Lake Superior - South Watershed Monitoring and Assessment Report

Minnesota Pollution Control Agency

June 2014

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Project dollars provided by the Clean Water Fund
(from the Clean Water, Land and Legacy Amendment).

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Document number: wq-ws3-04010102b

List of Acronyms

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

DO Dissolved Oxygen

DOP Dissolved Orthophosphate

E Eutrophic

E. Coli Escherichia coli

EQuIS Environmental Quality Information System

EMAP Environmental Monitoring and Assessment Program

EX Exceeds Criteria (Bacteria)

EXP Exceeds Criteria, Potential Impairment

EXS Exceeds Criteria, Potential Severe Impairment

FS Full Support

ETSC Endangered, threatened or special concern

FWMC Flow Weighted Mean Concentration

H Hypereutrophic

HUC Hydrologic Unit Code

IBI Index of Biotic Integrity

IF Insufficient Information

IWM Intensive Watershed Monitoring

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

MLRA Major Land Resource Area

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

NLF Northern Lakes and Forest

NRCS Natural Resources Conservation Service

NS Not Supporting

NT No Trend

OP Orthophosphate

P Phosphorous

PCB Poly Chlorinated Biphenyls

PFOS Perfluoroocatanesulfonic Acid or Perfluorooctane Sulfonate

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

TSVS Total Suspended Volatile Solids

USDA United States Department of Agriculture

USEPA United State Environmental Protection Agency

USGS United States Geological Survey

VHS Viral hemorrhagic septicemia

WPLMN Water Pollutant Load Monitoring Network

WAT Watershed Assessment Team

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Executive Summary

The Lake Superior - South Watershed (04010102) lies in northeastern Minnesota and covers approximately 624 mi^2 or 399,373 acres. A total of 16 lakes (>10 acres) and 695 stream assessment units (AUIDs) reside within this watershed. Streams are generally small to moderate in channel size, short, and vary in gradient due to their direct drainage towards Lake Superior. Both drinking water quality and the recreational value of lakes and streams are vital assets to the health and wealth of local economies throughout this watershed. These waterways not only provide local communities with drinking water for households and industry, but also offer habitat for aquatic life, riparian corridors for wildlife, and recreational opportunities such as fishing, swimming, and canoeing. The immaculate waters found within this watershed not only produce some of the highest quality stream trout fisheries in the state but also offer visitors many scenic and natural views. Today, over 87% of the Lake Superior - South Watershed is forested and utilized for timber production, hunting, fishing, hiking, and other recreational opportunities. Large tracts of public land exist within this watershed, including county land, national and state forests, wildlife management areas, and state parks.

In 2011, the Minnesota Pollution Control Agency (MPCA) undertook an intensive watershed monitoring effort of surface waters within the Lake Superior - South Watershed. Fifty-eight stream stations were sampled for biology at the outlets of variable sized subwatersheds. These locations included the mouth of the Beaver, Gooseberry, Split Rock, Knife, Sucker, and Lester Rivers, as well as the upstream outlets of major tributaries, and the headwater outlets of smaller streams. As part of this effort, MPCA staff joined with the Saint Louis River Alliance to conduct stream water chemistry sampling at the outlets of six streams. In 2013, a holistic approach was taken to assess all surface waterbodies within the Lake Superior - South Watershed for support of aquatic life, recreation, and consumption (where sufficient data was available). Additional data from other agencies, groups, and/or individuals were used in the assessment of designated beneficial uses. Forty-two stream segments and six lakes were assessed in this effort.

Of the assessed streams, only 28 AUIDs were considered to fully-support aquatic life and nine AUIDs fully-supported aquatic recreation. A total of eleven AUIDs did not support aquatic life and three did not support aquatic recreation. Specific impairment indicators found throughout this watershed included: fish and macroinvertebrate index of biological integrity, turbidity, dissolved oxygen, pH, mercury in fish tissue, mercury in the water column, and bacteria (E. coli). Fish collected from the Lester River (04010102-548 & -549) in 2011 tested above the states standard for mercury in fish tissue, resulting in an aquatic consumption impairment designation.

Six of the watershed's larger and more notable lakes were monitored in 2011 and 2012 by MPCA staff, citizen volunteers, and surface water assessment grantees. All assessed lakes met eutrophication standards for cool and warm water lakes in the Northern Lakes and Forest ecoregion, and had good water quality that indicated mesotrophic conditions. Three lakes (Lax, Tettegouche, and Nicado) had existing aquatic consumption impairments due to an exceedance of standards for mercury in fish tissue.

Overall, water quality conditions are good and can be attributed to the forest and wetlands that dominate land cover within the Lake Superior - South Watershed. Problem areas do occur and persist throughout the watershed but are typically limited to the lower reaches where stressors from land use practices may accumulate. Impairments found within this watershed are likely a function of both natural and anthropogenic stressors. Historical and recent forest cover changes, along with urban/industrial development, draining of wetlands, and damming of streams are likely stressors affecting biological communities within the watershed. A number of streams with exceptional biological, chemical, and physical parameters are worthy of additional protections in order to preserve their valuable aquatic resources.

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 waterbody 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 Lake Superior - South Watershed beginning in the summer of 2011. This report provides a summary of all water quality assessment results in the Lake Superior - South Watershed and incorporates all data available for the assessment process including watershed monitoring, volunteer monitoring and monitoring conducted by local government units.

I. 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 81 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 station 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 stations across Minnesota. Intensive water quality sampling occurs year round at all WPLMN stations. Data will also be used to assist with TMDL studies and implementation plans, watershed modeling efforts and watershed research projects.

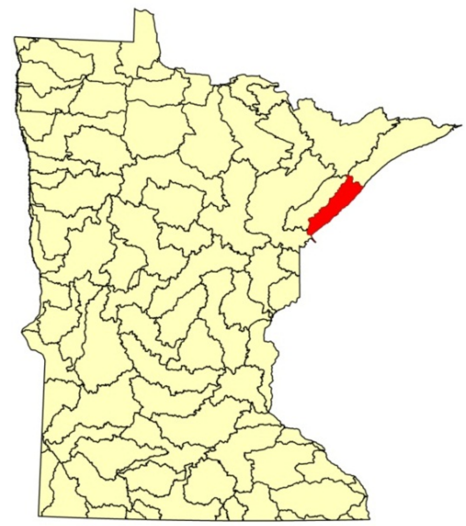

Figure 1. Major watersheds within Minnesota (8-Digit HUC).

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 81 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 stations are selected near the outlet of each of three watershed scales, 8-HUC, 10-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 10-HUC is the next smaller watershed scale which generally consists of major tributary streams with drainage areas ranging from 75 to 150 mi^2. Each 10-HUC outlet (green dots in Figure 3) is sampled for biology and water chemistry for the assessment of aquatic life and aquatic recreation use support. Within each 10-HUC, smaller watersheds (14 HUCs, typically 10-20 mi^2), are sampled at each outlet that flows into the major 10-HUC tributaries. Each of these minor watershed outlets is sampled for biology to assess aquatic life use support (red dots in Figure 3).

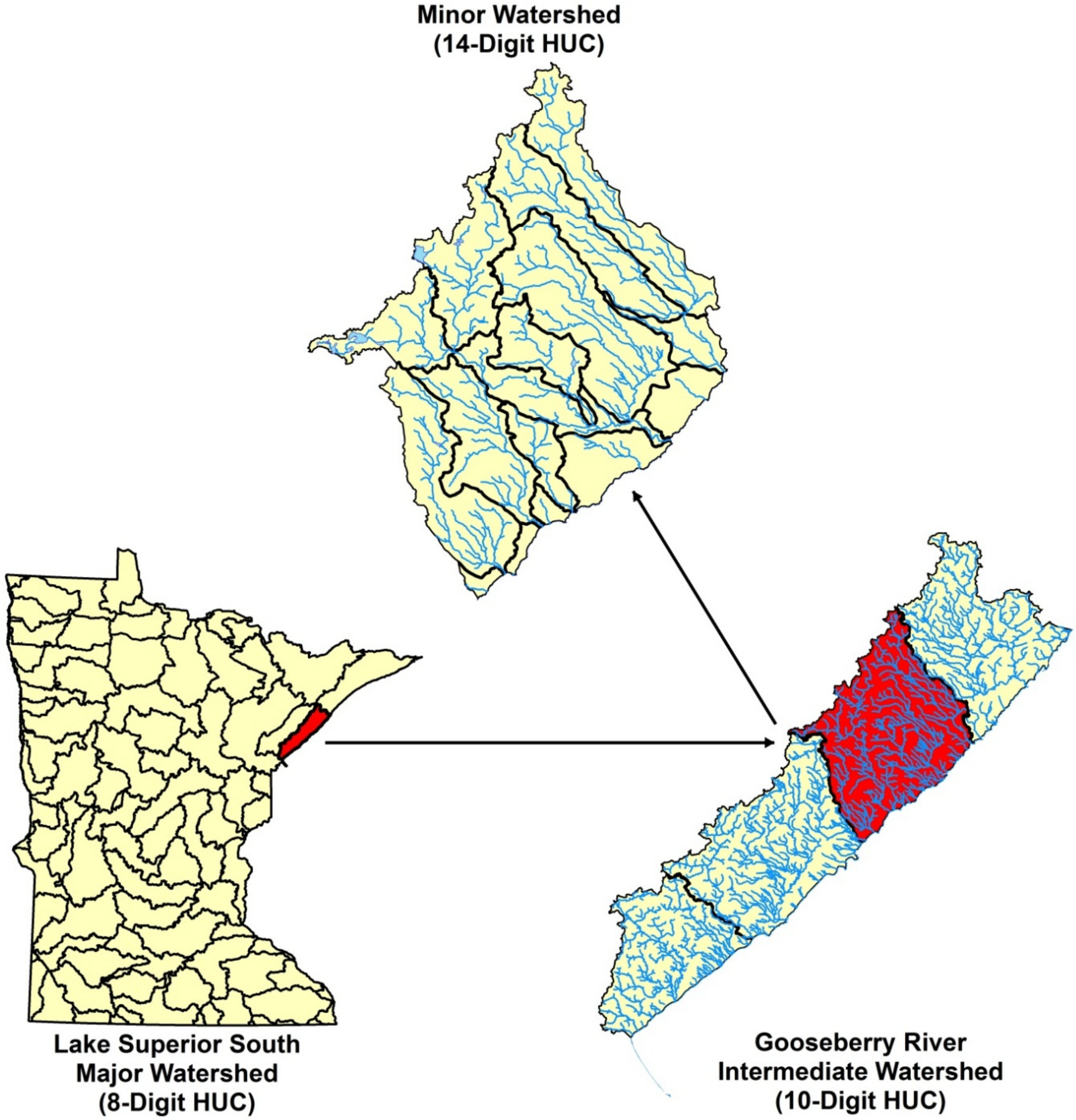

Figure 2. The Intensive Watershed Monitoring Design.

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 stations sampled as part of the intensive watershed monitoring effort in the Lake Superior - South Watershed are shown in Figure 3 and are listed in Appendix 2, Appendix 3, Appendix 4, Appendix 6, Appendix 7, and Appendix 9.

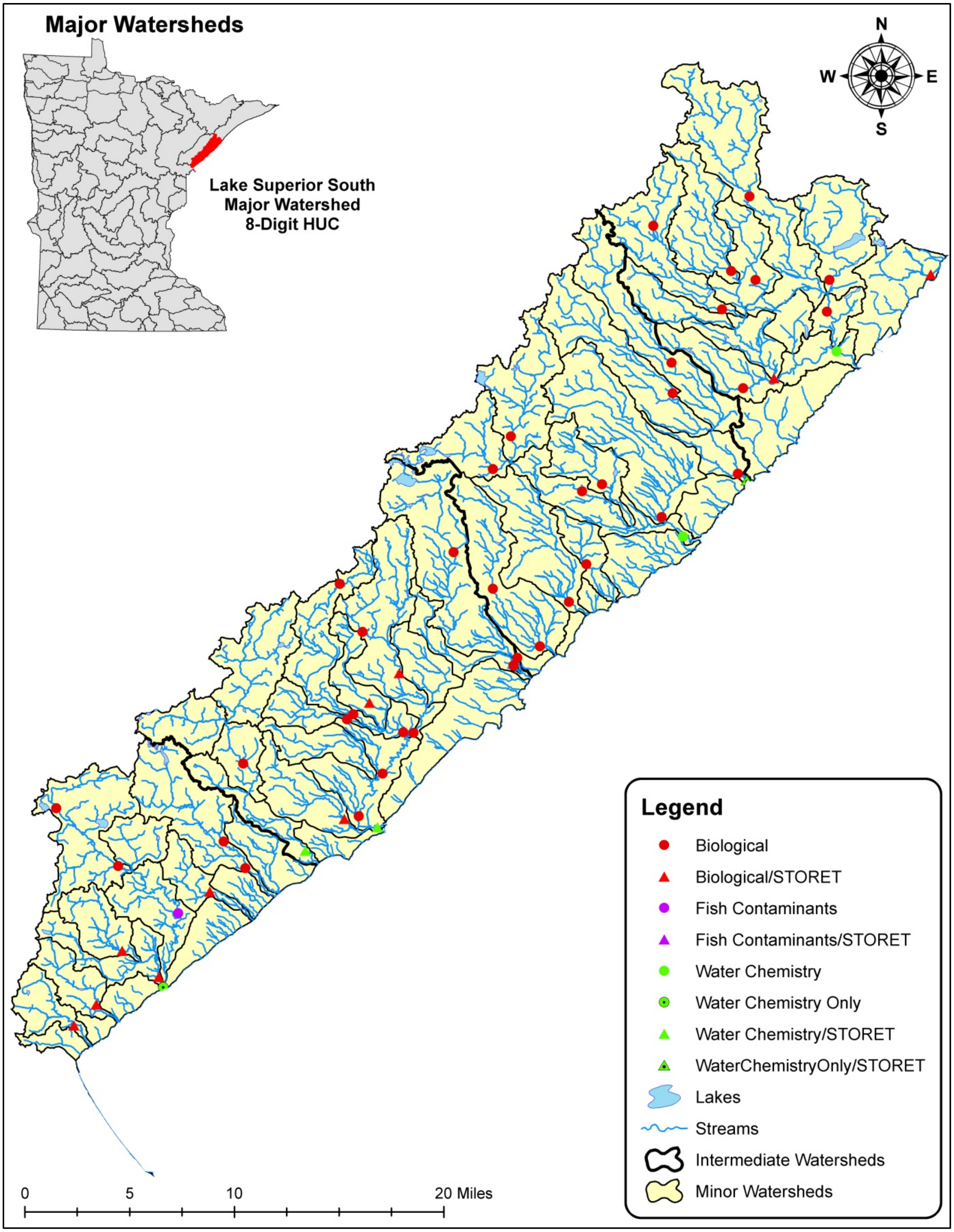

Figure 3. Intensive watershed monitoring stations for streams in the Lake Superior - South Watershed.

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

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 station 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 has been collected in the Lake Superior - South Watershed.

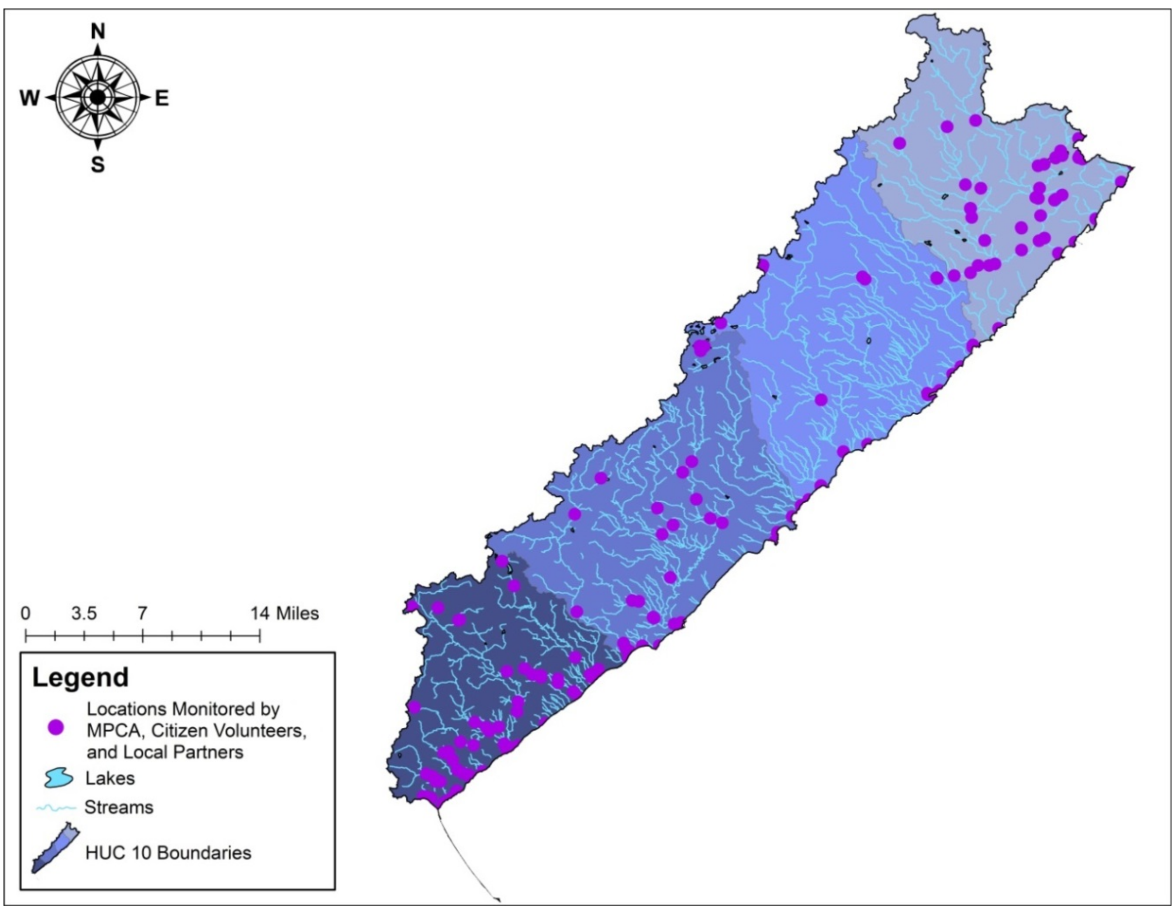

Figure 4. Monitoring locations of local groups, citizens and the MPCA lake monitoring staff in the Lake Superior - South Watershed.

II. Assessment Methodology

The Clean Water Act requires states to report on the condition of the waters of the state every two years. This biennial report to Congress contains an updated list of surface waters that are determined to be supporting or non-supporting of their designated uses as evaluated by the comparison of monitoring data to criteria specified by Minnesota Water Quality Standards (Minn. R. Ch. 7050 2008; https://www.revisor.leg.state.mn.us/rules/?id=7050). The assessment and listing process involves dozens of MPCA staff, other state agencies and local partners. The goal of this effort is to use the best data and best science available to assess the condition of Minnesota's water resources. For a thorough review of the assessment methodologies see: Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment 305(b) Report and 303(d) List (MPCA 2012). http://www.pca.state.mn.us/index.php/view-document.html?gid=8601.

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. Interpretations of narrative criteria for aquatic life in streams are based on multi-metric biological indices including the Fish Index of Biological Integrity (F-IBI), which evaluates the health of the fish community, and the Macroinvertebrate Index of Biological Integrity (M-IBI), which evaluates the health of the aquatic invertebrate community. 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 turbidity.

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 (TP), 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 a comparison of the monitoring data to water quality standards. This is largely an automated process performed by logic programmed into a database application and the results are referred to as 'Pre-Assessments'. 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 attenuating circumstances that should be considered (e.g., flow, time/date of data collection, or habitat).

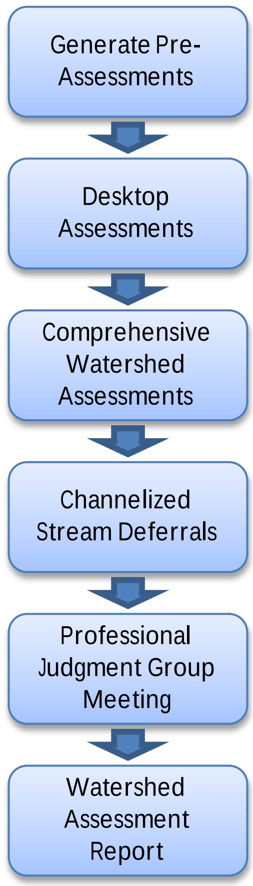

Figure 5. Flowchart of aquatic life use assessment process.

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. Implementing a comprehensive approach to water quality assessment requires a means of organizing and evaluating information to formulate a conclusion utilizing multiple lines of evidence. Occasionally, the evidence stemming from individual parameters are not in agreement and would result in discrepant assessments if the parameters were evaluated independently. However, the overall assessment considers each piece of evidence to make a use attainment determination based on the preponderance of information available. See the *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment 305(b) Report and 303(d) List* (MPCA 2012) http://www.pca.state.mn.us/index.php/view-document.html?gid=16988 for guidelines and factors considered when making such determinations.

Any new impairment (i.e., waterbody not attaining its beneficial use) is first reviewed using GIS to determine if greater than 50% of the assessment unit is channelized. Currently, the MPCA is deferring any new impairments on channelized reaches until new aquatic life use standards have been developed as part of the Tiered Aquatic Life Use (TALU) framework. For additional information, see: http://www.pca.state.mn.us/index.php/water/water-permits-and-rules/water-rulemaking/tiered-aquatic-life-use-talu-framework.html. There are currently no channelized reaches within the Lake

Superior - South Watershed with biological data, therefore all stream segments with data were assessed for aquatic life use support.

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 (USEPA) 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 ten 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.

III. Watershed Overview

The Lake Superior - South Watershed (04010102) occupies a cumulative total of 624 mi^2 or 399,373 acres of land within Minnesota. This watershed consists of a long narrow strip extending along Lake Superior from the southwest to the northeast. Elevations within this watershed range from a high of 1,250 feet above sea level to its lowest point on Lake Superior at 607 feet above sea level (NRCS, 2007). The largest portion of this watershed is in Lake County, with a slightly smaller proportion in St. Louis County.

The Lake Superior - South Watershed lies in the eastern portion of the Northern Lakes and Forest (NLF) Ecoregion (Figure 6). The NLF is dominated by relatively nutrient-poor glacial soils which support the growth of coniferous and northern hardwood forests (Omernik, 1988). This heavily forested ecoregion is made up of many steep, rolling hills, broad lacustrine basins, and extensive sandy outwash plains (Omernik, 1988). Soils within this ecoregion's are generally thicker than those to the north and lack the arability of soils in the adjacent ecoregions to the south (Omernik, 1988). Lakes are numerous in numbers throughout the NLF ecoregions and are clearer and less productive than those that are located to the south (Omernik, 1988). Throughout the NLF many Precambrian granitic bedrock outcropping exist between shallow-to-deep moraine deposits left by the last glacier retreat that dates back to 12,000 years ago (Omernik, 1988).

The United States Department of Agriculture (USDA) Major Land Resource Areas (MLRA) for the Lake Superior - South Watershed includes two classifications. The eastern half that lies along Lake Superior western shoreline is classified as Superior Lake Plain, while the western half that is located up the hill from Lake Superior is classified as Superior Stony and Rocky Loamy Plains and Hills, Western Part (Figure 7). Topography in the Superior Lake Plain is gently sloping to steep, with deep v-shaped ravines (USDA/NRCS, 2006). Soils consist of a clayey and loamy lakebed deposit with some organic material that tends to be well drained to somewhat poorly drained (NRCS, 2007). The Superior Stoney and Rocky Loamy Plains and Hills, Western Part is very diverse in soil types and can be a very shallow to deep dense loamy till, coarse glacial drift and outwash, silty glaciolacustrine sediment, local loess, alluvium, and organic material (USDA/NRCS, 2006). Bedrock outcrops are common in many places and the topography is gently sloping to very steep in locations (USDA/NRCS, 2006). Bogs and large wetland complexes are common in the headwaters of many subwatersheds. Given the geologic history of the valley, some natural springs can be found throughout this watershed. These spring-fed streams, along with many other naturally coldwater streams within the watershed, support or once supported brook, brown, and/or rainbow trout populations.

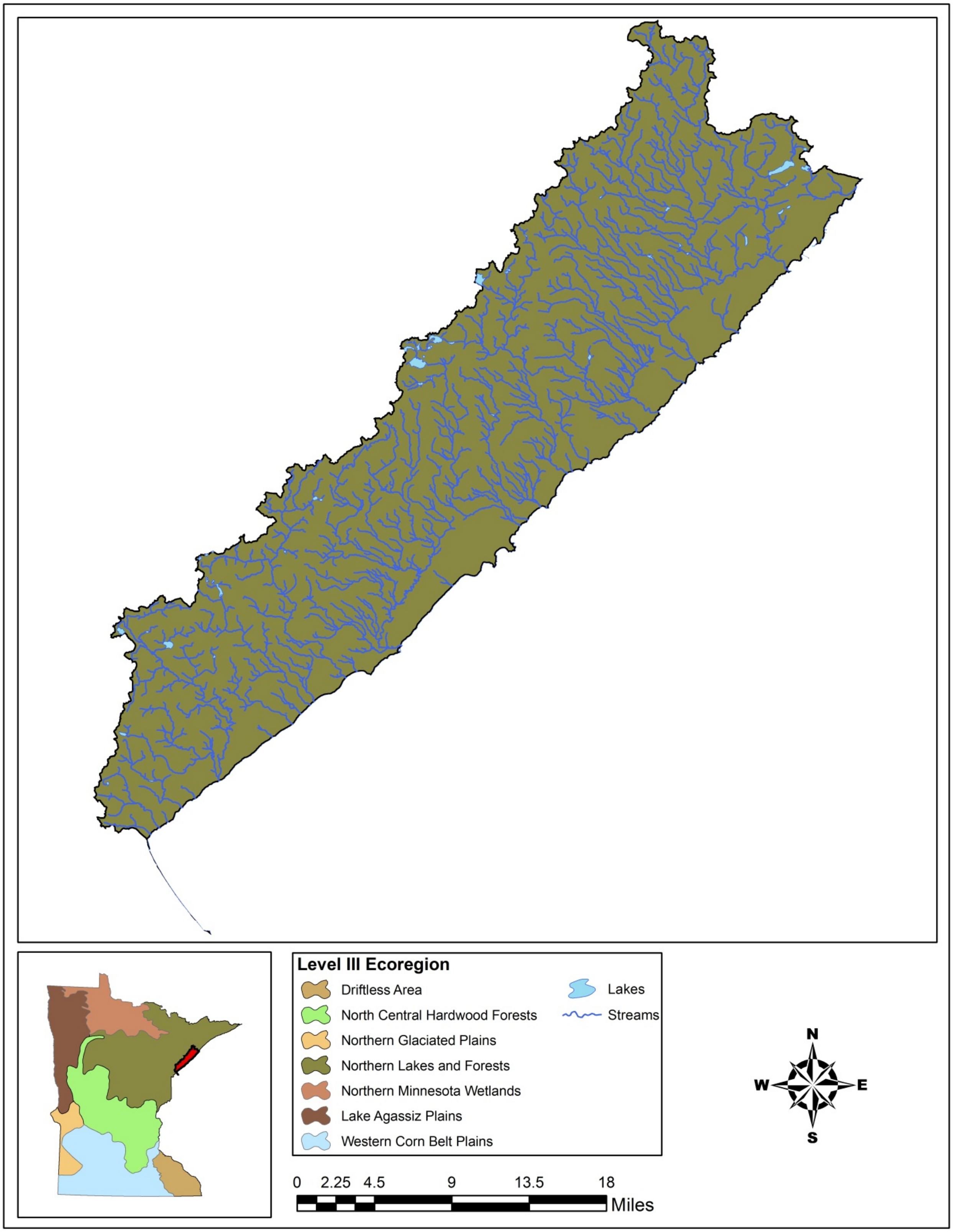

Figure 6. The Lake Superior - South Watershed within the Northern Lakes and Forest ecoregion of Northeast Minnesota.

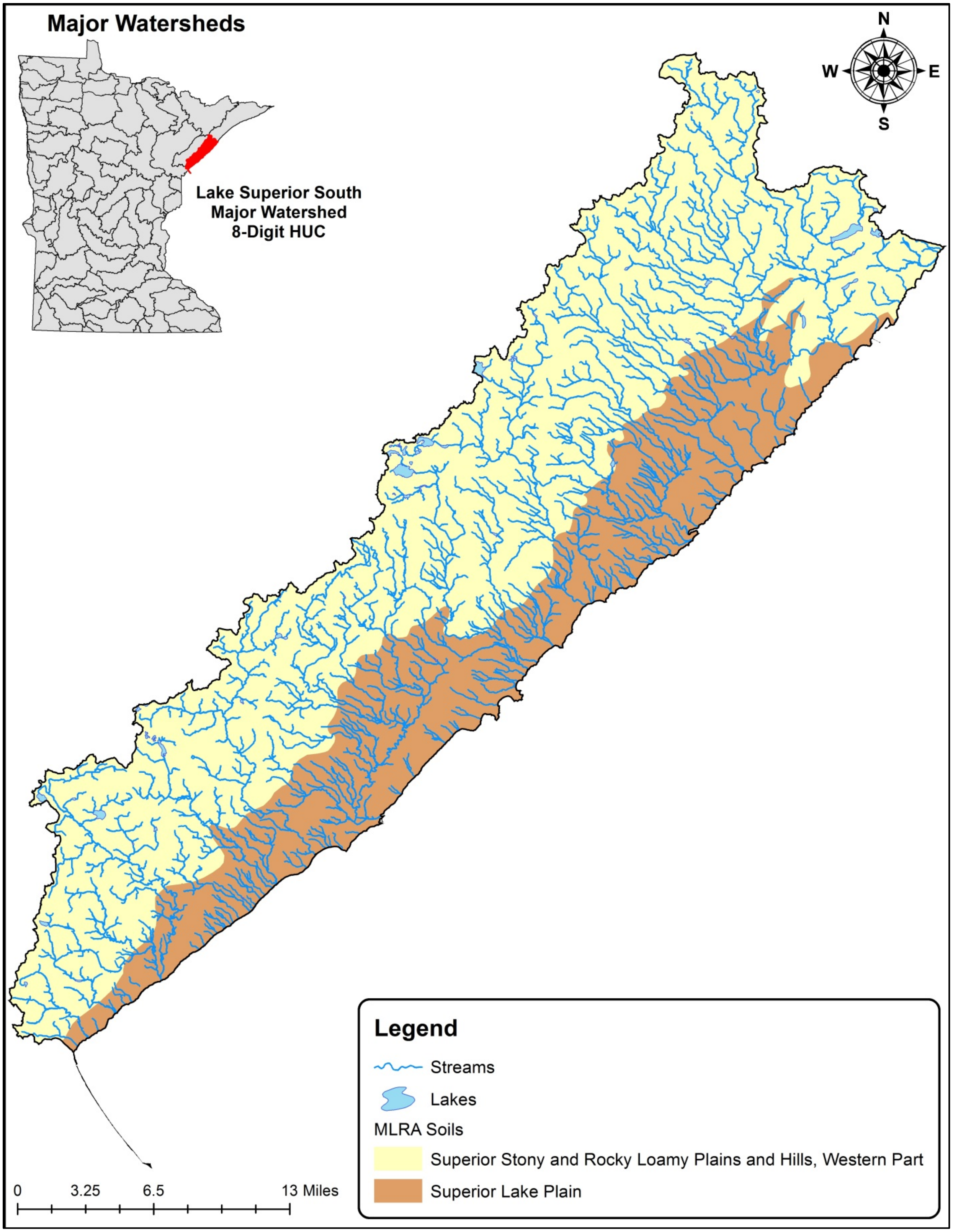

Figure 7. Major Land Resource Areas in the Lake Superior - South Watershed.

Land Use Summary

Historically, land cover in the Lake Superior - South Watershed was largely forest with a mixture of brushland, wetlands and open water. Pre-settlement vegetation was dominated by old growth forest of White Spruce, White Pine, Quaking Aspen and Paper Birch (Waters, 1977). The forest was dependent on infrequent low lying fires that cleared out thick brush and alders to regenerate saplings (Larson, 2007). Stream corridors were heavily forested and provided ample shade to tributary streams. The corridors consisted of small patches of thick alder, marsh, and sedge meadows in the river's meanders and abandoned oxbows (Waters, 1977). As these meandering streams moved towards the outlet and Lake Superior, they typically drop into a ravine that was heavily forested.

Although a large portion of the current land use within the Lake Superior - South Watershed is still forest, settlement of western Lake Superior that began in the 1800s has changed the landscape in many ways. As settlers arrived in the new territory, logging quickly became the largest occupation throughout the region. Small sawmills began to be constructed on the shoreline of Lake Superior, including at the mouth of the Beaver River, Knife River and the St. Louis Estuary (Waters, 1977). Many of the Lake Superior - South streams were never important as log-driving streams because they were generally narrow and short, drained smaller watersheds, and had a torrential rush near Lake Superior, which made them unsuitable for carrying logs (Waters, 1977). With the expansion of timber production in the St. Louis River and the Nemadji River drainage, Duluth-Superior quickly became a major port for industry. In the 1870s the railroad had arrived and soon spread north and east to transport timber from the arrowhead region to Duluth (Larson, 2007). With the increase of productivity from many logging camps the forest began to be cleared at a high rate, which depleted many of the old growth pine that once existed (Larson, 2007). With this decrease in large pine stands, most logging camps switched to producing railroad ties, cedar shingles, barrel staves, pulpwood and fuel wood (King, 2003). After much of the forest was depleted, numerous large fires burned through cutover lands (Larson, 2007). The disturbance transformed the forest from a pine dominated system to a forest consisting mostly of Quaking Aspen, Paper Birch and other deciduous species (Waters, 1977).

With the growth of the Duluth-Superior harbor, other industries began to expand and utilize resources within the area. As mining began to grow on the Iron Range, so did industries within the Lake Superior - South Watershed to refine those raw materials. Taconite ore processing plants were developed along shipping routes, including one in Silver Bay that was owned by Reserve Mining Company. For many years, Reserve Mining Company had disposed of its tailings by dumping them into Lake Superior at a rate of 67,000 tons a day (Waters, 1977). Through public concern about the degradation of Lake Superior and the safety of drinking water drawn from the lake, a push to develop a different disposal process began. After many years of debate and a heated court battle, the decision was made to create a tailing basin inland for waste materials (Waters, 1977). The tailing basin was developed in the Beaver River – Frontal Lake Superior Subwatershed, which has become known as Mile Post 7. In the construction of Mile Post 7, both Big Thirtynine and Little Thirtynine creeks were diverted which caused the loss of ten miles of trout waters (Waters, 1977). It also removed eight square miles of watershed from the Beaver River drainages, which likely resulted in the loss of Steelhead production in the lower reaches (Waters, 1977).

Currently, about 45% of the land within the watershed is owned by private landowners, with the second largest ownership being the State of Minnesota (42.2%) (NRCS, 2007). Because much of the land within this watershed is under the management of local, state, and federal governments it is open to public use. Forest is the most extensive land use with heavier development in centralized locations along Lake Superior historical shipping routes (Figure 8). Today, land cover within the Lake Superior - South Watershed is distributed as follows: 87.47 % forest/shrub, 4.52% developed, 3.50% rangeland, 3.23% wetland, 0.96 % open water, 0.19% barren/mining, and 0.13% cropland (Figure 8).

The NRCS estimates that there are 33 farms located in the Lake Superior - South Watershed, with approximately 66% of them operating on less than 180 acres, with the remaining farms operating on 180 acres to 1,000 acres. A total of 39 operators run those farms and approximately 52% of them are full time and do not rely on off-farm income. There are only eight permitted feedlots within the watershed with a total of 958 animal units (NRCS, 2007). These animal units consist of 26% cattle (beef and dairy), 13 % chickens, 3 % swine and 56% being other animals (NRCS, 2007). The main crop within the watershed is alfalfa and other grazing grasses, with a low percentage of row crops.

The population of this watershed is estimated at 71,417, equating to roughly 114 people per square mile (NRCS, 2007). A large proportion of the population in the Lake Superior - South Watershed lies within the city of Duluth and its suburbs. The two other main population centers are Two Harbors and Silver Bay. These cities and other remote cabins accommodate many seasonal visitors throughout the summer months. Three state parks, Tettegouche, Gooseberry Falls, Split Rock Lighthouse and the Superior Hiking Trail, provide recreational opportunities to visitors and residents.

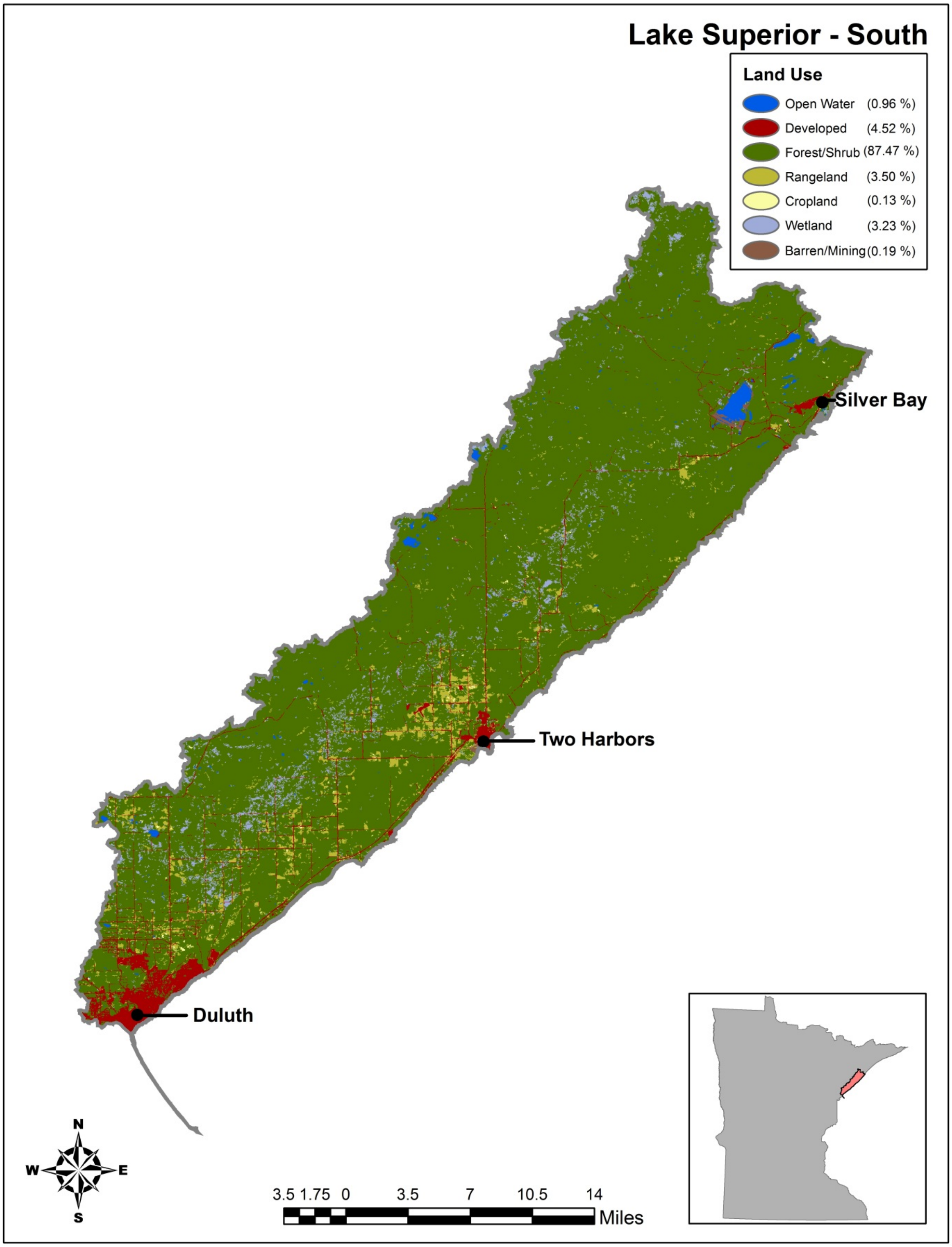

Figure 8. Land use in the Lake Superior - South Watershed.

Surface Water Hydrology

The Lake Superior - South Watershed contains four intermediate watersheds (10-digit HUC) and 60 minor watersheds (14-digit HUC). Major rivers include the Beaver, Split Rock, Gooseberry, Stewart, Knife, Sucker, French and Lester Rivers. In addition, many smaller tributaries flow directly into Lake Superior and into other major tributaries. Streams within this watershed are generally small to moderate in channel size, short, and vary in gradient due to their direct drainage towards Lake Superior. The majority of the streams tend to seep slowly through bogs and marshes at their headwaters and later begin their downhill slope through some of the most diverse landforms in the world (Waters, 1977). A large proportion of the streams are naturally meandering with little to no channelized sections. Mainstem lengths can vary between a few miles to over 20 miles, with average gradients between 50 to 100 feet per mile (Waters, 1977). Spectacular cascades and waterfalls occur on numerous streams near their outlets on Lake Superior and are the focal points of state parks along U.S. Highway 61.

Waterways within this major watershed are protected by the 1930 Shipstead-Nolan Act of Congress that prohibits the construction of dams or other water-fluctuation structures in St. Louis, Lake and Cook counties (Waters, 1977). This act was later supported by a Minnesota law of 1933 that effectively protects the waterfalls, rapids, and beaches of Lake Superior streams.

The Lake Superior - South Watershed lacks the number of lakes that are so prevalent throughout the NLF. Only 16 lakes greater than ten acres and 74,853 acres of wetlands exist with in this watershed. This lack of water storage may contribute to floodwaters that develop rapidly during times of snow-melt or heavy rain and extremely low flows during drought periods. Most streams near and within the city of Duluth are flashy, due to their smaller watershed area and gradient. Streams located in the middle section of this watershed are generally cooler, with trout (brook, brown, and rainbow) as the principal game fish. The vast majority of the streams within this watershed are naturally tea-colored to some degree and alkalinities are generally low (15-50 ppm).

Many of the streams found within this watershed provide excellent brook trout habitat in the headwaters but usually lack them below the old beach lines of Glacial Lake Duluth due to the warmer and silty water that is found near the outlets of most Lake Superior tributaries. Six-hundred and ninety-five stream AUIDs, totaling 1067 stream miles exist throughout this major watershed. Eight hundred stream miles are designated coldwater streams (2A).

There are ten dams located on various sized tributaries to Lake Superior, including the French River, Tischer Creek, Silver Creek, East Branch Knife River and other unnamed tributaries. Most of these dams were created before the mid-1970s and were originally established to create taconite tailing basins and/or impoundments for water storage. There is one long-term and continuous USGS stream flow monitoring station located near the mouth of the Knife River near Two Harbors.

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 Lake Superior - South Watershed is 15.6˚C; and the mean winter temperature is -10.6˚ C (MSCO, 2012).

Annual precipitation ranged from 20 to 28 inches in 2011 and 32 to 37 in 2012 (MSCO, 2012). The average precipitation normal range is between 27 to 31 inches (NRCS, 2007). During the water year, January 2011 to December 2011, which encompasses the time span in which the majority of the data was collected in the watershed, the precipitation levels were lower than normal (Figure 9). Additional information, including groundwater withdrawal, groundwater quality and stream flow, were collected in 2012, when a single heavy summer storm event caused the yearly total to be two to six inches above average.

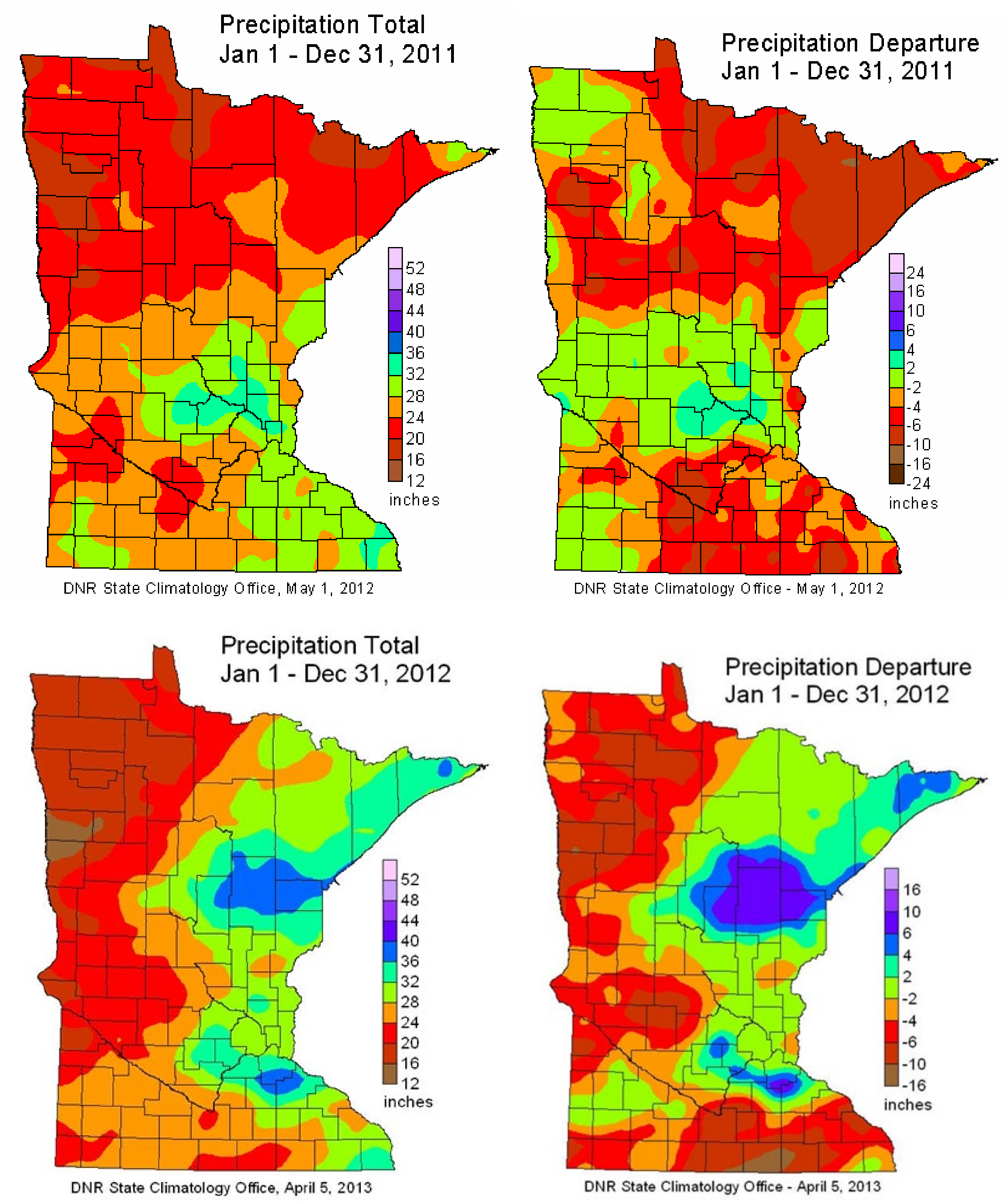

Figure 9. State-wide precipitation totals and departure from normal during the 2011 and 2012 water year.

[Figure 10](#) and [Figure 11](#) display the areal average representation of precipitation in Northeast Minnesota. An areal average is a spatial average of all the precipitation data collected within a certain area presented as a single dataset. This data is taken from the Western Regional Climate Center, available as a link off of the University of Minnesota Climate website: http://www.wrcc.dri.edu/spi/divplot1map.html.

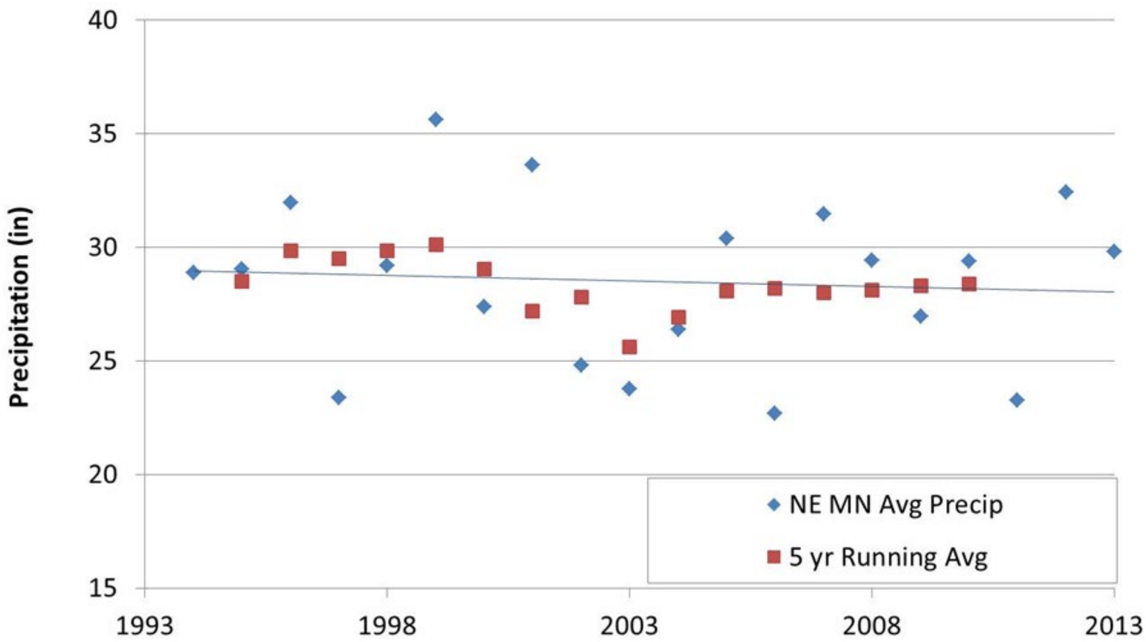

Figure 10. Precipitation trends in Northeast Minnesota (1993-2013) with five year running average (Red Dots).

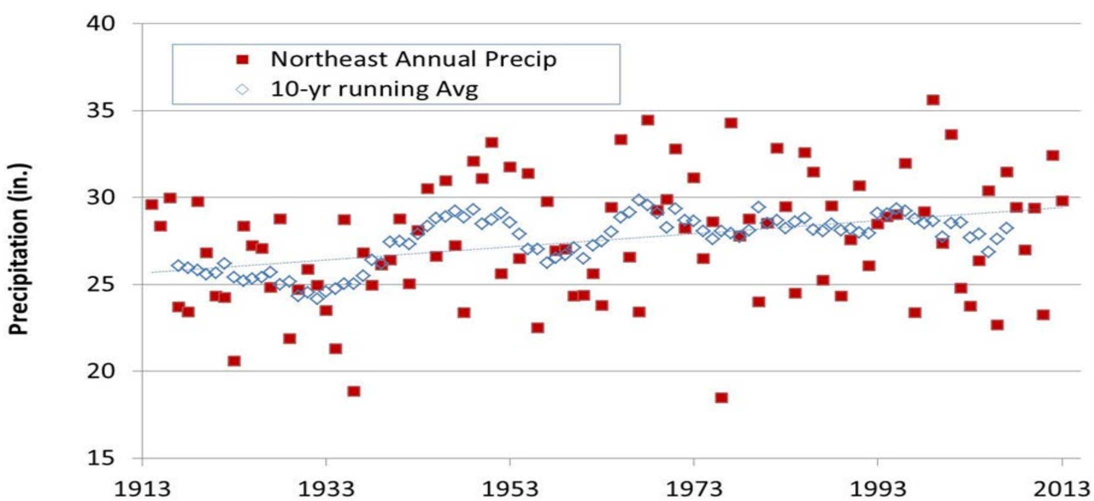

Figure 11. Precipitation trends in Northeast Minnesota (1913-2013) with ten year running average (Blue Dots).

Although data suggests no significant changes in rainfall for the last twenty years, it appears that precipitation in the Northeast region has risen slightly over the last 100 years. This follows the state-wide spatial average, which shows a statistically significant rising trend for the same time period. Though rainfall can vary in intensity and time of year, it would appear that Northeast Minnesota precipitation has increased slightly over this time period.

Hydrogeology

The precambrian volcanic rocks (Ojakangas, 1982) in the Lake Superior - South Watershed are often close to the land surface and are relatively impermeable. Consequently, water moving through surficial materials in the unsaturated zone may only slowly penetrate underlying bedrock. Water may accumulate and move along the interface between those unconsolidated (drift) deposits and the bedrock. The portion of groundwater wells lying in bedrock acts primarily as storage for water entering the well at the interface and through any bedrock fractures.

Groundwater flow, and discharge to surficial water bodies is, as a result of the underlying bedrock, determined by local factors like topography, extent of bedrock fractures and the permeability of surficial deposits. (MPCA, 1999)

Wetlands

Wetlands are common in the Lake Superior - South Watershed. National Wetlands Inventory data estimate 74,853 acres of wetlands — which is approximately 19% of the watershed area (Figure 12). This coverage is approximately the same as the current statewide wetland coverage (Kloiber & Norris, 2013). The predominant wetland cover type in the Lake Superior - South Watershed is forested swamp (Figure 12).

Glacial processes helped shape the current landform of the Lake Superior - South Watershed (Lusardi, 1997) and contributed to the wetland patterns that are present today. During the most recent advance glaciers alternately scoured many areas down to bedrock and deposited till in the form of ground and end moraines. As the ice retreated, Glacial Lake Duluth formed and deposited silt and clay sediments close to the current shore of Lake Superior. The resulting hilly terrain drops rapidly in elevation from the top-northwest border of the watershed to Lake Superior. The majority of the wetlands occur in the top two-thirds of the watershed where surface water concentrates in the flatter depressions and swales creating saturated soil conditions. Many of these wetlands are important for the streams in the watershed as they often provide source water through saturation-overland flow. Saturation-overland flow from wetlands can also influence stream water quality by delivering high dissolved organic matter (DOM)/low dissolved oxygen (DO) water as it very slowly drains from the surface of the wetland — where it mixes with anoxic pore water in organic soils — to the stream (Acreman & Holden, 2013).

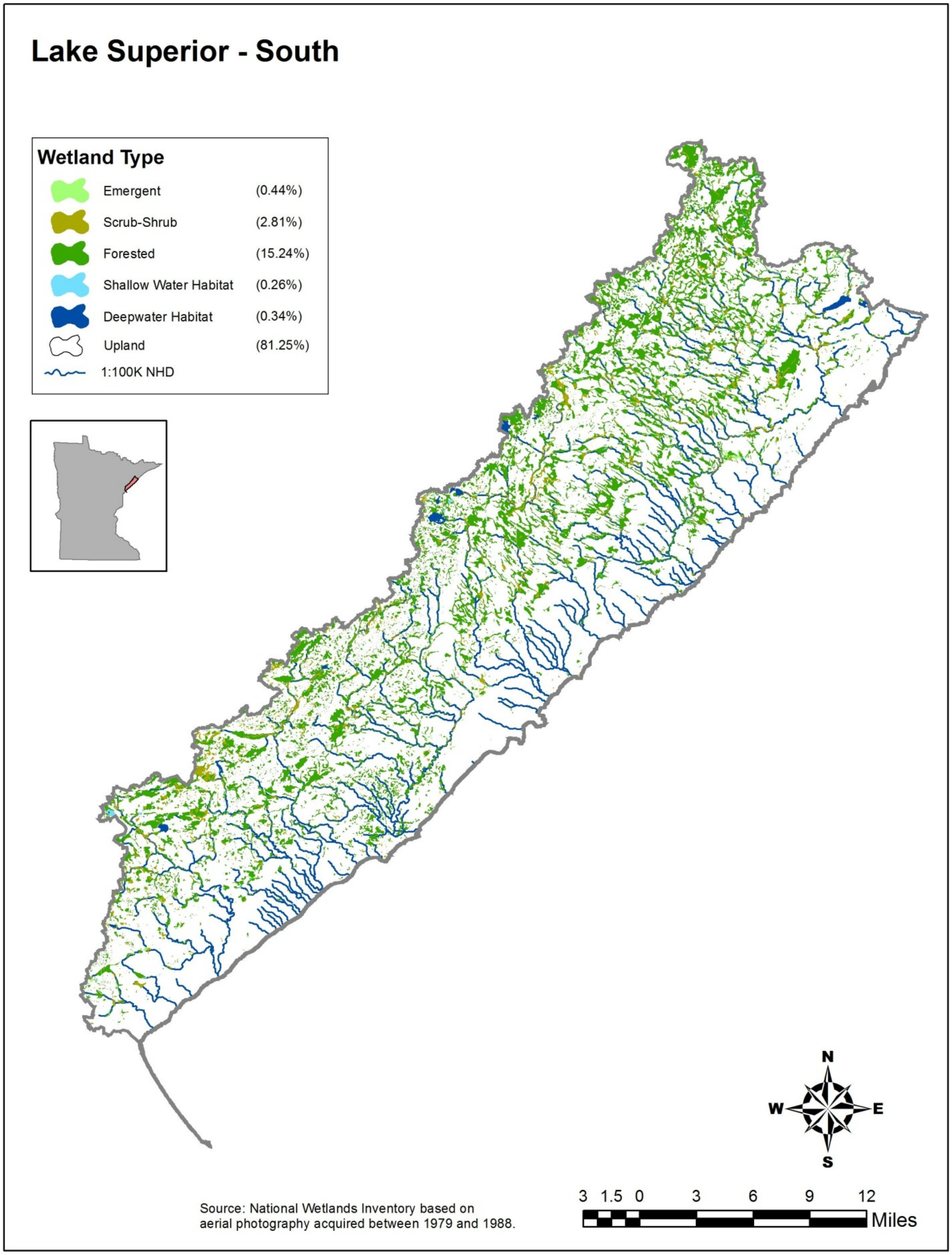

Figure 12. Wetlands with in the Lake Superior - South Watershed (National Wetland Inventory).

IV. Watershed-Wide Data Collection Methodology

Watershed Pollution Load Monitoring Network

Funded with appropriations from Minnesota's Clean Water Legacy Fund, the WPLMN is a long-term program designed to measure 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, and the outlets of the major tributaries (8 digit HUC scale) draining to these rivers. Since the program's inception in 2007, the WPLMN has adopted a multi-agency monitoring design that combines station specific stream flow data from USGS and MDNR flow gaging stations with water quality data collected by the MCES, local monitoring organizations, and Minnesota Pollution Control Agency WPLMN staff to compute annual pollutant loads at 79 river monitoring stations across Minnesota. Data will also be used to assist with: Total Maximum Daily Load studies and implementation plans; watershed modeling efforts; and watershed research projects. The network is currently expanding to a subwatershed level, which will effectively triple its size.

Intensive water quality sampling occurs throughout the year at all WPLMN stations. Between 29 and 32 mid-stream grab samples were collected per year at the Sucker River on County Road 290 near Palmers with sampling focused during periods of moderate to high flow (Figure 13). Because correlations between concentration and flow exist for many of the monitored analytes, and because these relationships can shift between storms or with season, 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 to sampling generally results in samples being well distributed over the entire range of flows.

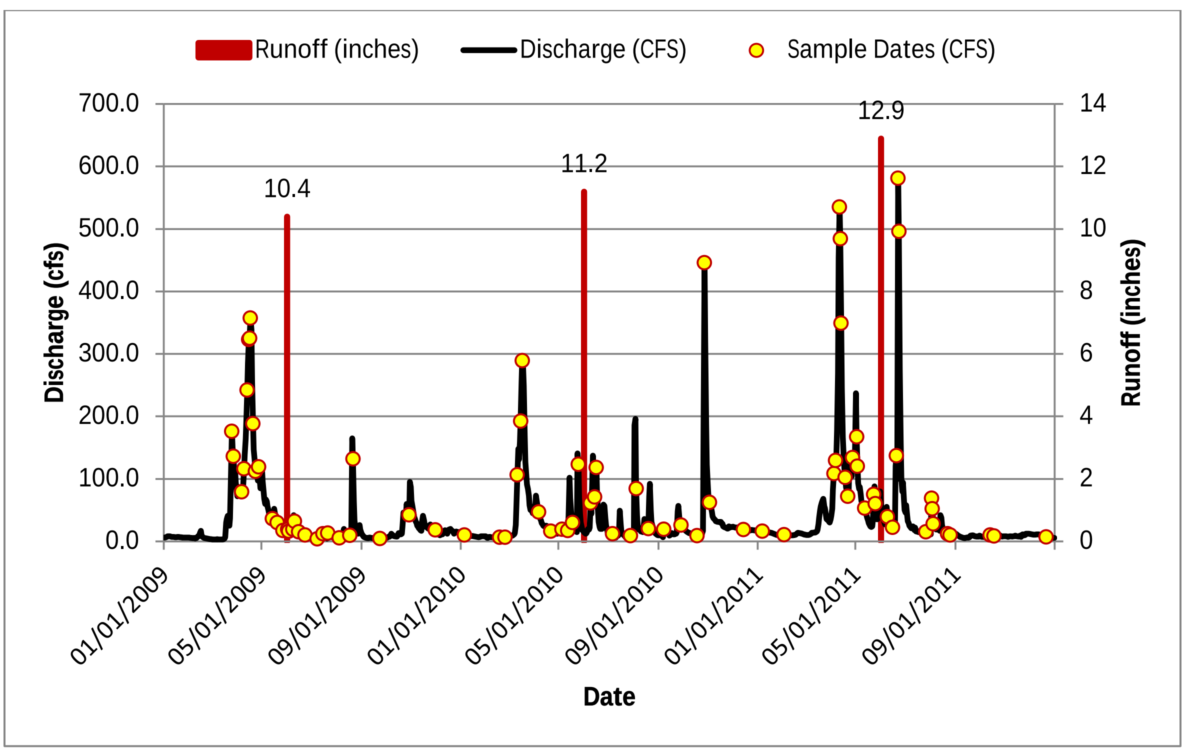

Figure 13. 2009-2011 Hydrograph, sampling regime and annual runoff for the Sucker River near Palmer, Minnesota

Annual water quality and daily average discharge data are coupled in the "Flux32," pollutant load model, originally developed by Dr. Bill Walker and recently upgraded by the U.S. Army Corp of Engineers and the MPCA. Flux32 allows the user to create seasonal or discharge constrained concentration/flow regression equations to estimate pollutant concentrations and loads on days when samples were not collected. Primary output 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), TP, dissolved orthophosphate (DOP) and nitrate plus nitrite nitrogen (nitrate-N).

Stream Water Chemistry Sampling

Six water chemistry stations were sampled from May thru September in 2010, and again June thru August of 2011, to provide sufficient water chemistry data to assess all components of the Aquatic Life and Recreation use standards. Following the Intensive Watershed Monitoring (IWM) design, water chemistry stations were placed at the outlet of each HUC-10 subwatershed that was >40 square miles in area (purple circles and green circles/triangles in (Figure 3). A SWAG was awarded to the Saint Louis River Alliance to conduct the monitoring at the six outlet locations in the Lake Superior - South Watershed (See Appendix 2 for locations of stream water chemistry monitoring stations. See Appendix 1 for definitions of stream chemistry analytes monitored in this study). Chemistry data on several other small streams within the Lake Superior - South Watershed collected within the SWAG also were reviewed and used for assessment purposes.

Stream Biological Sampling

The biological monitoring component of the intensive watershed monitoring in the Lake Superior - South Watershed was completed during the summer of 2011. A total of 33 stations were newly established across the watershed and sampled. These stations were located near the outlets of minor HUC-14 watersheds. In addition, 20 existing biological monitoring stations within the watershed were revisited in 2011. These monitoring stations were initially established as part of an Environmental Monitoring and Assessment Program (EMAP) study in 1997, or for the development of biocriteria, or they were historical MDNR biological stations. Two of the biological monitoring stations (11LS029 and 94LS001) that are included in the above totals were sampled only for macroinvertebrates as a result of flow regime and barrier falls and are not shown in Figure 3. While data from the last ten years contributed to the watershed assessments, the majority of data utilized for the 2013 assessment was collected in 2011. Three EMAP stations from 2010 and two additional stations that were established in 2013 to supplement additional monitoring request by the Watershed Assessment Team (WAT), were used in the assessment but are not shown in Figure 3. A total of 39 AUIDs were sampled for biology in the Lake Superior - South Watershed. The assessment of aquatic life use support, using biology as an indicator, was conducted on 37 AUIDs.

To measure the health of aquatic life at each biological monitoring station, indices of biological integrity (IBI), specifically fish and macroinvertebrate 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 F-IBI and M-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 5. Index of Biotic Integrity 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 6 and Appendix 7.

Fish Contaminants

Mercury and polychlorinated biphenyls were analyzed in fish tissue samples collected from the Lester River in 2011 by both the MPCA biomonitoring and MDNR fisheries staff. Six lakes in the watershed have been tested for mercury in fish: Nicado (38-0230-00), Tettegouche (38-0231-00), Bear (38-0405-00), Lax (38-0406-00), Bean (38-0409-00) and Christianson (38-0750-00). In addition, Bean and Christianson were also tested for PCBs in fish. Lake data that was collected and analyzed for mercury and PCBs in fish were collected by MDNR fisheries staff, with the most recent data being between 1984 and 2012.

Captured fish were wrapped in aluminum foil and frozen until they were thawed, scaled, filleted, and ground. The homogenized fillets were placed in 125 mL glass jars with Teflon™ lids and frozen until thawed for mercury or PCBs analyses. The Minnesota Department of Agriculture (MDA) Laboratory performed all mercury and PCBs analyses of fish tissue.

The Impaired Waters List is submitted every even year to the USEPA 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 0.20 mg/kg (200 ppb) for PFOS.

Prior to 2006, mercury concentrations in fish tissue were assessed for water quality impairment based on the 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 90th 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 ten years of data are used for statistical analysis. MPCA's Impaired Waters Inventory includes waterways that were assessed as impaired prior to 2006 as well as more recent impairments.

Poly Chlorinated Biphenyls in fish have not been monitored as intensively as mercury in the last three decades due to monitoring completed in the 1970s and 1980s. These earlier studies identified that 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

MPCA sampled Stewart Lake in 2011 and 2012, as part of the Clean Water Legacy Surface Water Monitoring project for the purpose of enhancing the dataset for lake assessment of aquatic recreation. The MPCA awarded a SWAG grant to the University of Minnesota's Natural Resource Research Institute to conduct lake monitoring on four other lakes within the watershed. Eagle Lake was monitored by the

South Saint Louis County SWCD as part of a separate SWAG. There are currently three volunteers enrolled in the MPCA's CLMP that are conducting lake monitoring within the watershed. Sampling methods are similar among monitoring groups and are described in the document entitled "MPCA Standard Operating Procedure for Lake Water Quality" found at http://www.pca.state.mn.us/publications/wq-s1-16.pdf. Lake water quality assessment methodology requires eight observations/samples within a ten 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 one million gallons/year (See Figure 27 for locations of permitted groundwater and surface water withdrawals). 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.

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 USGS maintains real-time stream flow gaging stations across the United States. Measurements can be viewed at http://waterdata.usgs.gov/nwis/rt.

Wetland Monitoring

The MPCA is actively developing methods and building capacity to conduct wetland quality monitoring and assessment. Currently, the MPCA does not monitor wetlands systematically by watershed. Our primary approach is to track changes in biological communities using statewide and ecoregional random surveys — where results from a small sample can be extrapolated to a larger population. The MPCA has developed macroinvertebrate and vegetation IBIs for depressional wetlands that have emergent marsh vegetation and open water, and has completed an initial baseline estimate of depressional wetland quality for Minnesota (MPCA 2012).

The large majority of wetlands in the Lake Superior - South Watershed are forested swamps (Figure 12), lacking the emergent marsh vegetation and open water needed to broadly apply the depressional IBIs. Only three MPCA depressional wetland monitoring stations have been established in the watershed; all are small beaver ponds associated with larger wetland complexes (Figure 14). The MPCA has conducted the field sampling and is in the process of compiling results for an expanded statewide random wetland quality survey that includes all wetland types. These results should be more applicable for documenting wetland condition in the Lake Superior - South Watershed when they become available. For more information please see the MPCA wetland monitoring and assessment webpage: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/wetlands/wetland-monitoring-and-assessment.html.

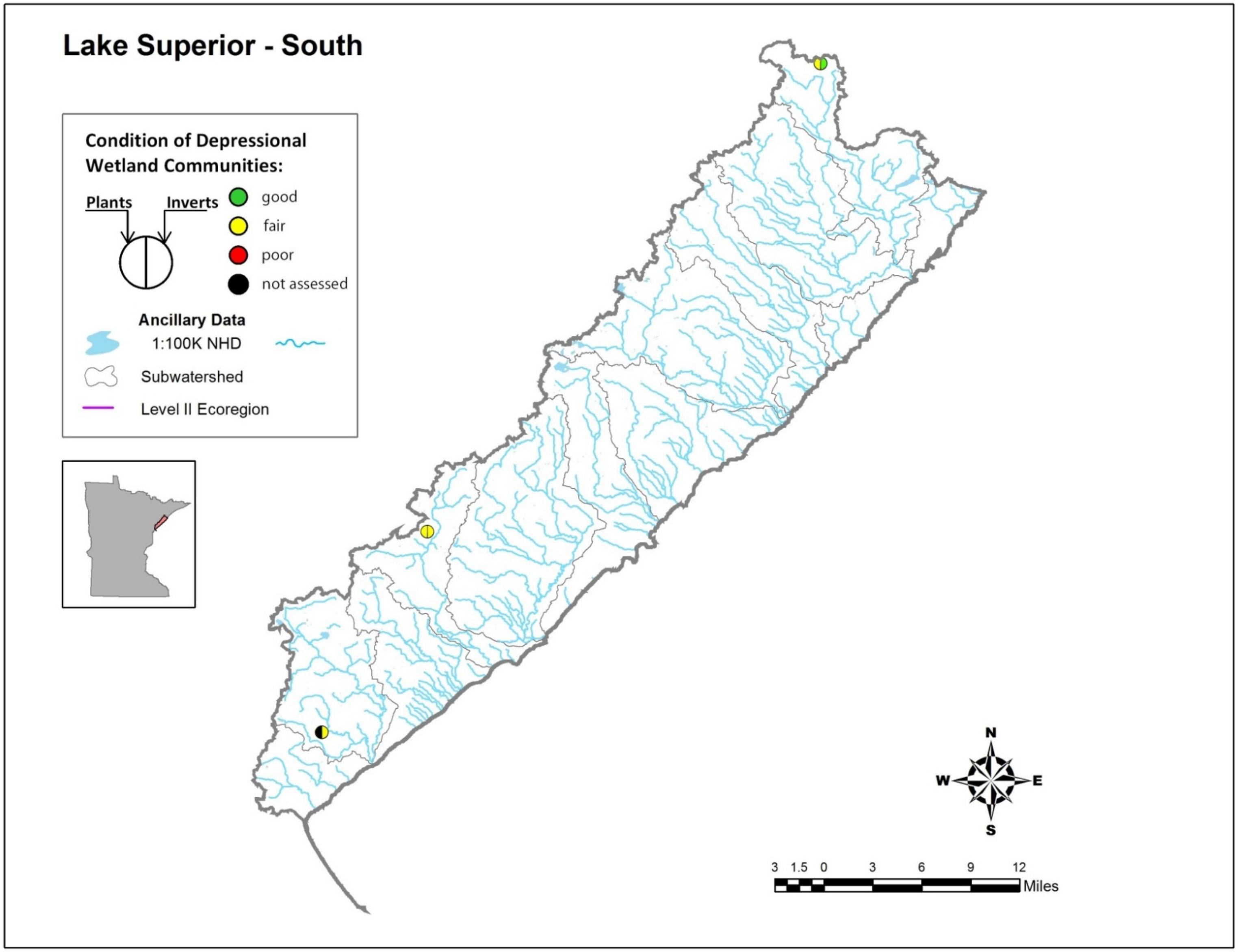

Figure 14. Condition of Depressional Wetland Communities in the Lake Superior - South Watershed.

V. Individual Watershed Results

HUC-10 Subwatersheds

Assessment results for aquatic life and recreation use are presented for each HUC-10 subwatershed within the Lake Superior - South Watershed. The primary objective is to portray all the assessment results (i.e. waters that support and do not support their designated uses) within a 10-HUC subwatershed resulting from the complex and multi-step assessment and listing process. A summary table of assessment results for the entire 8-HUC watershed including 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 HUC-10 subwatersheds contain the assessment results from the 2013 assessment cycle as well as any impairment listings from previous assessment cycles. Discussion of assessment results focuses primarily on the 2011 intensive watershed monitoring effort, but also considers available data from the last ten years.

The proceeding pages provide an account of each HUC-10 watershed. Each account includes a brief description of the subwatershed, and summary tables of the results for each of the following: a) stream aquatic life and aquatic recreation assessments, b) biological condition of channelized streams and ditches, c) stream habitat quality d) channel stability, and where applicable e) water chemistry for the HUC-10 outlet and f) 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 2013 assessment process (2014 USEPA 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 were 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 macroinvertebrate IBIs), dissolved oxygen, turbidity, chloride, pH and un-ionized ammonia (NH_3) 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) are not included in these tables. 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 HUC-10 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 HUC-10 section. These tables convey the results of the MSHA survey, which evaluates the habitat at 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 HUC-10 watershed.

Stream Stability Results

Stream channel stability information evaluated during each macroinvertebrate sampling visit is provided in each HUC-10 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 due 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 HUC-10 watershed.

Watershed Outlet Water Chemistry Results

These summary tables display the water chemistry results for the monitoring station representing the outlet of the HUC-10 watershed. This data along with other data collected within the ten 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 Lake Superior - South 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 HUC-10 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 4. Lake models and corresponding morphometric inputs can be found in Appendix 9.

Minnesota Lake Superior Beach Monitoring Program

Throughout Minnesota's Lake Superior Shore, the MDH routinely samples 39 public beaches to inform the public about risk of contracting water borne illness from exposure to contaminated waters. The MPCA uses these data to assess for recreational use, using similar assessment methodology to those applied for in-land streams. A total of 22 Lake Superior beach monitoring program stations are located in the Lake Superior - South Watershed and are mentioned in this report as they relate to stream and watershed health. More information can be found on the Minnesota Lake Superior Beach Monitoring Program website, http://www.mnbeaches.org/.

Beaver River – Frontal Lake Superior Subwatershed HUC0401010201

The Beaver River – Frontal Lake Superior Subwatershed drains 150 square miles of Lake County and is the third largest subwatershed. Many perennial streams can be found throughout this subwatershed; the main contributor to Lake Superior is the Beaver River (123 mi^2). The Beaver River consists of three branches: the Beaver River proper, the West Branch and the East Branch. Originating from a naturally impounded wetland, the Beaver River proper flows over 23.5 miles in a predominantly southeastern course to the city of Beaver Bay. Major tributaries Big Thirtynine Creek, Little Thirtynine Creek and Kit Creek join the river before it passes under CSAH 3. Both Big Thirtynine and Little Thirtynine Creek have been diverted to create a taconite ore tailing basin which is known as Mile Post 7. After passing under CSAH 3 the Beaver River is joined by the West Branch of the Beaver River (9 mi^2 drainage area). Several miles downstream the East Branch Beaver River (50 mi^2) joins the main branch. Numerous unnamed tributaries also join the Beaver River along its descent to Lake Superior. In addition to the Beaver River drainage, many smaller tributaries that directly contribute to Lake Superior can be found throughout the subwatershed. Most tributary streams and the Beaver River proper are designated coldwater streams.

There are a total of five lakes greater than ten acres within the Beaver River – Frontal Lake Superior Subwatershed.; Bean, Bear, Lax, Tettegouche and Nicado Lakes.

Land use within the subwatershed is predominantly forest (66.50%) followed by wetland (25.36%) and developed land (2.93%). Remaining land usage within the subwatershed includes: open water (2.3%), rangeland (1.79%), barren/mining (1.03%) and row-crop agriculture (0.09%). Much of the headwaters include large tracks of public forest land under the management of the Superior National Forest, MDNR (Finland State Forest, Tettegouche State Park), and Lake County.

The outlet of the Beaver River is in the city of Beaver Bay, downstream of Minnesota State Highway 61. The outlet is represented by the MPCA's STORET/EQuIS station S006-234 and biological station 11LS022.

Table 1. Aquatic life and recreation assessments on stream reaches: Beaver River – Frontal Lake Superior 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	Turbidity	Chloride	pH	NH3	Pesticides	Bacteria	Aquatic Life	Aquatic Rec.
04010102-529 **Palisade Creek** *Unnamed Cr to Lk Superior*	0.89	2A	98LS027	Upstream of Hwy 61, 1 mi. NE of Silver Bay	MTS	MTS	- -	- -	- -	- -	- -	- -	- -	FS	NA
04010102-530 **Beaver River, East Branch** *Unnamed Cr to Unnamed Cr*	5.22	2A	91LS029	Upstream of Heffelfinger Rd, 10 mi. NW of Silver Bay	MTS	MTS	- -	- -	- -	- -	- -	- -	- -	FS	NA
04010102-572 **Cedar Creek** *Unnamed Lk (38-0407-00) outlet to Unnamed Cr*	2.17	2A	11LS023	Upstream of Cedar Creek Rd, 2 mi. NW of Silver Bay	MTS	MTS	- -	- -	- -	- -	- -	- -	- -	FS	NA
04010102-535 **Beaver River, East Branch** *Cedar Cr to Unnamed Cr*	1.83	2A	11LS026	Upstream of CSAH 5, 1 mi. W of Silver Bay	MTS	MTS	- -	- -	- -	- -	- -	- -	- -	FS	NA
04010102-B44 **Little Thirtynine Creek** *Unnamed Cr to Unnamed Cr*	1.56	2A	11LS035	Upstream of CSAH 15, 6 mi. NW of Silver Bay	MTS	MTS	- -	- -	- -	- -	- -	- -	- -	FS	NA
04010102-B28 **Big Thirtynine Creek** *Unnamed Cr to Unnamed Cr*	1.44	2A	11LS034	Upstream of CSAH 15 (FH 11), 7 mi. NW of Silver Bay	MTS	MTS	- -	- -	- -	- -	- -	- -	- -	FS	NA
04010102-577 **Beaver River, West Branch** *Unnamed Cr to Unnamed Cr*	1.62	2A	11LS028	Downstream of Beaver Valley Rd, 3.5 mi. W of Beaver Bay	EXP	EXP	- -	- -	- -	- -	- -	- -	- -	NS	NA
04010102-501 **Beaver River** *Headwaters to Lk Superior*	23.4	2A	11LS027 94LS007 91LS026 94LS001 11LS022	Downstream of CSAH 15, 10 mi. NW of Silver Bay Upstream of N Shore SnMo Tr, 7 mi. W of Silver Bay Downstream of CSAH 3, 3mi. W of Beaver Bay Downstream of CSAH 4, 1 mi. NW of Beaver Bay Downstream of CSAH 4, 1 mi. NW of Beaver Bay	EXP	MTS	MTS	EXP	MTS	EXP	MTS	- -	MTS	NS	FS

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.

*Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.

Table 2. Minnesota Stream Habitat Assessment (MSHA): Beaver River – Frontal Lake Superior 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	98LS027	Palisade Creek	4.25	8.5	24	14	26	76.75	Good
1	91LS029	Beaver River, East Branch	5	15	21.6	16	27	84.6	Good
1	11LS023	Cedar Creek	5	15	23.4	15	27	85.4	Good
1	11LS026	Beaver River, East Branch	5	11.5	22	14	30	82.5	Good
1	11LS035	Little Thirtynine Creek	5	14	20	15	30	84	Good
1	11LS034	Big Thirtynine Creek	5	15	21.5	15	27	83.5	Good
1	11LS028	Beaver River, West Branch	5	10	18	12	22	67	Good
1	11LS027	Beaver River	5	14	15.1	15	23	72.1	Good
1	94LS007	Beaver River	5	14	24	15	26	84	Good
1	91LS026	Beaver River	4.25	10.5	21.6	10	25	71.35	Good
1	11LS022	Beaver River	2.25	8.5	22	14	28	74.75	Good
Average Habitat Results: *Beaver River – Frontal Lake Superior Subwatershed*			**4.61**	**12.36**	**21.2**	**14.09**	**26.46**	**78.72**	**Good**

Qualitative habitat ratings

- = Good: MSHA score above the median of the least-disturbed stations (MSHA > 66)
- = Fair: MSHA score between the median of the least-disturbed stations and the median of the most-disturbed stations (45 < MSHA < 66)
- = Poor: MSHA score below the median of the most-disturbed stations (MSHA < 45)

Table 3. Channel Condition and Stability Assessment (CCSI): Beaver River – Frontal Lake Superior Subwatershed.

# Visits	Biological Station ID	Stream Name	Stream Type	Upper Banks (43-4)	Lower Banks (46-5)	Substrate (37-3)	Channel Evolution (11-1)	CCSI Score (137-13)	CCSI Rating
1	98LS027	Palisade Creek	HBC	11	10	4	1	26	Stable
1	91LS029	Beaver River, East Branch	HBC	17	19	9	3	48	Moderately Unstable
1	11LS023	Cedar Creek	HBC	10	5	5	5	25	Stable
1	11LS026	Beaver River, East Branch	MHL	12	5	4	1	22	Stable
1	11LS035	Little Thirtynine Creek	HBC	10	5	4	5	24	Stable
1	11LS034	Big Thirtynine Creek	HBC	8	5	4	5	22	Stable
1	11LS028	Beaver River, West Branch	MHL	28	21	6	2	57	Moderately Unstable
1	11LS027	Beaver River	HBC/MHL	10	11	6	5	32	Fairly Stable
1	94LS007	Beaver River	HBC	10	5	4	5	24	Stable
1	91LS026	Beaver River	MHL	13	12	8	1	34	Fairly Stable
1	94LS001	Beaver River	MHL	8	5	4	5	22	Stable
Average Stream Stability Results: *Beaver River – Frontal Lake Superior Subwatershed*				**12.46**	**9.36**	**5.27**	**3.46**	**30.55**	**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: Beaver River - Frontal Lake Superior Subwatershed.

Station location:	Beaver River							
STORET/EQuIS ID:	S006-234							
Station #:	04010102-501							
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**NLF Ecoregion Expectation [2]**	**# of WQ Exceedances[1]**
Ammonia-nitrogen	mg/L	10	<0.02	<0.02	<0.02	0.016		0
Chloride	mg/L	10	1.5	60	21.6	230		0
Dissolved Oxygen (DO)	mg/L	1			9.4	7		0
pH		19	7.6	8.53	8.1	6.5 – 8.5	7.9	3
Secchi tube/Transparency Tube	100 cm	19	40	>100	63	>20		0
Transparency tube	60 cm	0				>20		
Turbidity	FNU	0				10	4	
Escherichia coli (geometric mean)	MPN/100ml	15	5.7	36	21	126		0
Escherichia coli	MPN/100ml	15	11	580	94	1260		0
Chlorophyll-a, Corrected	ug/L	0						
Inorganic nitrogen (nitrate and nitrite)	mg/L	10	<0.05	4.0	0.6	0.1		
Kjeldahl nitrogen	mg/L	10	0.3	0.7	0.5		0.18 – 0.73	
Orthophosphate	ug/L	0						
Pheophytin-a	ug/L	0						
Phosphorus	ug/L	10	16	33	23		50	
Specific Conductance	uS/cm	9	78	442	246		270	
Temperature, water	deg °C	19	10.7	23.1	18.3			
Total suspended solids	mg/L	10	3	9	4.7		5.6	
Total volatile solids	mg/L	10	<1	3	1.7			
Sulfate	mg/L	0						
Hardness	mg/L	0						

[1]Secchi Tube/Transparency tube standards are surrogate standards derived from the turbidity standard of 25. E. Coli standard for individual samples in 1260 MPN / 100ml; or monthly geometric mean of 126 MPN / 100 mL.

[2]Based on 1970-1992 summer data; see *Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions* (McCollor and Heiskary 1993). TKN range based on EPA Rivers and Streams in Nutrient Ecoregion VIII, NLF and NMW, EPA 822 B-01-015. 2001

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Beaver River-Frontal Lake Superior 10 HUC, a component of the IWM work conducted between May and September in 2010 and 2011. This specific data does not necessarily reflect all data that was used to assess the AUID.**

Table 5. Lake water aquatic recreation assessments: Beaver River – Frontal Lake Superior Subwatershed.

Name	DNR Lake ID	Area (acres)	Trophic Status	Percent Littoral	Max. Depth (m)	Avg. Depth (m)	CLMP Trend	Mean TP (µg/L)	Mean Chl-a (µg/L)	Secchi Mean (m)	Support Status
Lax	38-0406-00	273	M	65.2	10.6	3.1	NT	17.0	7.5	3.2	FS

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
1 – Depth is estimated

Summary

The Beaver River – Frontal Lake Superior Subwatershed had eight assessable stream segments, containing twelve biological monitoring stations, and one lake assessed for aquatic recreation (Table 1 and Table 5). Nearly all of the streams and lakes fully support aquatic life and aquatic recreation. MHSA scores throughout this subwatershed were good (>66), with many tributaries exhibiting excellent habitat conditions (Table 2). Channel Condition and Stability Index ratings indicated that the vast majority of stations were either "fairly stable" or "stable" (Table 3), with many streams exhibiting exceptional biological, chemical, and physical characteristics. Streams with these attributes are worthy of additional protection in order to preserve their valuable aquatic resources. Big Thirtynine (04010102-B28), Palisade (04010102-529), Cedar (04010102-572) and Little Thirtynine Creeks (04010102-B44) are just a few of the high quality resources found in this subwatershed. Only two streams within this subwatershed are not meeting aquatic life standards, including the West Branch Beaver River (04010102-577) and the Beaver River proper (04010102-501).

Just one biological monitoring station (11LS028) was located on the West Branch Beaver River with most conventional water chemistry parameters suggesting that water quality standards were being met. However, both F-IBI and M-IBI indicated a potential aquatic life impairment. This station featured the lowest MSHA score (67) within this subwatershed, with substrate, fish cover, and channel morphology being major contributors to the lowered score. Combining this information with the CCSI rating of "moderately unstable", it is likely that substrate composition is limiting the biological community within this reach. In addition, the overall thermal regime of the West Branch Beaver River may be contributing to the loss of sensitive coldwater obligate species, with brook trout stressful and lethal temperature limits reached frequently. An aerial photo review suggests that canopy development is poor along the river and is likely contributing to the increase in temperatures. A combination of land use and natural processes within this minor watershed are contributing to the loss of habitat for sensitive fish and macroinvertebrates.

In general, F-IBI and M-IBI scores on the Beaver River proper decrease as it neared Lake Superior. F-IBI score did improve near the confluence of Big Thirtynine Creek diversion Channel (94LS007) and is likely attributed to the improvement in habitat and water quality that is found within that vicinity. Although the fish community of the most downstream station (11LS002) resembled that of 91LS026, a slight increase in F-IBI was observed. The capture of one stocked rainbow trout positively influenced the F-IBI, and should not be considered an indication of increased water quality. M-IBI scores for three of the four stations were above the threshold of impairment. The most downstream station (94LS001) scored below the threshold but within the lower confidence interval. A decrease in taxa richness was observed at this station. Although not considered impaired for M-IBI, the downstream trend of M-IBI scores may provide further insight on the degradation of the Beaver River. The declining F-IBI and M-IBI that is found in the lower reaches of the Beaver River is likely a result of the accumulation of multiple anthropogenic stressors.

The water chemistry monitoring station for this subwatershed is located on the Beaver River (S006-234) at Minnesota State Highway 61 in the Community of Beaver Bay (Table 4). For most parameters, the data indicated excellent water quality with minimal to no water quality exceedances. Two existing aquatic life impairment (pH: 2002 and Turbidity: 1996) persist on the Beaver River proper. Data collected from 2010-2011 supported the existing aquatic life impairment based on the pH standard. Although exceedance values were only slightly higher than state standards, individual readings from each fish visit indicated an increase in alkalinity as stations neared the outlet, which is a-typical of most streams. This rise in alkalinity towards the outlet suggests human accelerated chemical weathering from land use (Kaushal et al, 2013). The turbidity impairment was supported by data collected within the ten year "assessment window", with 27 of 67 samples exceeding the ten NTU turbidity standard (40%

exceedance rate). Most exceedances occurred during high flow events and are similar to other Lake Superior tributaries with a turbidity impairment. Mercury in the water column was listed in 1998 and may be mitigated by addressing other chemical parameters. Dissolved oxygen levels were meeting standards, as expected given the high gradient and cool water temperatures at the monitoring station. One Lake Superior beach station was located in the vicinity of the Beaver River outlet at the Silver Bay Marina. Bacteria levels were low at this location and the beach was assessed as fully supporting recreational use.

Overall, the degradation of the Beaver River likely not only affects stream trout populations but may contribute to the loss of suitable habitat for steelhead and other anadromous fish in the lower reaches of the river. Current and historical land use changes are contributing to impairments found within this subwatershed.

One lake in this subwatershed, Lax, had sufficient data for review against the aquatic recreation use standard (Table 5). The lake has a 3,618 acre watershed, mostly drained by Nicado Creek; which enters the northeast portion of the lake. Nutrient and algal (i.e. chlorophyll-a) concentrations were low and reflective of the lake's forested watershed. Lax is more developed, deeper, and has a larger watershed area when compared to other assessed lakes in the Lake Superior - South watershed. Phosphorus, chlorophyll-a, and Secchi transparency data were consistent among years and variability was low within the lake. Rarely, did individual monthly samples have chlorophyll-a levels indicative of mild algae bloom conditions (> 10 µg/L). Three lakes (Tettegouche, Lax, and Nicado) within this watershed are considered impaired for aquatic consumption due to high levels of mercury in fish tissue. These aquatic consumption impairments are likely linked to atmospheric deposition of mercury from the global burning of fossil fuels.

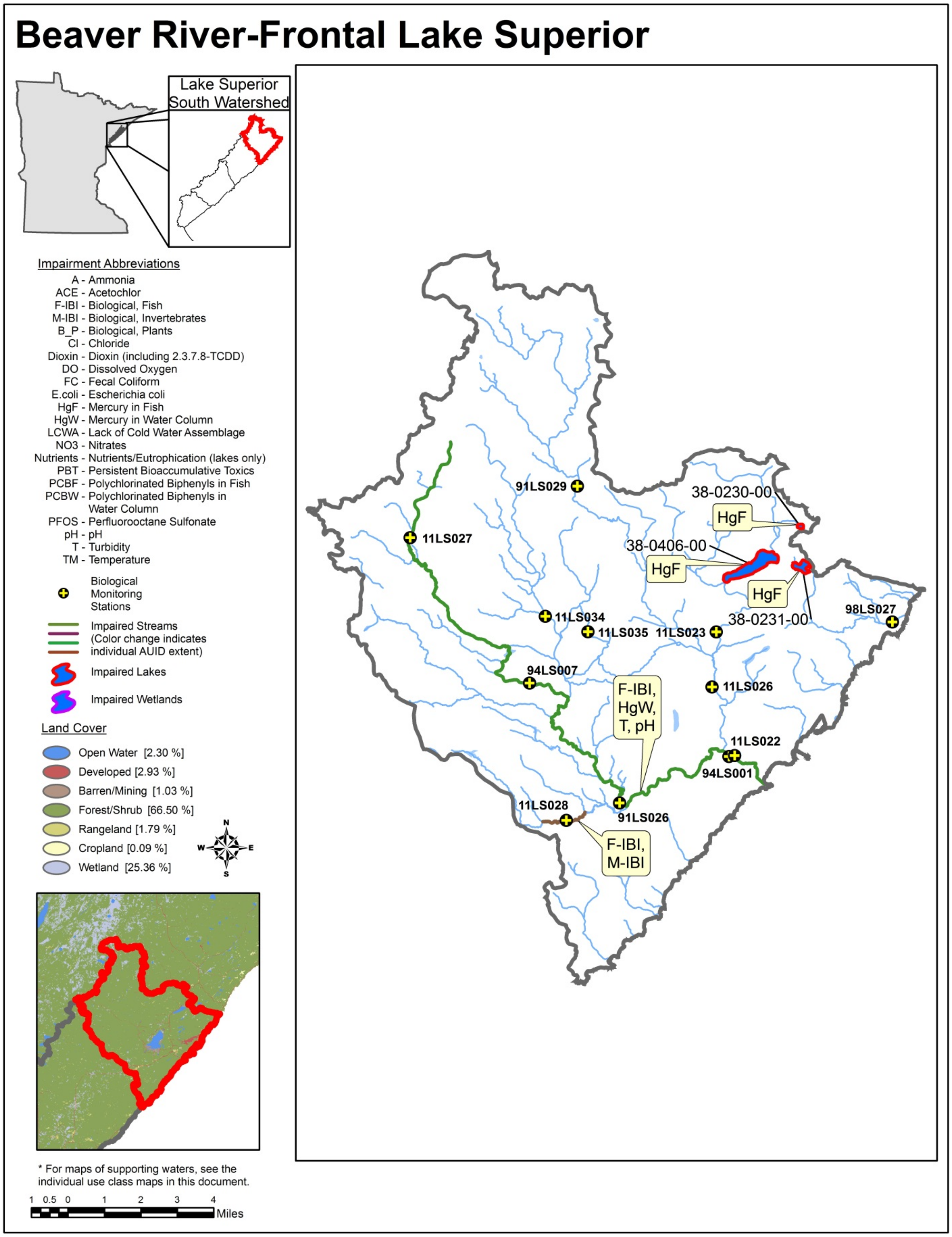

Figure 15. Currently listed impaired waters by parameter and land use characteristics in the Beaver River - Frontal Lake Superior Subwatershed.

Gooseberry River – Frontal Lake Superior Subwatershed HUC 0401010202

The Gooseberry River – Frontal Lake Superior Subwatershed drains 178.97 square miles of Lake County and is the largest subwatershed within the Lake Superior - South Watershed. Many perennial streams are present throughout this subwatershed, with the two largest drainage areas being the Gooseberry River (74.8 mi^2) and the Split Rock River (43.72 mi^2). Other smaller perennial streams that exist within this subwatershed include: Silver Creek, Crow Creek, Encampment River, Castle Danger Creek, Twins Port Creek, Dago Creek, Skunk Creek, Little Gooseberry River and many unnamed waterways. The Gooseberry River starts just south of Kane Lake and travels an estimated 23 miles to the southeast where it pours into Lake Superior, approximately 15 miles northeast of Two Harbors in Gooseberry Falls State Park. The Split Rock River consists of two branches, the East and West Branch Split Rock River, which converge 2.21 miles upstream of the Split Rock Lighthouse State Park. Most tributary streams to Lake Superior, including the Gooseberry and Split Rock Rivers, are designated trout streams.

There are a total of five lakes greater than ten acres within this subwatershed, with the most prominent lakes being Christianson and Highland.

This watershed is dominated by forest (71.18%), wetland (24.48%), and developed land (2.10%). Only 1.53% is rangeland, 0.59% is open water, 0.11% is row-crop agriculture, and 0.01 is barren/mining. The headwaters of this subwatershed consist of fairly remote public land that is managed by MDNR, Lake County and other entities.

There are two outlet water collection locations for this subwatershed; water sampled from the Gooseberry River were collected downstream of Minnesota State Highway 61, in Gooseberry State Park and water from the Split Rock River was collected upstream of Minnesota State Highway 61, five miles northeast of Castle Danger. The outlet station located on the Gooseberry River is represented by MPCA's STORET/EQuIS station S000-256 and biological station 11LS040. The other outlet location, the Split Rock River, is represented by MPCA's STORET/EQuIS station S006-235.

Table 6. Aquatic life and recreation assessments on stream reaches: Gooseberry River - Frontal Lake Superior 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	Turbidity	Chloride	pH	NH3	Pesticides	Bacteria	Aquatic Life	Aquatic Rec.
04010102-A44 **East Split Rock River** *Unnamed Cr to Unnamed Cr*	4.36	2A	11LS009	Upstream of N Alger Grade Rd, 10 mi. W of Beaver Bay	MTS	MTS	MTS	MTS	MTS	MTS	MTS	- -	MTS	FS	FS
04010102-520 **West Split Rock River** *Headwaters to Split Rock R*	12.02	2A	84LS022	Upstream of CSAH 3, 2 mi. E of Beaver Crossing	MTS	MTS	- -	- -	- -	- -	- -	- -	- -	FS	NA

AUID ***Reach Name,*** *Reach Description*	Reach Length (miles)	Use Class	Biological Station ID	Location of Biological Station	Aquatic Life Indicators:								Bacteria	Aquatic Life	Aquatic Rec.
					Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH3	Pesticides			
04010102-A41 **Unnamed Creek (Split Rock R Trib)** *T55 R9W S34, West Line to Split Rock R*	4.09	2A	11LS029	0.7 mi. NW of Hwy 61, In Split Rock Lighthouse State Park	- -	MTS	- -	- -	- -	- -	- -	- -	- -	FS	NA
04010102-519 **Split Rock River** *W Br Split Rock R to Lk Superior*	3.77	2A	- -	- -	- -	- -	MTS	IF	MTS	MTS	MTS	- -	MTS	IF	FS
04010102-740 **Little Gooseberry River** *Unnamed Cr to Gooseberry R*	2.06	2A	11LS004	Upstream of CSAH 2, 1.5 mi. N of Two Harbors	MTS	MTS	- -	- -	- -	- -	- -	- -	- -	FS	NA
04010102-668 **Dago Creek** *Headwaters to Unnamed Cr*	4.72	2A	11LS033	Upstream of Logging Rd, 4.5 mi. NW of Castle Danger	MTS	MTS	- -	- -	- -	- -	- -	- -	- -	FS	NA
04010102-551 **Skunk Creek** *T55 R10W S14, West Line to T54 R9W S16, South Line*	11.1	2A	10EM076 11LS031	Downstream of Unn Rd, 15 mi. NW of Two Harbors Downstream of Tr, N of Gooseberry Falls State Park	MTS	MTS	- -	- -	- -	- -	- -	- -	- -	FS	NA
04010102-502 **Gooseberry River** *Headwaters to Lk Superior*	22.97	2A	11LS030 97LS103 11LS040	Upstream of Big Noise Rd, 3 mi. E of Highland Upstream of CSAH 3, 10 mi. NE of Two Harbors Upstream of Hwy 61, In Gooseberry Falls State Park	MTS	MTS	MTS	MTS	MTS	MTS	MTS		MTS	FS	FS
04010102-515 **Crow Creek** *Headwaters to Lk Superior*	6.74	2A	98LS026	Downstream of CSAH 16, 7.5 mi. NE of Two Harbors	MTS	MTS	- -	- -	- -	- -	- -	- -	- -	FS	NA
04010102-554 **Encampment River** *T54 R10W S17, West Line to Lk Superior*	8.58	2A	13LS076 13LS075 11LS002	Upstream of Clark Rd, 8.5 mi. NW of Two Harbors Upstream of Town Rd, 7.5 mi. NW of Two Harbors End of Solitude Tr, 6.5 mi. NE of Two Harbors	IF	MTS	MTS	MTS	MTS	MTS	MTS	- -	MTS	IF[1]	FS
04010102-513 **Silver Creek** *Headwaters to Lk Superior*	12.9	2A	02LS004 11LS005	Upstream of CSAH 2, 6 mi. N of Two Harbors Downstream of CSAH 3, 4 mi. NE of Two Harbors	MTS	MTS	- -	MTS	- -	- -	- -	- -	- -	FS	NA

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.

*Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.

[1] Additional monitoring was requested by the WAT and took place in 2013. Data collected was still pending at the time of the 2014 draft impaired waters list and will be assessed before any future listings.

Table 7. Minnesota Stream Habitat Assessment (MSHA): Gooseberry River - Frontal Lake Superior 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	11LS009	East Split Rock River	5	15	21.5	14	23	78.5	Good
1	84LS022	West Split Rock River	5	14	20	17	34	90	Good
1	11LS029	Unnamed Creek (Split Rock River Trib.)	5	11.5	22	11	20	69.5	Good
1	11LS004	Little Gooseberry River	3.75	13.5	18.4	16	17	68.65	Good
1	11LS033	Dago Creek	5	15	22	7	18	67	Good
1	10EM076	Skunk Creek	5	14	22	5	32	78	Good
1	11LS031	Skunk Creek	5	10.5	22	13	26	76.5	Good
1	11LS030	Gooseberry River	5	15	21.6	17	28	86.6	Good
1	97LS103	Gooseberry River	5	11	20	7	30	73	Good
1	11LS040	Gooseberry River	3.5	11	22	11	28	75.5	Good
1	98LS026	Crow Creek	5	10	20.2	14	23	72.2	Good
1	13LS076	Encampment River	5	13	22.75	7	21	68.75	Good
1	13LS075	Encampment River	4.5	11	20	7	17	59.5	Fair
2	11LS002	Encampment River	4.5	14	18.3	5	22	64.3	Fair
1	02LS004	Silver Creek	3.5	10.5	22	12	27	75	Good
1	11LS005	Silver Creek	5	11.5	20.4	15	28	79.9	Good
Average Habitat Results: *Gooseberry River – Frontal Lake Superior Subwatershed*			**4.68**	**12.54**	**20.95**	**11.13**	**24.63**	**73.93**	**Good**

Qualitative habitat ratings

- = Good: MSHA score above the median of the least-disturbed stations (MSHA > 66)
- = Fair: MSHA score between the median of the least-disturbed stations and the median of the most-disturbed stations (45 < MSHA < 66)
- = Poor: MSHA score below the median of the most-disturbed stations (MSHA < 45)

Table 8. Channel Condition and Stability Assessment (CCSI): Gooseberry River – Frontal Lake Superior Subwatershed.

# Visits	Biological Station ID	Stream Name	Stream Type	Upper Banks (43-4)	Lower Banks (46-5)	Substrate (37-3)	Channel Evolution (11-1)	CCSI Score (137-13)	CCSI Rating
1	11LS029	East Split Rock River	HBC	24	7	4	1	36	Fairly Stable
1	11LS009	Unnamed Creek (Split Rock River Tributary)	HBC	10	5	4	5	24	Stable
1	11LS004	Little Gooseberry River	LGL	10	12	8	4	34	Fairly Stable
1	11LS033	Dago Creek	MHL	8	10	8	3	29	Fairly Stable
1	11LS031	Skunk Creek	MHL	12	5	4	5	26	Stable
1	11LS030	Gooseberry River	MHL	11	12	9	1	33	Fairly Stable
1	97LS103	Gooseberry River	MHL	10	5	4	5	24	Stable
1	11LS040	Gooseberry River	HBC	24	5	4	5	38	Fairly Stable
1	98LS026	Crow Creek	MHL	17	22	8	3	50	Moderately Unstable
1	13LS076	Encampment River	HBC	12	10	4	1	27	Stable
1	13LS075	Encampment River	HBC	13	13	6	1	33	Fairly Stable
2	11LS002	Encampment River	HBC	17.5	8	6.5	1	33	Fairly Stable
1	02LS004	Silver Creek	MHL	12	9	4	1	26	Stable
Average Stream Stability Results: *Gooseberry River – Frontal Lake Superior Subwatershed*				**13.89**	**9.46**	**5.65**	**2.77**	**31.77**	**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: Gooseberry River – Frontal Lake Superior Subwatershed.

Station location:	Gooseberry River							
STORET/EQuIS ID:	S000-256							
Station #:	04010102-502							
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard1**	**NLF Ecoregion Expectation 2**	**# of WQ Exceedances1**
Ammonia-nitrogen	mg/L	10	<0.02	0.02	<0.02	0.016		0
Chloride	mg/L	10	0.7	1.5	1.2	230		0
Dissolved Oxygen (DO)	mg/L	0				7		
pH		19	7.7	8.4	8.1	6.5 – 8.5	7.9	0
Secchi tube/Transparency Tube	100 cm	19	32	>100	>100	>20		0
Transparency tube	60 cm	0				>20		
Turbidity	FNU	0				10	4	
Escherichia coli (geometric mean)	MPN/100ml	15	24	50	31	126		0
Escherichia coli	MPN/100ml	15	12	290	59	1260		0
Chlorophyll-a, Corrected	ug/L	0						
Inorganic nitrogen (nitrate and nitrite)	mg/L	5	<0.01	0.04	<0.01			
Kjeldahl nitrogen	mg/L	10	0.2	0.8	0.5		0.18 – 0.73	
Orthophosphate	ug/L	0						
Pheophytin-a	ug/L	0						
Phosphorus	ug/L	10	7	50	21		50	
Specific Conductance	uS/cm	9	75	177	140		270	
Temperature, water	deg °C	19	10.4	24.3	18.6			
Total suspended solids	mg/L	10	<2	7	3		5.6	
Total volatile solids	mg/L	10	<1	2.0	<1			
Sulfate	mg/L	0						
Hardness	mg/L	0						

[1]Secchi Tube/Transparency tube standards are surrogate standards derived from the turbidity standard of 25.

[2]Based on 1970-1992 summer data; see Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions (McCollor and Heiskary 1993). TKN range based on EPA Rivers and Streams in Nutrient Ecoregion VIII, NLF and NMW, EPA 822 B-01-015. 2001

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Gooseberry River – Frontal Lake Superior Subwatershed, a component of the IWM work conducted between May and September in 2010 and 2011. This specific data does not necessarily reflect all data that was used to assess the AUID.**

Table 10. Outlet water chemistry results: Gooseberry River – Frontal Lake Superior Subwatershed.

Station location:	Split Rock River							
STORET/EQuIS ID:	S006-235							
Station #:	04010102-519							
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard1**	**NLF Ecoregion Expectation 2**	**# of WQ Exceedances1**
Ammonia-nitrogen	mg/L	10	<0.02	0.03	<0.02	0.016		0
Chloride	mg/L	10	0.75	6.2	2.86	230		0
Dissolved Oxygen (DO)	mg/L	1			7.5	7		0
pH		19	7.44	7.88	7.67	6.5 – 8.5	7.9	0
Secchi tube/Transparency Tube	100 cm	19	46	>100	>100	>20		0
Transparency tube	60 cm	0				>20		
Turbidity	FNU	0				10	4	
Escherichia coli (geometric mean)	MPN/100ml	15	26	29	27	126		0
Escherichia coli	MPN/100ml	15	17	200	42	1260		0
Chlorophyll-a, Corrected	ug/L	0						
Inorganic nitrogen (nitrate and nitrite)	mg/L	10	<0.05	0.16	<0.05			
Kjeldahl nitrogen	mg/L	10	0.2	1.0	0.56		0.18 – 0.73	
Orthophosphate	ug/L	0						
Pheophytin-a	ug/L	0						
Phosphorus	ug/L	10	9	45	19		50	
Specific Conductance	uS/cm	9	78	221	167		270	
Temperature, water	deg °C	19	10.8	23.2	18.1			
Total suspended solids	mg/L	10	<1	4	2.5		5.6	
Total volatile solids	mg/L	10	<1	2	1.25			
Sulfate	mg/L	0						
Hardness	mg/L	0						

[1]Secchi Tube/Transparency tube standards are surrogate standards derived from the turbidity standard of 25.

[2]Based on 1970-1992 summer data; see *Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions* (McCollor and Heiskary 1993). TKN range based on EPA Rivers and Streams in Nutrient Ecoregion VIII, NLF and NMW, EPA 822 B-01-015. 2001

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Gooseberry River – Frontal Lake Superior Subwatershed, a component of the IWM work conducted between May and September in 2010 and 2011. This specific data does not necessarily reflect all data that was used to assess the AUID.**

Table 11. Lake water aquatic recreation assessments: Gooseberry River – Frontal Lake Superior Subwatershed.

Name	DNR Lake ID	Area (acres)	Trophic Status	Percent Littoral	Max. Depth (m)	Avg. Depth (m)	CLMP Trend	Mean TP (µg/L)	Mean Chl-a (µg/L)	Secchi Mean (m)	Support Status
Christianson	38-0750-00	158	E	100	2.4	1.2	NT	26.5	6.1	0.9	FS
Highland	38-0753-00	125	M	100	1.5	11	NT	21.6	4.4	1.4	FS

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

Summary

The Gooseberry River – Frontal Lake Superior Subwatershed had 11 assessable stream segments containing 16 biological monitoring stations, and 2 lakes assessed for aquatic recreation (Table 6 and Table 11). All streams and lakes met the applicable standards or criteria and fully support aquatic life and aquatic recreation. The low amount of disturbance within the subwatershed almost assures excellent biological integrity. Several stations had exceptional performing biological, chemical and physical parameters and are worthy of additional protection in order to preserve their valuable aquatic resources. The West Split Rock River (04010102-520), Gooseberry River (04010102-502), East Split Rock River (04010102-A44) and Silver Creek (04010102-513) are just a few of the high quality streams found in this subwatershed.

The majority of the stations within this subwatershed contained "good" habitat, as demonstrated by the MSHA scores (Table 7). Two stations (11LS002 & 13LS075) located on the Encampment River (04010102-554) had "fair" rated habitat scores. Some tributaries to Lake Superior, including the Encampment River, have bed rock substrate that can limit the amount of fish cover available and can negatively influence the overall MSHA scores. This natural attribute of select streams can also be reflected in poorer than expected F-IBI and M-IBI scores. Channel Condition and Stability Index also indicated that most stream channels within this subwatershed were "stable" to "fairly stable" and exhibited exceptional macroinvertebrate habitat (Table 8). Stream temperatures throughout this subwatershed varied but all were exceptionally cold and suitable for brook trout.

F-IBI scores were all above their respective threshold with the exception of Crow Creek (98LS026). This station was below the impairment threshold but within the lower confidence level. The fish assemblage consisted of many pioneer species and was likely limited by in-stream habitat and barrier falls that prevented the migration of fish from Lake Superior. Stream temperatures at this station were exceptionally cold, with only 8% of the readings obtaining thermal stress for brook trout from June to September of 2007-2009 (MDNR, 2013). Overall, M-IBI scores varied but all stations had numerous sensitive taxa present and exhibited good taxa richness. This subwatershed contains two water chemistry monitoring stations located on the Gooseberry River and Split Rock River (Table 9 and Table 10). Sediment, nutrient, and bacteria levels were low, indicative of the relatively un-impacted, forested watershed. Data collected between 2010 and 2011 indicated full support of both aquatic life and aquatic recreational uses.

Christianson and Highland Lake were the only two assessable lakes within this subwatershed. Christianson Lake has a fairly undeveloped lakeshore and watershed, with only a few seasonal cabins located along the southeast shore. Average TP concentrations were relatively high, but still below the 30 µg/L standard. Secchi transparency was low, averaging 1.0 meter, and naturally limited by bog staining from the surrounding wetland watershed. Chlorophyll-a concentrations were lower than expected, also likely limited by the natural bog stain in the water column. Overall, the lake was assessed as fully supporting aquatic recreation (Table 11). Highland lake has similar development patterns, morphometry, and watershed characteristics to Christianson Lake. Highland Lake forms the headwaters of the Little Gooseberry River. The lake's phosphorus and chlorophyll-a concentrations were slightly lower, and Secchi transparency slightly higher, compared to Christianson. The lake fully supported aquatic recreation. Both of these shallow lakes are important sources of base flow to the Gooseberry River, and water quality conditions are at expected levels given their environmental setting.

A total of four Lake Superior beach monitoring stations are located in this subwatershed; Split Rock Lighthouse State Park, Split Rock River, Twin Points Public Access and Gooseberry Falls State Park. At all beaches, bacteria levels were consistently low and fully supported aquatic recreational use.

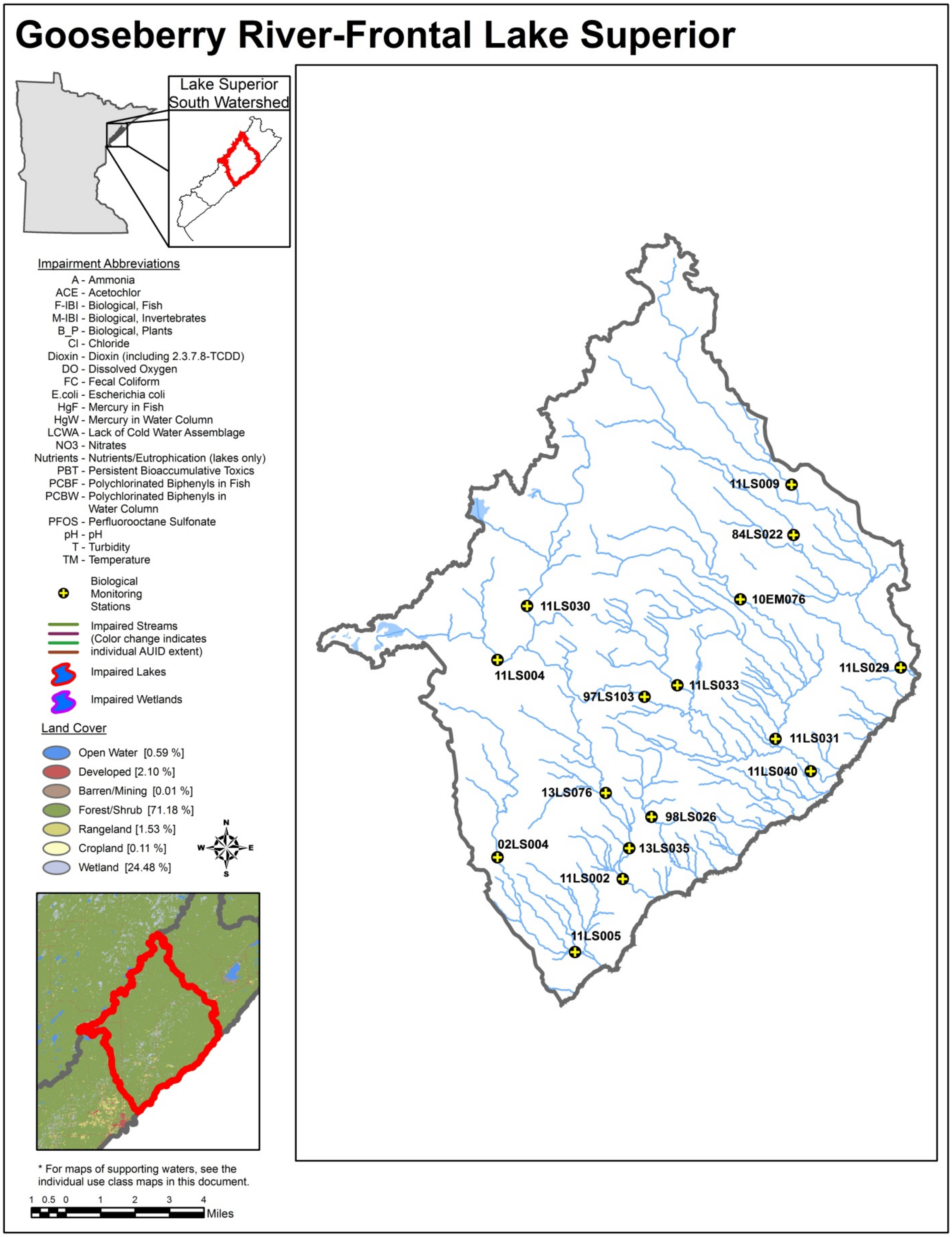

Figure 16. There are currently no listed impaired waters in the Gooseberry River – Frontal Lake Superior Watershed.

Knife River – Frontal Lake Superior Subwatershed HUC 0401010203

The Knife River – Frontal Lake Superior Subwatershed drains 176.35 square miles of Lake and Saint Louis Counties and is the second largest subwatershed. Many perennial streams are within this subwatershed, with the two largest drainage areas being the Knife River (86.48 mi^2) and the Sucker River (37.72 mi^2). Other smaller streams that exist within this subwatershed include: Little Sucker River, Skunk Creek, Stewart River, Little Stewart River, Ross Creek, Carlson Creek, Captain Jacobson Creek, West Branch Knife River, East Branch Knife River, Little Knife River and many unnamed waterways. Most tributary streams to Lake Superior, including the Knife and Sucker River, are designated trout streams.

There are four lakes greater than ten acres, including Paradise and Hart Lake.

This subwatershed is dominated by forest (68.98%), wetland (21.66%), and developed land (4.62%). Only 3.73% is rangeland, 0.61% is open water, 0.23% is row-crop agriculture and 0.17% is barren/mining. Land use throughout this watershed can vary greatly, with the heaviest forested areas at the headwaters.

There are two outlet collection locations for this subwatershed; water samples on the Knife River were collected upstream of County Road 102 (Church Street) in the city of Knife River and from the Sucker River upstream of St. Louis County Road 61 (Scenic Highway), 11 miles southwest of Two Harbors, Minnesota. The outlet station located on the Knife River is represented by MPCA's STORET/EQuIS station S006-240 and biological station 92LS050. The other outlet location on the Sucker River is represented by MPCA's STORET/EQuIS station S006-239 and the biological station 11LS041.

Table 12. Aquatic life and recreation assessments on stream reaches: Knife River – Frontal Lake Superior 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	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	Aquatic Life	Aquatic Rec.
04010102-A94 **Little Stewart River** *T53 R11W S3, West Line to Stewart R*	8.6	2A	99LS012	Upstream of Private Dr, off Press Camp Rd, 2 mi. NE of Two Harbors	MTS	MTS	- -	- -	- -	- -	- -	- -	- -	FS	NA
04010102-503 **Stewart River** *Headwaters (Stewart Lk 38-0744-00) to Lk Superior*	17.22	2A	99LS010 11LS006	Downstream of CR 302, 8 mi. NW of Two Harbors Adjacent to Stewart River Rd, 3 mi. NE of Two Harbors	MTS	MTS	- -	MTS	- -	- -	- -	- -	- -	FS	NA
04010102-528 **Skunk Creek** *Headwaters to Lk Superior*	2.75	2B	- -	- -	- -	- -	- -	EXP	MTS	MTS	MTS	- -	EX	NS	NS
04010102-887 **McCarthy Creek** *Unnamed Cr to Unnamed Cr*	1.53	2A	11LS007	Downstream of Carr Rd, 7.5 mi. NW of Knife River	MTS	MTS	- -	- -	- -	- -	- -	- -	- -	FS	NA
04010102-840 **Little Knife River** **(E Br Little Knife River)** *Unnamed Cr to Knife R*	0.84	2A	- -	- -	- -	- -	EXP	EXS	- -	MTS	- -	- -	- -	NS	NA
04010102-584 **Captain Jacobson Creek** *T53 R12W S33, North Line to W Br Knife R*	4.89	2A	11LS017	Upstream of CSAH 41, 6 mi. W of Two Harbors	MTS	MTS	- -	- -	- -	- -	- -	- -	- -	FS	NA
04010102-846 **Unnamed Creek (W Br Little Knife River)** *Unnamed Cr to W Br Knife R*	3.06	2A	11LS015	Upstream of CSAH 11, 6 mi. W of Two Harbors	MTS	MTS	- -	- -	- -	- -	- -	- -	- -	FS	NA
04010102-C16 **Knife River, West Branch** *T54 R12W S36, East Line to Unnamed Cr*	4.65	2B†	11LS010	Upstream of CR 266, 6 mi. W of Stewart	MTS	- -	- -	- -	- -	- -	- -	- -	- -	FS	NA
04010102-586 **Knife River, West Branch** *Unnamed Cr to Captain Jacobson Cr*	1.81	2A	11LS016	Downstream of CR 253, 6.5 mi. W of Two Harbors	MTS	MTS	- -	- -	- -	- -	- -	- -	- -	FS	NA
04010102-538 **Knife River, West Branch** *Unnamed Cr to Knife R*	1.54	2A	97LS100	Upstream of CSAH 9, 3 mi. SW of Two Harbors	MTS	MTS	- -	- -	- -	- -	- -	- -	- -	FS	NA

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	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	Aquatic Life	Aquatic Rec.
04010102-824 **Little Knife River** *Unnamed Cr to Unnamed Cr*	1.2	2A	11LS018	Upstream of CR 255, 2 mi. W of Knife River	MTS	MTS	- -	MTS	- -	- -	- -	- -	- -	FS	NA
04010102-504 **Knife River** *Headwaters to Lk Superior*	23.84	2A	11LS014 11LS008 11LS024 11LS025 10EM077 92LS050	Downstream of CR 111, 3.5 mi. NW of Two Harbors Upstream of CSAH 9, 3 mi. W of Two Harbors Upstream of CR 102, 2.5 N of Knife River Upstream of Shilhon Rd, 1 mi. W of Knife River SW of Shilhon Rd, 8 mi. SW of Two Harbors Upstream of CR 102 (Church St), in Knife River	MTS	MTS	MTS	EXS	MTS	MTS	MTS	- -	MTS	NS	FS
04010102-B01 **Brophy Creek** T53 R12W S19, North Line to *Big Sucker Cr*	0.31	2A	10EM141	NW of Fox Farm Rd, 1.5 mi. W of Two Harbors	MTS	MTS	- -	- -	- -	- -	- -	- -	- -	FS	NA
04010102-556 **Big Sucker Creek (Sucker River)** *T53 R12W S20, North Line to Unnamed Cr*	15.84	2A	97LS089	Upstream of CSAH 40, 8 mi. NE of Duluth	MTS	MTS	- -	IF	- -	- -	- -	- -	- -	FS	NA
04010102-555 **Big Sucker Creek (Sucker River)** *Unnamed Cr to Lk Superior*	2.12	2A	11LS041	Upstream of CR 290 , 1 mi. NW of Palmers	MTS	MTS	MTS	EXP	MTS	MTS	MTS	- -	MTS	NS	FS

Abbreviations for Indicator Evaluations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **MTS** = Meets criteria; **EXP** = Exceeds criteria, potential impairment; E**XS** = 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.

* Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.

† Reach was assessed based on use class included in the above table and existing use class as defined in Minn. R. 7050 is different. The MPCA is currently in the process of changing the existing use class for this AUID in rule based on an analysis of the biological community and temperature data.

Table 13. Minnesota Stream Habitat Assessment (MSHA): Knife River – Frontal Lake Superior 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	99LS012	Little Stewart River	5	15	24	15	28	87	Good
1	99LS010	Stewart River	5	13	19.1	14	25	76.1	Good
1	11LS006	Stewart River	5	14.5	20.2	5	30	74.7	Good
1	11LS007	McCarthy Creek	3.5	10	21.4	13	20	67.9	Good
1	11LS017	Captain Jacobson Creek	5	15	22.4	11	34	87.4	Good
1	11LS015	Unnamed Creek (W Br Little Knife River)	5	14.5	22.4	14	35	90.9	Good
1	11LS010	Knife River, West Branch	5	11	4	16	7	43	Poor
1	11LS016	Knife River, West Branch	5	14	20.7	14	34	87.7	Good
1	97LS100	Knife River, West Branch	4	14	20.7	13	19	70.7	Good
1	11LS018	Little Knife River	5	11	24	15	30	85	Good
1	11LS014	Knife River	5	15	20.6	15	35	90.6	Good
1	11LS008	Knife River	5	14	21.1	17	28	85.1	Good
1	11LS024	Knife River	5	9	20	14	25	73	Good
1	11LS025	Knife River	5	15	20	12	31	83	Good
1	10EM077	Knife River	5	14	22.85	7	36	84.85	Good
1	92LS050	Knife River	3.5	12	23.9	13	27	79.4	Good
1	10EM141	Brophy Creek	5	11	11.25	12	23	62.25	Fair
1	97LS089	Big Sucker Creek (Sucker River)	5	15	23.2	17	30	90.2	Good
1	11LS041	Big Sucker Creek (Sucker River)	4.5	14	24.95	16	30	89.45	Good
Average Habitat Results: *Knife River – Frontal Lake Superior Subwatershed*			**4.76**	**13.21**	**20.36**	**13.32**	**27.74**	**79.38**	**Good**

Qualitative habitat ratings
= Good: MSHA score above the median of the least-disturbed stations (MSHA > 66)
= Fair: MSHA score between the median of the least-disturbed stations and the median of the most-disturbed stations (45 < MSHA < 66)
= Poor: MSHA score below the median of the most-disturbed stations (MSHA < 45)

Table 14. Channel Condition and Stability Assessment (CCSI): Knife River – Frontal Lake Superior Subwatershed.

# Visits	Biological Station ID	Stream Name	Stream Type	Upper Banks (43-4)	Lower Banks (46-5)	Substrate (37-3)	Channel Evolution (11-1)	CCSI Score (137-13)	CCSI Rating
1	99LS010	Stewart River	HBC	10	4	4	5	23	Stable
1	11LS006	Stewart River	HBC	12	9	4	1	26	Stable
1	11LS007	McCarthy Creek	MHL	10	6	7	1	24	Stable
1	11LS017	Captain Jacobson Creek	MHL	8	5	4	1	18	Stable
1	11LS015	Unnamed Creek (West Branch Little Knife River)	HBC	12	7	4	4	27	Stable
1	11LS010	Knife River, West Branch	LGL	14	30	32	5	81	Severely Unstable
1	11LS016	Knife River, West Branch	HBC/MHL	11	6	6	4	27	Stable
1	97LS100	Knife River, West Branch	MHL	10	5	5	1	21	Stable
1	11LS018	Little Knife River	HBC	10	9	4	1	24	Stable
1	11LS014	Knife River	MHL	8	7	4	1	20	Stable
1	11LS008	Knife River	MHL	11	5	5	1	22	Stable
1	11LS024	Knife River	MHL	15	7	4	1	27	Stable
1	11LS025	Knife River	HBC	15	9	6	1	31	Fairly Stable
1	92LS050	Knife River	HBC	11	5	4	1	21	Stable
1	97LS089	Big Sucker Creek (Sucker River)	HBC	8	13	6	3	30	Fairly Stable
1	11LS041	Big Sucker Creek (Sucker River)	HBC	8	8	4	1	21	Stable
Average Stream Stability Results: *Knife River – Frontal Lake Superior Subwatershed*				**10.81**	**8.44**	**6.44**	**2**	**27.69**	**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 15. Outlet water chemistry results: Knife River – Frontal Lake Superior Subwatershed.

Station location:	Knife River							
STORET/EQuIS ID:	S006-240							
Station #:	04010102-504							
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**NLF Ecoregion Expectation [2]**	**# of WQ Exceedances[1]**
Ammonia-nitrogen	mg/L	10	<0.02	<0.02	<0.02	0.016		0
Chloride	mg/L	10	2.7	7.9	5.12	230		0
Dissolved Oxygen (DO)	mg/L	0				7		
pH		19	7.8	8.58	8.24	6.5 – 8.5	7.9	2
Secchi tube/Transparency Tube	100 cm	19	26	>100	>100	>20		0
Transparency tube	60 cm	0				>20		
Turbidity	FNU	0				10	4	
Escherichia coli (geometric mean)	MPN/100ml	15	44	89	44	126		0
Escherichia coli	MPN/100ml	15	11	2000	219	1260		1
Chlorophyll-a, Corrected	ug/L	0						
Inorganic nitrogen (nitrate and nitrite)	mg/L	10	<0.05	0.09	<0.05			
Kjeldahl nitrogen	mg/L	10	<0.2	1.0	0.56		0.18 – 0.73	
Orthophosphate	ug/L	0						
Pheophytin-a	ug/L	0						
Phosphorus	ug/L	10	6	66	27		50	
Specific Conductance	uS/cm	9	113	179	147		270	
Temperature, water	deg °C	19	10.4	28.1	19.6			
Total suspended solids	mg/L	10	<1	5	2.78		5.6	
Total volatile solids	mg/L	10	<1	3	1.3			
Sulfate	mg/L	0						
Hardness	mg/L	0						

[1]Secchi Tube/Transparency tube standards are surrogate standards derived from the turbidity standard of 25.
[2]Based on 1970-1992 summer data; see Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions (McCollor and Heiskary 1993). TKN range based on EPA Rivers and Streams in Nutrient Ecoregion VIII, NLF and NMW, EPA 822 B-01-015. 2001
****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Knife River – Frontal Lake Superior Subwatershed, a component of the IWM work conducted between May and September in 2010 and 2011. This specific data does not necessarily reflect all data that was used to assess the AUID.**

Table 16. Outlet water chemistry results: Knife River – Frontal Lake Superior Subwatershed.

Station location:	Sucker River							
STORET/EQuIS ID:	S006-239							
Station #:	04010102-555							
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**NLF Ecoregion Expectation [2]**	**# of WQ Exceedances[1]**
Ammonia-nitrogen	mg/L	10	<0.02	0.02	<0.02	0.016		0
Chloride	mg/L	10	0.9	2.3	1.6	230		0
Dissolved Oxygen (DO)	mg/L	0				7		
pH		19	7.52	8.56	8.23	6.5 – 8.5	7.9	1
Secchi tube/Transparency Tube	100 cm	19	90	>100	>100	>20		0
Transparency tube	60 cm	0				>20		
Turbidity	FNU	0				10	4	
Escherichia coli (geometric mean)	MPN/100ml	15	17	49	33	126		0
Escherichia coli	MPN/100ml	15	5	340	53	1260		0
Chlorophyll-a, Corrected	ug/L	0						
Inorganic nitrogen (nitrate and nitrite)	mg/L	9	<0.05	2.0	<0.05			
Kjeldahl nitrogen	mg/L	10	<0.02	0.8	0.54		0.18 – 0.73	
Orthophosphate	ug/L	0						
Pheophytin-a	ug/L	0						
Phosphorus	ug/L	9	6	22	17		50	
Specific Conductance	uS/cm	9	111	174	146		270	
Temperature, water	deg °C	19	10.7	26.1	18.9			
Total suspended solids	mg/L	9	<1	3	1.7		5.6	
Total volatile solids	mg/L	9	<1	3	<1			
Sulfate	mg/L	0						
Hardness	mg/L	0						

[1]Secchi Tube/Transparency tube standards are surrogate standards derived from the turbidity standard of 25.
[2]Based on 1970-1992 summer data; see *Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions* (McCollor and Heiskary 1993). TKN range based on EPA Rivers and Streams in Nutrient Ecoregion VIII, NLF and NMW, EPA 822 B-01-015. 2001
****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Knife River – Frontal Lake Superior Subwatershed, a component of the IWM work conducted between May and September in 2010 and 2011. This specific data does not necessarily reflect all data that was used to assess the AUID.**

Table 17. Lake water aquatic recreation assessments: Knife River – Frontal Lake Superior Subwatershed.

Name	DNR Lake ID	Area (acres)	Trophic Status	Percent Littoral	Max. Depth (m)	Avg. Depth (m)	CLMP Trend	Mean TP (µg/L)	Mean Chl-a (µg/L)	Secchi Mean (m)	Support Status
Paradise	69-0007-00	36	M	100	4.2	2.2[1]	NT	18	2.8	2.4	FS
Stewart	38-0744-00	264	M	100	4.2	1.9	NT	13.3	4.4	3.1	FS

Abbreviations: D -- Decreasing/Declining Trend; I -- Increasing/Improving Trends; NT – No Trend; O – Oligotrophic; H – Hypereutrophic; E – Eutrophic; M – Mesotrophic; [1] – Depth is estimated; FS – Full Support; NS – Non-Support; IF – Insufficient Information

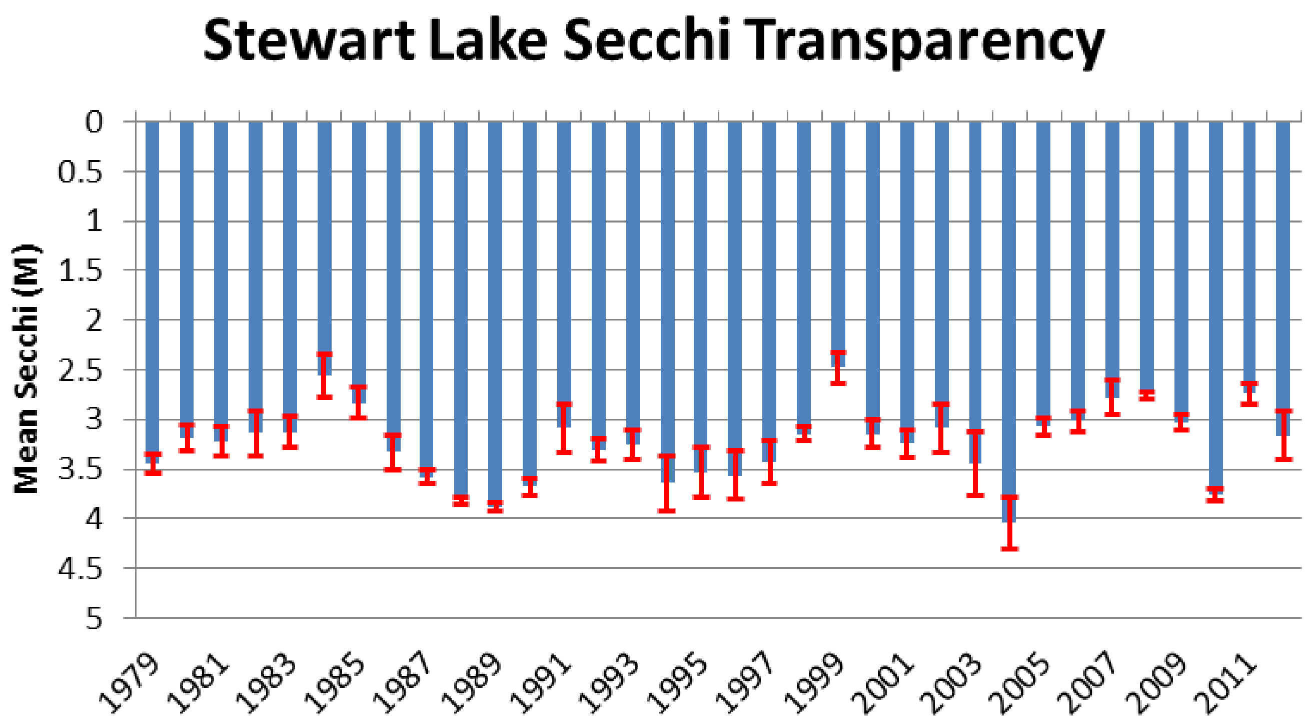

Figure 17. Stewart Lake Secchi Transparency Dataset.

Summary

There is considerable variation in results of specific parameters across the Knife River - Frontal Lake Superior Subwatershed, that in some cases appear to relate to the diversity of the landscape and land use patterns within the watershed. This subwatershed contains a total of 15 assessable stream segments, with a total of 19 biological monitoring stations, and two lakes assessed for aquatic recreation (Table 12 and Table 17). Habitat throughout this subwatershed was in "good" condition, as demonstrated by the MSHA scores (Table 13). One station (11LS010) scored poorly on MSHA and is attributed to the low gradient/fine sediments/headwater nature of that specific station. This same station also received a "severely unstable" rating from CCSI and skewed the overall CCSI score for this subwatershed from "stable" to "fairly stable" (Table 14). All biological parameters were meeting standards and in most cases exceeded far beyond the upper confidence interval. Streams that have exceptional biological, chemical, and physical parameters are worthy of additional protection in order to preserve their valuable aquatic resources. Some of the noteworthy streams within this watershed, as it pertains to biology, are McCarthy Creek (04010102-887), Big Sucker Creek (Sucker River) (04010102-556), Unnamed Creek (West Branch Little Knife River; 04010102-846), Captain Jacobson Creek (04010102-584), Stewart River (04010102-503) and Little Stewart River (04010102-A94).

Many tributaries to the Knife River proper had exceptional biology and water chemistry; however, portions of the Knife River continue to be listed based on chemical parameters. Before the 2013 assessments, the Knife River proper (04010102-504) was listed as not supporting aquatic life due to exceedances of the turbidity (1996) and pH (2002) standards. The Knife River proper was also listed as not supporting aquatic consumption due to high levels of mercury in the water column (1998). Since that time considerable monitoring, assessment and watershed projects have been implemented by the South Saint Louis SWCD. A jointly produced TMDL and implementation plan were recently completed and approved by the USEPA. For more information, see: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/lake-superior-basin-tmdl/project-knife-river-turbidity.html.

Data collected from the Knife River and the Sucker River from 2010-2011 indicated that sediment and water transparency levels were relatively clear (Table 15 and Table 16). The high transparency and low turbidity may be a result of sampling during moderate to lower flows when erosion and sedimentation are reduced. Although contradictory to the 2010-2011 data, the existing aquatic life impairment based on the turbidity standard was supported by data collected within the ten year "assessment window". Streams with larger catchments and higher gradient will tend to have higher turbidity in lower reaches, which is typical of most Lake Superior streams. These conditions are likely natural but can result in stressful conditions for biological communities and can be amplified by poor land use practices. Water sampling and stream flow monitoring will continue on the Sucker River as part of the MPCA and MDNR Watershed Pollutant Load Monitoring Network. For more information about the Sucker River, see the Load Monitoring section of this report, or this website: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/streams-and-rivers/watershed-pollutant-load-monitoring-network.html#products-data

Overall, both the Knife River (S006-240) and the Sucker River (S006-239) water chemistry monitoring stations indicated that the water quality was good. Nitrogen and phosphorus levels are comparable to other streams within the Lake Superior - South Watershed, and are within the NLF ecoregion range. Both monitoring stations showed few exceedances of the pH standard and where assessed as meeting the standard. As part of this assessment process, the pH impairment on the Knife River was removed (i.e. delisted) due to recent, extensive monitoring associated with the turbidity TMDL that showed that the pH standard was consistently met. Bacteria levels were low overall, and indicated full support of aquatic recreational use; during heavy rains bacteria counts can reach high levels, but concentrations return to low levels when stream flow levels recede. The existing mercury impairment found on the Knife River is likely linked to over land run off and could be mitigated by addressing other impairments. In addition, the Little Knife River (04010102-840) has existing aquatic life impairments due to exceedances of the turbidity (2008) and dissolved oxygen (2008) standards. No new data was assessed and the existing impairment carries forward.

Paradise and Stewart Lake were the only two assessable lakes within this subwatershed and are located ten miles outside of Two Harbors. Data collected in 2011 and 2012 on Stewart Lake indicated mesotrophic conditions and good water quality overall; phosphorus and chlorophyll concentrations and Secchi transparency values are meeting standards for aquatic recreation. Stewart Lake has a long term Secchi transparency dataset with annual data collected since 1979 by volunteers in the MPCA's CLMP. The long term mean transparency is 3.25 meters (10.6 feet) and there is no detectable trend in the dataset. Annual variability is evident in the dataset (Figure 17), which is normal, and likely related to climatic conditions. Paradise lake was monitored between 2004-2005 and indicated mesotrophic conditions. All standards were being met and the lake fully supported aquatic recreation.

This subwatershed contained seven Lake Superior beach stations with assessment level data; Stewart River, Flood Bay, Burlington Bay, Agate Bay, Knife River, Stony Point and Bluebird Landing. All but Burlington Bay fully supported aquatic recreation. Bacteria levels were occasionally high at this location, which may be attributed to its close proximity to Skunk Creek (04010102-528). Skunk creek, along with its existing aquatic life impairment due to an exceedance of the turbidity standard (2010), was listed as impaired for aquatic recreation due to high levels of bacteria (E. coli) in 2013. Any future TMDL in this area will concurrently investigate high bacteria concentrations at the beach and the adjacent Skunk Creek. Potential sources of bacteria to Skunk Creek include: pet and wildlife waste, urban storm water, leaking wastewater infrastructure and other prevalent land uses.

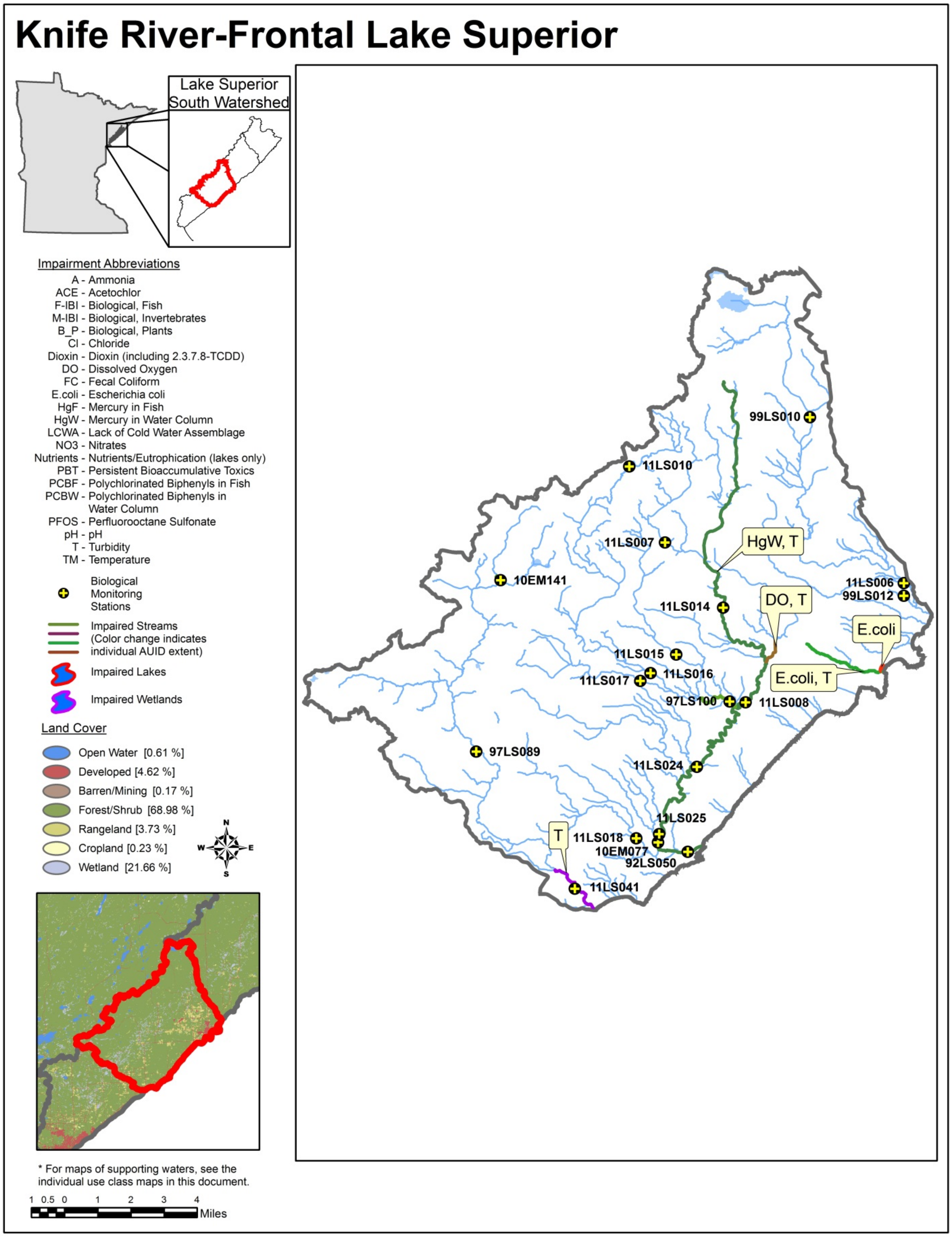

Figure 18. Currently listed impaired waters by parameter and land use characteristics in the Knife River – Frontal Lake Superior Subwatershed.

City of Duluth – Frontal Lake Superior Subwatershed HUC 0401010204

The city of Duluth – Frontal Lake Superior Subwatershed drains 118.19 square miles of Saint Louis County and is the smallest subwatershed. Many perennial streams occur within this subwatershed, with the largest contributing drainage being the Lester River (53.17 mi^2). Other streams that exist within this subwatershed include: Amity, Chester, Tischer and Schmidt Creek, Talmadge River, French River and many unnamed waterways. Most tributary streams to Lake Superior, including the Lester River, are designated trout streams.

There are a total of two lakes greater than ten acres, with both of the lakes being located in the Lester River drainage (Eagle and Antoinette).

Land use among drainages within this subwatershed varies considerably, from nearly 50% urban in some small Duluth streams to nearly 90% forest in the French River watershed. In most minor watersheds, land use transitions from forest/wetlands to more urban and rural residential development in the lower reach of the watershed. This watershed is dominated by forest (59.78%), wetland (18.00%), and developed land (16.49%). Only 4.80% is rangeland, 0.63% is open water, 0.25% is row-crop agriculture, and 0.05% is barren/mining.

Water samples from the outlet of this subwatershed were collected on the Lester River within Lester Park, which is located in the city of Duluth, downstream of London Road. The outlet is represented by MPCA's STORET/EQuIS station S006-238.

Table 18. Aquatic life and recreation assessments on stream reaches: City of Duluth – Frontal Lake Superior 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**	**Turbidity**	**Chloride**	**pH**	**NH_3**	**Pesticides**	**Bacteria**	**Aquatic Life**	**Aquatic Rec.**
04010102-698 **French River** *Unnamed Lk (69-182-00) to Lk Superior*	11.35	2A	11LS020 97LS104	Upstream of CSAH 43, 3.5 mi. NW of French River Upstream of CSAH 33, 2 mi. N of Duluth	MTS	MTS	MTS	EXP	MTS	MTS	--	--	MTS	NS	FS
04010102-508 **Talmadge River (Talmadge Creek)** *Headwaters to Lk Superior*	6.17	2A	11LS038	Adjacent to Private Drive, off McDonnell Rd, 1.5 mi. N of Clifton	EXP	MTS	EXP[1]	EXP	MTS	MTS	--	--	IF	NS	IF
04010102-540 **Amity Creek, East Branch** *Unnamed Cr to Amity Cr*	3.59	2A	97LS038	Downstream of CSAH 27, 1 mi. NW of Hawk Ridge Nature Reserve, N of Duluth	MTS	MTS	MTS	EXS	MTS	MTS	MTS	--	IF	NS	IF
04010102-511 **Amity Creek** *Unnamed Cr to Lester R*	2.25	2A	11LS036	Adjacent to Occidental Ave, 1 mi. upstream of Lester River bridge, in Duluth	MTS	MTS	MTS	EXS	MTS	MTS	MTS	--	--	NS	NA
04010102-549 **Lester River** *T52 R14W S23, North Line to Lk Superior*	20.22	2A	11LS021 91LS012 91LS009	Upstream of CSAH 34, 5 mi. E of Fredenberg Upstream of CSAH 37, 5.5 mi. E of Webster Upstream of Strand Rd, 4 mi. NE of Duluth	MTS	MTS	MTS	EXP	MTS	MTS	MTS	--	MTS	NS	FS
04010102-543 **Tischer Creek** *Headwaters to Unnamed Cr*	5.02	2A	95LS023	Adjacent to Columbus Ave, in Duluth	MTS	MTS	--	MTS	--	--	--	--	--	FS	NA
04010102-544 **Tischer Creek** *Unnamed Cr to Lk Superior*	1.49	2A	95LS021	Downstream of E 4th St, in Duluth	IF	MTS	IF	EXP	MTS	MTS	MTS	--	EX	IF[2]	NS
04010102-545 **Chester Creek** *E Br Chester Cr to Lk Superior*	2.72	2A	11LS039	Adjacent to end of Chester Bowl Drive (in Chester Park), in Duluth	MTS	MTS	MTS	IF	MTS	MTS	MTS	--	EX	FS	NS

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.
* Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50% channelized or having biological data limited to a station occurring on a channelized portion of the stream.
[1] Data assessed in 2013 suggest Dissolved Oxygen (DO) is currently meeting standards. A managerial decision was made to keep the existing DO impairment and address it in a future TMDL.
[2] Additional monitoring was requested by the WAT and took place in 2013. Data collected was still pending at the time of the 2014 draft impaired waters list and will be assessed before any future listings.

Table 19. Minnesota Stream Habitat Assessment (MSHA): City of Duluth – Frontal Lake Superior 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	11LS020	French River	4.5	13	22	12	33	84.5	Good
1	97LS104	French River	5	14	20.6	14	25	78.6	Good
1	11LS038	Talmadge River (Talmadge Creek)	5	15	24	13	30	87	Good
1	97LS038	Amity Creek, East Branch	3.5	11.5	22	8	24	69	Good
1	11LS036	Amity Creek	2	9.5	23.5	9	13	57	Fair
1	11LS021	Lester River	3.5	11	11.45	16	14	55.95	Fair
1	91LS012	Lester River	5	15	23	16	34	93	Good
1	91LS009	Lester River	3.75	12.5	21.4	14	34	85.65	Good
2	95LS023	Tischer Creek	3	11.75	20.45	13.5	31	79.7	Good
1	95LS021	Tischer Creek	0	8	22	13	28	71	Good
1	11LS039	Chester Creek	4.25	12.5	23.8	12	29	81.55	Good
Average Habitat Results: ***City of Duluth – Frontal Lake Superior Subwatershed***			**3.59**	**12.16**	**21.29**	**12.77**	**26.82**	**76.63**	**Good**

Qualitative habitat ratings
= Good: MSHA score above the median of the least-disturbed stations (MSHA > 66)
= Fair: MSHA score between the median of the least-disturbed stations and the median of the most-disturbed stations (45 < MSHA < 66)
= Poor: MSHA score below the median of the most-disturbed stations (MSHA < 45)

Table 20. Channel Condition and Stability Assessment (CCSI): City of Duluth – Frontal Lake Superior Subwatershed.

# Visits	Biological Station ID	Stream Name	Stream Type	Upper Banks (43-4)	Lower Banks (46-5)	Substrate (37-3)	Channel Evolution (11-1)	CCSI Score (137-13)	CCSI Rating
1	11LS020	French River	MHL	9	11	6	4	30	Fairly Stable
1	97LS104	French River	MHL	6	11	6	1	24	Stable
1	11LS038	Talmadge River (Talmadge Creek)	MHL	6	11	4	5	26	Stable
1	97LS038	Amity Creek, East Branch	HBC/MHL	15.5	14	6.5	1	37	Fairly Stable
1	11LS036	Amity Creek	HBC	11	5	4	1	21	Stable
1	11LS021	Lester River	MHL	6	14	22	3	45	Fairly Stable
1	91LS012	Lester River	HBC	6	7	4	3	20	Stable
1	91LS009	Lester River	MHL	9	9	4	1	23	Stable
1	95LS023	Tischer Creek	MHL	13	9	4	1	27	Stable
1	11LS039	Chester Creek	HBC	10	9	4	1	24	Stable
Average Stream Stability Results: *City of Duluth – Frontal Lake Superior Subwatershed*				**9.15**	**10**	**6.45**	**2.1**	**27.7**	**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 21. Outlet water chemistry results: City of Duluth – Frontal Lake Superior Subwatershed.

Station location:	Lester River							
STORET/EQuIS ID:	S006-238							
Station #:	04010102-549							
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**NLF Ecoregion Expectation [2]**	**# of WQ Exceedances[1]**
Ammonia-nitrogen	mg/L	10	<0.02	0.02	<0.02	0.016		0
Chloride	mg/L	10	0.9	2.3	1.6	230		0
Dissolved Oxygen (DO)	mg/L	0				7		
pH		19	7.52	8.56	8.23	6.5 – 8.5	7.9	1
Secchi tube/Transparency Tube	100 cm	19	90	>100	>100	>20		0
Transparency tube	60 cm	0				>20		
Turbidity	FNU	0				10	4	
Escherichia coli (geometric mean)	MPN/100ml	15	17	49	33	126		0
Escherichia coli	MPN/100ml	15	5	340	53	1260		0
Chlorophyll-a, Corrected	ug/L	0						
Inorganic nitrogen (nitrate and nitrite)	mg/L	9	<0.05	2.0	<0.05			
Kjeldahl nitrogen	mg/L	10	<0.02	0.8	0.54		0.18 – 0.73	
Orthophosphate	ug/L	0						
Pheophytin-a	ug/L	0						
Phosphorus	ug/L	9	6	22	17		50	
Specific Conductance	uS/cm	9	111	174	146		270	
Temperature, water	deg °C	19	10.7	26.1	18.9			
Total suspended solids	mg/L	9	<1	3	1.7		5.6	
Total volatile solids	mg/L	9	<1	3	<1			
Sulfate	mg/L	0						
Hardness	mg/L	0						

[1]Secchi Tube/Transparency tube standards are surrogate standards derived from the turbidity standard of 25.
[2]Based on 1970-1992 summer data; see *Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions* (McCollor and Heiskary 1993). TKN range based on EPA Rivers and Streams in Nutrient Ecoregion VIII, NLF and NMW, EPA 822 B-01-015. 2001
****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the City of Duluth – Frontal Lake Superior Subwatershed, a component of the IWM work conducted between May and September in 2010 and 2011. This specific data does not necessarily reflect all data that was used to assess the AUID.**

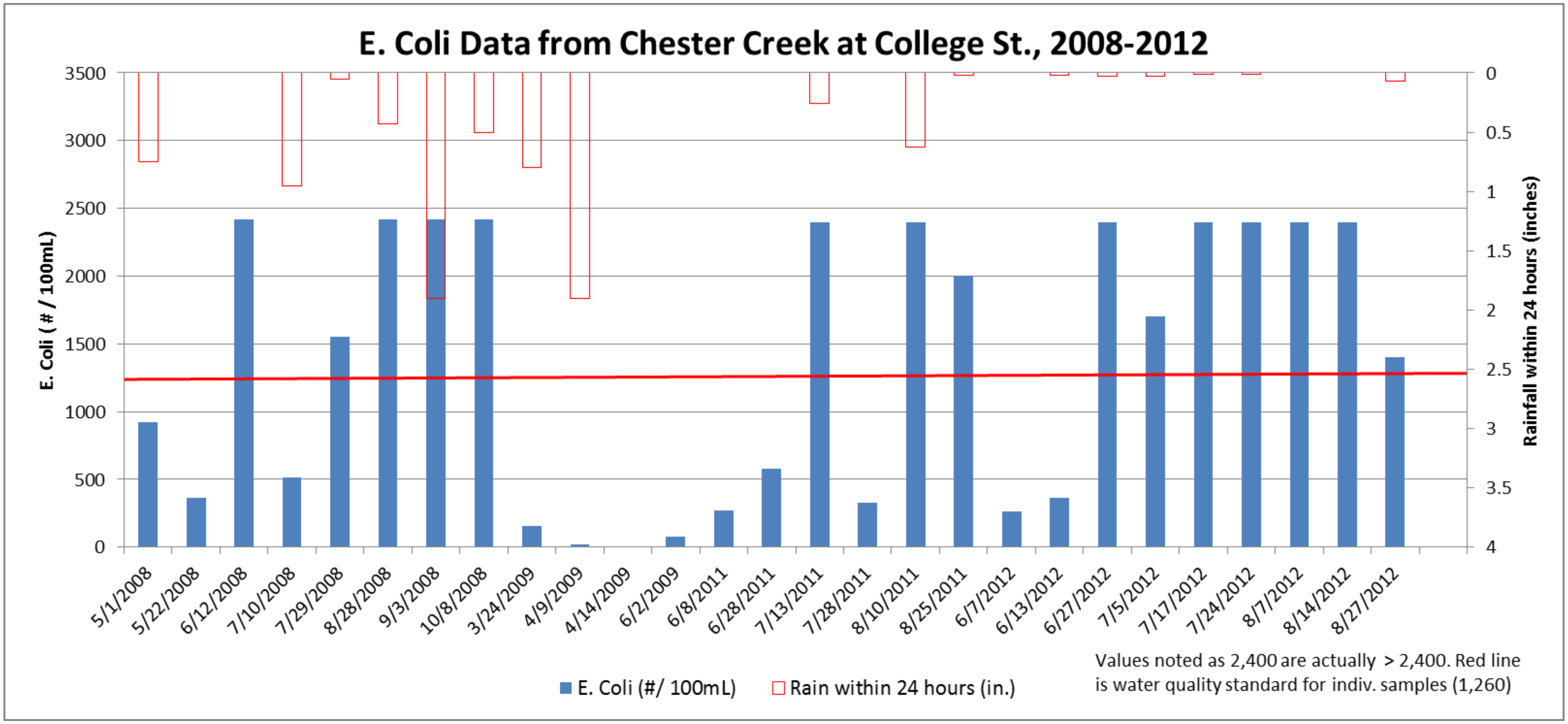

Figure 19. E. Coli bacteria concentrations in the 2012 assessment cycle. Individual maximum standard of 1260 colonies noted as red line.

Table 22. Lake water aquatic recreation assessments: City of Duluth – Frontal Lake Superior Subwatershed.

Name	DNR Lake ID	Area (acres)	Trophic Status	Percent Littoral	Max. Depth (m)	Avg. Depth (m)	CLMP Trend	Mean TP (µg/L)	Mean Chl-a (µg/L)	Secchi Mean (m)	Support Status
Eagle	69-0238-00	121	E	100	1.5[1]	1.0[1]	NT	32.7	9.4	2.8	FS

Abbreviations:	D -- Decreasing/Declining Trend	H – Hypereutrophic	FS – Full Support
	I -- Increasing/Improving Trends	E – Eutrophic	NS – Non-Support
	NT – No Trend	M – Mesotrophic	IF – Insufficient Information
	O -- Oligotrophic	[1] – Depth is estimated	

Summary

There is considerable variation in results of specific parameters across the city of Duluth – Frontal Lake Superior Subwatershed, that in some cases appear to relate to the diversity of the landscape and land use patterns within the watershed. This subwatershed contains a total of eight assessable stream segments, with a total of 11 biological monitoring stations, and one lake assessed for aquatic recreation (Table 18 and Table 22). As demonstrated by the MSHA scores, habitat within this subwatershed ranged from "good" to "fair", with an overall rating of "good" (Table 19). Despite heavily disturbed land use in some minor watersheds, in-stream habitat seems to be maintained. This data is also supported by the overall CCSI rating that fell between "stable" and "fairly stable" (Table 20). Most biological parameters were meeting standards, with portions of the Lester (04010102-549) and French Rivers (04010102-698) exceeding far beyond the upper confidence interval. Streams that have exceptional biological, chemical, and physical parameters are worthy of additional protection in order to preserve their valuable aquatic resources.

The Talmadge River, in addition to the existing aquatic life impairment due to exceedances in state standards for turbidity (1996) and DO (2004), was listed as non-support for the F-IBI in the 2013 assessment. One station (11LS038) was located on the Talmadge River and was dominated by pioneer species that are typically more tolerant to low flows, major fluctuations in water depth, increased water temperature, lower DO, and turbidity. Although recent DO data suggested full-support for aquatic life, a management decision was made to carry forward the existing DO impairment and address it in a future TMDL. The existing DO impairment is likely linked to flow fluctuations that may be contributing to the non-support for aquatic life based on the turbidity and F-IBI standards.

The MPCA's grantee and partner, the St. Louis River Alliance, recently conducted stream monitoring on several streams within the city of Duluth. The data collected on two highly valued streams within the city, Tischer and Chester Creeks, indicated high levels of E. coli bacteria. Both streams were assessed as impaired for aquatic recreation. Bacteria concentrations on Chester Creek were very high (> 2,400) during rain events and even during summer dry periods (Figure 19). On Tischer Creek, individual samples were not quite as high as in Chester Creek, but all the monthly geometric mean values exceeded standards. Potential sources of bacteria to both streams include pet and wildlife waste, urban storm water, and leaking wastewater infrastructure. The city of Duluth is actively inspecting, repairing and monitoring sewer lines in the vicinity. Source tracking of bacteria will be a component of the future impaired waters study.

A water chemistry monitoring station was established as part of the IWM process on the Lester River and indicated water quality standards were being met, with the exception of turbidity (Table 21). Turbidity impairments are the most common stressor for aquatic life within this subwatershed, with five of the eight stream segments assessed being listed. The high turbidity may correlate to the natural weathering of bank materials, extensive urbanization, and wide spread forest cover change. The turbidity standard also exceeded state standards on Tischer Creek (04010102-544) but was not listed due to additional monitoring requested by the WAT and will be addressed before any future listings.

The city of Duluth – Frontal Lake Superior Subwatershed contains assessment level data for Eagle Lake (Table 22). Eagle is a shallow lake covering 114 acres, within the headwaters of the Lester River watershed. The lake drains a relatively large 2,138 acre wetland dominated watershed and has a maximum depth of only six feet (the MDNR has never mapped the bathymetry or surveyed the lake's fisheries). A few residential properties and one farm are located along the southeast shore. Eagle Lake fully supported aquatic recreation. One phosphorus and chlorophyll sample caused the two year average to exceed standards; removing these outliers dropped the average to below standards.

Collectively the two year dataset indicated full support of aquatic recreation and is further supported by observations that algae levels are rarely at nuisance conditions; this decision was supported by the local government partner that collected the dataset (South St. Louis County Soil and Water Conservation District). Shallow lakes within the Northern Lakes and Forests Ecoregion tend to naturally be more productive than deeper, dimictic lakes.

This subwatershed contains assessment level data on ten Lake Superior beaches: French River, six East Duluth beaches, and three on the lake side of Park Point. Nine of these beaches fully supported aquatic recreation. One beach, Leif Erickson Park, was not meeting standards and did not support aquatic recreation. This decision was based on several factors including the history of water contact advisories posted at the beach, old infrastructure in the vicinity, and the likelihood that water quality at the beach is influenced by nearby Chester Creek, which is also impaired due to high bacteria levels.

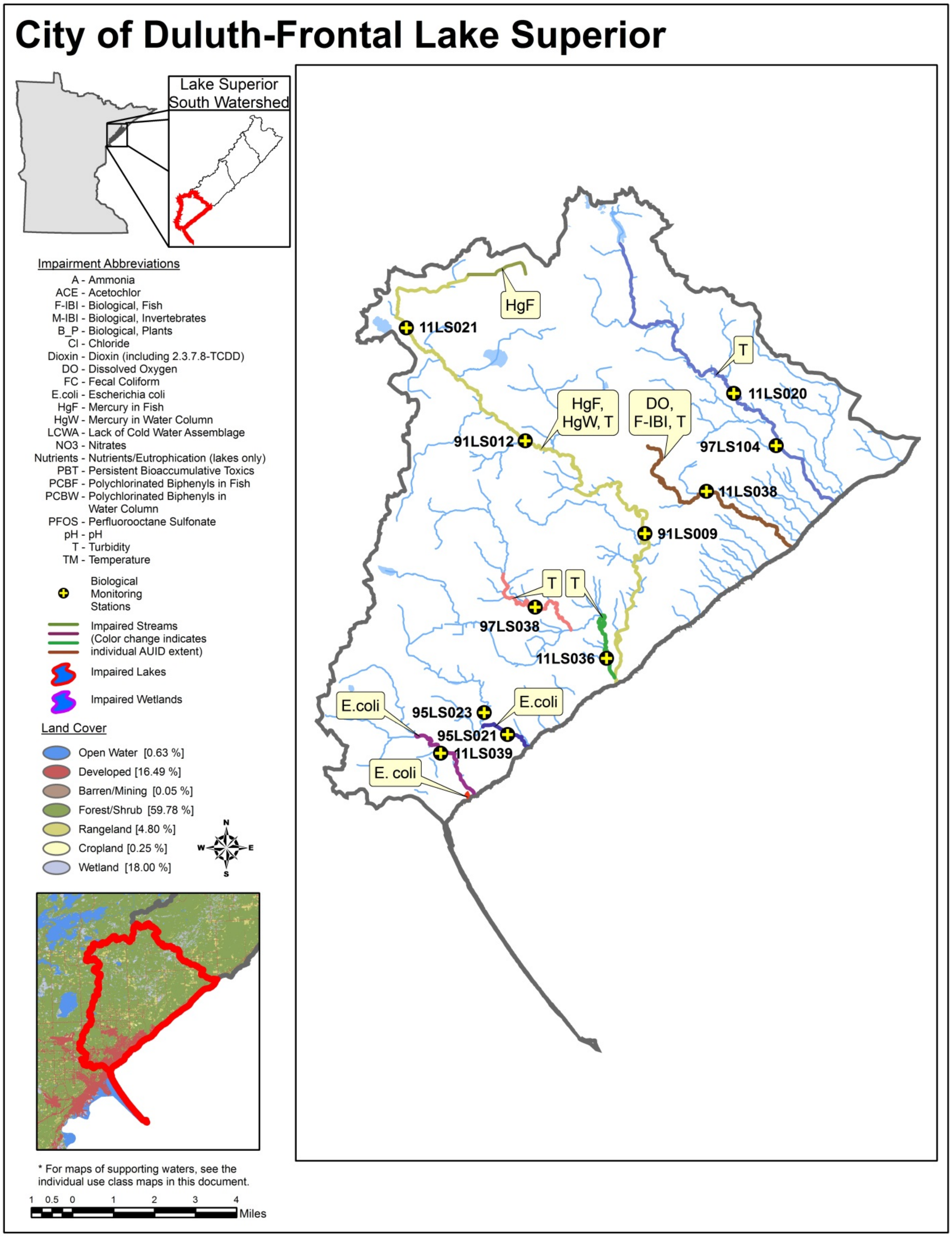

Figure 20. Currently listed impaired waters by parameter and land use characteristics in the city of Duluth – Frontal Lake Superior Subwatershed.

VI. Watershed-Wide Results and Discussion

Assessment results and data summaries are included below for the entire HUC-8 Lake Superior - South Watershed, grouped by sample type. Summaries are provided for load monitoring data results near the mouth of the Sucker River, aquatic life and recreation use assessment results in streams and lakes throughout the watershed, and for aquatic consumption results at select river and lake locations within 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 Lake Superior - South Watershed.

Pollutant Load Monitoring

The Sucker River is monitored on County Road 290 near Palmers. Many years of water quality data from throughout Minnesota combined with the previous analysis of Minnesota's ecoregion patterns, resulted in the development of three "River Nutrient Regions" (RNR), each with unique nutrient standards (MPCA, 2008). Of the state's three RNRs (North, Central, South), the Sucker River's monitoring station is located within the North RNR.

Annual flow weighed mean concentrations (FWMCs) were calculated and compared for years 2009-2011 (Figure 21, Figure 22, Figure 23, and Figure 24) and compared to the RNR standards (only TP and TSS draft standards are available for 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 RNR 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, over the most recent ten year period and not based on comparisons with FWMCs (MPCA, 2012). 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.

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 nitrate-N are generally regarded as "non-point" source derived pollutants originating from many small diffuse sources such as urban or agricultural runoff. Excess TP and DOP can be attributed to both "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 and DOP and nitrate-N concentrations tend 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.

Total Suspended Solids

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).

Currently, the state of Minnesota's TSS standards are in development and must be considered to be draft standards until approved. Within the North RNR, the river would be considered impaired when greater than 10% of the individual samples exceed the TSS draft standard of 15 mg/L. (MPCA, 2011). From 2009 – 2011, 22%, 10% and 26% of the samples exceeded the 15 mg/L draft standard, respectively. The computed FWMCs did not exceed the 15 mg/L draft standard as shown in Figure 21, which suggests periods of elevated flow carried less sediment per unit volume. Most TSS exceedences occurred during spring snow melt or high intensity rain events. The highest concentration (79 mg/L) occurred during a high intensity rain event in late June. Often, there is a strong correlation between pollutant loads and annual runoff volume; the differences may be due strictly to differences in annual runoff volume (Table 23).

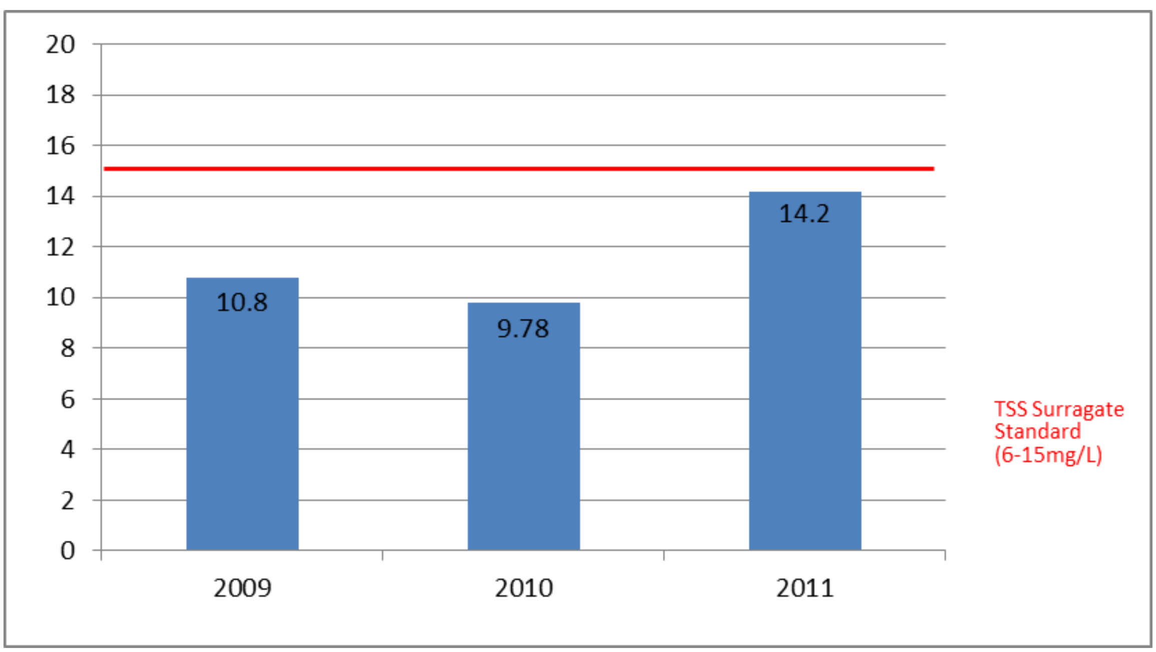

Figure 21. Total Suspended Solids (TSS) flow weighted mean concentrations in the Sucker River drainage.

Table 23. Annual pollutant loads by parameter calculated for the Sucker River.

	2009	2010	2011
Parameter	**Mass (Kg)**	**Mass (Kg)**	**Mass (Kg)**
Total Suspended Solids	293,358	286,468	482,096
Total Phosphorus	960	965	1,227
Ortho Phosphorus	195	300	420
Nitrate + Nitrite Nitrogen	1,927	2,182	1,822

Total Phosphorus

Nitrogen, phosphorus and potassium 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.

Total phosphorus standards for Minnesota's rivers are also in development and must be considered draft standards until approved. Within the North RNR, the TP draft standard is 0.050 mg/L as a summer average. Summer average violations of one or more "response" variables (pH, biological oxygen demand, DO flux, chlorophyll-a) must also occur along with the numeric TP violation for the water to be listed. In comparison of the data collected from 2009 to 2011, TP exceedences occurred 25%, 10% and 26%, respectively. Although there were exceedences to the draft standard, the flow weight mean did not exceed the draft standard (0.050 mg/L). The highest concentration (0.138 mg/L) occurred during a high intensity rain event in late June. The higher FWMC and loads in 2011 are likely due to a higher flow during snow melt and multiple flow events during the summer.

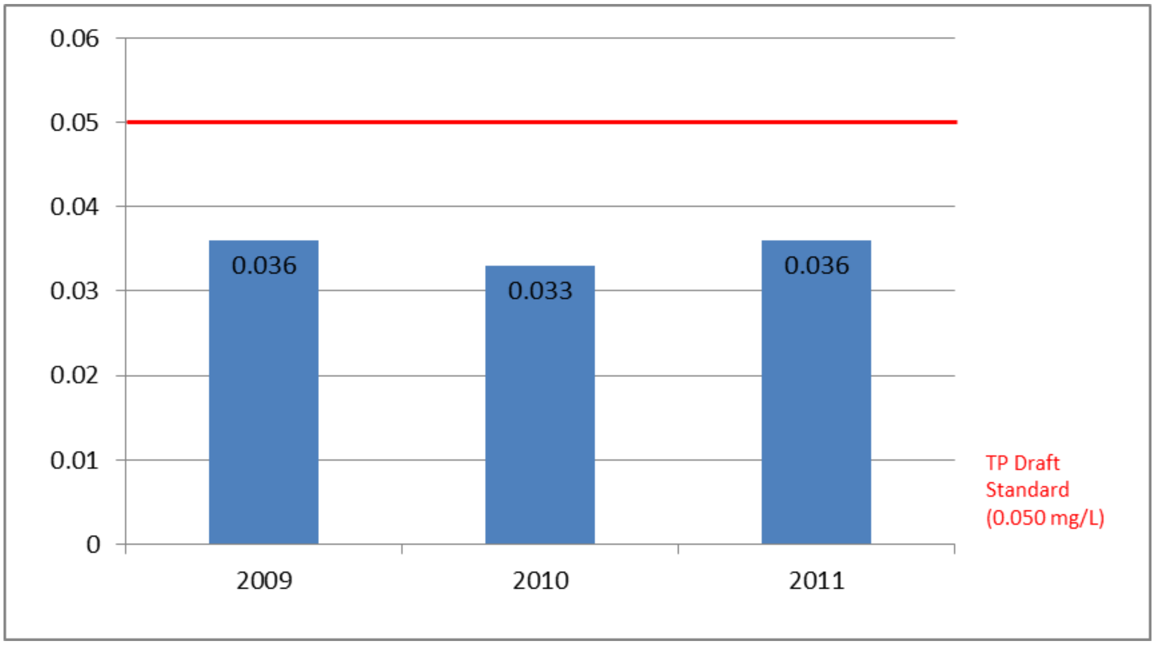

Figure 22. Total Phosphorus (TP) flow weighted mean concentrations for the Sucker River drainage.

Dissolved Orthophosphate

Dissolved Orthophosphate is a water soluble form of phosphorus that is readily available for plant uptake (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. The DOP:TP ratio of FWMCs from the three years were 19%, 30%, and 33%, respectively. Figure 23 and Table 23 show similar trends between years as seen in TP and TSS. This is not uncommon due to the relationship between DOP, TP and TSS.

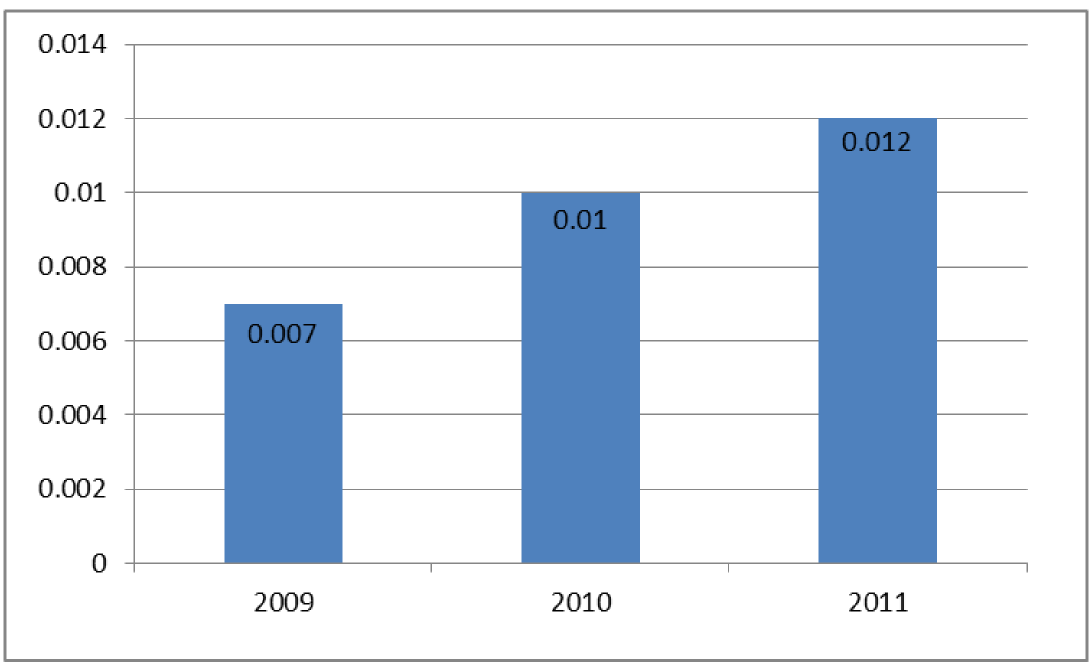

Figure 23. Dissolved Orthophosphate flow weighted mean concentrations for the Sucker River.

Nitrate plus Nitrite - Nitrogen

Nitrate and nitrite-N 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, 2008). Because nitrate and nitrite-nitrogen are water soluble, 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.

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. Draft nitrate-N standards have been proposed for the protection of aquatic life in lakes and streams. The draft acute value (maximum standard) for all Class 2 surface waters is 41 mg/L nitrate-N for a 1-day duration, and the draft chronic value for Class 2B (warm water) surface waters is 4.9 mg/L nitrate-N for a 4-day duration. In addition, a draft chronic value of 3.1 mg/L nitrate- N (4-day duration) was determined for protection of Class 2A (cold water) surface waters (MPCA, 2010).

Figure 24 shows the nitrate-N FWMCs over the three-year period for the Sucker River monitoring station. The FWMC for all three years were below the draft acute and chronic nitrate-N standards. From 2009 through 2011 there were no exceedences of the draft chronic standard.

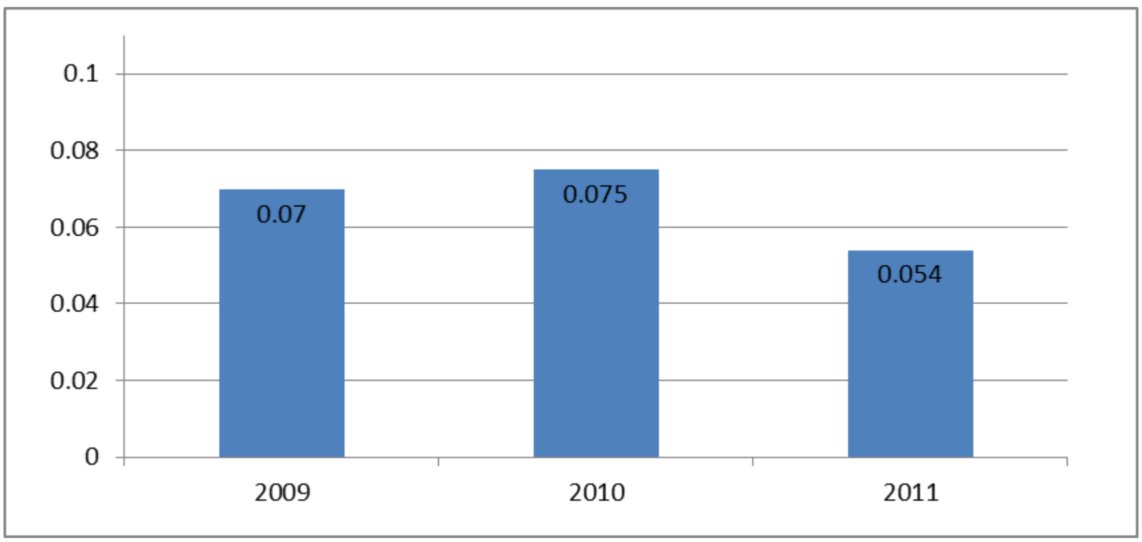

Figure 24. Nitrate + Nitrite Nitrogen (Nitrate-N) flow weighted mean concentrations for the Sucker River drainage.

Stream Water Quality

Forty-two of the 695 stream segments within this watershed were assessed (Table 24). Of the assessed streams, 28 streams were considered fully supportive of aquatic life and nine streams were fully supporting aquatic recreation. Throughout the watershed, 13 stream segments did not support aquatic life and/or recreation. Of those stream segments, eleven did not support aquatic life and three did not support aquatic recreation. The Lester River was the only stream assessed for fish consumption. It did not meet the standard and was listed for mercury in fish tissue.

Overall, water quality conditions are good, and reflect the forests and wetlands that dominate the land cover within the Lake Superior - South Watershed. Problem areas do occur and persist throughout this watershed but are limited to the lower reaches where stressors from natural processes and land use practices may accumulate. Total Suspended Solids and turbidity are elevated in most North Shore tributaries. Sources of the sediment and turbidity are numerous, and are a function of the watershed's geologic setting, the river's geomorphology and current/historical land use practices. Bio-accumulation of mercury in fish tissue and mercury within the water column may also be linked to overland runoff and land use practices. Dissolved Oxygen throughout the Lake Superior - South Watershed was good and can most likely be attributed to the cool water temperatures and high gradient nature of most waterways found within the watershed. Chloride and pH were also good and reflect the heavily forested watershed. Bacteria levels were elevated in some minor watershed that had heavy urban development and may be attributed to common anthropogenic stressors found in urbanized areas. Many coldwater streams are present throughout the Lake Superior - South Watershed with exceptional water quality and additional protections should be considered for streams that display outstanding biological, chemical and physical parameter.

Table 24. Assessment summary for stream water quality in the Lake Superior - South Watershed.

				Supporting		Non-Supporting			
Watershed	Area (Acres)	# Total AUIDs	# Assessed AUIDs	# Aquatic Life	# Aquatic Recreation	# Aquatic Life	# Aquatic Recreation	Insufficient Data	# Delisting's
Lake Superior – South HUC 8	**399,373**	**695**	**42**	**28**	**9**	**11**	**3**	**3**	**1**
Beaver River – Frontal Lake Superior	96,326.4	138	8	6	1	2	0	0	0
Gooseberry River – Frontal Lake Superior	114,541	171	11	9	4	0	0	2	0
Knife River – Frontal Lake Superior	112,864	225	15	11	2	4	1	0	1
City of Duluth – Frontal Lake Superior	75,641.6	161	8	2	2	5	2	1	0

Lake Water Quality

The Lake Superior - South Watershed contains 16 lakes greater than ten acres in size (Table 25). Six of the watershed's larger and notable lakes were monitored in 2011 and 2012 by a mix of MPCA staff, citizen volunteers and Surface Water Assessment Grantees. These lakes included Lax, Christianson, Highland, Stewart, Paradise and Eagle. All lakes met eutrophication standards for cool and warm water lakes in the Northern Lakes and Forest ecoregion, and had good water quality that indicated mesotrophic conditions. Concentrations of phosphorus and chlorophyll-a and Secchi transparencies, were at expected levels given the area's dominant forest and wetland land use and limited amounts of lakeshore development. Some lakes had naturally low transparency due to 'bog staining' from the surrounding wetlands.

Table 25. Assessment summary for lake water chemistry in the Lake Superior - South Watershed.

			Supporting	Non-Supporting		
Watershed	**Area (Acres)**	**Lake >10 Acres**	**# Aquatic Recreation**	**# Aquatic Recreation**	**Insufficient Data**	**# Delisting's**
Lake Superior – South HUC 8	**399,373**	**16**	**6**	**0**	**10**	**0**
Beaver River – Frontal Lake Superior	96,326.4	6	1	0	5	0
Gooseberry River – Frontal Lake Superior	114,541	6	2	0	4	0
Knife River – Frontal Lake Superior	112,864	2	2	0	0	0
City of Duluth – Frontal Lake Superior	75,641.6	2	1	0	1	0

Biological Monitoring

Fish

The Lake Superior Basin spans a total of 49,300 square miles, encompassing three states (Michigan, Minnesota and Wisconsin) and one Province (Ontario). Eighty-eight different species of fish can be found within this basin (including Lake Superior). Although the Lake Superior - South Watershed encompasses only a small percentage (~1%) of the entire basin, 30 species were sampled during this survey (Appendix 10). Historically, fisheries management in streams of this region has focused on the stocking of various trout species. This stocking began as early as 1895 and still continues to this date to supplement recreational fishing within the watershed. As a result, various stream trout can be captured throughout this watershed; including this watersheds only native stream trout, the brook trout (*Salvelinus fontinalis*).

The Lake Superior - South Watershed does not have any endangered species under federal law but has a total of six species listed by the state of Minnesota as being of special concern (Appendix 12). In addition, many introduced and invasive species are known to exist within the watershed, including zebra mussels (*Dreissena polymorpha*), quagga mussels (*Dreissena rostriformis bugensis*), spiny water flea (*Bythotrephes longimanus*) and numerous fish species (Appendix 12). Many of the fish species were either introduced during historical stocking efforts or likely through the exchange of ballast water from oceangoing vessels. This makes streams near the Duluth/Superior Harbor the most vulnerable to aquatic invasive species. In 2010, viral hemorrhagic septicemia (VHS), a microscopic fish disease was discovered in Lake Superior. This fish disease possesses a relatively high risk to fish health within the entire Lake Superior Basin. Only two introduced species were encountered during sampling for this report, including *Salmo trutta* (brown trout) and *Oncorhynchus mykiss* (rainbow trout).

Some fish species occurred in high densities while others had a more limited distribution and low numbers of individuals. The most ubiquitous and abundant fish species within the watershed was the *Rhinichthyns atratulus* (backnose dace), which was sampled at 56 of the 58 stations, totaling 9,287 individuals. Other fish species commonly found throughout the watershed included Creek Chub (*Semotilus atromaculatus*), longnose dace (*Rhinichthys cataractae*) and rainbow trout. A large proportion of the species found during sampling were coldwater obligate species and are relatively sensitive to chemical, biological, and physical changes. Other sensitive species that were found in relatively high number of stations include; brown trout, mottled sculpin (*Cottus bairdii*) and brook trout. Species that are typically found in warmwater systems were encountered in low densities and at limited stations. Overall, the present of relatively sensitive coldwater obligate species, with limited number of tolerant warmwater species indicate exceptional water quality. Problem areas do persist and are likely attributed to natural and anthropogenic stressors that can be found in select drainages.

One particular species, the mottled sculpin, was not collected during sampling of the Knife River proper and its associated tributaries. This entire drainage lacks any recent record of mottled sculpin but yet it is within this species distribution. Streams within the vicinity of the Knife River have prevalent populations and similar habitat features. The mottled sculpin is known to inhabit rocky, cool headwater streams, where they retreat under stones during daylight hours (Becker, 1983). This type of habitat is widespread in the Lake Superior basin, including the Knife River and its tributaries. Historical data from 1940 showed a ubiquitous population within the drainage, with the largest populations in the wider pools below the Knife River falls (Moyle, 1940). The lack of this sensitive coldwater species within the Knife River drainage may warrant further investigation into why a once prevalent population seems to have diminished to nothing.

Macroinvertebrates

Between 2002 and 2012 there were a total of 58 macroinvertebrate monitoring visits (representing 53 stations) within the Lake Superior - South Watershed. Of the 275 unique taxa observed within this watershed, approximately 30% of these represent sensitive taxa (Appendix 11). The most numerous taxa observed were *Rheotanytarsus, Ceratopsyche, Simulim, Polypedium, Lepidostoma, Tvetenia, Hydropsychidae, Baetis flavistriga* and *Chematopsyche*. Many of these taxa represent ubiquitous species found across Minnesota. The macroinvertebrate surveys did not identify species that are considered to be endangered, threatened or of special concern (ETSC) in Minnesota. However, many of the specimens collected during these surveys could be representatives of species on this list, based on their known range, distribution and habitat requirements. Many of the macroinvertebrate communities in the Lake Superior - South Watershed are representative of excellent/exceptional water quality. The subwatersheds within this basin should be managed to maintain these resources.

Watershed-Wide Condition

Fish and macroinvertebrate communities throughout the Lake Superior - South Watershed are in generally good condition, with most F-IBI and M-IBI scores meeting and exceeding impairment thresholds. Habitat, water chemistry and flow may all play a role in the diversity of the species and the relatively high frequency of sensitive species found. Macroinvertebrate communities in particular tend to perform relatively well, perhaps due to fairly diverse and abundant habitat found in most Lake Superior - South streams. Streams with exceptional biological, chemical and physical parameters are worthy of additional protections in order to preserve their valuable aquatic resources. Some of the most worthy waterways according to biological parameters, include McCarthy Creek (04010102-887), Unnamed Creek (West Branch Little Knife River; 04010102-846), Gooseberry River (04010102-502), Stewart River (04010102-503) and Captain Jacobson Creek (04010102-584). Problem areas do occur and persist and are likely a function of both natural and anthropogenic stressors. Many anthropogenic stressors are present throughout the Lake Superior - South Watershed and can vary widely between select drainages.

Fish Contaminant Results

A combined total of twelve fish species were tested for mercury and/or PCBs from six lakes and the Lester River. A total of 220 fish were tested between 1981 and 2012. Fish species are identified by their common name in Table 26, along with a summary of contaminant concentrations by waterway, fish species, and year. The table shows which contaminants, species, and years were sampled for a given lake. "No. Fish" indicates the total number of fish analyzed and "N" indicates the 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 and yellow perch. Since 1989, most of the samples have been skin-on fillets (FILSK) or for fish without scales (catfish and bullheads), skin-off fillets (FILET).

The Lester River was tested in 2011. A composite of five brown trout had a very low mercury concentration of 0.08 mg/kg and a PCBs concentration below the reporting limit of 0.025 mg/kg. Seven creek chub were also composited into one sample, which had a mercury concentration of 0.18 mg/kg and a PCBs concentration below the reporting limit of 0.025 mg/kg. Five rainbow troutwere tested individually. The mean mercury concentration was the same as the creek chub sample, 0.018 mg/kg, but one of the fish had a mercury concentration of 0.35 mg/kg. That high concentration resulted in a calculated 90th percentile mercury concentration that exceeded the 0.2 mg/kg standard; therefore, Lester River has been recommended for the Draft 2014 Impaired Waters List. Poly Chlorinated Biphenyls concentrations in the two largest rainbow trout were below the reporting limit of 0.025 mg/kg. Lester River has been on the Impaired Water List since 1998 for mercury in the water column. The water quality standard for mercury in the Lake Superior Basin is 1.3 ng/L (parts per trillion), which is lower the rest of the state (6.9 ng/L).

All waters listed as impaired due to elevated levels of mercury in fish are identified in Table 26 with a red asterisk (*). Three of the lakes are impaired and included under the Statewide Mercury TMDL. Tettegouche Lake (Lake ID 38-0231) was placed on the Impaired Waters List in 2002 based on the northern pike collected in 2000. Tettegouche northern pike were tested again in 2003 and 2012. The 2003 results were only slightly lower than the 2000 results and in 2012 mercury concentrations were much higher than in those two earlier years. A shift in fish size does not explain the increase in mercury because most of the northern pike were in the same size range in all years (Table 26). Northern pike from Christianson Lake (Lake ID 28-0750) had very high mercury concentrations when tested in 1981 and 1984; however, this lake was not included in the Impaired Waters List because the data are before 1990.

The highest mercury concentration from all tested fish was 1.24 mg/kg in a walleye from Lax Lake, collected in 2006. The mercury levels in largemouth bass and northern pike from Lax Lake were also relatively high.

Poly Chlorinated Biphenyls were tested in a splake from Bean Lake (Lake ID 38-0409-00) and a composite of five northern pike from Christianson Lake in 1981. The latter was below the PCBs reporting limit of 0.025 mg/kg. The reported concentration in the splake from Bean Lake was 0.016, which was above the reporting limit of 0.01 mg/kg. In all cases, PCBs concentrations were not high enough to trigger a fish consumption advisory, which could have led to a recommended impairment if the advisory were more restrictive than a meal per week.

Overall, the fish contaminant results shows PCBs are not a concern in the Lester River, Bean Lake or Christianson Lake. Mercury concentrations in fish tissue sufficiently high for classification as impaired in the Lester River, as well as in the lakes Tettegouche, Lax and Nicado. Christianson Lake (38-0750) should be tested again for mercury in northern pike because results from the 1980s indicate high mercury levels.

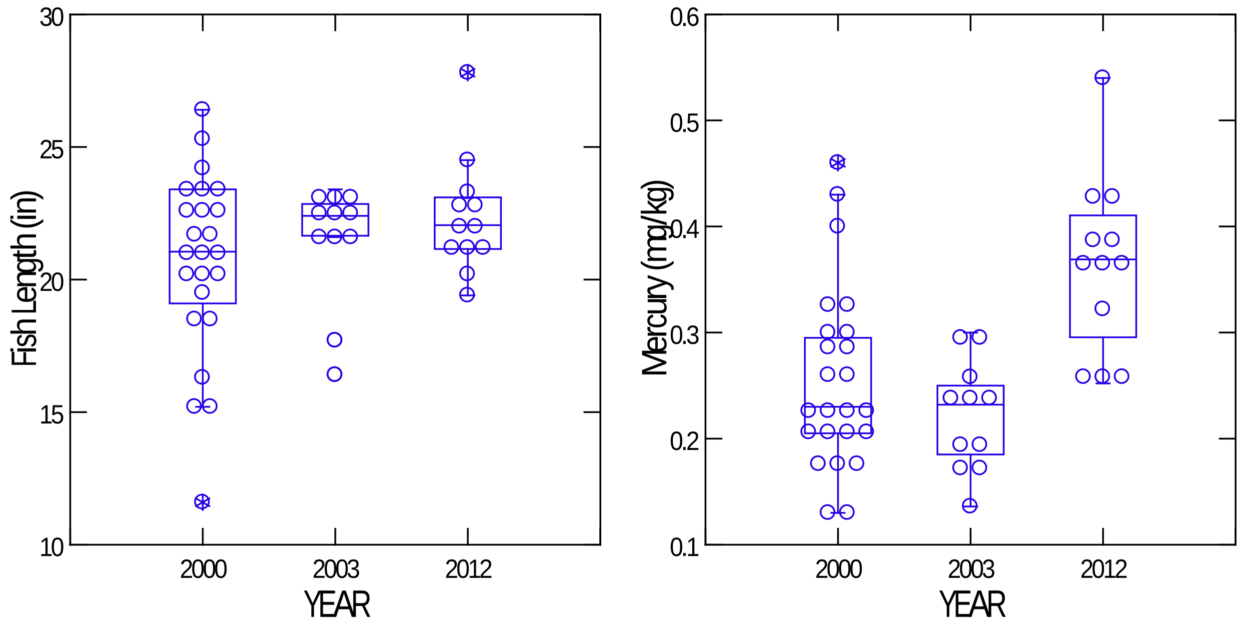

Figure 25. Box plots of fish lengths and mercury concentrations by collection year for northern pike from Tettegouche Lake.

Table 26. Summary statistics of mercury and PCBs, by waterway-species-year.

Waterway	AUID	Location	Species	Year	Anatomy[1]	No. fish	Length (in)			Mercury (mg/kg)				PCBs (mg/kg)	
							Mean	Min	Max	N	Mean	Min	Max	N	Mean
Lester River **	04010102 -548, -549	RM 14.2	Brown Trout	2011	FILSK	5	7.1	7.1	7.1	1	0.08	0.08	0.081	1	< 0.025
			Creek Chub	2011	FILSK	7	6.7	6.7	6.7	1	0.18	0.18	0.18	1	< 0.025
		Upstream of Strand RD	Rainbow Trout	2011	FILSK	5	10.5	8.8	14.3	5	0.18	0.12	0.35	2	< 0.025
Nicado*	38-0230-00		Northern Pike	2009	FILSK	5	20.4	19.5	21	5	0.343	0.305	0.416		
Tettegouche*	38-0231-00		Northern Pike	2000	FILSK	24	20.8	11.6	26.4	24	0.256	0.130	0.460		
				2003	FILSK	11	21.5	16.4	23.4	11	0.221	0.136	0.300		
				2012	FILSK	12	22.4	19.4	27.8	12	0.365	0.252	0.540		
			Yellow Perch	2000	WHORG	10	6.0	4.3	7.2	10	0.109	0.080	0.150		
				2003	WHORG	10	6.3	5.9	6.7	2	0.085	0.082	0.088		
Bear	38-0405-00		Smallmouth Bass	2008	FILSK	8	11.1	10.1	11.6	8	0.127	0.090	0.163		
			White Sucker	2008	FILSK	8	19.8	19.8	19.8	1	0.062				
			Yellow Perch	2008	FILSK	10	10.4	9.6	11.1	3	0.071	0.059	0.080		
Lax*	38-0406-00		Bluegill Sunfish	2006	FILSK	10	8.1	8.1	8.1	1	0.176				
			Black Crappie	2006	FILSK	3	9.7	9.7	9.7	1	0.138				
			Largemouth Bass	2008	FILSK	6	13.5	10.6	15.1	6	0.264	0.152	0.354		
			Northern Pike	1982	FILSK	11	24.7	18.2	32.2	4	0.283	0.260	0.300		
				2006	FILSK	5	26.0	22	30.6	5	0.530	0.289	0.919		
				2008	FILSK	5	18.6	16.2	24.5	5	0.202	0.177	0.233		
			Walleye	2006	FILSK	5	20.6	14	26.8	5	0.672	0.394	1.237		
Bean	38-0409-00		Rainbow Trout	2007	FILSK	5	12.3	10.3	13.3	5	0.019	0.017	0.022		
			Splake	1999	FILSK	10	12.3	10.8	16	10	0.086	0.060	0.180	1	0.016
				2007	FILSK	20	12.3	10	13.6	20	0.078	0.057	0.111		
Christianson	38-0750-00		Northern Pike	1981	FILSK	5	27.1	27.1	27.1	1	1.000			1	< 0.025
					WHORG	5	27.1	27.1	27.1	1	0.630				
				1984	FILSK	15	22.0	18.6	25.3	3	0.563	0.430	0.690		

[1] – Anatomy Codes: FILSK – Edible Fillet, WHORG – Whole Fish

* **Impaired for mercury in Fish Tissue as of 2012 Draft Impaired Waters List; categorized as EPA Class 4a for waters covered by the Statewide Mercury TMDL.**

** **Impaired for mercury in water column as of 1998 and categorized as EPA Class 5; recommended for 2014 Draft Impaired Waters List for mercury in fish tissue.**

Groundwater Quality

In 1999, the MPCA published a study of baseline water quality in northeast Minnesota. This report found that for this region "concentrations of major cations and anions were lower in surficial and buried drift aquifers compared to similar aquifers statewide, while concentrations of trace metals were higher. There appears to be interaction between surficial drift, buried unconfined aquifers and underlying bedrock. Processes occurring in the unsaturated zone appear to have less impact on water quality of these aquifers than in the remainder of the state. Water quality in Precambrian aquifers varies widely, probably due to wide variability in residence times. As residence time increases, concentrations of trace elements increase. Concentrations of most chemicals were well below drinking water criteria, but there were occasional exceedances of drinking criteria by metals such as beryllium, boron and manganese." The MPCA does not currently sample wells from the Lake Superior - South watershed (Figure 26). Samples from nearby wells in similar geology do not suggest a significant shift in regional groundwater quality since the baseline study.

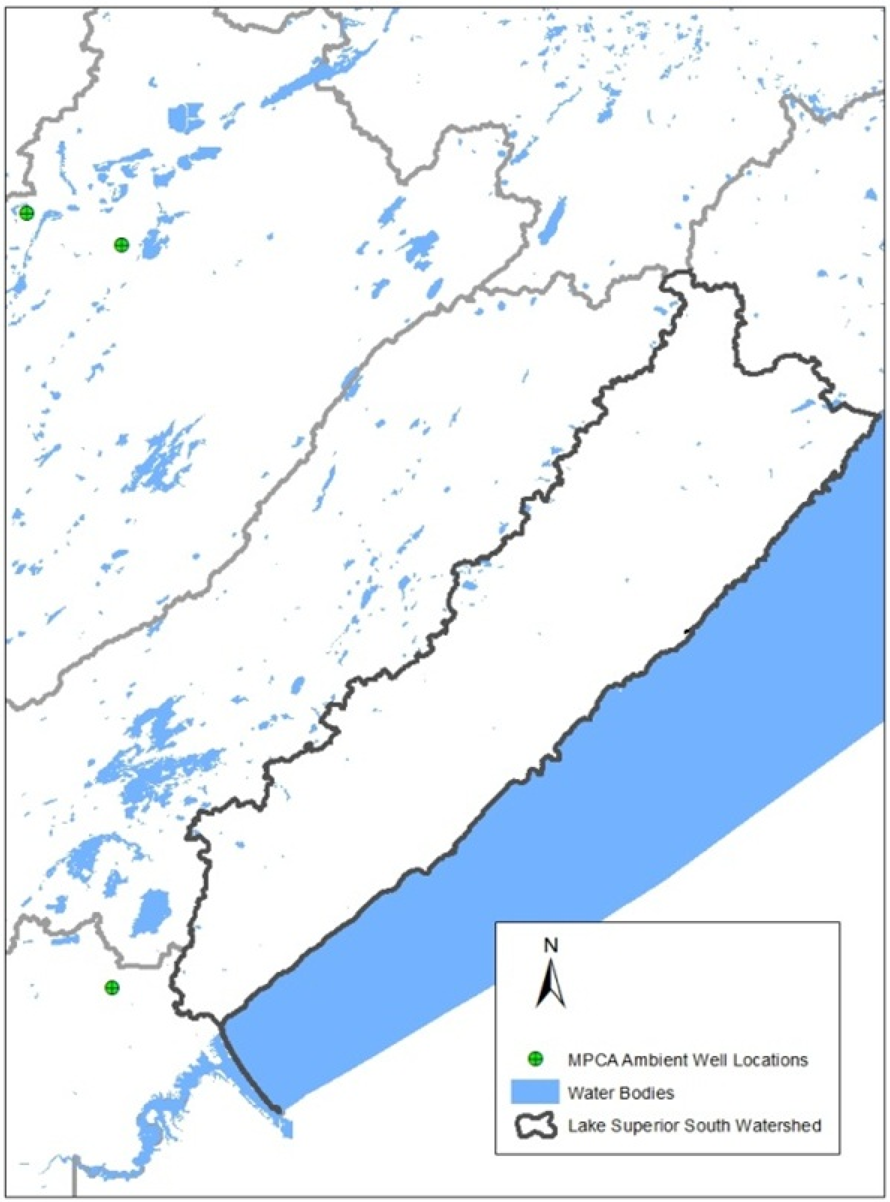

Figure 26. MPCA Ambient Groundwater Monitoring wells near the Lake Superior - South Watershed.

Displayed in Figure 27 are the locations of permitted high-capacity groundwater and surface water withdrawals in the Lake Superior - South Watershed. Blue symbols are groundwater withdrawals and red are surface water, taken from lake, stream or other surface water feature. The three largest permitted consumers of water in the state (in order) are municipalities, industry and irrigation. The withdrawals within the Lake Superior - South Watershed are mostly industrial use and irrigation. Due to the bedrock geology, groundwater is not heavily relied upon for high-capacity use.

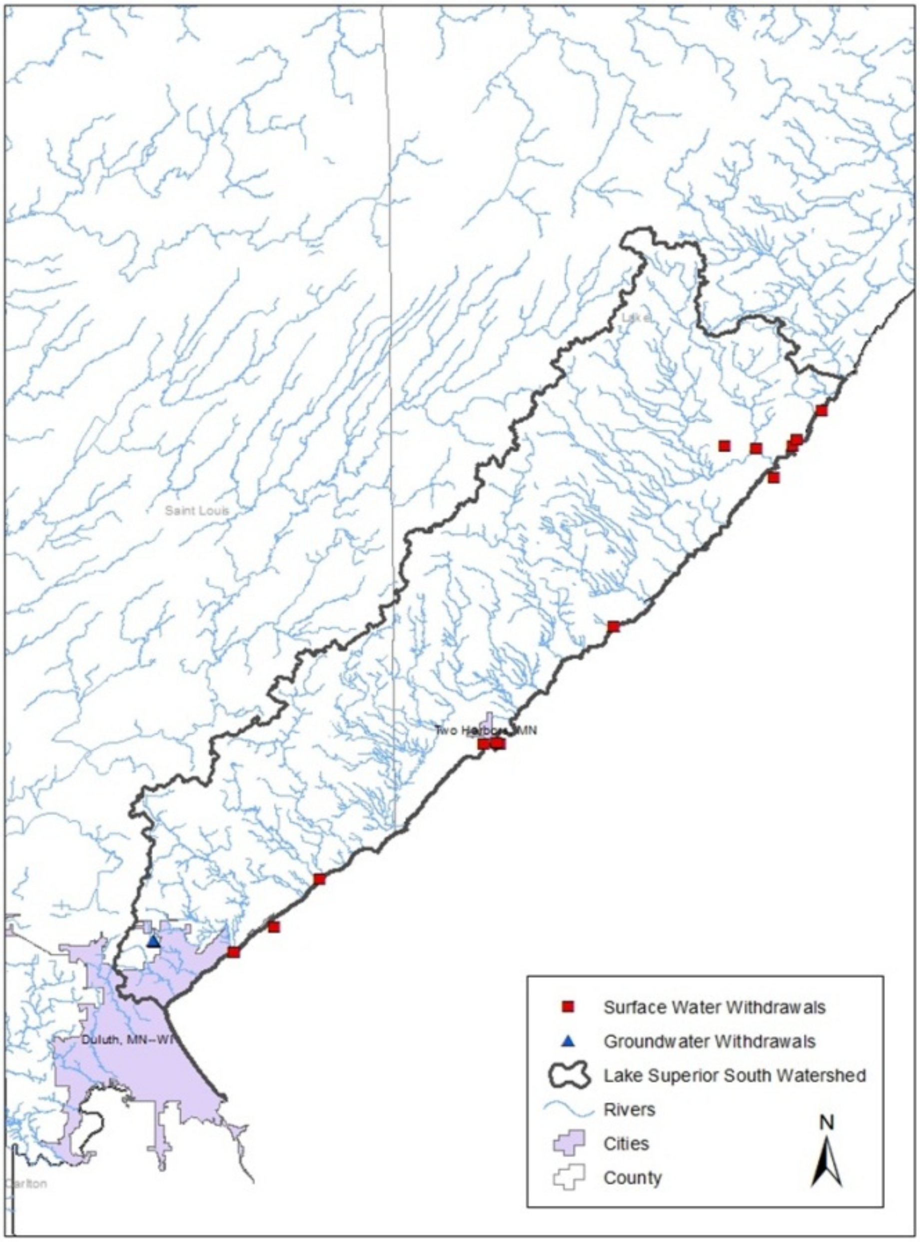

Figure 27. Locations of permitted high-capacity withdrawals in the Lake Superior - South Watershed.

Figure 28 displays total groundwater and surface water withdrawals from the watershed from 1991-2011. During this time period, surface water withdrawals exhibit no statistically significant trend and though the scale of the graph limits the viewable change, total groundwater withdrawals exhibit a significant rising trend (p=0.01).

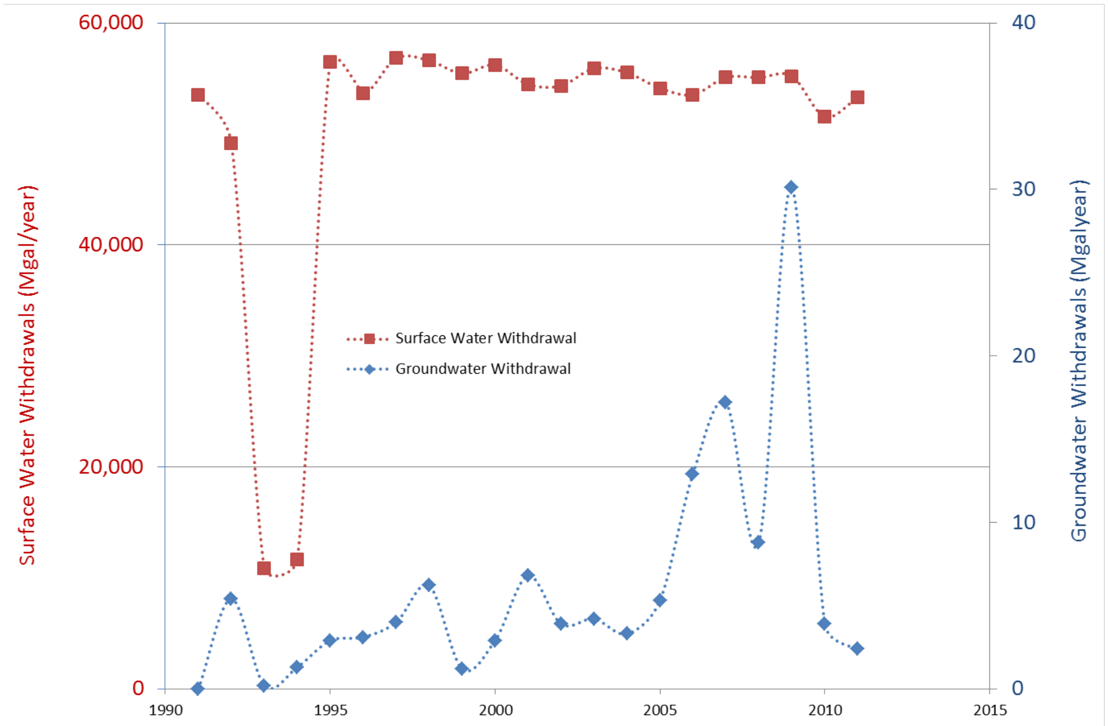

Figure 28. Total annual permitted groundwater and surface water withdrawals within the Lake Superior - South Watershed (1991-2011).

Stream Flow

The data shown in Figure 29, displays a slight decrease in stream flow in the Knife River over time, but not of statistical significance. Figure 30 displays July and August mean flows for the last 20 years for the same water body. Although July and August months appear to display a decreasing flow trend, only July months during this time period exhibit a slight decreasing statistically significant trend (p=0.05). By way of comparison, summer month flows have declined at a statistically significant rate at the majority of streams selected randomly for a study of statewide trends.

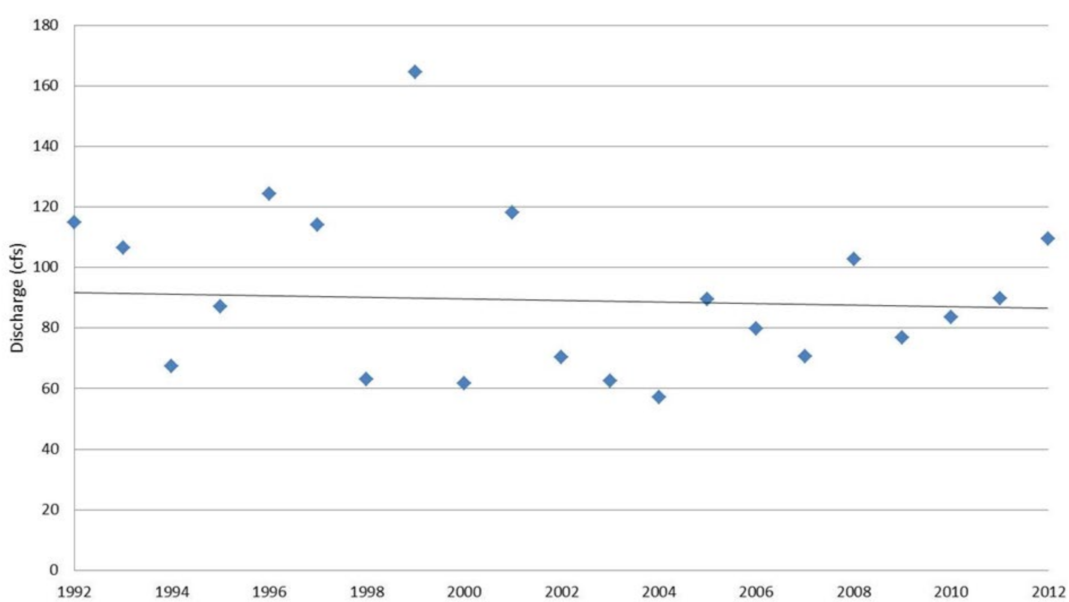

Figure 29. Annual Mean Discharge for the Knife River near Two Harbors, Minnesota (1992-2012).

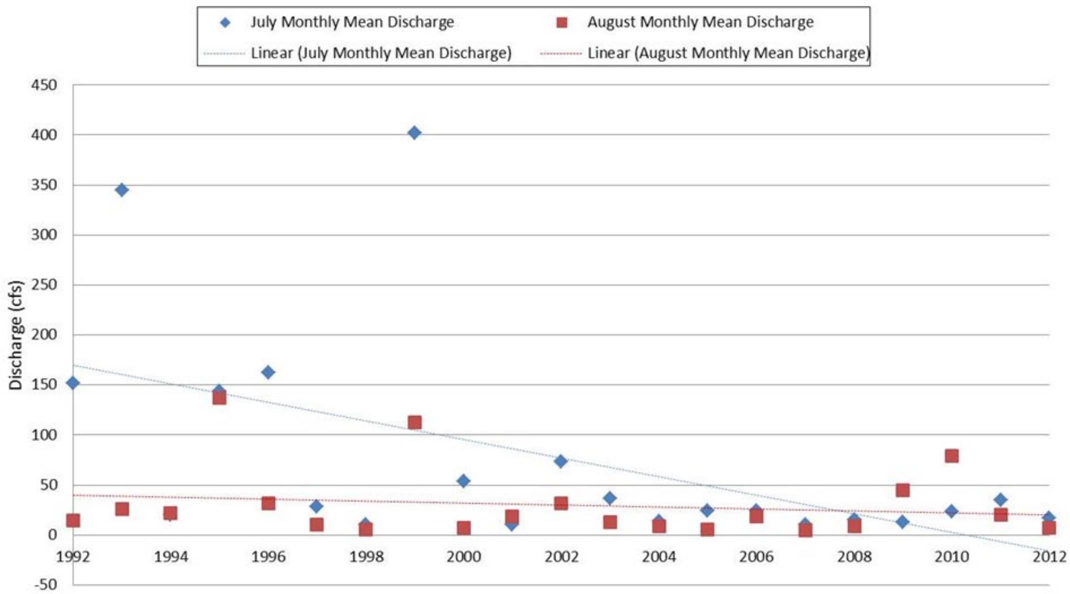

Figure 30. Mean monthly discharge measurements for July and August flows from the Knife River near Two Harbors, Minnesota (1992-2012).

Pollutant Trends for the Lake Superior - South Watershed

Water quality trends at long-term monitoring stations

Water Chemistry data were analyzed for trends (Table 27) for the long term period of record (1967-2009) and near term period of record (1995-2010). There were significant increases in nitrite/nitrates during the long term period of record for the Beaver River and a significant increase in chloride for both the Beaver and Lester River. The Beaver River saw a significant increase in nitrite/nitrate during the short term period. Conversely, there were significant decreases in TSS, TP and biological oxygen demand for the long term period of record while there was no trend with the near term period. No trend was observed for ammonia; however, this may be the result of insufficient data, especially within the most recent time period.

Table 27. Trends in the Lake Superior - South Watershed.

	Total Suspended Solids	Total Phosphorus	Nitrite/ Nitrate	Ammonia	Biochemical Oxygen Demand	Chloride
Beaver River South of CSAH-3 1.5 Mi NW of Beaver Bay (S000-252)(BV-4) (period of record 1973 - 2010)						
overall trend	**decrease**	**decrease**	**increase**	**no trend**	**decrease**	**increase**
estimated average annual change	-2.8%	-3.4%	3.7%		-1.0%	4.9%
estimated total change	-65%	-72%	248%		-30%	491%
1995 - 2010 trend	**no trend**	**no trend**	**increase**	**no trend**	**no trend**	little data
estimated average annual change			11.6%			
estimated total change			528%			
median concentrations first 10 years	4	0.03	0.01	0.06	1	3
median concentrations most recent 10 years	2	0.01	0.39	<0.03	1	7
Knife River Upstream of Old US-61 at Knife River (S000-257)(KN-0.2) (period of record 1973 - 2010)						
overall trend	**decrease**	**decrease**	**no trend**	**no trend**	**decrease**	**no trend**
estimated average annual change	-1.3%	-1.5%			-2.0%	
estimated total change	-40%	-44%			-52%	
1995 - 2010 trend	**no trend**	**no trend**	**no trend**	**no trend**	**no trend**	little data
estimated average annual change						
estimated total change						
median concentrations first 10 years	5	0.03	0.03	0.03	1	6
median concentrations most recent 10 years	2	0.01	0.03	<0.03	<0.5	5
Lester River above Superior St, Lester Pk at Duluth (S000-258)(LE-0.2) (period of record 1973						
overall trend	**decrease**	**decrease**	**no trend**	**no trend**	**no trend**	**increase**
estimated average annual change	-1.6%	-1.7%				2.0%
estimated total change	-45%	-48%				112%
1995 - 2010 trend	**no trend**	**no trend**	**no trend**	**no trend**	**no trend**	little data
estimated average annual change						
estimated total change						
median concentrations first 10 years	5	0.04	0.03	0.06	1	5
median concentrations most recent 10 years	2	0.02	<0.03	<0.03	1	11

(Analysis was performed using the Seasonal Kendall Test for Trends. Trends shown are significant at the 90% confidence level. Percentage changes are statistical estimates based on the available data. Actual changes could be higher or lower. A designation of "no trend" means that a statistically significant trend has not been found; this may simply be the result of insufficient data.)

(Concentrations are median summer (Jun-Aug) values, except for chlorides, which are median year-round values. All concentrations are in mg/L.)

Water Clarity Trends at Citizen Monitoring Stations

Citizen volunteer stream monitoring occurred at only six stations within the Lake Superior - South Watershed during the ten year assessment cycle. A total of 54 historical stream monitoring stations are present within this watershed. All citizen volunteer stream monitoring stations are showing no significant trends in water clarity. A total of three lakes were monitored within this watershed, with none of them showing any water clarity trends. Locations of citizen volunteer stations are displayed in Figure 4, with all historical and current stations identified.

Table 28. Water Clarity Trends at Citizen Stream Monitoring Stations.

Lake Superior - South HUC 04010102	Citizen Stream Monitoring Program	Citizen Lake Monitoring Program
number of stations w/ increasing trend	0	0
number of stations w/ decreasing trend	0	0
number of stations w/ no trend	6 (54 stations with historical data)	3

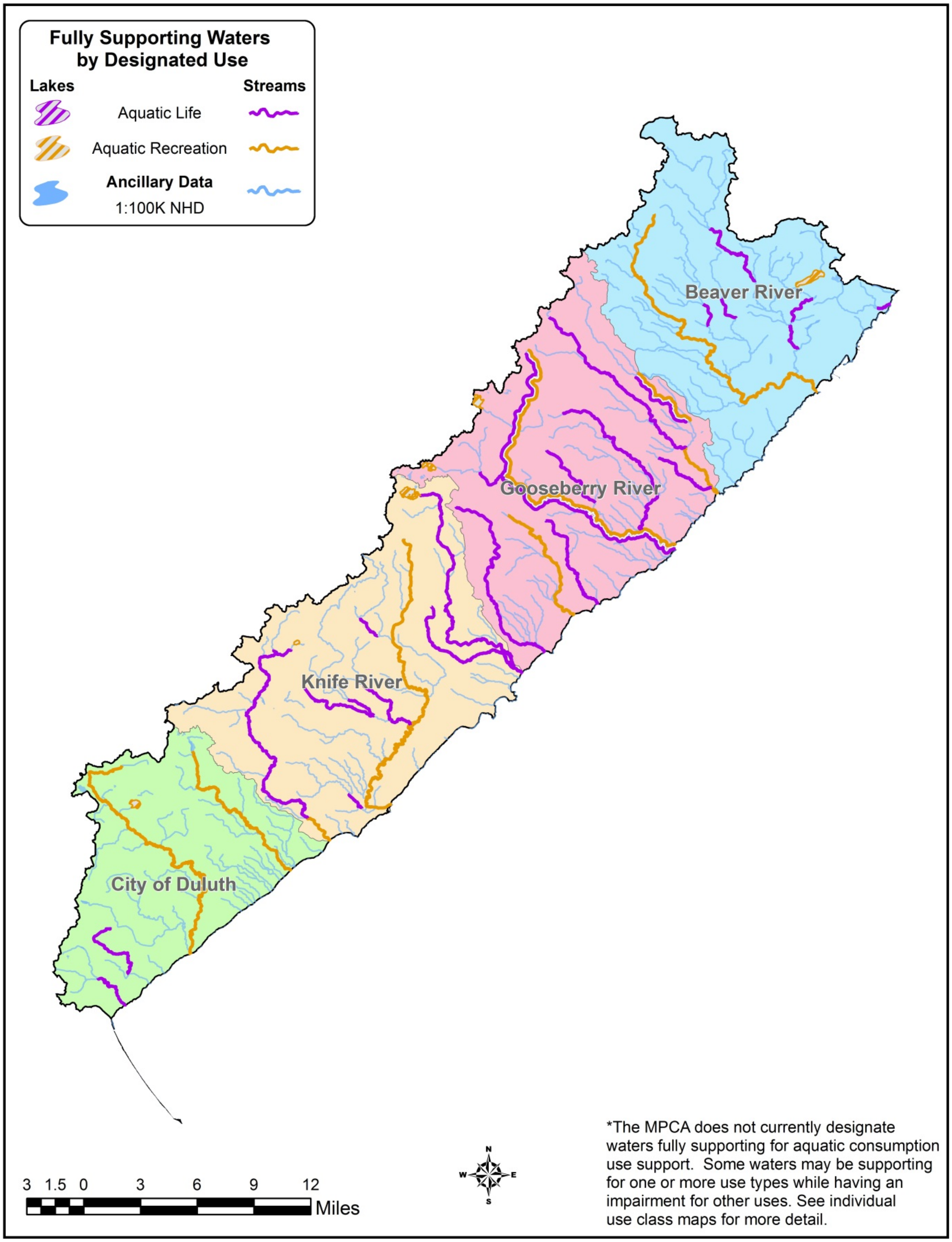

Figure 31. Fully supporting waters by designated use in the Lake Superior - South Watershed.

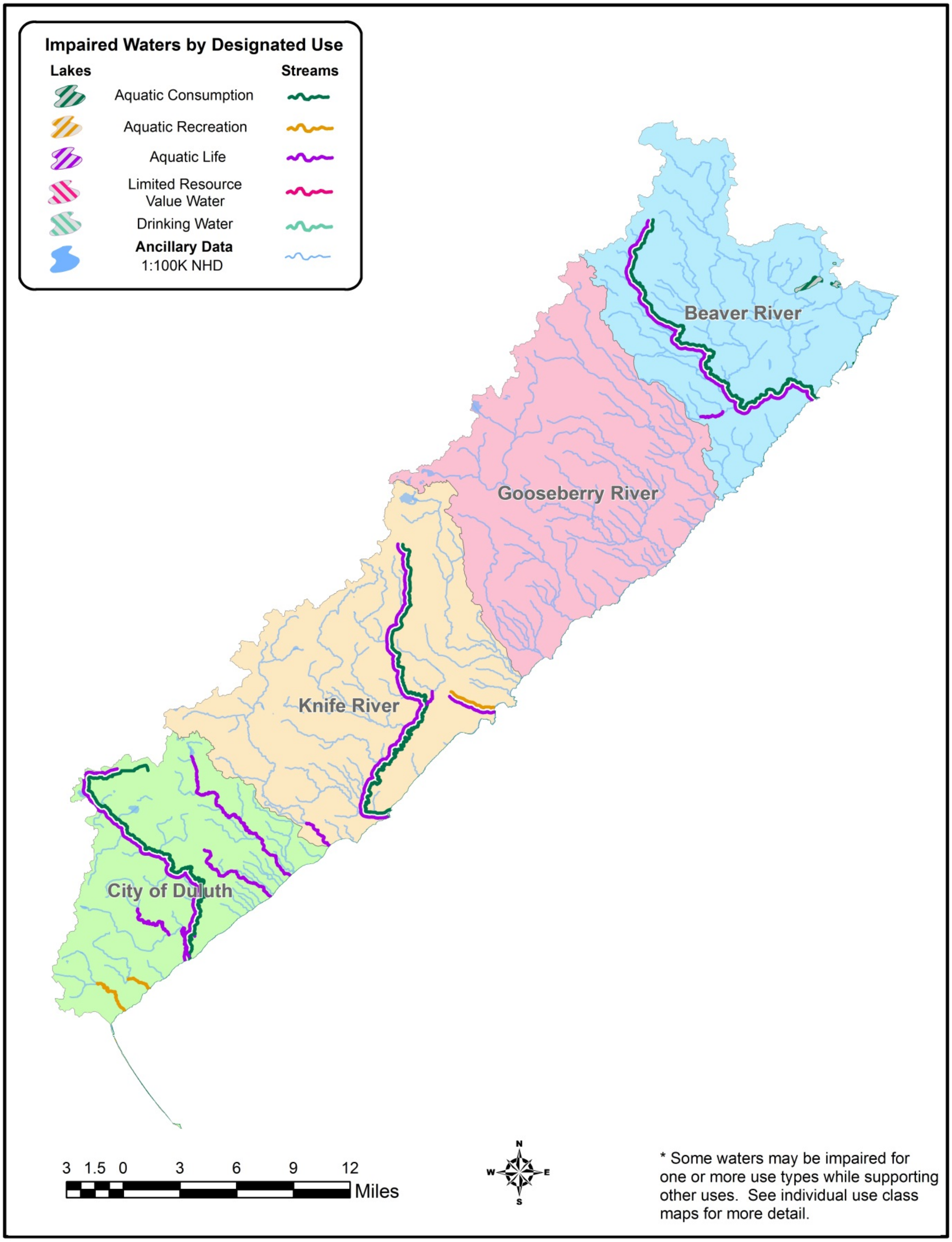

Figure 32. Impaired waters by designated use in the Lake Superior - South Watershed.

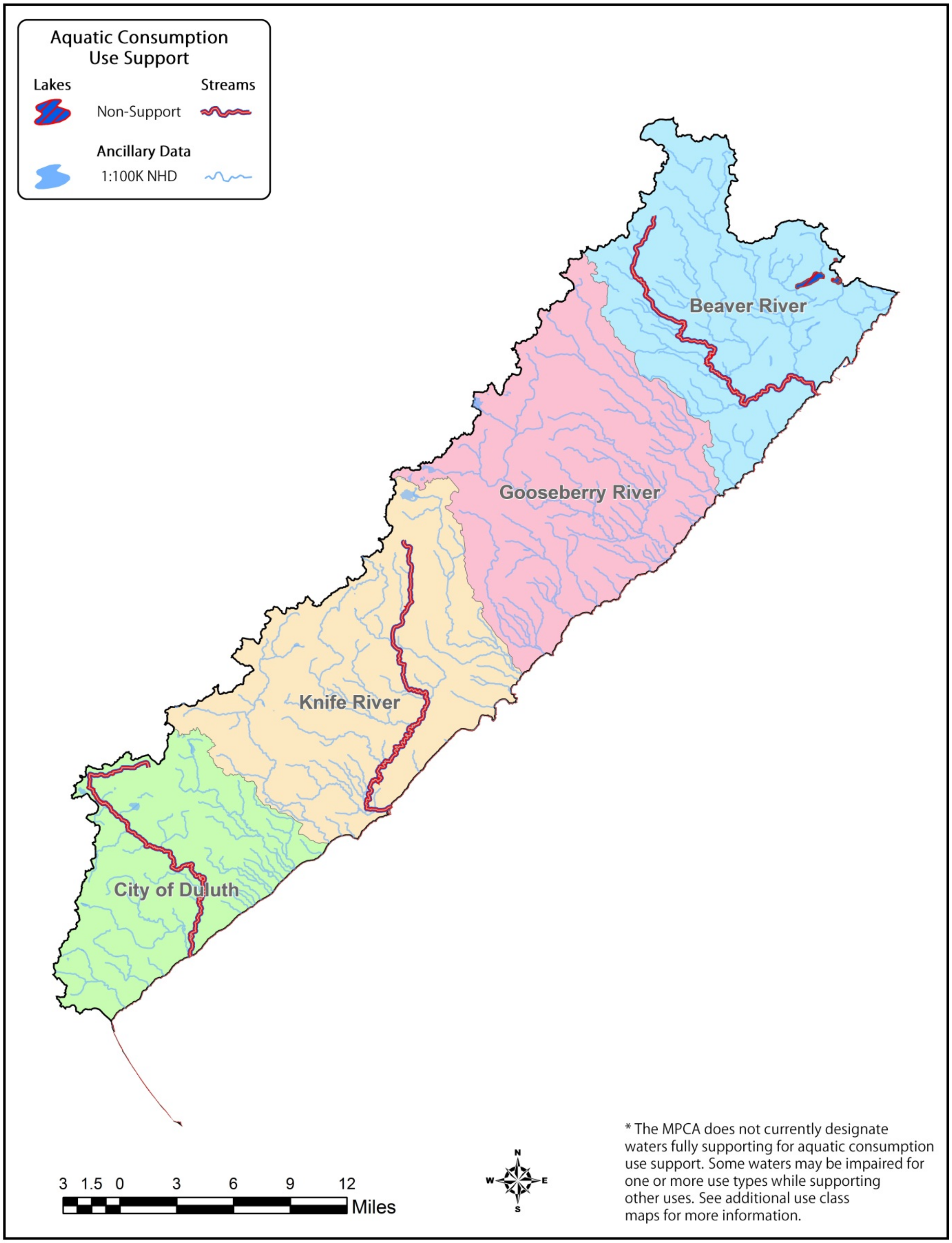

Figure 33. Aquatic consumption use support in the Lake Superior - South Watershed.

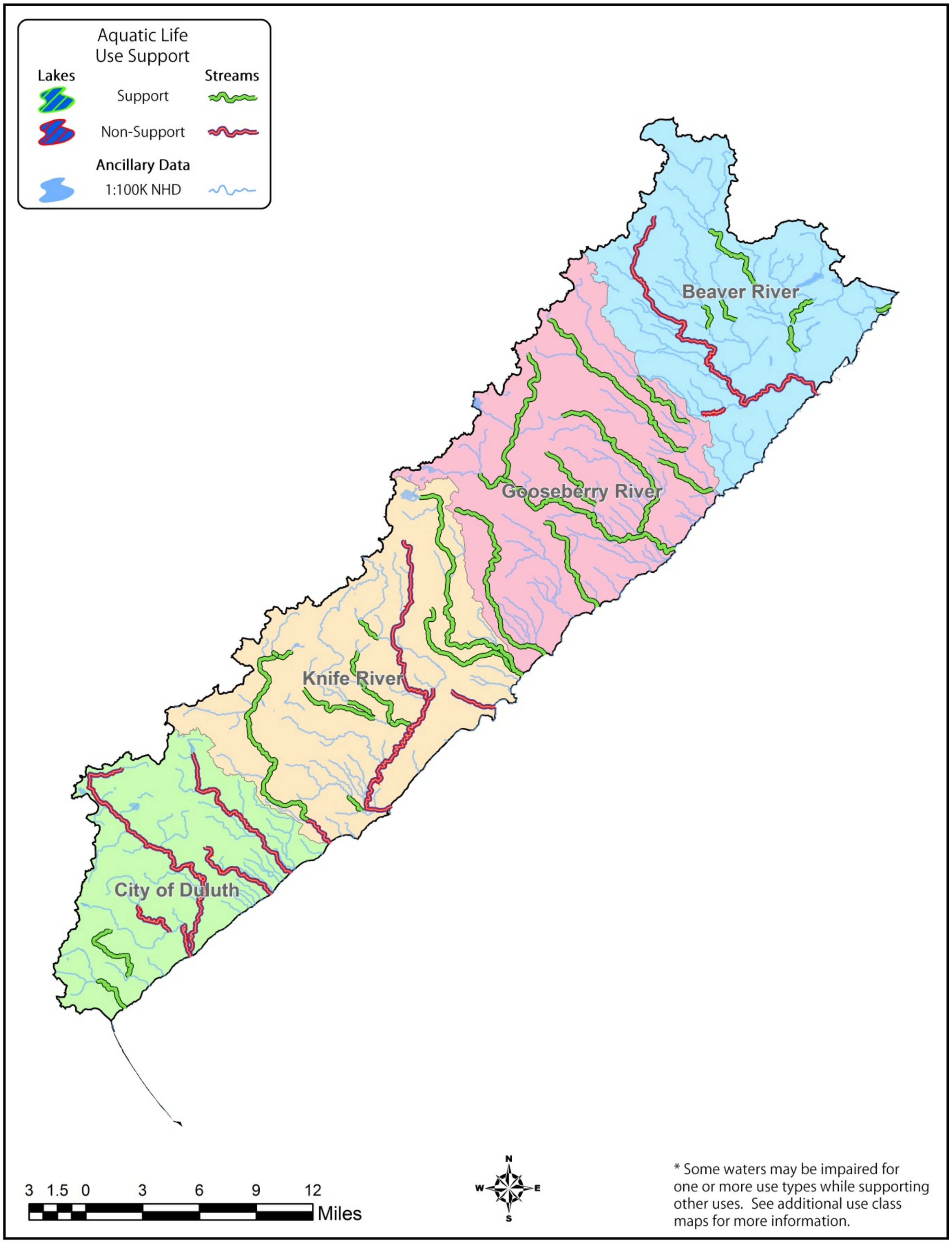

Figure 34. Aquatic life use support in the Lake Superior - South Watershed.

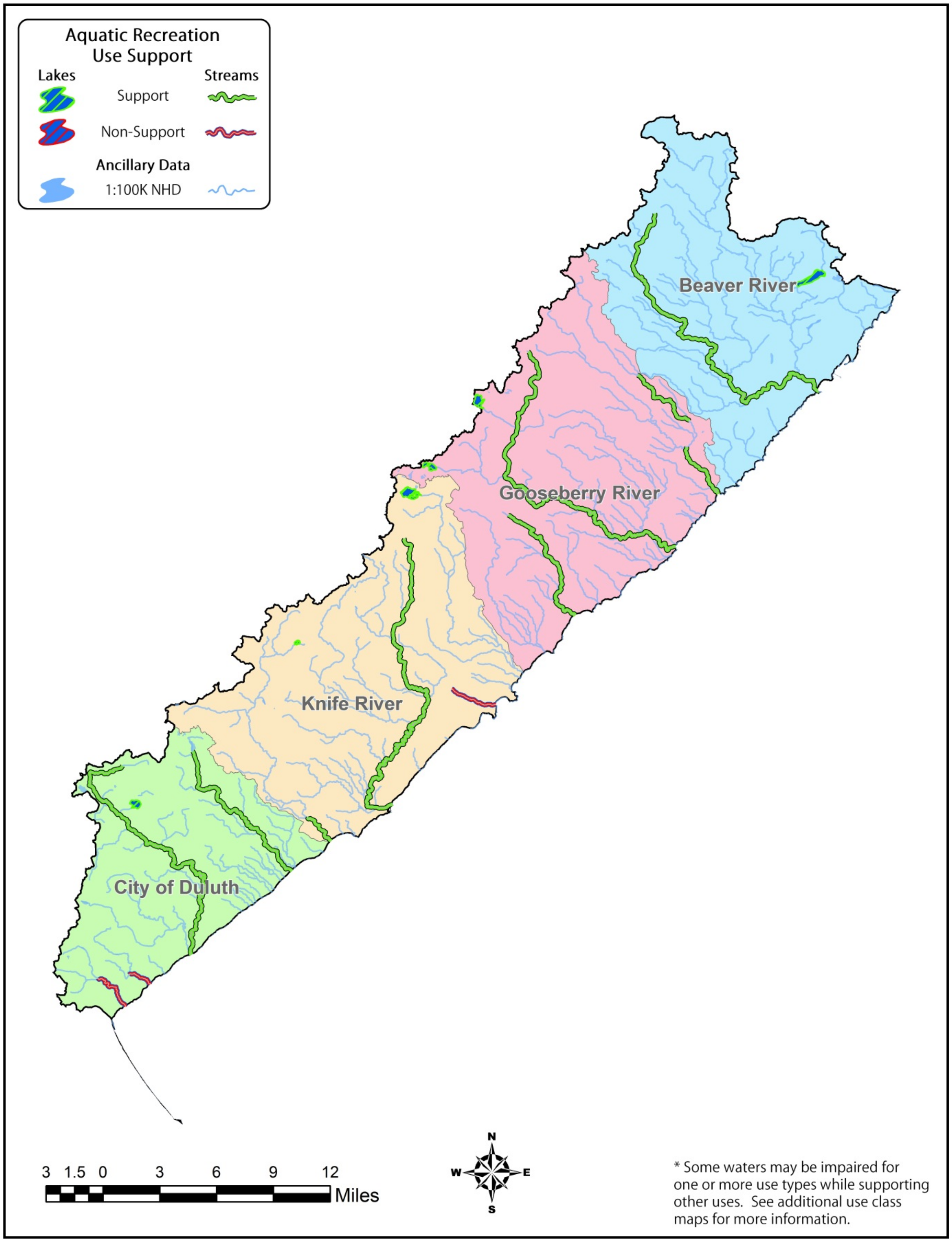

Figure 35. Aquatic recreation use support in the Lake Superior - South Watershed.

VII. Summaries and Recommendations

The “North Shore” of Lake Superior, known for its scenic views, towering pines and magnificent cascades, is home to some of Minnesota’s highest quality trout streams. This entire area, including the Lake Superior - South Watershed, is comprised of vast acreages of both upland and lowland forest. Recreational opportunities are abundant throughout this forested landscape with its streams and lakes as major focal points. This scenic watershed is only 45% privately owned leaving the majority of the land undeveloped and open to the public (NRCS, 2007). The undeveloped nature of this watershed is undoubtedly a key reason for the high water quality found in most parts of the Lake Superior - South Watershed.

Biological monitoring results identified numerous sensitive fish species within the Lake Superior - South Watershed. The majority of the stream segments that were assessable met biological criteria for both fish and macroinvertebrates, and at times significantly exceeded the biological impairment thresholds. A limited number of stations did not meet biological standards and were considered impaired for aquatic life uses. Though many of the reaches were found to be in good biological standing, some chemical aquatic life indicators were exceeding state standards. The chemical impairments, although not reflected in some F-IBI scores, may have a negative effect on biological composition, diversity, and overall health. Habitat, as indicated by MSHA scores, ranged from fair to good, with a relatively high amount of quality habitat accessible for biological communities. Many stations had a variety of habitat that allowed a diversity of species to persist and therefore to be collected during sampling for this report. In some cases high quality in-stream habitat may be mitigating any real change in biological composition from point and non-point pollutants.

Lake water quality is in relatively good condition, with six of the six lakes sampled meeting the eutrophication standards. While all six lakes were fully supporting aquatic recreation, three lakes in no particular order were considered to be of the highest quality; including Lax, Stewart and Paradise Lake. Eagle Lake was the closest to an impairment designation, and while meeting standards, should benefit from additional monitoring and watershed-protection efforts.

Impairments found on stream segments within the Lake Superior - South Watershed are likely a function of both natural and anthropogenic stressors. Streams with larger catchments and higher gradient will tend to have higher turbidity in lower reaches, which is typical of most Lake Superior streams. These conditions are natural, but can result in stressful conditions for biological communities and may be amplified by poor land use practices. Aquatic consumption impairments, caused primarily by atmospheric deposition of mercury from the global burning of fossil fuels, are one of the widest spread impairments in the watershed, including many lakes and rivers. Overland runoff from poor land use practices may be contributing to aquatic consumption impairments. Dissolved oxygen throughout the Lake Superior - South Watershed was in good standing and is attributed to the cool water temperatures and high gradient nature of most waterways found within the watershed. One existing DO impairment occurred on the Little Knife River (04010102-840) but was not revisited in 2011. pH was also meeting standards throughout most of the watershed, with the exception of the Beaver River (04010102-501). This impairment is most likely the result of anthropogenic stressors from historical and current land use practices, including effluent discharge from waste water treatment plants. A delisting of pH as an aquatic life impairment indicator was completed for the Knife River (04010102-504). Bacteria levels (E. coli) were in relatively good standings for most subwatersheds with the exception of three stream segments. Streams that were listed for an exceedance of state standards due to high levels of E. coli were generally found in minor watersheds with heavy urban development and may be attributed to common anthropogenic stressors found in urbanized areas. Two of the 22 Lake Superior beaches did not support aquatic recreation due to exceedances of the state’s bacteria standard. Both beaches were in the direct vicinity of streams that also were listed for high bacteria levels. Periodic high bacteria concentrations in those streams are likely attributing to the beaches non-support of aquatic recreation.

In general, groundwater quality in this watershed is in good condition and its chemistry is largely influenced by residence time in bedrock material; longer residence time will allow for increased concentrations of naturally-occurring elements. With regard to groundwater quantity, the direct correlation of increasing groundwater withdrawals and decreasing surficial water quantity has been documented in other areas of Minnesota such as Little Rock Creek and White Bear Lake. To provide a detailed analysis of withdrawals and water quantity is beyond the scope of this report. In the Lake Superior - South watershed, the relatively small reliance on groundwater for high-capacity use does not suggest priority for further groundwater review.

Overall, lakes and streams within the Lake Superior - South Watershed have benefited from little developmental pressure, but continue to show signs of high sensitivity to anthropogenic stressors like most northern Minnesota aquatic ecosystems. A continued vigilance is necessary to monitor areas where developmental pressures are or will be expected to occur. Point and non-point pollutants within this watershed are affecting water quality and quantity in select drainages, and will be addressed in future TMDLs. A combination of stressors, including urban/industrial development, forest cover change, draining of wetlands/lakes, and the damming of streams, are likely contributing to the reduction of sensitive species throughout the watershed. Streams within the city of Duluth – Frontal Lake Superior Subwatershed were the most impacted and are likely the result of urban/industrial development found within this subwatershed. An emphasis should be given to maintaining natural vegetative buffer areas along shore lines to prevent overland runoff and reduce erosion potential, and should be considered a key protection strategy to maintain the existing high quality of lakes and streams in this watershed. Some of the top aquatic resources found in this watershed include McCarthy Creek (04010102-887), Unnamed Creek (West Branch Little Knife River; 04010102-846) and Gooseberry River (04010102-502). A complete list of the top ten highest quality stream resources within this watershed as indicated by biological (F-IBI & M-IBI) and physical (MSHA) parameters are displayed in Table 29. Those streams that have exceptional biological, chemical and physical parameters are worthy of additional protections in order to preserve their valuable aquatic resources.

Table 29. Top ten stream resources in the Lake Superior - South Watershed as indicated by biological (F-IBI and M-IBI) and physical (MSHA) parameters.

Rank	Stream Name	Biological Station ID	Location of Biological Station
1	McCarthy Creek	11LS007	Downstream of Carr Rd, 7.5 mi. NW of Knife River
2	Unnamed Creek (W. Br. Little Knife River)	11LS015	Upstream of CSAH 11, 6 mi. W of Two Harbors
3	Gooseberry River	11LS030	Upstream of Big Noise Rd, 3 mi. E of Highland
		97LS103	Upstream of CSAH 3, 10 mi. NE of Two Harbors
		11LS040	Upstream of Hwy 61, In Gooseberry Falls State Park
4	Stewart River	99LS010	Downstream of CR 302, 8 mi. NW of Two Harbors
		11LS006	Adjacent to Stewart River Rd, 3 mi. NE of Two Harbors
5	Captain Jacobson Creek	11LS017	Upstream of CSAH 41, 6 mi. W of Two Harbors
6	Big Thirtynine Creek	11LS034	Upstream of CSAH 15 (FH 11), 7 mi. NW of Silver Bay
7	West Split Rock River	84LS022	Upstream of CSAH 3, 2 mi. E of Beaver Crossing
8	Palisade Creek	98LS027	Upstream of Hwy 61, 1 mi. NE of Silver Bay
9	Big Sucker Creek (Sucker River)	97LS089	Upstream of CSAH 40, 8 mi. NE of Duluth
10	Little Stewart River	99LS012	Upstream of Private Dr, off Press Camp Rd, 2 mi. NE of Two Harbors

Literature Cited

Acreman, M., & Holden, J. (2013). How Wetlands Affect Floods. *Wetlands, Volume 33, Issue 5*, 773-786.

Becker, G. C. (1983). *Fishes of Wisconsin.* Madison, WI: University of Wisconsin Press.

Division of Waters, Minnesota Conservation Department. (1959). *Hydrologic Atlas of Minnesota.* Saint Paul, MN: Minnesota Conservation Department.

James M. Omernik, A. L. (1988). *Ecoregions of the Upper Midwest States.* Chicago, IL: United State Environmental Protection Agency.

Kaushal, Sujay S; Likens, Gene E; Utz, Ryan M; Pace, Michael L; Grese, Melissa; Yepsen, Metthea. (2013). Increased River Alkalinization in the Eastern U.S. *Environmental Science & Technology*, 10203-10311.

King, F. A. (2003). *Minnesota Logging Railroads.* Minneapolis, MN: University of Minnesota Press.

Kloiber, S., & Norris, D. (2013). *Status and Trends of Wetlands in Minnesota: Wetland Quantity Trends from 2006 to 2011.* Saint Paul, MN: Minnesota Department of Natural Resources.

Larson, A. M. (2007). *The White Pine Industry in Minnesota: A History.* Minneapolis, MN: University of Minnesota Press.

Lenntech. (1998). *Lenntech - Water Treatment Solutions*. Retrieved 2014, from Acids & Alkalis in Freshwater: http://www.lenntech.com/aquatic/acids-alkalis.htm

Lory, J. A. (1999). *Agricultural Phosphorus and Water Quality.* Columbia, MO: University of Missour Extension.

Lusardi, B. (1997). *Minnesota at a Glance: Quaternary Glacial Geology.* Saint Paul, MN: Minnesota Geological Survey.

McCollor, S., & Heiskary, S. (1993). *Selected Water Quality Characteristics of Minimally Impacted Streams for Minnesota's Seven Ecoregions. Addendum to G. Fandrei, S. Heiskary, and S. McCollor. 1988. Descriptive Characteristics of Seven Ecoregions in Minnesota.* Saint Paul, MN1993: Minnesota Pollution Control Agency.

Meyer, R. W. (1991). *Everyone's Country Estate: A History of Minnesota's State Parks.* Minnesota Historical Society Press: Saint Paul, MN.

Midwestern Regional Climate Center (MRCC). (2013). *Midwestern Regional Climate Center*. Retrieved January 2014, from Climate Summaries: http://mrcc.isws.illinois.edu/climate_midwest/maps/mn_mapselector.htm

Minnesota Department of Agriculture - Pesticide and Fertilizer Management. (2009). *2009 Water Quality Monitoring Report.* Saint Paul, MN: Minnesota Department of Agriculture.

Minnesota Department of Natural Resources (MDNR). (2013, December). *Minnesota Department of Natural Resources*. Retrieved January 2014, from Water Year Precipitation Maps: http://www.climate.umn.edu/doc/hydro_yr_pre_maps.htm

Minnesota Department of Natural Resources (MDNR). (2013, January 8). Deserae Hendrickson (Duluth Area Fisheries Supervisor). (N. Mielke, S. Niemela, & B. Lundeen, Interviewers)

Minnesota Pollution Control Agency (MPCA). (2007). *Minnesota Statewide Mercury Total Maximum Daily Load.* Saint Paul, MN: Minnesota Pollution Control Agency.

Minnesota Pollution Control Agency (MPCA). (2008). *Regionalization of Minnesota's Rivers for Application of River Nutrient Criteria.* Saint Paul, MN: Minnesota Pollution Control Agency.

Minnesota Pollution Control Agency (MPCA). (2008). *Relation of Nutrient Concentrations and Biological Responses in Minnesota Streams: Applications for River Nutrient Criteria Development.* Saint Paul, MN: Minnesota Pollution Control Agency.

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

Minnesota Pollution Control Agency (MPCA). (2010). *Aquatic Life Water Quality Standards Technical Support Document for Nitrate.* Saint Paul, MN: Minnesota Pollution Control Agency.

Minnesota Pollution Control Agency (MPCA). (2011). *Aquatic Life Water Quality Standards Draft Technical Support Document for Total Suspended Solids (Turbidity).* Saint Paul, MN: Minnesota Pollution Control Agency.

Minnesota Pollution Control Agency (MPCA). (2012). *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 305(b) Report and 303(d) List.* Saint Paul, MN: Minnesota Pollution Control Agency.

Minnesota Pollution Control Agency (MPCA). (2012). *Status and Trends of Wetlands in Minnesota: Depressional Wetland Quality Baseline.* Saint Paul, MN: Minnesota Pollution Control Agency.

Minnesota Pollution Control Agency (MPCA). (2013, October 1). *Minnesota Pollution Control Agency*. Retrieved January 2014, from Minnesota Milestone River Monitoring Program: 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). (March 1999). *Baseline Water Quality of Minnesota's Principal Aquifers: Region 1, Northeastern Minnesota.* Saint Paul, MN: Minnesota Pollution Control Agency.

Minnesota Rules Chapter 7050. (2008). Standards for the Protection of the Quality and Purity of the Waters of the State. Saint Paul, MN: Revisor of Statutes and Minnesota Pollution Control Agency.

Minnesota State Climatologists Office (MSCO). (2012). *Minnesota Climatology Working Group*. Retrieved from State Climatology Office - DNR Division of Ecological and Water Resources - University of Minnesota: http://climate.umn.edu/

Minnesota State University, Mankato Water Resources Center; Minnesota Pollution Control Agency; Minnesota Repartment of Agriculture; United State Geological Survey. (2009). *State of the Minnesota River: Summary of Surface Water Quality Monitoring 2000-2008.* Mankato, MN: Minnesota State University, Mankato .

Moyle, J. B. (1940). *Survey of Knife River - Lake County, Minnesota.* Duluth, MN: Minnesota Department of Natural Resources.

Natural Resource Conservation Service (NRCS). (2007). *Rapid Watershed Assessment: Beaver-Lester (MN) HUC: 04010102.* Washington, DC: United States Department of Agriculture.

Ojakangas, R. W., & Matsch, C. L. (1982). *Minnesota's Geology.* University of Minnesota Press: Minneapolis, MN.

Omernik, J. M. (1988). *Ecoregions of the Upper Midwest States.* Chicago, IL: U. S. Environmental Protection Agency.

United State Department of Agriculture & Natural Resources Conservation Service (USDA/NRCS). (2006). *Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin.* Washington, D.C.: United States Department of Agriculture.

Waters, T. (1977). *The Rivers and Streams of Minnesota.* Minneapolis, MN: University of Minnesota Press.

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.''

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

Appendix 2 – Intensive Watershed Monitoring Water Chemistry Stations in the Lake Superior - South Watershed

Biological Station ID	STORET/EQuIS ID	Waterbody Name	Location	10-digit HUC
11LS022	S006-234	Beaver River	Downstream of Minnesota State Highway 61 in Beaver Bay, MN	0401010201
- -	S006-235	Split Rock River	Downstream of Minnesota State Highway 61 just 5 miles Northeast of Castle Danger, MN	0401010202
11LS040	S000-256	Gooseberry River	Downstream of Minnesota State Highway 61 in Gooseberry Falls State Park	0401010202
92LS050	S006-240	Knife River	Upstream of County Road 102 (Church Street) in Knife River, MN	0401010203
11LS041	S006-239	Sucker River	Upstream of County Road 61 (Scenic Highway) Bridge just 11 miles Southwest of Two Harbors, MN	0401010203
- -	S006-238	Lester River	Downstream of London Road in Duluth, MN	0401010204

Appendix 3 – AUID Table of Stream Assessment Results (by Parameter and Beneficial Use)

AUID DESCRIPTIONS					USES					BIOLOGICAL CRITERIA		WATER QUALITY STANDARDS					
Assessment Unit ID (AUID)	Stream Segment Name	Reach Description	Reach Length (Miles)	Use Class	Aquatic Life	Aquatic Recreation	Aquatic Consumption	Drinking Water	303d List Impairments 2012	Fish	Macroinvertebrates	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Bacteria (Aquatic Recreation)
	HUC 10: 0401010201 (Beaver River-Frontal Lake Superior)																
04010102-501	Beaver River	Headwaters to Lk Superior	23.4	2A	NS	FS	- -	IF	T, pH, HGW	EXP	MTS	MTS	EXP	MTS	EXP	MTS	MTS
04010102-529	Palisade Creek	Unnamed Cr to Lk Superior	0.89	2A	FS	NA	- -	- -	- -	MTS	MTS	- -	- -	- -	- -	- -	- -
04010102-530	Beaver River, East Branch	Unnamed Cr to Unnamed Cr	5.22	2A	FS	NA	- -	- -	- -	MTS	MTS	- -	- -	- -	- -	- -	- -
04010102-535	Beaver River, East Branch	Cedar Cr to Unnamed Cr	1.83	2A	FS	NA	- -	- -	- -	MTS	MTS	- -	- -	- -	- -	- -	- -
04010102-572	Cedar Creek	Unnamed Lk (38-0407-00) outlet to Unnamed Cr	2.17	2A	FS	NA	- -	- -	- -	MTS	MTS	- -	- -	- -	- -	- -	- -
04010102-577	Beaver River, West Branch	Unnamed Cr to Unnamed Cr	1.62	2A	NS	NA	- -	- -	- -	EXP	EXP	- -	- -	- -	- -	- -	- -
04010102-B28	Big Thirtynine Creek	Unnamed Cr to Unnamed Cr	1.44	2A	FS	NA	- -	- -	- -	MTS	MTS	- -	- -	- -	- -	- -	- -
04010102-B44	Little Thirtynine Creek	Unnamed Cr to Unnamed Cr	1.56	2A	FS	NA	- -	- -	- -	MTS	MTS	- -	- -	- -	- -	- -	- -
	HUC 10: 0401010202 (Gooseberry River-Frontal Lake Superior)																
04010102-502	Gooseberry River	Headwaters to Lk Superior	22.97	2A	FS	FS	- -	IF	- -	MTS	MTS	MTS	MTS	MTS	MTS	MTS	MTS
04010102-513	Silver Creek	Headwaters to Lk Superior	12.9	2A	FS	NA	- -	- -	- -	MTS	MTS	- -	MTS	- -	- -	- -	- -
04010102-515	Crow Creek	Headwaters to Lk Superior	6.74	2A	FS	NA	- -	- -	- -	MTS	MTS	- -	- -	- -	- -	- -	- -
04010102-519	Split Rock River	W Br Split Rock R to Lk Superior	3.77	2A	IF	FS	- -	IF	- -	- -	- -	MTS	IF	MTS	MTS	MTS	MTS
04010102-520	West Split Rock River	Headwaters to Split Rock R	12.02	2A	FS	NA	- -	- -	- -	MTS	MTS	- -	- -	- -	- -	- -	- -
04010102-551	Skunk Creek	T55 R10W S14, W Line to T54 R9W S16, S Line	11.1	2A	FS	NA	- -	- -	- -	MTS	MTS	- -	- -	- -	- -	- -	- -
04010102-554	Encampment River	T54 R10W S17, W Line to Lk Superior	8.58	2A	IF[1]	FS	- -	IF	- -	IF	MTS	MTS	MTS	MTS	MTS	MTS	MTS
04010102-668	Dago Creek	Headwaters to Unnamed Cr	4.72	2A	FS	NA	- -	NA	- -	MTS	MTS	- -	- -	- -	- -	- -	- -
04010102-740	Little Gooseberry River	Unnamed Cr to Gooseberry R	2.06	2A	FS	NA	- -	- -	- -	MTS	MTS	- -	- -	- -	- -	- -	- -

04010102-A41	Unnamed Creek (Split Rock R Trib)	T55 R9W S24, W Line to Split Rock R	4.09	2A	FS	NA	- -	- -	- -	- -	MTS	- -	- -	- -	- -	- -	- -
04010102-A44	East Split Rock River	Unnamed Cr to Unnamed Cr	4.36	2A	FS	FS	- -	IF	- -	MTS	MTS	MTS	MTS	MTS	MTS	MTS	MTS
	HUC 10: 0401010203 (Knife River-Frontal Lake Superior)																
04010102-503	Stewart River	Headwaters (Stewart Lk 38-0744-00) to Lk Superior	17.22	2A	FS	NA	- -	- -	- -	MTS	MTS	- -	MTS	- -	- -	- -	- -
04010102-504	Knife River	Headwaters to Lk Superior	23.84	2A	NS	FS	- -	IF	T, pH, HGW	MTS	MTS	MTS	EXS	MTS	MTS	MTS	MTS
04010102-528	Skunk Creek	Headwaters to Lk Superior	2.75	2B	NS	NS	- -	- -	T	- -	- -	- -	EXP	MTS	MTS	MTS	EX
04010102-538	Knife River, West Branch	Unnamed Cr to Knife River	1.54	2A	FS	NA	- -	- -	- -	MTS	MTS	- -	- -	- -	- -	- -	- -
04010102-555	Big Sucker Creek (Sucker River)	Unnamed Cr to Lk Superior	2.12	2A	NS	FS	- -	IF	T	MTS	MTS	MTS	EXP	MTS	MTS	- -	MTS
04010102-556	Big Sucker Creek (Sucker River)	T53 R12W S20, N Line to Unnamed Cr	15.84	2A	FS	NA	- -	- -	- -	MTS	MTS	- -	IF	- -	- -	- -	- -
04010102-584	Captain Jacobson Creek	T53 R12W S33, N Line to W Br Knife R	4.89	2A	FS	NA	- -	- -	- -	MTS	MTS	- -	- -	- -	- -	- -	- -
04010102-586	Knife River, West Branch	Unnamed Cr to Captain Jacobson Cr	1.81	2A	FS	NA	- -	- -	- -	MTS	MTS	- -	- -	- -	- -	- -	- -
04010102-824	Little Knife River	Unnamed Cr to Unnamed Cr	1.2	2A	FS	NA	- -	- -	- -	MTS	MTS	- -	MTS	- -	- -	- -	- -
04010102-825	Little Knife River	Unnamed Cr to Unnamed Cr	2.11	2A	IF	NA	- -	- -	- -	- -	- -	- -	MTS	- -	- -	- -	- -
04010102-840	Little Knife River (E Br Little Knife R)	Unnamed Cr to Knife R	0.84	2A	NS	NA	- -	- -	DO, T	- -	- -	EXP	EXS	- -	MTS	- -	- -
04010102-846	Unnamed Creek (W Br Little Knife R)	Unnamed Cr to W Br Knife R	3.06	2A	FS	NA	- -	- -	- -	MTS	MTS	- -	- -	- -	- -	- -	- -
04010102-847	Unnamed Creek (W Br Little Knife R)	Unnamed Cr to Unnamed Cr	2.4	2A	IF	NA	- -	- -	- -	- -	- -	MTS	MTS	- -	MTS	- -	- -
04010102-887	McCarthy Creek	Unnamed Cr to Unnamed Cr	1.53	2A	FS	NA	- -	- -	- -	MTS	MTS	- -	- -	- -	- -	- -	- -
04010102-A94	Little Stewart River	T53 R11W S3, W Line to Stewart R	8.6	2A	FS	NA	- -	- -	- -	MTS	MTS	- -	- -	- -	- -	- -	- -
04010102-B01	Brophy Creek	T53 R12W S19, N Line to Big Sucker Cr	0.31	2A	FS	NA	- -	- -	- -	MTS	MTS	- -	- -	- -	- -	- -	- -
04010102-C16	Knife River, West Branch	T54 R12W S36, E Line to Unnamed Cr	4.65	2B†	FS	NA	- -	NA	- -	MTS	- -	- -	- -	- -	- -	- -	- -
	HUC 10: 0401010204 (City of Duluth-Frontal Lake Superior)																
04010102-508	Talmadge River (Talmadge Creek)	Headwaters to Lk Superior	6.17	2A	NS	IF	- -	IF	DO, T	EXP	MTS	EXP[3]	EXP	MTS	MTS	- -	IF
04010102-509	Schmidt Creek	T51 R12W S17, N Line to Lk Superior	0.66	2A	IF	NA	- -	- -	- -	- -	- -	- -	MTS	- -	- -	- -	- -
04010102-511	Amity Creek	Unnamed Cr to Lester R	2.25	2A	NS	NA	- -	IF	T	MTS	MTS	MTS	EXS	MTS	MTS	MTS	- -
04010102-540	Amity Creek, East Branch	Unnamed Cr to Amity Cr	3.59	2A	NS	IF	- -	IF	- -	MTS	MTS	MTS	EXS	MTS	MTS	MTS	IF

04010102-541	Amity Creek	Mud Lk to E Br Amity Cr	6.73	2A	IF	NA	- -	- -	- -		- -	- -	- -	MTS	- -	- -	- -	- -
04010102-543	Tischer Creek	Headwaters to Unnamed Cr	5.02	2A	FS	NA	- -	- -	- -		MTS	MTS	- -	MTS	- -	- -	- -	- -
04010102-544	Tischer Creek	Unnamed Cr to Lk Superior	1.49	2A	IF[2]	NS	- -	IF	- -		IF	MTS	IF	EXP	MTS	MTS	MTS	EX
04010102-545	Chester Creek	E Br Chester Cr to Lk Superior	2.72	2A	FS	NS	- -	IF	- -		MTS	MTS	MTS	IF	MTS	MTS	MTS	EX
04010102-549	Lester River	T52 R14W S23, N Line to Lk Superior	20.22	2A	NS	FS	NS	IF	T, HGW		MTS	MTS	MTS	EXP	MTS	MTS	MTS	MTS
04010102-652	Chester Creek, East Branch	Headwaters to Chester Cr	3.4	2A	IF	NA	- -	- -	- -		- -	- -	- -	MTS	- -	- -	- -	- -
04010102-698	French River	Unnamed Lk (69-182-00) to Lk Superior	11.35	2A	NS	FS	- -	IF	T		MTS	MTS	MTS	EXP	MTS	MTS	- -	MTS
04010102-895	Unnamed Creek (Amity Creek Trib)	Headwaters to Amity Cr	0.71	2A	IF	NA	- -	- -	- -		- -	- -	IF	IF	IF	IF	- -	- -
04010102-C14	Unnamed Creek (Brewery Creek)	Headwaters to Lk Superior	0.36	2B	IF	NA	- -	- -	- -		- -	- -	- -	IF	- -	- -	- -	- -

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.

*Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.

† Reach was assessed based on use class included in the above table and existing use class as defined in Minn. R. 7050 is different. The MPCA is currently in the process of changing the existing use class for this AUID in rule based on an analysis of the biological community and temperature data.

[1] Additional biological monitoring on the Encampment River (04010102-554) was requested by the WAT and took place in 2013. Data collected was still pending at the time of the 2014 draft impaired waters list and will be assessed before any future listings.

[2] Additional monitoring (chemical & biological) on Tischer Creek (04010102-544) was requested by the WAT and took place in 2013. Data collected was still pending at the time of the 2014 draft impaired waters list and will be assessed before any future listings.

[3] Data assessed in 2013 suggest Dissolved Oxygen (DO) is currently meeting standards. A managerial decision was made to keep the existing DO impairment and address it in a future TMDL, as it may be linked to the non-support of other aquatic life indicators.

Appendix 4 – Assessment Results For lakes in the Lake Superior - South Watershed

Lake ID	Lake Name	County	HUC-10	Ecoregion	Lake Area (acres)	Max Depth (m)	Watershed Area (acres)**	% Littoral	Mean depth (m)*	Aquatic Recreation Support Status
38-0406-00	Lax	Lake	0401010201	NLF	273	10.6	3,618	65	3.1	FS
38-0231-00	Tetagouche	Lake	0401010201	NLF	67	4.5	240	100	1.1	N/A
38-0750-00	Christianson	Lake	0401010202	NLF	158	2.4	590	100	1.2	FS
38-0753-00	Highland	Lake	0401010202	NLF	106	1.5	1455	100	1.0	FS
38-0744-00	Stewart	Lake	0401010203	NLF	236	4.2	973	100	1.9	FS
69-0007-00	Paradise	St. Louis	0401010203	NLF	30	4.2	981	100	2.2	FS
69-0238-00	Eagle	St. Louis	0401010204	NLF	114	1.5	2138	100	1.0	FS

Abbreviations: **FS** – Full Support **N/A** – Not Assessed
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.
*These depths were estimated by MPCA Staff
** Area excludes the area of the lake

Appendix 5 – Minnesota Statewide IBI Thresholds and Confidence Limits

Class #	Class Name	Use Class	Threshold	Confidence Limit	Upper	Lower
Fish						
1	Southern Rivers	2B, 2C	39	±11	50	28
2	Southern Streams	2B, 2C	45	±9	54	36
3	Southern Headwaters	2B, 2C	51	±7	58	44
10	Southern Coldwater	2A	45	±9	58	32
4	Northern Rivers	2B, 2C	35	±9	44	26
5	Northern Streams	2B, 2C	50	±9	59	41
6	Northern Headwaters	2B, 2C	40	±16	56	24
7	Low Gradient	2B, 2C	40	±10	50	30
11	Northern Coldwater	2A	37	±10	47	27
Invertebrates						
1	Northern Forest Rivers	2B, 2C	51.3	±10.8	62.1	40.5
2	Prairie Forest Rivers	2B, 2C	30.7	±10.8	41.5	19.9
3	Northern Forest Streams RR	2B, 2C	50.3	±12.6	62.9	37.7
4	Northern Forest Streams GP	2B, 2C	52.4	±13.6	66	38.8
5	Southern Streams RR	2B, 2C	35.9	±12.6	48.5	23.3
6	Southern Forest Streams GP	2B, 2C	46.8	±13.6	60.4	33.2
7	Prairie Streams GP	2B, 2C	38.3	±13.6	51.9	24.7
8	Northern Coldwater	2A	26	±12.4	38.4	13.6
9	Southern Coldwater	2A	46.1	±13.8	59.9	32.3

Appendix 6 – Biological Monitoring Results – Fish IBI (Assessable Reaches)

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi²	Fish Class	Threshold	F-IBI	Visit Date
HUC 10: 0401010201 (Beaver River-Frontal Lake Superior)							
04010102-501	11LS027	Beaver River	4.64	11	37	36	7/26/2011
04010102-501	94LS007	Beaver River	15.99	11	37	64	7/26/2011
04010102-501	91LS026	Beaver River	54.08	11	37	23	6/13/2011
04010102-501	11LS022	Beaver River	121.83	11	37	35	6/14/2011
04010102-529	98LS027	Palisade Creek	5.43	11	37	81	7/28/2011
04010102-530	91LS029	Beaver River, East Branch	18.57	11	37	53	7/26/2011
04010102-535	11LS026	Beaver River, East Branch	46.90	11	37	48	7/25/2011
04010102-572	11LS023	Cedar Creek	14.45	11	37	65	7/27/2011
04010102-577	11LS028	Beaver River, West Branch	4.78	11	37	32	7/27/2011
04010102-B28	11LS034	Big Thirtynine Creek	13.57	11	37	64	7/26/2011
04010102-B44	11LS035	Little Thirtynine Creek	5.32	11	37	67	7/26/2011
HUC 10: 0401010202 (Gooseberry River-Frontal Lake Superior)							
04010102-502	11LS030	Gooseberry River	13.75	11	37	81	8/4/2011
04010102-502	97LS103	Gooseberry River	31.34	11	37	83	8/4/2011
04010102-502	11LS040	Gooseberry River	74.53	11	37	69	8/10/2011
04010102-513	02LS004	Silver Creek	9.22	11	37	58	8/9/2011
04010102-513	11LS005	Silver Creek	14.99	11	37	60	7/27/2011
04010102-515	98LS026	Crow Creek	3.86	11	37	34	8/2/2011
04010102-520	84LS022	West Split Rock River	11.92	11	37	57	7/27/2011
04010102-551	10EM076	Skunk Creek	11.15	11	37	62	8/17/2010
04010102-551	11LS031	Skunk Creek	26.24	11	37	63	8/11/2011

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Fish Class	Threshold	F-IBI	Visit Date
04010102-554	13LS076	Encampment River	7.49	11	37	52	7/24/2013
04010102-554	13LS075	Encampment River	12.34	11	37	49	7/24/2013
04010102-554	11LS002	Encampment River	15.89	11	37	46	7/24/2013
04010102-554	11LS002	Encampment River	15.89	11	37	38	8/3/2011
04010102-668	11LS033	Dago Creek	6.00	11	37	60	8/3/2011
04010102-740	11LS004	Little Gooseberry River	9.87	11	37	62	6/14/2011
04010102-A44	11LS009	East Split Rock River	11.53	11	37	58	7/26/2011
HUC 10: 0401010203 (Knife River-Frontal Lake Superior)							
04010102-503	99LS010	Stewart River	11.70	11	37	60	8/9/2011
04010102-503	11LS006	Stewart River	26.25	11	37	74	8/2/2011
04010102-504	11LS014	Knife River	14.72	11	37	98	7/27/2011
04010102-504	11LS008	Knife River	27.63	11	37	40	8/30/2011
04010102-504	11LS024	Knife River	58.30	11	37	45	8/30/2011
04010102-504	11LS025	Knife River	70.09	11	37	57	8/3/2011
04010102-504	10EM077	Knife River	74.28	11	37	60	7/19/2010
04010102-504	92LS050	Knife River	86.19	11	37	44	9/1/2011
04010102-538	97LS100	Knife River, West Branch	27.35	11	37	44	8/30/2011
04010102-555	11LS041	Big Sucker Creek	36.95	11	37	70	8/30/2011
04010102-556	97LS089	Big Sucker Creek	27.89	11	37	74	8/31/2011
04010102-584	11LS017	Captain Jacobson Creek	5.12	11	37	91	7/28/2011
04010102-586	11LS016	Knife River, West Branch	13.91	11	37	66	7/28/2011
04010102-824	11LS018	Little Knife River	9.00	11	37	54	7/28/2011
04010102-846	11LS015	Unnamed Creek (West Branch Little Knife River)	4.11	11	37	64	7/27/2011

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Fish Class	Threshold	F-IBI	Visit Date
04010102-887	11LS007	McCarthy Creek	3.73	11	37	83	8/9/2011
04010102-A94	99LS012	Little Stewart River	5.10	11	37	74	7/28/2011
04010102-B01	10EM141	Brophy Creek	2.51	11	37	56	6/22/2010
04010102-C16	11LS010	Knife River, West Branch	2.71	7	40	78	6/15/2011
HUC 10: 0401010204 (City of Duluth-Frontal Lake Superior)							
04010102-508	11LS038	Talmadge River	5.12	11	37	53	9/14/2011
04010102-511	11LS036	Amity Creek	16.29	11	37	74	6/20/2011
04010102-540	97LS038	Amity Creek, East Branch	7.55	11	37	54	6/20/2011
04010102-543	95LS023	Tischer Creek	5.31	11	37	37	6/20/2011
04010102-543	95LS023	Tischer Creek	5.31	11	37	35	8/13/2013
04010102-544	95LS021	Tischer Creek	7.21	11	37	32	8/13/2013
04010102-545	11LS039	Chester Creek	6.30	11	37	40	9/14/2011
04010102-549	11LS021	Lester River	5.31	11	37	61	9/14/2011
04010102-549	91LS012	Lester River	19.31	11	37	70	8/31/2011
04010102-549	91LS009	Lester River	29.69	11	37	69	8/31/2011
04010102-698	11LS020	French River	14.31	11	37	89	9/14/2011
04010102-698	97LS104	French River	18.17	11	37	84	6/21/2011

Appendix 7 – 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	M-IBI	Visit Date
HUC 10: 0401010201 (Beaver River-Frontal Lake Superior)							
04010102-501	11LS027	Beaver River	4.64	8	26	62	8/8/2011
04010102-501	94LS007	Beaver River	15.99	8	26	52	8/8/2011
04010102-501	91LS026	Beaver River	54.08	8	26	39	8/16/2011
04010102-501	94LS001	Beaver River	122.31	8	26	20	8/9/2011
04010102-529	98LS027	Palisade Creek	5.43	8	26	44	8/18/2011
04010102-530	91LS029	Beaver River, East Branch	18.57	8	26	24	8/3/2011
04010102-535	11LS026	Beaver River, East Branch	46.90	8	26	32	8/16/2011
04010102-572	11LS023	Cedar Creek	14.45	8	26	41	8/9/2011
04010102-577	11LS028	Beaver River, West Branch	4.78	8	26	17	8/3/2011
04010102-B28	11LS034	Big Thirtynine Creek	13.57	8	26	49	8/9/2011
04010102-B28	11LS034	Big Thirtynine Creek	13.57	8	26	54	8/9/2011
04010102-B44	11LS035	Little Thirtynine Creek	5.32	8	26	39	8/9/2011
HUC 10: 0401010202 (Gooseberry River-Frontal Lake Superior)							
04010102-502	11LS030	Gooseberry River	13.75	8	26	65	8/17/2011
04010102-502	97LS103	Gooseberry River	31.34	8	26	31	8/10/2011
04010102-502	11LS040	Gooseberry River	74.53	8	26	30	8/10/2011
04010102-513	02LS004	Silver Creek	9.22	8	26	49	8/17/2011
04010102-513	11LS005	Silver Creek	14.99	8	26	42	8/2/2011
04010102-515	98LS026	Crow Creek	3.86	8	26	28	8/8/2011
04010102-520	84LS022	West Split Rock River	11.92	8	26	60	8/3/2011
04010102-551	10EM076	Skunk Creek	11.15	8	26	35	8/25/2010

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Invert Class	Threshold	M-IBI	Visit Date
04010102-551	11LS031	Skunk Creek	26.24	8	26	38	8/11/2011
04010102-554	13LS076	Encampment River	7.49	8	26	52	7/24/2013
04010102-554	13LS075	Encampment River	12.34	8	26	49	7/24/2013
04010102-554	11LS002	Encampment River	15.89	8	26	46	7/24/2013
04010102-554	11LS002	Encampment River	15.89	8	26	35	8/18/2011
04010102-668	11LS033	Dago Creek	6.00	8	26	22	8/10/2011
04010102-740	11LS004	Little Gooseberry River	9.87	8	26	37	8/2/2011
04010102-A44	11LS009	East Split Rock River	11.53	8	26	48	8/10/2011
04010102-A41	11LS029	Unnamed Creek (Split Rock River Tributary)	2.88	8	26	33	8/10/2011
HUC 10: 0401010203 (Knife River-Frontal Lake Superior)							
04010102-503	99LS010	Stewart River	11.70	8	26	59	8/9/2011
04010102-503	11LS006	Stewart River	26.25	8	26	41	9/15/2011
04010102-504	11LS014	Knife River	14.72	8	26	51	8/16/2011
04010102-504	11LS008	Knife River	27.63	8	26	46	8/16/2011
04010102-504	11LS024	Knife River	58.30	8	26	40	8/16/2011
04010102-504	11LS025	Knife River	70.09	8	26	23	8/18/2011
04010102-504	10EM077	Knife River	74.28	8	26	38	9/17/2010
04010102-504	92LS050	Knife River	86.19	8	26	20	8/16/2011
04010102-538	97LS100	Knife River, West Branch	27.35	8	26	40	8/16/2011
04010102-555	11LS041	Big Sucker Creek	36.95	8	26	53	9/15/2011
04010102-556	97LS089	Big Sucker Creek	27.89	8	26	45	8/22/2011
04010102-584	11LS017	Captain Jacobson Creek	5.12	8	26	50	8/16/2011
04010102-586	11LS016	Knife River, West Branch	13.91	8	26	48	8/16/2011

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi²	Invert Class	Threshold	M-IBI	Visit Date
04010102-586	11LS016	Knife River, West Branch	13.91	8	26	48	8/16/2011
04010102-824	11LS018	Little Knife River	9.00	8	26	37	8/17/2011
04010102-846	11LS015	Unnamed Creek (West Branch Little Knife River)	4.11	8	26	57	8/16/2011
04010102-887	11LS007	McCarthy Creek	3.73	8	26	63	8/17/2011
04010102-A94	99LS012	Little Stewart River	5.10	8	26	44	8/2/2011
04010102-B01	10EM141	Brophy Creek	2.51	8	26	25	8/25/2010
04010102-B01	10EM141	Brophy Creek	2.51	8	26	36	8/25/2010
HUC 10: 0401010204 (City of Duluth-Frontal Lake Superior)							
04010102-508	11LS038	Talmadge River	5.12	8	26	37	8/22/2011
04010102-511	11LS036	Amity Creek	16.29	8	26	21	8/15/2011
04010102-540	97LS038	Amity Creek, East Branch	7.55	8	26	20	9/15/2011
04010102-540	97LS038	Amity Creek, East Branch	7.55	8	26	23	8/6/2012
04010102-543	95LS023	Tischer Creek	5.31	8	26	25	8/18/2011
04010102-543	95LS023	Tischer Creek	5.31	8	26	16	8/13/2013
04010102-544	95LS021	Tischer Creek	7.21	8	26	18	8/13/2013
04010102-545	11LS039	Chester Creek	6.30	8	26	17	8/18/2011
04010102-549	11LS021	Lester River	5.31	8	26	32	8/23/2011
04010102-549	91LS012	Lester River	19.31	8	26	54	8/23/2011
04010102-549	91LS009	Lester River	29.69	8	26	22	8/23/2011
04010102-549	91LS009	Lester River	29.69	8	26	48	8/17/2011
04010102-698	11LS020	French River	14.31	8	26	53	8/22/2011
04010102-698	97LS104	French River	18.17	8	26	53	9/15/2011

Appendix 8 – 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 9 – MINLEAP Model Estimates of Phosphorus Loads for Lakes in the Lake Superior - South 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
38-0406	Lax	17	19	7.5	5	3.2	3.1	33	118	18	44	3.51	1.0	3.18	M
38-0750	Christianson	26	21	6.2	6	0.9	2.8	41	26	24	50	0.63	1.2	0.99	M / E
38-0753	Highland	21	23	4.4	7	1.5	2.5	33	47	26	30	1.41	0.3	3.29	M
38-0744	Stewart	13	18	4.4	5	3.2	3.1	40	41	21	54	1.03	1.8	1.08	M
69-0007	Paradise	18	22	2.8	6	2.4	2.6	31	29	20	29	2.05	0.3	7.65	M
69-0238	Eagle	32	24	9.4	7	2.8	2.5	32	67	26	26	2.05	0.2	4.44	M / E

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

Appendix 10 – Fish species encountered during Biological Monitoring Surveys

Taxonomic Name	Common Name	Number of Stations Where Present	Quantity of Individuals Collected
Cypriniformes			
Catostomus catostomus	Longnose Sucker	1	2
Catostomus commersoni	White Sucker	32	449
Luxilus (Notropis) cornutus	Common Shiner	23	1062
Margariscus (Semotilis) margarita	Pearl Dace	27	316
Notropis heterolepis	Blacknose Shiner	4	6
Phoxinus eos	Northern Redbelly Dace	20	1249
Phoxinus neogaeus	Finescale Dace	8	75
Pimpephales promelas	Fathead Minnow	17	352
Rhinichthys atratulus	Blacknose Dace	56	9287
Rhinichthys cataractae	Longnose Dace	33	1873
Semotilis atromaculatus	Creek Chub	47	2816
Esociformes			
Esox lucius	Northern Pike	2	5
Umbra limi	Central Mudminnow	18	100
Gadiformes			
Lota lota	Burbot/Eelpout	1	5
Gasterosteiformes			
Culaea inconstans	Brook Stickleback	33	540
Perciformes			
Ambloplites rupestris	Rockbass	1	4
Etheostoma exile	Iowa Darter	5	30
Etheostoma nigrum	Johnny Darter	14	402
Lepomis gibbosus	Pumpkinseed	1	2
Lepomis macrochirus	Bluegill	3	7
Micropterus salmoides	Largemouth Bass	1	4
Perca flavescens	Yellow Perch	2	10
Percina caprodes	Logperch	1	1
Percopsiformes			
Percopsis omiscomaycus	Trout Perch	1	14
Salmoniformes			
Oncorhynchus mykiss (Salmo gairdneri)	Rainbow Trout	23	1406
Oncorhynchus tshawytscha	Chinook Salmon	1	5
Salmo trutta	Brown Trout	11	196
Salvelinus fontinalis	Brook Trout	28	534
Scorpaeniformes			
Cottus bairdi	Mottled Sculpin	20	270
Siluriformes			
Ameiurus (Ictalurus) melas	Black Bullhead	3	12

Appendix 11 – Macroinvertebrate species encountered during Biological Monitoring Surveys

Taxonomic Name	Number of Stations Where Present	Quantity of Individuals Collected
Amphipoda		
Gammarus	1	8
Hyalella	7	40
Coleoptera		
Dubiraphia	20	124
Dytiscidae	2	2
Elmidae	9	23
Gyrinus	2	3
Haliplidae	1	4
Haliplus	3	4
Helichus	2	2
Hydraena	3	4
Macronychus glabratus	2	8
Nigronia	13	21
Optioservus	48	486
Peltodytes	1	1
Stenelmis	19	48
Decapoda		
Orconectes	10	3
Diptera		
Ablabesmyia	12	24
Anopheles	2	8
Antocha	29	253
Atherix	28	101
Bezzia/Palpomyia	3	5
Brillia	6	7
Ceratopogoninae	8	13
Chironomini	7	8
Chironomus	1	1
Chrysops	4	4
Cladotanytarsus	7	12
Conchapelopia	9	9
Corynoneura	27	49
Cricotopus	48	498
Cryptochironomus	4	4
Cryptotendipes	1	1
Culicidae	1	1
Dicranota	7	7
Dicrotendipes	16	63
Diplocladius cultriger	1	1

Taxonomic Name	Number of Stations Where Present	Quantity of Individuals Collected
Dixa	1	2
Dixella	3	4
Dixidae	1	1
Dolichopodidae	1	1
Empididae	9	11
Ephydridae	6	9
Eukiefferiella	36	155
Helopelopia	2	4
Hemerodromia	18	38
Heterotrissocladius	4	5
Hexatoma	2	2
Krenosmittia	1	1
Labrundinia	6	14
Limnophila	1	1
Limnophyes	6	9
Lopescladius	5	14
Mallochohelea	3	3
Meropelopia/Thienemannimyia	3	21
Micropsectra	40	293
Microtendipes	34	122
Muscidae	1	2
Nanocladius	12	19
Neoplasta	1	1
Nilotanypus	5	7
Nilothauma	2	3
Orthocladiinae	11	22
Orthocladius	26	121
Orthocladius (Symposiocladius)	9	24
Pagastiella	2	3
Parachironomus	1	1
Paracricotopus	1	11
Parakiefferiella	16	41
Paralauterborniella nigrohalterale	1	1
Paramerina	7	10
Parametriocnemus	37	137
Paratanytarsus	14	34
Paratendipes	1	3
Phaenopsectra	14	15
Polypedilum	57	707
Potthastia	12	41
Procladius	4	7
Psectrocladius	2	7
Pseudochironomus	1	12

Taxonomic Name	Number of Stations Where Present	Quantity of Individuals Collected
Pseudorthocladius	1	1
Rheocricotopus	23	54
Rheotanytarsus	54	907
Roederiodes	6	10
Saetheria	1	1
Simulium	45	835
Stempellina	8	45
Stempellinella	42	215
Stenochironomus	7	18
Stictochironomus	1	1
Sublettea	9	39
Synorthocladius	7	36
Tabanidae	1	2
Tanypodinae	12	15
Tanytarsini	11	15
Tanytarsus	35	219
Thienemanniella	40	127
Thienemannimyia	43	169
Tipula	14	44
Tipulidae	2	2
Tribelos	3	6
Trissopelopia ogemawi	3	4
Tvetenia	51	553
Xenochironomus xenolabis	1	2
Xylotopus par	1	1
Zavreliella marmorata	1	1
Zavrelimyia	2	3
Ephemeropterea		
Acentrella	16	99
Acentrella parvula	9	109
Acentrella turbida	29	409
Acerpenna	13	57
Acerpenna macdunnoughi	1	1
Acerpenna pygmaeus	7	19
Baetidae	8	34
Baetis	15	93
Baetis brunneicolor	11	158
Baetis flavistriga	46	520
Baetis intercalaris	22	165
Baetis tricaudatus	17	110
Baetisca	2	2
Baetisca lacustris	2	2

Taxonomic Name	Number of Stations Where Present	Quantity of Individuals Collected
Caenis	19	176
Caenis youngi	2	10
Centroptilum	4	8
Diphetor hageni	4	37
Epeorus vitreus	16	69
Ephemera	3	5
Ephemera simulans	1	1
Ephemerella	6	67
Ephemerella excrucians	14	126
Ephemerellidae	10	38
Eurylophella	9	27
Fallceon quilleri	3	3
Heptageniidae	28	211
Hexagenia	1	1
Isonychia	12	57
Isonychia bicolor	2	3
Iswaeon	1	2
Labiobaetis propinquus	1	5
Leptophlebia bradleyi	1	1
Leptophlebiidae	18	65
Leucrocuta	28	214
Maccaffertium	33	281
Maccaffertium luteum	8	25
Maccaffertium vicarium	2	11
Paraleptophlebia	14	41
Plauditus	1	2
Procloeon	22	134
Serratella serrata	4	11
Stenacron	3	7
Tricorythodes	15	67
Gastropoda		
Ancylidae	3	10
Caecidotea	2	11
Ferrissia	31	157
Gyraulus	13	76
Helisoma anceps	8	92
Hydrobiidae	1	15
Lymnaeidae	6	9
Physa	38	350
Planorbidae	9	85
Valvata	1	1

Taxonomic Name	Number of Stations Where Present	Quantity of Individuals Collected
Hemiptera		
Aquarius	2	3
Corixidae	3	3
Gerridae	1	1
Sigara	1	1
Hirudinea		
Hirudinea	9	39
Lepidoptera		
Parapoynx	1	2
Megaloptera		
Sialis	7	9
Nematoda		
Nemata	8	10
Nematoda	1	3
Odonata		
Aeshna umbrosa	2	1
Aeshnidae	5	5
Boyeria grafiana	15	23
Boyeria vinosa	4	6
Calopterygidae	12	88
Calopteryx	7	27
Calopteryx aequabilis	6	11
Coenagrionidae	2	2
Cordulegaster	3	3
Cordulegaster maculata	3	3
Corduliidae	2	2
Enallagma	2	2
Epitheca canis	1	1
Gomphidae	34	153
Hagenius brevistylus	1	1
Hetaerina	2	4
Lestidae	1	1
Liodessus	1	1
Ophiogomphus	10	14
Ophiogomphus carolus	7	14
Ophiogomphus colubrinus	1	1
Somatochlora	2	2
Somatochlora minor	1	1
Oligochaeta		
Oligochaeta	2	7

Taxonomic Name	Number of Stations Where Present	Quantity of Individuals Collected
Plecoptera		
Acroneuria	6	11
Acroneuria abnormis	1	4
Acroneuria lycorias	28	67
Alloperla usa	4	4
Amphinemura linda	1	2
Capniidae	16	27
Chloroperlidae	2	2
Isoperla	1	2
Leuctra	3	17
Leuctridae	6	12
Paragnetina media	22	84
Perlesta	4	9
Perlidae	30	71
Perlodidae	6	15
Pteronarcys	12	16
Trichoptera		
Anabolia	1	2
Anacaena	4	5
Apatania	1	1
Brachycentridae	2	2
Brachycentrus	2	4
Brachycentrus americanus	4	17
Brachycentrus numerosus	1	1
Ceraclea	11	24
Ceratopsyche	42	907
Ceratopsyche alhedra	23	181
Ceratopsyche bronta	19	134
Ceratopsyche morosa	7	22
Ceratopsyche slossonae	38	306
Ceratopsyche sparna	15	130
Ceratopsyche vexa	1	1
Cheumatopsyche	41	506
Chimarra	18	74
Chimarra aterrima	5	94
Chimarra obscura	10	57
Dolophilodes distinctus	19	123
Glossosoma	12	43
Glossosoma intermedium	18	379
Glossosoma nigrior	10	76
Glossosomatidae	19	73
Goera	7	7

Taxonomic Name	Number of Stations Where Present	Quantity of Individuals Collected
Helicopsyche borealis	18	91
Hydatophylax argus	5	27
Hydrophilidae	1	1
Hydropsyche	4	17
Hydropsyche betteni	7	44
Hydropsychidae	32	522
Hydroptila	16	47
Hydroptilidae	8	9
Lepidostoma	45	612
Leptoceridae	13	23
Limnephilidae	16	61
Lype diversa	7	16
Micrasema	5	7
Micrasema gelidum	7	36
Micrasema rusticum	12	37
Mystacides	17	58
Nemotaulius hostilis	1	1
Neophylax	2	4
Neophylax concinnus	1	1
Neophylax mitchelli	2	4
Nyctiophylax (Paranyctiophylax)	1	1
Oecetis	6	11
Oecetis avara	22	78
Oecetis persimilis	8	20
Oxyethira	5	20
Philopotamidae	1	6
Phryganeidae	2	2
Phylocentropus	2	2
Polycentropodidae	2	2
Polycentropus	11	31
Protoptila	10	161
Psychomyia flavida	12	36
Psychomyiidae	1	1
Ptilostomis	2	4
Pycnopsyche	7	12
Rhyacophila	4	9
Rhyacophila fuscula	2	2
Triaenodes	1	2
Uenoidae	6	18
Unclassified		
Acari	51	367
Oligochaeta	43	190

Taxonomic Name	Number of Stations Where Present	Quantity of Individuals Collected
Turbellaria	4	9
Veneroida		
Pisidiidae	21	60

Appendix 12 – Lake Superior Basin fish species: Endangered, special concern, threatened and introduced

Minnesota Species Of Special Concern	
Taxonomic Name	**Common Name**
Acipenseriformes	
Acipenser fulvescens	Lake Sturgeon
Cypriniformes	
Notropis anogenus	Pugnose Shiner
Perciformes	
Etheostoma microperca	Least Darter
Petromyzoniformes	
Ichthyomyzon fossor	Northern Brook Lamprey
Salmoniformes	
Coregonus kiyi	Kiyi
Coregonus zenithicus	Shortjaw Cisco
Species Introduced	
Atheriniformes	
Labidesthes sicculus	Brook Silverside
Clupeiformes	
Alosa pseudoharengus	Alewife
Cypriniformes	
Cyprinus carpio	Common Carp
Gasterosteiformes	
Apeltes quadracus	Fourspine Stickleback
Gasterosteus aculeatus	Threespine Stickleback
Osmeriformes	
Osmerus mordax	Rainbow Smelt
Perciformes	
Morone americana	White Perch
Neogobius melanostomus	Round Goby
Proterorhinus marmoratus	Tubenose Goby
Petromyzoniformes	
Petromyzon marinus	Sea Lamprey
Salmoniformes	
Oncorhynchus gorbuscha	Pink Salmon
Oncorhynchus kisutch	Coho Salmon
Oncorhynchus mykiss	Rainbow Trout
Oncorhynchus tshawytscha	*Chinook Salmon*
Salmo salar	*Atlantic Salmon*
Salmo trutta	*Brown Trout*