.119	0.531				
		Walleye	1985	FILSK	9	2	15.7	13.0	18.3	0.195	0.160	0.230				
			2016	FILSK	7	7	19.1	14.1	23.5	0.598	0.182	0.928				
01-0104-00	FRENCH*	Black crappie	2011	FILSK	10	2	8.8	8.2	9.4	0.043	0.040	0.046				
		Northern pike	2011	FILSK	8	8	21.4	19.4	23.4	0.214	0.173	0.272				
		White sucker	2011	FILSK	5	1	18.4	18.4	18.4	0.058	0.058	0.058				
01-0105-00	FLEMING	Black bullhead	2017	FILSK	1	1	9.0	9.0	9.0	0.018	0.018	0.018				
		Black crappie	2008	FILSK	8	2	8.0	7.3	8.7	0.095	0.072	0.117				
			2017	FILSK	10	1	8.5	8.5	8.5	0.104	0.104	0.104				
		Bluegill sunfish	2008	FILSK	8	2	7.2	6.8	7.5	0.050	0.044	0.056				
		Brown bullhead	2017	FILSK	2	1	10.1	10.1	10.1	0.029	0.029	0.029				
		Northern pike	2008	FILSK	6	6	24.4	20.3	28.3	0.097	0.083	0.104				

WID	Waterway	Species	Year	Anatomy[1]	Total Fish	Number Samples	Length (in) Mean	Length (in) Min	Length (in) Max	Mercury (mg/kg) Mean	Mercury (mg/kg) Min	Mercury (mg/kg) Max	PCBs (mg/kg) N	PCBs (mg/kg) Mean	PCBs (mg/kg) Max	PCBs (mg/kg) < RL
			2017	FILSK	6	6	24.1	20.4	30.7	0.092	0.066	0.171				
		Yellow bullhead	2017	FILSK	2	1	12.3	12.3	12.3	0.096	0.096	0.096				
01-0123-00	ELM ISLAND*	Black bullhead	2013	FILET	5	1	12.6	12.6	12.6	0.175	0.175	0.175				
		Black crappie	2008	FILSK	6	1	9.2	9.2	9.2	0.305	0.305	0.305				
			2013	FILSK	10	2	8.9	8.4	9.3	0.281	0.258	0.303				
		Bluegill sunfish	2008	FILSK	6	1	7.8	7.8	7.8	0.060	0.060	0.060				
			2013	FILSK	9	2	8.0	7.4	8.5	0.103	0.102	0.103				
		Northern pike	2008	FILSK	5	5	23.4	19.5	28.6	0.305	0.213	0.474				
			2013	FILSK	8	8	23.3	17.6	30.5	0.448	0.240	0.640				
		Walleye	2008	FILSK	5	5	15.1	12.3	17.2	0.156	0.082	0.233				
01-0125-00	LONE*	Black crappie	2010	FILSK	8	2	12.3	10.9	13.6	0.022	0.021	0.022				
		Bluegill sunfish	2010	FILSK	10	2	7.6	7.3	7.9	0.066	0.064	0.068				
		Northern pike	2010	FILSK	8	8	17.4	15.9	23.2	0.172	0.113	0.389				
		Walleye	2010	FILSK	10	10	17.3	11.8	20.2	0.198	0.105	0.314				
01-0129-00	SISSABAGAMAH	Black crappie	2017	FILSK	7	1	9.7	9.7	9.7	0.113	0.113	0.113				
		Northern pike	2017	FILSK	10	10	18.1	15.2	26.0	0.238	0.109	0.474				
		Walleye	2017	FILSK	9	9	19.0	14.5	21.5	0.290	0.164	0.582				
		Yellow perch	2017	FILSK	5	1	11.0	11.0	11.0	0.135	0.135	0.135				
01-0136-00	WAUKENABO*	Black crappie	2015	FILSK	10	1	8.3	8.3	8.3	0.039	0.039	0.039				
		Bluegill sunfish	2015	FILSK	10	1	7.9	7.9	7.9	0.052	0.052	0.052				
		Largemouth bass	2007	FILSK	5	5	14.5	13.0	16.0	0.236	0.126	0.437				
		Northern pike	1985	FILSK	6	2	20.0	17.7	22.2	0.380	0.290	0.470				
			2007	FILSK	5	5	18.8	17.1	20.0	0.128	0.068	0.289				
			2015	FILSK	7	7	20.5	18.0	23.5	0.315	0.240	0.360				
		Walleye	1985	FILSK	11	3	18.1	14.2	22.6	0.333	0.190	0.610				
			2015	FILSK	8	8	17.8	14.9	21.0	0.256	0.163	0.363				
		Yellow bullhead	2015	FILET	5	1	13.2	13.2	13.2	0.161	0.161	0.161				
01-0137-00	ROUND*	Bluegill sunfish	2012	FILSK	10	2	8.8	8.3	9.2	0.067	0.063	0.071				
		Northern pike	2012	FILSK	8	8	22.7	18.3	28.1	0.288	0.218	0.403				
		Walleye	2012	FILSK	8	8	16.5	12.8	21.5	0.246	0.136	0.424				
		Yellow bullhead	2012	FILET	5	1	13.5	13.5	13.5	0.169	0.169	0.169				
01-0146-00	RIPPLE**	Bluegill sunfish	2008	FILSK	8	1	7.2	7.2	7.2	0.109	0.109	0.109				
		Northern pike	2008	FILSK	5	5	21.3	18.8	24.3	0.257	0.189	0.346				
		Walleye	2008	FILSK	5	5	16.6	15.0	19.2	0.520	0.202	1.173				

WID	Waterway	Species	Year	Anatomy[1]	Total Fish	Number Samples	Length (in)			Mercury (mg/kg)			PCBs (mg/kg)			
							Mean	Min	Max	Mean	Min	Max	N	Mean	Max	< RL
01-0147-00	ESQUAGAMAH	Northern pike	1985	FILSK	2	1	20.5	20.5	20.5	0.220	0.220	0.220				
		Walleye	2007	FILSK	6	6	18.2	17.4	19.3	0.137	0.095	0.158				
01-0159-00	FARM ISLAND*	Black crappie	1991	FILSK	10	1	10.4	10.4	10.4	0.069	0.069	0.069				
			2010	FILSK	10	2	10.5	9.5	11.4	0.031	0.029	0.033				
			2013	FILSK	8	2	10.1	9.2	11.0	0.082	0.073	0.091				
		Bluegill sunfish	2010	FILSK	10	2	7.4	6.9	7.9	0.030	0.028	0.031				
			2013	FILSK	10	2	7.5	7.1	7.9	0.045	0.042	0.047				
		Cisco (Lake herring)	1991	FILSK	4	2	15.8	14.7	16.8	0.053	0.038	0.068	1	0.01	0.01	Y
		Largemouth bass	1991	FILSK	10	2	13.6	10.5	16.7	0.265	0.140	0.390	1	0.01	0.01	Y
		Northern pike	1984	FILSK	12	3	23.3	18.0	30.6	0.233	0.150	0.340				
			1991	FILSK	21	4	25.0	18.7	32.3	0.210	0.130	0.310	3	0.01	0.01	Y
			2010	FILSK	8	8	19.3	16.9	26.3	0.119	0.094	0.154				
			2013	FILSK	8	8	20.9	16.4	28.5	0.249	0.203	0.284				
		Walleye	1984	FILSK	7	3	16.9	12.8	20.3	0.233	0.170	0.360				
			1991	FILSK	20	3	17.2	13.7	21.9	0.257	0.150	0.360	2	0.01	0.01	Y
			2010	FILSK	8	8	18.2	16.6	21.0	0.168	0.114	0.272				
			2013	FILSK	7	7	17.3	15.2	19.8	0.237	0.161	0.430				
		White sucker	1991	FILSK	9	2	13.7	10.5	16.9	0.025	0.020	0.029	1	0.01	0.01	Y
			2013	FILSK	4	1	15.0	15.0	15.0	0.025	0.025	0.025				
		Yellow bullhead	1991	FILET	8	1	11.2	11.2	11.2	0.150	0.150	0.150	1	0.01	0.01	Y
01-0161-00	HAMMAL*	Black crappie	2007	FILSK	8	1	9.7	9.7	9.7	0.082	0.082	0.082				
		Bluegill sunfish	2007	FILSK	7	1	7.3	7.3	7.3	0.047	0.047	0.047				
		Largemouth bass	2007	FILSK	6	6	12.3	11.2	13.6	0.126	0.083	0.216				
		Northern pike	2007	FILSK	6	6	22.9	18.3	27.3	0.183	0.134	0.266				
		Walleye	2007	FILSK	4	4	19.4	17.5	23.2	0.166	0.099	0.265				
01-0170-00	HANGING KETTLE*	Black crappie	2007	FILSK	8	1	7.7	7.7	7.7	0.067	0.067	0.067				
			2013	FILSK	10	2	9.1	8.7	9.5	0.155	0.137	0.173				
		Northern pike	1985	FILSK	10	3	22.6	19.8	27.0	0.303	0.270	0.330				
			2007	FILSK	6	6	16.5	15.0	20.0	0.179	0.131	0.359				
			2013	FILSK	8	8	20.5	18.7	24.0	0.294	0.262	0.323				
		Walleye	1985	FILSK	3	2	19.2	17.6	20.8	0.795	0.780	0.810				
		Yellow bullhead	2013	FILET	5	1	11.9	11.9	11.9	0.309	0.309	0.309				
01-0178-00	SPIRIT*	Black crappie	2010	FILSK	10	2	9.7	8.7	10.7	0.010	0.010	0.010				
		Bluegill sunfish	2010	FILSK	10	2	7.4	7.0	7.8	0.037	0.026	0.048				

WID	Waterway	Species	Year	Anatomy[1]	Total Fish	Number Samples	Length (in)			Mercury (mg/kg)			PCBs (mg/kg)			
							Mean	Min	Max	Mean	Min	Max	N	Mean	Max	< RL
		Northern pike	2010	FILSK	8	8	19.5	15.5	26.9	0.136	0.062	0.264				
		Walleye	2010	FILSK	4	4	16.4	14.7	20.1	0.144	0.101	0.232				
01-0179-00	HICKORY*	Black crappie	2010	FILSK	5	1	9.0	9.0	9.0	0.034	0.034	0.034				
		Bluegill sunfish	2010	FILSK	10	2	7.3	6.9	7.6	0.040	0.033	0.046				
		Northern pike	2010	FILSK	8	8	17.8	15.1	25.9	0.147	0.094	0.286				
		Walleye	2010	FILSK	6	6	21.0	18.1	25.4	0.290	0.177	0.542				
01-0182-00	PICKEREL*	Black crappie	1993	FILSK	10	1	8.3	8.3	8.3	0.099	0.099	0.099				
		Bluegill sunfish	2008	FILSK	6	1	7.6	7.6	7.6	0.090	0.090	0.090				
		Northern pike	1993	FILSK	19	4	24.7	18.2	30.7	0.328	0.160	0.460	1	0.01	0.01	Y
			2008	FILSK	3	3	24.2	21.4	28.3	0.238	0.204	0.281				
		Yellow bullhead	1993	FILET	10	1	11.7	11.7	11.7	0.120	0.120	0.120				
01-0188-00	BLIND*	Black crappie	2010	FILSK	8	2	7.8	7.7	7.9	0.035	0.030	0.040				
		Bluegill sunfish	2010	FILSK	7	1	7.0	7.0	7.0	0.041	0.041	0.041				
		Northern pike	2010	FILSK	10	10	22.2	18.5	33.0	0.140	0.098	0.279				
01-0208-00	SUIMPET*	Black crappie	2011	FILSK	10	2	8.9	8.2	9.5	0.088	0.088	0.088				
		Bluegill sunfish	2011	FILSK	10	2	6.7	6.1	7.2	0.044	0.038	0.050				
		Largemouth bass	2011	FILSK	10	10	12.5	10.2	16.2	0.253	0.115	0.406				
01-0209-00	CEDAR*	Black crappie	1992	FILSK	10	1	9.3	9.3	9.3	0.098	0.098	0.098				
		Cisco (Lake herring)	1992	FILSK	8	1	13.6	13.6	13.6	0.089	0.089	0.089	1	0.054	0.054	
		Northern pike	1992	FILSK	27	4	25.2	17.8	32.8	0.360	0.230	0.530	1	0.028	0.028	
			2014	FILSK	15	15	21.9	18.0	26.4	0.648	0.519	0.827				
		Walleye	1992	FILSK	29	4	19.8	13.4	26.4	0.405	0.230	0.600	1	0.037	0.037	
18-0034-00	BAY*	Black crappie	2014	FILSK	8	1	8.9	8.9	8.9	0.037	0.037	0.037				
		Bluegill sunfish	1992	FILSK	10	1	6.6	6.6	6.6	0.024	0.024	0.024				
		Cisco (Lake herring)	1992	FILSK	3	1	9.6	9.6	9.6	0.027	0.027	0.027	1	0.014	0.014	
		Northern pike	1992	FILSK	16	4	25.3	18.7	32.3	0.290	0.140	0.460	1	0.017	0.017	
			2014	FILSK	8	8	21.1	16.7	28.7	0.296	0.181	0.478				
		Walleye	1992	FILSK	20	4	19.8	14.0	25.8	0.248	0.100	0.450	1	0.016	0.016	
			2014	FILSK	8	8	20.0	15.1	26.6	0.387	0.255	0.599				
18-0038-00	CLEARWATER*	Black crappie	2007	FILSK	7	1	8.4	8.4	8.4	0.042	0.042	0.042				
		Bluegill sunfish	2007	FILSK	10	1	6.3	6.3	6.3	0.037	0.037	0.037				
		Largemouth bass	2007	FILSK	7	7	12.7	10.2	15.4	0.150	0.091	0.224				
		Northern pike	2007	FILSK	8	8	24.3	16.7	31.5	0.242	0.089	0.465				
		Smallmouth bass	2007	FILSK	2	2	16.3	14.0	18.5	0.225	0.131	0.318				

WID	Waterway	Species	Year	Anatomy[1]	Total Fish	Number Samples	Length (in)			Mercury (mg/kg)			PCBs (mg/kg)			
							Mean	Min	Max	Mean	Min	Max	N	Mean	Max	< RL
		Walleye	2007	FILSK	6	6	18.8	15.5	22.1	0.234	0.112	0.469				
18-0041-00	CROOKED**	Bluegill sunfish	2006	FILSK	10	1	6.6	6.6	6.6	0.045	0.045	0.045				
		Cisco (Lake herring)	2006	FILSK	5	2	14.4	11.7	17.0	0.049	0.039	0.059				
		Largemouth bass	2006	FILSK	5	5	11.2	10.5	11.9	0.149	0.133	0.161				
		Northern pike	2006	FILSK	7	7	18.8	14.6	26.2	0.250	0.081	0.741				
18-0044-00	HANKS**	Black crappie	2006	FILSK	6	1	10.8	10.8	10.8	0.053	0.053	0.053				
			2012	FILSK	10	2	9.2	8.1	10.3	0.037	0.032	0.042				
		Bluegill sunfish	2006	FILSK	10	1	6.6	6.6	6.6	0.053	0.053	0.053				
		Cisco (Lake herring)	2006	FILSK	8	2	14.7	13.5	15.8	0.031	0.028	0.033				
			2012	FILSK	5	1	13.6	13.6	13.6	0.047	0.047	0.047				
		Largemouth bass	2006	FILSK	2	2	12.8	11.2	14.3	0.222	0.154	0.290				
		Northern pike	2006	FILSK	6	6	25.0	20.0	36.4	0.334	0.245	0.745				
			2012	FILSK	8	8	19.6	16.6	27.1	0.199	0.106	0.326				
		Walleye	2006	FILSK	3	3	23.5	20.9	27.0	0.474	0.394	0.570				
18-0050-00	PORTAGE*	Black crappie	2006	FILSK	8	4	10.4	6.8	12.1	0.043	0.037	0.052				
		Bluegill sunfish	2012	FILSK	10	2	7.2	6.6	7.7	0.030	0.024	0.036				
		Cisco (Lake herring)	2012	FILSK	5	1	14.6	14.6	14.6	0.048	0.048	0.048				
		Northern pike	2006	FILSK	6	6	20.8	17.4	25.2	0.180	0.101	0.234				
			2012	FILSK	8	8	18.3	13.3	35.4	0.147	0.064	0.412				
		Walleye	2006	FILSK	3	3	26.3	22.7	29.0	0.571	0.521	0.652				
18-0090-00	SERPENT*	Bluegill sunfish	2008	FILSK	10	1	7.2	7.2	7.2	0.029	0.029	0.029				
		Largemouth bass	2008	FILSK	6	6	11.1	10.3	12.0	0.066	0.054	0.071				
		Northern pike	2008	FILSK	8	8	20.1	17.8	21.9	0.217	0.094	0.358				
		Walleye	2008	FILSK	7	7	18.3	14.6	22.8	0.141	0.080	0.234				
		White sucker	2008	FILSK	5	1	16.9	16.9	16.9	0.022	0.022	0.022				
18-0093-00	RABBIT*	Bluegill sunfish	1997	FILSK	10	1	7.7	7.7	7.7	0.070	0.070	0.070				
		Northern pike	1997	FILSK	10	10	21.7	16.2	37.5	0.280	0.130	0.780	3	0.01	0.01	Y
		Walleye	1997	FILSK	11	11	16.1	11.9	26.4	0.237	0.079	1.100	2	0.01	0.01	Y
18-0093-01	RABBIT (EAST PORTION)*	Bluegill sunfish	1997	FILSK	10	1	6.4	6.4	6.4	0.070	0.070	0.070				
			2009	FILSK	5	2	7.7	7.1	8.2	0.090	0.090	0.090				
		Largemouth bass	2009	FILSK	7	7	12.2	10.1	14.6	0.264	0.197	0.438				
			2015	FILSK	6	6	13.4	11.4	14.1	0.437	0.276	0.601				
		Northern pike	1997	FILSK	10	10	18.6	15.9	20.7	0.246	0.110	0.360	1	0.01	0.01	Y
			2009	FILSK	8	8	22.3	18.1	33.0	0.547	0.203	1.059				

WID	Waterway	Species	Year	Anatomy[1]	Total Fish	Number Samples	Length (in)			Mercury (mg/kg)			PCBs (mg/kg)			
							Mean	Min	Max	Mean	Min	Max	N	Mean	Max	< RL
			2015	FILSK	9	9	24.9	20.5	35.0	0.662	0.400	1.384				
		Walleye	2009	FILSK	7	7	22.3	18.5	25.8	0.723	0.619	0.878				
			2015	FILSK	6	6	19.0	14.4	24.2	0.661	0.455	0.884				
18-0093-02	RABBIT (WEST PORTION)*	Bluegill sunfish	2009	FILSK	10	2	6.9	6.7	7.1	0.047	0.035	0.058				
		Northern pike	2009	FILSK	7	7	23.0	17.8	32.0	0.305	0.187	0.447				
		Walleye	2009	FILSK	8	7	20.8	16.1	27.6	0.352	0.180	0.643				
18-0096-00	UPPER SOUTH LONG*	Black crappie	2013	FILSK	9	2	8.9	8.3	9.5	0.054	0.044	0.063				
		Bluegill sunfish	2013	FILSK	10	2	7.3	6.9	7.7	0.056	0.050	0.061				
		Cisco (Lake herring)	2013	FILSK	5	1	12.4	12.4	12.4	0.042	0.042	0.042				
		Northern pike	2013	FILSK	8	8	21.9	18.0	36.3	0.309	0.164	0.477				
		Walleye	2013	FILSK	7	7	16.6	13.5	18.7	0.328	0.260	0.385				
18-0104-00	NOKAY*	Bluegill sunfish	2008	FILSK	9	1	7.5	7.5	7.5	0.249	0.249	0.249				
		Northern pike	2008	FILSK	5	5	24.7	18.6	30.8	0.154	0.102	0.190				
		Walleye	2008	FILSK	6	6	19.0	15.1	22.9	0.121	0.027	0.180				
18-0117-00	BLACK HOOF*	Black crappie	2016	FILSK	10	1	8.1	8.1	8.1	0.041	0.041	0.041				
		Bluegill sunfish	2016	FILSK	10	1	7.5	7.5	7.5	0.059	0.059	0.059				
		Northern pike	1995	FILSK	4	1	21.3	21.3	21.3	0.180	0.180	0.180				
			2016	FILSK	8	8	22.1	17.4	29.0	0.156	0.117	0.216				
		Walleye	1995	FILSK	6	1	19.5	19.5	19.5	0.330	0.330	0.330	1	0.01	0.01	Y
			2016	FILSK	8	8	19.1	13.9	23.1	0.337	0.149	0.651				
18-0136-00	SOUTH LONG*	Bluegill sunfish	2013	FILSK	10	2	8.2	7.6	8.7	0.040	0.031	0.049				
		Northern pike	2013	FILSK	8	8	21.6	18.4	27.4	0.218	0.132	0.285				
		Walleye	2013	FILSK	8	8	19.1	17.5	21.9	0.205	0.165	0.306				
18-0145-00	RICE*	Black crappie	2004	FILSK	11	1	7.7	7.7	7.7	0.067	0.067	0.067				
			2014	FILSK	10	1	8.4	8.4	8.4	0.138	0.138	0.138				
		Bluegill sunfish	1984	FILSK	10	1	7.3	7.3	7.3	0.150	0.150	0.150	1	0.05	0.05	Y
			2004	FILSK	10	1	6.6	6.6	6.6	0.064	0.064	0.064				
		Largemouth bass	1978	PLUSK	5	1	11.2	11.2	11.2	0.410	0.410	0.410	1	0.107	0.107	Y
				WHORG	5	1	11.2	11.2	11.2	0.380	0.380	0.380	1	0.146	0.146	
		Northern pike	2014	FILSK	8	8	21.9	17.0	27.4	0.370	0.252	0.607				
		Redhorse, unknown species	1978	PLUSK	3	1	22.9	22.9	22.9	0.190	0.190	0.190	1	0.025	0.025	Y
				WHORG	3	1	22.9	22.9	22.9	0.120	0.120	0.120	1	0.01	0.01	Y
		Shorthead redhorse	1984	FILSK	5	1	15.3	15.3	15.3	0.300	0.300	0.300	1	0.05	0.05	Y
		Silver redhorse	1978	PLUSK	5	1	22.0	22.0	22.0	0.650	0.650	0.650	1	0.025	0.025	Y

WID	Waterway	Species	Year	Anatomy[1]	Total Fish	Number Samples	Length (in)			Mercury (mg/kg)			PCBs (mg/kg)			
							Mean	Min	Max	Mean	Min	Max	N	Mean	Max	< RL
				WHORG	7	2	19.4	16.8	22.0	0.170	0.100	0.240	2	0.067	0.121	
		Smallmouth bass	2014	FILSK	3	3	16.8	15.9	17.9	0.694	0.479	0.971				
		Walleye	1984	FILSK	4	1	13.3	13.3	13.3	0.500	0.500	0.500	1	0.05	0.05	Y
			2014	FILSK	7	7	17.2	12.4	21.5	0.556	0.396	0.708				
		Yellow bullhead	1984	FILET	5	1	12.5	12.5	12.5	0.070	0.070	0.070	1	0.05	0.05	Y
18-0155-00	CROW WING*	Black crappie	2010	FILSK	10	2	9.4	9.1	9.7	0.015	0.014	0.016				
		Bluegill sunfish	2010	FILSK	5	1	8.0	8.0	8.0	0.038	0.038	0.038				
		Largemouth bass	2010	FILSK	1	1	12.7	12.7	12.7	0.104	0.104	0.104				
		Northern pike	2010	FILSK	8	8	20.8	17.0	25.6	0.088	0.074	0.117				
		Walleye	2010	FILSK	7	7	23.0	15.4	28.8	0.327	0.086	0.579				
		Yellow bullhead	2010	FILET	3	1	13.5	13.5	13.5	0.101	0.101	0.101				
18-0161-00	SEBIE*	Black crappie	2007	FILSK	8	1	8.3	8.3	8.3	0.166	0.166	0.166				
		Bluegill sunfish	2007	FILSK	10	1	6.6	6.6	6.6	0.094	0.094	0.094				
		Northern pike	2007	FILSK	6	6	22.8	18.6	28.2	0.281	0.188	0.412				
		White sucker	2007	FILSK	8	1	16.1	16.1	16.1	0.102	0.102	0.102				
18-0170-00	UPPER DEAN*	Black crappie	2010	FILSK	11	2	8.0	7.6	8.3	0.191	0.157	0.225				
		Bluegill sunfish	2010	FILSK	10	2	7.1	6.8	7.4	0.115	0.104	0.126				
		Northern pike	2010	FILSK	7	7	22.7	19.4	29.8	0.218	0.167	0.345				
18-0242-00	UPPER MISSION*	Black crappie	2014	FILSK	1	1	7.7	7.7	7.7	0.033	0.033	0.033				
		Bluegill sunfish	2014	FILSK	20	2	6.9	6.6	7.3	0.042	0.041	0.043				
		Largemouth bass	2014	FILSK	8	8	13.4	12.0	15.5	0.192	0.152	0.284				
		Northern pike	2014	FILSK	16	16	23.3	19.9	27.8	0.222	0.106	0.362				
		Walleye	2014	FILSK	8	8	17.5	13.8	25.4	0.189	0.117	0.305				
18-0371-00	PERCH	Bluegill sunfish	2009	FILSK	10	2	6.9	6.7	7.0	0.065	0.065	0.065				
		Largemouth bass	2009	FILSK	4	4	13.3	9.1	15.0	0.623	0.250	0.791				
		Northern pike	2009	FILSK	8	8	20.7	15.7	29.9	0.311	0.225	0.422				
		Walleye	2009	FILSK	4	4	21.0	18.2	23.2	0.384	0.241	0.647				
18-0437-00	PORTSMOUTH MINE*	Black crappie	2010	FILSK	3	1	9.3	9.3	9.3	0.076	0.076	0.076				
		Bluegill sunfish	2010	FILSK	8	2	6.7	6.5	6.8	0.047	0.046	0.048				
		Largemouth bass	2010	FILSK	5	5	13.2	10.9	18.6	0.149	0.091	0.314				
		Northern pike	2010	FILSK	8	8	30.4	20.6	39.4	0.135	0.068	0.190				
		Rainbow trout	2010	FILSK	3	3	11.7	11.4	12.1	0.018	0.015	0.021				
18-0439-00	PENNINGTON MINE	Largemouth bass	1987	WHORG	5	1	8.9	8.9	8.9	0.150	0.150	0.150				
		Rainbow trout	1987	FILSK	3	1	9.9	9.9	9.9	0.063	0.063	0.063	1	0.012	0.012	Y

WID	Waterway	Species	Year	Anatomy[1]	Total Fish	Number Samples	Length (in)			Mercury (mg/kg)			PCBs (mg/kg)			
							Mean	Min	Max	Mean	Min	Max	N	Mean	Max	< RL
				WHORG	3	1	9.9	9.9	9.9	0.060	0.060	0.060				
18-0440-00	MAHNOMEN, ALSTEAD & ARCO	Bluegill sunfish	2010	FILSK	9	2	6.6	6.4	6.7	0.068	0.059	0.076				
		Northern pike	2010	FILSK	8	8	29.1	18.9	37.4	0.203	0.146	0.341				
		Smallmouth bass	2010	FILSK	8	8	14.1	9.5	18.6	0.161	0.084	0.273				
49-0035-00	GREEN PRAIRIE FISH	Bluegill sunfish	2000	FILSK	7	1	6.8	6.8	6.8	0.020	0.020	0.020				
			2017	FILSK	10	1	7.3	7.3	7.3	0.060	0.060	0.060				
		Northern pike	2000	FILSK	6	6	19.7	16.9	23.7	0.062	0.050	0.070				
			2017	FILSK	5	5	16.5	15.2	18.8	0.077	0.054	0.106				
77-0007-00	MOUND	Bluegill sunfish	2017	FILSK	10	1	6.5	6.5	6.5	0.075	0.075	0.075				
		Northern pike	2017	FILSK	7	7	16.5	14.2	20.0	0.129	0.095	0.202				
77-0023-00	BIG SWAN*	Black crappie	1996	FILSK	10	1	7.9	7.9	7.9	0.070	0.070	0.070				
		Bluegill sunfish	2016	FILSK	10	1	6.8	6.8	6.8	0.082	0.082	0.082				
		Northern pike	1996	FILSK	19	4	20.4	16.2	25.3	0.158	0.150	0.170				
			2016	FILSK	8	8	20.5	16.5	25.4	0.253	0.185	0.341				
		Walleye	1996	FILSK	17	5	19.7	13.9	26.6	0.316	0.140	0.580	1	0.01	0.01	Y
			2016	FILSK	8	8	17.5	11.3	29.0	0.341	0.167	0.587				
		White sucker	1996	FILSK	8	1	17.0	17.0	17.0	0.040	0.040	0.040				
77-0027-00	LONG**	Black crappie	2010	FILSK	10	2	9.9	9.5	10.3	0.062	0.061	0.063				
		Bluegill sunfish	2010	FILSK	10	2	6.8	6.4	7.2	0.143	0.138	0.147				
		Walleye	2010	FILSK	8	8	21.6	10.8	28.2	0.654	0.205	1.007				
		White sucker	2010	FILSK	1	1	21.4	21.4	21.4	0.132	0.132	0.132				
77-0034-00	LITTLE SWAN	Bluegill sunfish	2017	FILSK	10	1	7.7	7.7	7.7	0.238	0.238	0.238				
		Northern pike	2017	FILSK	8	8	19.1	16.0	22.3	0.328	0.221	0.494				
77-0035-00	BEAUTY	Bluegill sunfish	2017	FILSK	10	1	8.2	8.2	8.2	0.121	0.121	0.121				
		Northern pike	2017	FILSK	3	3	17.4	16.5	18.6	0.196	0.137	0.308				
77-0063-00	BIG	Bluegill sunfish	1993	FILSK	10	1	6.4	6.4	6.4	0.061	0.061	0.061				
		Northern pike	1993	FILSK	11	2	21.0	18.5	23.5	0.135	0.130	0.140	1	0.01	0.01	Y

Pollutant load monitoring

Watershed Pollutant Load Monitoring Network

The WPLMN has three stations within the Upper Mississippi River-Brainerd Watershed as shown in Table 33. The Mississippi River at Aitkin, is a "basin" site that is monitored year round, the other two stations are "subwatershed" sites, which are, monitored seasonally (ice out through October 31).

Table 33. WPLMN stream monitoring sites for the Mississippi River-Brainerd Watershed.

Site Type	Stream Name	USGS ID	DNR/MPCA ID	EQuIS ID
Basin	Mississippi River at Aitkin, MN	05227530	E10015001	S002-010
Subwatershed	Swan River near Sobieski	N/A	H10065002	S001-996
Subwatershed	Nokasippi River near Fort Ripley	05261520	H10103001	S002-956

Average annual FWMCs of TSS, TP, and NO_3+NO_2-N for major watershed stations statewide are presented in Figure 39, with the Upper Mississippi River-Brainerd Watershed outlined. Water runoff, a significant factor in pollutant loading, is also shown. Water runoff is the portion of annual precipitation that ends up in a river or stream; which is expressed in inches.

Excessive TSS, TP, and NO_3+NO_2-N in surface waters impacts aquatic life, vegetation growth, drinking water supplies, and recreation such as fishing and swimming. As a general rule, elevated levels of TSS and NO_3+NO_2-N are regarded as "non-point" source derived pollutants originating from many small diffuse sources such as urban or agricultural runoff. High levels of NO_3+NO_2-N is a concern for drinking water which may be affected by surface water inputs throughout a watershed. The abundance of other surface waters throughout the watershed such as lakes, small streams, and ditches have a greater impact on NO_3+NO_2-N concentrations in the groundwater supply. Excess TP can be attributed to both non-point as well as point sources such as industrial or wastewater treatment plants. Major "non-point" sources of phosphorus include dissolved phosphorus from fertilizers and phosphorus adsorbed to and transported with sediment during runoff. More information can be found at the WPLMN website.

When compared with other major watersheds throughout the state, Figure 39 shows the average annual TP and NO_3+NO_2-N FWMCs for the Mississippi River at Aitkin to be roughly equal to neighboring watersheds in the north central portions of Minnesota. TSS FWMCs are equal or slightly higher than surrounding watersheds but significantly lower than watersheds found in the southern and/or western portions of the state.

Substantial year-to-year variability in water quality occurs for most rivers and streams, including the Mississippi River. Variability can be attributed to snow and ice melt runoff, precipitation amounts, soil types, and/or land use among many others. Annual TSS, TP, and NO_3+NO_2-N FWMCs and loads for the Mississippi River at Aitkin are shown in Figure 40.

Figure 38. 2007-2016 Average annual TSS, TP, and NO3-NO2-N flow weighted mean concentrations, and runoff by major watershed.

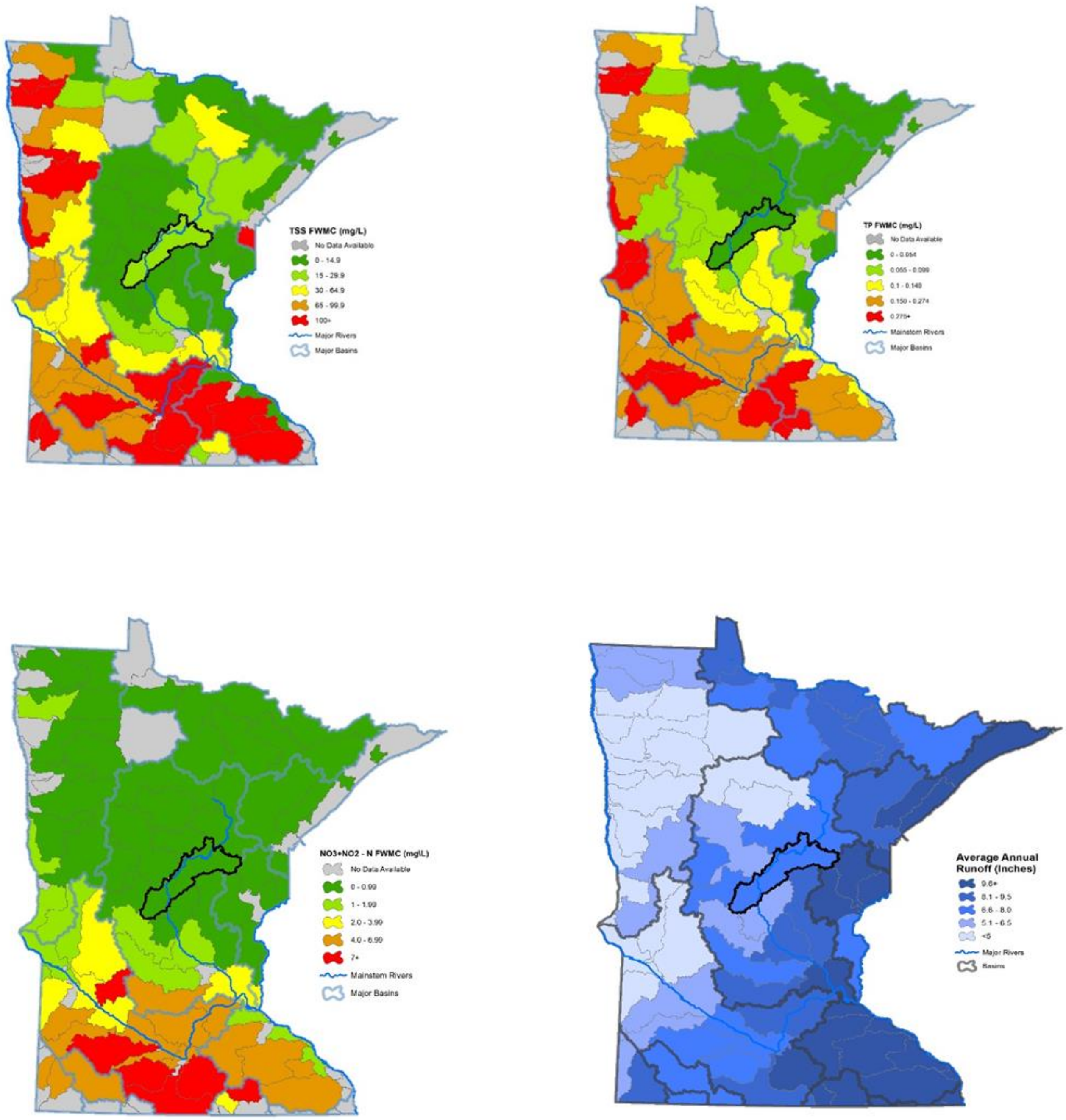
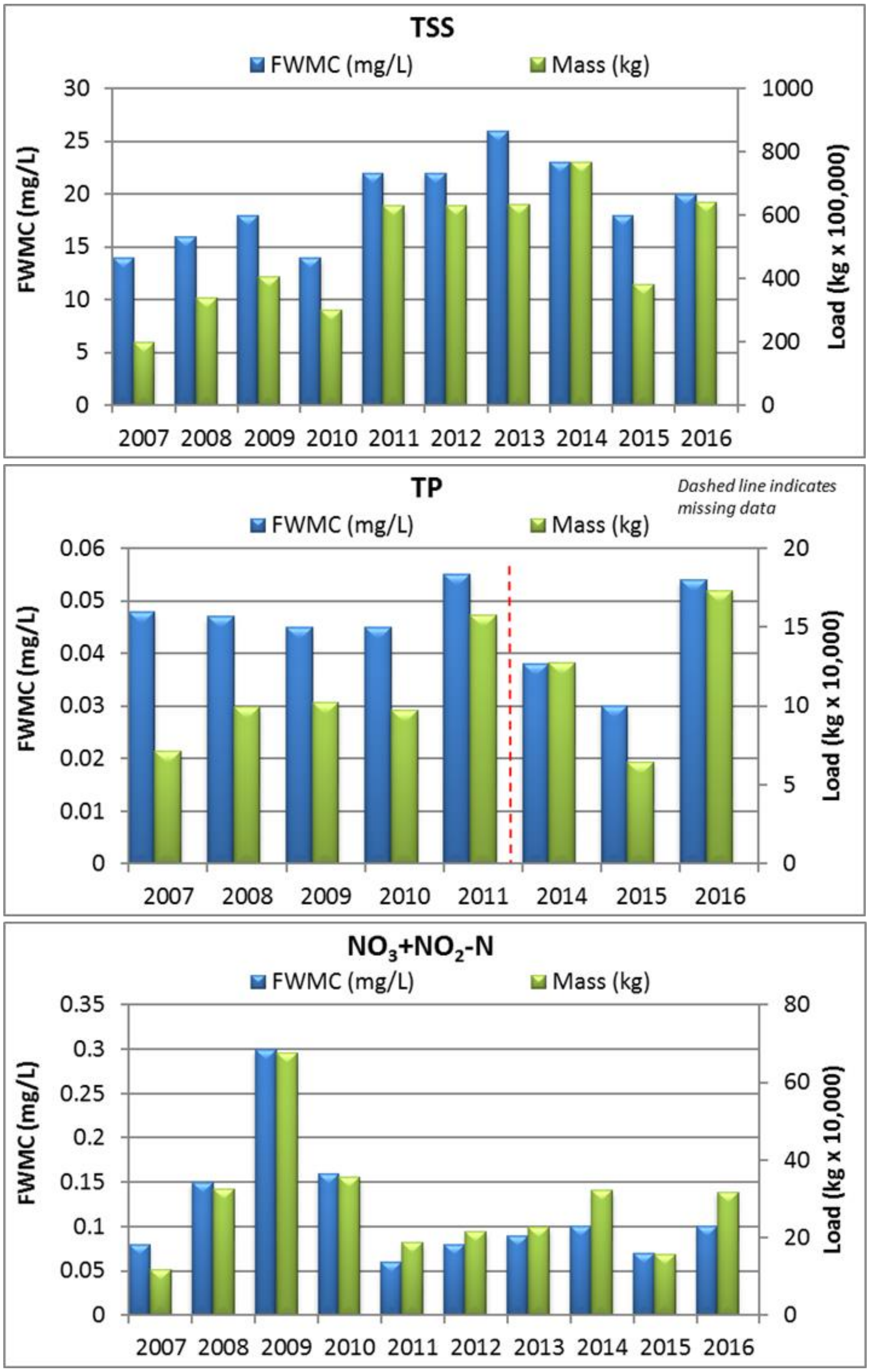


Figure 39. TSS, TP, and NO3+NO2-N flow weighted mean concentrations and loads for the Mississippi River at Aitkin, Minnesota, 2007-2016.



Land-use, soil textures, and drainage practices vary greatly from upstream to downstream within the Mississippi River-Brainerd Watershed. These differences are evident when reviewing concentration levels and impairments on the Mississippi River as it flows through the watershed. In the charts below, concentration levels of NO_3+NO_2-N, TP, and TSS at the Mississippi River in Aitkin were compared to two additional stations on the Mississippi River. The Mississippi River-Grand Rapids Watershed is adjacent upstream while the Mississippi River at Royalton station (Mississippi River-Sartell Watershed) is adjacent downstream. Each station has water quality data ranging from 2007-2016.

NO_3+NO_2-N concentrations (Figure 41) begin to rapidly rise in the Mississippi River, increasing over four fold from Grand Rapids to Aitkin and continue to climb downstream to Royalton. Although there are many ways for NO_3+NO_2-N to be transported, changes in soil type from sand dominated to more loamy soil (clay, silt, and sand) likely play a role in this increase. Loamy soils are more conducive to agriculture than sand, in turn increasing the concentrations of NO_3+NO_2-N as agricultural production increases. Loamy soils and the water within the soil are more easily transported through overland flow and/or field drainage thus contributing sediment and NO_3+NO_2-N into surface waters. Agriculture land use increases from <1% in the Grand Rapids Watershed to 10% in the Brainerd Watershed and continues to increase to 28% downstream in the Sartell Watershed. It should be noted that although concentrations increase, they are significantly below the Minnesota drinking water standard (10 mg/L).

Similarly, TP concentrations increase from Grand Rapids to Aitkin while continuing an upward trend downstream. Two average concentrations are reported in Figure 42, average FWMC and average summer FWMC (June through September) when the statewide TP standard is in effect. Concentrations are well below the state standard (0.05 mg/L) at Grand Rapids, however increase to a level just below the standard within the Brainerd Watershed where 45% of the annual samples (94/211) exceed the standard. It is important to note that for comparison to the standard, data is limited to June through September and evidence of eutrophciation must be present for an impairment to be determined. No river eutrophication impairments were found in the watershed or on this portion of the Mississippi River. Like NO_3+NO_2-N, excess TP can be contributed by runoff from pastures and croplands, which are the largest source of nonpoint phosphorus on a statewide basis. Increasing total phosphorus levels in the Mississippi may also be influenced by more nutrient rich soils as one moves downstream from Grand Rapids to Aitkin.

TSS concentrations show a dramatic increase of over six times (Figure 43) from Grand Rapids to Aitkin but significantly decrease at Royalton. As mentioned above, loamy soils are more prevalent within this watershed than in the upstream and downstream watersheds. Loamy soils are more easily detached and eroded when compared to the courser sediments within the adjacent watersheds. Samples taken over the ten year period helped provide data used to list this section of the Mississippi as impaired for TSS, with 58% (197/341) of the samples having a concentration above the state standard (15 mg/L), for the Northern Nutrient River Region. Soil types begin a transition once again near Brainerd, reversing back into more sandy soils while the river increases in size and volume. With less erodible soils, TSS concentrations decline to well below the standard, ending the TSS impairment at the confluence of the Crow Wing and Mississippi Rivers downstream of Brainerd.

Figure 40. Comparison of average NO3+NO2-N flow weighted mean concentrations for three stations on the Mississippi River, Minnesota, 2007-2016

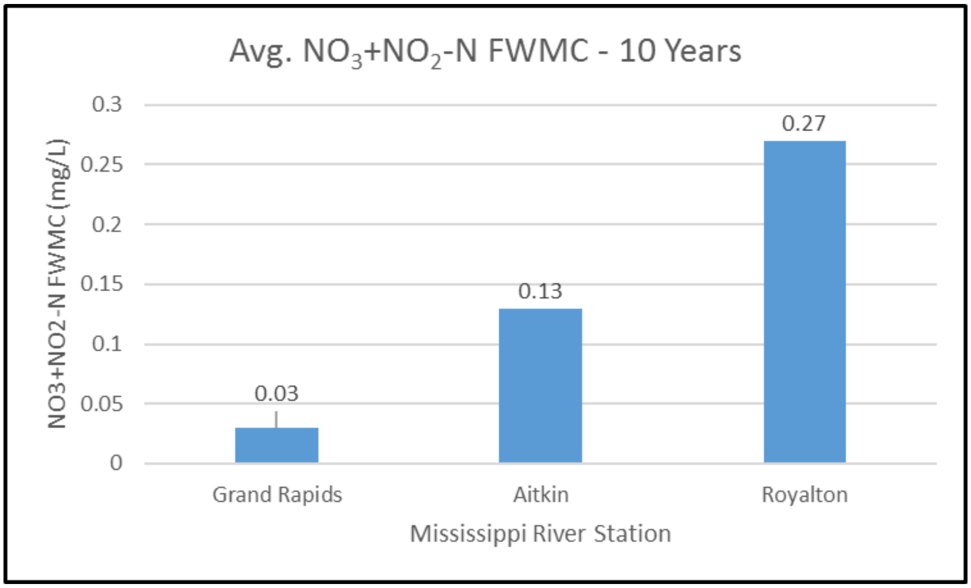


Figure 41. Comparison of average TP flow weighted mean concentrations for three stations on the Mississippi River, Minnesota, 2007-2011 and 2014-2016

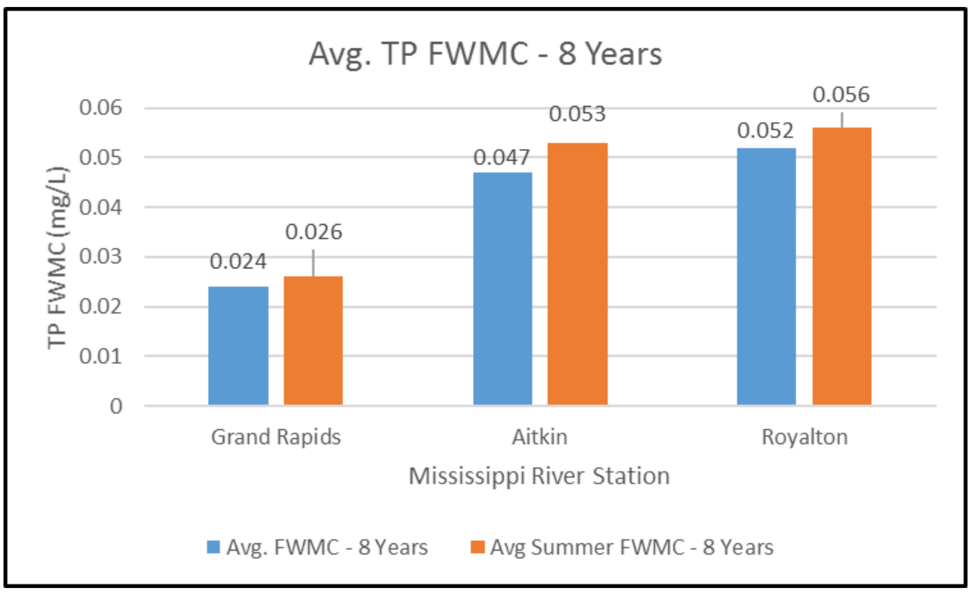
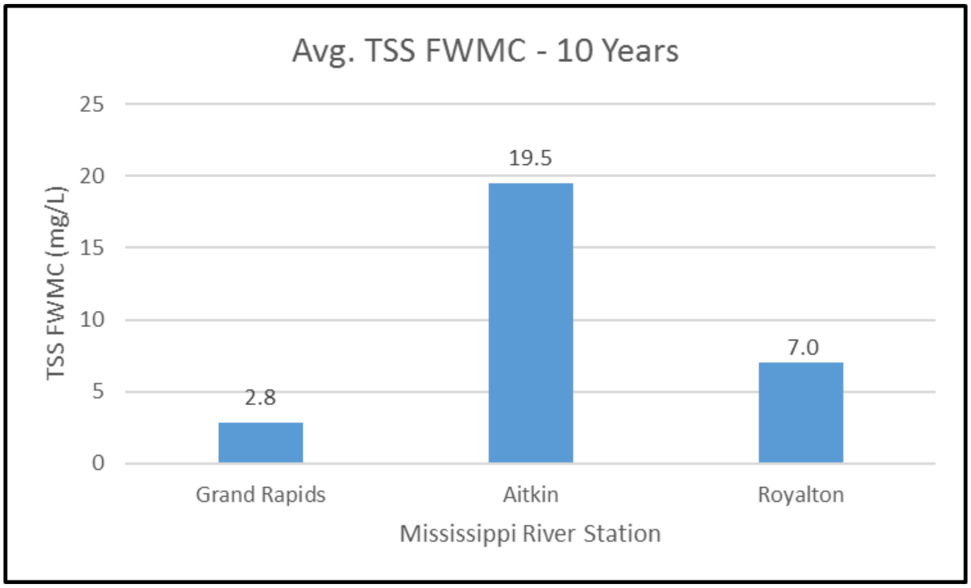


Figure 42. Comparison of average TSS flow weighted mean concentrations for three stations on the Mississippi River, Minnesota, 2007-2016.



The Nokasippi and Swan Rivers are subwatershed sites with data available for 2015 and 2016. Figure 44 shows TSS FWMCs to be significantly lower than those measured at the Mississippi River in Aitkin, but roughly in line with those measured at the Mississippi River in Royalton. Cursory observation of the NO_3+NO_2-N FWMCs in Figure 45 shows the concentrations to be four to eight times higher, respectively, than those found within the Mississippi River at Aitkin. Similarly, TP concentrations (Figure 46 at both subwatershed sites are at or above the levels found within the Mississippi River at Aitkin each of the years monitored. These two rivers, as well as other tributaries in the southern portion of the Mississippi River-Aitkin Watershed, have an increased acreage of agricultural lands. This is a likely reason that NO_3+NO_2-N and TP concentrations are increasing from upstream to downstream. Appendix 5.

Figure 43. Comparison of average TSS flow weighted mean concentrations and loads at the Nokasippi and Swan Rivers, Minnesota, 2015-2016.

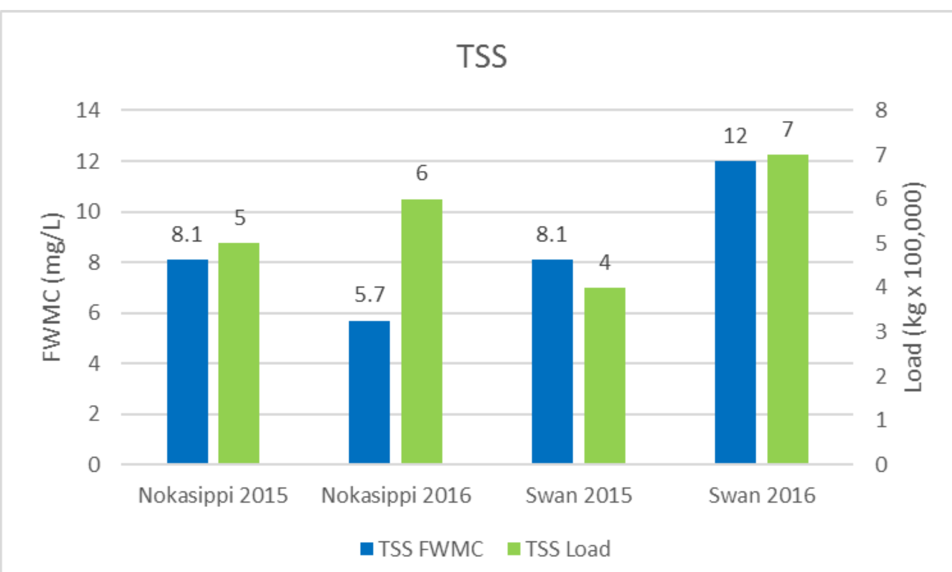


Figure 44. Comparison of average NO3+NO2-N flow weighted mean concentrations and loads at the Nokasippi and Swan Rivers, Minnesota, 2015-2016.

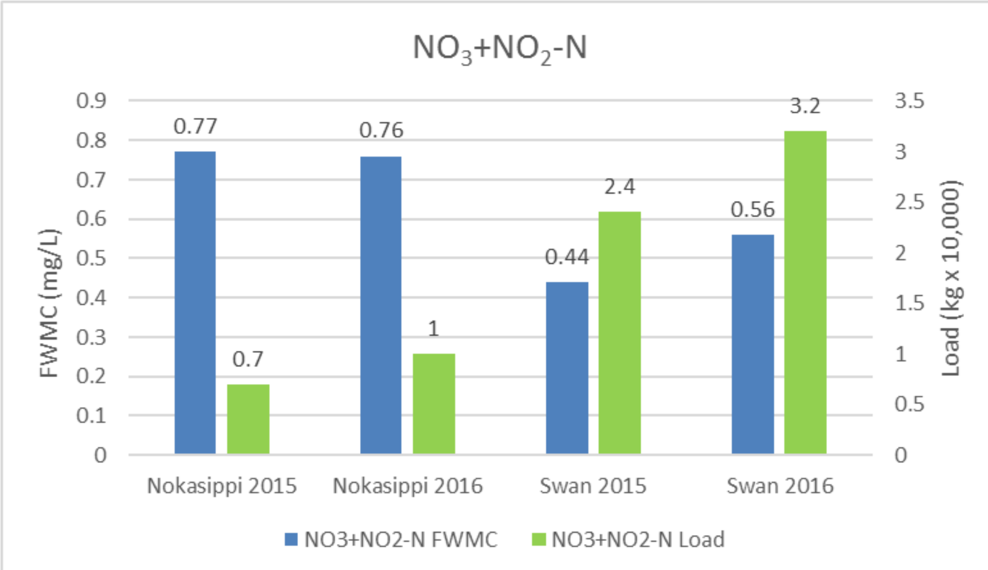
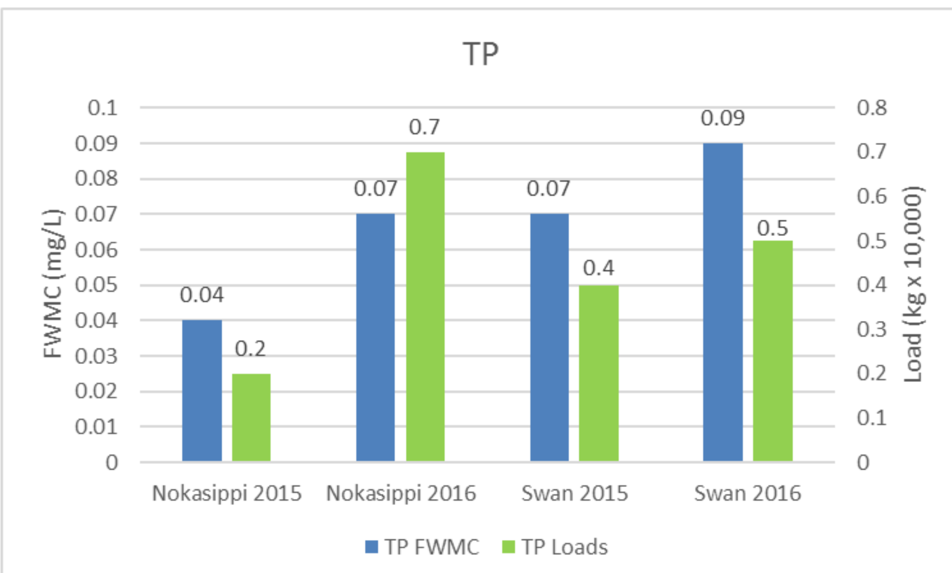


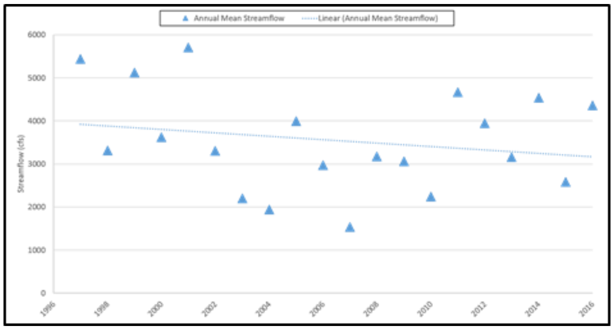
Figure 45. Comparison of average TP flow weighted mean concentrations and loads at the Nokasippi and Swan Rivers, Minnesota, 2015-2016.

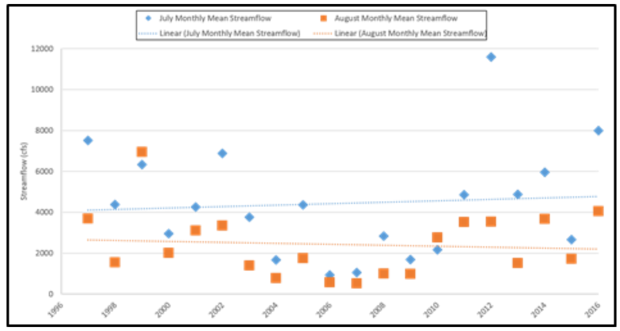


Stream flow

Stream flow data from the United States Geological Survey's real-time streamflow gaging stations for one river in the Upper Mississippi River-Brainerd Watershed was analyzed for annual mean discharge and summer monthly mean discharge (July and August). Figure 24 (*left*) is a display of the annual mean discharge for the Mississippi River at Brainerd, Minnesota from water years 1997 to 2016. The data shows that although streamflow appears to be decreasing over time, there is no statistically significant trend. Figure 47 (*right*) displays July and August mean flows for the same time frame, for the same water body. Graphically, the data appears to be slightly increasing in July and decreasing in August, but neither with significance. By way of comparison at a state level, summer month flows have declined at a statistically significant rate at a majority of streams selected randomly for a study of statewide trends (Streitz, 2011). For additional streamflow data throughout Minnesota, please visit the USGS website: http://waterdata.usgs.gov/mn/nwis/rt.

Figure 46. Annual mean (*left*) and monthly mean (*right*) streamflow for the Mississippi River at Brainerd, Minnesota (1997-2016) (Source: USGS, 2019)





Wetland condition

Wetland vegetation quality is high overall in Minnesota (Bourdaghs et al. 2015). This is driven by the large share of wetlands located in Mixed Wood Shield (i.e., northern forest) ecoregion where development and resulting stressors are much less widespread (and wetland condition is largely intact) compared to the rest of the state. Wetlands in exceptional or good vegetation condition have few (if any) changes in their expected native species composition or abundance distribution. Wetland vegetation quality is largely degraded in the remainder of the state, where non-native invasive plant species (most notably reed canary grass and Narrow leaf or Hybrid cattail) have replaced native wetland plant communities over the majority of the remaining wetland extent (Bourdaghs et al. 2015). High abundance of non-native invasive plant species is associated with a broad spectrum of wetland stressors and may also occur in the absence of stressors.

As the majority of the Upper Mississippi River–Brainerd Watershed lies within the Mixed Wood Shield ecoregion (Figure 15), wetland vegetation quality in the watershed is expected to be high overall. An estimated 84% of the wetland extent in the Mixed Wood Plains are in good to exceptional vegetation condition (Bourdaghs et al. 2015). In addition, wetland vegetation quality at monitoring sites in the Mixed Wood Plains ecoregion located near the Mixed Wood Shield border is often higher than the vegetation quality of wetlands for the ecoregion as a whole. Wetland quality impacts in the watershed are likely localized. Primary impacts to wetland vegetation quality include hydrology alterations and clearing associated to drainage ditches and farming and runoff from farm fields or directed stormwater in cities and town.

Figure 47. Fully supporting waters by designated use in the Upper Mississippi River-Brainerd Watershed River Watershed.

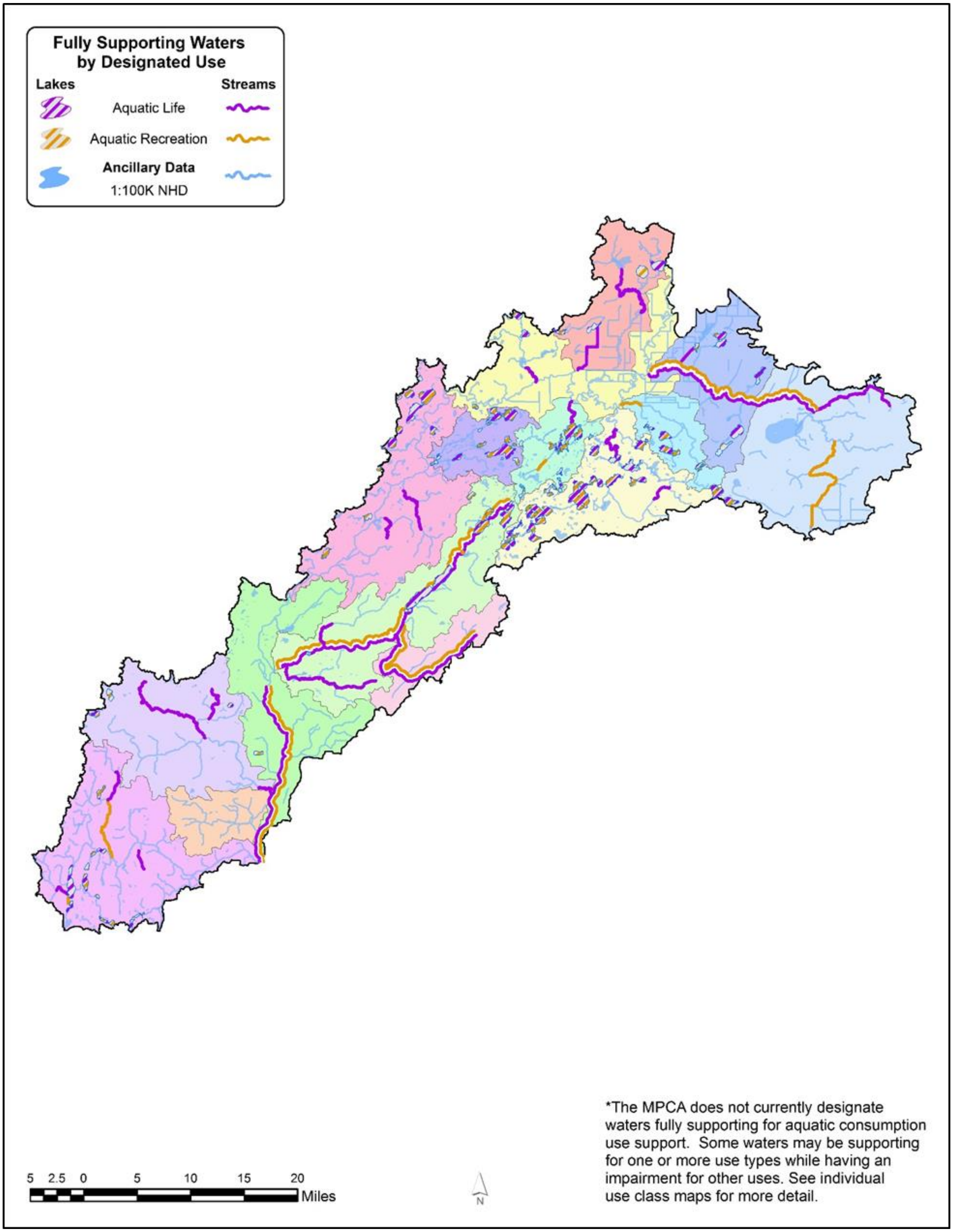


Figure 48. Impaired waters by designated use in the Upper Mississippi River-Brainerd Watershed River.

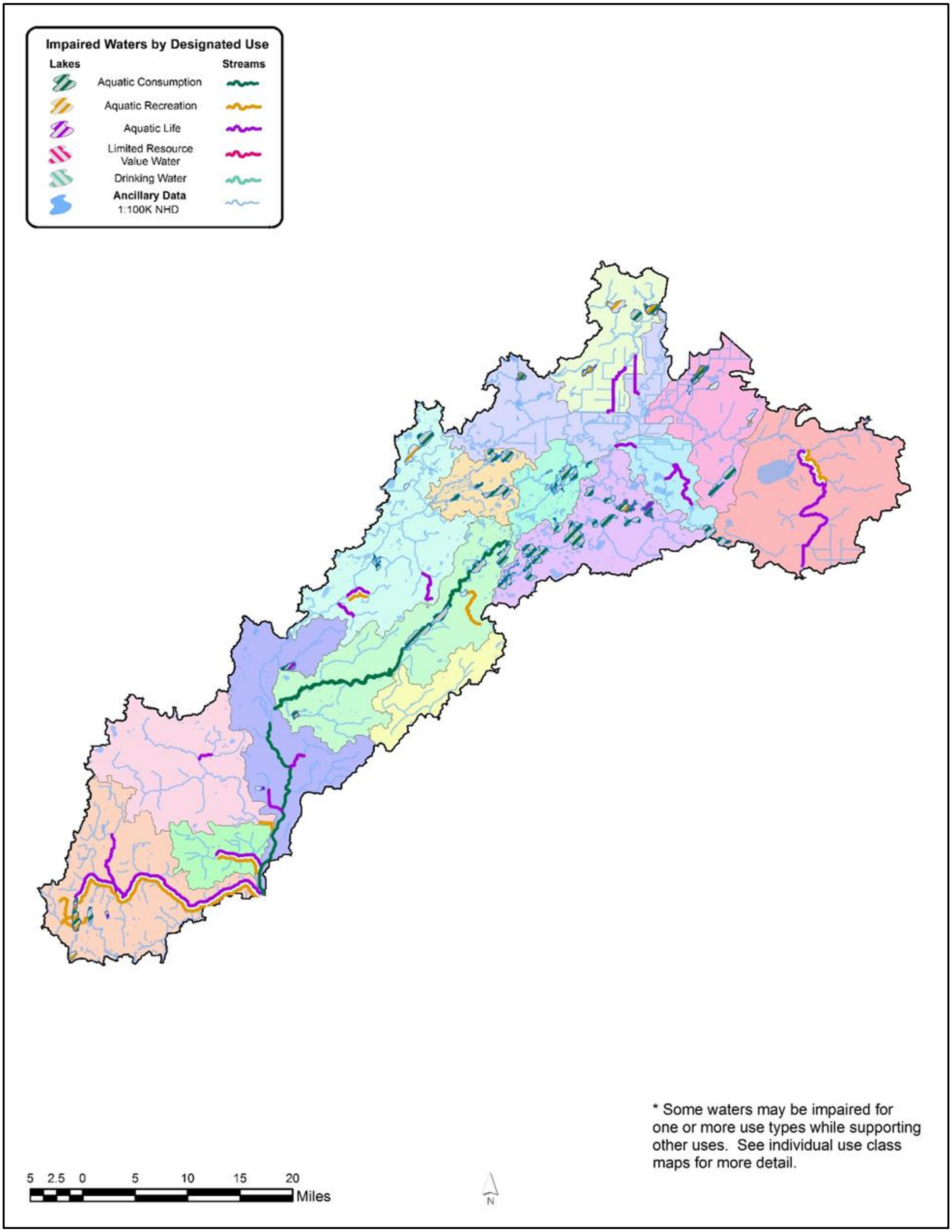


Figure 49. Aquatic consumption use support in the Mississippi River-Brainerd River Watershed.

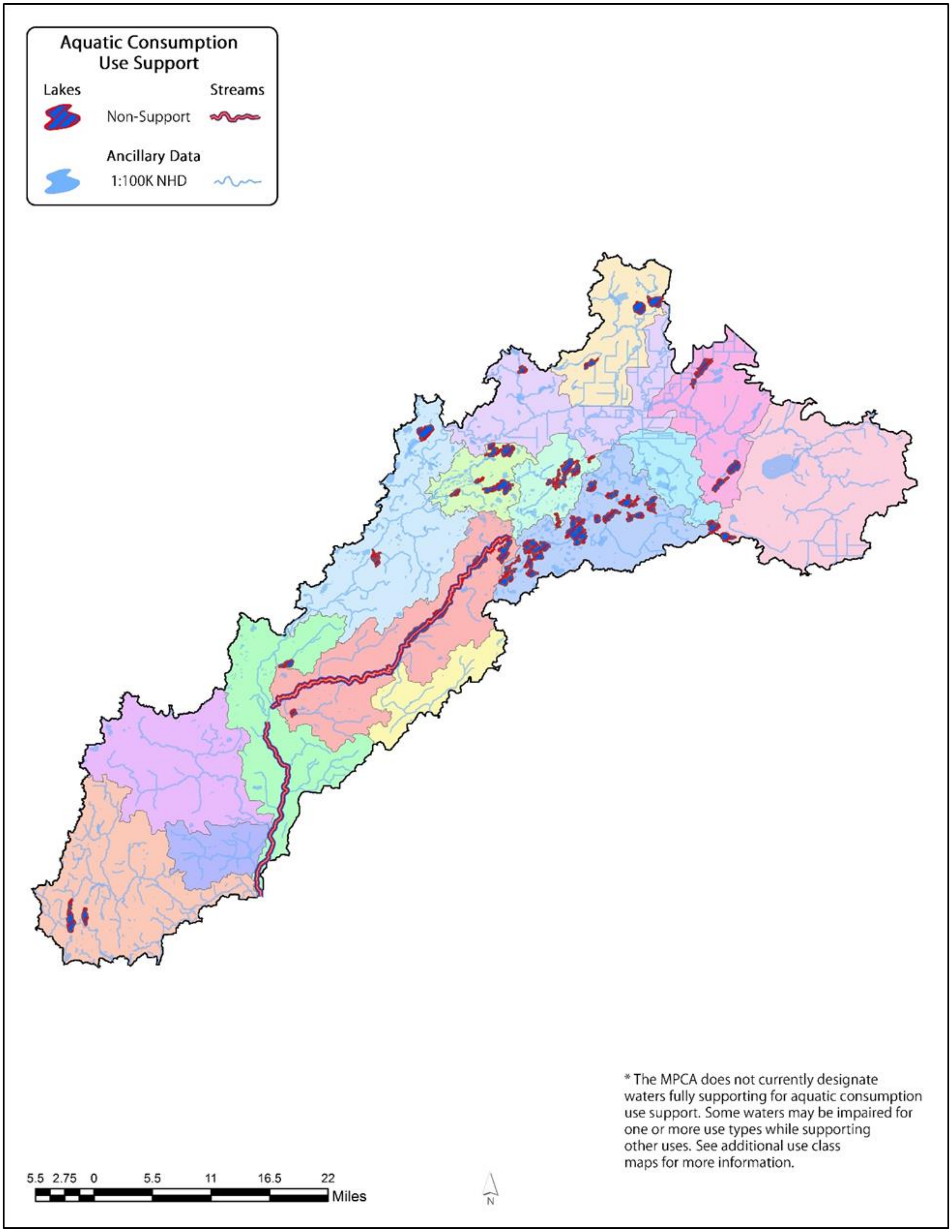


Figure 50. Aquatic life use support in the Upper Mississippi River-Brainerd Watershed River Watershed.

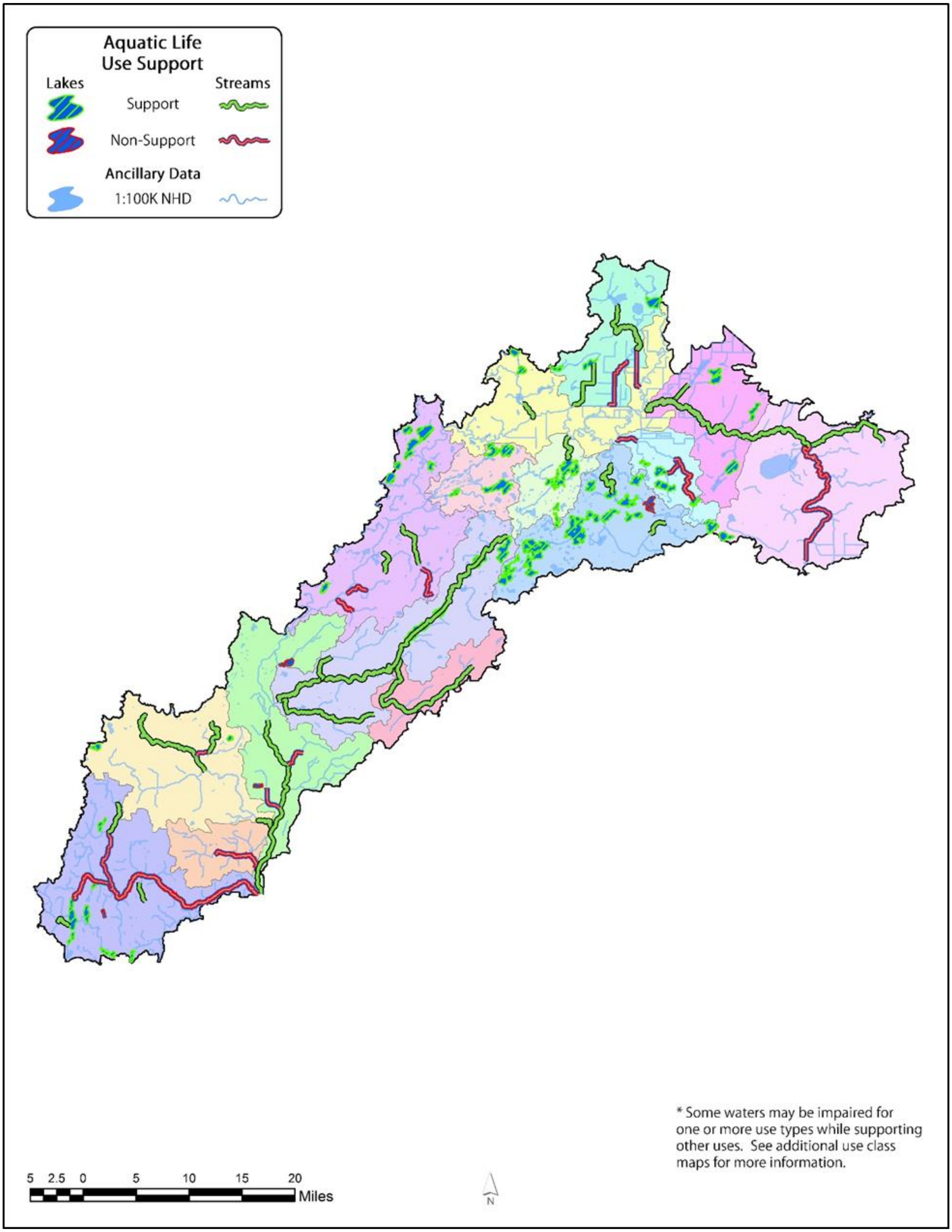
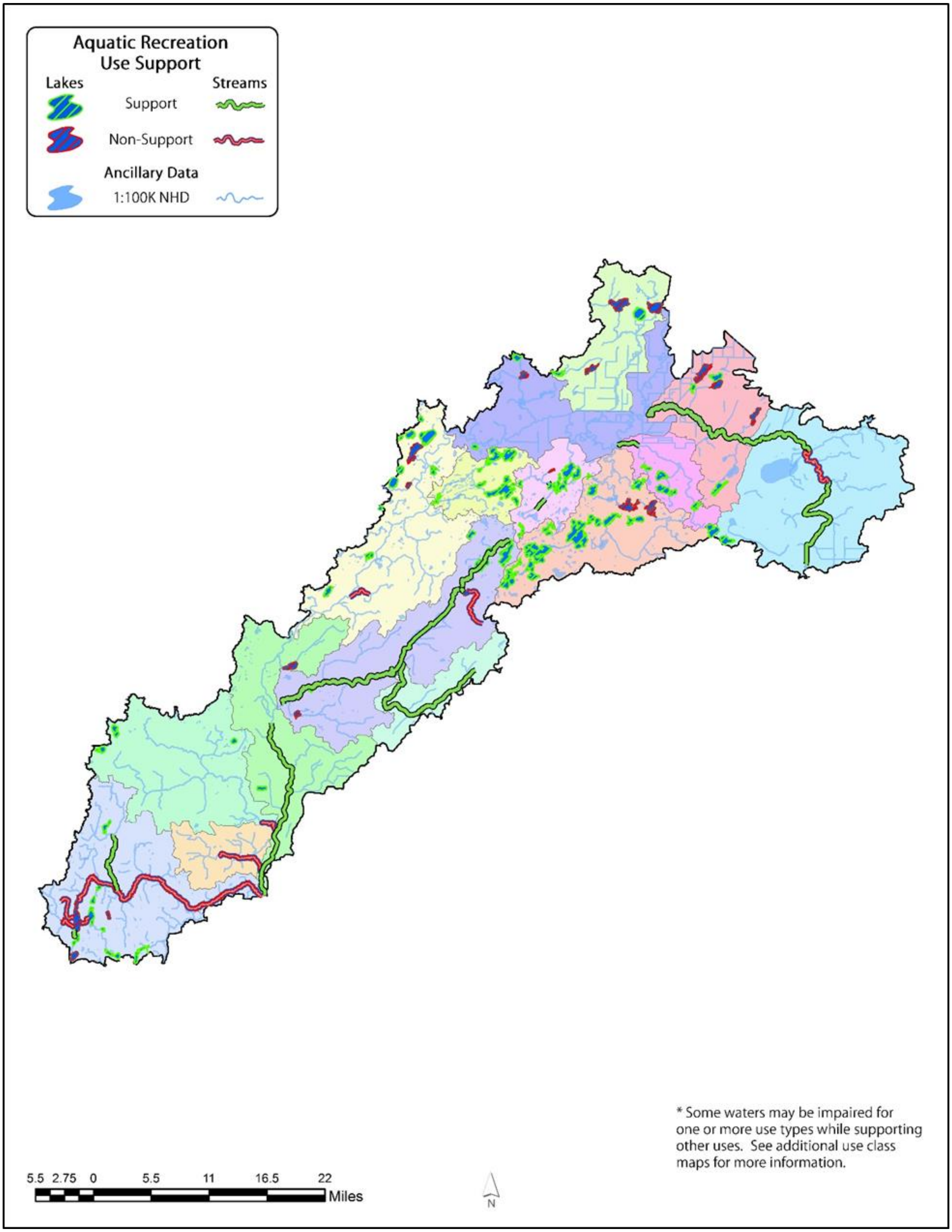


Figure 51. Aquatic recreation use support in the Upper Mississippi River-Brainerd Watershed River Watershed.



Transparency trends for the Upper Mississippi River-Brainerd Watershed

MPCA completes annual trend analysis on lakes and streams across the state based on long-term transparency measurements. The data collection for this work relies heavily on volunteers across the state and also incorporates any agency and partner data submitted to EQuIS. Citizen volunteer monitoring data is currently being collected at 14 stream and 103 lake sites in the watershed.

The trends are calculated using a Seasonal Kendall statistical test for waters with a minimum of eight years of transparency data; Secchi disk measurements in lakes and Secchi tube measurements in streams.

Table 34. Water clarity trends.

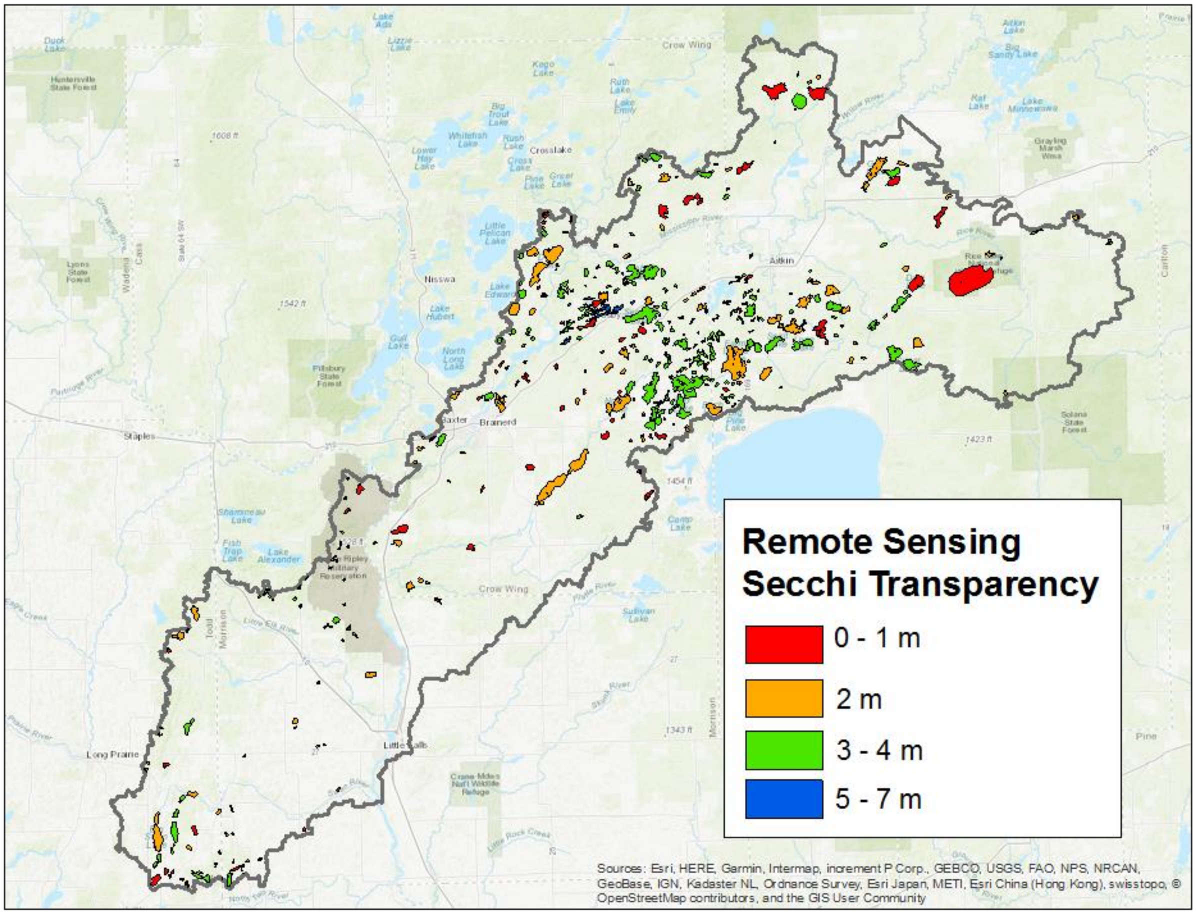
Mississippi-Brainerd HUC 07010104	Streams	Lakes
Number of sites w/increasing trend	0	39
Number of sites w/decreasing trend	2	21
Number of sites w/no trend	11	79

In June 2014, the MPCA published its final trend analysis of river monitoring data located statewide based on the historical Milestones Network. The network is a collection of 80 monitoring locations on rivers and streams across the state with good, long-term water quality data. The period of record is generally more than 30 years, through 2010, with monitoring at some sites going back to the 1950s. While the network of sites is not necessarily representative of Minnesota's rivers and streams as a whole, they do provide a valuable and widespread historical record for many of the state's waters. Starting in 2017, the MPCA will be switching to the Pollutant Load Monitoring Network for long-term trend analysis on rivers and streams. Data from this program has much more robust sampling and will cover over 100 sites across the state.

Remote sensing for lakes in the Upper Mississippi River-Brainerd Watershed

The University of Minnesota, in partnership with MPCA, conducts remote sensing of lake clarity. The information provides a snapshot of water transparency during late summer over a span of 30 years. Secchi disk transparency data is paired with satellite imagery to come up with estimates of water clarity across the state. While there are limitations to the data, such as cloud cover, vegetation, or stained water altering the estimated Secchi transparency, it does provide information to help prioritize monitoring and protection efforts on lakes, which do not have, water quality data.

Figure 52. Remotely sensed Secchi transparency on lakes in the Mississippi River-Brainerd Watershed.



Priority waters for protection and restoration in the Upper Mississippi River-Brainerd Watershed

The MPCA, DNR, and Board of Water and Soil Resources (BWSR) have developed methods to help identify waters that are high priority for protection and restoration activities. Protecting lakes and streams from degradation requires consideration of how human activities impact the lands draining to the water. In addition, helping to determine the risk for degradation allows for prioritization to occur; so limited resources can be directed to waters that would benefit most from implementation efforts.

The results of the analysis are provided to watershed project teams for use during WRAPS and One Watershed One Plan or other local water plan development. The results of the analysis are considered a preliminary sorting of possible protection priorities and should be followed by a discussion and evaluation with other resource agencies, project partners and stakeholders. Other factors that are typically considered during the protection prioritization process include: whether a water has an active lake or river association, is publically accessible, presence of wild rice, presence of invasive, rare or endangered species, as well as land use information and/or threats from proposed development. Opportunities to gain or enhance multiple natural resource benefits (“benefit stacking”) is another consideration during the final protection analysis. Waterbodies identified during the assessment process as vulnerable to impairment are also included in the summary below.

The results for selected indicators and the risk priority ranking for each lake are shown in Appendix 7. Protection priority should be given to lakes that are particularly sensitive to an increase in phosphorus with a documented decline in water quality (measured by Secchi transparency), a comparatively high percentage of developed land use in the area, or monitored phosphorus concentrations close to the water quality standard. In the Upper Mississippi River-Brainerd Watershed, highest protection priority is suggested for nine lakes: Lone, Round (01-0137-00), Gilbert, Hammal, Serpent, Long (01-0089-00), Nord, Rogers, and Sebie. Gun, French, Fleming, Round (01-0137-00), Ripple and Bass (77-0024-00) lakes were also identified as priorities for protection as fish community health was near the threshold and water quality was in decline.

The results for selected indicators and risk priority ranking for each stream are shown in Appendix 7. Stream protection is driven by how close the stream is to having an impaired biological community, density of roads and disturbed land use in the immediate and larger drainage area, and how much land is protected in the watershed. In the Upper Mississippi River-Brainerd Watershed, two Exceptional Use streams were identified as high priority: Nokasippi River (07010104-511) and unnamed creek (07010104-683). In addition, seven General Use streams, Whiteley Creek, Wakefield Brook, Ripple River, Nokasippi River, Little Nokasippi River, Little Elk River, and Schwanke Creek scored as high priority for protection efforts. While these streams currently meet standards, work done to maintain current condition is important to prevent impairment in the future.

Two lakes were identified as impaired, but very close to meeting water quality standards. Gun and Big Swan lakes were identified as impaired in previous assessments but has phosphorus very near the standard. Several streams were impaired for biology, specifically the fish community, and had culverts identified as the reason the fish community was poor. Actions to continue to improve lake condition and correcting culvert placement may allow for delisting in the near future.

Summaries and recommendations

The Upper Mississippi River-Brainerd Watershed is rich in water resources, and many maintain excellent water quality. Much of the watershed is privately owned (76%), yet an abundance of public waters and WMA's offer a wide array of recreational opportunities. Overall, biological communities found throughout the watershed are generally good. One section of the Nokasippi River (Hay Creek to Little Nokasippi River) had very good fish and macroinvertebrate communities, resulting in it being classified as an exceptional aquatic life use. The Nokasippi River along this reach also has exceptional habitat, and should be addressed by WRAPs to protect its natural riparian corridor.

Seventy-five species of fish have been documented within the Upper Mississippi River Basin. In 2016 and 2017, MPCA staff collected 56 of those species (this number only includes fish collected from tributaries to the Mississippi River) in the Upper Mississippi River-Brainerd Watershed. Four species (Brook Silverside, Brook Trout, Brown Trout, and Spottail Shiner) were observed at only one location. The most commonly sampled species in the watershed was Central Mudminnow, which was captured at 47 of the 50 sites. The Central Mudminnow is tolerant of a wide variety of habitats and water quality conditions, including low DO, and their abundance is likely due in part to the high proportion of low gradient, naturally low DO streams across the watershed.

The macroinvertebrate community in the Upper Mississippi River-Brainerd Watershed is generally diverse. Forty-eight visits were made to 45 stations from 2008-2018; 298 unique taxa were identified from these samples. Of these 48 visits, 31 were above the MIBI threshold and reflective of the good water quality of this watershed. The majority of the Upper Mississippi River-Brainerd Watershed was characterized by low gradient streams; however, some faster flow streams with riffle habitat were also sampled. On average, 43 taxa were collected per visit, with 16UM038 (Ripple River) having the highest richness (75 species) in 2017. A sole cold water station, 10UM146, is located on Whitely Creek and housed one notable caddisfly, *Lype diversa*. A site on Little Buffalo Creek (00UM015) housed the most cold water taxa; these midge genera were *Diamesa*, *Eukiefferiella*, and *Prodiamesa*. Little Buffalo Creek may be considered for cold water designation in the future, however, erosion issues and low DO concentrations must be addressed first. Additionally, eighteen sensitive taxa were collected with the majority of these sensitive individuals being caddisflies (ten taxa). The caddisfly *Oxyethira* was the most common sensitive genus, with 102 individuals collected over eleven unique visits. The most abundant taxa collected throughout the watershed were *Simulium*, *Hyalella*, *Polypedilum, Hydropsyche betteni*, and *Cheumatopsyche*, which are all tolerant to disturbance and ubiquitously distributed throughout Minnesota. There were no endangered, threatened, or species of special concern collected during this study. Overall, the macroinvertebrate community of the Upper Mississippi River-Brainerd Watershed is good health, but protection and restoration measures should be enacted to prevent further degradation.

Of the 69 streams that had chemistry or biological data available, forty stream reaches had sufficient data for an aquatic life assessment. Of the 15 impaired reaches, six had dissolved oxygen impairments. Low dissolved oxygen could be negatively affecting the fish and macroinvertebrate communities on these reaches. Low dissolved oxygen was observed on other reaches throughout the watershed; these conditions were the result of either a significant storm in the area that dropped several inches of rain in July 2016 or due to the influence of wetlands near the streams. Twenty-two reaches had sufficient data to assess aquatic recreation (*E. coli*); nine of these reaches are not supporting aquatic recreation use due to elevated bacteria levels. The majority of these *E. coli* impairments were found in the western portion of the watershed, which has more row crop and pasture lands than the eastern half of the watershed.

The watershed has an abundant number of lakes, and most have good water quality. There are 141 lakes in the watershed that have water quality measurements available, of those 92 had sufficient water quality data to assess aquatic recreation (nutrients) and 61 had sufficient data to assess aquatic life (fish). Seventy-four lakes fully supported aquatic recreation and 18 are not supporting aquatic recreation. Fifty-seven lakes were supporting for aquatic life, but only four lakes (Elm Island, Crow Wing, Green Prairie Fish, and Moose) were not meeting aquatic life standards.

The majority of lakes in the watershed that had full aquatic recreation assessments were deep lakes (greater than 15 ft deep or less than 80% littoral). Deeper lakes will stratify in summer months and have the capacity to store phosphorus lower in the water column (hypolimnion). This trapping of phosphorus limits the amount that is bioavailable for algae. On the other hand, shallow lakes can have higher phosphorus concentrations. Since they do not stratify, they cannot trap phosphorus due to frequent mixing and are prone to eutrophication and not supporting aquatic recreation. Of the 78 deep lakes in the watershed, 12 were found to have aquatic recreation impairments. Six of the 14 shallow lakes in the Mississippi River-Watershed were impaired for aquatic recreation. In general, the lakes impaired for excess nutrients are shallow or are in an agricultural or wetland dominated portion of the watershed.

Groundwater protection should be considered both for quantity and quality. Quantity is based on the amount of water withdrawn versus the amount of water being recharged to the aquifer. Groundwater withdrawals in the watershed have been increasing slightly over the last 20 years ($p<0.1$) while surface water withdrawals have decreased ($p<0.001$). The average potential groundwater recharge rate is above the state average, yet annual streamflow appears to be decreasing, albeit not at a statistically significantly rate. While fluctuations due to seasonal variations are normal, long-term changes in water levels should not be ignored.

Groundwater quality data from the MPCA Ambient Groundwater Monitoring Program indicated that although there were many detections of analytes, the majority were within water quality limits. There were detections of 74 and exceedances of seven contaminants. The pollution sensitivity of near-surface materials throughout the watershed should be considered. While many of the areas had very low to moderate rankings, some areas had high vulnerability, correlating with sand and gravel quaternary geology. These areas may experience a possible risk of contamination due to high infiltration rates. While it may appear that this watershed does not exhibit a great risk, it is important to continue to monitor potentially harmful sites in order to inhibit possible water pollution.

Additional and continued monitoring will increase the understanding of the health of the watershed and its groundwater resources and aid in identifying the extent of the issues present and risk associated. Increased localized monitoring efforts will help accurately define the risks and extent of any issues within the watershed. Adoption of best management practices will benefit both surface and groundwater.

Overall, a majority of rivers and streams in the Upper Mississippi River-Brainerd Watershed are in good condition. Biological communities are generally good, and bacteria impairments are not widespread and appear to be limited to areas of intensive land use (i.e. agricultural, development). Several streams in the watershed experience low levels of DO; some of these low readings might stem from natural conditions (i.e. flushing of wetlands), while others appear to be caused by anthropogenic stressors. It will be important for the WRAPs process to develop strategies to address the DO issues, along with any other stressors leading to aquatic life and aquatic recreation impairments. Some examples of actions that could help maintain the current conditions and prevent further degradation for surface waters include:

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- Protect natural vegetative buffers along riparian zones
- Limit the alteration and/or removal of wetlands
- Reduce the amount of agricultural, livestock, and urban runoff
- Evaluate dam/perched culvert locations and possible negative effects on fish communities
- Continue civic engagement within the watershed to educate on the benefits

Literature cited

Acreman, M., and J. Holden. 2013. How wetlands affect floods. Wetlands 33:773-786.

Bourdaghs, M. and J. Genet, M. Gernes, and E. Peters. 2015. Status and Trends of Wetlands in Minnesota: Vegetation Quality Baseline. Wq-bwm-1-09. Minnesota Pollution Control Agency, St. Paul, MN.

Brastrup, T. 1995. Little Buffalo Creek Initial Stream Survey. Minnesota Department of Natural Resources.

Erickson, M.L., Langer, S.K., Roth, J.L, and Kroening, S.E. (2014), Contaminants of Emerging Concern in Ambient Groundwater in Urbanized Areas of Minnesota, 2009-12 (ver. 1.2): U.S. Geological Survey Scientific Investigations Report 2014-5096. Retrieved from http://pubs.usgs.gov/sir/2014/5096/pdf/sir2014-5096.pdf

Jirsa, M.A., Boerboom, T. J., Chandler, V.W., Mossler, J. H., Runkel, A. C. and Setterholm, D. R. (2011), Geologic Map of Minnesota, Bedrock Geology, S-21. Minnesota Geological Survey. Using: *ArcGIS* [GIS software]. Version 10.3.1. Redlands, CA: Environmental Systems Research Institute. Retrieved from https://conservancy.umn.edu/handle/11299/101466

Kloiber, S.M. and Norris, D.J. 2013. Status and Trends of Wetlands in Minnesota: Wetland Quantity Trends from 2006 to 2011. Minnesota Department of Natural Resources. St. Paul, MN.

Kroening, S. and Ferrey, M. (2013), The Condition of Minnesota's Groundwater, 2007-2011. Document number: wq-am1-06. Retrieved from https://www.pca.state.mn.us/sites/default/files/wq-am1-06.pdf

Midwest Regional Climate Center. Climate Summaries. Historical Climate Data. Precipitation Summary. Station: 210355 Austin 3 S, MN. 1971-2000 NCDC Normals. https://mrcc.illinois.edu/mw_climate/climateSummaries/climSummOut_temp.jsp?stnId=USC00210939

Minnesota Department of Agriculture (MDA). 2009. 2009 Water Quality Monitoring Report. Pesticide and Fertilizer Management Division, Minnesota Department of Agriculture, St. Paul, Minnesota. http://mdawebdev.prod.acquia-sites.com/sites/default/files/inline-files/2017wqmrpt_final.pdf

Minnesota Department of Health (2018), Perfluoroalkyl Substances (PFAS). Retrieved from http://www.health.state.mn.us/divs/eh/hazardous/topics/pfcs/index.html#healtheffects

Minnesota Department of Health (2019), Manganese and Drinking Water. Retrieved from https://www.health.state.mn.us/communities/environment/water/contaminants/manganese.html

Minnesota Department of Natural Resources (2001), Figure1. Minnesota Ground Water Provinces. Retrieved from http://files.dnr.state.mn.us/natural_resources/water/groundwater/provinces/gwprov.pdf

Minnesota Department of Natural Resources (2016), Pollution Sensitivity of Near-Surface Materials. County Geologic Atlas Program. Using: *ArcGIS* [GIS software]. Version 10.3.1. Redlands, CA: Environmental Systems Research Institute. Retrieved from https://gisdata.mn.gov/dataset/geos-hydrogeology-atlas-hg02

Minnesota Department of Natural Resources: State Climatology Office (2019), Climate. Retrieved from http://www.dnr.state.mn.us/faq/mnfacts/climate.html

Minnesota Department of Natural Resources (2018a), Groundwater Provinces. Retrieved from https://www.dnr.state.mn.us/groundwater/provinces/index.html

Minnesota Department of Natural Resources (2018b), Water use- Water Appropriations Permit Program. Retrieved from http://www.dnr.state.mn.us/waters/watermgmt_section/appropriations/wateruse.html

Minnesota Department of Natural Resources: State Climatology Office (2018), Annual Precipitation Maps. Retrieved from http://www.dnr.state.mn.us/climate/historical/annual_precipitation_maps.html

Minnesota Geological Survey (MNGS). 1997. Minnesota at a Glance—Quaternary Glacial Geology. Minnesota Geological Survey, University of Minnesota, St. Paul, MN. http://conservancy.umn.edu/handle/59427

Minnesota Pollution Control Agency (MPCA). 2007b. Minnesota Statewide Mercury Total Maximum Daily Load. Minnesota Pollution Control Agency, St. Paul, Minnesota.

Minnesota Pollution Control Agency (2017), Drinking Water Standards for PFCs Updated. Retrieved from https://www.pca.state.mn.us/pfcs-in-drinking-water

Minnesota Pollution Control Agency (MPCA). 2008a. Watershed Approach to Condition Monitoring and Assessment. Appendix 5.2 *in* Biennial Report of the Clean Water Council. Minnesota Pollution Control Agency, St. Paul, Minnesota.

Minnesota Pollution Control Agency (MPCA). 2010a. Aquatic Life Water Quality Standards Draft Technical Support Document for Total Suspended Solids (Turbidity). http://www.pca.state.mn.us/index.php/view-document.html?gid=14922.

Minnesota Pollution Control Agency (MPCA). 2015. Technical guidance for designating aquatic life uses in Minnesota streams and rivers. Minnesota Pollution Control Agency, St. Paul, MN (Available at: https://www.pca.state.mn.us/sites/default/files/wq-s6-34.pdf).

Minnesota Pollution Control Agency (MPCA). Guidance Manual for Assessing the Quality of Minnesota Surface Water for the Determination of Impairment: 305(b) Report and 303(d) List. Environmental Outcomes Division, Minnesota Pollution Control Agency, St. Paul, Minnesota.

Minnesota Pollution Control Agency (MPCA). 2010d. Minnesota Milestone River Monitoring Report. http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/streams-and-rivers/minnesota-milestone-river-monitoring-program.html.

Minnesota Pollution Control Agency (MPCA). 2010e. Regionalization of Minnesota's Rivers for Application of River Nutrient Criteria. http://www.pca.state.mn.us/index.php/view-document.html?gid=6072.

Minnesota Pollution Control Agency (MPCA). 2015. Technical guidance for designating aquatic life uses in Minnesota streams and rivers. Minnesota Pollution Control Agency, St. Paul, MN (Available at: https://www.pca.state.mn.us/sites/default/files/wq-s6-34.pdf).

Minnesota Pollution Control Agency (MPCA). 2017. Incorporating Lake Protection Strategies into WRAPS Reports.

Minnesota Rules Chapter 7050. 2008. Standards for the Protection of the Quality and Purity of the Waters of the State. Revisor of Statutes and Minnesota Pollution Control Agency, St. Paul, Minnesota.

Morey, G.B., and Meints, J. (2000), Geologic Map of Minnesota, Bedrock Geology, S-20. Minnesota Geological Survey. Using: *ArcGIS* [GIS software]. Version 10.3.1. Redlands, CA: Environmental Systems Research Institute. Retrieved from https://mrdata.usgs.gov/geology/state/state.php?state=MN

National Resource Conservation Service (NRCS). 2007. Rapid Watershed Assessment: [Elk-Nokasippi Watershed] (MN/IA) HUC: 07010104. NRCS. USDA. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_022730.pdf

Smith, D.R., A. Ammann, C. Bartoldus, and M.M. Brinson. 1995. An approach for assessing wetland functions using hydrogeomorphic classification, reference wetlands, and functional indices. Wetlands Research Technical Report WRP-DE-9. US Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

State Climatology Office - DNR Division of Ecological and Water Resources. 2010. http://climateapps.dnr.state.mn.us/gridded_data/precip/monthly/monthly_gridded_precip.asp

Streitz, A. (2011), Minnesota Pollution Control Agency. Retrieved from http://www.mgwa.org/newsletter/mgwa2011-4.pdf

United States Environmental Protection Agency (2017), Secondary Drinking Water Standards: Guidance for Nuisance Chemicals. Retrieved from https://www.epa.gov/dwstandardsregulations/secondary-drinking-water-standards-guidance-nuisance-chemicals

United States Environmental Protection Agency (2018), National Primary Drinking Water Regulations. Retrieved from https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations#Organic

United States Geological Survey (2007), Ground Water Recharge in Minnesota. Retrieved from http://pubs.usgs.gov/fs/2007/3002/pdf/FS2007-3002_web.pdf

United States Geological Survey (2015), Mean Annual Potential Groundwater Recharge Rates from 1996-2010 for Minnesota. Methodology documented in Smith, E.A. and Westernbroek, S.M., 2015 Potential groundwater recharge for the state of Minnesota using the Soil-Water-Balance model, 1996-2010: U.S. Geological Survey Investigations Report 2015-5038. Using: *ArcGIS* [GIS software]. Version 10.3.1. Redlands, CA: Environmental Systems Research Institute. Retrieved from https://conservancy.umn.edu/handle/11299/60085

United States Geological Survey (2019), USGS 05242300 Mississippi River at Brainerd, MN. Retrieved from https://waterdata.usgs.gov/mn/nwis/inventory/?site_no=05242300

Weeks III, John (2006), Aitkin Flood Diversion Channel – Mississippi River Flood Diversion Canal Retrieved from https://www.johnweeks.com/river_mississippi/pages02/aitkinfloodch.html

Western Regional Climate Center (WRCC) (2018), U.S.A. Divisional Climate Data. Retrieved from http://www.wrcc.dri.edu/spi/divplot1map.html

Zhang, H. (1998), Geologic Atlas of Stearns County, Minnesota: Hydrogeology of the Quaternary Water Table System. County Atlas Series, Atlas C-10, part B, Plate 8 of 10, Hydrogeology of the Quaternary Water-table System.

Appendix 1 – Water chemistry definitions

Dissolved oxygen (DO) - Oxygen dissolved in water required by aquatic life for metabolism. Dissolved oxygen enters into water from the atmosphere by diffusion and from algae and aquatic plants when they photosynthesize. Dissolved oxygen is removed from the water when organisms metabolize or breathe. Low DO often occurs when organic matter or nutrient inputs are high, and light inputs are low.

Escherichia coli (*E. coli*) - A type of fecal coliform bacteria that comes from human and animal waste. *E. coli* levels aid in the determination of whether or not fresh water is safe for recreation. Disease-causing bacteria, viruses and protozoans may be present in water that has elevated levels of *E. coli*.

Nitrate plus Nitrite – Nitrogen - Nitrate and nitrite-nitrogen are inorganic forms of nitrogen present within the environment that are formed through the oxidation of ammonia-nitrogen by nitrifying bacteria (nitrification). Ammonia-nitrogen is found in fertilizers, septic systems and animal waste. Once converted from ammonia-nitrogen to nitrate and nitrite-nitrogen, these species can stimulate excessive levels of algae in streams. Because nitrate and nitrite-nitrogen are water soluble, transport to surface waters is enhanced through agricultural drainage. The ability of nitrite-nitrogen to be readily converted to nitrate-nitrogen is the basis for the combined laboratory analysis of nitrate plus nitrite-nitrogen (nitrate-N), with nitrite-nitrogen typically making up a small proportion of the combined total concentration. These and other forms of nitrogen exist naturally in aquatic environments; however, concentrations can vary drastically depending on season, biological activity, and anthropogenic inputs.

Orthophosphate - Orthophosphate (OP) is a water-soluble form of phosphorus that is readily available to algae (bioavailable). While orthophosphates occur naturally in the environment, river and stream concentrations may become elevated with additional inputs from wastewater treatment plants, noncompliant septic systems and fertilizers in urban and agricultural runoff.

pH - A measure of the level of acidity in water. Rainfall is naturally acidic, but fossil fuel combustion has made rain more acid. The acidity of rainfall is often reduced by other elements in the soil. As such, water running into streams is often neutralized to a level acceptable for most aquatic life. Only when neutralizing elements in soils are depleted, or if rain enters streams directly, does stream acidity increase.

Total Kjeldahl nitrogen (TKN) - The combination of organically bound nitrogen and ammonia in wastewater. TKN is usually much higher in untreated waste samples then in effluent samples.

Total phosphorus (TP) - Nitrogen (N), phosphorus (P) and potassium (K) are essential macronutrients and are required for growth by all animals and plants. Increasing the amount of phosphorus entering the system therefore increases the growth of aquatic plants and other organisms. Excessive levels of Phosphorous over stimulate aquatic growth and resulting in the progressive deterioration of water quality from overstimulation of nutrients, called eutrophication. Elevated levels of phosphorus can result in: increased algae growth, reduced water clarity, reduced oxygen in the water, fish kills, altered fisheries and toxins from cyanobacteria (blue green algae) which can affect human and animal health.

Total suspended solids (TSS) – TSS and turbidity are highly correlated. Turbidity is a measure of the lack of transparency or "cloudiness" of water due to the presence of suspended and colloidal materials such as clay, silt, finely divided organic and inorganic matter and plankton or other microscopic organisms. The greater the level of TSS, the murkier the water appears and the higher the measured turbidity.

Higher turbidity results in less light penetration, which may harm beneficial aquatic species and may favor undesirable algae species. An overabundance of algae can lead to increases in turbidity, further compounding the problem.

Unionized ammonia (NH3) - Ammonia is present in aquatic systems mainly as the dissociated ion $NH4^+$, which is rapidly taken up by phytoplankton and other aquatic plants for growth. Ammonia is an excretory product of aquatic animals. As it comes in contact with water, ammonia dissociates into $NH4^+$ ions and ^-OH ions (ammonium hydroxide). If pH levels increase, the ammonium hydroxide becomes toxic to both plants and animals.

Appendix 2.1 – Intensive watershed monitoring water chemistry stations in the Upper Mississippi River – Brainerd Watershed

EQuIS ID	Biological station ID	WID	Waterbody name	Location	Aggregated 12-digit HUC
S001-030	16UM051	07010104-502	Swan River	At Hwy 238, 3 mi. SW of Little Falls	0701010408-01
S002-950	16UM014	07010104-521	Little Elk River	At CR 13, 2 mi. SW of Belle Prarie	0701010407-01
S002-956	16UM028	07010104-511	Nokasippi River	At CR 2, 3.5 mi. SE of Lennox	0701010406-01
S004-326	16UM003	07010104-534	Daggett Brook	At Nokasippi River Rd SE , 9 mi. SE of Brainerd	0701010406-02
S006-242	00UM019	07010104-692	Rice River	At 362nd Lane Crossing, 6 mi. SW of McGregor	0701010401-02
S008-825	16UM037	07010104-693	Rice River	At Hwy 169, in Hassman	0701010401-01
S008-826	16UM047	07010104-659	Sissabogmah Creek	At CR 54, 2.5 mi. NE of Aitkin	0701010404-03
S008-827	16UM041	07010104-660	Ripple River	At 2nd Ave SE, in Aitkin	0701010402-01
S008-828	16UM031	07010104-522	Pike Creek	At CR 223, 1 mi. SW of Little Falls	0701010409-02
S008-834	16UM020	07010104-701	Little Willow River	Upstream of Unnamed Rd. (off Hwy 1), 0.5 mile N of Diversion Channel	0701010403-01
S008-835	16UM022	07010104-689	Little Willow River	Upstream of 450th St., 4 mi. SW of Lake Waukenabo	0701010403-01

Appendix 2.2 – Intensive watershed monitoring biological monitoring stations in the Upper Mississippi River – Brainerd Watershed

WID	Biological station ID	Waterbody name	Biological station location	County	Aggregated 12-digit HUC
07010104-502	16UM049	Swan River	Upstream of Cable Rd, 3.5 mi. E of Swanville	Morrison	Swan River
07010104-502	16UM050	Swan River	Upstream of Flicker Rd, 2 mi. W of Pillsbury	Todd	Swan River
07010104-502	16UM051	Swan River	Upstream of Hwy 238, 3 mi. SW of Little Falls	Morrison	Swan River
07010104-505	16UM036	Rice River	Upstream of CR 4, 8.5 mi. S of McGregor	Aitkin	Upper Rice River
07010104-505	98NF143	Rice River	0.5 mi. upstream of 300th Ln, 11.5 mi. S of McGrgor	Aitkin	Upper Rice River
07010104-509	16UM026	Nokasippi River	Upstream of Mill Rd, 9 mi. E of Brainerd	Crow Wing	Nokasippi River
07010104-509	16UM029	Nokasippi River	Upstream of CSAH 24, 8 mi. SE of Brainerd	Crow Wing	Nokasippi River
07010104-510	16UM027	Nokasippi River	Upstream of CR 45, 9 mi. S of Brainerd	Crow Wing	Nokasippi River
07010104-511	16UM028	Nokasippi River	Upstream of CSAH 2, 3.5 mi. SE of Lennox	Crow Wing	Nokasippi River
07010104-521	16UM014	Little Elk River	Upstream of Ginger Rd (CR 13), 2 mi. SW of Belle Prarie	Morrison	Little Elk River
07010104-522	16UM031	Pike Creek	Upstream of Fountain Rd., 1 mi. SW of Little Falls	Morrison	Pike Creek
07010104-525	16UM030	Pike Creek	Upstream of 85th Ave, 4 mi. W of Little Falls	Morrison	Pike Creek
07010104-529	16UM013	Little Elk River	Upstream of 50th Ave, 4 mi. NW of Randall	Morrison	Little Elk River
07010104-532	16UM017	Little Nokassissippi River	Adjacent to 273rd St, 6 mi. E of Fort Ripley	Crow Wing	Nokasippi River
07010104-534	16UM003	Daggett Brook	Upstream of Nokasippi River Rd, 8.5 mi. SE of Brainerd	Crow Wing	Daggett Brook
07010104-534	16UM004	Daggett Brook	Adjacent to CR 139 SE, 14 mi. SE of Brainerd	Crow Wing	Daggett Brook
07010104-536	16UM061	Wakefield Brook	Downstream of Soo Line Tr, 4 mi. SE of McGregor	Aitkin	Upper Rice River
07010104-543	16UM058	Trib. to Rice River	Downstream of Hwy 210, 2 mi. E of Hassman	Aitkin	Lower Rice River
07010104-570	16UM018	Little Swan River	Downstream of CSAH 12, In Pillsbury	Todd	Swan River
07010104-573	16UM009	Fletcher Creek	Downstream of 213th St, 2 mi. E of Camp Ripley Junction	Morrison	City of Little Falls-Mississippi River
07010104-579	16UM008	Fleming Brook	Upstream of Hwy 210, 5 mi. NW of Kimberly	Aitkin	Lower Rice River
07010104-580	16UM043	Sand Creek	Downstream of Hwy 210, 4.5 mi. NE of Brainerd	Crow Wing	City of Brainerd-Mississippi River
07010104-586	16UM012	Irish Creek	Downstream of 140th St, 2.5 mi. NE of Pillsburry	Morrison	Swan River
07010104-589	10UM146	Whiteley Creek	Upstream of Jordan Rd, 3 mi. NE of Brainerd	Crow Wing	City of Brainerd-Mississippi River
07010104-610	16UM001	Buffalo Creek	Downstream of Hwy 371 (Business), 2 mi. SW of Brainerd	Crow Wing	City of Brainerd-Mississippi River

WID	Biological station ID	Waterbody name	Biological station location	County	Aggregated 12-digit HUC
07010104-627	16UM044	Schwanke Creek	Upstream of Hwy 287, 7 mi. SE of Long Prarie	Todd	Swan River
07010104-641	16UM002	Cedar Creek	1 mi. upstream of Eagle St, 4 mi. NW of Aitkin	Aitkin	Cedar Creek
07010104-659	16UM047	Sissabogmah Creek	Downstream of CR 54, 2.5 mi. NE of Aitkin	Aitkin	Sisabagamah Creek
07010104-659	16UM171	Sissabogmah Creek	Upstream of CR 54, 2.5 mi. NE of Aitkin	Aitkin	Sisabagamah Creek
07010104-660	16UM041	Ripple River	Upstream of 1st Ave NE, in Aitkin	Aitkin	Ripple River
07010104-661	16UM038	Ripple River	Upstream of Twp Rd 119, 2.5 mi. S of Aitkin	Aitkin	Ripple River
07010104-666	16UM040	Ripple River	Upstream of CSAH 12, 2 mi. NW of Glory	Aitkin	Ripple River
07010104-677	16UM046	Sissabogmah Creek	Adjacent to 345th Pl, 6.5 mi. E of Aitkin	Aitkin	Sisabagamah Creek
07010104-678	16UM006	Dean Brook	Upstream of Dean Lake Rd, 8 mi. NE of Crosby	Crow Wing	City of Aitkin-Mississippi River
07010104-679	16UM042	Unnamed Creek	Upstream of CR 159, 4.5 mi. E of Brainerd	Crow Wing	City of Brainerd-Mississippi River
07010104-681	16UM055	Trib. to Mississippi River	Upstream of CR 282, 4 mi. N of Camp Ripley Junction	Morrison	City of Little Falls-Mississippi River
07010104-682	16UM011	Hay Creek	Upstream of CR 1, 2 mi. N of Randall	Morrison	Little Elk River
07010104-683	16UM060	Unnamed Creek	Upstream of Emerald Rd, 2 mi. N of Randall	Morrison	Little Elk River
07010104-684	16UM056	Trib. to Mississippi River	Upstream of 200th St, 4 mi. N of Little Falls	Morrison	City of Little Falls-Mississippi River
07010104-685	16UM007	Ditch to Swan River	Upstream of Cable Rd, 1 mi. E of Swanville	Morrison	Swan River
07010104-687	16UM019	Little Swan River	Downstream of 270th St, 9 mi. SW of Randall	Todd	Swan River
07010104-688	16UM032	Rabbit Creek	Upstream of Hwy 47, 6.5 mi. E of Aitkin	Aitkin	Sisabagamah Creek
07010104-689	16UM022	Little Willow River	Upstream of 450th St, 4 mi. SW of Lake Waukenabo	Aitkin	Little Willow River
07010104-691	17UM200	Little Willow River	Upstream of 430th St, 8 mi. NE of Aitkin	Aitkin	City of Aitkin-Mississippi River
07010104-692	00UM019	Rice River	Upstream of 362nd Ln, 2 mi. SE of Kimberly	Aitkin	Upper Rice River
07010104-693	16UM037	Rice River	Upstream of Hwy 210 (Adjacent to 405th St), 7 mi. NE of Aitkin	Aitkin	Lower Rice River
07010104-695	00UM015	Little Buffalo Creek	Downstream of Hwy 371 (Business), in Brainerd	Crow Wing	City of Brainerd-Mississippi River
07010104-697	16UM063	Unnamed ditch	Adjacent to CSAH 24, 8.5 miles N of Aitkin	Aitkin	Little Willow River
07010104-699	16UM010	Hay Creek	Upstream of CR 131, 8 mi. S of Brainerd	Crow Wing	Nokasippi River
07010104-701	16UM020	Little Willow River	Upstream of Unnamed Rd.(0.5 mi. W of Hwy 1), 5 mi. N of Aitkin	Aitkin	Little Willow River

Appendix 3.1 – Minnesota statewide IBI thresholds and confidence limits

Class #	Class name	Use class	Exceptional use threshold	General use threshold	Modified use threshold	Confidence limit
Fish						
1	Southern Rivers	2B	71	49	NA	±11
2	Southern Streams	2B	66	50	35	±9
3	Southern Headwaters	2B	74	55	33	±7
10	Southern Coldwater	2A	82	50	NA	±9
4	Northern Rivers	2B	67	38	NA	±9
5	Northern Streams	2B	61	47	35	±9
6	Northern Headwaters	2B	68	42	23	±16
7	Low Gradient	2B	70	42	15	±10
11	Northern Coldwater	2A	60	35	NA	±10
Invertebrates						
1	Northern Forest Rivers	2B	77	49	NA	±10.8
2	Prairie Forest Rivers	2B	63	31	NA	±10.8
3	Northern Forest Streams RR	2B	82	53	NA	±12.6
4	Northern Forest Streams GP	2B	76	51	37	±13.6
5	Southern Streams RR	2B	62	37	24	±12.6
6	Southern Forest Streams GP	2B	66	43	30	±13.6
7	Prairie Streams GP	2B	69	41	22	±13.6
8	Northern Coldwater	2A	52	32	NA	±12.4
9	Southern Coldwater	2A	72	43	NA	±13.8

Appendix 3.2 – Biological monitoring results – fish IBI (assessable reaches)

National Hydrography Dataset (NHD) Assessment Segment WID	Biological station ID	Stream segment name	Drainage area Mi^2	Fish class	Threshold	FIBI	Visit date
HUC 12: 0701010401-01 (Lower Rice River)							
07010104-693	16UM037	Rice River	293.86	Northern Streams	47	65.47	24-Aug-17
07010104-543	16UM058	Trib. to Rice River	20.94	Northern Headwaters	42	50.05	23-Aug-16
HUC 12: 0701010401-02 (Upper Rice River)							
07010104-649	10EM088	Rice River	121.07	Northern Streams	47	39.01	23-Jul-15
07010104-505	98NF143	Rice River	39.88	Northern Headwaters	42	31.39	13-Jun-16
07010104-536	16UM061	Wakefield Brook	15.01	Northern Headwaters	42	43.97	11-Jul-17
07010104-692	00UM019	Rice River	197.48	Northern Streams	47	50.56	09-Aug-17
07010104-505	16UM036	Rice River	81.82	Northern Streams	47	47.01	09-Aug-17
HUC 12: 0701010402-01 (Ripple River)							
07010104-660	16UM041	Ripple River	122.32	Northern Streams	47	67.09	14-Jun-16
07010104-661	16UM038	Ripple River	113.79	Northern Streams	47	66.27	27-Jun-17
07010104-661	16UM038	Ripple River	113.79	Northern Streams	47	46.12	14-Jun-16
07010104-666	16UM040	Ripple River	76.82	Northern Streams	35	40.15	27-Jul-17
07010104-666	16UM040	Ripple River	76.82	Northern Streams	35	39.76	14-Jun-16
HUC 12: 0701010403-01 (Little Willow River)							
07010104-689	16UM022	Little Willow River	48.05	Low Gradient	42	50.20	24-Aug-16
07010104-697	16UM063	Unnamed ditch	15.46	Northern Headwaters	23	23.52	16-Jun-16
07010104-701	16UM020	Little Willow River	65.25	Low Gradient	15	28.34	23-Aug-16
07010104-701	16UM020	Little Willow River	65.25	Low Gradient	15	0.00	27-Jul-17
HUC 12: 0701010404-01 (City of Aitkin-Mississippi River)							
07010104-678	16UM006	Dean Brook	27.35	Northern Headwaters	42	53.98	15-Jun-16
07010104-691	17UM200	Little Willow River	55.49	Low Gradient	15	39.38	27-Jul-17
HUC 12: 0701010404-02 (Cedar Creek)							
07010104-641	16UM002	Cedar Creek	45.87	Low Gradient	42	58.89	15-Jun-16

National Hydrography Dataset (NHD) Assessment Segment WID	Biological station ID	Stream segment name	Drainage area Mi^2	Fish class	Threshold	FIBI	Visit date
HUC 12: 0701010404-03 (Sisabagamah Creek)							
07010104-688	16UM032	Rabbit Creek	14.04	Low Gradient	42	34.32	11-Jul-17
07010104-677	16UM046	Sissabogmah Creek	9.54	Low Gradient	42	30.56	23-Jun-16
07010104-659	16UM171	Sissabogmah Creek	42.92	Low Gradient	42	52.67	23-Aug-16
HUC 12: 0701010405-01 (City of Brainerd-Mississippi River)							
07010104-695	00UM015	Little Buffalo Creek	5.41	Northern Headwaters	42	15.78	30-Jun-16
07010104-580	16UM043	Sand Creek	30.61	Northern Headwaters	42	77.22	22-Jun-17
07010104-610	16UM001	Buffalo Creek	10.42	Northern Headwaters	42	68.51	30-Jun-16
07010104-589	10UM146	Whiteley Creek	9.16	Northern Coldwater	35	42.80	07-Jul-10
07010104-589	10UM146	Whiteley Creek	9.16	Northern Coldwater	35	39.75	12-Jul-17
07010104-679	16UM042	Unnamed Creek	3.18	Low Gradient	15	70.99	23-Jun-16
HUC 12: 0701010406-01 (Nokasippi River)							
07010104-511	16UM028	Nokasippi River	187.64	Northern Streams	61	63.78	06-Sep-16
07010104-532	16UM017	Little Nokassissippi River	7.30	Northern Headwaters	42	71.46	26-Jul-16
07010104-532	16UM017	Little Nokassissippi River	7.30	Northern Headwaters	42	60.01	21-Jun-16
07010104-699	16UM010	Hay Creek	22.64	Low Gradient	42	88.61	16-Jun-16
07010104-509	16UM026	Nokasippi River	30.53	Northern Headwaters	42	75.91	15-Jun-16
07010104-510	16UM027	Nokasippi River	150.12	Northern Streams	47	50.95	27-Jun-16
07010104-509	16UM029	Nokasippi River	47.91	Northern Headwaters	42	66.18	16-Jun-16
HUC 12: 0701010406-02 (Daggett Brook)							
07010104-534	16UM004	Daggett Brook	26.54	Low Gradient	42	73.52	27-Jun-16
07010104-534	16UM003	Daggett Brook	50.84	Northern Streams	47	61.67	29-Aug-16
HUC 12: 0701010407-01 (Little Elk River)							
07010104-521	16UM014	Little Elk River	147.33	Northern Streams	47	55.45	28-Jun-16
07010104-529	16UM013	Little Elk River	26.75	Northern Headwaters	42	82.43	27-Jun-16
07010104-682	16UM011	Hay Creek	22.10	Low Gradient	42	69.02	29-Jun-16
07010104-683	16UM060	Unnamed Creek	11.39	Northern Headwaters	68	88.04	21-Jun-16
HUC 12: 0701010408-01 (Swan River)							

National Hydrography Dataset (NHD) Assessment Segment WID	Biological station ID	Stream segment name	Drainage area Mi^2	Fish class	Threshold	FIBI	Visit date
07010104-502	16UM050	Swan River	52.64	Northern Streams	47	63.95	23-Jun-16
07010104-570	10EM118	Little Swan River	26.17	Low Gradient	42	34.58	08-Jul-10
07010104-570	10EM118	Little Swan River	26.17	Low Gradient	42	32.07	07-Jun-10
07010104-502	16UM049	Swan River	145.45	Northern Streams	47	51.68	29-Jun-16
07010104-502	16UM050	Swan River	52.64	Northern Streams	47	58.26	04-Aug-16
07010104-687	16UM019	Little Swan River	9.62	Northern Headwaters	42	42.76	21-Jun-16
07010104-570	16UM018	Little Swan River	30.13	Northern Headwaters	42	33.26	23-Jun-16
07010104-570	16UM018	Little Swan River	30.13	Northern Headwaters	42	34.83	04-Aug-16
07010104-685	16UM007	Ditch to Swan River	7.97	Low Gradient	15	35.02	20-Jun-16
07010104-627	16UM044	Schwanke Creek	8.11	Northern Headwaters	42	50.27	25-Aug-16
07010104-502	16UM051	Swan River	177.93	Northern Streams	47	46.87	29-Jun-16
HUC 12: 0701010404-02 (City of Little Falls-Mississippi River)							
07010104-681	16UM055	Trib. to Mississippi River	7.32	Northern Headwaters	42	20.75	22-Jun-16
07010104-684	16UM056	Trib. to Mississippi River	13.68	Low Gradient	15	23.85	29-Aug-16
HUC 12: 0701010409-02 (Pike Creek)							
07010104-522	16UM031	Pike Creek	42.82	Northern Headwaters	42	64.87	30-Jun-16
07010104-522	10EM026	Pike Creek	21.62	Northern Headwaters	42	32.74	07-Jun-10
07010104-522	10EM026	Pike Creek	21.62	Northern Headwaters	42	42.53	15-Jun-15

Appendix 3.3 – Biological monitoring results – invert IBI (assessable reaches)

National Hydrography Dataset (NHD) Assessment Segment WID	Biological station ID	Stream segment name	Drainage area Mi²	Invert class	Threshold	FIBI	Visit date
HUC 12: 0701010401-01 (Lower Rice River)							
07010104-693	16UM037	Rice River	293.86	Northern Forest Streams GP	51	61.36	14-Sep-17
07010104-543	16UM058	Trib. to Rice River	20.94	Northern Forest Streams GP	51	48.30	30-Aug-16
HUC 12: 0701010401-02 (Upper Rice River)							
07010104-649	10EM088	Rice River	121.07	Northern Forest Streams GP	51	56.88	18-Aug-11
07010104-649	10EM088	Rice River	121.07	Northern Forest Streams GP	51	43.00	10-Aug-15
07010104-692	00UM019	Rice River	197.48	Northern Forest Streams GP	51	68.93	15-Aug-17
07010104-536	16UM061	Wakefield Brook	15.01	Northern Forest Streams RR	53	57.44	09-Aug-17
HUC 12: 0701010402-01 (Ripple River)							
07010104-660	16UM041	Ripple River	122.32	Northern Forest Streams RR	53	57.17	14-Aug-17
07010104-661	16UM038	Ripple River	113.79	Northern Forest Streams RR	53	68.76	09-Aug-17
07010104-666	16UM040	Ripple River	76.82	Northern Forest Streams GP	51	56.65	09-Aug-17
HUC 12: 0701010403-01 (Little Willow River)							
07010104-697	16UM063	Unnamed ditch	15.46	Northern Forest Streams GP	51	59.66	15-Aug-17
07010104-701	16UM020	Little Willow River	65.25	Northern Forest Streams GP	51	46.67	24-Aug-17
HUC 12: 0701010404-01 (City of Aitkin-Mississippi River)							
07010104-678	16UM006	Dean Brook	27.35	Northern Forest Streams RR	53	34.41	02-Aug-17
07010104-691	17UM200	Little Willow River	55.49	Northern Forest Streams GP	51	33.44	24-Aug-17
HUC 12: 0701010404-02 (Cedar Creek)							
07010104-641	16UM002	Cedar Creek	45.87	Northern Forest Streams GP	51	56.63	15-Aug-17

National Hydrography Dataset (NHD) Assessment Segment WID	Biological station ID	Stream segment name	Drainage area Mi^2	Fish class	Threshold	FIBI	Visit date
HUC 12: 0701010404-03 (Sisabagamah Creek)							
07010104-688	16UM032	Rabbit Creek	14.04	Low Gradient	42	34.32	11-Jul-17
07010104-677	16UM046	Sissabogmah Creek	9.54	Low Gradient	42	30.56	23-Jun-16
07010104-659	16UM171	Sissabogmah Creek	42.92	Low Gradient	42	52.67	23-Aug-16
HUC 12: 0701010405-01 (City of Brainerd-Mississippi River)							
07010104-695	00UM015	Little Buffalo Creek	5.41	Northern Headwaters	42	15.78	30-Jun-16
07010104-580	16UM043	Sand Creek	30.61	Northern Headwaters	42	77.22	22-Jun-17
07010104-610	16UM001	Buffalo Creek	10.42	Northern Headwaters	42	68.51	30-Jun-16
07010104-589	10UM146	Whiteley Creek	9.16	Northern Coldwater	35	42.80	07-Jul-10
07010104-589	10UM146	Whiteley Creek	9.16	Northern Coldwater	35	39.75	12-Jul-17
07010104-679	16UM042	Unnamed Creek	3.18	Low Gradient	15	70.99	23-Jun-16
HUC 12: 0701010406-01 (Nokasippi River)							
07010104-511	16UM028	Nokasippi River	187.64	Northern Streams	61	63.78	06-Sep-16
07010104-532	16UM017	Little Nokassissippi River	7.30	Northern Headwaters	42	71.46	26-Jul-16
07010104-532	16UM017	Little Nokassissippi River	7.30	Northern Headwaters	42	60.01	21-Jun-16
07010104-699	16UM010	Hay Creek	22.64	Low Gradient	42	88.61	16-Jun-16
07010104-509	16UM026	Nokasippi River	30.53	Northern Headwaters	42	75.91	15-Jun-16
07010104-510	16UM027	Nokasippi River	150.12	Northern Streams	47	50.95	27-Jun-16
07010104-509	16UM029	Nokasippi River	47.91	Northern Headwaters	42	66.18	16-Jun-16
HUC 12: 0701010406-02 (Daggett Brook)							
07010104-534	16UM004	Daggett Brook	26.54	Low Gradient	42	73.52	27-Jun-16
07010104-534	16UM003	Daggett Brook	50.84	Northern Streams	47	61.67	29-Aug-16
HUC 12: 0701010407-01 (Little Elk River)							
07010104-521	16UM014	Little Elk River	147.33	Northern Streams	47	55.45	28-Jun-16
07010104-529	16UM013	Little Elk River	26.75	Northern Headwaters	42	82.43	27-Jun-16
07010104-682	16UM011	Hay Creek	22.10	Low Gradient	42	69.02	29-Jun-16
07010104-683	16UM060	Unnamed Creek	11.39	Northern Headwaters	68	88.04	21-Jun-16

HUC 12: 0701010408-01 (Swan River)							
07010104-502	16UM050	Swan River	52.64	Northern Streams	47	63.95	23-Jun-16
07010104-570	10EM118	Little Swan River	26.17	Low Gradient	42	34.58	08-Jul-10
07010104-570	10EM118	Little Swan River	26.17	Low Gradient	42	32.07	07-Jun-10
07010104-502	16UM049	Swan River	145.45	Northern Streams	47	51.68	29-Jun-16
07010104-502	16UM050	Swan River	52.64	Northern Streams	47	58.26	04-Aug-16
07010104-687	16UM019	Little Swan River	9.62	Northern Headwaters	42	42.76	21-Jun-16
07010104-570	16UM018	Little Swan River	30.13	Northern Headwaters	42	33.26	23-Jun-16
07010104-570	16UM018	Little Swan River	30.13	Northern Headwaters	42	34.83	04-Aug-16
07010104-685	16UM007	Ditch to Swan River	7.97	Low Gradient	15	35.02	20-Jun-16
07010104-627	16UM044	Schwanke Creek	8.11	Northern Headwaters	42	50.27	25-Aug-16
07010104-502	16UM051	Swan River	177.93	Northern Streams	47	46.87	29-Jun-16
HUC 12: 0701010404-02 (City of Little Falls-Mississippi River)							
07010104-681	16UM055	Trib. to Mississippi River	7.32	Northern Headwaters	42	20.75	22-Jun-16
07010104-684	16UM056	Trib. to Mississippi River	13.68	Low Gradient	15	23.85	29-Aug-16
HUC 12: 0701010409-02 (Pike Creek)							
07010104-522	16UM031	Pike Creek	42.82	Northern Headwaters	42	64.87	30-Jun-16
07010104-522	10EM026	Pike Creek	21.62	Northern Headwaters	42	32.74	07-Jun-10
07010104-522	10EM026	Pike Creek	21.62	Northern Headwaters	42	42.53	15-Jun-15

Appendix 4.1 – Fish species found during biological monitoring surveys

Common name	Number of stations where present	Quantity of stations where present
bigmouth shiner	6	129
black bullhead	18	575
black crappie	5	15
blackchin shiner	3	3
blacknose dace	21	1553
blacknose shiner	12	319
bluegill	20	203
bluntnose minnow	9	100
bowfin	4	9
brassy minnow	10	276
brook silverside	1	1
brook stickleback	29	1307
brook trout	1	12
brown bullhead	2	2
brown trout	1	5
burbot	17	74
central mudminnow	47	3451
central stoneroller	4	32
common shiner	32	1452
creek chub	30	1966
fathead minnow	24	907
finescale dace	7	24
Gen: redhorses	1	1
golden shiner	13	139
greater redhorse	3	10
green sunfish	7	23
hornyhead chub	17	852
hybrid sunfish	2	11
Iowa darter	9	38
johnny darter	36	1278
largemouth bass	12	189
logperch	7	287
longnose dace	7	165
mottled sculpin	8	179
northern pike	25	144
northern redbelly dace	17	783
pearl dace	12	906
pumpkinseed	10	38
rock bass	23	708
shorthead redhorse	10	94

silver redhorse	3	10
smallmouth bass	4	33
spotfin shiner	7	39
spottail shiner	1	1
tadpole madtom	17	129
trout-perch	2	12
walleye	9	25
white sucker	46	1547
yellow bullhead	4	9
yellow perch	30	310

Appendix 4.2 – Macroinvertebrate species found during biological monitoring surveys

Taxon	Sum of Quantity of Visits Where Present	Sum of Quantity of Individuals Collected
Acari		
Acari	30	92
Amphipoda		
Amphipoda	2	11
Crangonyx	6	32
Gammaridae	1	3
Gammarus	3	125
Hyalella	31	1109
Architaenioglossa		
Campeloma	1	7
Viviparus	1	1
Basommatophora		
Ferrissia	32	236
Fossaria	3	7
Gyraulus	14	160
Helisoma anceps	1	1
Lymnaea stagnalis	3	3
Lymnaeidae	2	2
Physa	2	6
Physella	23	199
Planorbella	5	10
Planorbella trivolvis	1	1
Planorbidae	7	11
Promenetus exacuous	3	7
Pseudosuccinea columella	1	1
Stagnicola	2	3
Branchiobdellida		

Taxon	Sum of Quantity of Visits Where Present	Sum of Quantity of Individuals Collected
Branchiobdellida	2	2
Coleoptera		
Anacaena	1	1
Ancyronyx variegatus	4	10
Berosus	1	1
Coptotomus	1	1
Dineutus	3	3
Dubiraphia	29	209
Dytiscidae	9	12
Enochrus	1	3
Gymnochthebius	1	1
Gyrinus	7	9
Haliplus	11	26
Helichus	3	8
Hydraena	2	2
Hydrophilidae	1	1
Hygrotus	1	1
Ilybius	1	1
Liodessus	2	3
Macronychus glabratus	14	140
Neoporus	3	3
Optioservus	18	135
Peltodytes	1	1
Stenelmis	23	183
Tropisternus	2	2
Decapoda		
Cambaridae	2	2
Cambarus	6	6
Orconectes	17	27
Diptera		
Ablabesmyia	25	84
Acricotopus	1	1
Anopheles	4	4
Antocha	2	3
Atherix	5	52
Atrichopogon	2	2
Bezzia	1	5
Brillia	10	14
Ceratopogonidae	2	2
Ceratopogoninae	9	16
Chaetocladius	2	2

Taxon	Sum of Quantity of Visits Where Present	Sum of Quantity of Individuals Collected
Chaoborus	1	4
Chironomini	7	12
Chironomus	8	103
Chrysops	3	3
Cladopelma	1	1
Cladotanytarsus	4	10
Clinotanypus	1	5
Conchapelopia	2	2
Corynoneura	10	20
Cricotopus	27	105
Cryptochironomus	1	1
Diamesa	1	1
Dicranota	6	15
Dicrotendipes	14	90
Diplocladius cultriger	1	1
Dixa	1	1
Dixella	4	5
Dixidae	2	2
Doncricotopus bicaudatus	1	1
Empididae	12	19
Endochironomus	3	4
Ephydridae	10	22
Eukiefferiella	5	30
Forcipomyiinae	1	1
Glyptotendipes	5	7
Guttipelopia	1	1
Hemerodromia	27	102
Hydrobaenus	2	24
Labrundinia	15	23
Limnophyes	4	5
Lopescladius	2	4
Micropsectra	25	400
Microtendipes	24	84
Nanocladius	5	6
Neoplasta	2	5
Nilotanypus	4	4
Nilothauma	2	3
Odontomesa	1	1
Odontomyia	1	1
Orthocladiinae	9	11
Orthocladius	4	6
Orthocladius (Symposiocladius)	6	15

Taxon	Sum of Quantity of Visits Where Present	Sum of Quantity of Individuals Collected
Parachironomus	1	1
Paracladopelma	1	1
Parakiefferiella	6	6
Paramerina	3	3
Parametriocnemus	15	87
Paraphaenocladius	1	1
Paratanytarsus	25	302
Paratendipes	8	11
Pentaneura	8	26
Phaenopsectra	15	44
Pilaria	2	2
Polypedilum	44	604
Potthastia	1	1
Procladius	6	14
Prodiamesa	1	7
Psectrocladius	1	3
Rheocricotopus	14	46
Rheotanytarsus	40	549
Saetheria	1	1
Sciomyzidae	1	1
Simulium	38	1452
Stempellinella	23	67
Stenochironomus	30	175
Stictochironomus	3	3
Stratiomyidae	1	1
Synorthocladius	1	1
Tabanidae	3	4
Tanypodinae	14	24
Tanytarsini	14	39
Tanytarsus	33	312
Thienemanniella	16	39
Thienemannimyia	1	1
Thienemannimyia Gr.	38	292
Thienemannimyia senata	1	1
Tipula	7	17
Tribelos	5	14
Tvetenia	9	21
Xenochironomus xenolabis	10	41
Xylotopus par	3	9
Zavreliella marmorata	1	1
Zavrelimyia	10	29
Ephemeroptera		

Taxon	Sum of Quantity of Visits Where Present	Sum of Quantity of Individuals Collected
Acentrella	1	1
Acentrella parvula	6	19
Acerpenna	17	80
Acerpenna pygmaea	13	122
Anafroptilum	1	2
Baetidae	3	3
Baetis	15	191
Baetis brunneicolor	14	200
Baetis flavistriga	12	68
Baetis intercalaris	11	88
Baetisca	1	1
Caenis	2	12
Caenis diminuta	30	474
Caenis hilaris	8	28
Caenis tardata	1	1
Callibaetis	1	1
Ephemera	3	3
Fallceon	1	1
Heptagenia	3	5
Heptageniidae	3	17
Hexagenia	1	1
Isonychia	2	2
Iswaeon	9	139
Labiobaetis	1	3
Labiobaetis dardanus	1	6
Labiobaetis frondalis	5	29
Labiobaetis propinquus	12	71
Leptophlebiidae	24	232
Leucrocuta	9	31
Maccaffertium	22	188
Maccaffertium exiguum	2	3
Maccaffertium luteum	1	7
Maccaffertium mediopunctatum	1	1
Maccaffertium mexicanum	1	1
Maccaffertium terminatum	1	2
Maccaffertium vicarium	10	26
Paraleptophlebia	1	1
Plauditus	1	1
Procloeon	11	50
Pseudocloeon	1	33
Pseudocloeon propinquum	2	15
Stenacron	19	143

Taxon	Sum of Quantity of Visits Where Present	Sum of Quantity of Individuals Collected
Stenacron interpunctatum	1	8
Stenacron minnetonka	1	1
Stenonema femoratum	1	1
Sympetrum semicinctum	1	3
Teloganopsis deficiens	1	2
Tricorythodes	7	39
Haplotaxida		
Oligochaeta	38	332
Hemiptera		
Belostoma flumineum	13	18
Corixidae	6	36
Gerridae	1	2
Hesperocorixa	1	1
Mesovelia	2	2
Neoplea striola	3	9
Notonecta	3	9
Pleidae	1	1
Ranatra	3	3
Rhagovelia	1	4
Rheumatobates	1	11
Heterostropha		
Valvata	1	1
Hirudinea		
Hirudinea	24	234
Isopoda		
Caecidotea	11	146
Lepidoptera		
Crambidae	1	1
Lepidoptera	1	1
Paraponyx	1	1
Parapoynx	2	2
Petrophila	1	1
Megaloptera		
Chauliodes	1	1
Sialis	4	5
Nematoda		
Nemata	8	23
Neotaenioglossa		
Hydrobiidae	19	275

Taxon	Sum of Quantity of Visits Where Present	Sum of Quantity of Individuals Collected
Odonata		
Aeshna	3	3
Aeshna umbrosa	3	4
Aeshnidae	4	6
Anax junius	3	3
Anisoptera	1	1
Basiaeschna janata	1	1
Boyeria	2	2
Boyeria vinosa	7	13
Calopterygidae	3	4
Calopteryx	12	47
Calopteryx aequabilis	13	49
Calopteryx maculata	1	11
Coenagrionidae	17	115
Corduliidae	5	6
Epitheca	1	1
Epitheca canis	3	3
Gomphidae	1	1
Ischnura	1	5
Libellulidae	1	1
Macromia illinoiensis	1	1
Ophiogomphus	1	1
Ophiogomphus rupinsulensis	3	3
Somatochlora	2	2
Somatochlora walshii	1	1
Zygoptera	1	1
Platyhelminthes		
Trepaxonemata	7	11
Plecoptera		
Acroneuria	10	28
Paragnetina media	9	16
Pteronarcys	1	1
Trichoptera		
Brachycentrus numerosus	3	204
Ceraclea	14	56
Ceratopsyche	8	19
Ceratopsyche alhedra	1	2
Ceratopsyche bronta	4	7
Ceratopsyche morosa	5	22
Ceratopsyche slossonae	5	92
Ceratopsyche sparna	1	12

Taxon	Sum of Quantity of Visits Where Present	Sum of Quantity of Individuals Collected
Cheumatopsyche	33	568
Chimarra	1	4
Glossosomatidae	4	8
Glyphopsyche irrorata	2	2
Helicopsyche borealis	16	82
Hydropsyche	10	158
Hydropsyche betteni	29	569
Hydropsyche bidens	1	5
Hydropsyche placoda	1	4
Hydropsyche simulans	1	11
Hydropsychidae	20	159
Hydroptila	14	105
Hydroptilidae	7	17
Lepidostoma	3	3
Leptoceridae	7	10
Limnephilidae	13	29
Limnephilus	1	3
Lype diversa	3	7
Macrostemum zebratum	1	5
Micrasema rusticum	6	16
Molanna	1	1
Mystacides	2	3
Nectopsyche diarina	2	3
Nectopsyche exquisita	2	3
Neophylax concinnus	1	11
Neophylax fuscus	5	64
Neophylax oligius	2	6
Neureclipsis	4	34
Nyctiophylax	7	10
Oecetis avara	8	16
Oecetis furva	5	20
Oecetis testacea	10	52
Oxyethira	11	102
Phryganeidae	3	14
Phylocentropus	1	1
Platycentropus	1	1
Polycentropodidae	6	6
Polycentropus	1	2
Protoptila	4	31
Psychomyia flavida	6	27
Ptilostomis	9	44
Pycnopsyche	12	125

Taxon	Sum of Quantity of Visits Where Present	Sum of Quantity of Individuals Collected
Triaenodes	11	44
Uenoidae	1	7
Veneroida		
Pisidiidae	30	184

Appendix 5 – Minnesota Stream Habitat Assessment Results

Habitat information documented during each fish-sampling visit is provided. This table convey the results of the Minnesota Stream Habitat Assessment (MSHA) survey, which evaluates the section of stream sampled for biology and can provide an indication of potential stressors (e.g., siltation, eutrophication) impacting fish and macroinvertebrate communities. The MSHA score is comprised of five scoring categories including adjacent land use, riparian zone, substrate, fish cover and channel morphology, which are summed for a total possible score of 100 points. Scores for each category, a summation of the total MSHA score, and a narrative habitat condition rating are provided in the tables for each biological monitoring station. Where multiple visits occur at the same station, the scores from each visit have been averaged. The final row in each table displays average MSHA scores and a rating for the aggregated HUC-12 subwatershed.

# Visits	Biological station ID	Reach name	Land use (0-5)	Riparian (0-15)	Substrate (0-27)
2	16UM002	Cedar Creek	3.38	9.25	5.50
Average Habitat Results: ***[Cedar Creek] Aggregated 12 HUC***					
3	16UM006	Dean Brook	5.00	9.17	17.33
2	17UM200	Little Willow	1.00	7.25	12.00
2	00UM015	Little Buffalo	2.25	7.75	14.65
4	10UM146	Whiteley	3.56	11.75	17.63
3	16UM001	Buffalo	4.08	11.83	18.63
3	16UM042	Unnamed	0.83	5.33	7.67
2	16UM043	Sand Creek	4.25	13.00	20.72
2	16UM055	Trib. to	3.25	12.50	18.50
2	16UM056	Trib. to	4.00	9.50	8.00
2	16UM003	Daggett	2.25	7.50	21.43
3	16UM004	Daggett	2.75	11.83	8.67
2	16UM011	Hay Creek	5.00	11.75	8.75
2	16UM013	Little Elk	4.00	11.50	21.93
2	16UM014	Little Elk	3.25	10.50	21.80
3	16UM060	Unnamed	4.67	12.67	14.97
4	16UM020	Little Willow	1.88	7.50	8.25
2	16UM022	Little Willow	5.00	10.50	5.00
4	16UM063	Unnamed	4.13	10.13	15.68
Average Habitat Results: ***[Little Willow River] Aggregated 12 HUC***					
2	16UM037	Rice River	4.50	9.50	11.00
2	16UM058	Trib. to Rice	4.00	8.50	11.30
2	16UM010	Hay Creek	2.50	10.50	11.00
3	16UM017	Little	4.00	11.17	21.93
2	16UM026	Nokasippi	3.25	11.75	20.93
1	16UM027	Nokasippi	5.00	10.00	19.00
2	16UM028	Nokasippi	3.25	11.50	19.00
2	16UM029	Nokasippi	4.13	10.00	18.85
Average Habitat Results: ***[Nokasippi River]***					

3	10EM026	Pike Creek	0.50	4.17	10.22
2	16UM030	Pike Creek	3.25	10.25	16.80
2	16UM031	Pike Creek	2.50	7.50	17.42
3	16UM038	Ripple River	4.25	12.00	22.23
3	16UM040	Ripple River	4.25	9.67	7.67
2	16UM041	Ripple River	3.50	10.25	18.35
2	16UM032	Rabbit Creek	3.88	10.50	15.70
3	16UM046	Sissabogmah	4.25	12.00	11.00
2	16UM047	Sissabogmah	3.75	9.50	9.00
1	16UM171	Sissabogmah	4.00	7.00	9.00
Average Habitat Results: [Sisabagamah Creek]					
2	10EM118	Little Swan	3.75	13.50	14.00
2	16UM007	Ditch to	1.88	11.50	12.45
2	16UM012	Irish Creek	3.25	11.00	4.50
3	16UM018	Little Swan	2.75	10.83	13.33
2	16UM019	Little Swan	4.38	10.00	15.20
2	16UM044	Schwanke	1.25	9.25	18.32
2	16UM049	Swan River	2.63	8.00	13.00
3	16UM050	Swan River	2.83	12.00	21.18
2	16UM051	Swan River	2.50	6.50	17.00
2	00UM019	Rice River	5.00	11.25	15.18
2	10EM088	Rice River	5.00	13.00	14.77
2	16UM036	Rice River	4.50	11.50	14.00
4	16UM061	Wakefield	4.13	7.75	14.33
1	98NF143	Rice River	5.00	14.00	16.25

Qualitative habitat ratings

= Good: MSHA score above the median of the least-disturbed sites (MSHA>66)

= Fair: MSHA score between the median of the least-disturbed sites and the median of the most-disturbed sites (45 < MSHA < 66)

= Poor: MSHA score below the median of the most-disturbed sites (MSHA<45)

Appendix 6 – Lake protection and prioritization results

Lake ID	Lake Name	Mean TP (ug/L)	Secchi Trend	% Disturbed Land Use	Load reduction goal (pounds/year)	Priority
01-0089-00	Long	17.3	Declining trend	9%	33	A
01-0091-00	Rabbit	12.7	No evidence of trend	14%	15	A
18-0061-00	Cascade	16.0	Insufficient data	22%	1	A
18-0161-00	Sebie	42.6	Declining trend	12%	144	A
18-0243-00	Lower Mission	37.5	No evidence of trend	20%	106	A
01-0087-00	Sugar	12.2	No evidence of trend	4%	6	A
01-0100-00	Jenkins	12.0	Insufficient data	15%	2	A
01-0102-00	Wilkins	19.9	Improving trend	16%	12	A
01-0117-00	Nord	18.3	Declining trend	9%	11	A
01-0161-00	Hammal	15.4	Declining trend	12%	10	A
18-0050-00	Portage	17.2	No evidence of trend	22%	16	A
18-0067-00	Reno	17.4	Insufficient data	25%	3	A
18-0072-00	Shirt	12.8	Insufficient data	9%	5	A
18-0093-01	Rabbit (East Portion)	13.4	Improving trend	11%	24	A
18-0093-02	Rabbit (West Portion)	13.9	Improving trend	11%	22	A
18-0184-00	Rogers	12.1	Declining trend	9%	5	A
18-0256-00	Bass	20.1	Improving trend	12%	5	A
18-0320-01	Gilbert	11.7	Declining trend	21%	18	A
18-0323-00	Sorenson	10.1	Improving trend	13%	1	A
77-0022-00	Mons	17.0	No data provided	38%	3	A
77-0027-00	Long	25.3	No evidence of trend	54%	32	A

77-0032-00	Lady	22.8	Insufficient data	75%	18	A
77-0063-00	Big	22.1	No data provided	11%	12	A
01-0093-00	Clear	11.8	Improving trend	23%	5	A
01-0125-00	Lone	8.6	Declining trend	14%	4	A
01-0137-00	Round	9.9	Declining trend	6%	7	A
01-0209-01	Cedar	13.4	No evidence of trend	12%	69	A
18-0034-00	Bay	13.0	Improving trend	17%	78	A
18-0038-00	Clearwater	18.5	No evidence of trend	8%	21	A
18-0041-02	Crooked	13.9	Improving trend	13%	9	A
18-0090-00	Serpent	17.0	Declining trend	36%	42	A
18-0239-00	Silver	16.1	No evidence of trend	24%	3	A
18-0306-00	Bass	12.4	Insufficient data	29%	4	A
18-0371-00	Perch	12.2	No evidence of trend	53%	4	A
18-0437-00	Portsmouth Mine	6.0	Insufficient data	27%	4	A
18-0439-00	Pennington Mine	7.0	Insufficient data	44%	1	A
49-0081-00	Pine	11.8	No evidence of trend	19%	2	A
77-0007-00	Mound	15.5	Improving trend	13%	4	A
77-0024-00	Bass	17.6	Insufficient data	38%	3	A
77-0067-00	Pine Island	13.8	No evidence of trend	20%	4	A
01-0069-00	Portage	31.3	No evidence of trend	2%	28	B
01-0074-00	Turner	29.5	No data provided	15%	4	B
01-0115-00	Section Ten	20.3	Insufficient data	8%	21	B
01-0129-00	Sissabagamah	17.6	Insufficient data	8%	25	B
01-0132-00	Hanson	20.0	No data provided	6%	8	B
01-0149-00	Mallard	20.5	Insufficient data	6%	13	B

01-0178-00	Spirit	13.2	No evidence of trend	11%	87	B
18-0044-00	Hanks	12.1	Improving trend	15%	16	B
18-0059-00	Black	12.6	Insufficient data	9%	3	B
18-0060-00	Agate	21.6	Improving trend	3%	6	B
18-0069-00	Portage	18.0	No evidence of trend	11%	19	B
18-0076-00	Placid	17.9	No evidence of trend	6%	8	B
18-0096-00	Upper South Long	24.1	No evidence of trend	19%	212	B
18-0099-00	Eagle	15.8	Insufficient data	17%	43	B
18-0104-00	Nokay	20.9	No evidence of trend	12%	85	B
18-0112-00	Wolf	17.1	Insufficient data	5%	3	B
18-0117-00	Black Hoof	34.5	Insufficient data	15%	41	B
18-0121-00	Rice	23.0	Insufficient data	9%	2	B
18-0129-00	Island	14.8	No data provided	4%	6	B
18-0136-00	South Long	34.3	Improving trend	18%	382	B
18-0169-00	Stark	19.5	No evidence of trend	6%	14	B
18-0259-00	Bonnie	19.9	No evidence of trend	9%	2	B
18-0320-02	Gilbert (West Bay)	16.3	No evidence of trend	21%	17	B
49-0035-00	Green Prairie Fish	28.6	No evidence of trend	19%	13	B
49-0056-00	Round	21.7	Improving trend	16%	9	B
49-0086-00	Long	22.9	Insufficient data	25%	7	B
77-0021-00	Twin	39.4	No data provided	68%	18	B
77-0026-00	Moose	72.0	Improving trend	61%	14	B
77-0029-00	Buck	19.0	No data provided	51%	10	B

77-0035-00	Beauty	21.8	No evidence of trend	9%	7	B
01-0159-00	Farm Island	20.1	No evidence of trend	12%	152	B
18-0242-00	Upper Mission	23.6	No evidence of trend	11%	46	B
01-0027-00	Sheriff	29.1	No data provided	2%	4	C
01-0092-00	Swamp	29.9	Insufficient data	1%	16	C
01-0096-00	Dam	21.2	No evidence of trend	5%	53	C
01-0097-00	Newstrom	72.0	Insufficient data	1%	47	C
01-0104-00	French	19.9	Insufficient data	6%	45	C
01-0120-00	Section Twelve	23.6	Insufficient data	8%	17	C
01-0146-00	Ripple	30.2	No evidence of trend	7%	350	C
01-0155-00	Camp	20.0	Insufficient data	1%	3	C
01-0156-00	Spectacle	29.0	Insufficient data	4%	4	C
01-0170-00	Hanging Kettle	28.3	No evidence of trend	9%	318	C
01-0171-00	Diamond	27.9	No data provided	11%	229	C
01-0176-00	Little Pine	18.7	No evidence of trend	9%	99	C
01-0179-00	Hickory	13.9	Insufficient data	15%	72	C
01-0181-00	Blue	7.2	No data provided	0%	1	C
01-0182-00	Pickerel	61.0	Insufficient data	7%	22	C
01-0206-00	Birch	17.5	Insufficient data	1%	7	C
18-0053-00	Rice	48.3	No data provided	3%	25	C
18-0068-00	Rice	28.0	Insufficient data	7%	14	C
18-0087-00	Casey	136.8	No data provided	15%	39	C
18-0110-00	Grave	53.0	Insufficient data	17%	85	C
18-0126-01	Mahnomen	45.7	Insufficient data	17%	165	C
18-0131-00	Clinker	14.0	Insufficient data	7%	16	C

18-0135-00	Turner	14.6	Insufficient data	5%	18	C
18-0139-00	Little Rabbit	23.1	No data provided	15%	114	C
18-0140-00	Black Bear	11.8	Insufficient data	2%	15	C
18-0145-00	Rice	35.7	Insufficient data	50%	11,834	C
18-0147-00	Round	52.3	Insufficient data	15%	621	C
18-0170-00	Upper Dean	38.5	No data provided	3%	41	C
18-0181-00	Lower Dean	32.0	Insufficient data	1%	91	C
18-0240-00	Fawn	53.8	Insufficient data	21%	33	C
18-0254-00	Little Bass	10.5	Insufficient data	3%	5	C
77-0011-00	Buckhead	37.0	Insufficient data	8%	3	C
77-0034-00	Little Swan	21.4	No data provided	41%	86	C
01-0099-00	Gun	33.7	No evidence of trend	5%	84	NA
01-0105-00	Fleming	61.8	Declining trend	8%	71	NA
01-0123-00	Elm Island	40.5	Improving trend	9%	405	NA
01-0136-00	Waukenabo	27.1	No evidence of trend	5%	59	NA
01-0147-00	Esquagamah	43.5	No evidence of trend	5%	120	NA
01-0188-00	Blind	37.3	No evidence of trend	12%	47	NA
18-0155-00	Crow Wing	38.8	Declining trend	43%	96	NA
77-0009-00	Trace	115.1	Insufficient data	62%	19	NA
77-0023-00	Big Swan	49.3	Improving trend	61%	159	NA

Appendix 7 – Stream protection and prioritization results

WID	Stream Name	TALU	Cold/Warm	Community Nearly Impaired	Riparian Risk	Watershed Risk	Current Protection Level	Protection Priority Class
07010104-511	Nokasippi River	Exceptional	warm	one	medium	med/high	med/low	A
07010104-683	Unnamed creek	Exceptional	warm	one	med/low	med/low	med/low	B
07010104-589	Whiteley Creek	General	cold	both	med/low	med/high	med/low	A
07010104-536	Wakefield Brook	General	warm	both	medium	medium	medium	A
07010104-660	Ripple River	General	warm	one	high	med/high	med/low	A
07010104-510	Nokasippi River	General	warm	one	medium	med/high	low	A
07010104-543	Unnamed ditch	General	warm	one	high	med/high	medium	A
07010104-532	Little Nokasippi River	General	warm	one	medium	med/high	med/low	A
07010104-521	Little Elk River	General	warm	neither	high	high	med/low	A
07010104-627	Schwanke Creek	General	warm	neither	med/high	high	low	A
07010104-580	Sand Creek	General	warm	one	medium	medium	med/low	A
07010104-687	Little Swan River	General	warm	one	med/low	medium	low	A
07010104-509	Nokasippi River	General	warm	one	medium	medium	medium	B
07010104-529	Little Elk River	General	warm	neither	med/high	med/high	low	B
07010104-534	Daggett Brook	General	warm	neither	med/high	med/high	low	B
07010104-678	Dean Brook	General	warm	one	med/high	med/low	medium	B
07010104-641	Cedar Creek	General	warm	neither	high	med/high	medium	B
07010104-661	Ripple River	General	warm	neither	med/high	med/high	med/low	B
07010104-699	Hay Creek	General	warm	neither	med/low	med/high	low	B
07010104-692	Rice River	General	warm	one	low	med/low	med/high	B
07010104-693	Rice River	General	warm	neither	medium	medium	medium	B
07010104-689	Little Willow River	General	warm	neither	low	medium	med/high	C
07010104-697	Unnamed ditch	Modified	warm	one	high	medium	medium	A
07010104-685	Unnamed creek	Modified	warm	neither	medium	high	low	B
07010104-666	Ripple River	Modified	warm	neither	medium	med/high	med/low	B