Leech Lake River Watershed Monitoring and Assessment Report

Minnesota Pollution Control Agency

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AUID Assessment Unit Identification Determination

CCSI Channel Condition and Stability Index

CD County Ditch

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

CWLA Clean Water Legacy Act

DOP Dissolved Orthophosphate

E Eutrophic

EQuIS Environmental Quality Information System

EX Exceeds Criteria (Bacteria)

EXP Exceeds Criteria, Potential Impairment

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

M Mesotrophic

MCES Metropolitan Council Environmental Services

MDA Minnesota Department of Agriculture

MDH Minnesota Department of Health

MDNR Minnesota Department of Natural Resources

MINLEAP Minnesota Lake Eutrophication Analysis Procedure

MPCA Minnesota Pollution Control Agency

MSHA Minnesota Stream Habitat Assessment

MTS Meets the Standard

N Nitrogen

Nitrate-N Nitrate Plus Nitrite Nitrogen

NA Not Assessed

NHD National Hydrologic Dataset

NH3 Ammonia

NS Not Supporting

NT No Trend

OP Orthophosphate

P Phosphorous

PCB Poly Chlorinated Biphenyls

PWI Protected Waters Inventory

RNR River Nutrient Region

SWAG Surface Water Assessment Grant

SWCD Soil and Water Conservation District

SWUD State Water Use Database

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

WPLMN Water Pollutant Load Monitoring Network

Executive summary

The Leech Lake River Watershed lies within the Northern Lakes and Forests ecoregion of North Central Minnesota. Encompassing an area of 1,335 square miles, this heavily forested watershed contains numerous wetlands, over 750 lakes, and approximately 277 miles of streams and rivers. Leech Lake, one of Minnesota's most valuable fisheries, is located within the watershed. Woman Lake, Tenmile Lake, and many other highly valued resources used for recreation are also located here. Major rivers and streams include the Leech Lake River, Boy River, Steamboat River, Kabekona River, and Necktie River. A substantial portion of the watershed lies within the Chippewa National Forest and the Leech Lake Indian Reservation. Currently development within the watershed is light; however, demographers expect development to increase substantially within this region. A small amount of agricultural land use, primarily pasture and hay, occurs within the watershed. Almost 20% of the land in the watershed consists of open water. The largely undeveloped land within the Leech Lake River Watershed supports excellent water quality and diverse biological communities. The watershed is an important resource for fisheries, wildlife, and many local economies.

In 2012, the Minnesota Pollution Control Agency (MPCA) began an intensive watershed monitoring (IWM) effort of lakes and streams within the Leech Lake River Watershed. Nineteen stream sites were sampled for biology at the outlet of variable sized subwatersheds. As part of this effort, MPCA staff joined with local partners to complete stream water chemistry sampling at the outlets of five subwatersheds. In 2015, lakes and streams with sufficient data to make an assessment were assessed for aquatic life, aquatic recreation, and aquatic consumption use support. During this process, 12 stream segments (AUIDs) were assessed for aquatic life; eight of these were assessed for aquatic recreation use. Eighty-five lakes were assessed for aquatic recreation.

Ten out of 12 stream segments fully supported aquatic life use. The remaining two segments did not support aquatic life and were determined impaired. Only one of the eight segments assessed for aquatic recreation was found to be impaired. Both aquatic life impairments were the result of poor fish and/or macroinvertebrate communities. In both cases, natural wetland influence and the corresponding lack of habitat heterogeneity were determined to be the cause of the poor aquatic communities. Wetlands have a significant influence on aquatic ecosystems within the Leech Lake River Watershed. The flushing of organic matter from wetlands into streams causes dissolved oxygen levels to decline significantly. This phenomenon was observed during intensive water chemistry monitoring at locations on the Boy River. Dissolved oxygen levels likely fluctuate as a result of wetland influence on other systems such as the Leech Lake River, Steamboat River, and lower Kabekona River. Several stream segments were not assessed for aquatic life due to prevalent wetland conditions within the monitoring site.

The Leech Lake River Watershed has a high density of lakes with good water quality. Of the 85 lakes assessed for aquatic recreation, Hart Lake was the only lake found to not support aquatic recreation use. Hart Lake is one of the few shallow lakes in the Leech Lake River watershed. The shallow depth allows nutrients to be recycled from the bottom sediments during wind events causing internal loading.

Most lakes within the Leech Lake River Watershed are deep and have the ability to assimilate phosphorus within lake bed sediments. Those two characteristics help limit internal nutrient loading and reduce the amount phosphorus being transferred to lakes located downstream (and ultimately into Leech Lake). The high connectivity between waterbodies within the Leech Lake River Watershed may increase the risk of eutrophication due to nutrient loading from land use or other human activities.

Introduction

Water is one of Minnesota's most abundant and precious resources. The 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 (CWLA) 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 Leech Lake River Watershed beginning in the summer of 2012. This report provides a summary of all water quality assessment results in the Leech Lake River 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 (Figure 1). 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: Watershed Approach to Condition Monitoring and Assessment (MPCA 2008) (http://www.pca.state.mn.us/publications/wq-s1-27.pdf).

Pollutant load monitoring network

The Watershed Pollutant Load Monitoring Network (WPLMN) is a long-term monitoring approach designed to measure levels of key pollutants in the state's watersheds and compare regional differences and long-term trends in water quality among Minnesota's major rivers including the Red, Rainy, St. Croix, Mississippi and Minnesota. Since the network's inception in 2007, the WPLMN has adopted a multi-agency monitoring design that combines site specific stream flow data from United States Geological Survey (USGS) and Minnesota Department of Natural Resources (MDNR) flow gaging stations, with water quality data collected by the Metropolitan Council Environmental Services (MCES), local monitoring organizations and Minnesota Pollution Control Agency WPLMN staff to compute annual pollutant loads at 79 river monitoring sites across Minnesota. Intensive water quality sampling occurs year round at all WPLMN sites. Data will also be used to assist with TMDL studies and implementation plans, watershed modeling efforts and watershed research projects.

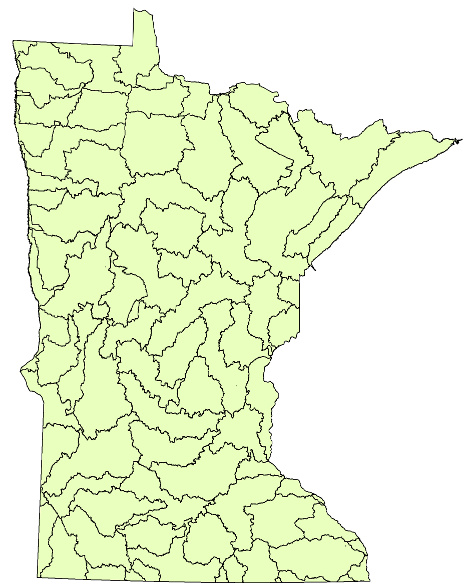

Figure 1. Major Watersheds within Minnesota

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 2). 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 2). 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 3) 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 mi^2. Each aggregated 12-HUC outlet (green triangles 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 mi^2), 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 3).

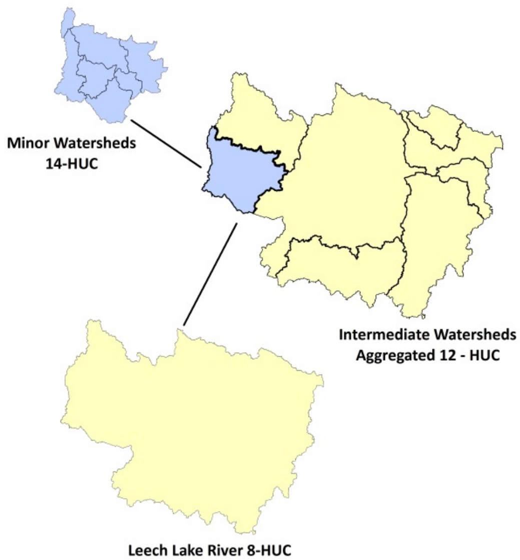

Figure 2. The Intensive Watershed Monitoring Design.

Within the intensive watershed monitoring strategy, lakes are selected to represent the range of conditions and lake type (size and depth) found within the watershed. Lakes most heavily used for recreation (all those greater than 500 acres and at least 25% of lakes 100-499 acres) are monitored for water chemistry to determine if recreational uses, such as swimming and wading, are being supported. Lakes are sampled monthly from May-September for a two-year period. There is currently no tool that allows us to determine if lakes are supporting aquatic life; however, a method that includes monitoring fish and aquatic plant communities is in development.

Specific locations for sites sampled as part of the intensive monitoring effort in the Leech Lake River Watershed are shown in Figure 3 and are listed in Appendix 2, Appendix 4.2, and Appendix 4.3.

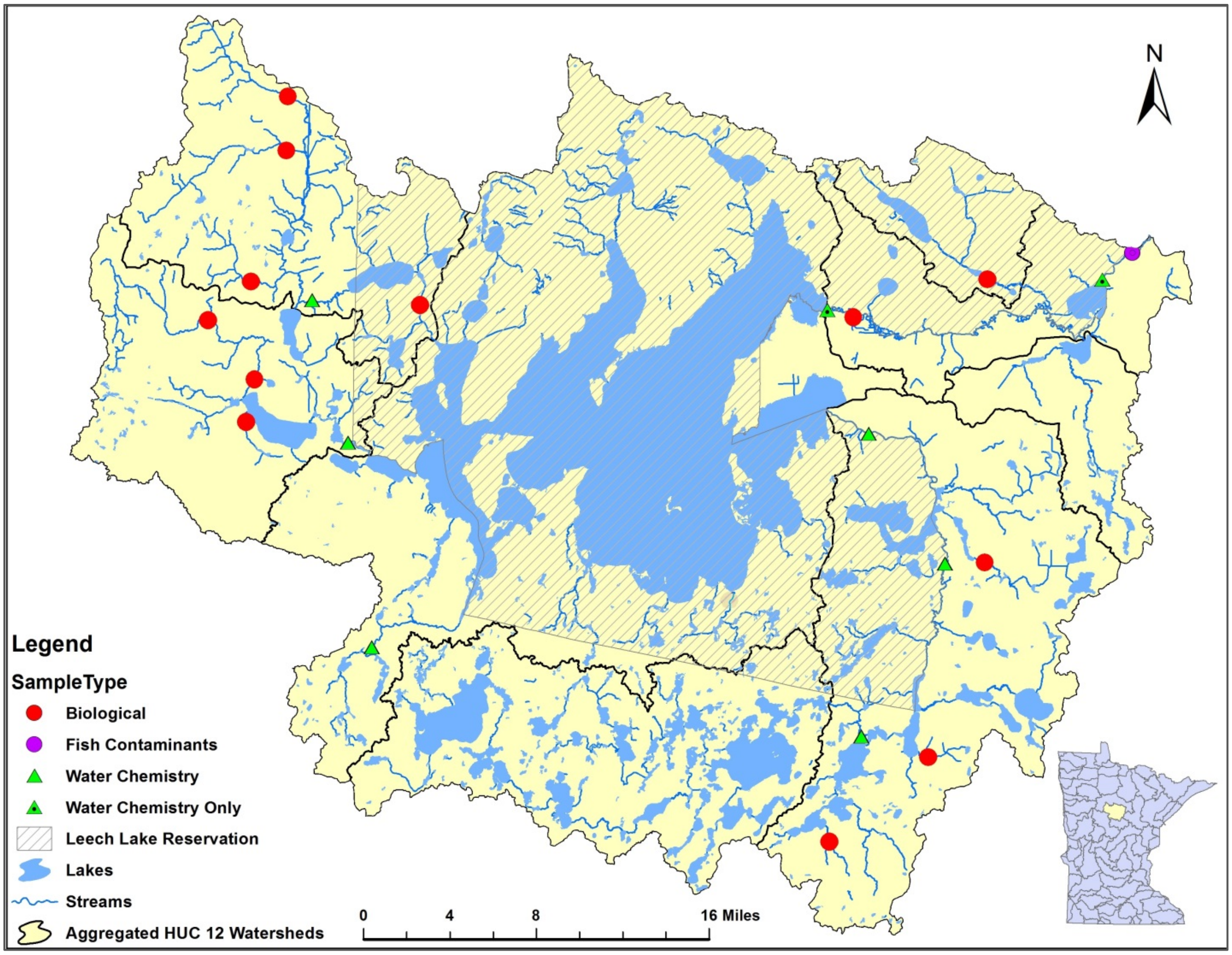

Figure 3. Intensive Watershed Monitoring Sites for Streams in the Leech Lake River Watershed.

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 and 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.

The MPCA also 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 4 provides an illustration of the locations where citizen monitoring data were used for assessment in the Leech Lake River Watershed.

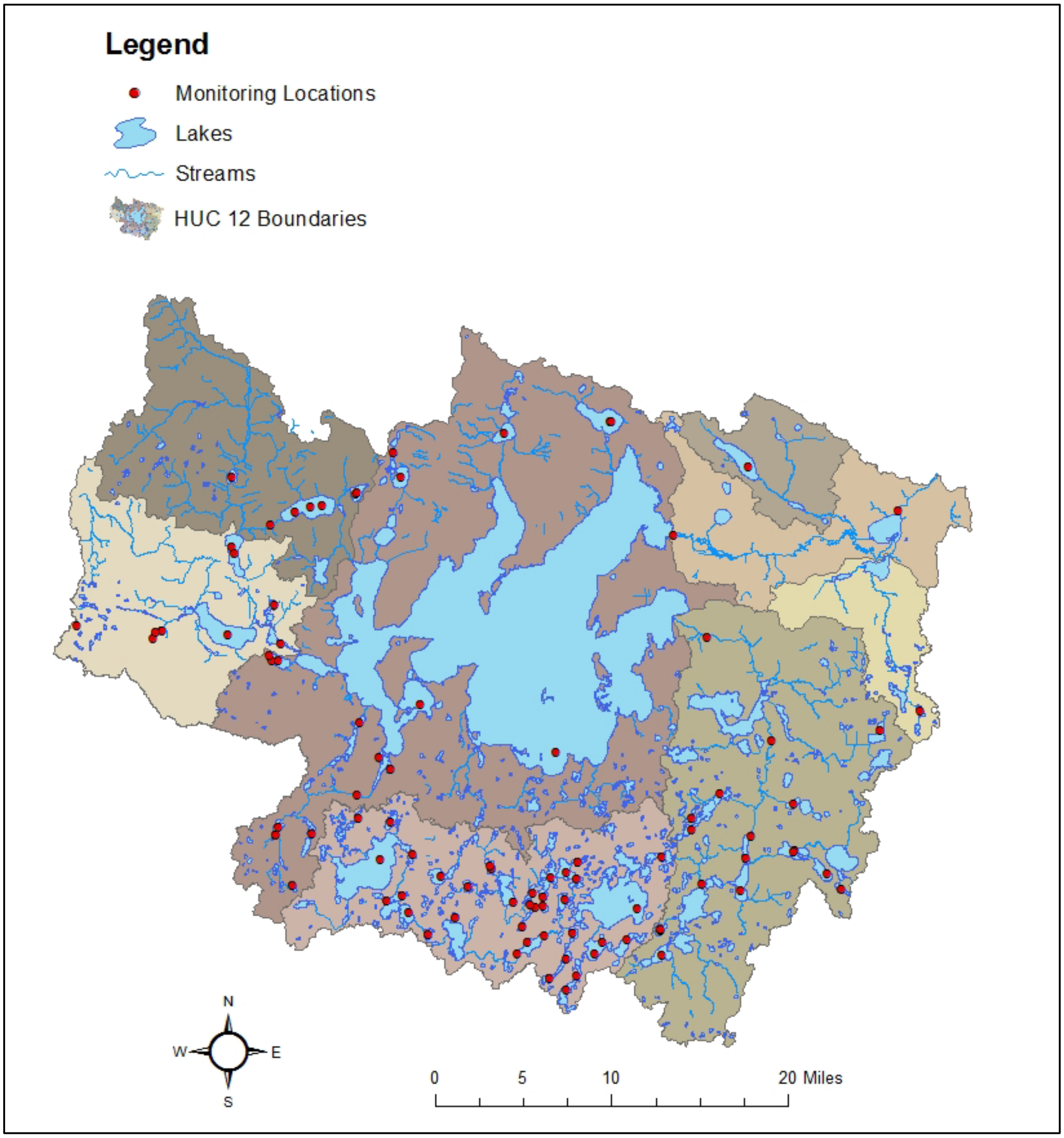

Figure 4. Monitoring locations of local groups, citizens and the MPCA Lake Monitoring Staff in the Leech Lake River Watershed.

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 2014) 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 life means the maintenance of a healthy aquatic community, including fish, invertebrates and plants. The sampling of aquatic organisms for assessment is called biological monitoring. Biological monitoring 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 IBI's for (fish and macroinvertebrates) since these communities can respond differently to various types of pollution. Because the rivers and streams in Minnesota are physically, chemically, and biologically diverse IBI's are developed separately for different stream classes to account for this natural variation. Further interpretation of biological community data are 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, including pH, dissolved oxygen, un-ionized ammonia nitrogen, chloride and TSS.

Protection for aquatic life uses 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 waters with channels that have been directly altered by humans (e.g., maintained for drainage, riprapped). These tiered uses are determined before assessment based on the attainment of the applicable biological criteria and/or an assessment of the habitat. For additional information, see: https://www.pca.state.mn.us/water/tiered-aquatic-life-use-talu-framework.

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.

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 AUID), comprised of the 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 MDNR. The Protected Waters Inventory (PWI) provides the identification numbers for lake, reservoirs and wetlands. These identification numbers serve as the AUID 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 5.

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 are valid and appropriate for assessment purposes. Tiered use designations are determined before data are 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.

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).

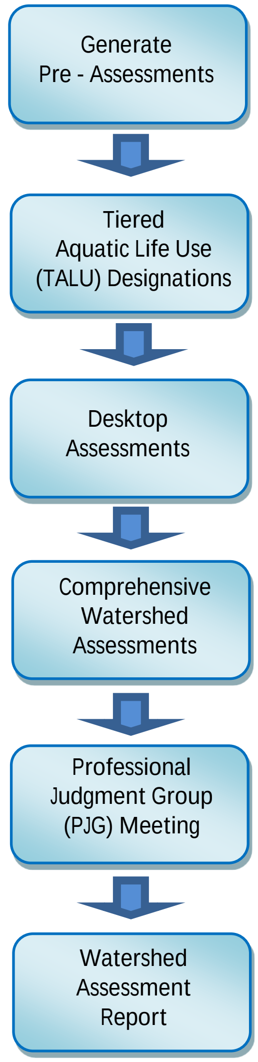

Figure 5. Flowchart of Aquatic Life Use Assessment Process.

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. Iimplementing 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 2014) https://www.pca.state.mn.us/sites/default/files/wq-iw1-04.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 AUID). 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.

Data management

It is MPCA policy to use all credible and relevant monitoring data to assess surface waters. The MPCA relies on data it collects along with data from other sources, such as sister agencies, local governments and volunteers. The data must meet rigorous quality assurance protocols before being used. All monitoring data required or paid for by MPCA are entered into Environmental Quality Information System (EQuIS), MPCA's data system and are also uploaded to the US Environmental Protection Agency's data warehouse. Data for monitoring projects with federal or state funding are required to be stored in EQuIS (e.g., Clean Water Partnership, CWLA Surface Water Assessment Grants and TMDL program). Many local projects not funded by MPCA also choose to submit their data to the MPCA in an EQuIS-ready format so that the monitoring data may be utilized in the assessment process. Prior to each assessment cycle, the MPCA sends out a request for monitoring data to local entities and partner organizations.

Period of record

The MPCA uses data collected over the most recent 10-year period for all water quality assessments. This time-frame provides a reasonable assurance that data will have been collected over a range of weather and flow conditions and that all seasons will be adequately represented; however, data for the entire period is not required to make an assessment. The goal is to use data that best represents current water quality conditions. Therefore, recent data for pollutant categories such as toxics, lake eutrophication, and fish contaminants may be given more weight during assessment.

Watershed overview

The Leech Lake River Watershed covers 857,971 acres (1,335 square miles) of north central Minnesota. Much of the watershed is heavily forested and contains large areas of wetland and open water. Portions of the watershed are found in Cass, Hubbard, and Beltrami County. The Leech Lake Reservation encompasses a large portion of the watershed. Over half of the watershed lies within the Chippewa National Forest. Some of Minnesota's most valuable fish and wildlife resources reside within the Leech Lake River Watershed. The Leech Lake Band of Ojibwe use watershed resources such as wild rice and fisheries for sustenance. Many local economies depend on the rivers, streams, and lakes of the watershed for their recreational value. Draining out of Leech Lake, the Leech Lake River begins below the Leech Lake Dam and flows eastward towards its confluence with the Mississippi River. The river passes through northeastern Cass County and serves as a portion of the Leech Lake Indian Reservation Boundary. The entire 25 mile course of the Leech Lake River also lies within the Chippewa National Forest. The river features a wetland riparian and maintains a low gradient character throughout its course. Other rivers within the Leech Lake River Watershed include the Boy River, Steamboat River, Necktie River, and Kabekona River. Over 750 lakes are in the Leech Lake River Watershed, covering an area of 166,374 acres. Leech Lake is the largest lake within the watershed, encompassing an area of 112,000 acres. Other major lakes found within the watershed include Boy, Tenmile, Kabekona, Woman, and Steamboat. Municipalities within the watershed include Hackensack, Walker, Laporte, Benedict, Longville, Federal Dam, Whipolt, and Boy River.

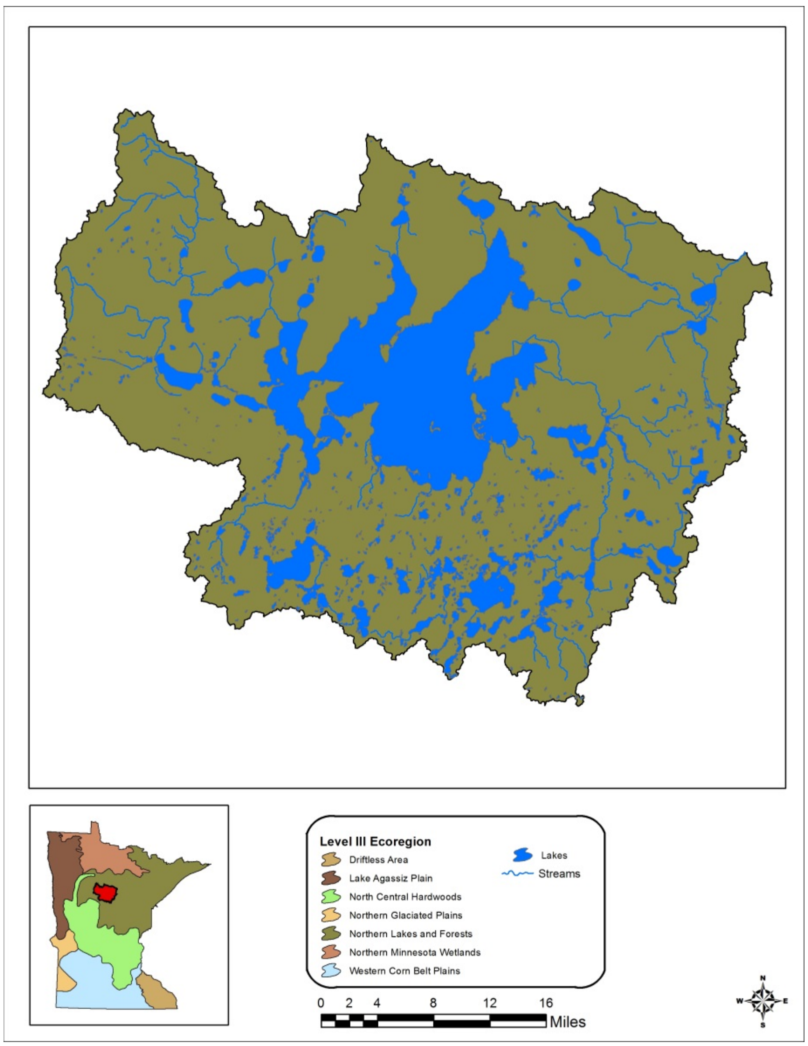

Figure 6. The Leech Lake River Watershed within the Northern Lakes and Forest Ecoregion of North Central Minnesota.

The Leech Lake River Watershed lies within the Northern Lakes and Forest ecoregion (Figure 6). The glacial soils of the NLF region are thick and nutrient poor (Omernik *et al.* 1988). Moraine hills, undulating till plains and lacustrine basins occur in the NLF ecoregion (Omernik *et al.* 1988). Northern hardwood forests and coniferous forests commonly occur within this ecoregion (Omernik *et al.* 1988). The many lakes characteristic of this region are often clear due to low nutrient input from the infertile soil and forested watersheds.

Land use summary

The Leech Lake River Watershed originally was occupied by the Dakota Indian tribe; the Ojibwe tribe arrived in the area during the 1700s. The area was abundant with wild rice and other natural resources such as fur bearing mammals and fish. The abundant natural resources and the quest to locate the headwaters of the great Mississippi River drew European explorers to the area as early as the late 1600's. Early settlements consisted of military forts and fur trading posts. Fur trading remained the most prominent industry in the area until the mid 1800s. In 1855 a treaty with the Mississippi Band of Chippewa Indians ceded their lands within northern Minnesota to the United States Government. The treaty was responsible for the creation of the Leech Lake Indian Reservation. By now, most of the white pine in Minnesota had been cut; however, existing treaties prevented the logging of white pines on reservations (Minnesota American Indian Chamber of Commerce 2016). The passage of the Nelson Act in 1889, opened reservation lands to logging, and logging now became the most prominent industry in the Leech Lake area (MAICC 2016). The industry assisted in populating the area by providing jobs, raw materials for construction, and by creating markets for agriculture (Larson, 2007). The 225,000 acre Chippewa National Forest was established in 1908, to prevent widespread logging on the Leech Lake Reservation (MAICC 2016). Over half of the Leech Lake River Watershed lies within the Chippewa National Forest. Nevertheless, widespread logging still occurred throughout the land within the Chippewa National Forest (MAICC 2016).

During the early 1900s, as logging in northern Minnesota began to decline, lumber companies sold large amounts of cut over land to farmers and other prospective settlers (Larson, 2007). Agriculture became the primary land use within northern Minnesota. Clearing the land of stumps and other trees was an incredibly difficult task (Granger and Kelly 2005). For this reason, the fields on most cutover farms remained fairly small. By 1939 most farms in the cut over region of Minnesota were 103 acres in size; less than 40 of those acres were cleared (Granger and Kelly 2005). Tillable land was used for hay to raise dairy cattle and land not suitable for crops was fenced off for livestock (Granger and Kelly 2005). Today, most farms within the Leech Lake River Watershed remain small in size. The NRCS estimates that there are 427 farms within the watershed; over half of those farms are smaller than 180 acres (NRCS 2016). Only 0.6% of the land within the Leech Lake River Watershed is used for row crop production. Rangeland accounts for another 4.2% of agricultural related land use within the watershed. Despite years of intensive logging, the majority of the watershed remains forested (57.9%). Open water accounts for the next largest land cover percentage. The vast expanse of Leech Lake, as well as the other numerous lakes within the watershed, amount to 19.4% of land area. Many lakes within the Leech Lake River Watershed continue to produce a rich wild rice crop. Wetlands occupy 16.1% of the watershed. Currently, only 1.8% of the watershed is developed; however, according to state demographers, the population of the watershed is expected to increase significantly in 20 years. Significant increases in development will result in additional stress on surface water resources.

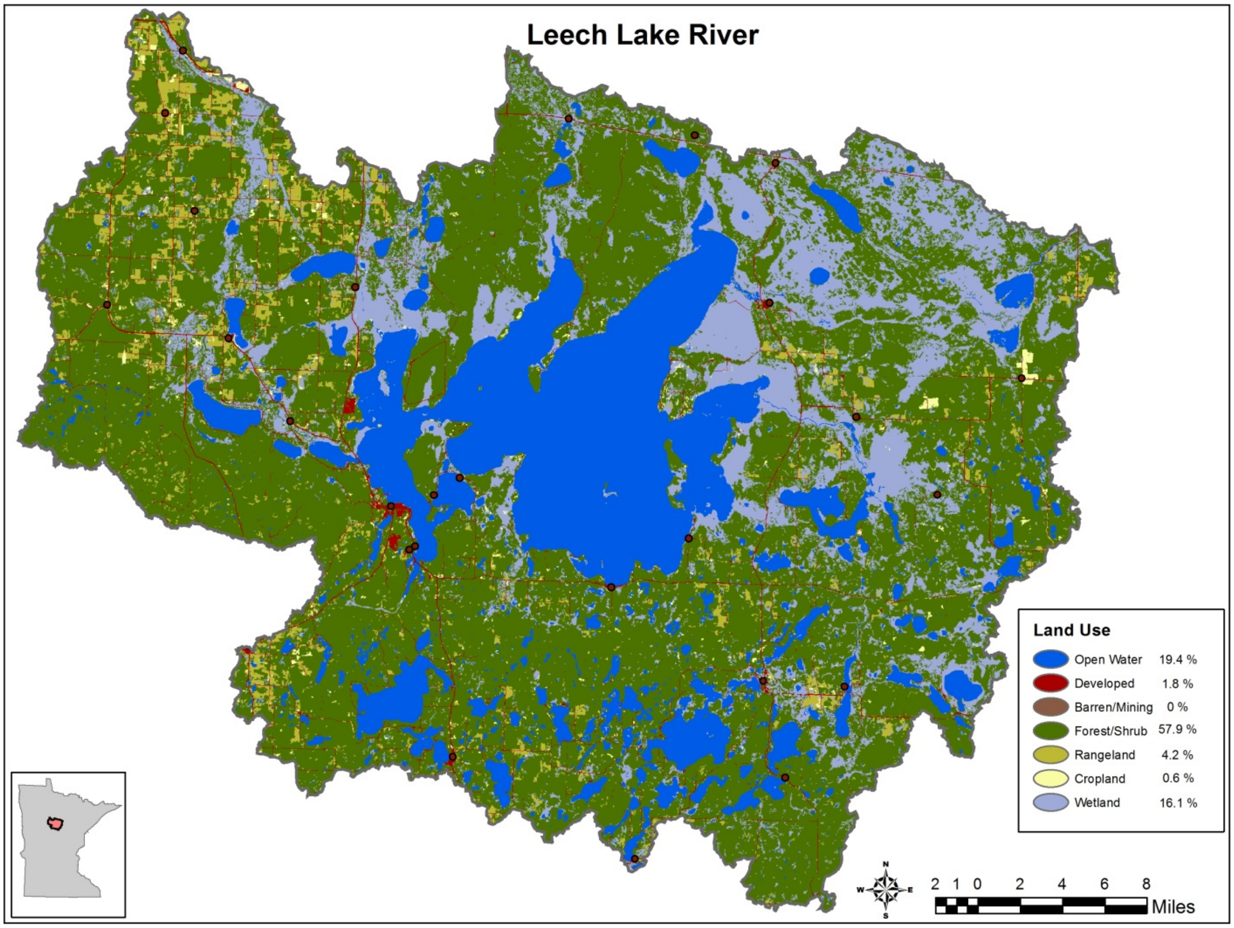

Figure 7. Land use in the Leech Lake River Watershed.

Surface water hydrology

The Leech Lake River serves as the major outlet of Leech Lake, the third largest lake in Minnesota. The Leech Lake River begins below the Leech Lake Dam and flows east for approximately 25 miles before draining into the Mississippi River. Sixmile Brook and the Bear River are the only two major tributaries that flow directly into the Leech Lake River; most other major streams and rivers within the watershed serve as inlets to Leech Lake. Sixmile Brook originates out of Sixmile Lake and flows southeast for several miles before its confluence with the Leech Lake River. Immediately after the Sixmile Brook confluence the Leech Lake River is joined by the Bear River. The Bear River flows out of Goose Lake and into the Leech Lake River after draining 44.27 square miles of land within the eastern portion of the watershed. The Leech Lake River then enters Mud Lake – a large shallow wildlife lake located in the Mud Goose Wildlife Management Area. The river exits Mud Lake through a dam on the north end and flows northeast approximately three miles before emptying into the Mississippi River.

The Boy River, Steamboat River, and Kabekona River serve as major inlets to Leech Lake. The Boy River is the most significant inlet – draining almost 400 square miles of land within the Leech Lake River Watershed. Heavily influenced by lakes and wetlands, the Boy River originates from Tenmile Lake and flows approximately 46 miles before entering Boy Bay of Leech Lake. Along its path to Leech Lake, the Boy River passes through several other lakes including: Birch Lake, Pleasant Lake, Big Deep Lake, Woman Lake, Inguadona Lake, and Boy Lake.

The Steamboat River originates out of Steamboat Lake and flows south for approximately four miles before entering Steamboat Bay of Leech Lake. The river has low gradient and features a wetland dominated riparian area. Although the Steamboat River has a short flow length, the river along with the tributaries that flow into Steamboat Lake drain a collective 134 square miles of land within the Leech Lake River Watershed. The most significant tributary to Steamboat Lake is the Necktie River. The Necktie River originates from a wetland near the community of Rosby and flows primarily southward for 19 miles before entering Steamboat Lake. Early in its course the river is a low gradient cold water stream that supports a brook trout fishery. Tributaries to the Necktie River include the cold water stream Bungashing Creek and Pokety Creek.

The Kabekona River originates from a wetland area in the Paul Bunyan State Forest and flows 25 miles before entering Kabekona Bay of Leech Lake. At its headwaters, the Kabekona River is a cold water stream which flows toward the southeast. Eventually the Kabekona River begins to flow eastward before turning sharply toward the south and entering Kabekona Lake. After exiting Kabekona Lake the Kabekona River is a low gradient warm water stream with wetland like habitat. The river continues to flow southeast for several miles before entering Kabekona Bay of Leech Lake. Several small unnamed tributaries enter the Kabekona River along its path to Leech Lake.

Other direct tributaries to Leech Lake include Shingobee Creek, Sucker Creek, Portage Creek, and Crooked Creek. Shingobee Creek originates out of Steel Lake and flows 9.25 miles before entering Shingobee Bay of Leech Lake. Sucker Creek flows south out of Lower Sucker Lake for approximately 3.20 miles before entering the north end of Sucker Bay on Leech Lake. Portage Creek flows south out of Portage Lake for 3.40 miles before entering Waboose Bay of Leech Lake. Many other small, unnamed tributaries flow directly into Leech Lake. Over 750 lakes are found within the Leech Lake River Watershed, occupying an area of 166,374 acres. Lakes influence the hydrology of every major river within the watershed. Approximately 10.9% of the streams within the Leech Lake River Watershed are ditches or straightened stream channels that have been altered to promote drainage (Figure 9). Most watersheds in the north central and northeast region of Minnesota have a lower percentage of modified stream channels (Figure 8) when compared to other regions of the state.

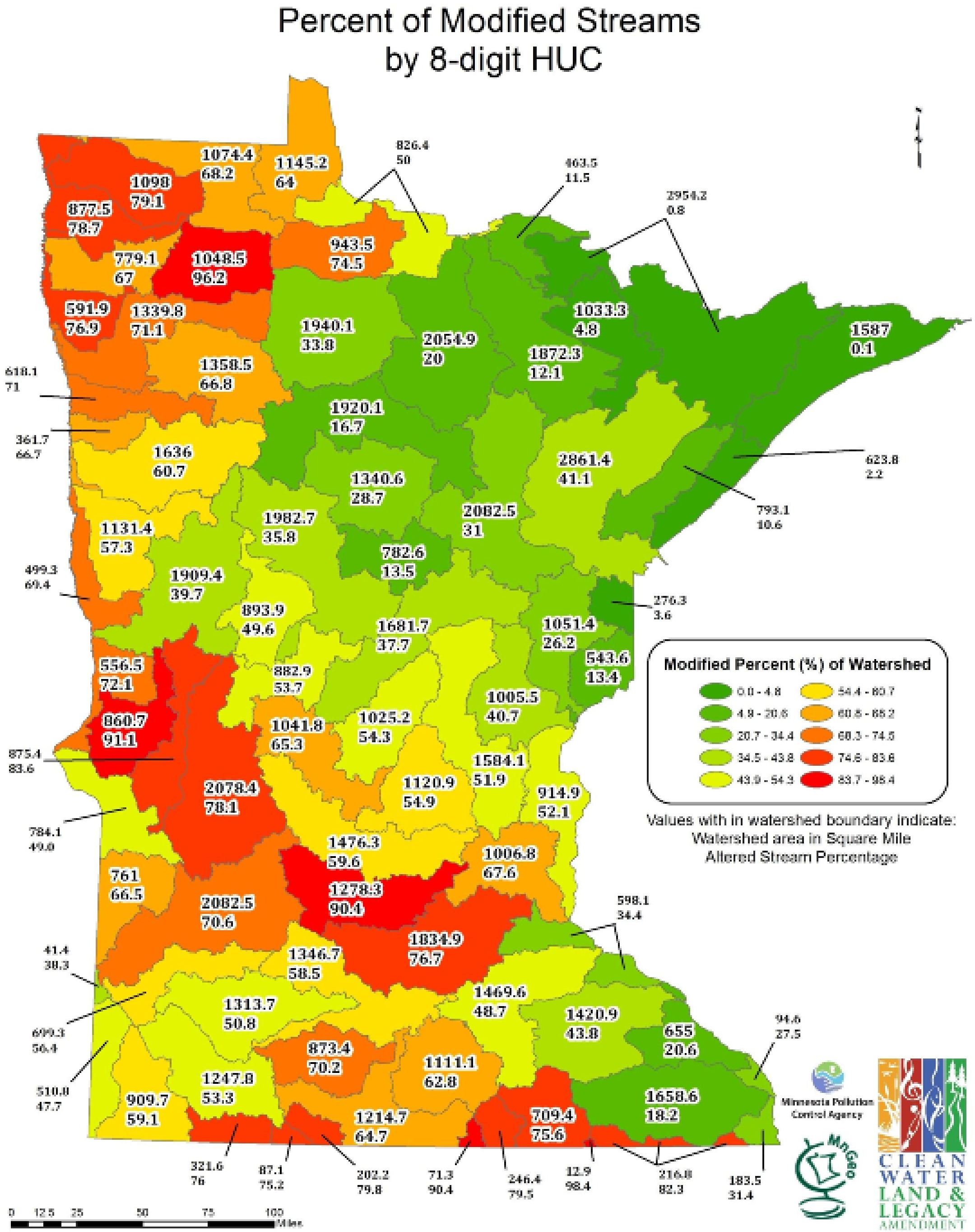

Figure 8. Map of Percent Modified Streams by Major Watershed (8-HUC).

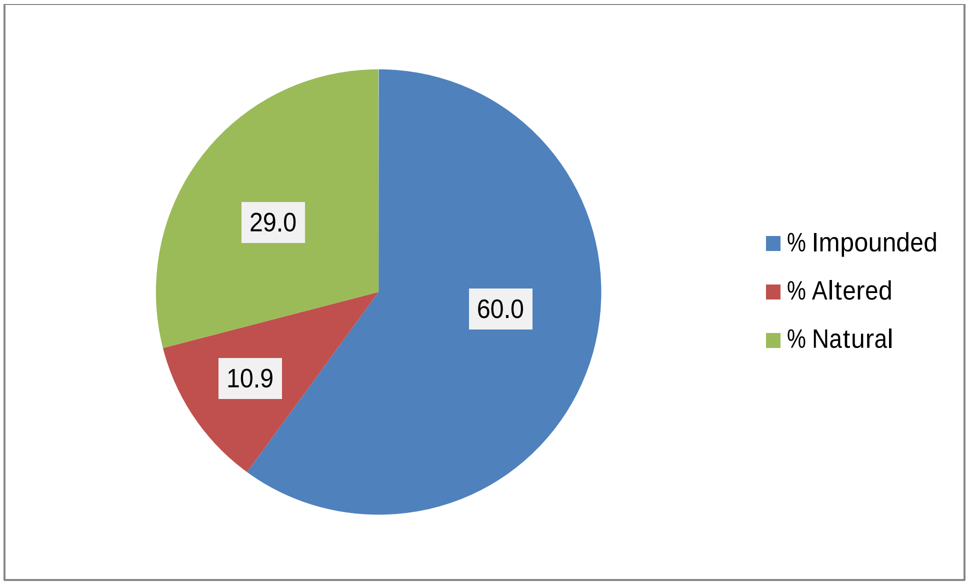

Figure 9. Comparison of natural to altered streams in the Leech Lake River Watershed (percentages derived from the state-wide altered water course project).

Climate and precipitation

The ecoregion has a continental climate, marked by warm summers and cold winters. The mean annual temperature for Minnesota is 4.5˚C. The mean summer temperature for the Leech Lake River Watershed is 17.8˚C and the mean winter temperature is -11.6˚ C (Minnesota State Climatologists Office, 2003).

Precipitation is the source of almost all water inputs to a watershed. Figure 10 shows two representations of precipitation for calendar year 2012. On the left is total precipitation, showing the typical pattern of increasing precipitation toward the eastern portion of the state. According to this map, the Leech Lake River Watershed area received 24 to 32 inches of precipitation in 2012. The display on the right shows the amount those precipitation levels departed from normal. For the Leech Lake Watershed area it shows that precipitation ranged from two inches below normal to six inches above normal in 2012, when the IWM process began.

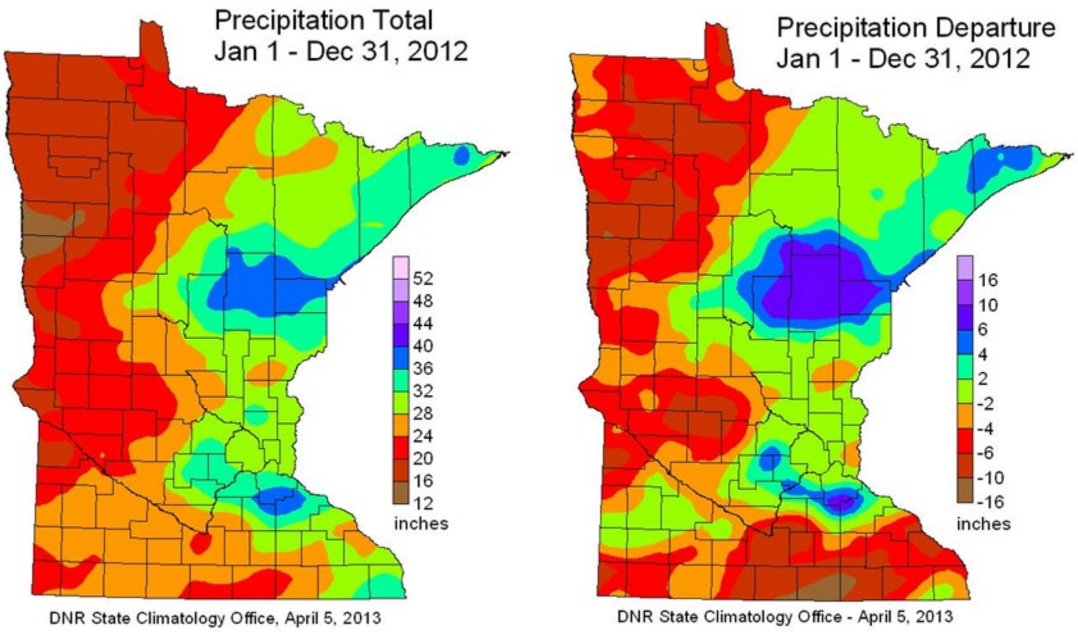

Figure 10. State Wide Precipitation Levels during the 2012 Water Year.

The Leech Lake River Watershed is located in the north central precipitation region. Figure 11 and Figure 12 (below) display the areal average representation of precipitation in north central Minnesota for 20 and 100 years, respectively. An areal average is a spatial average of all the precipitation data collected within a certain area presented as a single dataset. These data are taken from the Western Regional Climate Center, available as a link off of the University of Minnesota Climate website. Though rainfall can vary in intensity and time of year, rainfall totals in the north central region display no significant trend over the last 20 years. However, precipitation in north central Minnesota exhibits a statistically significant rising trend over the past 100 years (p=0.01). This is a strong trend and matches similar trends throughout Minnesota.

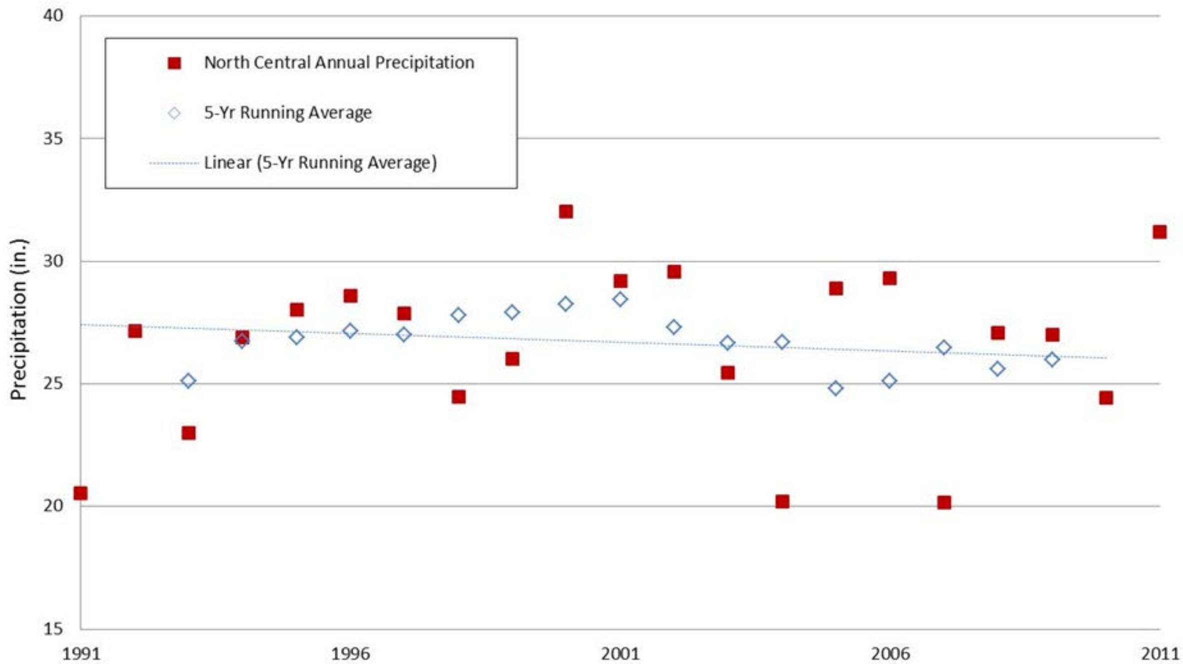

Figure 11. Precipitation trends in North Central Minnesota (1991-2011) with five year running average.

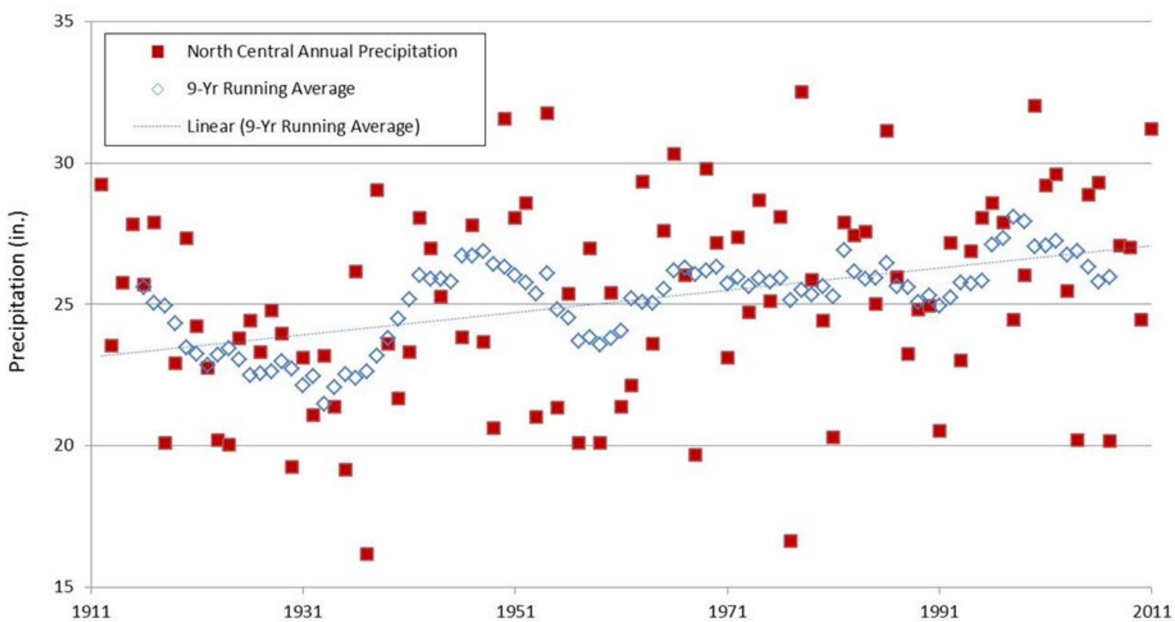

Figure 12. Precipitation trends in North Central Minnesota (1911-2011) with nine year running average.

Hydrogeology and groundwater quality

The Leech Lake River Watershed is located on the northern edge of the north central hydrogeologic region (Figure 13). The watershed is within the Upper Mississippi River Basin and was formed by the advancement and retreating of the Wadena, Des Moines and Rainy Glacial Lobes. This region is dominated by glacial deposits, such as glacial till, lacustrine basins, outwash plains, moraines, and beach ridges. The Wadena Lobe deposits are gray in color, calcareous with small amounts of shale, and are mainly outwash and drumlin fields. Similarly, the Des Moines Lobe deposits are gray and calcareous but have a finer-texture than other glacial deposits. Finally, the Rainy Lobe deposits are primarily outwash with some drumlin fields as well, but they are identified as brown or gray in color and are noncalcareous. (MPCA, 1998)

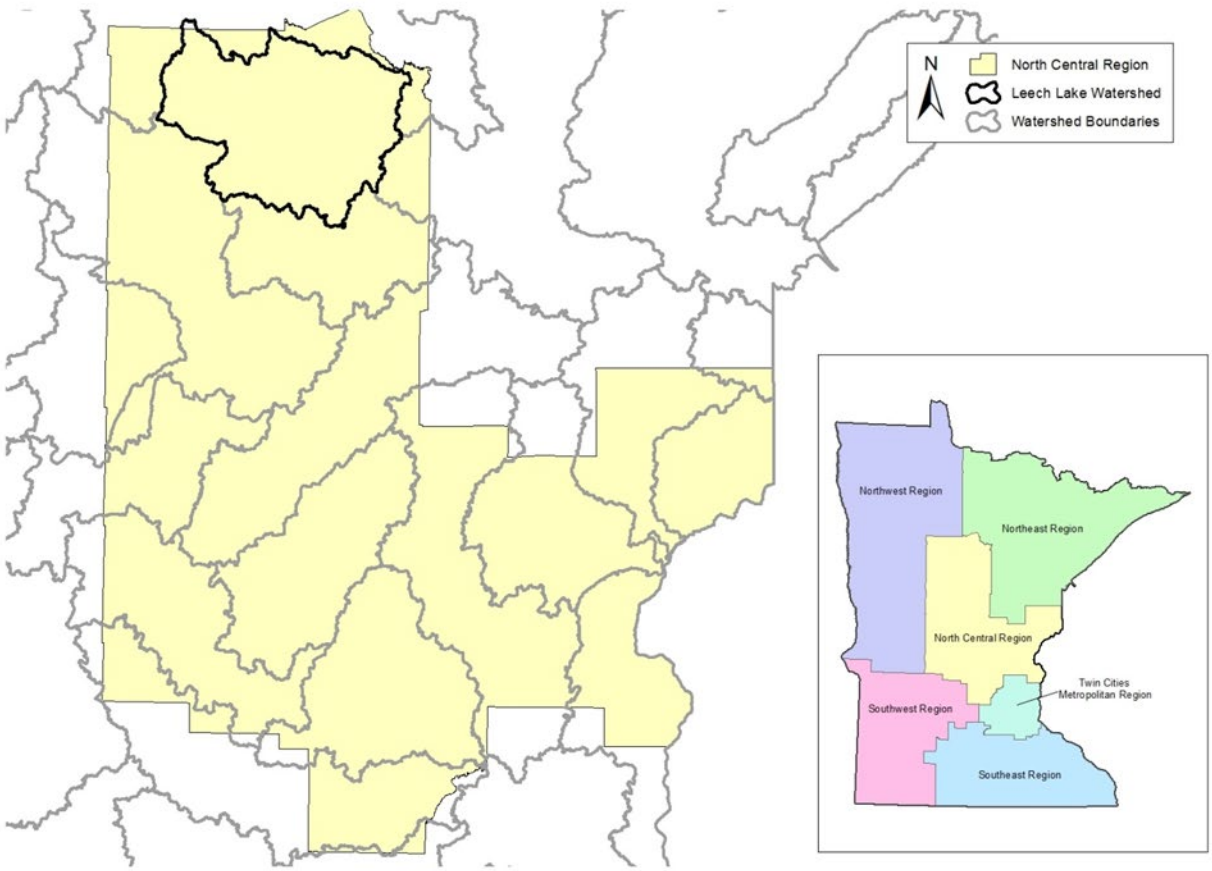

Figure 13. Leech Lake River Watershed within the North Central Hydrogeologic Region.

This region also primarily consists of surficial and buried sand and gravel aquifers. The surficial and buried drift aquifers are comprised of well-sorted sand and gravel. The main aquifer included in the surficial drift category is the Quaternary Water Table Aquifer (QWTA). This aquifer is a predominant source of groundwater withdrawal due to its saturated state; however, the aquifer is shallow with less than 10-feet of confining material at the land surface. Shallow aquifers tend to be very vulnerable to contamination from anthropogenic sources. The buried sand and gravel aquifers consist of confined and unconfined aquifers that include the Quaternary Buried Artesian Aquifer (QBAA), the Quaternary Buried Unconfined Aquifer (QBUA), and the Quaternary Buried Undifferentiated Aquifer (QBUU). These aquifers are similar to the surficial aquifer, but they tend to less responsive to groundwater recharge with longer travel paths (MPCA, 1998).

The Leech Lake River Watershed falls within one of Minnesota's six Ground Water Provinces: the Central Province (Figure 14). This province is characterized by "sand aquifers in generally thick sandy and clayey glacial drift overlying Precambrian and Cretaceous bedrock. Fractured and weathered Precambrian bedrock is used locally as a water source" (MDNR 2001).

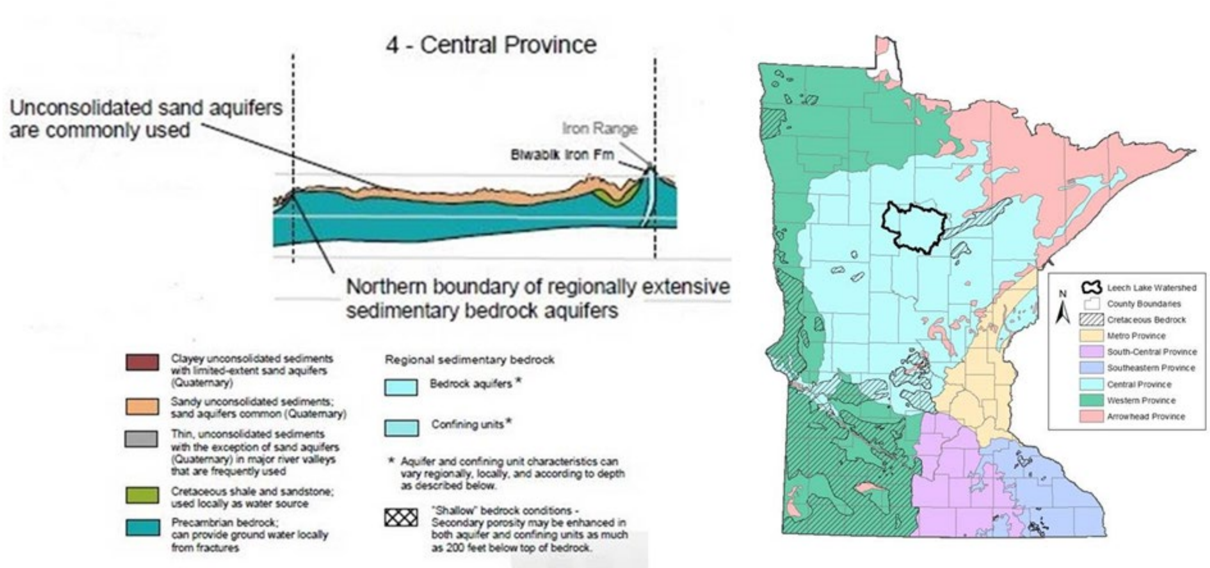

Figure 14. Central Province generalized cross-section (Source: MDNR, 2001).

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. 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 Leech Lake River Watershed, the primary average annual recharge rate to surficial materials is four to eight inches per year, with some areas recharging at a rate of eight to ten inches per year (Figure 15).

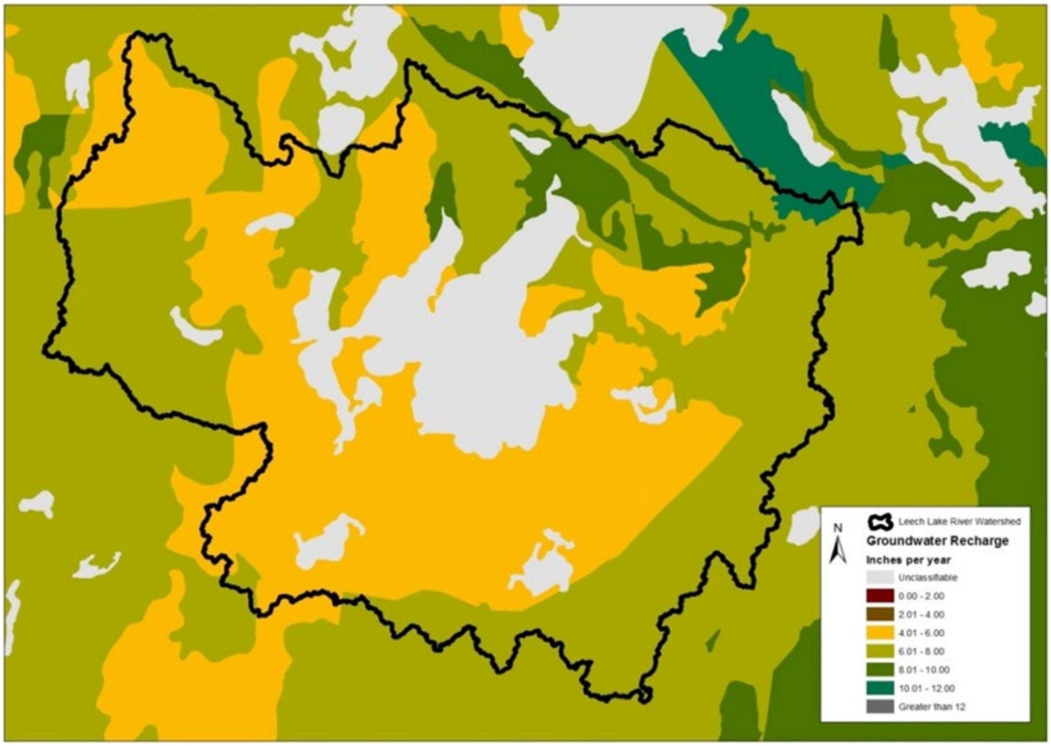

Figure 15. Average Annual Recharge Rate to Surficial Materials in Leech Lake River Watershed (1971-2000).

High capacity withdrawals

The MDNR permits all high capacity water withdrawals where the pumped volume exceeds 10,000 gallons/day or one million gallons/year. Permit holders are required to track water use and report back to the MDNR yearly. Information on the program and the program database are found at: http://www.dnr.state.mn.us/waters/watermgmt_section/appropriations/wateruse.html.

The changes in withdrawal volume detailed in this report are a representation of water use and demand in the watershed and are taken into consideration when the MDNR issues permits for water withdrawals. Other factors not discussed in this report but considered when issuing permits include: interactions between individual withdrawal locations, cumulative effects of withdrawals from individual aquifers, and potential interactions between aquifers. This holistic approach to water allocations is necessary to ensure the sustainability of Minnesota's groundwater resources.

The three largest permitted consumers of water in the state (in order) are municipalities, industry and irrigation. The withdrawals within the Leech Lake River Watershed are mostly for irrigation (major crop and non-crop) and municipal use (waterworks). The locations of permitted groundwater withdrawals within the Leech Lake River Watershed are displayed in Figure 16.

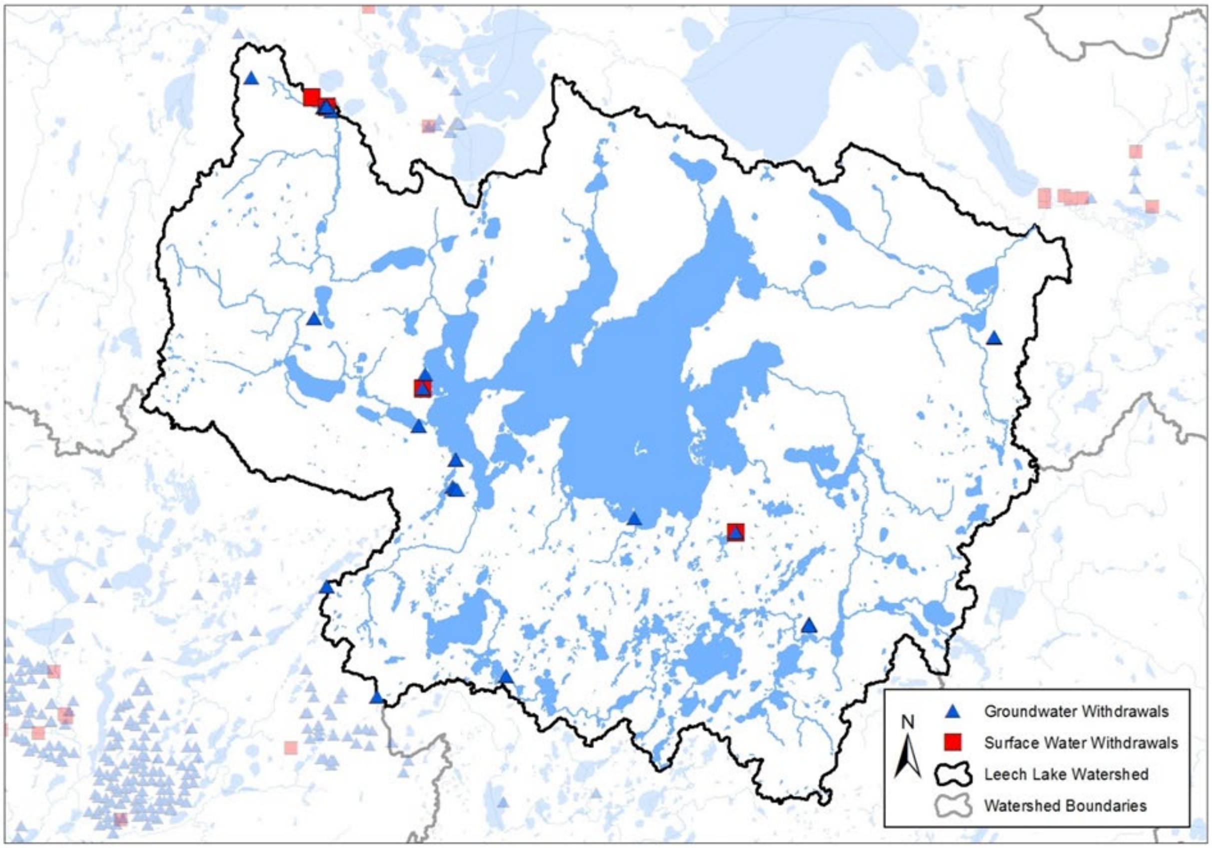

Figure 16. Locations of Permitted Groundwater Withdrawals in the Leech Lake River Watershed.

Total groundwater withdrawals from the watershed from 1991-2011 are displayed below as blue diamonds along with total surface water withdrawals as red squares (Figure 17). During this time period within the Leech Lake River Watershed, groundwater withdrawals exhibit a slight statistical rising trend (p=0.05) while surface water withdrawals exhibit a greater statistical rising trend (p=0.01).

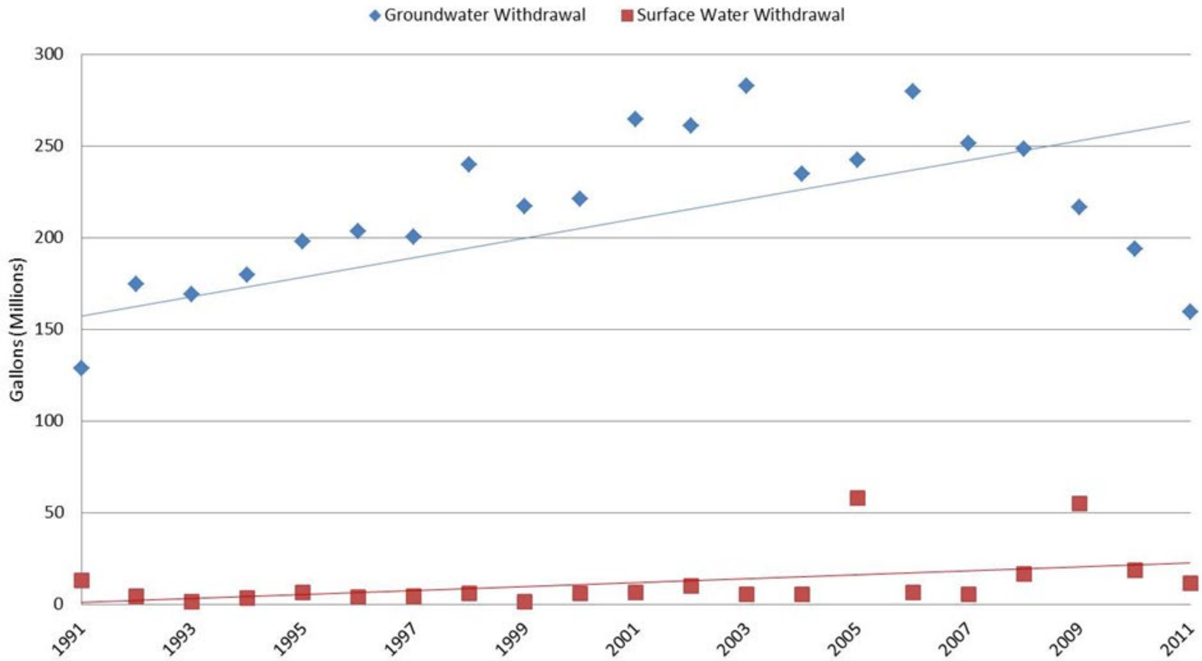

Figure 17. Total Annual Groundwater and Surface Water Withdrawals in the Leech Lake River Watershed (1991-2011).

Wetlands

The Leech Lake River Watershed surface geology primarily consists of ground moraine and outwash plains in the northern half of the watershed, resulting mostly from the Wadena Lobe of the Itasca Moraine Complex. This rolling hill, valley, and flat outwash till geology created ideal conditions for a diverse wetland resource to develop in several hydrogeomorphic settings including: depressional, slope, floodplains, and peatland flats. The southern part of the Leech Lake River Watershed lies within the End Moraine of the Wadena Lobe below a broad outwash plain where the Itasca and St. Croix Moraine outwash complexes converged. This surface geology also creates ideal landscape features to support a rich diversity of wetlands. The Leech Lake River Watershed is part of the Mississippi River drainage in the coniferous forest region of Minnesota. Wetlands are important ecosystems, they slow and retain water on the land thereby providing flood reduction and pollutant treatment for protection or restoration of downstream waters as well as providing vital habitat for a wide variety of plants and wildlife (Mitsch and Gosselink 2007). The National Wetland Inventory (NWI) provides a somewhat recent estimate of wetland resources. In the Leech Lake River Watershed the NWI is based on imagery data from 1983. Changes to wetlands have undoubtedly occurred since the early 1980's up to the present, though the NWI remains the best data available to estimate wetland extent. Minnesota natural resource agencies are cooperating to update the state NWI over a 10-year period. The update is slated for completion in 2019, with the north central and northwest regions of the state (including the Leech Lake River Watershed) being the last region of the state where the NWI is updated http://www.dnr.state.mn.us/eco/wetlands/nwi_proj.html.

Based on the current NWI, (excluding open water portions of lakes, ponds, and rivers) the Leech Lake River Watershed supports approximately 206,540 acres of wetlands which is equivalent to 24.1% of the watershed area. Forested wetlands are the most extensive wetland class making up 8% of the watershed or nearly 69,000 acres. Forested wetlands include hardwood swamps, coniferous swamps, and forested bogs. Shrub dominated wetlands are a close second, comprising 7% of the Leech Lake River Watershed or just over 60,000 acres. Wetlands dominated by herbaceous emergent vegetation (i.e. grasses, sedges, bulrushes or arrowheads) comprise roughly 58,700 acres or about 6.85% of the watershed. Shallow water habitats occur in about 2.4% of the watershed area or 20,900 acres (Figure 18).

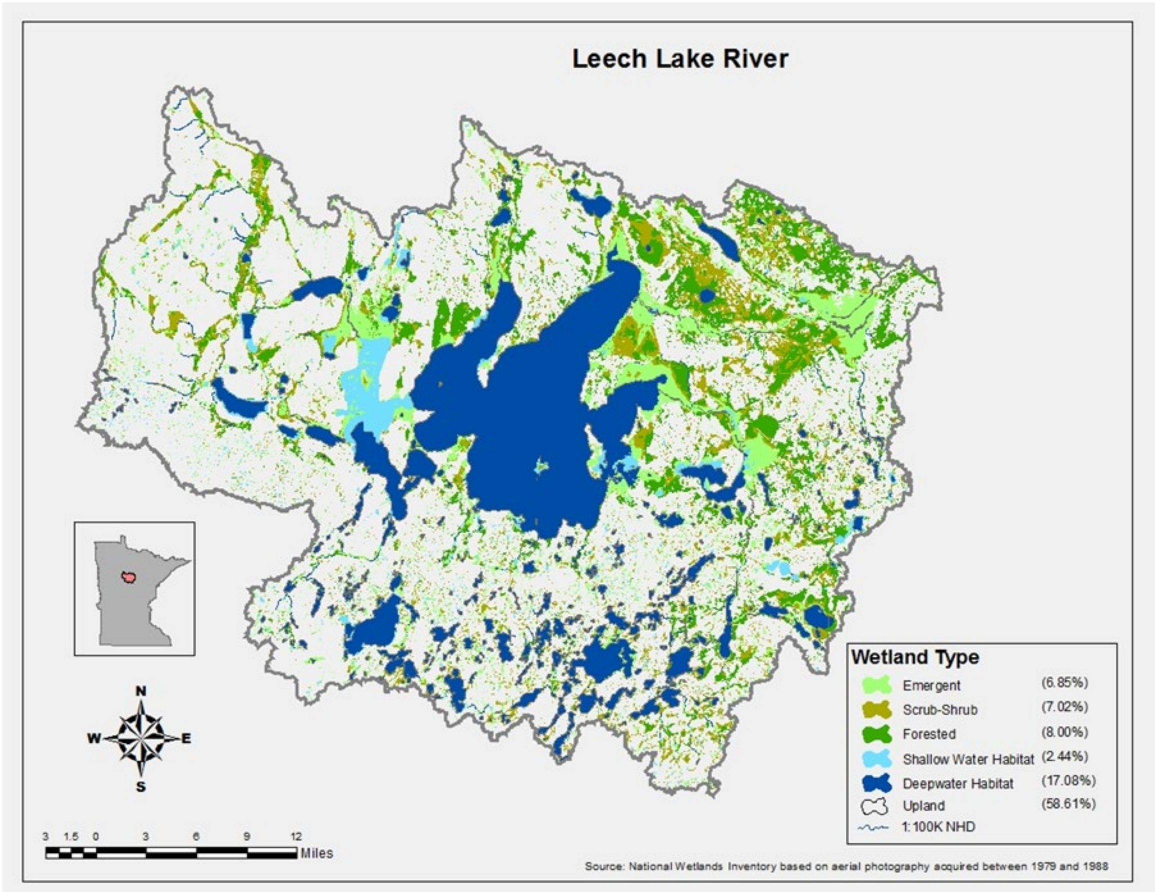

Figure 18. Distribution of wetlands and deep water habitats (lakes and rivers) by National Wetland Inventory Type in the Leech Lake River 8-HUC Watershed.

Digital soils data can be used to estimate historic wetland extent prior to European settlement, which initiated significant conversion of wetlands. There are a few caveats about using the digit soil Natural Resources Conservation Service (NRCS) digital soil survey map units (SSURGO) data: 1) since the SSURGO data are generated county by county there may be subtle differences in some attribute interpretations across multiple counties; 2) soils in most deep water areas (lakes, rivers and permanently flooded wetlands) are generally not mapped; 3) there are differences in mapping resolution and approaches between SSURGO data and national wetland inventory data which can lead to fine scale errors in comparing these two data sets; and 4) recent wetland restorations may not adequately account for fine scale differences in SSURGO or NWI datasets.

Considering these caveats, analysis of SSURGO map units whose drainage condition was classed as "poorly drained" or "very poorly drained" was used as a proxy for historic wetland extent. Analysis of the SSURGO data finds approximately 196,200 acres of wetland or 22.9% of the Leech Lake River Watershed may have historically been wetland. Comparing this estimate to the 24.1% of the watershed mapped as wetland today suggests there has been minimal wetland loss in this watershed. Particularly in the southwestern and southern region of the Leech Lake River Watershed, significant numbers of smaller (typically 0.5 – 5 acre) depressional wetlands are mapped in NWI but are largely unmapped in SSURGO. Thus, it is not surprising NWI finds slightly higher wetland extent within these regions.

Watershed-wide data collection methodology

Pollutant load monitoring

Intensive water quality sampling occurs throughout the year at all WPLMN sites. Between 20 and 35 mid-stream grab samples were collected annually from the Leech Lake River at the Mud Lake Dam south of Ball Club, Minnesota. Sampling frequency was focused more intensely during periods of moderate to high flow. Correlations between concentration and flow exist for many of the monitored analytes. Also, these relationships can shift between storms or with season; therefore, computation of accurate load estimates requires frequent sampling of all major runoff events. Low flow periods are also sampled and are well represented but sampling frequency tends to be less as concentrations are generally more stable when compared to periods of elevated flow. Despite discharge related differences in sample collection frequency, this staggered approach generally results in the distribution of samples over the entire flow range.

Annual water quality and daily average discharge data are coupled in the "Flux32,"pollutant load model, originally developed by Dr. Bill Walker. The model was recently upgraded by the U.S. Army Corp of Engineers and the MPCA. The Flux 32 model allows the user to create concentration/flow regression equations to estimate pollutant concentrations and loads on days when samples were not collected. Primary outputs include annual and daily pollutant loads and flow weighted mean concentrations (pollutant load/total flow volume). Loads and flow weighted mean concentrations are calculated for total suspended solids (TSS), total phosphorus (TP), dissolved orthophosphate (DOP), and nitrate plus nitrite nitrogen (nitrate-N).

Discharge values are not available for the monitoring site on the Leech Lake River so loads and flow weighted means were not calculated. A rating curve will be developed over the next few years so that loads and flow weighted means can be calculated for the next round of assessments.

Stream water sampling

Eight water chemistry stations were sampled from May - September in 2012, and again from June - September of 2013, to provide sufficient water chemistry data to assess all components of the Aquatic Life and Recreation Use Standards. Following the IWM design, water chemistry stations were placed at the outlet of each aggregated 12-HUC subwatershed that was >40 square miles in area (purple circles and green triangles in Figure 3. A Surface Water Assessment Grant (SWAG) was awarded to Cass County and the Headwaters Science Center to collect water chemistry at the eight IWM locations in the Leech Lake River Watershed. Please refer to Appendix 2 for locations of stream water chemistry monitoring sites. Appendix 1 lists the definitions of stream chemistry analytes monitored in this study. Water chemistry data was also submitted by Leech Lake Band of Ojibwe and was used in addition to water chemistry data collect under the IWM design.

Stream flow methodology

MPCA and the MDNR 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 subwatersheds are available at the MDNR/MPCA Cooperative Stream Gaging webpage at: http://www.dnr.state.mn.us/waters/csg/index.html.

Stream biological sampling

The biological monitoring component of IWM in the Leech Lake River Watershed was completed during the summer of 2012. A total of 16 sites were newly established across the watershed and sampled.

These sites were located near the outlets of most minor 14-HUC watersheds. In addition, three existing biological monitoring stations within the watershed were revisited in 2012. These monitoring stations were initially established in 2009, to collect data for biocriteria development. While data from the last 10 years contributed to the watershed assessments, the majority of data utilized for the 2015 assessment was collected in 2012. A total of 18 AUIDs were sampled for biology in the Leech Lake River Watershed. Waterbody assessments to determine aquatic life use support were conducted for 12 AUIDs. 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 and invertebrate IBIs, 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 Fish IBI and Invertebrate IBI. 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 4.1). 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 Appendix 4.

Fish contaminants

Mercury was analyzed in fish tissue samples collected from the Leech Lake River and 32 lakes in the watershed. Polychlorinated biphenyls (PCBs) were measured in fish from the river and 10 lakes. MPCA biomonitoring staff collected the fish from the river in 2012. MDNR fisheries staff collected all other fish. In addition, five fish from Leech Lake were tested for perfluorochemicals (PFCs) in 2010. PFCs became a contaminant of emerging concern in 2004 when high concentrations were measured in fish from the Mississippi River. Extensive statewide monitoring of lakes and rivers for PFCs in fish was continued through 2010. After 2010, more focused monitoring for PFCs continued in known contaminated waters, such as the Mississippi River, several lakes in the Twin Cities Metropolitan Area, and some reservoirs in the Duluth area.

Captured fish were wrapped in aluminum foil and frozen until they were thawed, scaled (or skinned), filleted, and ground to a homogenized tissue sample. For mercury or PCBs analyses, homogenized fillets were placed in 125 mL glass jars with Teflon™ lids and frozen until thawed for lab analysis. The Minnesota Department of Agriculture (MDA) Laboratory performed all mercury and PCBs analyses of fish tissue. For PFCs, whole fish were shipped to AXYS Analytical Services Ltd in Sidney, British Columbia, Canada. AXYS did the fish measurements and processing before analyzing the tissue samples for 13 PFCs. The PFC that primarily bioaccumulates in fish and is a known health concern for human consumption is perfluorooctane sulfonate (PFOS).

The Impaired Waters List is submitted every even year to the EPA for the agencies approval. MPCA has included waters impaired for contaminants in fish on the Impaired Waters List since 1998. Impairment assessment for PCBs and PFOS 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 because of PCBs or PFOS, 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 (200 ppb) for PFOS.

Before 2006, mercury in fish tissue was assessed for water quality impairment based on MDH's fish consumption advisory. An advisory more restrictive than a meal per week was classified as impaired for mercury in fish tissue. Since 2006, 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, which is one of Minnesota's water quality standards for mercury. At least five fish samples per species are required to make this assessment and only the last 10 years of data are used for statistical analysis. MPCA's Impaired Waters List includes waterways that were assessed as impaired prior to 2006 as well as more recent impairments.

PCBs in fish were intensively monitored in the 1970s and 1980s, showing high concentrations of PCBs were only a concern downstream of large urban areas in large rivers, such as the Mississippi River and in Lake Superior. Therefore, continued widespread frequent monitoring of smaller river systems was not necessary. The current watershed monitoring approach includes screening for PCBs in representative predator and forage fish collected at the pour point stations in each major watershed.

Lake water sampling

There are currently 57 volunteers enrolled in the MPCA's Citizens Lake Monitoring Program (CLMP) that are conducting lake monitoring within the watershed. Sixteen Lakes were sampled by Cass County through the SWAG (Surface Water Assessment Grant) and twelve lakes were sampled by MPCA staff. 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 water quality assessment standard requires eight observations/samples within a 10-year period for phosphorus, chlorophyll-a, and Secchi depth.

Groundwater quality

The MPCA'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 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.

Groundwater/surface water withdrawals

The MDNR permits all high capacity water withdrawals where the pumped volume exceeds 10,000 gallons/day or 1 million gallons/year. Permit holders are required to track water use and report back to the DNR yearly. Information on the program and the program database are found at: http://www.dnr.state.mn.us/waters/watermgmt_section/appropriations/wateruse.html.

The changes in withdrawal volume detailed in this report are a representation of water use and demand in the watershed and are taken into consideration when the MDNR issues permits for water withdrawals. Other factors not discussed in this report but considered when issuing permits include: interactions between individual withdrawal locations, cumulative effects of withdrawals from individual aquifers, and potential interactions between aquifers. This holistic approach to water allocations is necessary to ensure the sustainability of Minnesota's groundwater resources.

Groundwater quantity

Monitoring wells from the MDNR Observation Well Network track the elevation of groundwater across the state. The elevation of groundwater is measured as depth to water in feet and reflects the fluctuation of the water table as it rises and falls with seasonal variations and anthropogenic influences. Data from these wells and others are available at: http://www.dnr.state.mn.us/waters/groundwater_section/obwell/waterleveldata.html.

Stream flow

The United States Geological Survey (USGS) maintains real-time streamflow gaging stations across the United States. Measurements can be viewed at http://waterdata.usgs.gov/nwis/rt.

Wetland monitoring

The MPCA began biological monitoring of wetlands in the early 1990s, focusing on wetlands with emergent vegetation (i.e., marshes) in a depressional geomorphic setting. This work resulted in the development of plant and macroinvertebrate (aquatic bugs, snails, leeches, and crustaceans) indices of biological integrity (IBIs) for evaluating the ecological condition or health of depressional wetlands. Recently the MPCA wetland plant monitoring program has begun transitioning toward use of Floristic Quality Assessment (FQA) for assessing wetland condition based on the plant community. Future watershed wetland assessment reports will begin to use FQA wetland assessment results. One advantage to the FQA approach is the methods have been adapted to assess all classes (types) of Minnesota wetlands, in contrast to wetland IBIs which are used only in depressional or 'marsh' type wetlands that have a seasonal - permanent water column. The wetland IBI approach has been discussed in other watershed reports and is used here. Both the invertebrate and plant IBIs are scored on a 0 to 100 scale with higher scores indicating better condition. These indicators have been used in a survey of wetland condition where results can be summarized statewide and for each of Minnesota's three Level II ecoregions (Genet 2012).

Individual subwatershed results

HUC-12 subwatersheds

Assessment results for aquatic life and recreation use are presented for each aggregated 12-HUC subwatershed within the Leech Lake River 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 (note: a summary table of assessment results for the entire 8-HUC watershed that includes aquatic consumption and drinking water assessments, where applicable, is included in Appendix 3). 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 12-HUC subwatersheds contain the assessment results from the 2015 Assessment Cycle as well as any impairment listings from previous assessment cycles. Discussion of assessment results focuses primarily on the 2012 intensive watershed monitoring effort, but also considers available data from the last ten years.

The proceeding pages provide an account of each aggregated 12-HUC subwatershed. Each account includes a brief description of the subwatershed, and tables summarizing the results for each of the following: stream aquatic life and aquatic recreation assessments, stream habitat quality, channel stability, water chemistry for the aggregated 12-HUC outlet (if available), and lake aquatic recreation assessments. Following the tables is a narrative summary of the assessment results and pertinent water quality projects completed or planned for the 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 subwatershed (i.e., where sufficient information was available to make an assessment). Primarily, these tables reflect the results of the 2012 assessment process 2014 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 5). Assessment of aquatic life is derived from the analysis of biological (fish and invertebrate IBIs), dissolved oxygen, TSS, chloride, pH and un-ionized ammonia (NH3) data, while the assessment of aquatic recreation in streams is based solely on bacteria (Escherichia coli or fecal coliform) data. Included in each table is the specific aquatic life use classification for each stream reach: cold water community (2A); cool or warm water community (2B); or indigenous aquatic community (2C). Stream reaches that do not have sufficient information for either an aquatic life or aquatic recreation assessment (from current or previous assessment cycles) may not be included in these tables, but are included in Appendix 4.2 and Appendix 4.3. 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 12-HUC subwatershed as well as in the watershed-wide results and discussion section.

Stream habitat results

Habitat information documented during each fish sampling visit is provided in each aggregated 12-HUC subwatershed section. These tables 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 12-HUC subwatershed.

Stream stability results

Stream channel stability information evaluated during each invertebrate sampling visit is provided in each aggregated 12-HUC subwatershed section. These tables display the results of the Channel Condition and Stability Index (CCSI) which rates the geomorphic stability of the stream reach sampled for biology. The CCSI rates three regions of the stream channel (upper banks, lower banks, and bottom) which may provide an indication of stream channel geomorphic changes and loss of habitat quality which may be related to changes in watershed hydrology, stream gradient, sediment supply, or sediment transport capacity. The CCSI was recently implemented in 2008, and is collected once at each biological station. Consequently, the CCSI ratings are only available for biological visits sampled in 2010 or later. The final row in each table displays the average CCSI scores and a rating for the aggregated 12-HUC subwatershed.

Subwatershed outlet water chemistry results

These summary tables display the water chemistry results for the monitoring station representing the outlet of the aggregated 12-HUC subwatershed. This data along with other data collected within the 10 year assessment window can provide valuable insight on water quality characteristics and potential parameters of concern within the watershed. Parameters included in these tables are those most closely related to the standards or expectations used for assessing aquatic life and recreation. While not all of the water chemistry parameters of interest have established water quality standards, McCollor and Heiskary (1993) developed ecoregion expectations for a number of parameters that provide a basis for evaluating stream water quality data and estimating attainable conditions for an ecoregion. For comparative purposes, water chemistry results for the Leech Lake River Watershed are compared to expectations developed by McCollor and Heiskary (1993) that were based on the 75th percentile of a long-term dataset of least impacted streams within each ecoregion.

Lake assessments

A summary of lake water quality is provided in the aggregated 12-HUC subwatershed sections where available data exists. For lakes with sufficient data, basic modeling was completed. Assessment results for all lakes in the watershed are available in Appendix 3.2. Lake models and corresponding morphometric inputs can be found in Appendix 5.2.

Steamboat River Subwatershed HUC 0701010201-01

The Steamboat River Subwatershed drains approximately 134 square miles of land within the northwestern portion of the Leech Lake River Watershed. The Steamboat River originates out of Steamboat Lake and flows south for approximately four miles before entering Steamboat Bay of Leech Lake. The river has a low gradient and a wetland dominated riparian area. Several tributaries flow into Steamboat Lake. The most significant tributary is the Necktie River. The Necktie River originates from a wetland near the community of Rosby. Early in its course the Necktie River is a low gradient cold water stream that supports a brook trout fishery. The Necktie River flows toward the southeast for approximately six miles before turning toward the south. After flowing southward for approximately two miles the Necktie River is joined by Bungashing Creek. Bungashing Creek drains the west central portion of the Steamboat River Subwatershed. The Necktie River continues flowing southward another six miles before towards the east where it is joined by a small tributary known as Pokety Creek. After the confluence of Pokety Creek, the Necktie winds eastward for several miles before emptying into Steamboat Lake. Other major lakes within the subwatershed include Little Portage and Swamp Lake. Land use is primarily forest (57.9%) followed by wetland (16.9%), rangeland (17.1%), open water (3.7%), developed land (3.1%), and cropland (1.3%). Communities within the subwatershed include Farris, Nary, Guthrie, and Wilkinson. In 2012, the MPCA collected biological samples from five monitoring stations, one of which was intensively monitored for water chemistry. The monitoring stations were located on five stream segments.

Table 1. Aquatic life and recreation assessments on stream reaches: Steamboat River Subwatershed. Reaches are organized upstream to downstream in the table.

AUID *Reach Name*, Reach Description	Reach Length (miles)	Use Class	Biological Station ID	Location of Biological Station	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Chloride	pH	NH_3	Pesticides	Aquatic Rec. Indicators: Bacteria	Nutrients	Aquatic Life	Aquatic Rec.
07010102-550 Necktie River Unnamed ditch to T145 R32W S16, east line	6.93	CWg	09UM085	Upstream of CSAH 45, 6 mi SE of Bemidji	MTS	IF	IF	IF	-	IF	-	-	-	-	IF	NA
07010102-502 Necktie River Pokety Creek to Steamboat Lake	6.03	WWg	12UM088	Upstream of CR 45, 5 mi. W of Wilkenson	NA	-	NA	SUP	SUP	SUP	SUP	-	SUP	-	NA	SUP
07010102-505 Bungashing Creek T145 R33W S34, south line to Necktie R	7.49	CWe	12UM096	Downstream of CR 45, 3 mi. SE of Nary	MTS	MTS	IF	IF	-	IF	-	-	-	-	SUP	NA
07010102-527 Pokety Creek T144 R33W S24, north line to Necktie R	4.54	WWg	12UM097	Downstream of 414th St, 3 mi. S of Guthrie	MTS	-	IF	IF	-	IF	-	-	-	-	SUP	NA
07010102-507 Steamboat River Steamboat Lake to Leech Lake	3.91	WWg	12UM138	Downstream of HWY 371, 0.5 mi. E of Wilkenson	NA	-	IF	MTS	-	IF	-	-	-	-	NA	NA

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 2014 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 2. Minnesota Stream Habitat Assessment (MSHA): Steamboat River Subwatershed.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
2	09UM085	Necktie River	4.1	12.2	8.5	14	22	60.8	Fair
1	12UM096	Bungashing Creek	5	12	20.9	17	33	87.9	Good
1	12UM097	Pokety Creek	5	14.5	9	11	19	58.5	Fair
1	12UM088	Necktie River	5	9.5	10.6	10	23	58.1	Fair
1	12UM138	Steamboat River	5	10	9	13	12	49.0	Fair
Average Habitat Results: *Steamboat River Subwatershed*			**5**	**11.6**	**11.6**	**13**	**21.9**	**62.8**	**Fair**

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)

Table 3. Channel Condition and Stability Assessment (CCSI): Steamboat River Subwatershed.

# Visits	Biological Station ID	Stream Name	Upper Banks (43-4)	Lower Banks (46-5)	Substrate (37-3)	Channel Evolution (11-1)	CCSI Score (137-13)	CCSI Rating
2	09UM085	Necktie River	6.5	8.5	13	2.5	30.5	Fairly stable
2	12UM096	Bungashing Creek	7	13.5	10.5	2	33	Fairly stable
Average Stream Stability Results: *Steamboat River Subwatershed*			**6.7**	**11**	**11.7**	**2.2**	**31.7**	**Fairly Stable**

Qualitative channel stability ratings

= stable: CCSI < 27 = fairly stable: 27 < CCSI < 45 = moderately unstable: 45 < CCSI < 80 = severely unstable: 80 < CCSI < 115 = extremely unstable: CCSI > 115

Table 4. Outlet water chemistry results: Steamboat River Subwatershed.

Station location:	**Necktie River at County State Aid Highway 45. Site is located 2.5 miles northeast of Laporte, Minnesota.**						
STORET/EQuIS ID:	**S006-256**						
Station #:	**0701010201-04**						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	ug/L	10	0.2	4.2	1.5	40	0
Chloride	mg/L	11	4	8	6	230	0
Dissolved Oxygen (DO)	mg/L	19	1.7	11.3	6.1	5	8
pH		19	7.1	8.5	7.7	6.5 - 9	0
Secchi Tube	100 cm	19	100	100	100	varies	
Total suspended solids	mg/L	11	1	5	3	varies	
Escherichia coli (geometric mean)	MPN/100ml	3	31	57	-	126	0
Escherichia coli	MPN/100ml	16	14	138	36	1260	0
Chlorophyll-a, Corrected	ug/L	-	-	-	-	-	-
Inorganic nitrogen (nitrate and nitrite)	mg/L	11	0.03	0.03	0.03	-	-
Kjeldahl nitrogen	mg/L	11	0.4	0.7	0.6	-	-
Orthophosphate	ug/L	-	-	-	-	-	-
Pheophytin-a	ug/L	-	-	-	-	-	-
Phosphorus	ug/L	11	32	107	66	-	-
Specific Conductance	uS/cm	19	372	469	422	-	-
Temperature, water	deg °C	19	13.5	25.8	20.7	-	-
Sulfate	mg/L	11	3	3	3	-	-
Hardness	mg/L	11	174	229	206	-	-

[1]Secchi Tube standards are surrogate standards derived from the total suspended solids standard of 15 mg/L.

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Steamboat River Subwatershed, a component of the IWM work conducted between May and September from 2012 and 2013. This specific data does not necessarily reflect all data that was used to assess the AUID.**

Table 5. Lake assessments: Steamboat River Subwatershed.

Name	DNR Lake ID	Area (acres)	Trophic Status	Percent Littoral	Max. Depth (m)	Mean Depth (m)	CLMP Trend	Mean TP (µg/L)	Mean chl-a (µg/L)	Mean Secchi (m)	AQR Support Status	AQL Support Status
Portage	11-0490-00	360	M	48.3	19.8	6.4	NT	16.1	4.6	3.4	FS	NA
Steamboat	11-0504-00	1,761	M	30	28.3	11.0	I	19.0	4.4	3.8	FS	NA
Hart	29-0063-00	208	E	100	3.2			43.4	38.8	1.1	NS	IF

Abbreviations: D -- Decreasing/Declining Trend; I -- Increasing/Improving Trends; NT – No Trend; **H** – Hypereutrophic; **E** – Eutrophic; **M** – Mesotrophic; **O** - Oligotrophic; **FS** – Full Support; **NS** – Non-Support; **IF** – Insufficient Information

Key for Cell Shading: = existing impairment, listed prior to 2012 reporting cycle; = new impairment; = full support of designated use

Summary

Three stream segments (AUIDs) within the Steamboat River Subwatershed were assessed for aquatic life use support. Biological monitoring stations 09UM085 and 12UM088 were located on the Necktie River. A FIBI score of 100 at station 09UM085, on the upper cold water segment of the Necktie River, was the highest FIBI score in the entire Leech Lake River Watershed. Beaver activity appears to be influencing the habitat within this segment. As a result, substrate at station 09UM085 consisted almost entirely of silt and there was very little woody debris. While the limited habitat did not appear to negatively impact the fish community, it may have contributed to low MIBI scores from both the 2012 and 2013 visits. Cold water obligate invertebrate taxa were present in all samples but the diversity of the invertebrate community was low. Additional monitoring will be conducted in 2016 to determine if better habitat and invertebrate communities are located outside the sampling reach. Aquatic life use will be assessed using the results from additional monitoring.

The lower station (12UM088) was located approximately two miles above the confluence of the Necktie River with Steamboat Lake. The sampling reach was dominated by wetland like habitat with dense macrophytes, both emergent and submergent, present throughout the reach. Several large wetland areas were also located upstream of the station. The fish community contained predominately wetland species such as yellow perch and various bullhead species resulting in a FIBI score that was slightly below the impairment threshold. Invertebrates were not sampled at this location because most of the station was not wadeable. Dissolved oxygen levels were periodically low during the 2012 monitoring year. The poor fish community and occurrence of low dissolved oxygen likely occur naturally as a result of the influence of the surrounding wetlands. As a result, dissolved oxygen was not assessed for this reach (AUID 07010102-502). The Necktie River met the standard for bacteria and is considered full support for aquatic recreation use.

Several monitoring stations were located on smaller streams in the subwatershed. One brook trout was captured on Bungashing Creek (12UM096), a designated cold water stream. The sample was dominated by pearl dace and contained several other sensitive species. The high FIBI and MIBI scores (74.6 and 52, respectively) qualified this reach as exceptional; this was the only stream segment within the Leech Lake River Watershed to receive this designation. Pokety Creek (12UM097) was originally designated as a cold water stream but data from temperature loggers deployed over the summer suggest that it is cool water. The fish sample contained some sensitive species and the FIBI score was good. Invertebrates were not sampled at 12UM097 because there was no definable channel at the time of sampling (two months after the fish sample was obtained).

The Steamboat River (12UM138) had an extensive wetland riparian area and thick submergent vegetation across the channel. Low numbers of primarily wetland inhabiting species were collected in 2012 and 2013, resulting in poor FIBI scores. Not surprisingly, low dissolved oxygen levels were also measured at both fish visits. The segment was not assessed due to heavy wetland influence and a lack of a suitable FIBI for large low gradient streams.

Three lakes in the Steamboat River Subwatershed were assessed for aquatic recreation. Hart Lake is shallow with an extensive wild rice bed around the periphery. The lake is home to many species of waterfowl. The Necktie River flows into Hart Lake from the north and exits on the south side. Hart Lake's watershed is primarily forested, open water, and wetlands with limited amounts of pasture and cropland. The large watershed-to-lake ratio of 208:1 makes identifying sources of nutrients difficult. High nutrient levels in Hart Lake suggest that during certain times of the year high concentrations of phosphorus causes high chlorophyll-a (Chl-a) concentrations and nuisance algal blooms. Water clarity in Hart Lake is influenced by bog stained water, suspended algae, and high total suspended solids (TSS) concentrations. The Necktie River was previously ditched but the channel has reestablished itself to a natural condition with good sinuosity. In spite of this, the hydrology of the Necktie River may still be altered by historical ditching, accelerating the transport of nutrients from the watershed into Hart Lake. Other activities in Hart Lake's watershed include eight feedlots, minimal logging, and permitted facilities such as gravel pits and wood mills. The impacts of these activities on Hart Lake are likely negligible. Another factor that may contribute to the poor water quality in Hart Lake is water depth. Hart Lake is one of the few shallow lakes in the Leech Lake River Watershed. The shallow depth allows nutrients to be recycled from the bottom sediments during wind events causing internal loading.

Two additional lakes, Steamboat and Portage, fully supported aquatic recreation. Steamboat Lake has good water quality, despite the fact that the Necktie River enters into Steamboat Lake downstream of Hart Lake. The deep basin of Steamboat Lake has the ability to assimilate phosphorus within its sediments, which would mitigate any additional loading from the Necktie River. Portage Lake has a small contributing watershed and good water quality.

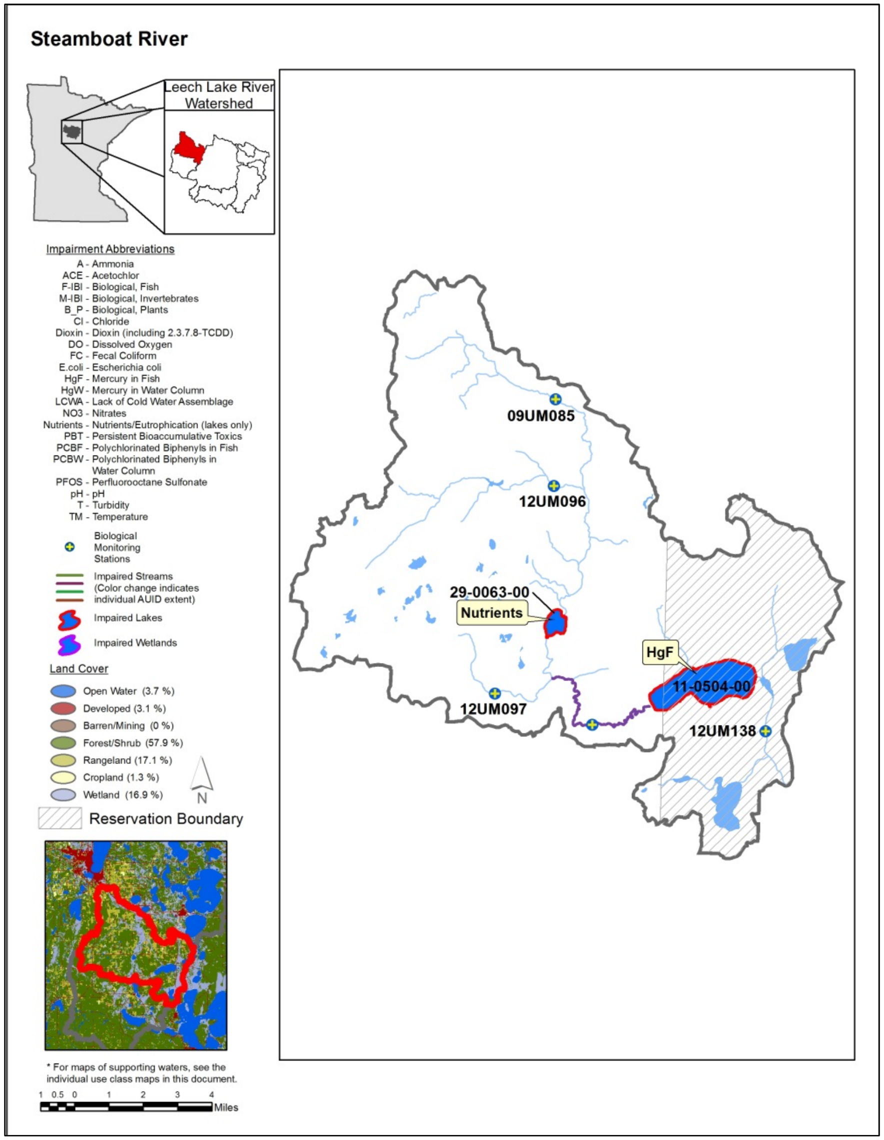

Figure 19. Currently listed impaired waters by parameter and land use characteristics in the Steamboat River Subwatershed

Kabekona River Subwatershed HUC 0701010202-01

The Kabekona River Subwatershed drains approximately 120 square miles of land within the western portion of the Leech Lake River Watershed. The Kabekona River is a beautiful cold water stream with a naturally reproducing population of brook trout. The river originates from a wetland area in the Paul Bunyan State Forest and flows toward the southeast for several miles. Eventually the Kabekona River begins to wind eastward and then turns sharply toward the south near the community of Laporte. The river continues to flow south until it enters the western side of Kabekona Lake. After it flows out of the eastern side of Kabekona Lake, the Kabekona River becomes low gradient stream with a very wetland influenced channel. The river then winds toward the southeast for several miles and enters Kabekona Bay of Leech Lake. Numerous small unnamed tributaries enter the Kabekona River. Tributaries to Kabekona Lake include Sucker Creek and Gulch Creek. Other major lakes within the subwatershed include Garfield, Oak, and Horseshoe. Land within the subwatershed is primarily forested (73.2%) followed by wetland (10.5%), rangeland (6.9%), open water (5.9%), and developed (2.6%). The communities of Kabekona, Laporte, and Benedict are found within the Kabekona River Subwatershed. In 2012, the MPCA collected biological samples from four monitoring stations within the subwatershed. One station was intensively monitored for water chemistry. The monitoring stations were located on three stream segments within the subwatershed.

Table 6. Aquatic life and recreation assessments on stream reaches: Kabekona River Subwatershed. Reaches are organized upstream to downstream in the table.

					Aquatic Life Indicators:										
AUID ***Reach Name*,** *Reach Description*	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Chloride	pH	NH_3	Pesticides	Bacteria	**Aquatic Life**	**Aquatic Rec.**
07010102-511 Kabekona River Headwaters to Kabekona Lake	16.47	CWg	09UM084 12UM102	Upstream of CR 257, 2 mi. E of Kabekona Upstream of CR 93, 2 mi. SW of Laporte	MTS	MTS	MTS	EXS	SUP	MTS	-	-	EXS	SUP	IMP
07010102-611 Sucker Branch Lester Lake to Kabekona Lake	2.12	WWg	12UM094	Downstream of CR 37, 4 mi. SW of Laporte	MTS	MTS	IF	IF	-	IF	-	-	-	SUP	NA
07010102-528 Kabekona River Kabekona Lake to Leech Lake (Kabekona Bay)	5.33	WWg	12UM090	Downstream of CR 38, 0.5 mi. S of Benedict	NA	-	EXS	MTS	MTS	MTS	MTS	-	MTS	NA	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 2014 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. Minnesota Stream Habitat Assessment (MSHA): Kabekona River Subwatershed.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
3	09UM084	Kabekona River	4.6	14	18.1	14.3	26.3	77.5	Good
1	12UM094	Sucker Branch	5	13.5	18.2	11	28	75.7	Good
1	12UM090	Kabekona River	5	11	3	13	6	38	Poor
		Average Habitat Results: *Kabekona River Subwatershed*	**4.8**	**12.8**	**13.1**	**12.8**	**20.1**	**63.7**	**Fair**

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)

Table 8. Channel Condition and Stability Assessment (CCSI): Kabekona River Subwatershed.

# Visits	Biological Station ID	Stream Name	Upper Banks (43-4)	Lower Banks (46-5)	Substrate (37-3)	Channel Evolution (11-1)	CCSI Score (137-13)	CCSI Rating
1	09UM084	Kabekona River	7	8	4	3	22	Stable
1	12UM094	Sucker Branch	19	9	6	3	37	Fairly stable
		Average Stream Stability Results: *Kabekona River Subwatershed*	**13**	**8.5**	**5**	**3**	**29.5**	**Fairly stable**

Qualitative channel stability ratings

= stable: CCSI < 27 = fairly stable: 27 < CCSI < 45 = moderately unstable: 45 < CCSI < 80 = severely unstable: 80 < CCSI < 115 = extremely unstable: CCSI > 115

Table 9. Outlet water chemistry Results: Kabekona River Subwatershed .

Station location:	**Kabekona River at CSAH-38, 5.one mile southeast of Laporte, Minnesota.**						
STORET/EQuIS ID:	**S007-103**						
Station #:	**0701010202-01**						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	ug/L	10	0.2	3.3	1.3	40	0
Chloride	mg/L	11	4	4	4	230	0
Dissolved Oxygen (DO)	mg/L	19	2.7	10.8	6.6	5	5
pH		19	7.0	8.5	7.8	6.5 - 9	0
Secchi Tube	100 cm	19	100	100	100	varies	
Total suspended solids	mg/L	11	1	4	2	varies	
Escherichia coli (geometric mean)	MPN/100 ml	3	2	7	-	126	0
Escherichia coli	MPN/100 ml	16	1	10	6	1260	0
Chlorophyll-a, Corrected	ug/L	-	-	-	-	-	-
Inorganic nitrogen (nitrate and nitrite)	mg/L	11	0.03	0.03	0.03	-	-
Kjeldahl nitrogen	mg/L	3	0.4	0.4	0.4	-	-
Orthophosphate	ug/L	-	-	-	-	-	-
Pheophytin-a	ug/L	-	-	-	-	-	-
Phosphorus	ug/L	11	12	21	16	-	-
Specific Conductance	uS/cm	19	322	360	336	-	-
Temperature, water	deg °C	19	14.1	26.7	21.3	-	-
Sulfate	mg/L	11	3	3	3	-	-
Hardness	mg/L	11	2	173	145	-	-

[1]Secchi Tube standards are surrogate standards derived from the total suspended solids standard of 15 mg/L.

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Kabekona River Subwatershed, a component of the IWM work conducted between May and September from 2012 and 2013. This specific data does not necessarily reflect all data that was used to assess the AUID.**

Table 10. Lake water aquatic recreation assessments: Kabekona River Subwatershed.

Name	DOW#	Area (ha)	Trophic Status	Percent Littoral	Max. Depth (F)	Avg. Depth (F)	CLMP Trend	Mean TP (µg/L)	Mean Chl-a (µg/L)	Secchi Mean (F)	Support Status
Horseshoe	29-0059-00	267	O		15.2			11.7	4.5	3.9	FS
Garfield	29-0061-00	954	M	53.2	9.1	4.3	NT	15.9	9.6	3.3	FS
Kabekona	29-0075-00	2,435	O	23.6	40.5	15.3	I	11.5	3.0	4.0	FS
Twenty-One	29-0130-00	33	O	82.1	15.7			9.3	2.2	5.3	FS
Nelson	29-0131-00	38	O	97	5.9			10.1	3.0	4.9	FS
Bass	29-0132-00	18	M		0.0			13.3	8.7	2.5	FS
McCarty	29-0224-00	12	O	63.6	9.8			9.9	4.4	3.4	FS

Abbreviations: ↘ -- Decreasing/Declining Trend; ↗ -- Increasing/Improving Trends; NT – No Trend; **H** – Hypereutrophic; **E** – Eutrophic; **M** – Mesotrophic; **FS** – Full Support; **NS** – Non-Support; **IF** – Insufficient Information

Summary

Two stream segments within the Kabekona River Subwatershed were assessed for aquatic life. All biological monitoring stations were located on the Kabekona River, except station 12UM094, which was located on Sucker Branch. Sucker Branch had abundant coarse substrate and good channel development. The fish sample contained a few sensitive species and the FIBI score was good. The MIBI score (82.5) was the highest MIBI score in the Leech Lake River Watershed. Stations 09UM084 and 12UM102 were located on the cold water designated segment of the Kabekona River. Station 09UM084 was visited in 2010, 2011, and 2013. Consistent numbers of brook trout and mottled sculpin were captured during each visit. FIBI scores ranged from good to exceptional. Station 12UM102, located downstream of station 09UM084, also had brook trout and sculpin but contained more warm water species. The FIBI score from the 2012 sample was good. All MIBI scores were good for both stations; sensitive taxa and cold water obligate taxa were present in all samples.

The furthest downstream site on the Kabekona River (12UM090) was located on a five mile segment between Kabekona Lake and Kabekona Bay of Leech Lake. This segment flowed through extensive wetlands and the channel had a lot of submergent vegetation. Aquatic life use was not assessed on this segment because of the wetland characteristics. The segment met the standard for bacteria and fully supported aquatic recreation.

Seven lakes in the Kabekona River Subwatershed fully support aquatic recreation: Horseshoe, Garfield, Kabekona, Twenty-One, Nelson, Bass, and McCarty. Twenty-One, Nelson, Bass, and McCarty are all small lakes located within the Paul Bunyan State Forest. As a result, these lakes have protected watersheds with little human disturbance and a minimal risk of water quality degradation. Horseshoe Lake is not located within the Paul Bunyan State Forest but it also has a small, forested watershed and a low risk of water quality degradation. Kabekona Lake is the largest and deepest lake in the subwatershed; it is a high value resource with significant development around its shoreline. The lake's depth allows for assimilation of phosphorus within lake bed sediments. This benefit helps to sequester phosphorus loads that enter the lake from runoff and human disturbances within the watershed. Adoption of best management practices by lake shore home owners will ensure Kabekona continues to have excellent water quality. Garfield Lake supports aquatic recreation but it has the most potential for degradation. The city of La Porte borders Garfield Lake; both the watershed and shoreline have significant development. Compared to other lakes in this subwatershed, Garfield is relatively shallow and any additional nutrient loads would likely result in degraded water quality and greater probability of algae blooms.

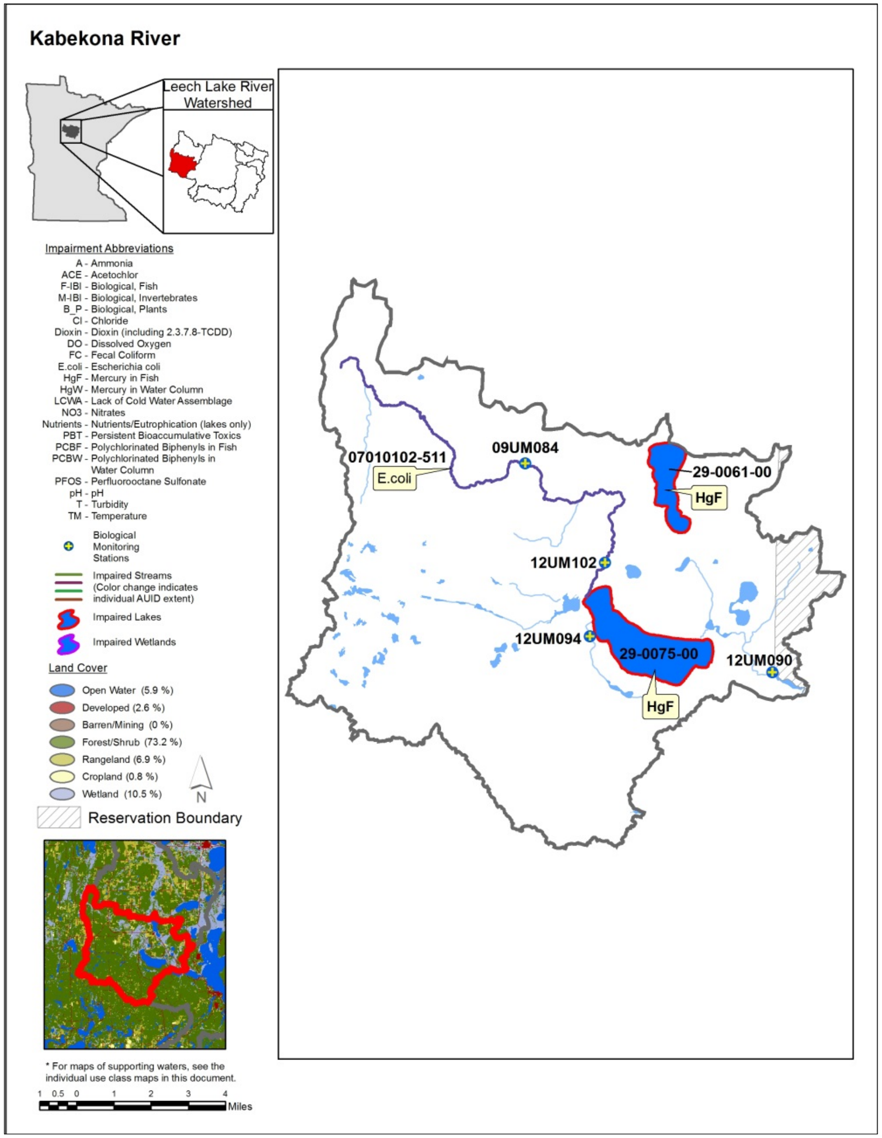

Figure 20. Currently listed impaired waters by parameter and land use characteristics in the Kabekona River Subwatershed.

Leech Lake Subwatershed HUC 0701010205-01

The Leech Lake Subwatershed drains approximately 519 square miles of land within the central portion of the Leech Lake River Watershed. Almost the entire subwatershed lies within the Leech Lake Indian Reservation and the Chippewa National Forest. The subwatershed encompasses Leech Lake and many of its numerous tributaries including Shingobee Creek, Sucker Creek, Portage Creek, and other small streams. Shingobee Creek flows north out of Steel Lake for a short distance before entering the south end of Shingobee Lake. After Shingobee Lake the creek flows east for several miles before turning northeast and entering Shingobee Bay of Leech Lake. Sucker Creek flows south out of Lower Sucker Lake and into the north end of Sucker Bay on Leech Lake. Portage Creek flows south out of Portage Lake and into Waboose Bay of Leech Lake. Other major lakes within the subwatershed include Portage, Benedict, Welsh, Crooked, and Lower Sucker. The land in the subwatershed is primarily forested (45.8%) followed by open water (34.1%), wetland (16.4%), developed land (1.6%), rangeland (1.8%) and cropland (0.3%). The communities of Walker, Whipholt, Ah-gwah-ching, and Onigum are found within the Leech Lake subwatershed. In 2012, the MPCA monitored one biological monitoring station (on one stream segment) within the subwatershed. The number of monitoring sites was limited due to the close proximity of the many lakes and wetlands throughout the subwatershed.

Table 11. Aquatic life and recreation assessments on stream reaches: Leech Lake Subwatershed. Reaches are organized upstream to downstream in the table.

					Aquatic Life Indicators:								Aquatic Rec. Indicators:			
AUID ***Reach Name***, *Reach Description*	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Chloride	pH	NH_3	Pesticides	Bacteria	Nutrients	**Aquatic Life**	**Aquatic Rec.**
07010102-530 Shingobee River Unnamed creek (Howard Lake outlet) to Unnamed creek (Anoway Lake outlet)	3.67	WWg	12UM091	Upstream of CR 83, 3 mi. E of Akeley	MTS	MTS	MTS	IF	MTS	MTS	MTS	-	MTS	-	SUP	SUP

Abbreviations for Indicator Evaluations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **MTS** = Meets criteria; **EXP** = Exceeds criteria, potential impairment; **EXS** = Exceeds criteria, potential severe impairment; **EX** = Exceeds criteria (Bacteria).

Abbreviations for Use Support Determinations: **NA** = Not Assessed, **IF** = Insufficient Information, **NS** = Non-Support, **FS** = Full Support
Key for Cell Shading: = existing impairment, listed prior to 2012 reporting cycle; = new impairment; = full support of designated use.

Table 12. Minnesota Stream Habitat Assessment (MSHA): Leech Lake Subwatershed.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
2	12UM091	Shingobee River	5	11	15.7	14	23.5	69.2	Good
		Average Habitat Results: *Leech Lake Subwatershed*	5	11	15.7	14	23.5	69.2	Good

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)

Table 13. Channel Condition and Stability Assessment (CCSI): Leech Lake Subwatershed.

# Visits	Biological Station ID	Stream Name	Upper Banks (43-4)	Lower Banks (46-5)	Substrate (37-3)	Channel Evolution (11-1)	CCSI Score (137-13)	CCSI Rating
1	12UM091	Shingobee River	8	15	9	3	35	Fairly stable
		Average Stream Stability Results: *Leech Lake Subwatershed*	**8**	**15**	**9**	**3**	**35**	**Fairly stable**

Qualitative channel stability ratings

= stable: CCSI < 27 = fairly stable: 27 < CCSI < 45 = moderately unstable: 45 < CCSI < 80 = severely unstable: 80 < CCSI < 115 = extremely unstable: CCSI > 115

Table 14. Outlet water chemistry results: Leech Lake Subwatershed.

Station location:	**Shingobee River at CSAH-83/Forest Rt 2314, three miles east of Akeley, Minnesota.**						
STORET/EQuIS ID:	**S007-102**						
Station #:	**0701010205-01**						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	ug/L	10	0.3	3.7	1.7	40	0
Chloride	mg/L	11	1	3	2	230	0
Dissolved Oxygen (DO)	mg/L	20	5.7	9.4	7.6	5	0
pH		20	7.5	8.2	7.9	6.5 - 9	0
Secchi Tube	100 cm	20	100	100	100	varies	
Total suspended solids	mg/L	11	1	8	4	varies	
Escherichia coli (geometric mean)	MPN/100ml	3	43	81	-	126	0
Escherichia coli	MPN/100ml	16	15	110	62	1260	0
Chlorophyll-a, Corrected	ug/L	-	-	-	-	-	-
Inorganic nitrogen (nitrate and nitrite)	mg/L	11	0.03	0.03	0.03	-	-
Kjeldahl nitrogen	mg/L	9	0.3	0.5	0.4	-	-
Orthophosphate	ug/L	-	-	-	-	-	-
Pheophytin-a	ug/L	-	-	-	-	-	-
Phosphorus	ug/L	11	29	46	37	-	-
Specific Conductance	uS/cm	20	341	388	358	-	-
Temperature, water	deg °C	20	12.6	26.8	21.9	-	-
Sulfate	mg/L	11	3	3	3	-	-
Hardness	mg/L	11	143	195	171	-	-

[1]Secchi Tube standards are surrogate standards derived from the total suspended solids standard of 15 mg/L.

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Leech Lake Subwatershed, a component of the IWM work conducted between May and September from 2012 and 2013. This specific data does not necessarily reflect all data that was used to assess the AUID.**

Table 15. Lake assessments: Leech Lake Subwatershed.

Name	DNR Lake ID	Area (acres)	Trophic Status	Percent Littoral	Max. Depth (m)	Mean Depth (m)	CLMP Trend	Mean TP (µg/L)	Mean chl-a (µg/L)	Mean Secchi (m)	AQR Support Status	AQL Support Status
Three Island	11-0177-00	287	M	100	4.0			16.1	4.6	3.7	FS	NA
Leech (Main Basin)	11-0203-01	101995	M		45.7	4.9	NT	17.1	3.0	2.9	FS	NA
Leech (Kabekona Bay)	11-0203-02	970	M		45.7	8.1	IF	13.9	3.8	3.9	FS	NA
Leech (Ah-Gwah-Chin)	11-0203-03	65	M		45.7		NT			3.6	IF	NA
Leech (Shingobee Bay)	11-0203-04	319	M		45.7		I	17.9	5.3	3.7	FS	NA
Portage	11-0204-00	1528	E	45.3	16.2	5.1	IF	25.7	11.9	2.2	FS	NA
Horseshoe	11-0284-00	130	M	100	3.7			24.0		2.7	IF	NA
Pine	11-0292-00	258	M	62	7.6			14.6	5.6	3.7	FS	NA
Lower Sucker	11-0313-00	571	E	51	10.7	4.4		27.5	14.8	2.4	IF	NA
Jack	11-0400-00	141	O	20	24.4			9.7	2.4	4.7	FS	NA
Howard	11-0472-00	372	O	27.3	18.6			8.4	2.1	4.5	FS	NA
Long	11-0480-00	273	M	30	24.4	6.9		12.8	3.4	4.0	FS	IF
May	11-0482-00	135	O	40	15.2	5.4		9.1	2.5	5.8	FS	IF
Twin	11-0484-00	162	E	100	3.0			34.4	2.3	1.7	FS	NA
Thirteen	11-0488-00	554	M	73.4	17.1	3.9		15.8	4.6	3.9	FS	NA
Welch	11-0493-00	190	M	41.1	18.0			20.8	7.3	2.8	FS	NA
Crooked	11-0494-00	551	M		22.6	6.3		22.0	4.7	2.7	FS	IF
Williams	29-0015-00	92	O	44.6	9.8		IF	11.5	2.7	5.7	FS	NA
Shingobee	29-0043-00	168	M	27.2	11.9		D	17.8	6.7	3.7	FS	NA
Benedict	29-0048-00	471	O	39.1	27.7	10.4	NT	9.4	2.1	3.5	FS	IF

Abbreviations:
D -- Decreasing/Declining Trend
I -- Increasing/Improving Trends
NT – No Trend

H – Hypereutrophic
E – Eutrophic
M – Mesotrophic
O - Oligotrophic

FS – Full Support
NS – Non-Support
IF – Insufficient Information

Key for Cell Shading: = existing impairment, listed prior to 2014 reporting cycle; = new impairment; = full support of designated use

Summary

The fish community and habitat in the upper portion of the Shingobee River (station 12UM091) was nearly exceptional (MSHA Score = 72.2, FIBI = 66). The fish sample contained sensitive species and insectivores. Excellent habitat was present within the sampling reach. Surprisingly, the MIBI score from the 2012 sample was somewhat low so another attempt was made to sample macroinvertebrates in 2014. Unfortunately the site could not be sampled due to an impoundment created by a large beaver dam. Earlier in 2014, prior to sampling invertebrates, a fish sample was collected before the stream was impounded. The 2014 fish sample FIBI score (73) was exceptional. Water chemistry data indicated that the stream fully supported aquatic life and aquatic recreation.

All 16 lakes in the Leech Lake Subwatershed that were assessed supported aquatic recreation use. Four additional lakes had limited data and were not assessed. The Leech Lake Watershed is highly connected through hydrologic pathways. A network of smaller lakes and streams all drain into Leech Lake contributing to its overall nutrient budget. These lakes have diverse morphometric characteristics, ranging from shallow eutrophic basins to deep oligotrophic basins. Eutrophic lakes such as Portage, Lower Sucker, and Twin have the highest concentrations of phosphorus in the Leech Lake Subwatershed. Depending on connectivity and discharge volume these lakes could be potential sources of phosphorous to Leech Lake. City planners and lake shore residents should consider implementing best management practices to maintain good water quality in Leech Lake and the surrounding lakes. Direct flow pathways to Leech Lake should be identified and monitored for potential phosphorous inputs. In addition any potentially detrimental land use activities should be located in areas of the watershed with minimal hydrologic connections. Protection of the surrounding watershed and its flow path ways are vital to maintaining good water quality throughout this watershed. An effort should be made to maintain current water quality conditions by mitigating any potential impacts of altered land use or detrimental human activity within the watershed.

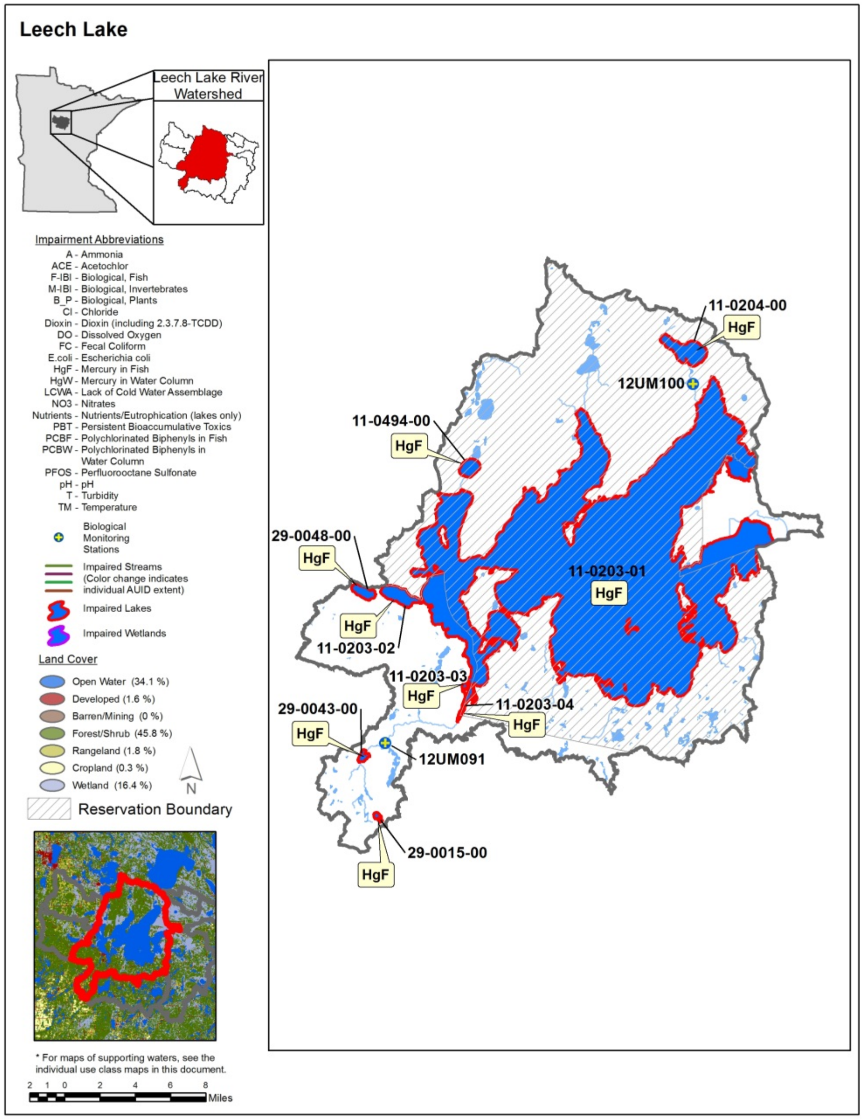

Figure 21**. Currently listed impaired waters by parameter and land use characteristics in the Leech Lake Subwatershed.**

Woman Lake Subwatershed HUC 0701010203-01

The Woman Lake Subwatershed drains approximately 162 square miles of land within the south central portion of the Leech Lake River Watershed. The headwaters of the Boy River, a major tributary of Leech Lake, are found within the subwatershed. Originating from Tenmile Lake, the Boy River flows generally east through a series of lakes before entering Woman Lake. The Boy River exits Woman Lake through a dam and passes into the next subwatershed. Other tributary streams found within the subwatershed are generally short and flow directly into lakes. There are many lakes within the Woman Lake Subwatershed; major lakes include Tenmile, Woman, Pleasant, Birch, Blackwater, Big Deep, Mule, Stony, Webb, Baby, and Mann Lake. The land in the subwatershed is primarily forested (64.4%) followed by open water (22.9%), wetland (7.3%), rangeland (2.9%), developed land (2.1%), and cropland (0.3%). No stream segments were monitored for biology due to the proximity of lakes and wetlands to all prospective monitoring locations.

Table 16. Lake assessments: Woman Lake Subwatershed.

Name	DNR Lake ID	Area (acres)	Trophic Status	Percent Littoral	Max. Depth (m)	Mean Depth (m)	CLMP Trend	Mean TP (µg/L)	Mean chl-a (µg/L)	Mean Secchi (m)	AQR Support Status	AQL Support Status
Girl	11-0174-00	414	M	67	24.7	5.0	NT	13.5	4.0	4.4	FS	IF
Mule	11-0200-00	518	M	44.3	14.3	6.2	NT	14.3	3.9	4.8	FS	NA
Broadwater Bay	11-0201-01	768	M	47.7	13.1	4.7		14.1	5.1	3.8	FS	IF
Woman (Main Basin)	11-0201-02	4754	M		18.3	5.8	I	14.4	4.0	4.3	FS	IF
Silver	11-0202-00	118	M	77.1	6.1			18.9	5.2	3.5	FS	NA
Ponto	11-0234-00	379	O		18.3	8.0	D	8.9	2.3	5.9	FS	NA
One	11-0244-00	70	O		0.0					4.8	IF	NA
Island	11-0257-00	183	M	57	12.2		NT	12.1	2.9	6.2	FS	NA
Long	11-0258-00	238	M	67	11.3		IF	13.5	2.6	5.1	FS	NA
McKeown	11-0261-00	164	M	86.9	11.3		NT	12.1	2.8	4.8	FS	NA
Kid	11-0262-00	166	M		15.8		NT	13.1	3.1	4.1	FS	NA
Child	11-0263-00	283	M	49.9	8.8	3.8	NT	16.5	4.9	3.8	FS	NA
Kerr	11-0268-00	80	M	35.6	24.1		NT	14.1	2.9	5.2	FS	NA
Lost	11-0269-00	71	M		7.9			15.7	4.1	4.2	FS	NA
Trillium	11-0270-00	150	E	66.9	14.6		I	25.1	7.9	2.9	FS	NA
Widow	11-0273-00	199	O	41.1	14.0	5.6	I	10.2	2.2	5.3	FS	NA
Blackwater	11-0274-00	758	M	47	20.4	5.9	I	14.4	3.7	4.3	FS	NA

Big Deep	11-0277-00	530	O	9.1	30.5	15.9	NT			6.5	IF	NA
Sand	11-0279-00	149	O	40.9	16.5	6.4	NT	9.8	2.1	6.3	FS	NA
Barnum	11-0281-00	147	O	62.7	8.8	3.1	NT	10.5	2.9	5.1	FS	NA
Man	11-0282-00	488	O	9.5	26.8	10.6	D	10.9	3.0	3.4	FS	NA
Baby	11-0283-00	729	M	33	21.0	6.9	I	12.7	3.6	4.4	FS	IF
Moccasin	11-0296-00	272	O	45	29.0	6.0		9.5	2.7	5.9	FS	NA
Webb	11-0311-00	718	M	36.8	25.6	6.9	NT	12.6	2.6	4.5	FS	NA
Stony	11-0371-00	562	O	30	15.2	7.2	D	11.0	2.3	6.2	FS	NA
Larson	11-0374-00	207	M		17.7			17.3	6.9	2.9	FS	NA
Surprise	11-0375-00	25	M	68.8	22.3			22.7	6.1	2.6	FS	NA
Blueberry	11-0376-00	23	E		0.0			30.6	10.6	1.7	IF	NA
Paquet	11-0381-00	134	M	80.6	5.8			21.5	5.5	3.5	FS	NA
Boss	11-0382-00	106	M		8.5			19.7	4.9	3.9	FS	NA
Pleasant	11-0383-00	1085	M	39.5	21.9	6.7	I	14.9	4.1	4.8	FS	NA
Little Webb	11-0387-00	221	M	60.2	11.3		NT	14.5	3.1	4.5	FS	IF
Birch	11-0412-00	1256	M	59	13.7	4.1	I	15.3	4.0	4.1	FS	IF
Ten Mile	11-0413-00	5025	M	28	63.4	15.7	I	15.6	1.8	5.7	FS	IF
Bass	11-0474-00	274	M		9.1			16.6	4.9	3.8	FS	NA
Portage	11-0476-00	279	O	34.1	25.6	9.9		7.8	2.1	7.6	FS	IF
Crystal	11-0502-00	190	O	82.7	12.5	2.9		10.3	2.5	4.7	FS	NA
Diamond Pond	11-1013-00	5	E		0.0			28.0	77.7	0.9	IF	NA

Abbreviations:

D -- Decreasing/Declining Trend
I -- Increasing/Improving Trends
NT – No Trend

H – Hypereutrophic
E – Eutrophic
M – Mesotrophic
O - Oligotrophic

FS – Full Support
NS – Non-Support
IF – Insufficient Information

Key for Cell Shading: ☐ = existing impairment, listed prior to 2014 reporting cycle; ☐ = new impairment; ☐ = full support of designated use

Summary

Thirty four lakes in the Women Lake Subwatershed were assessed for aquatic recreation. Four additional lakes had limited data but not enough for assessment. All thirty four assessed lakes fully supported aquatic recreation use, including prominent lakes such as Woman, Ten Mile, and Birch (Table 16). The Woman Lake Subwatershed has a high density of lakes that are connected to one another through a network of stream channels and diffuse wetlands. Surface water flows from the western portion of the subwatershed toward the east and exits through the Boy River. The largest lake in the subwatershed is Ten Mile, which is located in the headwaters of the watershed. Ten Mile Lake is a high value resource that has been studied in depth and is currently part of the SLICE (Sustaining Lakes in a Changing Environment) or Sentinel Lakes long term monitoring program. A link to the current Ten Mile report can be found here: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/lakes/sentinel-lakes.html. Woman Lake is the second largest lake in the watershed and is just upstream of the outlet to the Boy River. Water quality is exceptional in Woman Lake as well. The high density of lakes with excellent water quality in this subwatershed makes a compelling case for the adoption of protection strategies to minimize the impact on water quality from poor land use practices and development pressure. Residents within the subwatershed should be educated on the types of best management practices that will preserve the high water quality of these lakes for future generations.

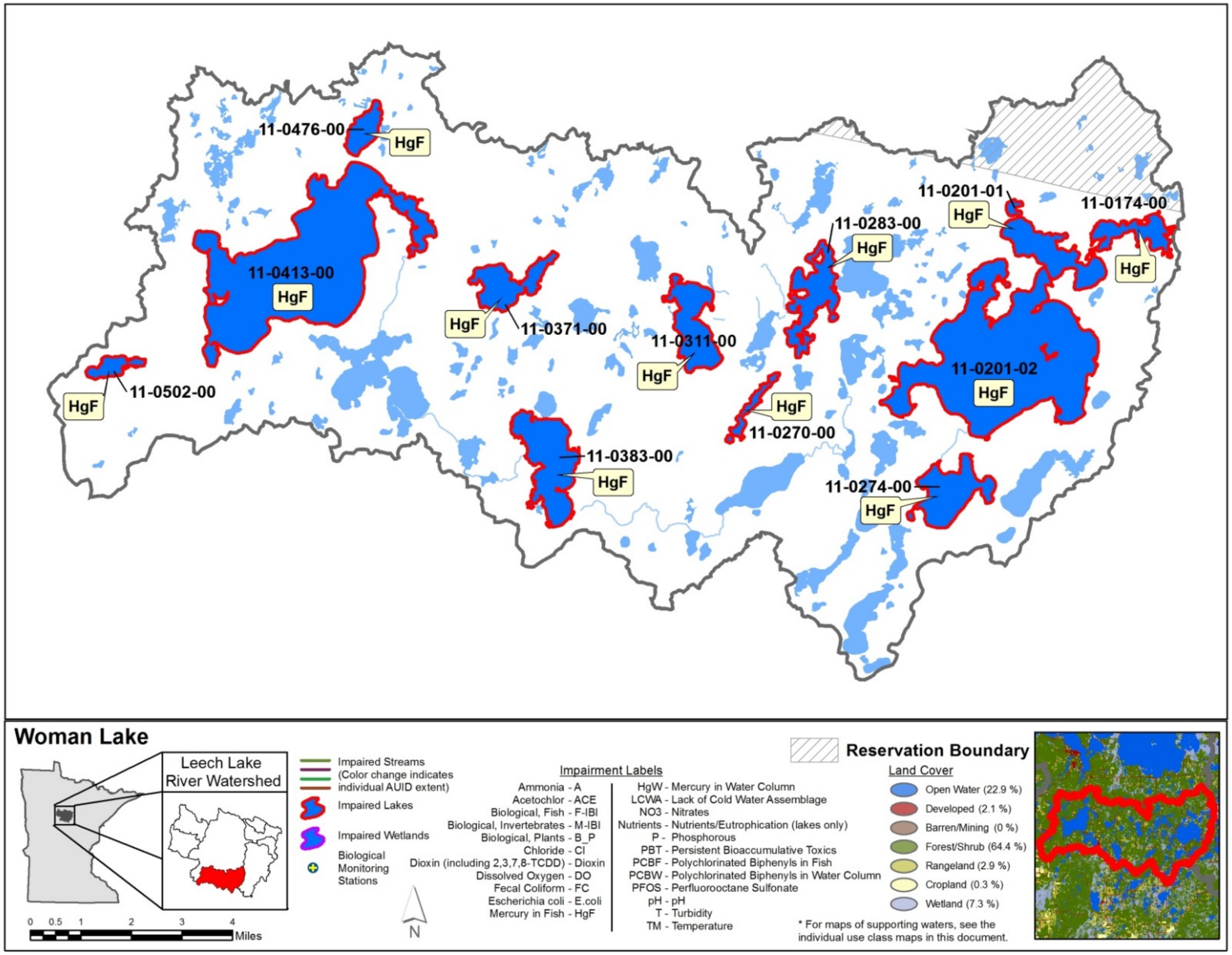

Figure 22. Currently listed impaired waters by parameter and land use characteristics in the Woman Lake Subwatershed.

Boy River Subwatershed HUC 0701010204-01

The Boy River Subwatershed drains approximately 232 square miles of land within the eastern portion of the Leech Lake River Watershed. The Boy River is the most significant tributary within the subwatershed. The Boy River exits Woman Lake through a dam and flows east into Inguadona Lake. The Boy River exits Inguadona Lake and continues flowing northward, passing through Boy Lake and entering Boy Bay of Leech Lake. Smaller tributaries within the subwatershed include Spring Creek, Northby Creek, the Swift River, and many other unnamed tributaries that mostly flow directly into lakes. Spring Creek drains a small area located in the far southeast corner of the Leech Lake River Watershed. Originating from a wetland, Spring Creek flows north and empties into Wabedo Lake. Northby Creek is a small stream that flows west into Inguadona Lake. The Swift River originates from Moon Lake and flows west through Little Swift Lake and Swift Lake before entering the Boy River on the north end of Boy Lake. Major lakes within the subwatershed include Wabedo, Inguadona, Little Boy, Boy, Swift, Long Lake, Lower Trelipe, Upper Trelipe, and Thunder. Land in the subwatershed is primarily forested (55.4%) followed by wetland (29.1 %), open water (11.1%), rangeland (2.5%), developed land (1.5%), and cropland (0.4%). The communities of Longville, Boy River, Tobique, and Inguadona are found within the Boy River Subwatershed. In 2012, the MPCA monitored six biological monitoring stations on six stream segments. Intensive water chemistry monitoring was conducted at three locations on the Boy River at sites coinciding with two of the biological monitoring stations.

Table 17. Aquatic life and recreation assessments on stream reaches: Boy River Subwatershed. Reaches are organized upstream to downstream in the table.

AUID ***Reach Name***, *Reach Description*	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Chloride	pH	NH_3	Pesticides	**Aquatic Rec. Indicators:** Bacteria	Nutrients	**Aquatic Life**	**Aquatic Rec.**
07010102-610 Spring Creek Headwaters to Wabedo Lake	3.66	WWg	12UM106	Downstream of CR 47, 2.5 mi. SW of Wabedo	MTS	EXS	IF	IF	-	IF	-	-	-	-	IMP	NA
07010102-524 Boy River Woman Lake to Rice Lake	6.18	WWg	12UM086		NA	-	IF	MTS	MTS	MTS	MTS	-	MTS	-	NA	SUP
07010102-612 Unnamed creek Headwaters to Northby Creek	0.17	WWg	12UM107	Upstream of S Inguadona Dr NE, 5 mi. SE of Longville	EXS	EXS	IF	IF	-	IF	-	-	-	-	IMP	NA
07010102-520 Boy River Inguadona Lake to Boy Lake	9.41	WWg	00UM012	Upstream of C.R. 53, 9 mi. NW Remer	MTS	MTS	MTS	MTS	MTS	MTS	MTS	-	MTS	-	SUP	SUP
07010102-538, Swift River Little Swift Lake to Swift Lake	2.03	WWg	12UM109	Upstream of CR 53, 6.5 mi. NW of Remer	MTS	MTS	IF	IF	-	IF	-	-	-	-	SUP	NA
07010102-518 Boy River Boy Lake to Leech Lake	8.35	WWg	12UM089	Upstream of CR 8, 2.5 mi. W of Boy River	NA	-	IF	MTS	MTS	MTS	MTS	-	MTS	-	NA	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 2014 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 18. Minnesota Stream Habitat Assessment (MSHA): Boy River Subwatershed.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
2	12UM106	Spring Creek	5	11	16	12	15	59	Fair
1	12UM107	Unnamed Creek	5	12	9.2	12	25	63.2	Fair
3	00UM012	Boy River	5	12.3	19.1	14.6	24.6	75.7	Good
2	12UM109	Swift River	5	11	8.1	14	14	52.1	Fair
		Average Habitat Results: *Boy River Subwatershed*	**5**	**11.5**	**13.1**	**13.1**	**19.6**	**62.5**	**Fair**

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)

Table 19. Channel Condition and Stability Assessment (CCSI): Boy River Subwatershed.

# Visits	Biological Station ID	Stream Name	Upper Banks (43-4)	Lower Banks (46-5)	Substrate (37-3)	Channel Evolution (11-1)	CCSI Score (137-13)	CCSI Rating
1	12UM106	Spring Creek	10	9	15	2	36	Fairly stable
1	12UM107	Unnamed Creek	4	9	18	4	35	Fairly stable
2	00UM012	Boy River	7.5	11.5	7.5	2.5	29	Fairly stable
1	12UM109	Swift River	8	11	6	3	28	Fairly stable
		Average Stream Stability Results: *Boy River Subwatershed*	**7.3**	**10.1**	**11.6**	**2.8**	**32**	**Fairly stable**

Qualitative channel stability ratings

= stable: CCSI < 27 = fairly stable: 27 < CCSI < 45 = moderately unstable: 45 < CCSI < 80 = severely unstable: 80 < CCSI < 115 = extremely unstable: CCSI > 115

Table 20. Outlet water chemistry results: Boy River Subwatershed.

Station location:	**Boy River at Sioux Camp Road northeast. Site is located two miles southeast of Longville, Minnesota.**						
STORET/EQuIS ID:	**S006-261**						
Station #:	**0701010204-01**						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	ug/L	10	0.7	2.3	1.1	40	0
Chloride	mg/L	10	2	5	3	230	0
Dissolved Oxygen (DO)	mg/L	20	1.2	14.1	5.5	5	11
pH		21	7.5	8.4	7.8	6.5 - 9	0
Secchi Tube	100 cm	21	100	100	100	varies	
Total suspended solids	mg/L	10	2	3	3	varies	
Escherichia coli (geometric mean)	MPN/100 ml	3	27	34	-	126	0
Escherichia coli	MPN/100 ml	15	8	54	26	1260	0
Chlorophyll-a, Corrected	ug/L	-	-	-	-	-	-
Inorganic nitrogen (nitrate and nitrite)	mg/L	10	0.03	0.03	0.03	-	-
Kjeldahl nitrogen	mg/L	10	0.4	5.7	1.0	-	-
Orthophosphate	ug/L	-	-	-	-	-	-
Pheophytin-a	ug/L	-	-	-	-	-	-
Phosphorus	ug/L	9	21	42	29	-	-
Specific Conductance	uS/cm	21	234	290	266	-	-
Temperature, water	deg °C	21	12.4	26.1	20.6	-	-
Sulfate	mg/L	10	3	3	3	-	-
Hardness	mg/L	10	119	147	129	-	-

[1]Secchi Tube standards are surrogate standards derived from the total suspended solids standard of 15 mg/L.

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Boy River Subwatershed, a component of the IWM work conducted between May and September from 2012 and 2013. This specific data does not necessarily reflect all data that was used to assess the AUID.**

Table 21. Outlet water chemistry results: Boy River Subwatershed.

Station location:	**Boy River at Tobique Road Northeast. Site IS 8.5 Miles northwest of Remer, Minnesota.**						
STORET/EQuIS ID:	**S006-262**						
Station #:	**0701010204-01**						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	ug/L	10	1.1	11.8	3.0	40	0
Chloride	mg/L	10	3	3	3	230	0
Dissolved Oxygen (DO)	mg/L	19	0.7	15.0	7.4	5	3
pH		20	7.4	8.5	8.1	6.5 - 9	0
Secchi Tube	100 cm	20	100	100	100	varies	
Total suspended solids	mg/L	10	2	10	6	varies	
Escherichia coli (geometric mean)	MPN/100ml	3	15	20	-	126	0
Escherichia coli	MPN/100ml	15	3	27	13	1260	0
Chlorophyll-a, Corrected	ug/L	-	-	-	-	-	-
Inorganic nitrogen (nitrate and nitrite)	mg/L	10	0.03	0.03	0.03	-	-
Kjeldahl nitrogen	mg/L	10	0.5	0.7	0.6	-	-
Orthophosphate	ug/L	-	-	-	-	-	-
Pheophytin-a	ug/L	-	-	-	-	-	-
Phosphorus	ug/L	9	22	36	28	-	-
Specific Conductance	uS/cm	20	242	367	272	-	-
Temperature, water	deg °C	20	13.9	26.3	21.5	-	-
Sulfate	mg/L	10	3	3	3	-	-
Hardness	mg/L	10	124	149	133	-	-

[1]Secchi Tube standards are surrogate standards derived from the total suspended solids standard of 15 mg/L.

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Boy River Subwatershed, a component of the IWM work conducted between May and September from 2012 and 2013. This specific data does not necessarily reflect all data that was used to assess the AUID.**

Table 22. Outlet water chemistry results: Boy River Subwatershed.

Station location:	Boy River at CSAH-8, 2.5 miles west of Boy River, Minnesota.						
STORET/EQuIS ID:	S007-293						
Station #:	0701010204-01						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	ug/L	10	0.8	3.1	1.7	40	0
Chloride	mg/L	11	2	3	3	230	0
Dissolved Oxygen (DO)	mg/L	20	0.4	11.8	6.5	5	5
pH		21	7.5	8.5	7.9	6.5 - 9	0
Secchi Tube	100 cm	21	51	100	98	varies	
Total suspended solids	mg/L	11	1	5	3	varies	
Escherichia coli (geometric mean)	MPN/100ml	2	3	6	-	126	0
Escherichia coli	MPN/100ml	15	1	10	4	1260	0
Chlorophyll-a, Corrected	ug/L	-	-	-	-	-	-
Inorganic nitrogen (nitrate and nitrite)	mg/L	11	0.03	0.03	0.03	-	-
Kjeldahl nitrogen	mg/L	11	0.5	0.8	0.6	-	-
Orthophosphate	ug/L	-	-	-	-	-	-
Pheophytin-a	ug/L	-	-	-	-	-	-
Phosphorus	ug/L	11	13	25	21	-	-
Specific Conductance	uS/cm	21	247	285	268	-	-
Temperature, water	deg °C	21	12.7	28.0	21.1	-	-
Sulfate	mg/L	11	3	3	3	-	-
Hardness	mg/L	11	109	142	129	-	-

[1]Secchi Tube standards are surrogate standards derived from the total suspended solids standard of 15 mg/L.

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Boy River Subwatershed, a component of the IWM work conducted between May and September from 2012 and 2013. This specific data does not necessarily reflect all data that was used to assess the AUID.**

Table 23. Lake assessments: Boy River Subwatershed.

Name	DNR Lake ID	Area (acres)	Trophic Status	Percent Littoral	Max. Depth (m)	Mean Depth (m)	CLMP Trend	Mean TP (µg/L)	Mean chl-a (µg/L)	Mean Secchi (m)	AQR Support Status	AQL Support Status
Little Bass	11-0063-00	134	M	59.8	9.1			13.5	5.3	3.9	FS	NA
Big Sand	11-0077-00	730	M	86.3	7.0	2.1		21.6	9.9	3.1	FS	IF
Little Sand	11-0092-00	408	M	100	3.7	2.1	NT	15.1	2.1	3.0	FS	NA
Laura	11-0104-00	1,248	M		1.5			21.1	3.9	1.1	FS	IF
Upper Trelipe	11-0105-00	415	O	34.7	21.0		I	11.9	3.4	4.6	FS	NA
Inguadona (N. Bay)	11-0120-01	354	M		23.2	4.7	D	15.1	6.5	2.7	FS	IF
Inguadona (S. Bay)	11-0120-02	764	M		23.2	6.7	NT	17.4	5.8	3.3	FS	IF
Mabel	11-0121-00	182	M	100	4.3			13.7	2.4	3.2	FS	NA
West Twin	11-0125-00	206	M		1.5			13.6	2.6	1.8	FS	NA
Lower Trelipe	11-0129-00	608	M	59.1	9.8	3.8	NT	19.2	8.1	2.1	FS	IF
Swift	11-0133-00	351	M	52.6	14.9		IF	20.4	8.1	2.6	FS	NA
Long (Main Basin)	11-0142-02	643	M		35.1		D	13.2	3.2	5.9	FS	NA
Long (S.W. Bay)	11-0142-04	273	M		35.1		NT	12.2	2.5	5.7	FS	NA
Boy	11-0143-00	3,647	E	63	13.7	3.7		24.1	7.6	2.5	FS	NA
Rice	11-0162-00	223	M	77.8	9.1					3.2	IF	NA
Cooper	11-0163-00	133	M		21.3		I	14.9	3.3	4.0	FS	NA
Little Boy	11-0167-00	1423	M	34	21.9	7.4		18.8	6.1	3.3	FS	IF
McCarthey	11-0168-00	148	E		0.0			74.4	12.0	1.3	IF	NA
Hunter	11-0170-00	176	O		14.6		I	7.5	1.6	8.7	FS	NA
Wabedo (N.E. Bay)	11-0171-01	577	M		29.0	6.4		19.4	6.3	3.0	FS	NA
Wabedo (S.W. Bay)	11-0171-02	622	M		29.0	9.7	D	22.4	7.0	2.9	FS	NA
Kego	11-0182-00	114	M	65.8	17.7			17.0	5.4	4.1	FS	NA
Town Line	11-0190-00	666	M		2.7			14.5	2.4	2.1	FS	IF

Abbreviations:
D -- Decreasing/Declining Trend
I -- Increasing/Improving Trends
NT – No Trend

H – Hypereutrophic
E – Eutrophic
M – Mesotrophic
O - Oligotrophic

FS – Full Support
NS – Non-Support
IF – Insufficient Information

Key for Cell Shading: = existing impairment, listed prior to 2014 reporting cycle; = new impairment; = full support of designated use

Summary

Station 12UM106, located on Spring Creek, was visited twice in 2012. The FIBI scores from both visits were good. Both fish samples consisted of multiple wetland species. The MIBI score was poor; as a result this segment is impaired for aquatic life use support. Habitat within Spring Creek appears to be limiting macroinvertebrate community development. The upstream portion of the Spring Creek Watershed contains over 60 beaver dams and is heavily wetland influenced. Low dissolved oxygen levels occur naturally from wetland drainage. The low gradient of Spring Creek also contributes to low flow velocities and a lack of coarse substrate necessary to support a more robust invertebrate community. The resulting impairment appears to be naturally occurring. Station 12UM107 was located on an unnamed tributary to Northby Creek. The FIBI score (0) was the lowest in the Leech Lake River Watershed. The MIBI score was also poor. This segment of Northby Creek is impaired for aquatic life due to both the FIBI and MIBI. Multiple beaver dams are present both upstream and downstream of the monitoring station. Extensive wetlands are also present in the north by Creek Watershed. The beaver dams prevent fish passage and greatly restrict flow during the summer months. Low dissolved oxygen levels likely occur frequently due to the influence of the surrounding wetlands. The resulting impairment appears to be naturally occurring and will be listed as a natural background impairment.

Wetland habitat characteristics also prevented the assessment of aquatic life on two segments of the Boy River (07010102-524 and 07010102-518). Numerous wetland species and low numbers of sensitive species were present in the fish samples at both biological monitoring stations. The low levels of dissolved oxygen and low IBI scores at each station are likely naturally occurring due to wetland influence.

The biological monitoring station on the middle stretch of the Boy River (07010102-520) was higher gradient and had excellent habitat (MSHA = 75.6) characterized by riffles and coarse substrate. The segment supports aquatic life based on both water quality and biological data. The FIBI score from the 2012 fish sample was lower than expected and likely the result of prolonged high water levels prior to sampling. The FIBI score from the 2013 visit was exceptional. Twenty-seven species of fish were collected in one sample at this station making this the most diverse community within the entire Leech Lake River Watershed. Both samples contained several sensitive species, lithophilic spawners, and benthic insectivores. Macroinvertebrates were sampled during 2012, 2013, and 2014. Poor MIBI scores from the 2012 and 2014 samples are also likely the result of prolonged high flows prior to sampling. The 2013 sample was collected under normal conditions and given more consideration during the assessment process. Sensitive taxa were present in all macroinvertebrate samples.

Station 12UM109 was located on the Swift River just upstream of Swift Lake. Wetland characteristics were present throughout the sampling reach. The FIBI and MIBI scores were good. Both the fish and macroinvertebrate samples were representative of a wetland type stream community.

Twenty three lakes in the Boy River Subwatershed were assessed for aquatic recreation. Two additional lakes had limited data but not enough for assessment. All 23 assessed lakes fully supported aquatic recreation including prominent lakes such as Big Sand, Laura, Inguadona, Long, and Boy (Table 23).The majority of the lakes in the Boy River Watershed drain to the north through the Boy River and into Leech Lake. Protecting these lakes is important to preserve the water quality in Leech Lake. Phosphorus loads transported downstream through these lakes will ultimately end up in Leech Lake. McCarthy Lake had unusually high phosphorus concentrations compared to other lakes in the watershed. However, after closer examination McCarthy Lake looks to be a shallow isolated lake basin attached to Little Boy Lake and poses no threat of degrading water quality.

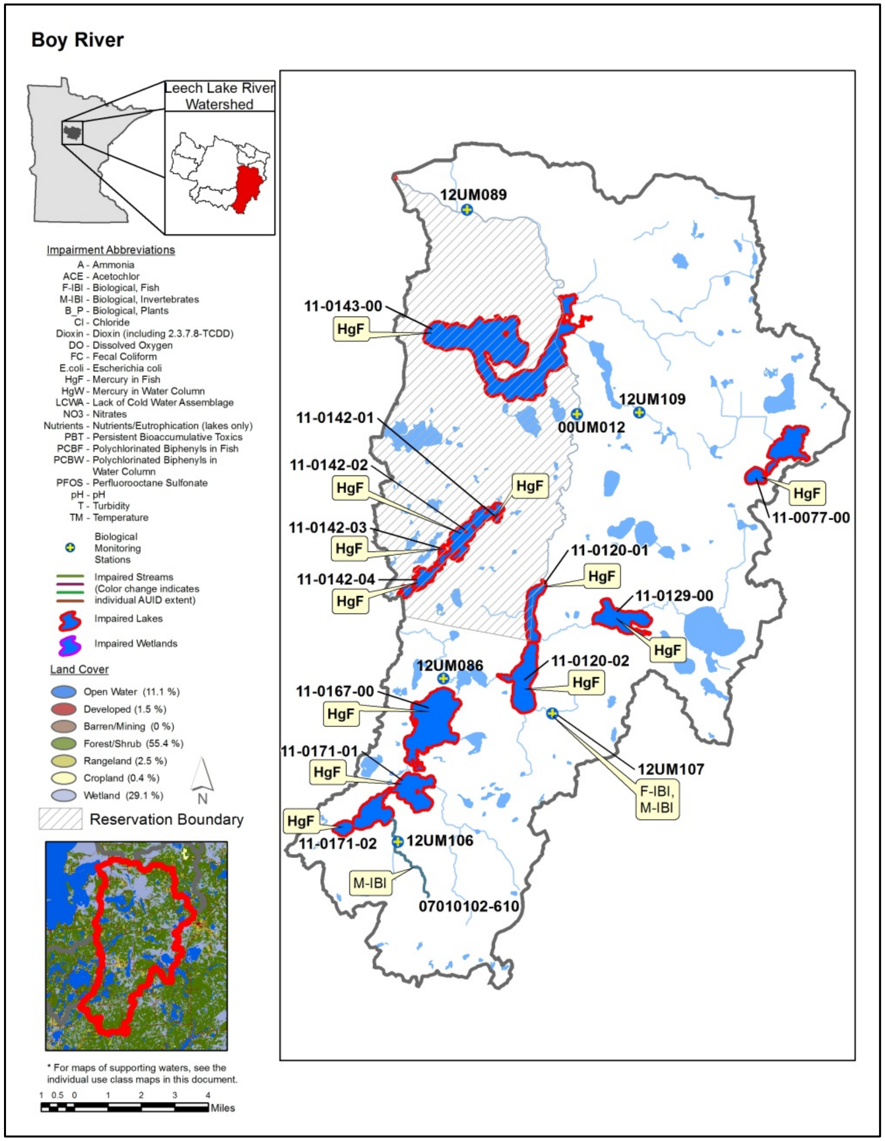

Figure 23. Currently listed impaired waters by parameter and land use characteristics in the Boy River Subwatershed.

Bear River Subwatershed HUC 0701010206-02

The Bear River Subwatershed drains approximately 44 square miles of land within the eastern portion of the Leech Lake River Watershed. The Bear River and Little Bear Creek are the two most significant streams within the subwatershed. The Bear River originates from a series of small wetland lakes near Grave Lake. The river winds northward for several miles before entering the Mud Goose WMA and emptying into Goose Lake. Little Bear Creek originates from a wetland west of Goose Lake and flows east into Goose Lake. Major lakes include Grave and Goose Lake. Land within the watershed is primarily forested (65.1%) followed by wetland (24.1%), open water (5.6%), rangeland (2.1%), cropland (1.9%), and developed land (1.2%). One biological monitoring station was located within the subwatershed. The station was not sampled due to an impoundment created by a large beaver dam prior to sampling. No assessable water chemistry data was collected in the Bear River Subwatershed.

Table 24. Lake assessments: Bear River Subwatershed.

Name	DNR Lake ID	Area (acres)	Trophic Status	Percent Littoral	Max. Depth (m)	Mean Depth (m)	CLMP Trend	Mean TP (µg/L)	Mean chl-a (µg/L)	Mean Secchi (m)	AQR Support Status	AQL Support Status
Grave	11-0086-00	369	O	34.7	16.8		NT	11.3	2.7	5.1	FS	IF
Knight	11-0087-00	133	M	100	3.0			18.5	4.0	4.0	FS	NA

Abbreviations: D -- Decreasing/Declining Trend; I -- Increasing/Improving Trends; NT – No Trend; **H** – Hypereutrophic; **E** – Eutrophic; **M** – Mesotrophic; **O** - Oligotrophic; **FS** – Full Support; **NS** – Non-Support; **IF** – Insufficient Information

Key for Cell Shading: = existing impairment, listed prior to 2014reporting cycle; = new impairment; = full support of designated use

Summary

Grave and Knight Lakes support aquatic recreation. Goose Lake had limited data but not enough for assessment. The Bear River Subwatershed has very few lakes because surface waters drain through the Bear River and exit the Leech Lake River Watershed. All three lakes are located in the headwaters of the Bear River Subwatershed and have small lake catchments. Water quality should remain good due to limited human disturbances within the watershed.

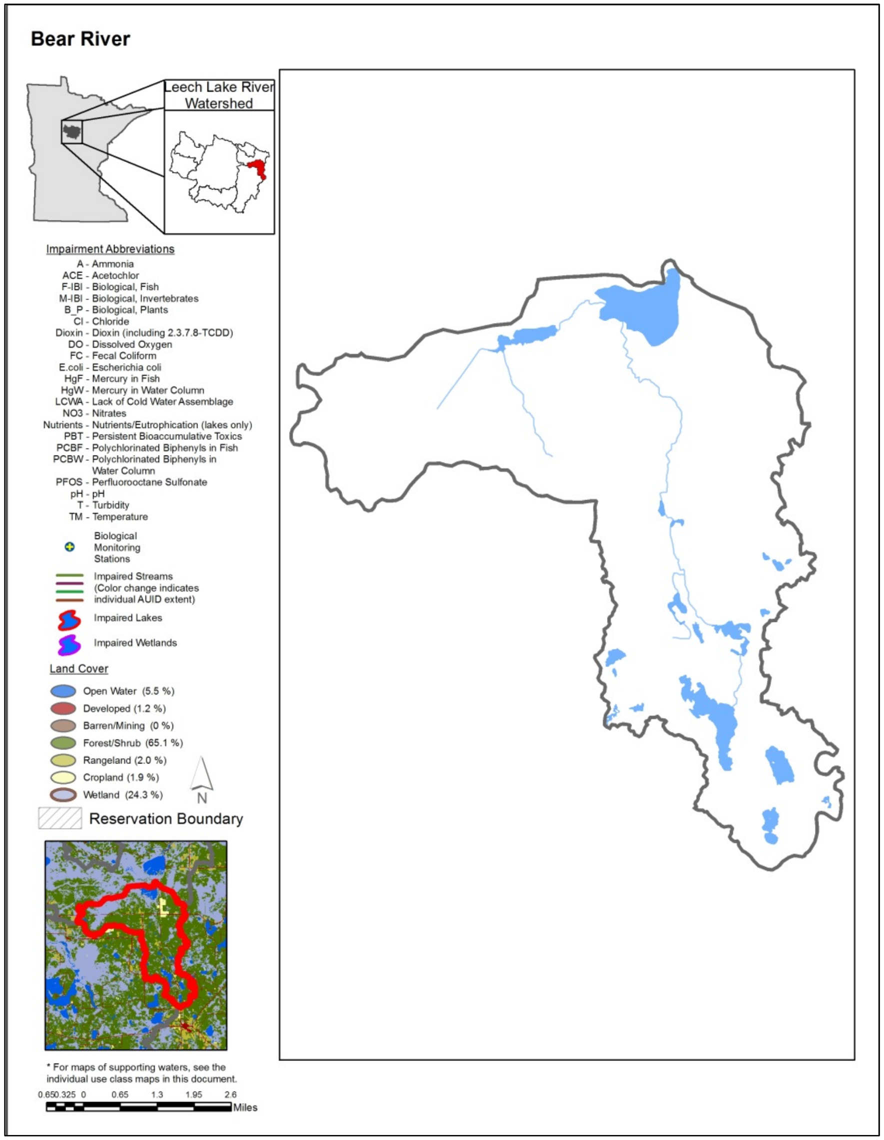

Figure 24. Currently listed impaired waters by parameter and land use characteristics in the Bear River Subwatershed.

Sixmile Brook Subwatershed HUC 0701010206-03

The Sixmile Brook Subwatershed drains approximately 40 square miles of land within the northeastern portion of the Leech Lake River Watershed. Sixmile Brook originates out of Sixmile Lake and flows south east a short distance before encountering Bear Brook. Bear Brook flows south out of Nushka Lake for approximately two miles before becoming impounded by a dam. After passing through the dam, Bear Brook continues south for a half mile before entering Sixmile Brook. After the confluence of Bear Brook, Sixmile Brook winds southeast for another five miles before entering the Leech Lake River. Sixmile Lake is the only major lake within the subwatershed. Land within the watershed is primarily wetland (55.7%) followed by forest (36.2%), open water (6.2%), and developed land (1.9%). The community of Bena is within the Sixmile Brook Subwatershed. In 2012, the MPCA monitored one biological monitoring station within the subwatershed.

Table 25. Aquatic Life and recreation assessments on reaches: Sixmile Brook Subwatershed. Reaches are organized upstream to downstream in the table.

AUID *Reach Name*, *Reach Description*	Reach Length (miles)	Use Class	Biological Station ID	Location of Biological Station	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Chloride	pH	NH_3	Pesticides	Aquatic Rec. Indicators: Bacteria	Nutrients	Aquatic Life	Aquatic Rec.
07010102-515 Sixmile Brook Sixmile Lake to Leech Lake River	11.28	WWg	12UM110	Upstream of FR 2339, 8.5 mi. SE of Bena	MTS	MTS	IF	IF	-	IF	-	-	-	-	SUP	NA

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 2014 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. Minnesota Stream Habitat Assessment (MSHA): Sixmile Brook Subwatershed.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	12UM110	Sixmile Brook	5	11	3	14	9	42	Poor
		Average Habitat Results: *Sixmile Brook Subwatershed*	**5**	**11**	**3**	**14**	**9**	**42**	**Poor**

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)

Table 27. Channel Condition and Stability Assessment (CCSI): Sixmile Brook Subwatershed.

# Visits	Biological Station ID	Stream Name	Upper Banks (43-4)	Lower Banks (46-5)	Substrate (37-3)	Channel Evolution (11-1)	CCSI Score (137-13)	CCSI Rating
1	12UM110	Sixmile Brook	9	9	15	3	36	Fairly stable
Average Stream Stability Results: *Sixmile Brook Subwatershed*			**9**	**9**	**15**	**3**	**36**	**Fairly stable**

Qualitative channel stability ratings

= stable: CCSI < 27 = fairly stable: 27 < CCSI < 45 = moderately unstable: 45 < CCSI < 80 = severely unstable: 80 < CCSI < 115 = extremely unstable: CCSI > 115

Table 28. Lake assessments: Sixmile Brook Subwatershed.

Name	DNR Lake ID	Area (acres)	Trophic Status	Percent Littoral	Max. Depth (m)	Mean Depth (m)	CLMP Trend	Mean TP (µg/L)	Mean chl-a (µg/L)	Mean Secchi (m)	AQR Support Status	AQL Support Status
Sixmile	11-0146-00	1,297	M	47	68	6.4		19.4	6.6	2.8	FS	NA

Abbreviations:

D -- Decreasing/Declining Trend
I -- Increasing/Improving Trends
NT – No Trend

H – Hypereutrophic
E – Eutrophic
M – Mesotrophic
O - Oligotrophic

FS – Full Support
NS – Non-Support
IF – Insufficient Information

Key for Cell Shading: = existing impairment, listed prior to 2012 reporting cycle; = new impairment; = full support of designated use

Summary

Station 12UM110 was located on Sixmile Brook, approximately three miles downstream of Sixmile Lake and 3.5 miles upstream of the confluence with the Leech Lake River. In 2012, a prolonged period of high water created conditions that promoted choking emergent vegetation throughout the stream channel and prevented sampling the station. Flow conditions in 2013 were normal and the FIBI score from the 2013 visit was good. The sampling reach had wetland characteristics; therefore, the fish community was dominated by species typical of wetland habitat. The MIBI score was also good despite the prevalence of wetland habitat. Sixmile Lake fully supported aquatic recreation. Water quality should remain good as long as Sixmile Lake's Watershed remains forested and wetland with minimal human disturbances

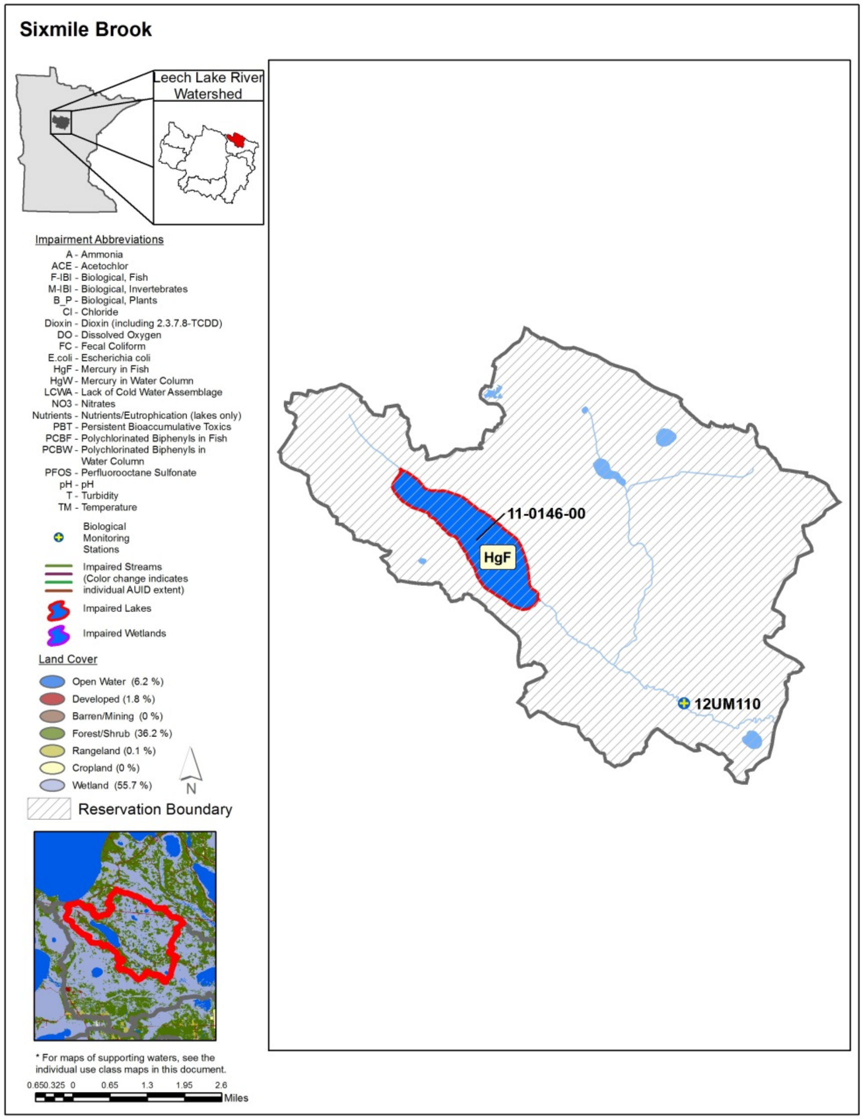

Figure 25. Currently listed impaired waters by parameter and land use characteristics in the Sixmile Brook Subwatershed.

Leech Lake River Subwatershed HUC 0701010206-01

The Leech Lake River Subwatershed drains approximately 85 square miles of land within the northeastern portion of the Leech Lake River Watershed. The subwatershed contains the entire Leech Lake River. The Leech Lake River flows east out of Leech Lake through a dam located in the community of Federal Dam. The river continues east for approximately 13 miles before receiving water from the tributary Sixmile Brook. Sixmile Brook originates out of Sixmile Lake and flows southeast for several miles before its confluence with the Leech Lake River. Immediately after the Sixmile Brook confluence the Leech Lake River is joined by the Bear River. The Bear River flows out of Goose Lake and into the Leech Lake River after draining 44 square miles of land within the eastern portion of the watershed. The Leech Lake River then enters Mud Lake – a large shallow wildlife lake located in the Mud Goose Wildlife Management Area. The river exits Mud Lake through a dam on the north end and flows northeast approximately three miles before emptying into the Mississippi River. The land within the subwatershed is primarily wetland (55.3%) followed by forest (36.9%), open water (3.7%), rangeland (2.8%), and developed land (1.2%). The community of Federal Dam is within the Leech Lake River Subwatershed. In 2012, the MPCA obtained samples from two biological monitoring stations on two stream segments within the subwatershed. Water chemistry was intensively monitored at two locations within the subwatershed.

Table 29. Aquatic life and recreation assessments on stream reaches: Leech Lake River Subwatershed. Reaches are organized upstream to downstream in the table.

AUID *Reach Name*, Reach Description	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Chloride	pH	NH_3	Pesticides	**Aquatic Rec. Indicators:** Bacteria	Nutrients	**Aquatic Life**	**Aquatic Rec.**
07010102-501 Leech Lake River Leech Lake to Sixmile Brook	12.86	WWg	12UM112	1 mile downstream of CR 8, in Federal Dam	MTS	-	IF	MTS	MTS	MTS	MTS	-	MTS	-	SUP	SUP
07010102-606 Leech Lake River Mud-Goose Lake Dam to Mississippi River	3.71	WWg	12UM113	Downstream of Mud Lake, 3 mi. S of Ball Club	MTS	-	EXS	MTS	MTS	MTS	NA	-	MTS	-	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 2014 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 30. Minnesota Stream Habitat Assessment (MSHA): Leech Lake River Subwatershed.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	12UM112	Leech Lake River	5	11	16	12	10	54	Fair
2	12UM113	Leech Lake River	4.7	10.2	15.3	10	12.5	53.3	Fair
Average Habitat Results: *Leech Lake River Subwatershed*			**4.8**	**10.6**	**15.7**	**11**	**11.2**	**53.6**	**Fair**

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)

Table 31. Outlet water chemistry results: Leech Lake River Subwatershed.

Station location:	**Leech Lake River at CR-139 at Mud Lake Dam, 8.5 mi southwest of Deer River, Minnesota.**						
STORET/EQuIS ID:	**S001-925**						
Station #:	**0701010206-04**						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	ug/L	39	0.1	4.6	1.1	40	0
Chloride	mg/L	10	2	4	3	230	0
Dissolved Oxygen (DO)	mg/L	45	0.5	10.9	6.2	5	17
pH		47	7.2	8.6	7.8	6.5 - 9	0
Secchi Tube	100 cm	52	100	100	100	varies	
Total suspended solids	mg/L	39	1	6	3	varies	
Escherichia coli (geometric mean)	MPN/100ml	5	4	21	-	126	0
Escherichia coli	MPN/100ml	16	1	38	11	1260	0
Chlorophyll-a, Corrected	ug/L	8	1.1	2.4	1.7	-	-
Inorganic nitrogen (nitrate and nitrite)	mg/L	41	0.03	0.05	0.05	-	-
Kjeldahl nitrogen	mg/L	41	0.6	1.3	0.8	-	-
Orthophosphate	ug/L	14	5	8	6	-	-
Pheophytin-a	ug/L	8	1.3	2.6	1.9	-	-
Phosphorus	ug/L	10	23	38	30	-	-
Specific Conductance	uS/cm	48	159	292	257	-	-

Temperature, water	deg °C	48	5.9	26.6	20.0	-	-
Sulfate	mg/L	10	3	3	3	-	-
Hardness	mg/L	10	101	138	127	-	-

[1]Secchi Tube standards are surrogate standards derived from the total suspended solids standard of 15 mg/L.

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Leech Lake River Subwatershed, a component of the IWM work conducted between May and September from 2012 and 2013. This specific data does not necessarily reflect all data that was used to assess the AUID.**

Table 32. Outlet water chemistry results: Leech Lake River Subwatershed.

Station location:	**Leech Lake River CSAH-8, Federal Dam.**						
STORET/EQuIS ID:	**S000-180**						
Station #:	**0701010206-01**						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	ug/L	9	0.6	6.0	2.7	40	0
Chloride	mg/L	11	2	4	3	230	0
Dissolved Oxygen (DO)	mg/L	20	4.4	10.2	8.1	5	1
pH		20	7.9	8.6	8.3	6.5 - 9	0
Secchi Tube	100 cm	21	100	100	100	varies	
Total suspended solids	mg/L	11	1	10	4	varies	
Escherichia coli (geometric mean)	MPN/100ml	3	7	11	-	126	0
Escherichia coli	MPN/100ml	16	1	47	13	1260	0
Chlorophyll-a, Corrected	ug/L	-	-	-	-	-	-
Inorganic nitrogen (nitrate and nitrite)	mg/L	11	0.03	0.03	0.03	-	-
Kjeldahl nitrogen	mg/L	11	0.5	0.8	0.6	-	-
Orthophosphate	ug/L	-	-	-	-	-	-
Pheophytin-a	ug/L	-	-	-	-	-	-
Phosphorus	ug/L	11	20	30	23	-	-
Specific Conductance	uS/cm	20	246	283	270	-	-
Temperature, water	deg °C	20	10.4	26.5	21.0	-	-
Sulfate	mg/L	11	3	3	3	-	-
Hardness	mg/L	11	115	137	126	-	-

[1]Secchi Tube standards are surrogate standards derived from the total suspended solids standard of 15 mg/L.

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Leech Lake River Subwatershed, a component of the IWM work conducted between May and September from 2012 and 2013. This specific data does not necessarily reflect all data that was used to assess the AUID.**

Table 33. Lake assessments: Leech Lake River Subwatershed.

Name	DNR Lake ID	Area (acres)	Trophic Status	Percent Littoral	Max. Depth (m)	Mean Depth (m)	CLMP Trend	Mean TP (µg/L)	Mean chl-a (µg/L)	Mean Secchi (m)	AQR Support Status	AQL Support Status
Drumbeater	11-0145-00	398	E		0.8			65.0	30.6		IF	NA

Abbreviations:
D -- Decreasing/Declining Trend
I -- Increasing/Improving Trends
NT – No Trend
H – Hypereutrophic
E – Eutrophic
M – Mesotrophic
O - Oligotrophic
FS – Full Support
NS – Non-Support
IF – Insufficient Information

Key for Cell Shading: = existing impairment, listed prior to 2014 reporting cycle; = new impairment; = full support of designated use

Summary

Both biological monitoring stations were located on the Leech Lake River. Station 12UM112 was approximately 1.5 miles downstream of Leech Lake on a segment of river confined between the Leech Lake Dam and Mud-Goose Lake Dam. The 2012 FIBI score was good. Nineteen species of fish were captured, including numerous sensitive species and several species of game fish (walleye, crappie, and largemouth bass). Station 12UM113 was visited twice during 2012, and the same FIBI score was obtained at each visit. The FIBI score was lower than the score from station 12UM112 but still good. Fourteen species of fish were captured, including several sensitive species and some game fish species. Macroinvertebrate data was not assessed at either station because the water was too deep to obtain a good sample.

Water chemistry data was monitored from two locations on the Leech Lake River. Dissolved oxygen concentrations exceeded the standard on the 3.7 mile long stretch from Mud-Goose Lake Dam to the Mississippi River (the impairment is attributed to conditions related to the dam). All water chemistry parameters were good on the 13 mile long reach from Leech Lake to Sixmile Brook. Both reaches fully support aquatic life based on water chemistry and the FIBI. Bacteria levels throughout the Leech Lake River were low and fully support aquatic recreation.

Drumbeater Lake is the only lake in the Leech Lake River Watershed. The lake is shallow and surrounded by bog and wetland which drains to the Leech Lake River. Not enough data was available to assess Drumbeater Lake.

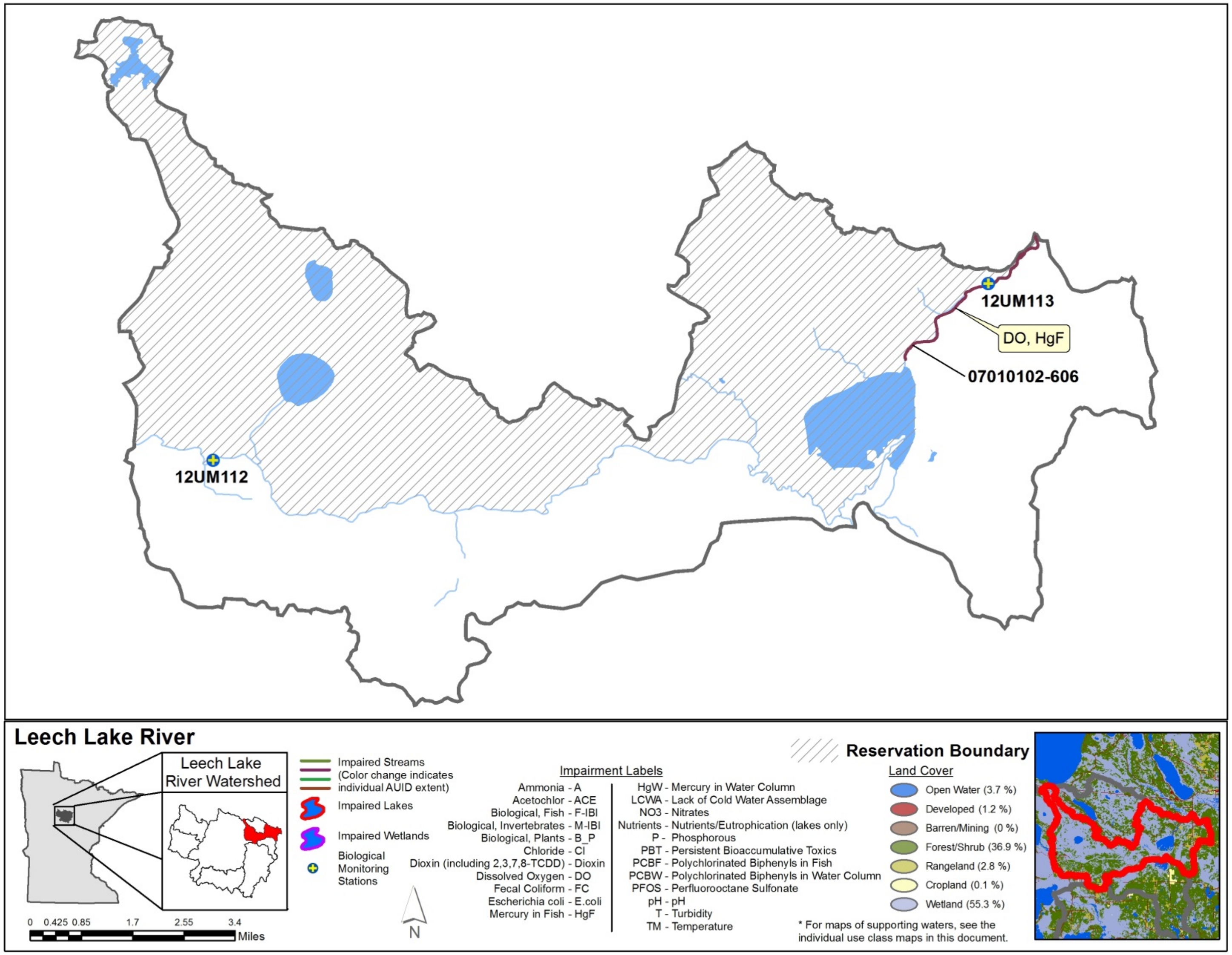

Figure 26. Currently listed impaired waters by parameter and land use characteristics in the Leech Lake River Subwatershed.

Watershed-wide results and discussion

Assessment results and data summaries are included below for the entire 8-HUC watershed unit of the Leech Lake River Watershed, grouped by sample type. Summaries are provided for load monitoring data results near the mouth of the river, aquatic life and recreation uses in streams and lakes throughout the watershed, and for aquatic consumption results at select river and lake locations along the watershed. Additionally, groundwater monitoring results and long-term monitoring trends 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 Leech Lake River Watershed.

Pollutant load monitoring

The Leech Lake River is monitored at the Mud Lake Dam south of Ball Club. Many years of water quality data from throughout Minnesota, combined with previous analysis of Minnesota's ecoregion patterns, resulted in the development of three "River Nutrient Regions" (RNR) (MPCA 2010a), each with unique nutrient standards. Of the state's three RNR's (North, Central, South), the Leech Lake River's load monitoring station is located within the North RNR. It should be noted that, while a FWMC exceeding given water quality standard is generally a good indicator that the water body is out of compliance with the River Nutrient Region standard, the rule does not always hold true. Waters of the state are listed as impaired based on the percentage of individual samples exceeding the numeric standard, generally 10% and greater (MPCA 2010a), over the most recent 10 year period and not based on comparisons with FWMCs. A river with a FWMC above a water quality standard, for example, would not be listed as impaired if less than 10% of the individual samples collected over the assessment period were above the standard. Discharge values are not available for the monitoring site on the Leech Lake River so loads and flow weighted means were not calculated. A rating curve will be developed over the next few years so that loads and flow weighted means can be calculated for the next round of assessments.

Pollutant sources affecting rivers are often diverse and can be quite variable from one watershed to the next depending on land use, climate, soils, slopes, and other watershed factors. However, as a general rule, elevated levels of total suspended solids (TSS) and nitrate plus nitrite-nitrogen (nitrate-N) are generally regarded as "non-point" source derived pollutants originating from many small diffuse sources such as urban or agricultural runoff. Excess total phosphorus (TP) and dissolved orthophosphate (DOP) can be attributed to either "non-point" as well as "point" or end of pipe sources such as industrial or waste water treatment plants. Major "non-point" sources of phosphorus include dissolved phosphorus from fertilizers and phosphorus adsorbed to and transported with sediment during runoff.

Within a given watershed, pollutant sources and source contributions can also be quite variable from one runoff event to the next depending on factors such as canopy development, soil saturation level, and precipitation type and intensity. Surface erosion and in-stream sediment concentrations, for example, will typically be much higher following high intensity rain events prior to canopy development, rather than after low intensity post-canopy events where less surface runoff and more infiltration occur. Precipitation type and intensity influence the major course of storm runoff, routing water through several potential pathways including overland, shallow and deep groundwater, and/or tile flow. Runoff pathways along with other factors determine the type and levels of pollutants transported in runoff to receiving waters and help explain between-storm and temporal differences in FWMCs and loads, barring differences in total runoff volume. During years when high intensity rain events provide the greatest proportion of total annual runoff, concentrations of TSS and TP tend to be higher with DOP and nitrate-N concentrations tending to be lower. In contrast, during years with high snow melt runoff and less intense rainfall events, TSS levels tend to be lower while TP, DOP, and nitrate-N levels tend to be elevated. In many cases, it is a combination of climatic factors from which the pollutant loads are derived.

Total Suspended Solids (TSS)

Water clarity refers to the transparency of water. 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. By definition, turbidity is caused primarily by suspension of particles that are smaller than one micron in diameter in the water column.

Analysis has shown a strong correlation to exist between the measures of TSS and turbidity. The greater the level of TSS, the murkier the water appears and the higher the measured turbidity. High turbidity results in reduced light penetration that harms beneficial aquatic species and favors undesirable algae species (MPCA and MSUM 2009). An overabundance of algae can lead to increases in turbidity, further compounding the problem. Periods of high turbidity often occur when heavy rains fall on unprotected soils. Upon impact, raindrops dislodge soil particles and overland flow transports fine particles of silt and clay into rivers and streams (MPCA and MSUM 2009).

Within the North RNR, the TSS standard is 15 mg/L (MPCA 2010c), when greater than 10% of the individual samples exceed the draft standard, the river is out of compliance. Discharge values are not available for the monitoring site on the Leech Lake River so loads and flow weighted means were not calculated. The mean concentration (not flow weighted) of TSS's in the Leech Lake River is displayed in Figure 27.

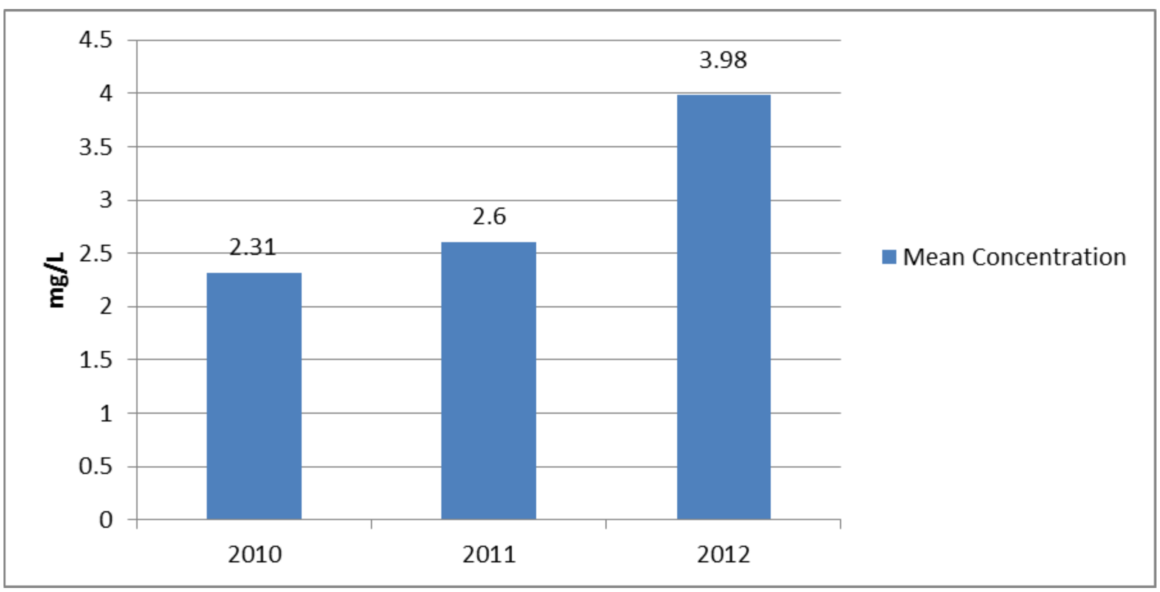

Figure 27. Total suspended solids mean concentrations in the Leech Lake River Watershed.

Total Phosphorus (TP)

Nitrogen (N), phosphorus (P), and potassium (K) are essential macronutrients and are required for growth by all animals and plants. Lack of sufficient nutrient levels in surface water often restricts the growth of aquatic plant species (University of Missouri Extension 1999). In freshwaters such as lakes and streams, phosphorus is typically the nutrient limiting growth; increasing the amount of phosphorus entering a stream or lake will increase the growth of aquatic plants and other organisms. Although phosphorus is a necessary nutrient, excessive levels overstimulate aquatic growth in lakes and streams resulting in reduced water quality. The progressive deterioration of water quality from overstimulation of nutrients is called eutrophication where, as nutrient concentrations increase, the surface water quality is degraded (University of Missouri Extension 1999). Elevated levels of phosphorus in rivers and streams 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 (University of Missouri Extension 1999). In "non-point" source dominated watersheds, TP concentrations are strongly correlated with stream flow. During years of above average precipitation, TP loads are generally highest. Within the North RNR, the TP standard is 50 ug/L as a summer average. Summer average violations of one or more "response" variables (pH, biological oxygen demand (BOD), dissolved oxygen flux, chlorophyll-a) must also occur along with the numeric TP violation for the water to be listed. Discharge values are not available for the monitoring site on the Leech Lake River so loads and flow weighted means were not calculated. The mean concentration (not flow weighted) of total phosphorus in the Leech Lake River is displayed in Figure 28.

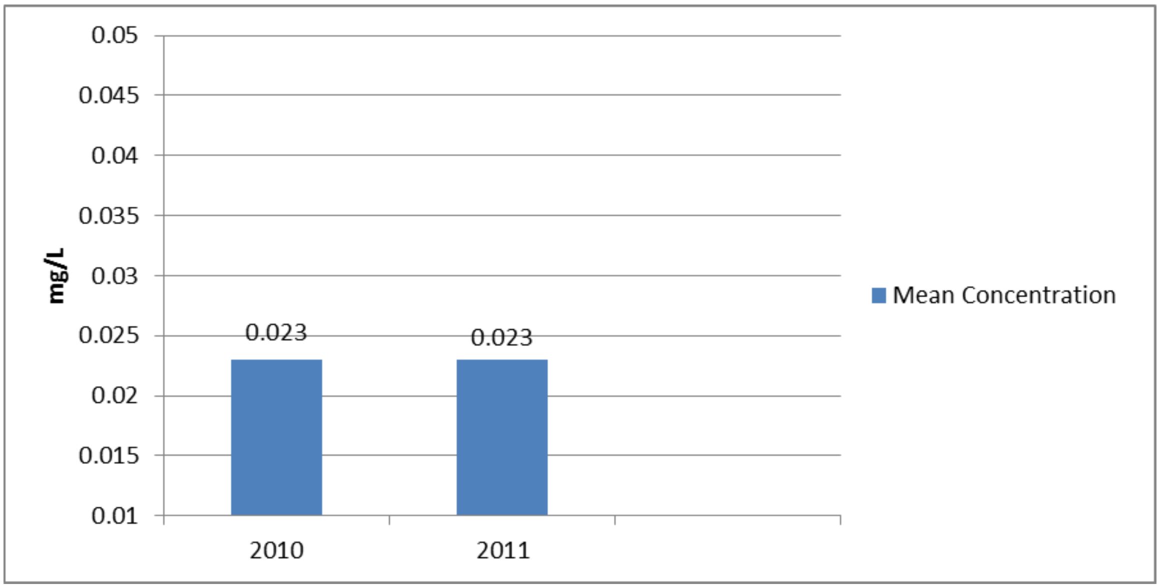

Figure 28. Total phosphorous mean concentrations in the Leech Lake River Watershed.

Dissolved Orthophosphate (DOP)

DOP is a water soluble form of phosphorus that is readily available to algae (bioavailable) (MPCA and MSUM 2009). While orthophosphates occur naturally in the environment, river and stream concentrations may become elevated with additional inputs from waste water treatment plants, noncompliant septic systems, and fertilizers in urban and agricultural runoff. Computation of DOP to TP ratios from 2010 and 2011, as well as yearly mean values are not possible because most of the orthophosphorus concentrations are reported as non-detect.

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, they too, like phosphorus, can stimulate excessive levels of some algae species in streams (MPCA, 2013). Nitrate and nitrite-nitrogen are water soluble, so transport to surface waters is enhanced through agricultural drainage. The ability of nitrite-N to be readily converted to nitrate-nitrogen is the basis for the combined laboratory analysis of nitrate plus nitrite-nitrogen, 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. Environmentally, studies have shown that the elevated nitrate-nitrogen levels in the Minnesota River basin contribute to hypoxia (low levels of dissolved oxygen) in the Gulf of Mexico. This occurs by nitrate-nitrogen stimulating the growth of algae which, through death and biological decomposition, consume large amounts of dissolved oxygen and thereby threaten aquatic life (MPCA and MSUM, 2009). Calculation of yearly means for nitrate plus nitrite nitrogen are not possible because most of the values are reported as non-detect.

Nitrate- N can also be a common toxicant to aquatic organisms in Minnesota's surface waters, with invertebrates appearing to be the most sensitive to nitrate toxicity. The acute value (maximum standard) for all Class 2 surface waters is 41 mg/L nitrate-N for a one-day duration, and the chronic value for Class 2B (warm water) surface waters is 4.9 mg/L nitrate-N for a four-day duration. In addition, the chronic value of 3.1 mg/L nitrate-N (four-day duration) was determined for protection of Class 2A (cold water) surface waters (MPCA, Aquatic Life Water Quality Standards Technical Support Document for Nitrate, Nov 2010).

Stream water quality

Within the Leech Lake River Watershed, 16 of the 112 stream reaches had sufficient data to make an assessment for aquatic life and/or aquatic recreation (Table 34). Of the assessed stream reaches, 10 streams fully supported of aquatic life and two did not. Eight of the nine streams that were assessed for aquatic recreation were supporting; only one was not.

Table 34. Assessment summary for stream water quality in the Leech Lake River Watershed.

				Supporting		Non-supporting			
Watershed	**Area (acres)**	**# Total AUIDs**	**# Assessed AUIDs**	**# Aquatic Life**	**# Aquatic Recreation**	**# Aquatic Life**	**# Aquatic Recreation**	**Insufficient Data**	**# Delistings**
Leech Lake River **HUC 8**	**857,971**	**112**	**16**	**10**	**7**	**2**	**1**	**1**	**0**
Steamboat River	85,825	19	3	2	1	0	0	1	0
Kabekona River	77,236	12	3	2	1	0	1	0	0
Leech Lake	332,672	34	1	1	1	0	0	0	0
Woman Lake	104,319	9	0	0	0	0	0	0	0
Boy River	148,714	21	6	2	3	2	0	0	0
Leech Lake River	54,963	8	2	2	2	0	0	0	0
Bear River	28,337	5	0	-	-	-	-	-	0
Sixmile Brook	25,901	4	1	1	0	0	0	0	0

Lake water quality

The Leech Lake River Watershed has a high density of lakes with good water quality. Ninety six lake basins had at least one water quality measurement available; 85 of those basins had enough water quality information to conduct a formal aquatic recreation use assessment. Hart Lake was the only lake found to not support aquatic recreation. The hydrology of contributing lake catchments and basin morphology of lakes in the Leech Lake River Watershed provide a favorable environment for good water quality. Water flows from lake to lake through a network of streams and wetlands from the headwaters of smaller aggregated HUC-12 watersheds. As water passes through deep lake basins phosphorus can be removed as organic matter settles out and becomes tied to bottom sediments. This beneficially removes available phosphorous from downstream waters. As a result, lake water quality is in good condition throughout the Leech Lake River Watershed.

Table 35. Assessment summary for lake water chemistry in the Leech Lake River Watershed.

			Supporting		Non-supporting			
Watershed	Area (acres)	Lakes >10 Acres	# Aquatic Life	# Aquatic Recreation	# Aquatic Life	# Aquatic Recreation	Insufficient Data	# Delistings
[07010102] **HUC 8**	**857,971**	**397**	**-**	**84**	**-**	**1**	**11**	**0**
0701010201-01	85,826	22	-	2	-	1	-	0
0701010202-01	77,237	31	-	7	-	-	-	0
0701010203-01	104,319	122	-	34	-	-	4	0
0701010204-01	148,715	94	-	21	-	-	2	0
0701010205-01	332,672	105	-	17	-	-	3	0
0701010206-01	54,964	3	-	0	-	-	1	0
0701010206-02	28,337	15	-	2	-	-	1	0
0701010206-03	25,901	5	-	1	-	-	-	0

Fish contaminant results

Fifteen fish species from the river and lakes were tested for contaminants. A total of 1,943 fish were tested between 1970 and 2013. Fish species are identified by codes that are defined by their common and scientific names in Table 36. Table 37 summarizes contaminant concentrations by waterway, fish species, and year. "No. Fish" indicates the total number of fish analyzed and "N" indicates the number of samples. The number of fish exceeds the number of samples when fish are combined into a composite sample. This was typically done for panfish, such as bluegill sunfish (BGS) and yellow perch (YP). Since 1989, most of the samples have been skin-on fillets (FILSK) or for fish without scales (catfish and bullheads), skin-off fillets (FILET).

Fish from the Leech Lake River were collected in 2012. The mercury concentrations from three northern pike (NP), one white sucker (WSU), and a composite of five yellow perch were above the 0.2 mg/kg water quality standard for mercury in fish tissue. Total PCB concentrations in two northern pike and the white sucker were below the reporting limit of 0.025 mg/kg. All waters that are listed as impaired for mercury in fish are identified in Table 37 with a red asterisk (*); one asterisk indicates it is impaired and falls under the Statewide Mercury TMDL; two asterisks indicate the mercury levels were too high for inclusion in the Statewide TMDL and they require a separate TMDL. Only four of the 32 lakes tested were not impaired for mercury in fish tissue. Twenty-one of the lakes impaired are covered under the Statewide TMDL. The remaining seven lakes are impaired and require additional TMDLs. Leech Lake River went on the Impaired Waters List in 2014, based on the fish collected in 2012 and is included in the Statewide TMDL.

All the lakes requiring a TMDL had at least one fish species with the 90th percentile mercury concentration exceeding 0.57 mg/kg. From all tested fish in the Leech Lake watershed, the highest mercury concentration was 1.92 mg/kg in a northern pike from Portage Lake, collected in 2010 (the only year of results from this lake). Most of the PCB concentrations in fish tissue from the lakes were near or below the reporting limit. The highest PCB concentration was 0.100 mg/kg in a walleye from Ten Miles Lake, collected in 1989. Perfluorooctane sulfonate (PFOS) concentrations were below the reporting limit in five walleye and five yellow perch in Leech Lake. Overall, the fish contaminant results indicate PCBs have not been at levels of concern in the Leech Lake River Watershed; however, mercury concentrations in fish tissue are relatively high in the river and most of the tested lakes in the watershed.

Table 36. Fish species codes, common names and scientific names.

Species	Common Name	Scientific Name
BGS	Bluegill sunfish	*Lepomis macrochirus*
BKB	Black bullhead	*Ictalurus melus*
BKS	Black crappie	*Pomoxis nigromaculatis*
C	Common Carp	*Cyprinus carpio*
LMB	Largemouth bass	*Micropterus salmoides*
LWH	Lake whitefish	*Coregonus clupeaformis*
ML	Muskellunge	*Esox masquinongy*
NP	Northern pike	*Esox Lucius*
RKB	Rock bass	*Ambloplites rupestris*
SF	Pumpkinseed sunfish	*Lepomis gibbosus*
SMB	Smallmouth bass	*Micropterus dolomieu*
SUF	Sunfish family	*Centrarchidae*
WE	Walleye	*Sander vitreus*
WSU	White sucker	*Catostomus commersoni*
YEB	Yellow bullhead	*Ictalurus natalis*
YP	Yellow perch	*Perca flavescens*

Table 37. Summary statistics of mercury and PCBs, by waterway-species-year.

WATERWAY	AUID	SPECIES[1]	YEAR	ANATOMY[2]	NO. FISH	Length (in)			Mercury (mg/kg)				PCBs (mg/kg)			PFOS (mg/kg)		
						Mean	Min	Max	N	Mean	Min	Max	N	Mean	Max	N	Mean	Max
LEECH LAKE R. *	07010102-606	NP	2012	FILSK	3	18.3	16.8	19.6	3	0.303	0.251	0.361	2	< 0.025	< 0.025			
		WSU	2012	FILSK	1	20.3			1	0.382			1	< 0.025				
		YP	2012	FILSK	5	10.6			1	0.271								
BABY*	11028300	BGS	1995	FILSK	10	6.4	6.4	6.4	1	0.056	0.056	0.056						
			2012	FILSK	10	6.7	6.4	7.0	2	0.045	0.044	0.045						
		CIS	1995	FILSK	8	10.6	10.6	10.6	1	0.043	0.043	0.043	1	< 0.01				
		ML	1995	FILSK	5	25.8	19.6	34.1	3	0.380	0.120	0.900	1	< 0.01				
		NP	1995	FILSK	16	24.4	15.4	33.4	5	0.218	0.100	0.370	1	< 0.01				
			2012	FILSK	7	23.7	20.0	30.4	7	0.224	0.159	0.301						
		SMB	1995	FILSK	3	15.6	13.6	17.5	2	0.230	0.200	0.260	1	< 0.01				
			2012	FILSK	7	14.9	13.2	17.2	7	0.191	0.147	0.226						
		WE	1995	FILSK	9	22.1	19.4	24.4	3	0.560	0.360	0.720	1	< 0.01				
			2012	FILSK	8	16.4	12.4	22.6	8	0.233	0.125	0.507						
BENEDICT**	29004800	BGS	2006	FILSK	10	7.4	7.4	7.4	1	0.100	0.100	0.100						
		CIS	2006	FILSK	8	9.8	9.8	9.8	1	0.098	0.098	0.098						
		NP	2006	FILSK	8	25.6	17.9	33.4	8	0.804	0.537	1.319						
		WE	2006	FILSK	7	18.4	12.4	29.5	7	0.542	0.220	1.393						
		WSU	2006	FILSK	2	14.4	12.6	16.1	2	0.022	0.012	0.031						
BIG BOY	11014300	BGS	2013	FILSK	10	8.6	7.9	9.3	2	0.037	0.027	0.047						
		BKS	2013	FILSK	10	12.3	10.3	14.2	2	0.080	0.065	0.094						
		LMB	2013	FILSK	2	10.0	9.8	10.1	2	0.101	0.083	0.119						
		NP	2013	FILSK	8	19.6	16.1	34.9	8	0.156	0.112	0.295						
		WE	2013	FILSK	8	16.6	12.6	21.3	8	0.163	0.101	0.262						
		WSU	2013	FILSK	5	18.0	18.0	18.0	1	0.031	0.031	0.031						
		YP	2013	FILSK	5	8.2	8.2	8.2	1	0.133	0.133	0.133						
Big Sand*	11007700	BGS	2010	FILSK	3	7.6	7.6	7.6	1	0.048	0.048	0.048						
		BKS	2010	FILSK	8	8.5	8.3	8.7	2	0.029	0.025	0.033						
		LMB	2010	FILSK	8	15.4	14.5	16.1	8	0.257	0.212	0.305						
		NP	2010	FILSK	5	24.8	18.4	32.4	5	0.224	0.113	0.469						
BIG SAND*		WE	2010	FILSK	2	18.0	16.6	19.4	2	0.173	0.146	0.200						
		YP	2010	FILSK	5	7.6	7.6	7.6	1	0.011	0.011	0.011						
BIRCH	11041200	LMB	2007	FILSK	5	11.6	8.0	14.5	5	0.131	0.059	0.180						

WATERWAY	AUID	SPECIES[1]	YEAR	ANATOMY[2]	NO. FISH	Length (in)			Mercury (mg/kg)				PCBs (mg/kg)			PFOS (mg/kg)		
						Mean	Min	Max	N	Mean	Min	Max	N	Mean	Max	N	Mean	Max
		NP	1991	FILSK	1	19.3	19.3	19.3	1	0.110	0.110	0.110						
		WE	1991	FILSK	1	15.7	15.7	15.7	1	0.220	0.220	0.220						
BLACKWATER*	11027400	BGS	2008	FILSK	7	7.3	7.3	7.3	1	0.033	0.033	0.033						
		BKS	2008	FILSK	5	8.9	8.9	8.9	1	0.029	0.029	0.029						
		CIS	2008	FILSK	4	18.2	18.2	18.2	1	0.084	0.084	0.084						
		LMB	2008	FILSK	5	12.3	9.5	13.7	5	0.255	0.151	0.359						
		NP	2008	FILSK	5	22.2	18.0	26.1	5	0.190	0.152	0.286						
		SMB	2008	FILSK	5	12.3	8.5	18.0	5	0.161	0.061	0.490						
		WE	2008	FILSK	5	16.8	13.3	20.9	5	0.215	0.117	0.484						
BOY**	11014300	BGS	2005	FILSK	9	7.2	7.2	7.2	1	0.045	0.045	0.045						
		CIS	2005	FILSK	6	17.1	16.4	18.2	6	0.066	0.050	0.089						
		LMB	2005	FILSK	3	11.5	10.2	13.8	3	0.092	0.088	0.095						
		NP	2005	FILSK	5	25.6	21.8	30.0	5	0.479	0.128	1.359						
		WE	2005	FILSK	6	20.1	16.1	24.2	6	0.234	0.135	0.341						
CROOKED*	11049400	BGS	2010	FILSK	8	7.0	6.5	7.4	2	0.049	0.049	0.049						
		BKS	2010	FILSK	3	11.0	8.5	13.5	2	0.046	0.020	0.072						
CROOKED (Continued)		CIS	2010	FILSK	3	15.3	15.3	15.3	1	0.077	0.077	0.077						
		LMB	2010	FILSK	5	12.9	10.8	14.0	5	0.158	0.123	0.190						
		NP	2010	FILSK	8	23.1	19.0	31.6	8	0.280	0.133	0.482						
		WE	2010	FILSK	6	19.6	15.8	27.4	6	0.346	0.185	0.574						
		YP	2010	FILSK	4	7.5	7.5	7.5	1	0.063	0.063	0.063						
CRYSTAL*	11050200	BKS	2005	FILSK	10	9.2	9.2	9.2	1	0.166	0.166	0.166						
		LMB	2005	FILSK	6	14.3	12.8	16.2	6	0.351	0.259	0.458						
		NP	2005	FILSK	4	35.9	26.4	41.5	4	0.322	0.295	0.340						
		WE	2005	FILSK	5	19.5	15.8	25.9	5	0.359	0.153	0.627						
		WSU	2005	FILSK	4	17.2	17.2	17.2	1	0.053	0.053	0.053						
GARFIELD*	29006100	BGS	2005	FILSK	8	7.7	7.7	7.7	1	0.036	0.036	0.036						
		NP	2005	FILSK	5	24.7	21.8	27.2	5	0.128	0.119	0.149						
		WE	2005	FILSK	5	18.0	14.2	24.0	5	0.128	0.060	0.271						
		WSU	2005	FILSK	4	19.1	19.1	19.1	1	0.040	0.040	0.040						
GIRL*	11017400	BGS	1992	FILSK	10	5.8	5.8	5.8	1	0.043	0.043	0.043						
			2012	FILSK	8	7.7	7.5	7.9	2	0.058	0.056	0.059						
		BKS	2012	FILSK	7	9.6	8.6	10.6	2	0.030	0.029	0.031						

WATERWAY	AUID	SPECIES[1]	YEAR	ANATOMY[2]	NO. FISH	Length (in) Mean	Length (in) Min	Length (in) Max	Mercury (mg/kg) N	Mercury (mg/kg) Mean	Mercury (mg/kg) Min	Mercury (mg/kg) Max	PCBs (mg/kg) N	PCBs (mg/kg) Mean	PCBs (mg/kg) Max	PFOS (mg/kg) N	PFOS (mg/kg) Mean	PFOS (mg/kg) Max
		CIS	1992	FILSK	10	14.7	13.3	16.1	2	0.078	0.055	0.100	1	0.013				
			2012	FILSK	5	17.5	17.5	17.5	1	0.060	0.060	0.060						
		LMB	2012	FILSK	6	12.5	10.0	14.3	6	0.170	0.131	0.232						
		NP	1992	FILSK	20	26.4	18.8	36.0	4	0.290	0.140	0.550	1	< 0.01				
			2012	FILSK	8	22.5	14.2	29.8	8	0.249	0.096	0.681						
		WE	1992	FILSK	3	12.9	12.9	12.9	1	0.110	0.110	0.110						
			2012	FILSK	7	21.3	14.0	27.3	7	0.359	0.101	0.812						
		YP	2012	FILSK	9	7.8	7.3	8.3	2	0.077	0.072	0.082						
INGUADONA*	11012000	BGS	1991	FILSK	10	6.6	6.6	6.6	1	0.030	0.030	0.030						
			2009	FILSK	10	7.3	6.7	7.9	2	0.055	0.050	0.059						
		BKS	2009	FILSK	7	11.1	10.5	11.7	2	0.079	0.051	0.106						
		CIS	1991	FILSK	12	14.8	13.8	15.7	2	0.045	0.041	0.049	1	< 0.01				
		LMB	2009	FILSK	3	14.7	13.0	16.7	3	0.242	0.209	0.262						
		NP	1991	FILSK	25	19.5	14.0	25.0	4	0.265	0.120	0.360	2	< 0.01	< 0.01			
			2009	FILSK	8	20.7	16.5	31.6	8	0.235	0.107	0.323						
Inguadona		WE	1991	FILSK	18	17.2	12.4	21.7	3	0.250	0.160	0.380	2	< 0.01	< 0.01			
			2009	FILSK	8	18.7	15.3	24.1	8	0.326	0.198	0.498						
		WSU	1991	FILSK	1	17.0	17.0	17.0	1	0.064	0.064	0.064	1	< 0.01				
KABEKONA**	29007500	CIS	1993	FILSK	7	11.6	11.6	11.6	1	0.063	0.063	0.063						
		NP	1993	FILSK	16	25.2	19.7	32.7	4	0.303	0.170	0.490	1	< 0.01				
		SF	1993	FILSK	10	5.7	5.7	5.7	1	0.064	0.064	0.064						
		WE	1993	FILSK	24	18.5	10.9	27.3	6	0.335	0.110	0.640	1	< 0.01				
			2003	FILSK	5	12.5	12.0	14.0	5	0.876	0.759	1.050						
LEECH *	11020300	BGS	1990	FILSK	6	6.5	6.5	6.5	1	0.028	0.028	0.028	1	< 0.01				
		BKS	2012	FILSK	6	8.0	8.0	8.0	1	0.036	0.036	0.036						
		CIS	1997	FILSK	14	14.2	13.5	14.8	2	0.063	0.060	0.065	2	< 0.01	< 0.01			
LEECH (Continued)			2002	FILSK	5	15.6	15.6	15.6	1	0.065	0.065	0.065						
		LWH	1993	FILSK	11	22.4	19.3	25.8	3	0.030	0.012	0.057	2	0.026	0.026			
		ML	1990	FILSK	2	25.6	22.0	29.2	2	0.170	0.150	0.190	2	0.019	0.028			
		NP	1970	PLUG	2	21.1	20.8	21.4	2	0.190	0.160	0.220						
			1984	FILSK	5	22.3	22.3	22.3	1	0.210	0.210	0.210						
			1990	FILSK	28	20.9	14.4	26.8	12	0.175	0.065	0.450	12	0.012	0.024			
			1997	FILSK	20	21.0	17.9	27.7	20	0.181	0.090	0.380	3	< 0.01	< 0.01			

WATERWAY	AUID	SPECIES[1]	YEAR	ANATOMY[2]	NO. FISH	Length (in)			Mercury (mg/kg)				PCBs (mg/kg)			PFOS (mg/kg)		
						Mean	Min	Max	N	Mean	Min	Max	N	Mean	Max	N	Mean	Max
			2002	FILSK	5	21.4	16.8	26.0	5	0.135	0.054	0.181						
			2006	FILSK	23	24.7	18.2	29.2	23	0.335	0.117	0.627						
			2009	FILSK	15	24.0	15.6	30.5	15	0.291	0.077	0.550						
		WE	1984	FILSK	5	18.6	18.6	18.6	1	0.260	0.260	0.260	1	< 0.05				
			1993	FILSK	26	19.1	11.8	26.2	11	0.300	0.075	0.580	5	0.012	0.019			
			1997	FILSK	21	15.5	12.4	20.2	21	0.132	0.055	0.320	4	< 0.01	< 0.01			
			2002	FILSK	6	17.5	14.6	20.9	6	0.107	0.063	0.168						
			2006	FILSK	8	19.6	13.6	23.4	8	0.382	0.130	0.838						
			2010	FILSK	5	17.6	14.2	21.3								5	< 4.65	< 4.93
			2012	FILSK	6	19.6	14.6	23.5	6	0.268	0.143	0.566						
		WSU	1970	PLUSK	1	18.5	18.5	18.5	1	0.160	0.160	0.160						
			1984	FILSK	5	16.8	16.8	16.8	1	0.070	0.070	0.070						
			1990	FILSK	21	15.3	11.7	19.1	7	0.037	< 0.02	0.072	7	0.011	0.019			
		YP	1997	FILSK	20	10.0	9.4	10.6	2	0.170	0.130	0.210						
			2002	FILSK	8	10.1	10.1	10.1	1	0.060	0.060	0.060						
			2006	WHORG	10	5.7	5.1	6.1	3	0.048	0.035	0.068						
			2010	FILSK	5	9.1	8.3	10.4								5	< 4.88	< 4.93
LITTLE BOY*	11016700	BGS	1990	FILSK	10	6.8	6.8	6.8	1	0.058	0.058	0.058	1	< 0.01				
			2011	FILSK	8	6.6	5.7	7.4	2	0.030	0.023	0.036						
		LMB	2011	FILSK	2	14.0	13.8	14.2	2	0.160	0.138	0.182						
		NP	1990	FILSK	17	21.0	12.2	31.5	4	0.166	0.082	0.260	4	< 0.01	< 0.01			
			2011	FILSK	8	19.1	15.2	23.4	8	0.154	0.081	0.269						
		SMB	2011	FILSK	1	14.5	14.5	14.5	1	0.115	0.115	0.115						
LITTLE BOY* (Cont)		WE	2011	FILSK	3	20.4	14.8	24.7	3	0.206	0.134	0.321						
		WSU	1990	FILSK	13	17.1	12.7	21.6	3	0.035	< 0.02	0.049	3	0.011	0.012			
			2011	FILSK	3	17.8	17.8	17.8	1	0.060	0.060	0.060						
		YP	2011	FILSK	10	8.8	8.3	9.2	2	0.099	0.091	0.106						
LONG*	11014200	BGS	1993	FILSK	10	6.0	6.0	6.0	1	0.062	0.062	0.062						
			2010	FILSK	7	6.3	6.3	6.3	1	0.052	0.052	0.052						
		BKS	2010	FILSK	3	9.9	9.9	9.9	1	0.088	0.088	0.088						
		CIS	2010	FILSK	5	14.6	14.6	14.6	1	0.120	0.120	0.120						
		LMB	2010	FILSK	8	13.3	10.9	14.8	8	0.188	0.134	0.383						

WATERWAY	AUID	SPECIES[1]	YEAR	ANATOMY[2]	NO. FISH	Length (in)			Mercury (mg/kg)				PCBs (mg/kg)			PFOS (mg/kg)		
						Mean	Min	Max	N	Mean	Min	Max	N	Mean	Max	N	Mean	Max
		NP	1993	FILSK	25	22.5	13.9	30.5	6	0.368	0.210	0.620	2	< 0.01	< 0.01			
			2010	FILSK	8	20.1	14.5	33.4	8	0.197	0.053	0.751						
		WE	1993	FILSK	11	19.7	11.7	26.6	4	0.298	0.180	0.470	2	0.018	0.025			
			2010	FILSK	6	18.2	11.4	23.7	6	0.372	0.068	1.042						
		WSU	1993	FILSK	1	20.8	20.8	20.8	1	0.095	0.095	0.095	1	0.041				
LOWER SUCKER	11031300	BGS	2011	FILSK	10	8.4	7.9	8.8	2	0.030	0.025	0.035						
		BKS	2011	FILSK	10	12.5	12.1	12.9	2	0.039	0.029	0.049						
		NP	2011	FILSK	8	19.0	17.8	20.5	8	0.059	0.046	0.105						
		WE	2011	FILSK	4	18.3	14.5	23.5	4	0.094	0.064	0.139						
		WSU	2011	FILSK	5	17.6	17.6	17.6	1	0.016	0.016	0.016						
LOWER TRELIPE*	11012900	BGS	2009	FILSK	6	8.7	8.7	8.7	1	0.058	0.058	0.058						
		BKS	2009	FILSK	9	10.4	9.3	11.4	2	0.053	0.053	0.053						
L. TRELIPE		LMB	2009	FILSK	5	13.5	12.5	14.3	5	0.157	0.112	0.180						
		NP	2009	FILSK	8	22.0	17.5	32.1	8	0.170	0.120	0.289						
		WE	2009	FILSK	5	17.8	12.6	19.3	5	0.174	0.067	0.256						
MULE	11020000	BGS	2008	FILSK	6	7.1	7.1	7.1	1	0.024	0.024	0.024						
		BKS	2008	FILSK	4	10.7	10.7	10.7	1	0.019	0.019	0.019						
		CIS	2008	FILSK	3	15.6	15.6	15.6	1	0.022	0.022	0.022						
		LMB	2008	FILSK	5	12.0	10.1	14.3	5	0.070	0.042	0.134						
		NP	2008	FILSK	5	22.2	18.0	27.0	5	0.133	0.088	0.186						
		SMB	2008	FILSK	5	13.8	10.8	16.0	5	0.079	0.040	0.107						
		WE	2008	FILSK	5	18.6	13.7	22.5	5	0.086	0.073	0.101						
PLEASANT*	11038300	BGS	2001	FILSK	10	7.7	7.7	7.7	1	0.036	0.036	0.036						
PLEASANT*		BKS	2001	FILSK	10	10.8	10.8	10.8	1	0.026	0.026	0.026						
(Cont)			2001	FILSK	6	23.9	18.7	31.0	6	0.155	0.078	0.335						
		NP	2012	FILSK	15	19.5	14.0	26.8	15	0.112	0.059	0.248						
		WE	2001	FILSK	7	21.1	17.0	26.8	7	0.246	0.120	0.634						
		WSU	2001	FILSK	5	19.1	19.1	19.1	1	0.048	0.048	0.048						
PORTAGE*	11020400	BGS	2007	FILSK	10	8.1	8.1	8.1	1	0.072	0.072	0.072						
		CIS	2007	FILSK	8	13.9	13.9	13.9	1	0.026	0.026	0.026						
		LMB	2007	FILSK	1	11.1	11.1	11.1	1	0.075	0.075	0.075						
		NP	2007	FILSK	6	24.6	15.0	34.3	6	0.167	0.071	0.342						
		WE	2007	FILSK	6	18.6	14.7	24.3	6	0.258	0.147	0.541						

WATERWAY	AUID	SPECIES[1]	YEAR	ANATOMY[2]	NO. FISH	Length (in)			Mercury (mg/kg)				PCBs (mg/kg)			PFOS (mg/kg)		
						Mean	Min	Max	N	Mean	Min	Max	N	Mean	Max	N	Mean	Max
		YP	2007	FILSK	10	8.3	8.3	8.3	1	0.082	0.082	0.082						
PORTAGE**	11047600	BGS	2010	FILSK	9	7.9	7.4	8.4	2	0.059	0.053	0.064						
		NP	2010	FILSK	8	24.6	16.2	37.7	8	0.473	0.071	1.919						
		SMB	2010	FILSK	8	14.9	11.0	18.0	8	0.220	0.090	0.311						
		WE	2010	FILSK	7	20.5	14.7	24.6	7	0.249	0.100	0.407						
		WSU	2010	FILSK	5	17.2	17.2	17.2	1	0.024	0.024	0.024						
		YP	2010	FILSK	5	8.4	8.4	8.4	1	0.108	0.108	0.108						
SHINGOBEE*	29004300	NP	1999	FILSK	24	22.8	13.6	33.3	24	0.326	0.170	0.530						
			2000	FILSK	7	14.2	8.8	22.8	7	0.163	0.040	0.330						
		YP	1999	WHORG	22	5.8	3.7	7.5	12	0.118	0.080	0.170						
			2000	WHORG	18	4.7	2.6	10.3	8	0.138	0.080	0.260						
SIXMILE*	11014600	BGS	2013	FILSK	8	6.5	5.6	7.3	2	0.025	0.025	0.025						
		BKS	2013	FILSK	5	11.7	11.7	11.7	1	0.053	0.053	0.053						
		CIS	2013	FILSK	4	14.1	14.1	14.1	1	0.040	0.040	0.040						
		LMB	2013	FILSK	1	12.2	12.2	12.2	1	0.105	0.105	0.105						
		NP	1992	FILSK	13	24.4	17.8	30.7	4	0.228	0.062	0.360	1	< 0.01				
			2013	FILSK	8	21.2	16.5	25.3	8	0.162	0.093	0.222						
		WE	1992	FILSK	15	19.6	12.7	26.1	4	0.285	0.110	0.460	1	< 0.01				
			2013	FILSK	7	16.0	12.6	22.4	7	0.189	0.139	0.323						
		WSU	1992	FILSK	5	17.8	17.8	17.8	1	0.036	0.036	0.036	1	< 0.01				
		YP	1992	FILSK	10	9.3	9.3	9.3	1	0.040	0.040	0.040						
			2013	FILSK	5	8.0	8.0	8.0	1	0.107	0.107	0.107						
STEAMBOAT**	11050400	BGS	2003	FILSK	10	6.5	6.5	6.5	1	0.062	0.062	0.062						
		NP	2003	FILSK	5	25.3	22.2	29.5	5	0.569	0.419	0.758						
		SUF	2003	FILSK	2	8.6	8.6	8.6	1	0.085	0.085	0.085						
		WE	2003	FILSK	5	19.1	16.9	23.2	5	0.414	0.324	0.596						
		WSU	2003	FILSK	4	16.2	16.2	16.2	1	0.072	0.072	0.072						
STONY*	11037100	BGS	2008	FILSK	7	7.0	7.0	7.0	1	0.040	0.040	0.040						
		BKS	2008	FILSK	8	10.1	10.1	10.1	1	0.040	0.040	0.040						
		LMB	2008	FILSK	5	12.7	9.4	15.6	5	0.168	0.091	0.246						
		NP	2008	FILSK	5	24.1	20.4	30.2	5	0.303	0.207	0.418						

						Length (in)			Mercury (mg/kg)				PCBs (mg/kg)			PFOS (mg/kg)		
WATERWAY	AUID	SPECIES[1]	YEAR	ANATOMY[2]	NO. FISH	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Max	N	Mean	Max
		SMB	2008	FILSK	5	14.9	14.4	16.1	5	0.136	0.102	0.180						
		WE	2008	FILSK	5	17.0	15.5	20.1	5	0.177	0.143	0.237						
TEN MILE**	11041300	BGS	2006	FILSK	10	6.5	6.5	6.5	1	0.043	0.043	0.043						
			2008	FILSK	5	6.4	6.4	6.4	1	0.039	0.039	0.039						
		BKS	1991	FILSK	1	10.6	10.6	10.6	1	0.060	0.060	0.060						
			2006	FILSK	8	10.1	10.1	10.1	1	0.080	0.080	0.080						
			2008	FILSK	6	7.8	7.8	7.8	1	0.040	0.040	0.040						
		CIS	1991	FILSK	1	12.0	12.0	12.0	1	0.023	0.023	0.023						
		LMB	1991	FILSK	1	12.2	12.2	12.2	1	0.260	0.260	0.260						
			2006	FILSK	5	12.4	10.2	13.8	5	0.153	0.116	0.225						
			2007	FILSK	10	10.0	7.6	14.9	10	0.143	0.055	0.374						
			2008	FILSK	4	11.0	9.8	13.8	4	0.204	0.151	0.259						
		LWH	1991	FILSK	1	20.2	20.2	20.2	1	0.020	< 0.02	< 0.02	1	< 0.01				
			2006	FILSK	7	17.6	17.6	17.6	1	0.044	0.044	0.044						
			2008	FILSK	4	19.5	19.5	19.5	1	0.065	0.065	0.065						
		NP	1989	FILSK	4	21.9	20.0	23.8	2	0.230	0.170	0.290	2	0.011	0.012			
			2006	FILSK	5	23.7	19.5	28.2	5	0.411	0.198	0.648						
			2008	FILSK	20	21.2	16.3	30.2	20	0.265	0.058	0.649						
TEN MILE (Continued)		RKB	2008	FILSK	6	8.6	8.6	8.6	1	0.070	0.070	0.070						
		SF	2008	FILSK	6	7.5	7.5	7.5	1	0.166	0.166	0.166						
		SMB	2006	FILSK	5	14.4	11.5	16.7	5	0.151	0.114	0.231						
			2008	FILSK	4	15.1	14.3	15.7	4	0.131	0.121	0.145						
		WE	1989	FILSK	5	20.5	16.2	24.0	3	0.753	0.210	1.400	3	0.074	0.100			
			2006	FILSK	5	21.1	14.6	26.5	5	0.329	0.103	0.611						
			2008	FILSK	5	20.9	19.2	22.1	5	0.246	0.160	0.443						
		WSU	1989	FILSK	4	18.8	18.8	18.8	1	0.056	0.056	0.056	1	0.018				
		YP	2008	WHORG	4	5.8	5.8	5.8	1	0.040	0.040	0.040						
TRILLIUM*	11027000	BGS	1997	FILSK	10	5.6	5.6	5.6	1	0.160	0.160	0.160						
		NP	1997	FILSK	10	20.7	14.5	30.0	10	0.303	0.110	0.530	3	< 0.01	< 0.01			
		YEB	1997	FILET	10	7.9	7.9	7.9	1	0.440	0.440	0.440						
			2002	FILET	8	9.0	9.0	9.0	1	0.373	0.373	0.373						
WABEDO*	11017100	BGS	2009	FILSK	10	6.9	6.5	7.3	2	0.066	0.048	0.084						

WATERWAY	AUID	SPECIES[1]	YEAR	ANATOMY[2]	NO. FISH	Length (in)			Mercury (mg/kg)				PCBs (mg/kg)			PFOS (mg/kg)		
						Mean	Min	Max	N	Mean	Min	Max	N	Mean	Max	N	Mean	Max
		BKS	2009	FILSK	9	9.9	9.3	10.5	2	0.036	0.035	0.036						
		LMB	2009	FILSK	8	10.9	10.0	12.7	8	0.175	0.145	0.293						
		NP	2009	FILSK	8	25.9	18.5	34.7	8	0.313	0.138	0.486						
		SMB	2009	FILSK	5	14.5	11.0	16.5	5	0.245	0.170	0.329						
		WE	2009	FILSK	8	15.2	12.1	19.5	8	0.286	0.189	0.473						
WEBB*	11031100	BGS	2010	FILSK	6	6.8	6.8	6.8	1	0.042	0.042	0.042						
		BKS	2010	FILSK	8	8.3	7.9	8.7	2	0.029	0.025	0.033						
		LMB	2010	FILSK	8	10.9	9.4	12.4	8	0.132	0.107	0.166						
		NP	2010	FILSK	8	18.8	16.1	25.1	8	0.157	0.105	0.195						
		WE	2010	FILSK	8	18.1	12.5	21.3	8	0.176	0.111	0.234						
WILLIAMS**	29001500	LMB	2000	FILSK	7	16.4	14.8	17.8	7	0.487	0.230	0.660						
WILLIAMS (Continued)		NP	1999	FILSK	24	24.6	11.4	31.2	24	0.341	0.110	0.920						
			2000	FILSK	1	21.3	21.3	21.3	1	0.150	0.150	0.150						
			2002	FILSK	13	22.5	13.6	27.6	13	0.336	0.095	0.682						
		YP	1999	WHORG	15	6.1	3.5	7.0	12	0.093	0.040	0.140						
			2000	WHORG	8	6.5	4.3	8.0	8	0.086	0.040	0.170						
			2002	WHORG	10	6.6	6.2	6.9	2	0.067	0.063	0.070						
WOMAN*	11020100	BGS	1990	FILSK	10	7.3	7.3	7.3	1	0.034	0.034	0.034	1	< 0.01				
WOMAN*			2009	FILSK	4	7.7	7.7	7.7	1	0.023	0.023	0.023						
		BKS	2009	FILSK	5	10.3	9.9	10.6	2	0.027	0.024	0.029						
		NP	1990	FILSK	18	23.1	19.0	28.1	3	0.163	0.140	0.200	3	< 0.01	< 0.01			
			2009	FILSK	6	23.9	16.7	30.0	6	0.275	0.173	0.370						
		SMB	2009	FILSK	2	14.4	13.6	15.2	2	0.104	0.086	0.121						
		WE	1990	FILSK	9	13.2	9.8	16.5	2	0.105	0.070	0.140	2	< 0.01	< 0.01			
			2009	FILSK	5	17.6	14.0	21.7	5	0.151	0.072	0.294						
		WSU	1990	FILSK	11	14.3	12.0	16.6	2	0.024	< 0.02	0.027	2	< 0.01	< 0.01			
		YEB	1990	FILET	8	10.2	10.2	10.2	1	0.110	0.110	0.110	1	< 0.01				
		YP	2009	FILSK	4	9.7	9.7	9.7	1	0.072	0.072	0.072						

Groundwater monitoring

The Leech Lake River Watershed is located in Central Minnesota with five types of aquifers: Paleozoic, Precambrian, Cretaceous, buried sand and gravel, and surficial sand and gravel aquifers. A baseline study conducted by the MPCA found that the groundwater quality in most of these aquifers in this region is considered very good when compared to other areas with similar aquifers (MPCA, 1998).

The results of this study identified few exceedances of drinking water criteria with nitrate being the greatest concern for this region. The exceedances identified that concentrations occurred primarily in the surficial sand and gravel aquifers due to anthropogenic influences, while the other aquifers tend to be well protected and less susceptible to contamination. Any exceedances in the protected aquifers are mostly likely due to naturally occurring chemicals, such as boron, manganese, iron and arsenic. The primary Volatile Organic Compounds (VOCs) that were identified were chemicals associated with well disinfection (chloroform), gasoline, and fuel oils (toluene); however all VOC concentrations were below drinking water criteria. There are currently four MPCA Ambient Groundwater Monitoring wells in the Leech Lake River Watershed. The locations of wells within the Leech Lake River Watershed are displayed in Figure 29. The results from sampling of these wells do not greatly differ from the results of the baseline study.

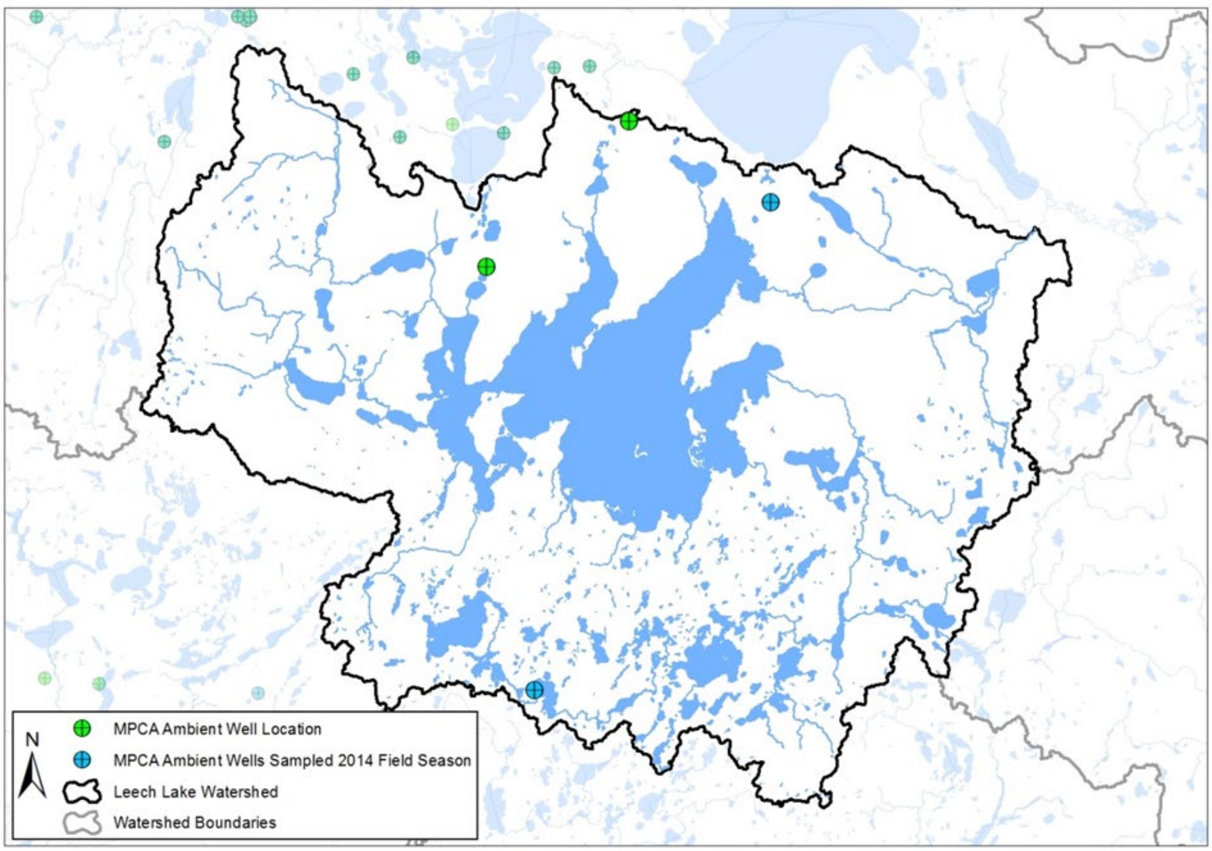

Figure 29. MPCA ambient groundwater monitoring well locations within and surrounding the Leech Lake River Watershed.

The Minnesota Department of Agriculture (MDA) is responsible for monitoring groundwater quality in agricultural areas of the state. The geographic area known as Central Sands (which encompasses the Leech Lake River Watershed) is particularly vulnerable to agricultural chemical movement due to the following hydrogeologic conditions: shallow groundwater beneath coarse, sandy-textured soils.

In 2013, pesticides were detected in the Central Sands region but not at levels exceeding drinking water criteria (MDA, 2014). Nitrate, however, was present in 98% of the wells sampled and at a median concentration of 16.00 milligrams per liter (mg/L). Of those samples, 13% were at or below background level of 3 mg/L, 17% were within 3.01 and 10.00 mg/L, and 68% were above drinking water standard of 10.00 mg/L (MDA, 2014). Though nitrate is not uncommon in agricultural areas, the median concentration is above the Health risk limit of 10 mg/L. Additionally, a recent MPCA report on the statewide condition of Minnesota's groundwater found that the Central Minnesota region has the highest median nitrate concentrations in the state, with approximately 40% of the shallow sand and gravel aquifer wells exceeding the maximum contaminant level (MCL) of 10 mg/L (Kroening and Ferrey, 2013). High nitrate concentrations are typically associated with agricultural and urban land use overlying shallow aquifers, due to the sensitivity of the aquifer to human influence. Although there is concern for high nitrate concentrations, the concentrations have not significantly changed in the last 15 years (Kroening and Ferry, 2013). The MDA's data implies that the concentrations are limited to the uppermost portions of the aquifers (Kroening and Ferry, 2013).

Another source of information on groundwater quality comes from the Minnesota Department of Health. Mandatory testing for arsenic of all newly constructed wells has found that 10.4% of all wells installed from 2008 to 2013 have arsenic levels above the MCL for drinking water of 10 micrograms per liter (MDH). In West Central Minnesota, the there is a higher concern for arsenic contamination, considering that approximately 50% of 869 domestic wells sampled identified arsenic concentrations that exceeded the drinking standards (MDH, 2001; Kroening & Ferry, 2013) (Figure 30).

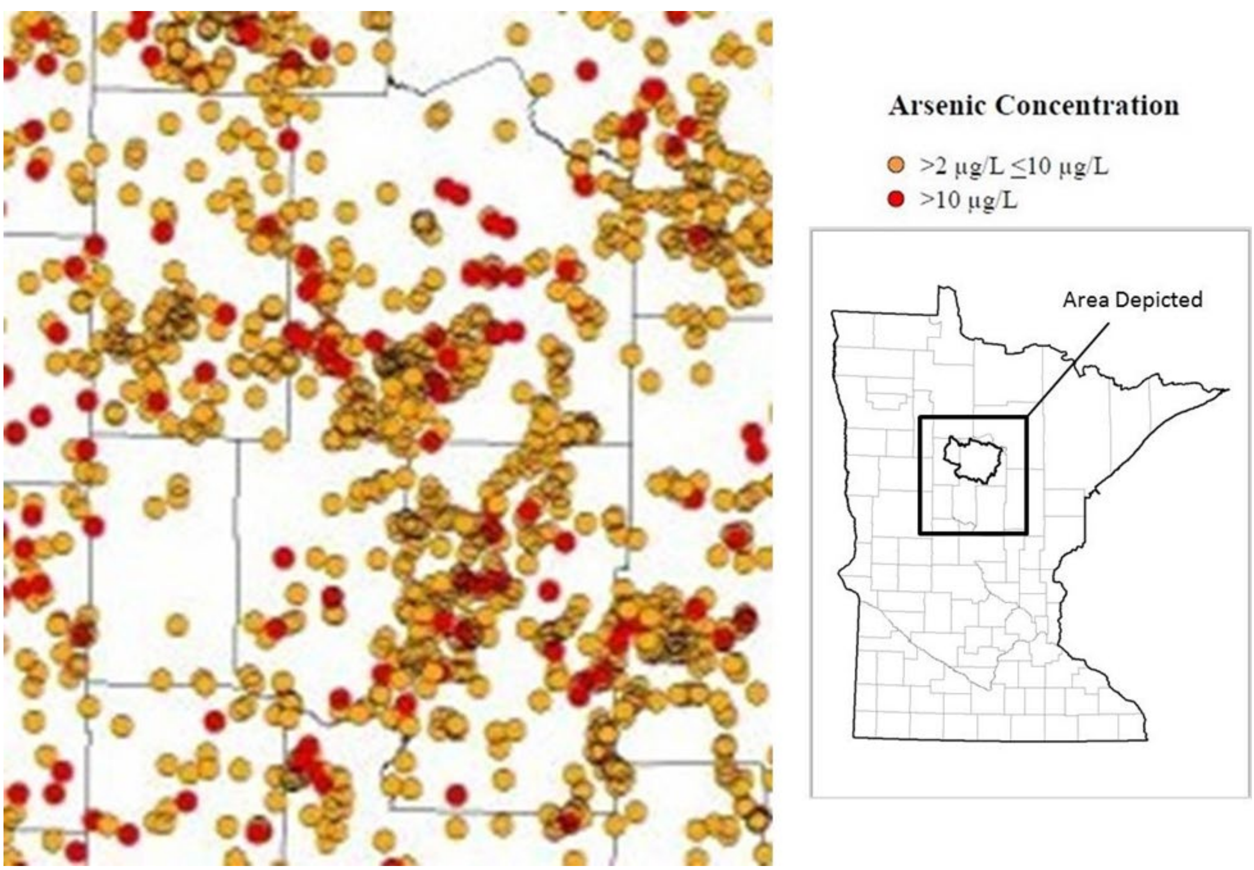

Figure 30. Arsenic occurrence in the New Wells in Central Minnesota (2008-2012) (Source: MDH, 2012).

Stream flow

The United States Geological Survey (USGS) maintains real-time stream flow gaging stations across the United States. Measurements can be viewed at: http://waterdata.usgs.gov/nwis/rt. Stream flow for the Leech Lake River watershed was analyzed for annual mean discharge and summer monthly mean discharge (July and August). The annual mean discharge for the **Mississippi River** at Ball Club, Minnesota (from 2008 to 2013) is displayed in Figure 31. The July and August monthly mean flows are displayed in Figure 32. Although both figures appear to display an increasing flow trend, the data indicates there is no statistically significant trend. By way of comparison, summer month flows have declined at a statistically significant rate at a majority of streams selected randomly for a study of statewide trends.

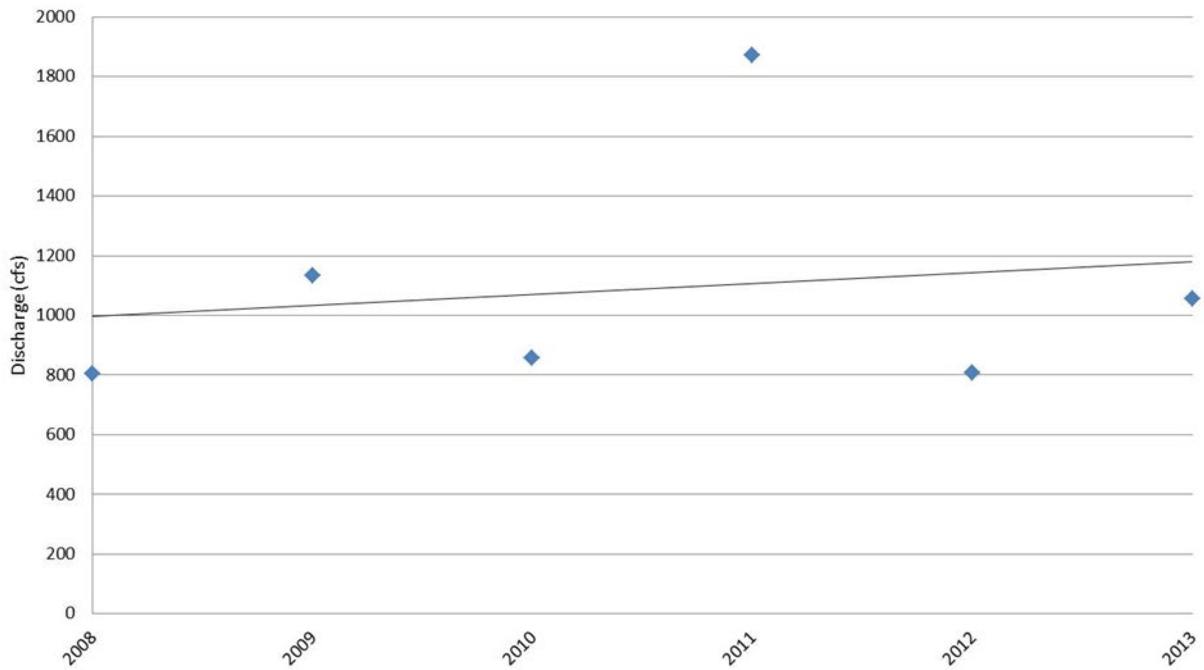

Figure 31. Annual mean discharge for Mississippi River at Ball Club, Minnesota (2008-2013).

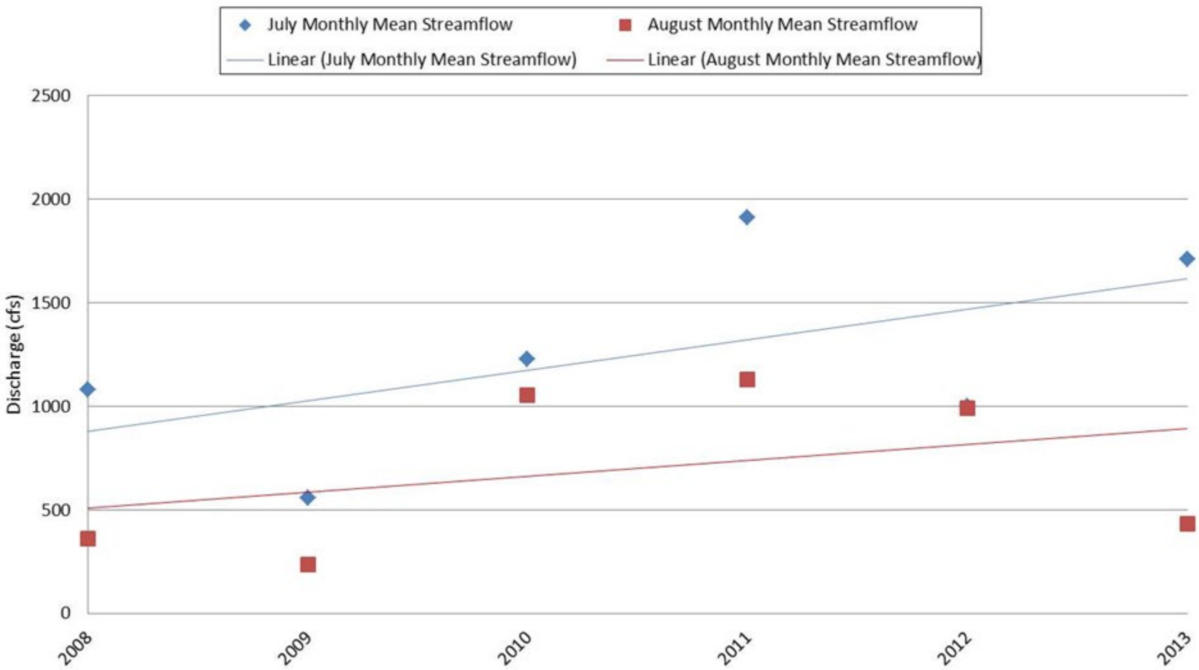

Figure 32. Mean monthly discharge for Mississippi River at Ball Club, Minnesota (2008-2013).

Wetland condition

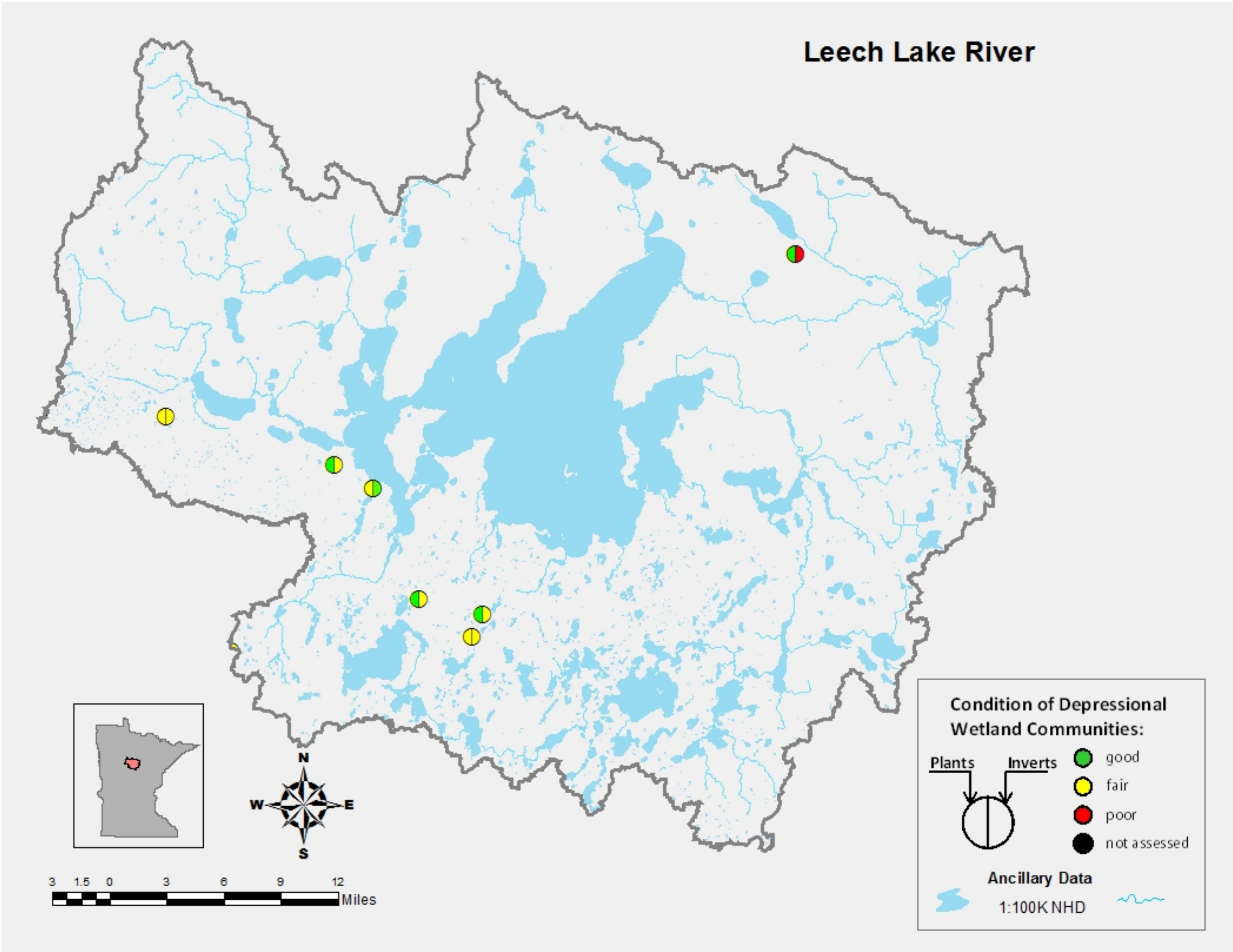

Figure 33. Depressional wetland IBI results (Invertebrate and Plant Community Indices) for seven MPCA wetland biological study sites located in the Leech Lake River 8-HUC Watershed.

IBIs based on plants and invertebrates were used to determine the health of wetlands in this watershed. Both the invertebrate and plant IBIs are scored on a 0 to 100 scale with higher scores indicating better condition. These indicators were also used in a statewide survey of wetland condition stratified by Minnesota's three Level II ecoregions (Genet 2012). The Leech Lake River Watershed occurs entirely within the Mixed Wood Shield Ecoregion. Genet (2012) reported depressional wetland condition in the Mixed Wood Shield Ecoregion to be mostly in good condition. Using the invertebrate IBI indicator, 60% of the wetlands were in good condition, 29% were in fair condition and the remaining 11% of depressional wetlands were found to be in poor condition. Plant results were similar, where 54% of the wetlands were estimated to be in good condition, 29% were in fair condition and 17% were in poor condition.

MPCA ambient wetland biological condition data (based on IBIs) has been collected at seven depressional wetlands in the Leech Lake River Watershed. These sites were mostly distributed in the southwest region of the Leech Lake River Watershed (Figure 33). Five of these study sites were sampled in 2004 and 2005 to develop an initial dataset for IBI development in the Mixed Wood Shield Ecoregion. These wetland sites were selected intentionally to represent the full range of biological condition from very poor to high quality near pristine condition. The remaining two wetland sites were selected at random as part of the baseline statewide depressional wetland survey (Genet 2012).

Invertebrate community IBI scores at these seven sites ranged from 42 to 67 (0 to 100 scale with 100 being high integrity). Figure 33 illustrates the corresponding biological condition for these seven wetlands based on invertebrate and plant IBIs. One of these sites represented a good condition, five of the sites were in fair condition and one of the sites was in poor condition based on the invertebrate indicator. The difference between Good and Fair was set at the upper 25^{th} percentile of IBI scores within a set of ecoregion least disturbed reference sites (Genet 2012). The difference between Poor and Fair was based on the lower 5^{th} percentile of the reference site range. The plant results from these seven wetlands ranged from 46 to 84. Based on the plant indicator three of the sites were considered to be in fair condition. These three sites were all part of the IBI development data set. The remaining four wetlands were considered to be in good condition using the plant indicator. Two of these four "good condition" wetlands were part of the indicator development data set and two were sampled as part of the depressional wetland survey. No watershed scale pattern is evident in this small set of wetland study sites however the results generally parallel the statistically valid condition estimates of depressional wetlands in the Mixed Wood Shield Level II Ecoregion (Genet 2012).

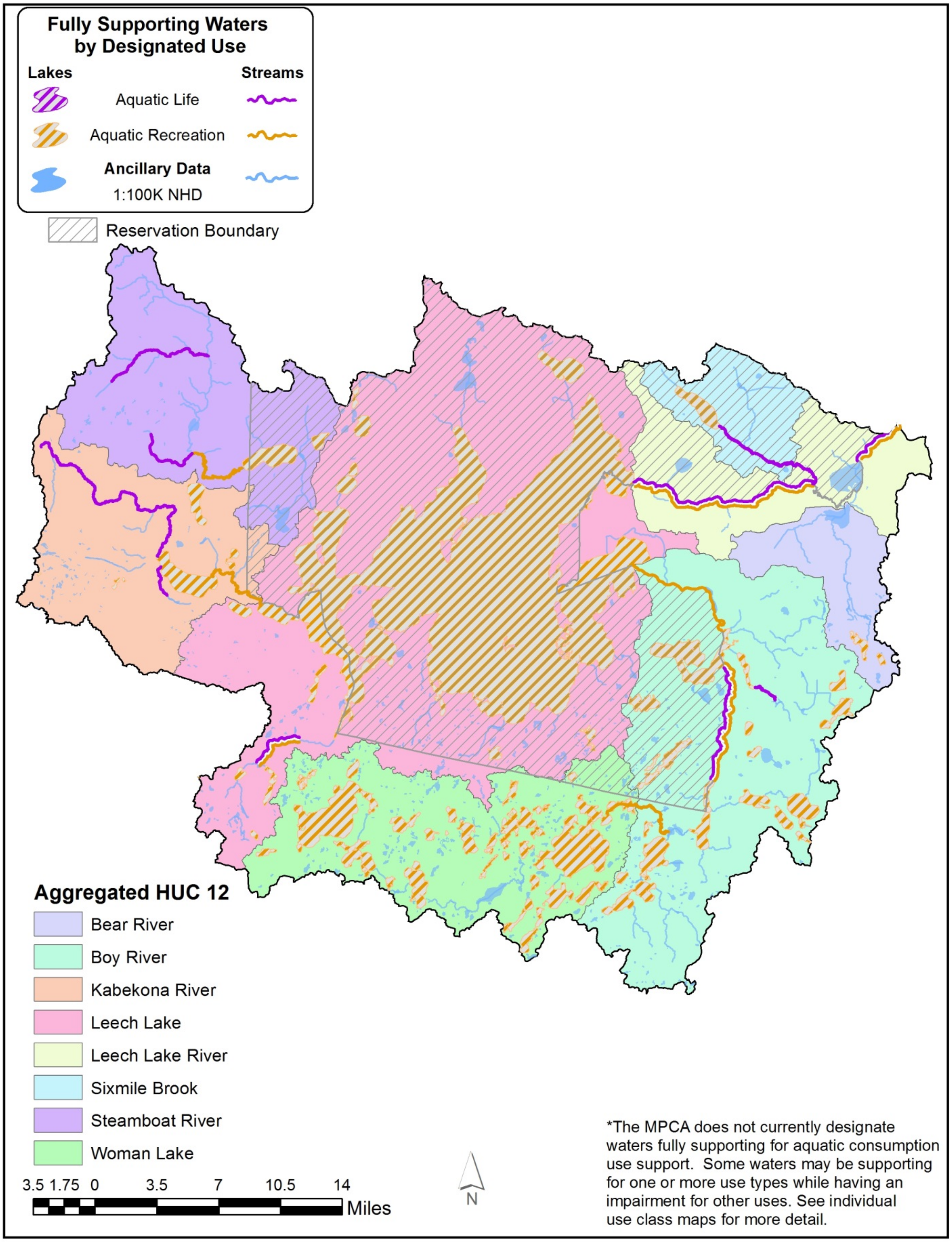

Figure 34. Fully supporting waters by designated use in the Leech Lake River Watershed.

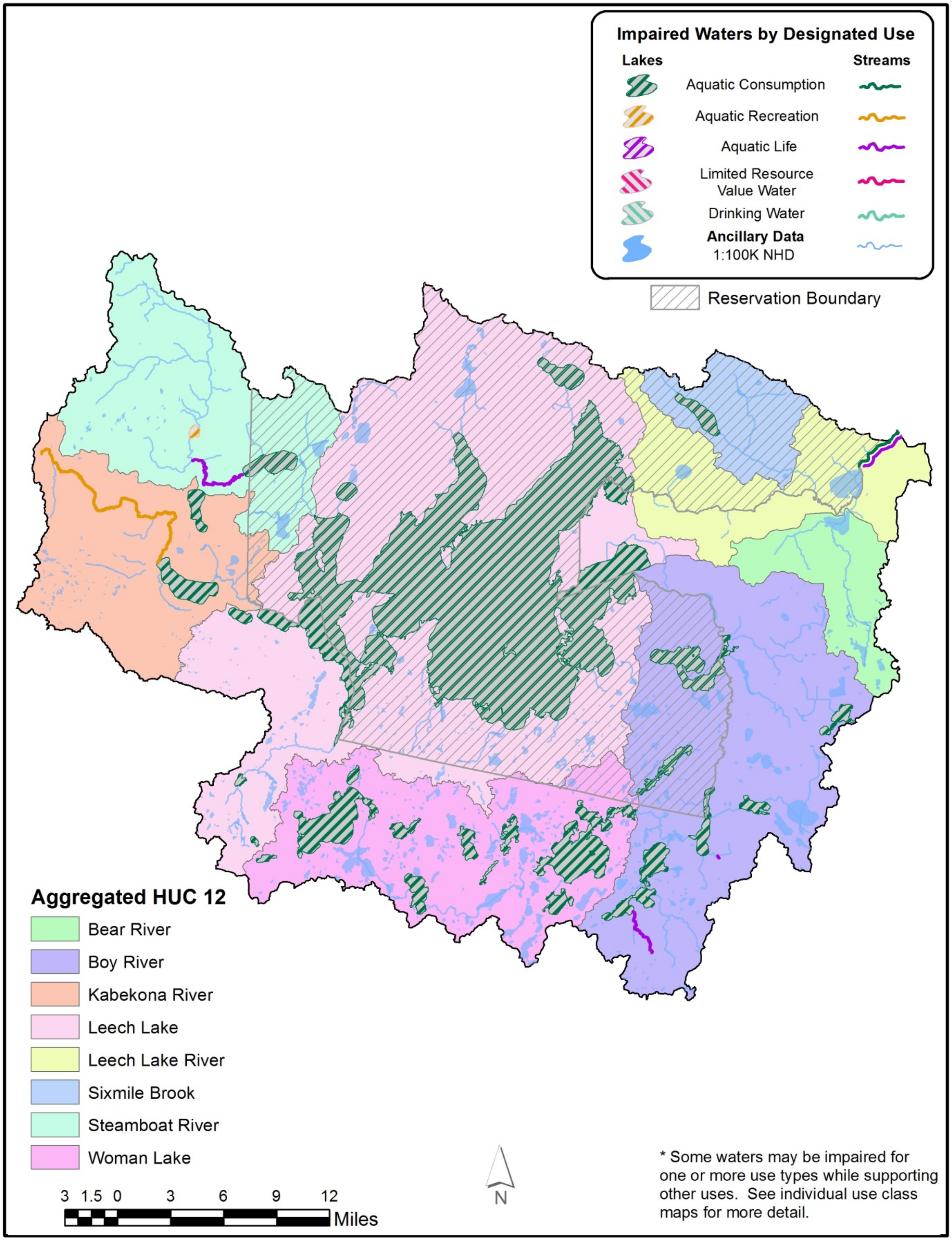

Figure 35. Impaired waters by designated use in the Leech Lake River Watershed.

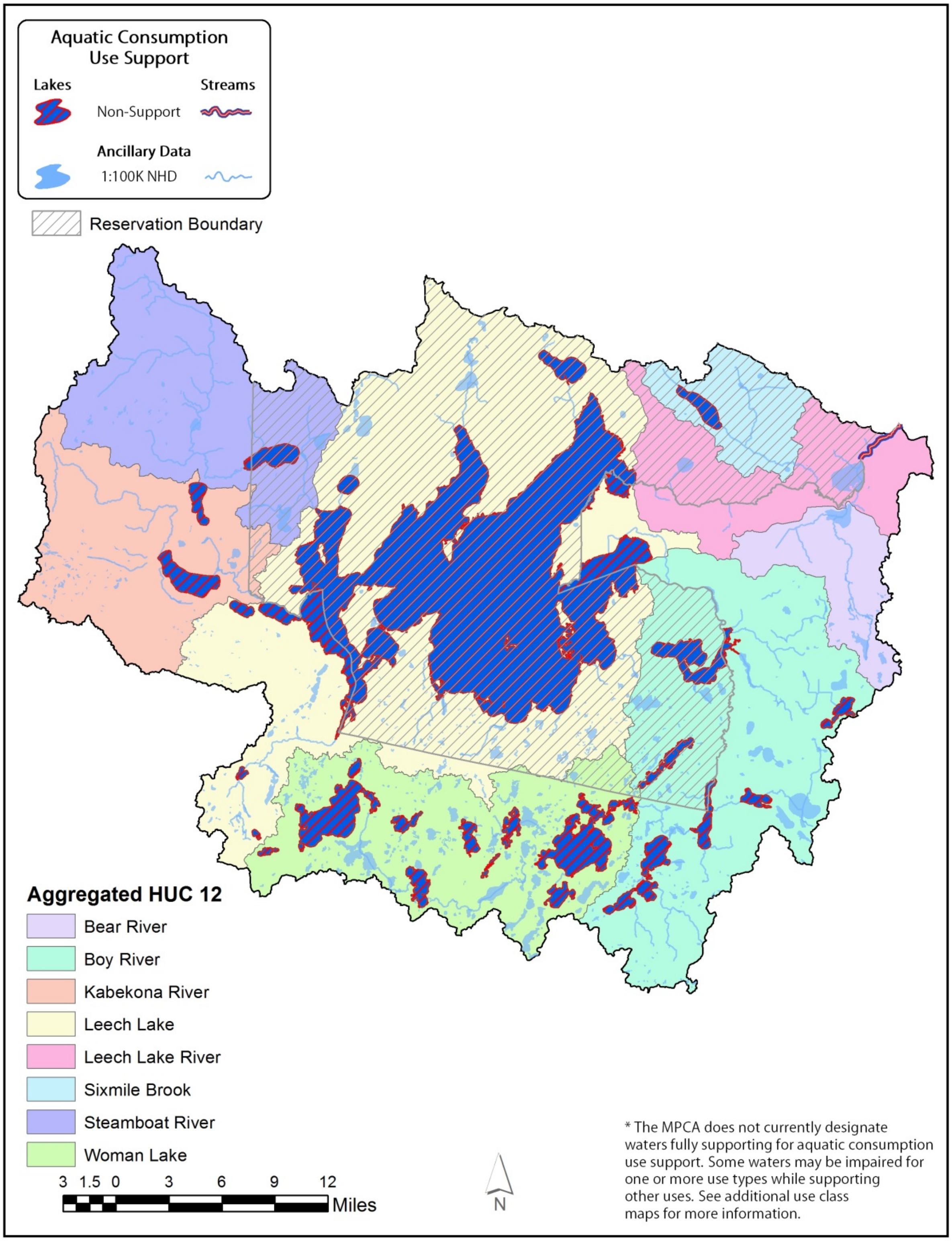

Figure 36. Aquatic consumption use support in the Leech Lake River Watershed.

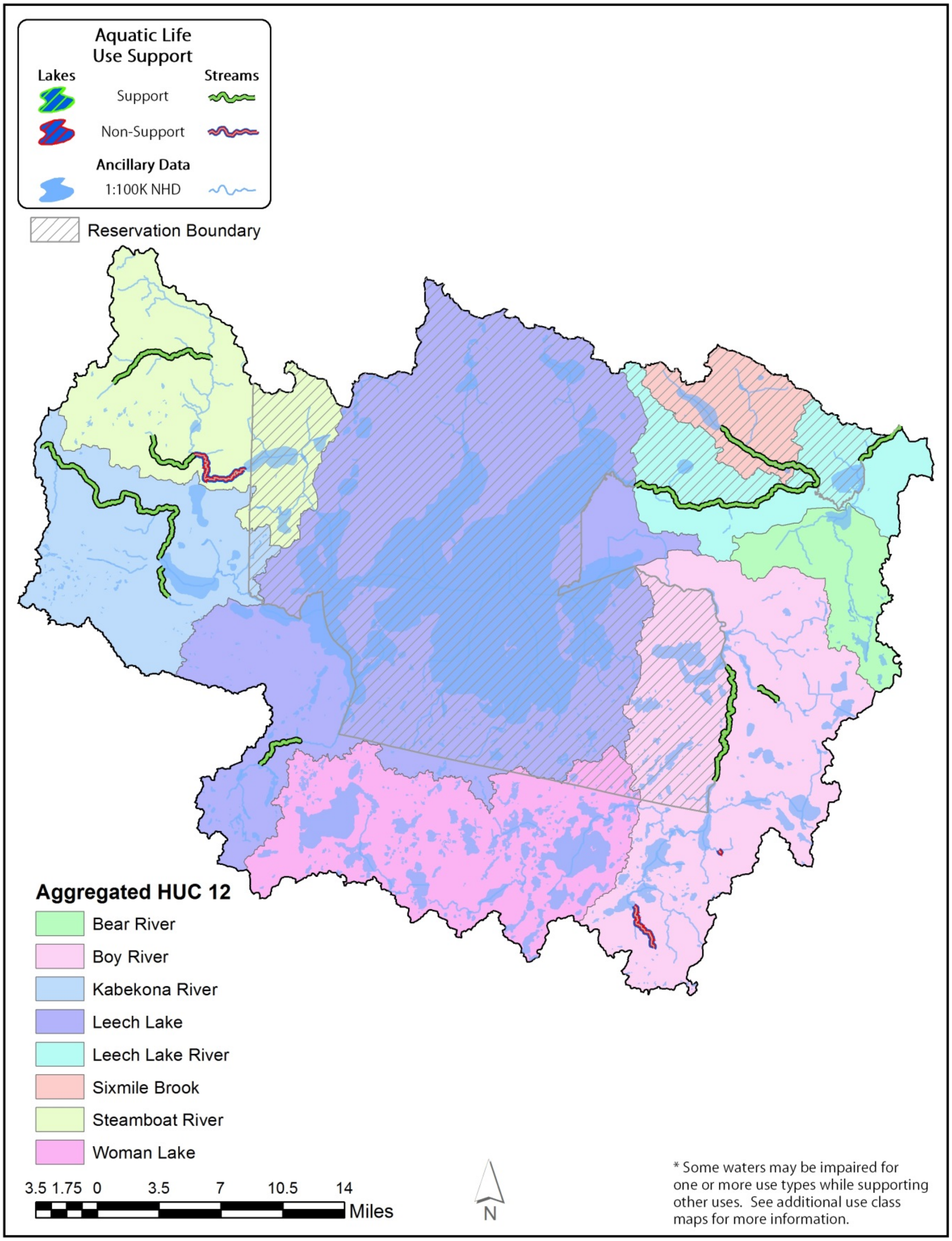

Figure 37. Aquatic life use support in the Leech Lake River Watershed.

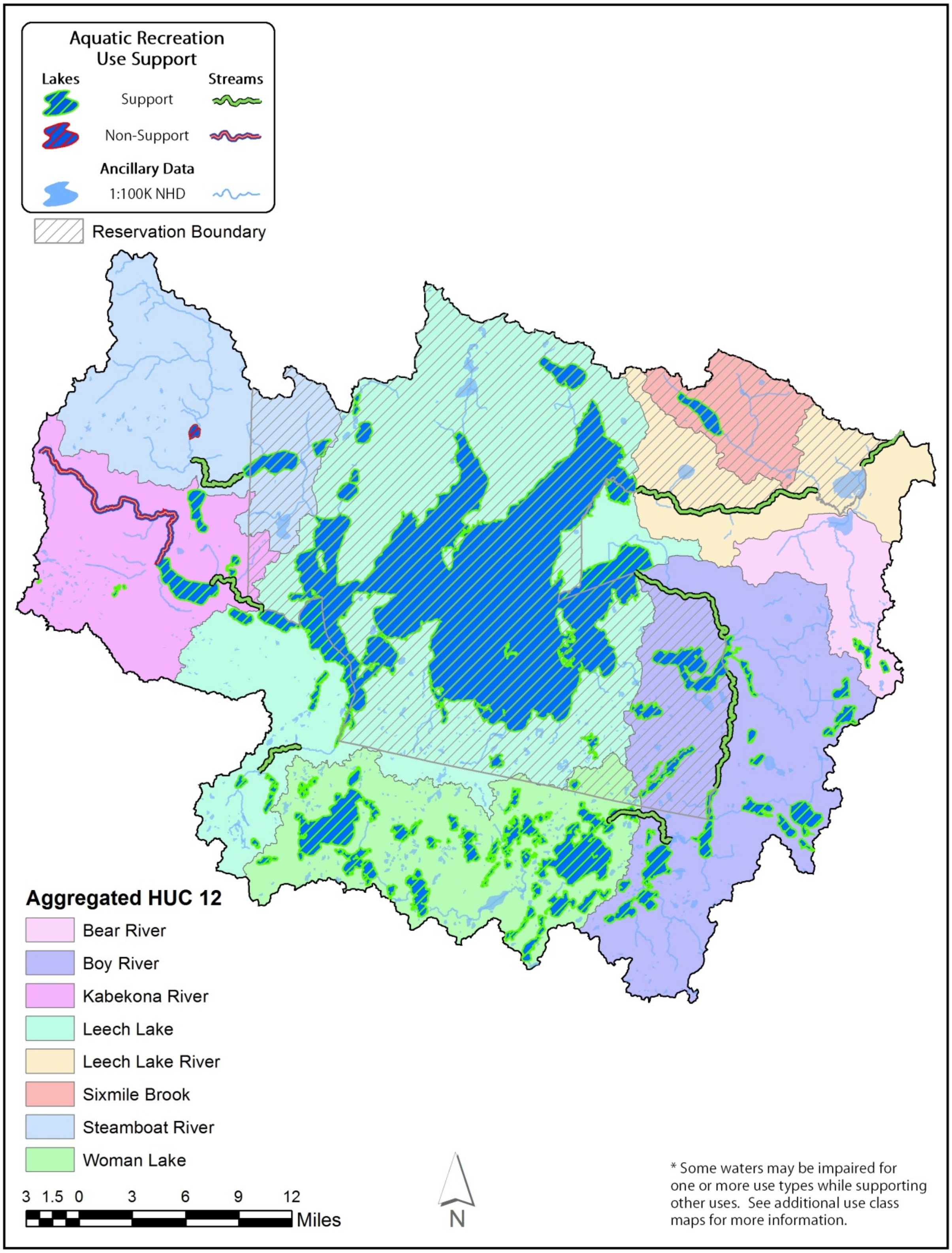

Figure 38. Aquatic recreation use support in the Leech Lake River Watershed.

Water clarity trends at citizen monitoring sites

Citizen volunteer monitoring occurs at only one stream in the watershed. Water clarity has shown no trend.

Table 38. Water clarity trends at Citizen Stream Monitoring Sites

Leech Lake River Watershed HUC 07010102	Citizen Stream Monitoring Program	Citizen Lake Monitoring Program
number of sites w/ increasing trend	0	19
number of sites w/ decreasing trend	0	7
number of sites w/ no trend	1	29

Remote sensing transparency data

Remote sensing data was used to describe lake transparency in areas where water chemistry data has not been collected or were difficult to access. With remote sensing data, comparisons can be made at the state and watershed scale. Remote sensing provides insight into water quality by estimating transparency values for lakes void of TP, Chl-a, or Secchi data. Satellite imagery is used with Secchi transparency measurements to form a relationship that allows for predictions of transparency values across the state. This provides a snap shot of lake transparency during the time of satellite pass over.

Currently, remote sensing data has been analyzed on approximately a five-year basis from 1975 to 2008 with seven years of remote sensing data available. At this frequency the data allows for a simple average lake transparency value to be calculated at the state or watershed scale. Comparisons of lake transparencies may also be made between individual lakes during any single year. This data does not allow for trends analysis due to the small number of remote sensing data points available at this time.

Remote sensing data was used to describe lake transparencies on 143 lakes without water chemistry data in the Leech Lake River Watershed. One hundred twenty seven lakes had estimated transparencies greater than the Northern Lakes and Forest Ecoregion Eutrophication Standard of 2.0 m. Sixteen lakes had estimates of transparencies that fell below the 2.0 m eutrophication standard. These lakes may warrant further investigation into water quality conditions. However, confounding variables must be examined as well, such as lake depth and color, which may impact the remote sensing data. Overall, transparencies look to be in good to excellent condition for the majority of lakes without water chemistry data. Lakes with excellent remote sensing lake transparency data may be considered candidates for protection strategies given their exceptional condition.

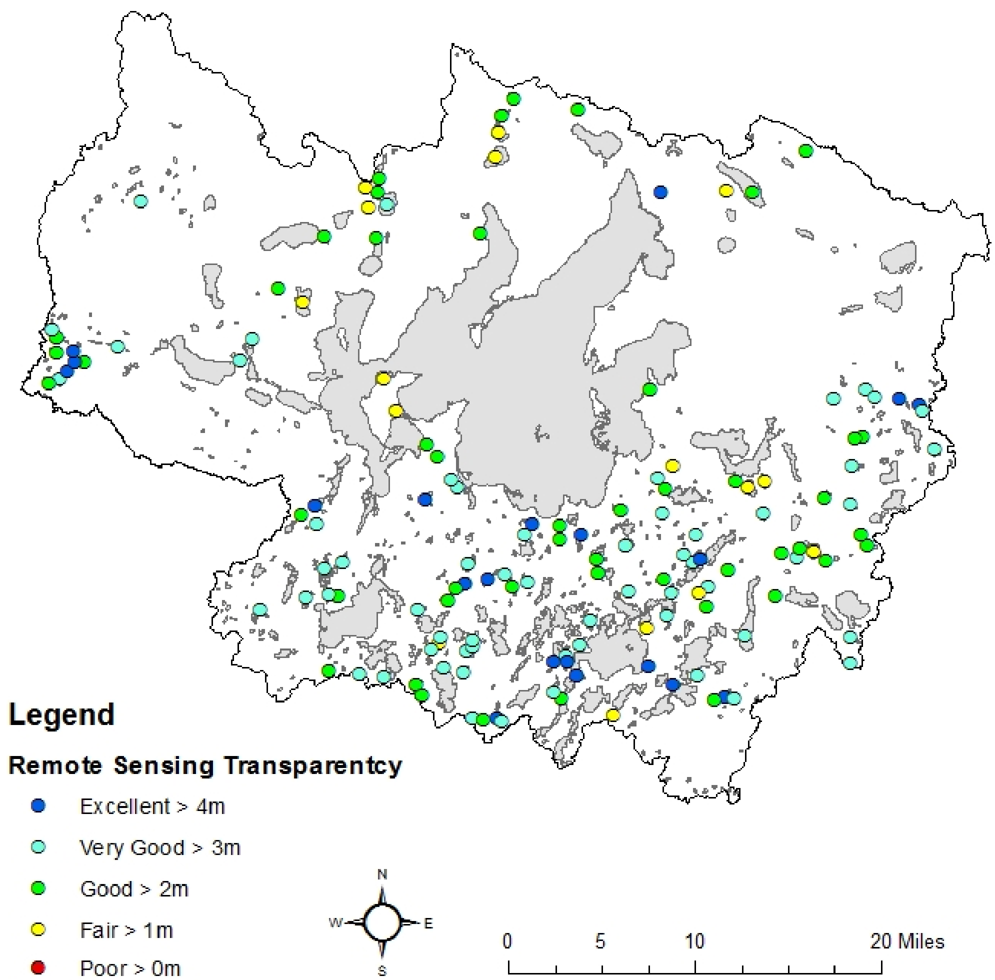

Figure 39. Remote Sensing Transparency Data on lakes without Observed Water Chemistry Data within the Leech Lake River Watershed.

Summaries and recommendations

Seventy five species of fish have been documented within the Upper Mississippi River Basin. MPCA biological monitoring crews captured 46 species of fish during the IWM process in the Leech Lake River Watershed. The pugnose shiner, a species of special concern, was captured at a monitoring station located on the lower reach of the Kabekona River. The presence of the least darter, another species of special concern, was documented in a 2000 survey conducted on the Boy River. Both the least darter and the pugnose shiner are intolerant of turbidity, eutrophication, and vegetation removal (Becker 1983). Both species are endangered or extirpated in many states across their range. The presence of these species within the Leech Lake River Watershed is indicative of excellent water quality and aquatic habitat. The most diverse fish community within the watershed was sampled on the Boy River at station 00UM012. Twenty seven species of fish were collected from this station. The majority of fish samples collected within the watershed contained 7-12 species. Yellow perch, central mudminnows, and largemouth bass were the most commonly sampled species. All three species were sampled at most stations; however, significantly greater numbers of yellow perch were collected. Yellow perch and largemouth bass are found in a wide variety of habitat but prefer vegetated lakes and backwaters. The central mudminnow prefers stagnant or slow flowing, vegetated waters commonly associated with wetlands and low gradient streams. The prevalence of lakes and wetlands throughout the Leech Lake River Watershed provides ideal habitat for these species. Walleye, a species which prefers lakes and larger rivers, were sampled at stations on the Boy River and Leech Lake River. Other commonly sampled species within the Leech Lake River Watershed include the white sucker, northern pike, and common shiner. All of these species are commonly found in clear water lakes and streams throughout the Midwest.

The majority of fish samples obtained from warm water streams contained at least 38% non- tolerant insectivorous taxa. Species such as the yellow perch and blackchin shiner are insectivores. Insectivores feed upon invertebrates and rely on the existence of a stable invertebrate population. Any disturbances within a watershed that cause a reduction in invertebrate abundance will also cause a reduction in insectivorous fish species. The persistence of a stable macroinvertebrate community at many locations within the Leech Lake River Watershed indicates good water quality and low disturbance. Low numbers of darter and simple lithophilic spawning species were sampled from the larger streams within the watershed. Both of these taxa types require clean coarse substrate to survive. The absence of these species generally is an indicator of degradation; however, larger rivers within the watershed (i.e. Boy River, Leech Lake River, Steamboat River) are wetland influenced and naturally devoid of coarse substrate.

Twenty unique visits were made to 11 sites within the Leech Lake River Watershed to sample macroinvertebrates. During these sampling efforts, 39 sensitive taxa were collected at 55% of the sampling visits. A mayfly from the genus Acerpenna and a midge from the genus Stempellinella were the most widespread sensitive genera, though a Caddis from the genus Oxyethira was the most abundant sensitive genera. The most abundant genera sampled in the watershed were Simulium, Hyalella, Baetis, Polypedilum, and Hydrobiidae. These five organisms are moderately tolerant to disturbance and represent diverse functional feeding groups. The diversity of functional feeding groups combined with observed habitat data suggests good habitat heterogeneity within much of the system. Coarse substrates, such as wood and rocks, were present at 91% of sites in the Leech Lake River Watershed. These habitats are particularly important habitats for many sensitive macroinvertebrates. Overall, the health of the macroinvertebrate community in the Leech Lake River watershed is good. However with projected growth of 60% by 2030, it is imperative to protect the streams that are currently healthy and work to restore the streams that are not. The connectedness of lakes and streams in the Leech Lake River Watershed would suggest that recolonization of sensitive taxa to impaired waters is likely possible with well executed efforts.

The majority of the streams within the Leech Lake River Watershed featured biological communities that were in good condition. The healthy biological communities are the result of good habitat and overall low disturbance within the watershed. Excellent habitat and/or biology exist in streams such as Shingobee Creek, the upper Necktie River, and Bungashing Creek. The top five highest quality stream resources within the Leech Lake River Watershed as indicated by the fish, invertebrate, and habitat conditions at the biological monitoring station are listed in Table 39. Streams with reduced habitat heterogeneity (and lower MSHA scores) were the result of natural wetland influence and lower stream gradient. Streams that flow through wetlands are often characterized by fine sediments, emergent macrophytes (i.e. cattails, wild rice, sedges) within the margins of the channel, and abundant submergent macrophytes. Large woody debris is often limited in these streams due to the absence of trees within the immediate flood plain. The lower stream gradient typical of these streams, though favorable of increased channel stability, reduces channel development. Examples of these stream types include the lower reach of the Boy River, Leech Lake River, Steamboat River, and lower Kabekona River. Wetlands also influence dissolved oxygen levels in these systems. Large precipitation events flush organic matter and water from wetlands into streams causing dissolved oxygen to decline to levels that are stressful to aquatic life. The profound influence of wetlands on some stream reaches caused some parameters (such as dissolved oxygen) to not be appropriate for aquatic life use assessment. Under such circumstances, aquatic life was assessed using just the available biological data. Nevertheless, wetlands are extremely valuable due to their role in maintaining water quality and for the many ecosystem processes they provide. Wetlands are a major contributor to the excellent water quality within the Leech Lake River Watershed; they must be protected to maintain this level of water quality into the future. The forests throughout the watershed also play an important role in maintaining water quality. Development pressure is expected to increase in the Leech Lake River Watershed, as well as the North Central region of Minnesota in general (Gould, Walker, & Frazell 2009). Careful consideration must be given to how land use alterations will affect water resources. Implementing protection strategies for sensitive areas to maintain good water quality will be more cost effective than restoration of a degraded resource. The Leech Lake River Watershed is too valuable as a resource to allow it to become degraded from overdevelopment.

The Leech Lake River Watershed has high hydrologic connectivity formed by a vast network of lakes, streams, and wetlands that flow towards the most dramatic water body feature on the landscape: Leech Lake. Water quality in this watershed has benefitted greatly from the presence of large forest and wetland regions combined with limited development. The lakes in this watershed are among some of the highest valued water resources in Minnesota and are a large part of local economies. The majority of lakes in the Leech Lake River Watershed are deep and have the ability to assimilate phosphorus within lake bed sediments. This limits internal nutrient loading within these lakes and prevents the transfer of phosphorus to lakes further downstream (and ultimately into Leech Lake). Typically, shallow lakes have higher phosphorus concentrations because they do not have the ability to assimilate phosphorus. In this case aquatic vegetation with in these lakes and stream channels become important and should be protected in order to aid in phosphorus removal and nutrient up take. Highly connected watersheds can also be at increased risk for eutrophication if nutrient loads from land use or human activities increase causing water quality to degrade. The first priority for watershed management in the Leech Lake River Watershed should be based on protection. This should include protecting natural areas such as wetlands and forests near lakes and streams. Wetlands, in an unaltered state, act as surface water storage areas that filter water moving to downstream lakes. Development should be planned with water quality in mind to limit impacts or detrimental practices that could cause water quality to degrade in the future.

Table 39. Top Five Stream Resources in the Leech Lake River Watershed, as Indicated by Biological (FIBI and MIBI) and Physical (MSHA) Parameters.

Rank	Stream Name	Biological Station ID	Location of Biological Station	FIBI	MIBI	MSHA
1	Bungashing Cr	12UM096	Downstream of CSAH 45, 3 mi. SE of Nary	74.64	51.96	87.9
2	Shingobee Cr	12UM091	Upstream of CR 83, 3 mi. E of Akeley	73.51	50.58	72.2
3	Kabekona River	09UM084	Upstream of CR 257, 2 mi. E of Kabekona	68.96	53.97	77.5
4	Boy River	00UM012	Upstream of CR 53, 9 mi. NW of Remer	61.65	52.88	75.7
5	Necktie River	09UM085	Upstream of CSAH 45, 6 mi. SE of Bemidji	100	18.08	60.8

Literature cited

Becker, George C. 1983. Fishes of Wisconsin. University of Wisconsin Press, Madison.

Genet, J. A. 2012. Status and trends of wetlands in Minnesota: Depressional Wetland Quality Baseline. Minnesota Pollution Control Agency, Biological Monitoring Program, St. Paul. 80 pp. Available: http://www.pca.state.mn.us/index.php/view-document.html?gid=17741

Gould, L., Rachel W., and Kevin F. 2009. Understanding Our Population Trends (part of Community Conversations: Minnesota's Changing Demographics). League of Minnesota Cities, St. Paul. Available: http://www.lmc.org/media/document/1/populationtrends.pdf?inline=true.

Granger, S. and S. Kelly. 2005. Historic Context Study of Minnesota Farms, 1820 – 1960 (Vol 1). Gemini Research, Morris, MN. Available from: http://www.dot.state.mn.us/culturalresources/docs/crunit/vol1.pdf.

Heiskary, S., and S. McCollor. 1993. Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions. Addendum to Fandrei, G., S. Heiskary, and S. McCollor. 1988. Descriptive Characteristics of the Seven Ecoregions in Minnesota. Division of Water Quality, Program Development Section, Minnesota Pollution Control Agency, St. Paul.

Kroening, S. and M. Ferrey. 2013. The Condition of Minnesota's Groundwater, 2007-2011. Minnesota Pollution Control Agency, St. Paul. Available: https://www.pca.state.mn.us/sites/default/files/wq-am1-06.pdf.

Larson, Agnes M. 2007. The White Pine Industry in Minnesota. University of Minnesota Press, Minneapolis.

Minnesota Department of Agriculture (MDA): Pesticide and Fertilizer Management. 2014. 2013 Water quality Monitoring Report. Minnesota Department of Agriculture Report MAU-14-101, St. Paul.

Minnesota American Indian Chamber of Commerce (MAICC). 2015. Leech Lake Band of Ojibwe. Minnesota American Indian Chamber of Commerce, St. Paul. Available from http://www.maicc.org/meet-the-minnesota-tribes/leech-lake-band-of-ojibwe/.

Minnesota Department of Health (MDH). 2001. The Minnesota Arsenic Study (MARS), ATSDR. Minnesota Department of Health, St. Paul. Available: http://www.health.state.mn.us/divs/eh/hazardous/topics/arsenicstudy.pdf.

Minnesota Department of Health (MDH). 2012. Arsenic Occurrence in New Wells, August 2008-January 2012. Minnesota Department of Health, St. Paul. Available: http://www.health.state.mn.us/divs/eh/wells/waterquality/arsenicmap.pdf.

Minnesota Department of Health (MDH). 2015. Drinking Water Quality. Minnesota Department of Health, St. Paul. https://apps.health.state.mn.us/mndata/arsenic_wells#.

Minnesota Department of Natural Resources (MDNR): Waters. 2001. Figure 1: Minnesota Ground Water Provinces. Minnesota Department of Natural Resources, St. Paul. Available: http://files.dnr.state.mn.us/natural_resources/water/groundwater/provinces/gwprov.pdf.

Minnesota Department of Natural Resources (MDNR): State Climatology Office. 2003. Climate. Minnesota Department of Natural Resources, St. Paul. Available: http://www.dnr.state.mn.us/faq/mnfacts/climate.html.

Minnesota Department of Natural Resources (MDNR). 2014. Lake Finder. Minnesota Department of Natural Resources, St. Paul. Available: http://www.dnr.state.mn.us/lakefind/index.html.

Minnesota Department of Natural Resources (MDNR). 2014. Ground Water Level Data. Minnesota Department of Natural Resources, St. Paul. Available: http://www.dnr.state.mn.us/waters/groundwater_section/obwell/waterleveldata.html.

Minnesota Department of Natural Resources (MDNR). 2014. Water use - Water Appropriations Permit Program. Minnesota Department of Natural Resources, St. Paul. Available: http://www.dnr.state.mn.us/waters/watermgmt_section/appropriations/wateruse.html.

Minnesota Pollution Control Agency (MPCA). 1998. Baseline Water Quality of Minnesota's Principal Aquifers: Region 2, North Central Minnesota. Minnesota Pollution Control Agency, St. Paul. Available: https://www.pca.state.mn.us/sites/default/files/gwbasefs.pdf.

Minnesota Pollution Control Agency (MPCA). 2007a. Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment 305(b) Report and 303(d) List. Environmental Outcomes Division, Minnesota Pollution Control Agency, St. Paul.

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

Minnesota Pollution Control Agency (MPCA). 2008a. Watershed Approach to Condition Monitoring and Assessment. Appendix 7 *in* Biennial Report of the Clean Water Council. Minnesota Pollution Control Agency, St. Paul.

Minnesota Pollution Control Agency (MPCA) and Minnesota State University of Mankato. 2009. State of the Minnesota River, Summary of Surface Water Quality Monitoring 2000-2008. Minnesota Pollution Control Agency, St. Paul. Available: http://mrbdc.mnsu.edu/sites/mrbdc.mnsu.edu/files/public/reports/basin/state_08/2008_fullreport1109.pdf?field_pubtitle_value=State+of+the+Minnesota+River&field_pubauthor_value=&body_value=&taxonomy_vocabulary_1_tid%255B%255D=1258&=Apply.

Minnesota Pollution Control Agency (MPCA). 2010. Aquatic Life Water Quality Standards Technical Support Document for Nitrate. Minnesota Pollution Control Agency, St. Paul. Available: http://www.pca.state.mn.us/index.php/view-document.html?gid=14949.

Minnesota Pollution Control Agency (MPCA). 2010d. Minnesota Milestone River Monitoring Report. Minnesota Pollution Control Agency, St. Paul. Available: 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. Minnesota Pollution Control Agency, St. Paul. Available: http://www.pca.state.mn.us/index.php/view-document.html?gid=6072.

Minnesota Pollution Control Agency (MPCA). 2011. Aquatic Life Water Quality Standards Draft Technical Support Document for Total Suspended Solids (Turbidity). Minnesota Pollution Control Agency, St. Paul. Available: http://www.pca.state.mn.us/index.php/view-document.html?gid=14922.

Minnesota Pollution Control Agency (MPCA). 2013. Regionalization of Minnesota's Rivers for Application of River Nutrient Criteria. Minnesota Pollution Control Agency, St. Paul. Available: http://www.pca.state.mn.us/index.php/view-document.html?gid=14948.

Minnesota Pollution Control Agency (MPCA). 2014. 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 Pollution Control Agency. 2014. Leech Lake River Watershed. Minnesota Pollution Control Agency, St. Paul. Available: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/watersheds/leech-lake-river.html.

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.

Mitsch, W.J. and J.G. Gosslink. 2007. Wetlands, 4th ed. Wiley Publications, Hoboken, NJ.

National Resource Conservation Service (NRCS). 2014. Rapid Watershed Assessment: Leech Lake Watershed (MN) HUC: 07010102 United States Department of Agriculture, Washington, D.C. Available: http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_022266.pdf.

Omernik, J.M. and A.L. Gallant. 1988. Ecoregions of the Upper Midwest States. EPA/600/3-88/037. United States Environmental Protection Agency, Corvallis, OR.

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

United States Geological Survey (USGS). 2014. USGS Current Water Data for Minnesota. Available: http://waterdata.usgs.gov/mn/nwis/rt.

University of Missouri Extension. 1999. Agricultural Phosphorus and Water Quality. Pub. G9181. Available: http://extension.missouri.edu/publications/DisplayPub.aspx?P=G9181.

Western Regional Climate Center. 2015. USA Divisional Climate Data. Western Regional Climate Center, Reno, NV. Available: http://www.wrcc.dri.edu/spi/divplot1map.html.

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 waste water 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.

Specific Conductance - The amount of ionic material dissolved in water. Specific conductance is influenced by the conductivity of rainwater, evaporation and by road salt and fertilizer application.

Temperature - Water temperature in streams varies over the course of the day similar to diurnal air temperature variation. Daily maximum temperature is typically several hours after noon, and the minimum is near sunrise. Water temperature also varies by season as doe's air temperature.

Total Kjehldahl 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.

Total Suspended Volatile Solids (TSVS) - Volatile solids are solids lost during ignition (heating to 500 degrees C.) They provide an approximation of the amount of organic matter that was present in the water sample. ''Fixed solids'' is the term applied to the residue of total, suspended, or dissolved solids after heating to dryness for a specified time at a specified temperature. The weight loss on ignition is called ''volatile solids.''

Unnionized 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 - Intensive watershed monitoring water chemistry stations in the Leech Lake River Watershed

Biological Station ID	STORET/ EQuIS ID	Waterbody name	Location	12-digit HUC
12UM088	S006-256	Necktie River	At County State Aid Highway 45, 2.5 MILES Northeast of Laporte	0701010201-04
12UM090	S007-103	Kabekona River	At CSAH-38, 5.1 Miles southeast of Laporte	0701010202-01
12UM091	S007-102	Shingobee Creek	At CSAH-83/Forest Rt 2314, 3 Miles east of Akeley	0701010205-01
12UM086	S006-261	Boy River	At Sioux Camp Road NE, 2 Miles Southeast of Longville	0701010204-01
00UM012	S006-262	Boy River	At Tobique Road NE, 8.5 Miles Northwest of Remer	0701010204-01
12UM089	S007-293	Boy River	At CSAH-8, 2.5 Miles west of Boy River	0701010204-01
-	S000-180	Leech Lake River	At CSAH 8, in Federal Dam	0701010206-01
-	S001-925	Leech Lake River	At CR-139 At Mud Lake Dam, 8.5 Mi Southwest of Deer River	0701010206-04

Appendix 3.1 - AUID table of stream assessment results (by parameter and beneficial use)

AUID DESCRIPTIONS				USES						WATER QUALITY STANDARDS									
										Aquatic Life Indicators:								Aquatic Rec. Indicators:	
Assessment Unit ID (AUID)	Stream Reach Name	Reach Description	Reach Length (Miles)	Use Class	Aquatic Life	Aquatic Recreation	Aquatic Consumption	Drinking Water	303d listed impairments 2014	Fish	Macroinvertebrates	Dissolved Oxygen	TSS	Chloride	pH	NH3	Pesticides	Bacteria	Nutrients
HUC 12: 0701010201-01 (Steamboat River)																			
07010102-550	Necktie River	Unnamed ditch to T145 R32W S16, east line	6.93	1B, 2Ag 3B	IF	NA	NA	NA		MTS	IF	IF	IF	-	IF	-	-	-	-
07010102-502	Necktie River	Upstream of CR 45, 5 mi. W of Wilkenson	6.03	2Bg 3C	NA	FS	NA	NA		NA	-	NA	MTS	MTS	MTS	MTS	-	MTS	-
07010102-505	Bungashing Creek	Downstream of CR 45, 3 mi. SE of Nary	7.49	1B, 2Ag 3B	FS	NA	NA	NA		MTS	MTS	IF	IF	-	IF	-	-	-	-
07010102-527	Pokety Creek	Downstream of 414th St, 3 mi. S of Guthrie	4.54	1B, 2Bg 3B	FS	NA	NA	NA		MTS	-	IF	-	-	IF	-	-	-	-
07010102-507	Steamboat River	Downstream of HWY 371, 0.5 mi. E of Wilkenson	3.91	2Bg 3C	NA	NA	NA	NA		NA	-	IF	IF	-	IF	-	-	-	-
HUC 12: 0701010202-01 (Kabekona River)																			
07010102-511	Kabekona River	Headwaters to Kabekona Lake	16.47	1B, 2Ag 3B	FS	NS	NA	NA		MTS	MTS	MTS	EX	MTS	MTS	-	-	EX	-
07010102-611	Sucker Branch	Downstream of CR 37, 4 mi. SW of Laporte	2.12	2Bg 3C	FS	NA	NA	NA		MTS	MTS	IF	IF	-	IF	-	-	-	-
07010102-528	Kabekona River	Downstream of CR 38, 0.5 mi. S of Benedict	5.33	2Bg 3C	NA	FS	NA	NA		MTS	-	EX	MTS	MTS	MTS	MTS	-	MTS	-
HUC 12: 0701010205-01 (Leech Lake)																			
07010102-530	Shingobee River	Unnamed creek (Howard Lake outlet) to Unnamed creek (Anoway Lake outlet)	3.67	2Bg 3C	FS	FS	NA	NA		MTS	MTS	MTS	IF	MTS	MTS	MTS	-	MTS	-

HUC 12: 0701010204-01 (Boy River)																				
07010102-610	Spring Creek	Headwaters to Wabedo Lake	3.66	2Bg 3C	NS	NA	NA	NA			MTS	EXP	IF	IF	-	IF	-	-	-	-
07010102-612	Unnamed Creek	Headwaters to Northby Creek	0.17	2Bg 3C	NS	NA	NA	NA			EXS	EXS	IF	IF	-	IF	-	-	-	-
07010102-524	Boy River	Woman Lake to Rice Lake	6.18	2Bg 3C	NA	FS	NA	NA			-	-	EX	MTS	MTS	MTS	MTS	-	MTS	-
07010102-520	Boy River	Inguadona Lake to Boy Lake	9.41	2Bg 3C	FS	FS	NA	NA			MTS	MTS	MTS	MTS	MTS	MTS	MTS	-	MTS	-
07010102-538	Swift River	Little Swift Lake to Swift Lake	2.03	2Bg 2C	FS	NA	NA	NA			MTS	MTS	IF	IF	-	IF	-	-	-	-
07010102-518	Boy River	Boy Lake to Leech Lake	8.35	2Bg 2C	NA	FS	NA	NA			NA	-	IF	MTS	MTS	MTS	MTS	-	MTS	-
HUC 12: 0701010206-03 (Sixmile Brook)																				
07010102-515	Sixmile Brook	Sixmile Lake to Leech Lake River	11.28	2Bg 2C	FS	NA	NA	NA			MTS	MTS	IF	IF	-	IF	-	-	MTS	-

Full Support (FS); Not Supporting (NS); Insufficient Data (IF); Not Assessed (NA); Meets standards or ecoregion expectations (MT/MTS), Potential Exceedence (EXP), Exceeds standards or ecoregion expectations (EX/EXS).
Key for Cell Shading: ☐= existing impairment, listed prior to 2012 reporting cycle; ☐= new impairment; ☐= full support of designated use.

ID DESCRIPTIONS				USES							WATER QUALITY STANDARDS: Aquatic Life Indicators:								Aquatic Rec. Indicators:	
Assessment Unit ID (AUID)	Stream Reach Name	Reach Description	Reach Length (Miles)	Use Class	Aquatic Life	Aquatic Recreation	Aquatic Consumption	Drinking Water	303d listed impairments 2014		Fish	Macroinvertebrates	Dissolved Oxygen	TSS	Chloride	pH	NH3	Pesticides	Bacteria	Nutrients
HUC 12: 0701010206-01 (Leech Lake River)																				
07010102-501	Leech Lake River	Leech Lake to Sixmile Brook	12.86	2Bg 2C	FS	FS	NA	NA			MTS	-	IF	MTS	MTS	MTS	MTS	-	MTS	-
07010102-606	Leech Lake River	Mud-Goose Lake Dam to Mississippi River	3.71	2Bg 2C	FS	FS	NS	NA			MTS	-	EX	MTS	MTS	MTS	MTS	-	MTS	-

Full Support (FS); Not Supporting (NS); Insufficient Data (IF); Not Assessed (NA); Meets standards or ecoregion expectations (MT/MTS), Potential Exceedence (EXP), Exceeds standards or ecoregion expectations (EX/EXS).
Key for Cell Shading: ☐= existing impairment, listed prior to 2012 reporting cycle; ☐= new impairment; ☐= full support of designated use.

Appendix 3.2 - Assessment results for lakes in the Leech Lake River Watershed

Lake ID	Lake Name	County	HUC-12	Ecoregion	Lake Area (acres)	Max Depth (m)	Watershed Area (acres)	% Littoral	Mean depth (m)	AQR Support Status	AQL Support Status
11006300	Little Bass	Cass	0701010204-01	NLF	139	30		60		FS	NA
11007400	Ododikossi	Cass	0701010204-01	NLF	13						
11007500	Oxbow	Cass	0701010204-01	NLF	68						
11007700	Big Sand	Cass	0701010204-01	NLF	730	23	3021	86	2.1	FS	IF
11007800	Moon	Cass	0701010204-01	NLF	46						
11008000	Lower Milton	Cass	0701010206-02	NLF	79						
11008100	Upper Milton	Cass	0701010206-02	NLF	24						
11008200	Cedar	Cass	0701010206-02	NLF	21						
11008300	Tamarack	Cass	0701010204-01	NLF	32						
11008400	Dewey	Cass	0701010204-01	NLF	28						
11008500	Sullivan	Cass	0701010206-02	NLF	42						
11008600	Grave	Cass	0701010206-02	NLF	372	55		35		FS	IF
11008700	Knight	Cass	0701010206-02	NLF	131	10		100		FS	NA
11008800	Wahneshin	Cass	0701010204-01	NLF	37						
11008900	Bebow	Cass	0701010204-01	NLF	13						
11009000	Grass	Cass	0701010204-01	NLF	16						
11009100	Green	Cass	0701010204-01	NLF	31						
11009200	Little Sand	Cass	0701010204-01	NLF	409	12	3583	100	2.1	FS	NA
11009300	Wilson	Cass	0701010206-02	NLF	84	10		100		IF	NA

11009400	Tidd	Cass	0701010206-02	NLF	46						
11009500	Taylor	Cass	0701010204-01	NLF	31						
11009700	Upper Menton	Cass	0701010206-02	NLF	12						
11009800	Lower Menton	Cass	0701010206-02	NLF	15						
11009900	Chain O'Lakes	Cass	0701010206-02	NLF	28						
11010400	Laura	Cass	0701010204-01	NLF	1,255	5				FS	IF
11010500	Upper Trelipe	Cass	0701010204-01	NLF	421	69		35		FS	NA
11010600	Peterson	Cass	0701010204-01	NLF	32						
11010700	Lucille	Cass	0701010204-01	NLF	99						
11010800	Unnamed	Cass	0701010204-01	NLF	16						
11010900	Unnamed	Cass	0701010204-01	NLF	16						
11011800	Camp Two	Cass	0701010204-01	NLF	84						
11011900	Woodcamp	Cass	0701010204-01	NLF	12						
11012000	Inguadona	Cass	0701010204-01	NLF	1,133						
11012001	Inguadona (N. Bay)	Cass	0701010204-01	NLF	359	76	166631		4.7	FS	IF
11012002	Inguadona (S. Bay)	Cass	0701010204-01	NLF	774	76	146675		6.7	FS	IF
11012100	Mabel	Cass	0701010204-01	NLF	184	14		100		FS	NA
11012200	Unnamed	Cass	0701010204-01	NLF	17						
11012300	Twin	Cass	0701010204-01	NLF	272						
11012400	Wax	Cass	0701010204-01	NLF	88						
11012500	West Twin	Cass	0701010204-01	NLF	198	5				FS	NA

11012600	Phelon	Cass	0701010204-01	NLF	18						
11012700	Unnamed	Cass	0701010204-01	NLF	11						
11012800	Lost Girl	Cass	0701010204-01	NLF	22						
11012900	Lower Trelipe	Cass	0701010204-01	NLF	618	32	14915	59	3.8	FS	IF
11013000	Unnamed	Cass	0701010204-01	NLF	21						
11013100	Little Swift	Cass	0701010204-01	NLF	55						
11013200	Tobique	Cass	0701010204-01	NLF	17						
11013300	Swift	Cass	0701010204-01	NLF	357	49		53		FS	NA
11013400	Portage	Cass	0701010204-01	NLF	137						
11013500	Rabbit	Cass	0701010204-01	NLF	30						
11013600	Lomish	Cass	0701010204-01	NLF	272						
11013700	Nushka	Cass	0701010206-03	NLF	78						
11013800	Rice	Cass	0701010206-03	NLF	55						
11014100	Charles	Cass	0701010204-01	NLF	30						
11014200	Long	Cass	0701010204-01	NLF	1,007						
11014201	Long (South of Main)	Cass	0701010204-01	NLF	26						
11014202	Long (Main Basin)	Cass	0701010204-01	NLF	674	115				FS	NA
11014203	Long (North of Main)	Cass	0701010204-01	NLF	22						
11014204	Long (South West Bay)	Cass	0701010204-01	NLF	285	115				FS	NA
11014300	Boy	Cass	0701010204-01	NLF	3,466	45	241221	63	3.7	FS	NA
11014400	Blacksmith	Cass	0701010206-01	NLF	150						

11014500	Drumbeater	Cass	0701010206-01	NLF	390	2.5				IFNS	NA
11014600	Sixmile	Cass	0701010206-03	NLF	1,323	68	7485	47	6.4	FS	NA
11016200	Rice	Cass	0701010204-01	NLF	270	30		78		IF	NA
11016300	Cooper	Cass	0701010204-01	NLF	133	70				FS	NA
11016400	Jack	Cass	0701010203-01	NLF	83						
11016500	Swede	Cass	0701010203-01	NLF	38						
11016600	Shurd	Cass	0701010204-01	NLF	49						
11016700	Little Boy	Cass	0701010204-01	NLF	1,452	72	26121	34	7.4	FS	IF
11016800	McCarthey	Cass	0701010204-01	NLF	151					IFNS	NA
11016900	Heffron	Cass	0701010203-01	NLF	57						
11017000	Hunter	Cass	0701010204-01	NLF	182	48				FS	NA
11017100	Wabedo	Cass	0701010204-01	NLF	1,226						
11017101	Wabedo (North East Bay)	Cass	0701010204-01	NLF	593	95	20540		6.4	FS	NA
11017102	Wabedo (South West Bay)	Cass	0701010204-01	NLF	633	95	10821		9.7	FS	NA
11017200	Bracket	Cass	0701010204-01	NLF	49						
11017300	Thirty-Six	Cass	0701010204-01	NLF	13						
11017400	Girl	Cass	0701010203-01	NLF	428	81	104373	67	5.0	FS	IF
11017500	Gooseberry	Cass	0701010205-01	NLF	21						
11017700	Three Island	Cass	0701010205-01	NLF	288	13		100		FS	NA
11017800	Football	Cass	0701010204-01	NLF	14						
11018000	Lundeen	Cass	0701010204-01	NLF	74						

11018100	Maple	Cass	0701010204-01	NLF	76							
11018200	Kego	Cass	0701010204-01	NLF	121	58		66			FS	NA
11018300	Boxell	Cass	0701010203-01	NLF	66							
11018400	Bullhead	Cass	0701010204-01	NLF	38							
11018500	Gijik	Cass	0701010204-01	NLF	86							
11018600	Craig	Cass	0701010203-01	NLF	40							
11018700	Nellie	Cass	0701010203-01	NLF	24							
11018800	Carnahan	Cass	0701010203-01	NLF	31							
11018900	Tamarack	Cass	0701010204-01	NLF	41							
11019000	Town Line	Cass	0701010204-01	NLF	698	9					FS	IF
11019100	Haugen	Cass	0701010205-01	NLF	16							
11019200	Blackduck	Cass	0701010205-01	NLF	41							
11019300	Mad Dog	Cass	0701010205-01	NLF	22							
11019400	Iverson	Cass	0701010205-01	NLF	74							
11019500	Camp	Cass	0701010205-01	NLF	54							
11019600	Aultman	Cass	0701010205-01	NLF	24							
11019700	Hole-In-Bog	Cass	0701010205-01	NLF	72							
11020000	Mule	Cass	0701010203-01	NLF	525	47	2289	44	6.2		FS	NA
11020100	Woman	Cass	0701010203-01	NLF	5,520							
11020101	Broadwater Bay	Cass	0701010203-01	NLF	795	43	99601	48	4.7		FS	IF
11020102	Woman (main lake)	Cass	0701010203-01	NLF	4,925	60	94890		5.8		FS	IF

11020200	Silver	Cass	0701010203-01	NLF	121	20		77		FS	NA
11020300	Leech	Cass	0701010204-01	NLF	110,311						
11020301	Leech (Main Basin)	Cass	0701010205-01	NLF	109,349	150	749099		4.9	FS	NA
11020302	Leech (Kabekona Bay)	Cass	0701010205-01	NLF	962	150	98022		8.1	FS	NA
11020303	Leech (Ah-Gwah-Chin)	Cass	0701010205-01	NLF	81	150				IF	NA
11020304	Leech (Shingobee Bay)	Cass	0701010205-01	NLF	369	150				FS	NA
11020400	Portage	Cass	0701010205-01	NLF	1,539	53	10121	45	5.1	IF	NA
11023400	Ponto	Cass	0701010203-01	NLF	388	60	1439		8.0	FS	NA
11024400	One	Cass	0701010203-01	NLF	73					IF	NA
11025700	Island	Cass	0701010203-01	NLF	184	40		57		FS	NA
11025800	Long	Cass	0701010203-01	NLF	246	37		67		FS	NA
11025900	Primer	Cass	0701010203-01	NLF	43						
11026000	Unnamed	Cass	0701010203-01	NLF	17						
11026100	McKeown	Cass	0701010203-01	NLF	168	37		87		FS	NA
11026200	Kid	Cass	0701010203-01	NLF	168	52				FS	NA
11026300	Child	Cass	0701010203-01	NLF	285	29	77972	50	3.8	FS	NA
11026400	Barrow	Cass	0701010203-01	NLF	30						
11026500	Little Woman	Cass	0701010203-01	NLF	36						
11026600	Squeedunk	Cass	0701010203-01	NLF	17						
11026700	Pick	Cass	0701010203-01	NLF	35						
11026800	Kerr	Cass	0701010203-01	NLF	83	79		36		FS	NA

11026900	Lost	Cass	0701010203-01	NLF	69	26				FS	NA
11027000	Trillium	Cass	0701010203-01	NLF	155	48		67		FS	NA
11027100	Pancake	Cass	0701010203-01	NLF	17						
11027200	IXL	Cass	0701010203-01	NLF	95						
11027300	Widow	Cass	0701010203-01	NLF	197	46	3459	41	5.6	FS	NA
11027400	Blackwater	Cass	0701010203-01	NLF	767	67	6753	47	5.9	FS	NA
11027500	Sand	Cass	0701010203-01	NLF	41						
11027600	Little Deep	Cass	0701010203-01	NLF	33						
11027700	Big Deep	Cass	0701010203-01	NLF	536	100		9	15.9	IF	NA
11027800	Unnamed (Bass Pond)	Cass	0701010203-01	NLF	12						
11027900	Sand	Cass	0701010203-01	NLF	149	54	2259	41	6.4	FS	NA
11028000	Donkey	Cass	0701010203-01	NLF	50						
11028100	Barnum	Cass	0701010203-01	NLF	151	29	987	63	3.1	FS	NA
11028200	Man	Cass	0701010203-01	NLF	491	88	25897	10	10.6	FS	NA
11028300	Baby	Cass	0701010203-01	NLF	737	69	21768	33	6.9	FS	IF
11028400	Horseshoe	Cass	0701010205-01	NLF	127	12		100		IF	NA
11028500	Rat	Cass	0701010205-01	NLF	87						
11028600	Haynes	Cass	0701010205-01	NLF	33						
11028700	Lauer	Cass	0701010205-01	NLF	21						
11028800	Wawa	Cass	0701010205-01	NLF	68						
11028900	Cedar	Cass	0701010205-01	NLF	135						

11029000	Mud	Cass	0701010205-01	NLF	169						
11029100	Haugen	Cass	0701010205-01	NLF	25						
11029200	Pine	Cass	0701010205-01	NLF	261	25		62		FS	NA
11029300	Spearns	Cass	0701010205-01	NLF	17						
11029400	Pollywog	Cass	0701010205-01	NLF	18						
11029500	Hazel	Cass	0701010203-01	NLF	15						
11029600	Moccasin	Cass	0701010203-01	NLF	272	95	2155	45	6.0	FS	NA
11029700	South Stocking	Cass	0701010205-01	NLF	46						
11029800	Goose	Cass	0701010203-01	NLF	24						
11029900	Unnamed	Cass	0701010203-01	NLF	15						
11030200	Little Portage	Cass	0701010205-01	NLF	69						
11031000	Blind	Cass	0701010203-01	NLF	37						
11031100	Webb	Cass	0701010203-01	NLF	744	84	14534	37	6.9	FS	NA
11031200	Teepee	Cass	0701010205-01	NLF	21						
11031300	Lower Sucker	Cass	0701010205-01	NLF	592	35	18884	51	4.4	IFNS	NA
11031500	Grass	Cass	0701010205-01	NLF	113						
11031600	Upper Sucker	Cass	0701010205-01	NLF	113						
11031700	Middle Sucker	Cass	0701010205-01	NLF	286						
11036900	Little Boy	Cass	0701010203-01	NLF	67						
11037000	Round	Cass	0701010203-01	NLF	23						
11037100	Stony	Cass	0701010203-01	NLF	563	50	2360	30	7.2	FS	NA
11037200	Tower	Cass	0701010203-01	NLF	15						

11037300	Sylvester	Cass	0701010203-01	NLF	49						
11037400	Larson	Cass	0701010203-01	NLF	194	58				FS	NA
11037500	Surprise	Cass	0701010203-01	NLF	22	73		69		FS	NA
11037600	Blueberry	Cass	0701010203-01	NLF	23					IFNS	NA
11037700	Horseshoe	Cass	0701010203-01	NLF	58						
11037800	Woodchuck	Cass	0701010203-01	NLF	14						
11037900	Fish	Cass	0701010203-01	NLF	35						
11038000	Peterson	Cass	0701010203-01	NLF	33						
11038100	Paquet	Cass	0701010203-01	NLF	145	19		81		FS	NA
11038200	Boss	Cass	0701010203-01	NLF	106	28				FS	NA
11038300	Pleasant	Cass	0701010203-01	NLF	1,099	72	39078	40	6.7	FS	NA
11038400	Long	Cass	0701010203-01	NLF	78						
11038500	Mud	Cass	0701010203-01	NLF	38						
11038700	Little Webb	Cass	0701010203-01	NLF	226	37		60		FS	IF
11038800	Little Turtle	Cass	0701010205-01	NLF	23						
11038900	Hanson	Cass	0701010205-01	NLF	34						
11039000	Shell	Cass	0701010205-01	NLF	16						
11039100	Big Hanson	Cass	0701010205-01	NLF	18						
11039200	Spruce	Cass	0701010205-01	NLF	23						
11039300	Bag	Cass	0701010205-01	NLF	20						
11039400	Hovde	Cass	0701010205-01	NLF	133						
11039500	Long	Cass	0701010203-01	NLF	58						

11039600	Diamond	Cass	0701010203-01	NLF	77							
11039700	Bluebill	Cass	0701010203-01	NLF	45							
11039800	Four-One-Eight	Cass	0701010203-01	NLF	12							
11039900	Cub	Cass	0701010203-01	NLF	22							
11040000	Jack	Cass	0701010205-01	NLF	142	80		20		FS	NA	
11040100	Turtle	Cass	0701010205-01	NLF	75							
11040200	Rice	Cass	0701010205-01	NLF	89							
11040300	Wabegon	Cass	0701010205-01	NLF	42							
11040400	Deep	Cass	0701010205-01	NLF	24							
11040500	Nomad	Cass	0701010205-01	NLF	15							
11040600	Life Raft	Cass	0701010205-01	NLF	39							
11041200	Birch	Cass	0701010203-01	NLF	1,267	45	30456	59	4.1	FS	IF	
11041300	Ten Mile	Cass	0701010203-01	NLF	5,080	208	25518	28	15.7	FS	IF	
11041400	Gould	Cass	0701010205-01	NLF	98							
11041600	Experiment	Cass	0701010205-01	NLF	14							
11045700	Chub	Cass	0701010203-01	NLF	61							
11045800	Perry	Cass	0701010203-01	NLF	37							
11046400	Third	Cass	0701010205-01	NLF	33							
11046500	Fourth	Cass	0701010205-01	NLF	58							
11046501	Fourth (north portion)	Cass	0701010205-01	NLF	18							
11046502	Fourth (south portion)	Cass	0701010205-01	NLF	41							

11046600	Fifth	Cass	0701010205-01	NLF	52						
11046700	Ten	Cass	0701010205-01	NLF	26						
11046800	Alice	Cass	0701010205-01	NLF	96						
11046900	Anway	Cass	0701010205-01	NLF	21						
11047000	Thirty-Four	Cass	0701010205-01	NLF	17						
11047100	Recreation	Cass	0701010205-01	NLF	11						
11047200	Howard	Cass	0701010205-01	NLF	386	61		27		FS	NA
11047300	Cripple	Cass	0701010203-01	NLF	22						
11047400	Bass	Cass	0701010203-01	NLF	278	30				FS	NA
11047500	Gadbolt	Cass	0701010203-01	NLF	68						
11047600	Portage	Cass	0701010203-01	NLF	277	84	2324	34	9.9	FS	IF
11047700	Little Bass	Cass	0701010203-01	NLF	114						
11047701	Little Bass (Main)	Cass	0701010203-01	NLF	14						
11047702	Little Bass (East Bay)	Cass	0701010203-01	NLF	135						
11047800	Wheeler	Cass	0701010203-01	NLF	28						
11047900	Muskrat	Cass	0701010203-01	NLF	35						
11048000	Long	Cass	0701010205-01	NLF	284	80	4374	30	6.9	FS	IF
11048100	Cedar	Cass	0701010205-01	NLF	36						
11048200	May	Cass	0701010205-01	NLF	143	50	5363	40	5.4	FS	IF
11048300	Swamp	Cass	0701010201-01	NLF	600						
11048400	Twin	Cass	0701010205-01	NLF	169	10		100		FS	NA

11048600	Hessie	Cass	0701010205-01	NLF	34						
11048700	Little Twin	Cass	0701010205-01	NLF	112						
11048800	Thirteen	Cass	0701010205-01	NLF	555	56	7109	73	3.9	FS	NA
11048900	Little Moss	Cass	0701010205-01	NLF	83						
11049000	Portage	Cass	0701010201-01	NLF	361	65	2886	48	6.4	FS	NA
11049100	Steamboat Bay	Cass	0701010201-01	NLF	67						
11049200	Faherty	Cass	0701010205-01	NLF	20						
11049300	Welch	Cass	0701010205-01	NLF	195	59		41		FS	NA
11049400	Crooked	Cass	0701010205-01	NLF	565	74	13105		6.3	FS	IF
11049600	Camp	Cass	0701010205-01	NLF	30						
11050200	Crystal	Cass	0701010203-01	NLF	190	41	1273	83	2.9	FS	NA
11050400	Steamboat	Cass	0701010201-01	NLF	1,756	93	71834	30	11.0	FS	NA
11051500	High Bank	Cass	0701010203-01	NLF	24						
11051700	Chub	Cass	0701010206-03	NLF	53						
11052700	Cyphers	Cass	0701010203-01	NLF	11						
11052900	Conklin	Cass	0701010205-01	NLF	19						
11053100	Bobolink	Cass	0701010205-01	NLF	38						
11053300	Unnamed	Cass	0701010205-01	NLF	12						
11053400	Ivans	Cass	0701010205-01	NLF	11						
11053500	Unnamed	Cass	0701010204-01	NLF	11						
11053600	Tadpole	Cass	0701010204-01	NLF	18						
11053700	County	Cass	0701010204-01	NLF	14						

11053800	Unnamed	Cass	0701010204-01	NLF	19						
11053900	Unnamed	Cass	0701010204-01	NLF	15						
11054000	Johnson	Cass	0701010204-01	NLF	11						
11054300	Mink	Cass	0701010204-01	NLF	12						
11054400	Unnamed	Cass	0701010203-01	NLF	15						
11054600	Unnamed	Cass	0701010203-01	NLF	21						
11054800	Young	Cass	0701010203-01	NLF	32						
11054900	Unnamed	Cass	0701010203-01	NLF	22						
11055000	Unnamed	Cass	0701010203-01	NLF	10						
11055200	Unnamed	Cass	0701010203-01	NLF	18						
11055300	Unnamed	Cass	0701010203-01	NLF	10						
11055500	Unnamed	Cass	0701010203-01	NLF	11						
11055600	Unnamed	Cass	0701010203-01	NLF	11						
11055800	Buck	Cass	0701010204-01	NLF	17						
11056000	Unnamed	Cass	0701010203-01	NLF	12						
11056100	Unnamed	Cass	0701010203-01	NLF	23						
11056800	Unnamed	Cass	0701010204-01	NLF	13						
11057200	Blueberry	Cass	0701010204-01	NLF	11						
11057300	Unnamed (Louise)	Cass	0701010204-01	NLF	22						
11057400	Crooked	Cass	0701010204-01	NLF	14						
11057900	Unnamed	Cass	0701010204-01	NLF	21						
11058000	Unnamed	Cass	0701010204-01	NLF	15						

11058100	Unnamed	Cass	0701010204-01	NLF	18						
11059500	Cranberry	Cass	0701010203-01	NLF	22						
11074400	Unnamed	Cass	0701010204-01	NLF	15						
11074800	Unnamed	Cass	0701010204-01	NLF	12						
11074900	Unnamed	Cass	0701010204-01	NLF	15						
11075200	Unnamed	Cass	0701010204-01	NLF	13						
11075400	Unnamed	Cass	0701010204-01	NLF	12						
11075500	Unnamed	Cass	0701010204-01	NLF	13						
11075800	Unnamed	Cass	0701010204-01	NLF	14						
11076200	Unnamed	Cass	0701010204-01	NLF	36						
11079300	Unnamed	Cass	0701010204-01	NLF	16						
11079400	Unnamed	Cass	0701010205-01	NLF	15						
11079700	Unnamed	Cass	0701010203-01	NLF	14						
11080000	Blot	Cass	0701010205-01	NLF	35						
11080300	Unnamed	Cass	0701010206-02	NLF	11						
11080400	Unnamed	Cass	0701010206-02	NLF	14						
11080600	Unnamed	Cass	0701010206-02	NLF	10						
11080700	Unnamed	Cass	0701010204-01	NLF	14						
11080900	Current	Cass	0701010205-01	NLF	11						
11081000	Unnamed	Cass	0701010205-01	NLF	28						
11084000	Unnamed	Cass	0701010203-01	NLF	14						
11084100	Unnamed	Cass	0701010203-01	NLF	13						

11084200	Unnamed	Cass	0701010203-01	NLF	13						
11084400	Unnamed	Cass	0701010203-01	NLF	10						
11084700	Three Island	Cass	0701010203-01	NLF	45						
11084800	Unnamed	Cass	0701010203-01	NLF	11						
11084900	Unnamed	Cass	0701010203-01	NLF	12						
11085000	Unnamed	Cass	0701010203-01	NLF	19						
11085100	Unnamed	Cass	0701010203-01	NLF	33						
11085200	Unnamed	Cass	0701010203-01	NLF	25						
11086600	Unnamed	Cass	0701010203-01	NLF	13						
11086700	Unnamed	Cass	0701010203-01	NLF	12						
11087100	Unnamed	Cass	0701010205-01	NLF	22						
11087300	North Stocking	Cass	0701010205-01	NLF	22						
11087500	Weed	Cass	0701010203-01	NLF	13						
11087700	Unnamed	Cass	0701010203-01	NLF	14						
11087800	Unnamed	Cass	0701010203-01	NLF	16						
11088000	Unnamed	Cass	0701010205-01	NLF	50						
11088300	Unnamed	Cass	0701010205-01	NLF	10						
11088800	Unnamed	Cass	0701010203-01	NLF	19						
11088900	Unnamed	Cass	0701010203-01	NLF	13						
11089000	Unnamed	Cass	0701010203-01	NLF	29						
11089200	Million	Cass	0701010203-01	NLF	22						
11089800	Lost	Cass	0701010205-01	NLF	25						

11091000	Unnamed	Cass	0701010205-01	NLF	11						
11092100	Unnamed	Cass	0701010205-01	NLF	25						
11092200	Unnamed	Cass	0701010206-01	NLF	181						
11092300	Unnamed	Cass	0701010206-03	NLF	25						
11093300	Unnamed	Cass	0701010203-01	NLF	16						
11093600	Unnamed	Cass	0701010203-01	NLF	29						
11093900	Unnamed	Cass	0701010205-01	NLF	24						
11094300	Unnamed	Cass	0701010205-01	NLF	35						
11094800	Unnamed	Cass	0701010206-02	NLF	148						
11095500	Unnamed	Cass	0701010205-01	NLF	14						
11097900	Unnamed	Cass	0701010204-01	NLF	15						
29000700	Island	Hubbard	0701010205-01	NLF	78						
29000800	Mastny	Hubbard	0701010205-01	NLF	12						
29001000	Gauldin	Hubbard	0701010205-01	NLF	27						
29001200	Spring	Hubbard	0701010205-01	NLF	17						
29001300	Mary	Hubbard	0701010205-01	NLF	31						
29001400	Doe	Hubbard	0701010205-01	NLF	12						
29001500	Williams	Hubbard	0701010205-01	NLF	98	32		45		FS	NA
29002200	Steel	Hubbard	0701010205-01	NLF	57						
29002300	Robinson	Hubbard	0701010205-01	NLF	36						
29002400	Unnamed	Hubbard	0701010205-01	NLF	17						
29004300	Shingobee	Hubbard	0701010205-01	NLF	172	39		27		FS	NA

29004400	Mud	Hubbard	0701010205-01	NLF	34						
29004800	Benedict	Hubbard	0701010205-01	NLF	464	91	12553	39	10.4	FS	IF
29004900	Lester	Hubbard	0701010202-01	NLF	55						
29005000	Unnamed	Hubbard	0701010202-01	NLF	10						
29005400	Spring	Hubbard	0701010201-01	NLF	43						
29005800	Willow	Hubbard	0701010202-01	NLF	79						
29005900	Horseshoe	Hubbard	0701010202-01	NLF	264	50				FS	NA
29006000	Oak	Hubbard	0701010202-01	NLF	58						
29006100	Garfield	Hubbard	0701010202-01	NLF	960	30	3349	53	4.3	FS	IF
29006200	Unnamed	Hubbard	0701010201-01	NLF	10						
29006300	Hart	Hubbard	0701010201-01	NLF	226	10.5		100		NS	
29007000	Unnamed	Hubbard	0701010201-01	NLF	21						
29007500	Kabekona	Hubbard	0701010202-01	NLF	2,433	133	61897	24	15.3	FS	NA
29007600	Knutson	Hubbard	0701010201-01	NLF	30						
29012200	1st Little Gulch	Hubbard	0701010202-01	NLF	10						
29012300	2nd Little Gulch	Hubbard	0701010202-01	NLF	19						
29012500	4th Little Gulch	Hubbard	0701010202-01	NLF	11						
29012600	Gillett	Hubbard	0701010202-01	NLF	44						
29012700	Crappie	Hubbard	0701010202-01	NLF	23						
29012800	Island	Hubbard	0701010202-01	NLF	54						
29012900	Coon	Hubbard	0701010202-01	NLF	23						
29013000	Twenty-One	Hubbard	0701010202-01	NLF	36	51.5		82		FS	IF

29013100	Nelson	Hubbard	0701010202-01	NLF	40	19.5		97		FS	IF
29013200	Bass	Hubbard	0701010202-01	NLF	21					FS	IF
29013300	Unnamed	Hubbard	0701010201-01	NLF	22						
29013400	Upper Thatcher	Hubbard	0701010201-01	NLF	29						
29013500	Hatchers	Hubbard	0701010201-01	NLF	33						
29013600	Horsehead	Hubbard	0701010201-01	NLF	34						
29013700	DeHart	Hubbard	0701010201-01	NLF	48						
29013800	Unnamed	Hubbard	0701010201-01	NLF	11						
29013900	Kimball	Hubbard	0701010201-01	NLF	26						
29014000	Kenny	Hubbard	0701010202-01	NLF	12						
29014100	Douglas	Hubbard	0701010201-01	NLF	19						
29015200	Teepee	Hubbard	0701010202-01	NLF	11						
29015400	Teepee	Hubbard	0701010202-01	NLF	24						
29015500	Sheridan	Hubbard	0701010202-01	NLF	69						
29019100	Spur	Hubbard	0701010202-01	NLF	18						
29019200	Unnamed	Hubbard	0701010202-01	NLF	15						
29021800	Shanty	Hubbard	0701010202-01	NLF	44						
29022000	Halverson	Hubbard	0701010202-01	NLF	21						
29022400	McCarty	Hubbard	0701010202-01	NLF	13	32		64		FS	IF
29022500	Camp Seven	Hubbard	0701010202-01	NLF	15						
29031900	Unnamed	Hubbard	0701010203-01	NLF	14						
29032400	Bauer	Hubbard	0701010201-01	NLF	13						

29034600	Unnamed	Hubbard	0701010201-01	NLF	18						
29036500	Unnamed	Hubbard	0701010205-01	NLF	11						
29036800	Unnamed	Hubbard	0701010205-01	NLF	13						
29042600	Unnamed	Hubbard	0701010202-01	NLF	11						
29042800	Unnamed	Hubbard	0701010201-01	NLF	23						
29043900	Unnamed	Hubbard	0701010201-01	NLF	35						
29047800	Unnamed	Hubbard	0701010202-01	NLF	11						
29047900	Unnamed (Berm)	Hubbard	0701010202-01	NLF	10						
29056700	Unnamed	Hubbard	0701010201-01	NLF	10						
29056900	Unnamed	Hubbard	0701010202-01	NLF	131						

Abbreviations: **FS** – Full Support **N/A** – Not Assessed
NS – Non-Support
IF – Insufficient Information

Key for Cell Shading: ☐ = existing impairment, listed prior to 2014 reporting cycle; ☐ = new impairment; ☐ = full support of designated use.

*These depths were created by MPCA Staff.

Appendix 4.1 - 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, 2C	71	49	NA	±11
2	Southern Streams	2B, 2C	66	50	35	±9
3	Southern Headwaters	2B, 2C	74	55	33	±7
10	Southern Coldwater	2A	82	50	NA	±9
4	Northern Rivers	2B, 2C	67	38	NA	±9
5	Northern Streams	2B, 2C	61	47	35	±9
6	Northern Headwaters	2B, 2C	68	42	23	±16
7	Low Gradient	2B, 2C	70	42	15	±10
11	Northern Coldwater	2A	60	35	NA	±10
Invertebrates						
1	Northern Forest Rivers	2B, 2C	77	49	NA	±10.8
2	Prairie Forest Rivers	2B, 2C	63	31	NA	±10.8
3	Northern Forest Streams RR	2B, 2C	82	53	NA	±12.6
4	Northern Forest Streams GP	2B, 2C	76	51	37	±13.6
5	Southern Streams RR	2B, 2C	62	37	24	±12.6
6	Southern Forest Streams GP	2B, 2C	66	43	30	±13.6
7	Prairie Streams GP	2B, 2C	69	41	22	±13.6
8	Northern Coldwater	2A	52	32	NA	±12.4
9	Southern Coldwater	2A	72	43	NA	±13.8

Appendix 4.2 - Biological monitoring results – Fish IBI (assessable reaches)

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Fish Class	Threshold	FIBI	Visit Date
HUC 12: 0701010201-01 (Steamboat River)							
07010102-550	09UM085	Necktie River	16.69	11	35	51.96	7/15/10
07010102-550	09UM085	Necktie River	16.69	11	35	100.00	7/11/12
07010102-505	12UM096	Bungashing Creek	27.66	11	35	74.64	7/10/12
07010102-527	12UM097	Pokety Creek	13.84	6	42	60.00	7/10/12
HUC 12: 0701010202-01 (Kabekona River)							
07010102-511	09UM084	Kabekona River	38.67	11	35	47.46	7/15/10
07010102-511	09UM084	Kabekona River	38.67	11	35	58.06	7/10/12
07010102-511	09UM084	Kabekona River	38.67	11	35	68.96	7/2/13
07010102-511	12UM102	Kabekona River	51.54	11	35	49.57	7/25/12
07010102-611	12UM094	Sucker Branch	20.38	6	42	49.69	7/10/12
HUC 12: 0701010205-01 (Leech Lake)							
07010102-530	12UM091	Shingobee River	22.97	6	42	66.05	7/9/12
07010102-530	12UM091	Shingobee River	22.97	6	42	73.51	7/16/14

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Fish Class	Threshold	FIBI	Visit Date
HUC 12: 0701010204-01 (Boy River)							
07010102-610	12UM106	Spring Creek	8.31	7	42	73.03	6/12/2012
07010102-610	12UM106	Spring Creek	8.31	7	42	44.54	9/4/2012
07010102-612	12UM107	Northby Creek	5.31	6	42	0	8/21/2012
07010102-520	00UM012	Boy River	287.90	5	47	53.49	9/5/2012
07010102-520	00UM012	Boy River	287.90	5	47	61.65	7/3/2013
07010102-538	12UM109	Swift River	23.81	7	42	49.35	7/25/2012
07010102-538	12UM109	Swift River	23.81	7	42	64.19	7/2/2013
HUC 12: 0701010206-03 (Sixmile Brook)							
07010102-515	12UM110	Sixmile Brook	36.2	7	42	43.20	7/2/2013
HUC 12: 0701010206-01 (Leech Lake River)							
07010102-501	12UM112	Leech Lake River	1181.45	4	38	57.99	8/28/2012
07010102-606	12UM113	Leech Lake River	1336.86	4	38	45.70	7/2/2012
07010102-606	12UM113	Leech Lake River	1336.86	4	38	45.30	8/21/2012

Appendix 4.3 - Biological monitoring results-macroinvertebrate IBI (assessable reaches)

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Invert Class	Threshold	MIBI	Visit Date
HUC 12: 0701010201-01 (Steamboat River)							
07010102-505	12UM096	Bungashing Creek	27.66	8	32	27.42	8/9/2012
07010102-505	12UM096	Bungashing Creek	27.66	8	32	51.96	8/8/2013
07010102-550	09UM085	Necktie River	16.69	8	32	33.98	9/15/2009
07010102-550	09UM085	Necktie River	16.69	8	32	18.08	8/9/2012
07010102-550	09UM085	Necktie River	16.69	8	32	13.38	8/8/2013
HUC 12: 0701010202-01 (Kabekona River)							
07010102-511	09UM084	Kabekona River	38.67	8	32	44.69	9/15/2009
07010102-511	09UM084	Kabekona River	38.67	8	32	47.91	8/14/2012
07010102-511	09UM084	Kabekona River	38.67	8	32	53.97	8/14/2012
07010102-511	12UM102	Kabekona River	51.41	8	32	49.21	8/14/2012
07010102-511	09UM084	Kabekona River	38.67	8	32	43.78	8/8/2013
07010102-611	12UM094	Sucker Branch	20.38	3	53	82.47	8/14/2012
07010102-611	12UM094	Sucker Branch	20.38	3	53	72.62	8/14/2012
HUC 12: 0701010205-01 (Leech Lake)							
07010102-530	12UM091	Shingobee River	22.97	3	53	50.58	8/14/2012
HUC 12: 0701010204-01 (Boy River)							
07010102-520	00UM012	Boy River	287.90	3	53	37.22	9/5/2012
07010102-520	00UM012	Boy River	287.90	3	53	52.88	8/8/2013
07010102-520	00UM012	Boy River	287.90	3	53	39.98	8/28/2014
07010102-538	12UM109	Swift River	23.81	4	51	70.48	8/28/2012
07010102-610	12UM106	Spring Creek	8.31	4	51	36.34	8/13/2012
07010102-612	12UM107	Trib to Northby Creek	0.31	4	51	25.15	8/21/2012
HUC 12: 0701010206-03 (Sixmile Brook)							
07010102-515	12UM110	Sixmile Brook	36.32	4	51	71.78	8/8/2013

Appendix 5.1 - Minnesota's ecoregion based lake eutrophication standards

Ecoregion	TP µg/L	Chl-a µg/L	Secchi meters
NLF – Lake Trout (Class 2A)	< 12	< 3	> 4.8
NLF – Stream trout (Class 2A)	< 20	< 6	> 2.5
NLF – Aquatic Rec. Use (Class 2B)	< 30	< 9	> 2.0
NCHF – Stream trout (Class 2A)	< 20	< 6	> 2.5
NCHF – Aquatic Rec. Use (Class 2B)	< 40	< 14	> 1.4
NCHF – Aquatic Rec. Use (Class 2B) Shallow lakes	< 60	< 20	> 1.0
WCBP & NGP – Aquatic Rec. Use (Class 2B)	< 65	< 22	> 0.9
WCBP & NGP – Aquatic Rec. Use (Class 2B) Shallow lakes	< 90	< 30	> 0.7

Appendix 5.2 - MINLEAP model estimates of phosphorus loads for lakes in the Leech Lake River Watershed

Lake ID	Lake Name	Obs TP (µg/L)	MINLEAP TP (µg/L)	Obs Chl-a (µg/L)	MINLEAP Chl-a (µg/L)	Obs Secchi (m)	MINLEAP Secchi (m)	Avg. TP Inflow (µg/L)	TP Load (kg/yr)	Background TP (µg/L)	%P Retention	Outflow (hm3/yr)	Residence Time (yrs)	Areal Load (m/yr)	Trophic Status
11-0077-00	Big Sand	22	24	10	7	3.1	2.5	60	191	28.9	0.6	3.2	1.8	1.1	M
11-0092-00	Little Sand	15	28	2	9	3.0	2.2	56	198	31.5	0.5	3.6	0.9	2.2	M
11-0120-01	Inguadona (N. Bay)	15	44	7	17	2.7	1.5	52	8086	22.5	0.2	155.3	0.0	108.4	M
11-0120-02	Inguadona (S. Bay)	17	38	6	14	3.3	1.7	52	7146	20.7	0.3	136.9	0.2	44.3	M
11-0129-00	Lower Trelipe	19	29	8	9	2.1	2.1	53	759	23.7	0.5	14.2	0.7	5.8	M
11-0143-00	Boy	24	36	8	12	2.5	1.8	53	11897	23.6	0.3	226.4	0.3	15.3	E
11-0146-00	Sixmile	19	18	7	4	2.8	3.2	58	441	21.4	0.7	7.7	4.1	1.5	M
11-0167-00	Little Boy	19	23	6	7	3.3	2.5	54	1351	20.3	0.6	25.1	1.6	4.4	M
11-0171-01	Wabedo (N.E. Bay)	19	29	6	9	3.0	2.1	53	1029	21.9	0.5	19.4	0.7	8.3	M
11-0171-02	Wabedo (S.W. Bay)	22	21	7	5	2.9	2.8	54	561	18.3	0.6	10.4	2.4	4.1	M

11-	Girl	13	41	4	15	4.4	1.6	52	5077	21.6	0.2	97.4	0.1	58.1	M
11-0200-00	Mule	14	17	4	4	4.8	3.4	59	142	25.6	0.7	2.4	5.2	1.2	M
11-0201-01	Broadwater Bay	14	38	5	13	3.8	1.7	52	4867	22.2	0.3	93.1	0.2	30.0	M
11-0201-02	Woman (Main Basin)	14	25	4	7	4.3	2.4	54	4881	21.3	0.5	90.8	1.3	7.7	M
11-0203-01	Leech (Main Basin)	17	20	3	5	2.9	2.9	57	42448	23.0	0.6	750.9	2.7	1.8	M
11-0203-02	Leech (Kabekona Bay)	14	34	4	11	3.9	1.9	52	4803	21.7	0.4	91.8	0.3	23.4	M
11-0204-00	Portage	26	20	12	5	2.2	2.9	57	583	21.0	0.7	10.2	3.0	1.7	E
11-0234-00	Ponto	9	14	2	3	5.9	3.9	60	93	24.9	0.8	1.5	8.0	1.0	O
11-0263-00	Child	17	43	5	16	3.8	1.5	52	3791	27.1	0.2	72.7	0.1	63.5	M
11-0273-00	Widow	10	24	2	7	5.3	2.5	54	179	26.4	0.6	3.3	1.5	4.1	O
11-0274-00	Blackwater	14	20	4	5	4.3	2.9	56	373	24.7	0.6	6.7	2.8	2.2	M
11-0279-00	Sand	10	23	2	7	6.3	2.6	54	118	28.0	0.6	2.2	1.7	3.6	O

11-0281-00	Barnum	11	24	3	7	5.1	2.5	57	57	32.8	0.6	1.0	1.8	1.7	O
11-0282-00	Man	11	27	3	8	3.4	2.2	53	1283	18.7	0.5	24.4	0.9	12.3	O
11-0283-00	Baby	13	27	4	8	4.4	2.3	53	1098	20.9	0.5	20.6	1.0	7.0	M
11-0296-00	Moccasin	10	19	3	5	5.9	3.0	56	121	27.4	0.7	2.2	3.1	2.0	O
11-0311-00	Webb	13	24	3	7	4.5	2.5	54	747	23.8	0.6	13.9	1.5	4.8	M
11-0313-00	Lower Sucker	28	31	15	10	2.4	2.0	53	949	23.3	0.4	17.9	0.5	7.7	E
11-0371-00	Stony	11	15	2	4	6.2	3.7	60	148	26.5	0.7	2.5	6.4	1.1	O
11-0383-00	Pleasant	15	28	4	8	4.8	2.2	53	1957	24.3	0.5	36.9	0.8	8.4	M
11-0412-00	Birch	15	29	4	9	4.1	2.1	53	1550	22.2	0.5	29.0	0.7	5.7	M
11-0413-00	Ten Mile	16	12	2	2	5.7	4.7	58	1540	14.4	0.8	26.4	12.3	1.3	M
11-0476-00	Portage	8	16	2	4	7.6	3.5	56	129	25.2	0.7	2.3	4.9	2.1	O
11-0480-00	Long	13	23	3	6	4.0	2.6	54	228	19.3	0.6	4.2	1.8	3.8	M

11-0482-00	May	9	31	2	10	5.8	2.0	53	268	21.7	0.4	5.1	0.5	9.3	O
11-0488-00	Thirteen	16	25	5	7	3.9	2.4	55	378	27.3	0.5	6.9	1.3	3.1	M
11-0490-00	Portage	16	20	5	5	3.4	3.0	56	162	22.8	0.7	2.9	3.0	2.0	M
11-0494-00	Crooked	22	26	5	8	2.7	2.3	53	668	20.5	0.5	12.5	1.1	5.6	M
11-0502-00	Crystal	10	24	3	7	4.7	2.5	57	73	31.9	0.6	1.3	1.8	1.7	O
11-0504-00	Steamboat	19	25	4	7	3.8	2.4	53	3584	19.4	0.5	67.8	1.2	9.5	M
29-0048-00	Benedict	9	23	2	7	3.5	2.6	53	636	18.9	0.6	11.9	1.6	6.3	O
29-0061-00	Garfield	16	18	10	5	3.3	3.2	61	220	24.0	0.7	3.6	4.3	0.9	M
29-0075-00	Kabekona	12	20	3	5	4.0	2.9	53	3144	17.8	0.6	58.9	2.5	6.0	O

Abbreviations: **H** – Hypereutrophic **M** – Mesotrophic --- No data
E – Eutrophic **O** – Oligotrophic

Appendix 6 – Fish species found during biological monitoring surveys

Common name	Quantity of samples where present	Quantity of individuals collected
banded killifish	1	2
black bullhead	11	97
black crappie	5	15
blackchin shiner	6	121
blacknose dace	11	468
blacknose shiner	9	90
bluegill	13	183
bluntnose minnow	5	19
bowfin	3	8
brassy minnow	2	4
brook stickleback	6	59
brook trout	9	186
brown bullhead	10	90
burbot	5	11
central mudminnow	21	471
common shiner	15	395
creek chub	9	188
fathead minnow	1	1
finescale dace	6	46
golden shiner	11	323
greater redhorse	1	2
hornyhead chub	6	573
Iowa darter	1	2
johnny darter	13	136
largemouth bass	19	154
least darter	1	3
logperch	4	171
longnose dace	5	211
mimic shiner	4	114
mottled sculpin	10	120
muskellunge	2	2
northern pike	14	72
northern redbelly dace	6	82
pearl dace	4	173
pugnose shiner	1	1
pumpkinseed	11	48
rock bass	11	521
shorthead redhorse	4	8
slimy sculpin	1	18
spotfin shiner	2	19
spottail shiner	1	25

tadpole madtom	7	69
walleye	3	7
white sucker	12	153
yellow bullhead	11	37
yellow perch	19	979

Appendix 7 – Macroinvertebrate species found during biological monitoring surveys

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
ACARI		
Acari	31	155
AMPHIPODA		
Amphipoda	1	3
Gammarus	3	9
Hyalella	37	1297
Hyalella azteca	1	117
COLEOPTERA		
Agabus	1	1
Anacaena	1	1
Ancyronyx variegatus	2	2
Dineutus	1	1
Dubiraphia	14	62
Dytiscidae	3	4
Elmidae	1	1
Gyrinus	5	7
Haliplus	11	27
Hydraena	6	17
Hydrochus	1	3
Hydrophilidae	2	2
Hygrotus	1	1
Liodessus	4	26
Macronychus	1	2
Macronychus glabratus	9	27
Neoporus	1	1
Optioservus	4	13

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
COLEOPTERA (cont.)		
Peltodytes	1	1
Stenelmis	18	81
Tropisternus	2	3
DECAPODA		
Cambaridae	2	2
Orconectes	9	9
DIPTERA		
Ablabesmyia	29	139
Anopheles	9	18
Atherix	3	3
Atrichopogon	1	1
Bezzia	2	3
Bezzia / Palpomyia	4	8
Brillia	5	8
Cardiocladius	1	4
Ceratopogonidae	4	6
Ceratopogoninae	7	9
Chironomini	9	22
Chironomus	7	69
Chrysops	2	2
Cladopelma	2	7
Cladotanytarsus	5	6
Clinotanypus	3	6
Conchapelopia	5	7
Corynoneura	12	23
Cricotopus	31	150
Cryptochironomus	3	3
Cryptotendipes	3	5
Dasyhelea	1	7
Diamesinae	1	1
Dicranota	1	1
Dicrotendipes	11	49
Dixella	3	4
Doncricotopus bicaudatus	1	2
Empididae	9	13
Endochironomus	9	67
Ephydridae	4	8
Eukiefferiella	2	2
Glyptotendipes	4	5

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
DIPTERA (cont)		
Guttipelopia	1	1
Gymnometriocnemus	1	1
Hemerodromia	20	107
Labrundinia	17	33
Larsia	4	9
Lauterborniella agrayloides	4	10
Limnophyes	6	12
Lopescladius	3	5
Mallochohelea	1	2
Micropsectra	8	54
Microtendipes	20	45
Nanocladius	3	4
Nilotanypus	6	8
Nilothauma	2	2
Odontomyia / Hedriodiscus	1	1
Orthocladiinae	5	12
Orthocladius	4	6
Orthocladius (Symposiocladius)	1	2
Parachironomus	2	2
Parakiefferiella	4	7
Paralauterborniella nigrohalterale	3	3
Paramerina	5	16
Parametriocnemus	9	16
Paratanytarsus	16	132
Paratendipes	4	7
Pentaneura	7	12
Phaenopsectra	13	26
Polypedilum	38	779
Procladius	13	25
Psectrocladius	7	9
Rheocricotopus	14	36
Rheotanytarsus	34	671
Saetheria	1	3
Serromyia	1	2
Simulium	33	1432
Stempellinella	16	46
Stenochironomus	11	22

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
Stratiomyidae	1	1
Synorthocladius	3	8
Tabanidae	1	1
Tanypodinae	17	42
Tanytarsini	19	58
Tanytarsus	32	553
Thienemanniella	22	60
Thienemannimyia	3	7
Thienemannimyia Gr.	32	257
Thienemannimyia senata	1	1
Tipula	4	7
Tribelos	2	5
Tvetenia	14	37
Xenochironomus xenolabis	3	6
Zavreliella maramorata	1	1
EPHEMEROPTERA		
Acentrella	1	1
Acentrella parvula	2	6
Acentrella turbida	1	4
Acerpenna	18	106
Acerpenna pygmaea	15	120
Baetidae	13	41
Baetis	8	33
Baetis brunneicolor	6	36
Baetis flavistriga	5	39
Baetis intercalaris	6	29
Baetisca	3	3
Caenis	16	196
Caenis diminuta	4	40
Caenis Diminuta Gr.	6	156
Caenis hilaris	1	4
Caenis Hilaris Gr.	4	34
Callibaetis	1	1
Ephemerellidae	1	1
Heptageniidae	12	51
Iswaeon	18	480
Labiobaetis	3	3
Labiobaetis dardanus	2	5
Labiobaetis propinquus	18	130
Leptophlebia	2	71

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
Leptophlebiidae	12	42
Leucrocuta	5	12
Maccaffertium	15	119
Maccaffertium exiguum	2	2
Maccaffertium mediopunctatum	5	18
Maccaffertium terminatum	1	1
Maccaffertium vicarium	3	18
Paracloeodes minutus	1	1
Paraleptophlebia	5	108
Plauditus	4	18
Procloeon	5	18
Stenacron	6	18
Stenonema	1	11
Tricorythodes	14	48
GASTROPODA		
Amnicola	2	72
Ferrissia	9	53
Fossaria	4	6
Gyraulus	8	19
Helisoma	2	4
Helisoma anceps	3	3
Hydrobiidae	24	534
Laevapex fuscus	1	3
Lymnaea stagnalis	3	3
Lymnaeidae	8	15
Menetus	2	2
Physa	23	147
Planorbella	4	4
Planorbidae	10	24
Planorbula armigera	1	1
Promenetus exacuous	3	4
Stagnicola	1	45
Valvata	4	12
Viviparidae	1	1
HEMIPTERA		
Aphididae	1	3
Belostoma	2	12
Belostoma flumineum	7	8
Belostomatidae	1	1
Corixidae	5	7

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
HEMIPTERA (cont)		
Hesperocorixa	1	1
Lethocerus	1	1
Mesovelia	2	2
Microvelia	2	2
Neoplea striola	11	41
Notonecta	3	3
Palmacorixa	1	1
Ranatra	2	2
Rhagovelia	1	1
Sigara	1	1
Trichocorixa	1	1
HIRUDINEA		
Hirudinea	14	41
HYDROZOA		
Hydrozoa	2	2
ISOPODA		
Caecidotea	1	2
LEPIDOPTERA		
Crambidae	3	4
Paraponyx	1	8
Petrophila	5	7
Pyralidae	2	2
Synclita	1	5
NEMATA		
Nemata	2	5
ODONATA		
Aeshna	5	30
Aeshna umbrosa	2	2
Aeshnidae	2	2
Anax	1	1
Anax junius	2	2
Argia	6	13
Argia apicalis	2	2
Basiaeschna janata	1	1
Boyeria	1	1
Calopterygidae	10	55
Calopteryx	15	40
Calopteryx aequabilis	7	20
Calopteryx maculata	1	1
Coenagrionidae	25	128

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
Enallagma	1	1
Epitheca	2	2
Epitheca canis	1	1
Gomphidae	4	4
Gomphus	2	2
Hetaerina americana	1	1
Ischnura	1	1
Libellulidae	1	1
Neurocordulia	1	4
Ophiogomphus	2	7
Ophiogomphus carolus	1	1
Somatochlora	3	6
OLIGOCHAETA		
Oligochaeta	28	295
PLECOPTERA		
Acroneuria	1	1
Acroneuria abnormis	2	2
Acroneuria lycorias	2	3
Isoperla	1	1
Paragnetina media	4	10
Perlidae	2	2
Perlodidae	1	1
Pteronarcys	1	1
TREPAXONEMATA		
Trepaxonemata	1	5
TRICHOPTERA		
Agarodes	1	1
Agarodes distinctus	1	1
Brachycentrus numerosus	6	97
Ceraclea	1	4
Ceratopsyche	14	104
Ceratopsyche bronta	1	1
Ceratopsyche morosa	4	138
Ceratopsyche slossonae	3	15
Cheumatopsyche	31	338
Chimarra	13	74
Glossosoma	1	1
Glossosomatidae	1	3
Helicopsyche	2	26
Helicopsyche borealis	9	148
Hydropsyche	16	85

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
TRICHOPTERA (cont)		
Hydropsyche betteni	19	104
Hydropsyche incommoda	1	1
Hydropsyche placoda	3	38
Hydropsyche scalaris	1	1
Hydropsyche simulans	1	6
Hydropsychidae	26	370
Hydroptila	13	33
Hydroptilidae	9	21
Lepidostoma	5	9
Leptoceridae	10	20
Leptocerus	1	1
Leptocerus americanus	1	6
Limnephilidae	6	27
Limnephilus	1	13
Micrasema	4	13
Mystacides	4	9
Nectopsyche	4	8
Nectopsyche diarina	4	10
Nectopsyche exquisita	3	6
Neophylax concinnus	1	4
Neophylax fuscus	2	10
Neophylax oligius	3	9
Neureclipsis	8	18
Ochrotrichia	2	3
Oecetis	2	9
Oecetis Avara Gr.	6	14
Oecetis furva	4	4
Oecetis testacea	5	30
Oxyethira	20	105
Philopotamidae	1	2
Phryganeidae	6	8
Polycentropodidae	5	5
Polycentropus	2	2
Protoptila	3	19
Ptilostomis	6	9
Pycnopsyche	2	2
Triaenodes	5	8
TUBELLARIA		
Turbellaria	11	84
VENEROIDA Pisidiidae	31	206