Grand Marais Creek Watershed Monitoring and Assessment Report

Minnesota Pollution Control Agency

June 2016

Authors

MPCA Grand Marais Creek Watershed
Report Team:

Karsten Klimek, Nathan Sather, Benjamin Lundeen,
Denise Oakes, Scott Niemela, Jesse Anderson,
Michael Sharp, Michael Bourdaghs,
Dave Christopherson, David Duffey, Bruce Monson,
Shawn Nelson, Kris Parson, Michael Bourdaghs,
Andrew Butzer
Red Lake Watershed District
Middle Snake Tamarac Rivers Watershed District
Emmons and Olivier Resources, Inc.
Minnesota Department of Natural Resources
Board of Water and Soil Resources
Minnesota Department of Health
Minnesota Department of Agriculture
West Polk County Soil and Water Conservation District
West Polk County Natural Resources Conservation Service
West Polk County Soil and Water Conservation District
West Polk County Natural Resources Conservation Service

Contributors / acknowledgements

Citizen Stream Monitoring Program
Volunteers

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

Minnesota Pollution Control Agency

520 Lafayette Road North | Saint Paul, MN 55155-4194 |

651-296-6300 | 800-657-3864 | Or use your preferred relay service. | Info.pca@state.mn.us

This report is available in alternative formats upon request, and online at www.pca.state.mn.us.

Document number: wq-ws3-09020306b

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AUID Assessment Unit Identification Determination

BWSR Board of Water and Soil Resources

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

CW Cold water community

CWA Clean Water Act

CWLA Clean Water Legacy Act

DNR Minnesota Department of Natural Resources

DO Dissolved Oxygen

DOP Dissolved Orthophosphate

E. coli Escherichia coli

EPA Environmental Protection Agency

EQuIS Environmental Quality Information System

EX Exceeds Criteria (Bacteria)

EXP Exceeds Criteria, Potential Impairment

EXS Exceeds Criteria, Potential Severe Impairment

FIBI Fish Index of Biological Integrity

FQA Floristic Quality Assessment

FS Full Support

FWMC Flow Weighted Mean Concentration

H Hypereutrophic

HGM hydrogeomorphically

HUC Hydrologic Unit Code

IBI Index of Biotic Integrity

IF Insufficient Information

IMP Impaired (Fails Standards)

IWM Intensive Watershed Monitoring survey

K Potassium

LRVW Limited Resource Value Water

M Mesotrophic

MCES Metropolitan Council Environmental Services

MDA Minnesota Department of Agriculture

MDH Minnesota Department of Health

MIBI Macroinvertebrate Index of Biological Integrity

mg/L Milligrams per liter

MINLEAP Minnesota Lake Eutrophication Analysis Procedure

MPCA Minnesota Pollution Control Agency

MSHA Minnesota Stream Habitat Assessment

MTS Meets the Standard

MWLMP Major Watershed Load Monitoring Program

MWP Mixed Wood Plains

MWS Mixed Wood Shield

N Nitrogen

NA Not Assessed

Nitrate-N Nitrate Plus Nitrite Nitrogen

NHD National Hydrologic Dataset

NH3 Ammonia

NS Not Supporting

NT No Trend

NWI National Wetlands Inventory

OP Orthophosphate

ORVW Outstanding Resource Value Waters

P Phosphorous

pH Acidity/Basicity (Alkalinity)

PJG Professional Judgment Group

PCB Poly Chlorinated Biphenyls

PWI Protected Waters Inventory

RLWD Red Lake Watershed District

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 Temperate Prairies

TP Total Phosphorous

TSS Total Suspended Solids

UAA Use Attainability Analysis

USGS United States Geological Survey

WPLMN Water Pollutant Load Monitoring Network

WQ Water Quality

WW Warm water community

Executive summary

In 2012 the Minnesota Pollution Control Agency (MPCA) conducted an Intensive Watershed Monitoring survey (IWM) of the Grand Marais Creek Watershed. IWM is a comprehensive survey of streams, lakes, and groundwater in each of Minnesota's 80 major watersheds. Biological communities (i.e. fish and macroinvertebrates), habitat and water chemistry data were collected from streams and rivers and used to assess surface waters for aquatic life, aquatic recreation, and aquatic consumption. The data were also used to compute loads through the Major Watershed Load Monitoring Program (MWLMP) on Grand Marais Creek. The monitoring was completed by staff from the MPCA and Surface Water Assessment Grant (SWAG) recipients. There are no lakes in the Grand Marais Creek Watershed.

Initially, 35 sites were selected near the outlet of minor watersheds to characterize the conditions. Data were obtained at seven of them due to the fact that many are temporal (contain water only seasonally). Streams within the Grand Marais Creek Watershed have been severely altered through both ditching and tiling to better suit the agricultural land use. These alterations coupled with the fact that the area is naturally low gradient and not designed to transport water very quickly have resulted in even more of the streams to be temporal, stagnant, and more wetland characteristic.

Five reaches were assessed for aquatic life use with all of them being impaired (i.e. not meeting water quality standards) and five reaches were assessed for aquatic recreation, with three impairments and two full support designations.

Aquatic life in Grand Marais Creek Watershed, as indicated by the fish and macroinvertebrate (bug) communities, is in a very poor and stressed condition. This is unfortunate as the most direct and effective measure of the integrity of a water body is the status of its living systems. The aquatic life in streams provides an integrated measure of everything that has happened during their life cycle, as well as what has happened upstream and upland (Karr and Chu, 1999). Failure to protect the biology of our waters may result in a failure to protect the human uses of that water (Karr and Chu, 1999).

Most of waterways in the Grand Marais Creek Watershed have a very low gradient. As a result the vast majority (72%) of them are constructed ditches or natural reaches that have been straightened (channelized) to promote agricultural drainage. Left in their natural state, surface water in the Grand Marais Creek Watershed would move slowly through the landscape but ditching practices throughout the watershed have modified the hydrology to speed up the drainage process. Stream straightening and channelization may be short-term solutions to minimize flooding of agricultural fields, but in the long term such practices increase flow velocity of outside bends in meanders; the result is often severe stream bank erosion and high sediment inputs (Waters, 1995). As a result, the water chemistry often changes in fairly predictable ways, exhibiting characteristics that are commonly seen with this type of land use. Nutrients (principally phosphorous) and total suspended solids often exceed water quality standards. Dissolved oxygen, ammonia, chloride, and pH may also pose problems in these highly modified stream systems.

Grand Marais Creek at County Road 64 was the most data rich station for water chemistry. The station was monitored as part of the IWM process as well as MPCA's Watershed Pollutant Load Monitoring Network. Over 100 samples were collected with 86% of them exceeding the MPCA's phosphorous standard established for the Red River Basin/Southern Region. Many of the samples were collected during high flow conditions and may have also been affected by backwater from the Red River of the North. The water quality was also poor during periods of dry weather when dissolved oxygen levels at some stations was low and stagnant conditions caused pH levels to occasionally exceed standards.

Bacteria monitoring (i.e. Escherichia coli [E. coli]) revealed conditions that were not suitable for recreational contact at three water chemistry stations. The only water chemistry station with low enough levels of bacteria to support aquatic recreation was on the most downstream portion of Grand

Marais Creek. Although it's assumed that these waters are not principally used for aquatic recreation, it is noteworthy that bacteria concentrations are high in most monitored locations.

In the early 1900's a State/County project to increase drainage diverted the lower six miles of Grand Marais Creek into a ditch that emptied into the Red River a short distance upstream of its original confluence. A recently completed restoration project (Project 60) has restored the flow back into the original natural, meandering channel. The old cut-off channel has been buffered, and will only receive flow during >1.25 year recurrence interval high flow events. This completed restoration should greatly enhance the water quality at the outlet.

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. Water management efforts of the MPCA are tied to the 1972 Federal Clean Water Act (CWA) which requires states to adopt water quality standards to protect their water resources and the designated uses of those waters, such as for drinking water, recreation, fish consumption and aquatic life. States are required to provide a summary of the status of their surface waters and develop a list of water bodies that do not meet established standards. Such waters are referred to as "impaired waters" and the state must make appropriate plans to restore these waters, including the development of Total Maximum Daily Loads (TMDLs). A TMDL is a comprehensive study determining the assimilative capacity of a waterbody, identifying all pollution sources causing or contributing to impairment, and an estimation of the reductions needed to restore a water body so that it can once again support its designated use.

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

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

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

This watershed-wide monitoring approach was implemented in the Grand Marais Creek Watershed beginning in the summer of 2012. This report provides a summary of all water quality assessment results in the Grand Marais Creek Watershed and incorporates all data available for the assessment process including watershed monitoring, volunteer monitoring and monitoring conducted by local government units.

The watershed monitoring approach

The watershed approach is a 10-year rotation for monitoring and assessing waters of the state on the level of Minnesota's 80 major watersheds (Figure 1). The major benefit of this approach is the integration of monitoring resources to provide a more complete and systematic assessment of water quality at a geographic scale useful for the development and implementation of effective TMDLs, project planning, effectiveness monitoring and protection strategies. The following paragraphs provide details on each of the four principal monitoring components of the watershed approach. For additional information see: Watershed Approach to Condition Monitoring and Assessment (MPCA 2008) (http://www.pca.state.mn.us/publications/wq-s1-27.pdf).

Watershed pollutant load monitoring network

Funded with appropriations from Minnesota's Clean Water Legacy Fund, the Watershed Pollutant Load Monitoring Network (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 site specific stream flow data from United States Geological Survey (USGS) and Minnesota Department of Natural Resources (DNR) flow gaging stations with water quality data collected by the Metropolitan Council Environmental Services (MCES), local monitoring organizations, and Minnesota Pollution Control Agency to compute pollutant loads from 201 streams and rivers across Minnesota. Monitoring sites span three ranges of scale with annual loads calculated for Basin and Major Watershed sites and seasonal loads for Subwatershed sites:

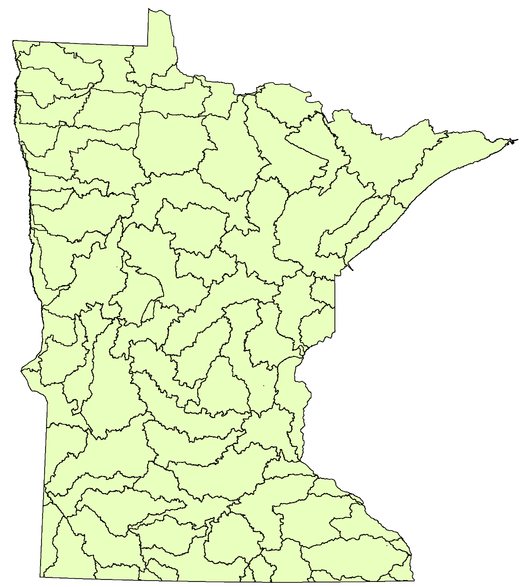

Figure 1. Major watersheds within Minnesota

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

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

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

WPLMN data will also be used to assist with: TMDL studies and implementation plans; watershed modeling efforts; watershed research projects and watershed restoration and protection strategies.

More information can be found at the WPLMN website (https://www.pca.state.mn.us/water/watershed-pollutant-load-monitoring-network) including a map of the sites.

Intensive watershed monitoring

The intensive watershed monitoring strategy utilizes a nested watershed design allowing the sampling of streams within watersheds from a coarse to a fine scale (Figure 2.). Each watershed scale is defined by a hydrologic unit code (HUC). These HUCs define watershed boundaries for water bodies within a similar geographic and hydrologic extent. The foundation of this approach is the 80 major watersheds (8-HUC) within Minnesota. Using this approach many of the smaller headwaters and tributaries to the main stem river are sampled in a systematic way so that a more holistic assessment of the watershed can be conducted and problem areas identified without monitoring every stream reach. Each major watershed is the focus of attention for at least one year within the 10-year cycle.

River/stream sites are selected near the outlet of each of three watershed scales, 8-HUC, aggregated 12-HUC and 14-HUC (Figure 2). Within each scale, different water uses are assessed based on the opportunity for that use (i.e., fishing, swimming, supporting aquatic life such as fish and insects). The major river watershed is represented by the 8-HUC scale. The outlet of the major 8-HUC watershed (green triangle in Figure 3) is sampled for biology (fish and macroinvertebrates), water chemistry and fish contaminants to allow for the assessment of aquatic life, aquatic recreation and aquatic consumption use support. The aggregated 12-HUC is the next smaller subwatershed scale which generally consists of major tributary streams with drainage areas ranging from 75 to 150 mi2. Each aggregated 12-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 aggregated 12-HUC, smaller watersheds (14 HUCs, typically 10-20 mi2), are sampled at each outlet that flows into the major aggregated 12-HUC tributaries. Each of these minor subwatershed outlets is sampled for biology to assess aquatic life use support (red dots in Figure 3).

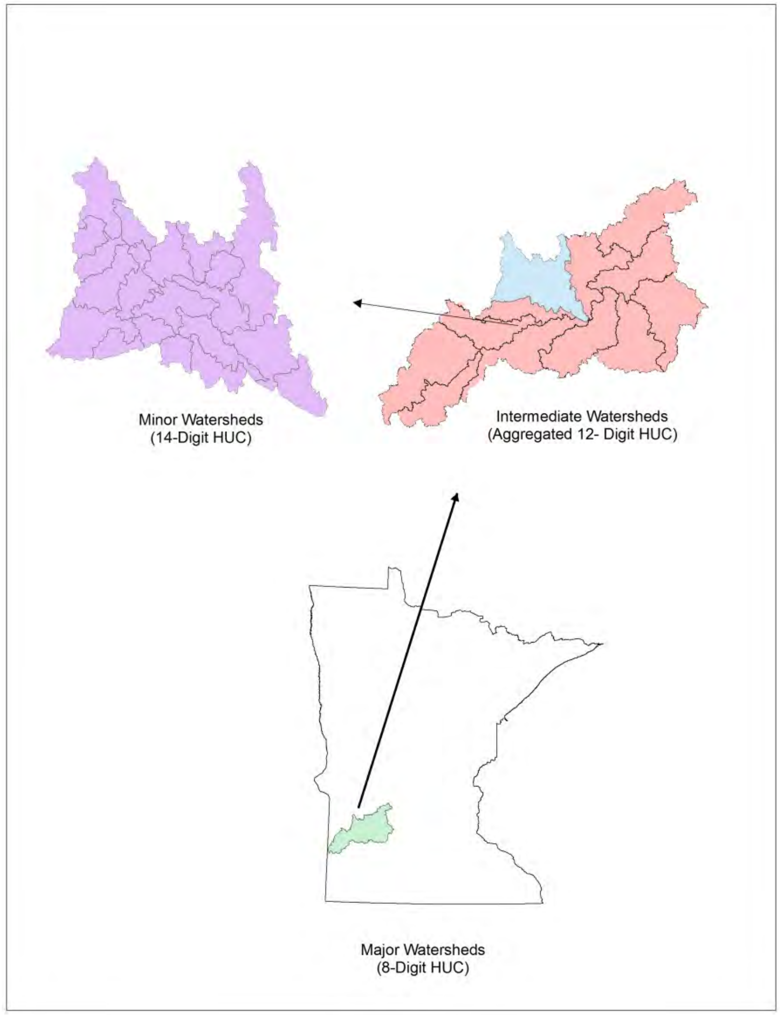

Figure 2. The intensive watershed monitoring design.

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

Specific locations for sites sampled as part of the intensive monitoring effort in the Grand Marais Creek Watershed are shown in Figure 3 and are listed in Appendix 2.

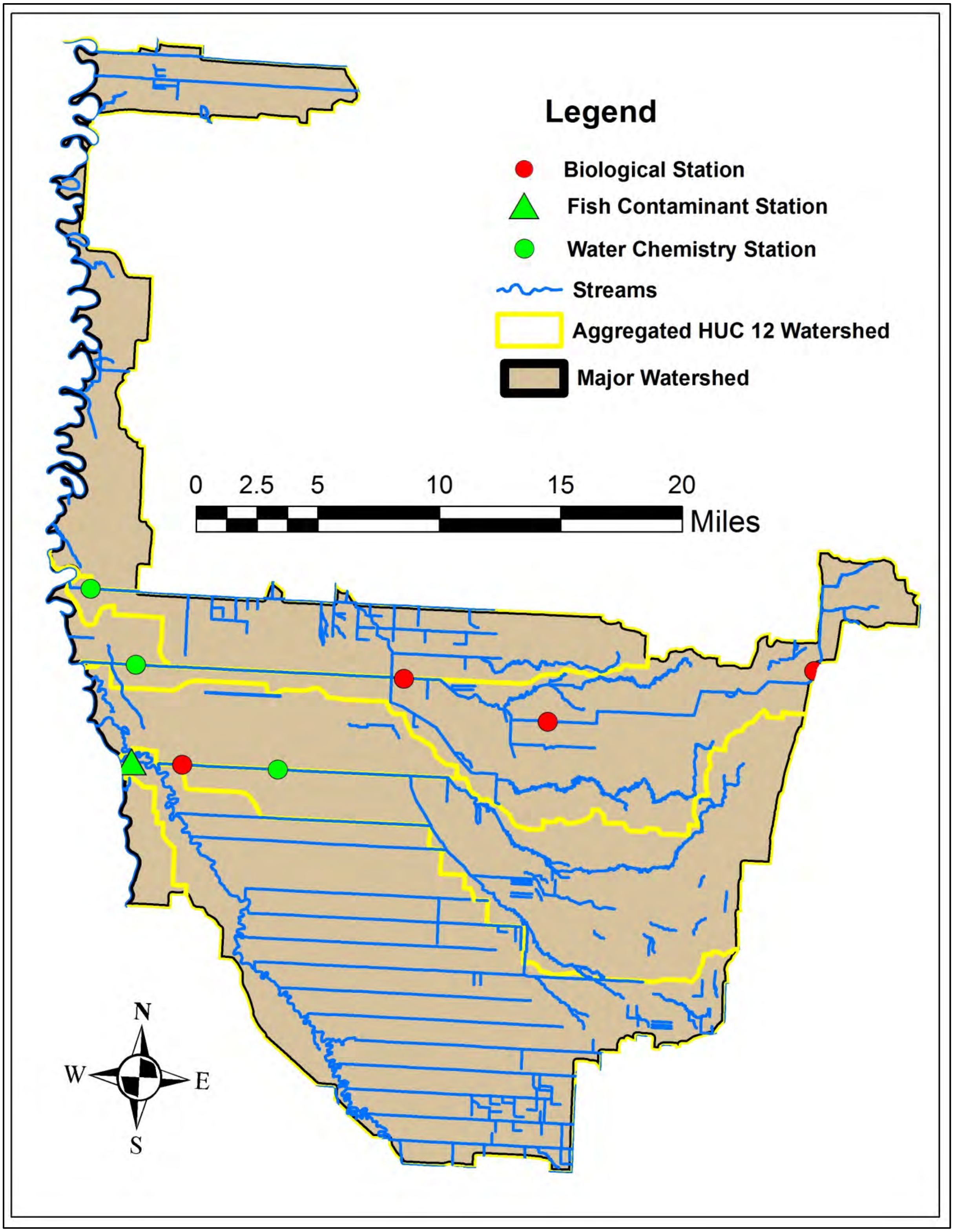

Figure 3. Intensive watershed monitoring sites for streams in the Grand Marais Creek Watershed.

Citizen and local monitoring

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

The MPCA also coordinates two programs aimed at encouraging long term citizen surface water monitoring: the Citizen Lake Monitoring Program (CLMP) and the Citizen Stream Monitoring Program (CSMP). Like the permanent load monitoring network, having citizen volunteers monitor a given lake or stream site monthly and from year to year can provide the long-term picture needed to help evaluate current status and trends. Citizen monitoring is especially effective at helping to track water quality changes that occur in the years between intensive monitoring years. Currently there are no CLMP or CSMP volunteers in the Grand Marais Creek Watershed and lakes are absent from this area.

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

Water quality standards

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

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

Protection for aquatic life uses are divided into three tiers: Exceptional, General, and Modified (Table 1). Exceptional Use waters support fish and macroinvertebrate communities that have minimal changes in structure and function from the natural condition. General Use waters harbor "good" assemblages of fish and macroinvertebrates that can be characterized as having an overall balanced distribution of the assemblages and with the ecosystem functions largely maintained through redundant attributes. Modified Use waters have been extensively altered through legacy physical modifications which limit the ability of the biological communities to attain the General Use. Currently the Modified Use is only applied to waters with channels that have been directly altered by humans (e.g., maintained for drainage). These tiered uses are determined before assessment based on the attainment of the applicable biological criteria and/or an assessment of the habitat. For additional information, see: http://www.pca.state.mn.us/index.php/water/water-permits-and-rules/water-rulemaking/tiered-aquatic-life-use-talu-framework.html).

Table 1. Tiered aquatic life use.

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

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

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

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

Assessment units

Assessments of use support in Minnesota are made for individual waterbodies. The waterbody unit used for river systems, lakes and wetlands is called the “assessment unit”. A stream or river assessment unit usually extends from one significant tributary stream to another or from the headwaters to the first tributary. A stream “reach” may be further divided into two or more assessment reaches when there is a change in use classification (as defined in Minn. R., ch. 7050) or when there is a significant morphological feature, such as a dam or lake, within the reach. Therefore, a stream or river is often segmented into multiple assessment units that are variable in length. The MPCA is using the 1:24,000 scale high resolution National Hydrologic Dataset (NHD) to define and index stream, lake and wetland assessment units. Each river or stream reach is identified by a unique waterbody identifier (known as its AUID), comprised of the USGS eight digit hydrologic unit code (8-HUC) plus a three character code that is unique within each HUC. Lake and wetland identifiers are assigned by the Minnesota Department of Natural Resources (DNR). 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 a “catchable” size and accumulate unacceptable levels of pollutants, there is a good chance they have traveled a considerable distance. The impaired reach is defined by the location of significant barriers to fish movement such as dams upstream and downstream of the sampled reach and thus often includes several assessment units.

Determining use attainment

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

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

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

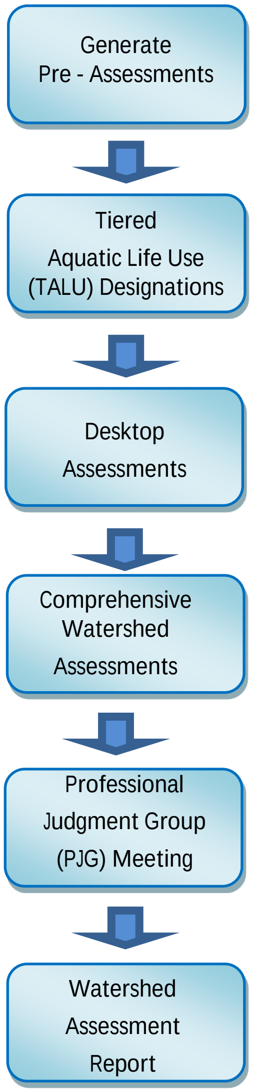

Figure 4: Flowchart of aquatic life use assessment process.

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 2014) https://www.pca.state.mn.us/sites/default/files/wq-iw1-04.pdf for guidelines and factors considered when making such determinations.

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

Data management

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

Period of record

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

Watershed overview

The Grand Marais Creek Watershed is located in northwest MN within Marshall, Polk, and Pennington Counties. The watershed drains over 298,000 surface area acres (466 mi2) of land, and for the most part is very low gradient with a poorly defined floodplain. The majority of the area has been converted from tall-grass prairie to cropland over the last few hundred years. Today approximately 92% of the Grand Marais Creek watershed is utilized for some form of crop production. Small towns including Fisher and Oslo make up about 5% of the watersheds land area (Figure 6). Their viability is almost wholly dependent on the local farm economy. With such a large percentage of the land converted to row crop agriculture it is not surprising that soil loss from farm fields has long been a problem within the watershed. Soil is transported largely through field runoff, stream bank erosion, and wind erosion. Hydrological alteration of stream channels through ditching and destruction of the stream riparian zones exacerbates soil loss.

Major rivers and streams within this watershed include the Red River, Grand Marais Creek, Judicial Ditch 1, County Ditch 2, and County Ditch 75. Grand Marais Creek originates just east of the Red Lake River approximately 1.5 miles northwest of the town of Fisher. From its origin, Grand Marais Creek flows to the northwest, paralleling the Red Lake River for approximately 41 miles before it reaches its confluence with the Red River about eight miles north of East Grand Forks. The Red River forms the western border of the Grand Marais Creek Watershed in Minnesota. The Red River originates in Breckenridge at the confluence of the Otter Tail and Bois de Sioux River and flows north for over 550 miles to Lake Winnipeg in Canada. On its route, it flows through the cities of Fargo, Moorhead, and Grand Forks. The river also serves as the border between Minnesota and North Dakota.

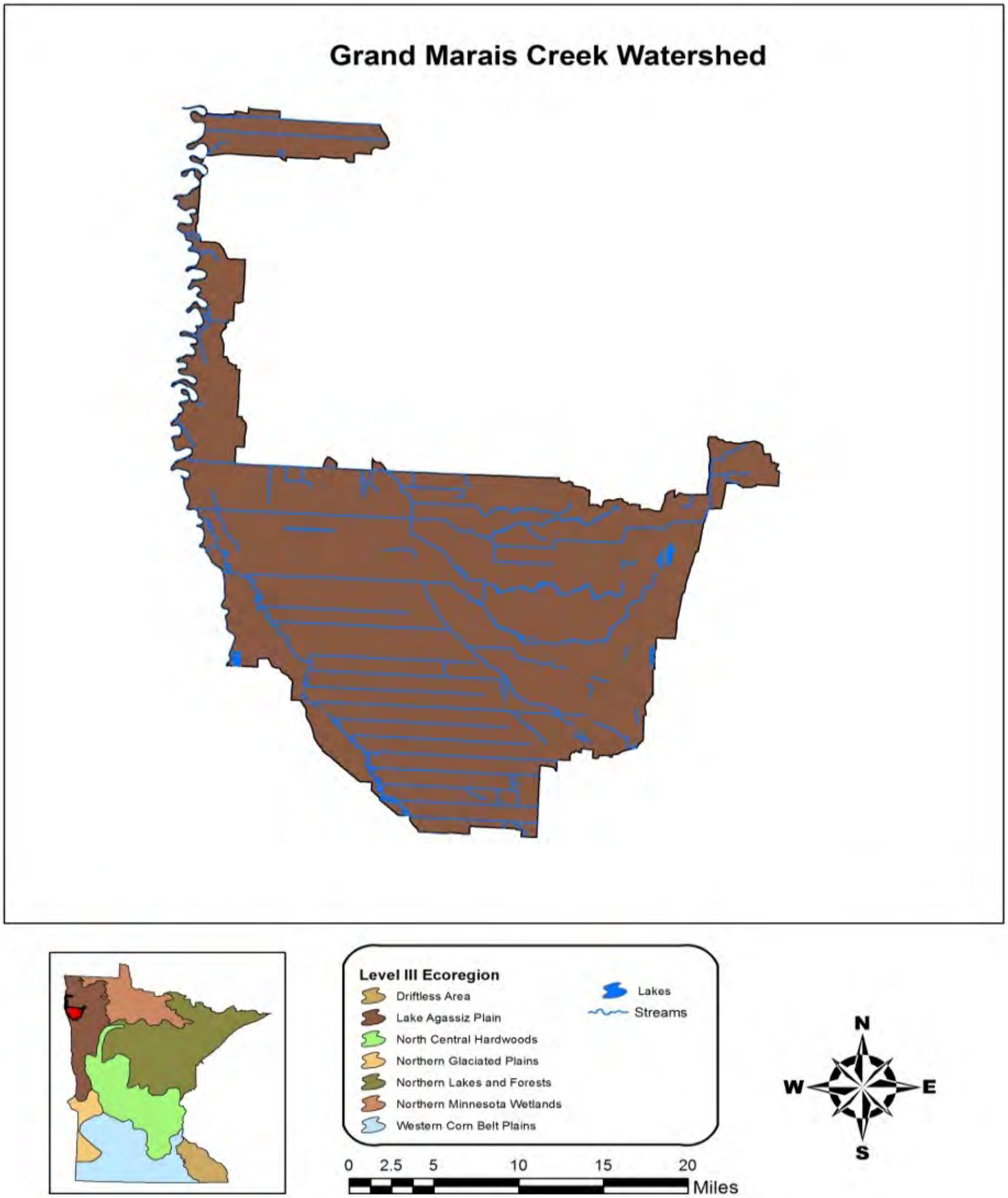

Figure 5. The Grand Marais Creek Watershed within the Lake Agassiz Plain Ecoregion of northwestern Minnesota.

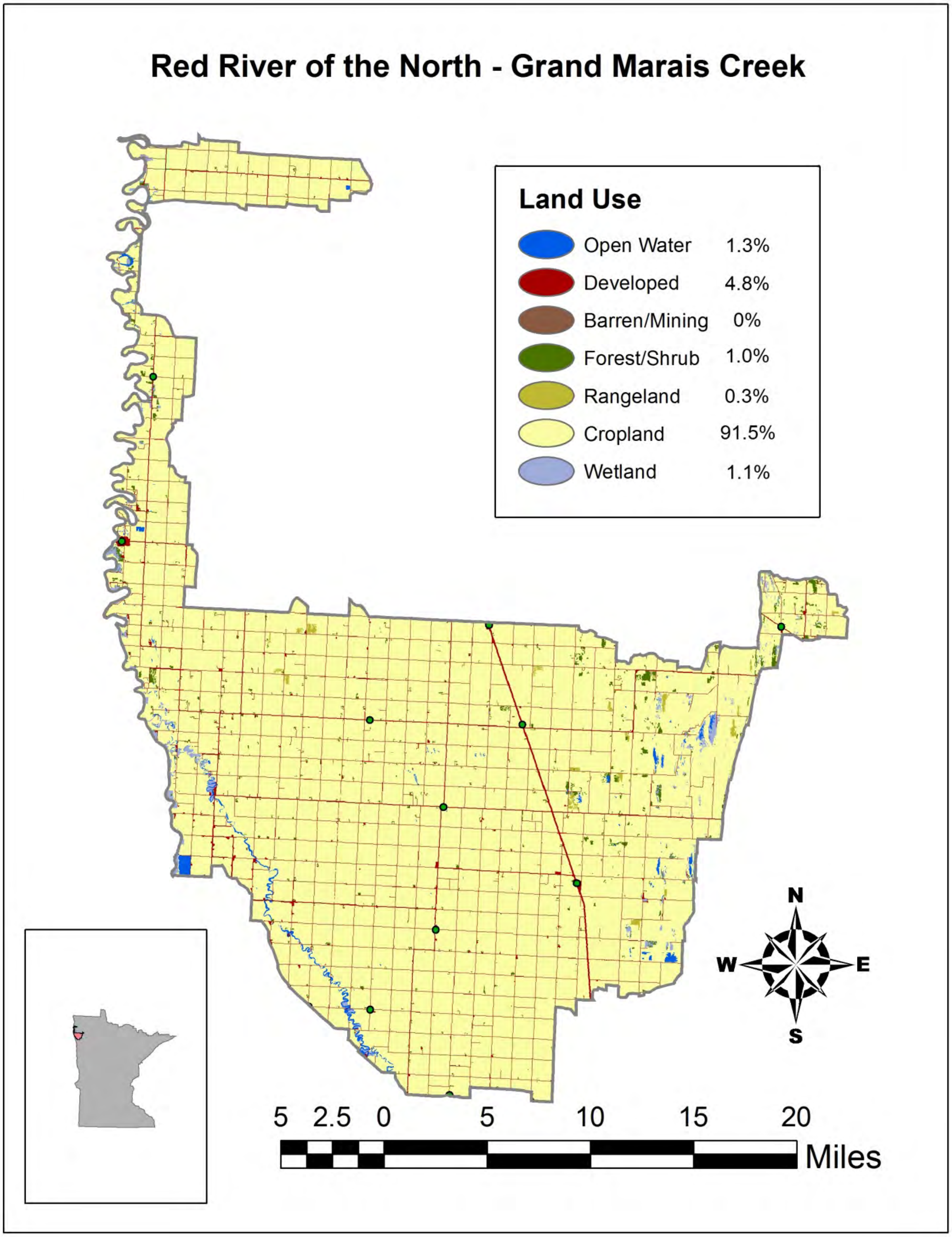

Figure 6. Land use in the Grand Marais Creek Watershed.

Surface water hydrology

The Grand Marais Creek Watershed is part of the Red River Basin which is located in northwestern Minnesota and southeastern North Dakota. The Red River originates in Breckenridge at the confluence of the Otter Tail and Bois de Sioux River at an approximate elevation of 943 feet above sea level and flows north for over 550 miles to Lake Winnipeg in Canada. On its route, it flows through the cities of Fargo, Moorhead, and Grand Forks. The river also serves as the border between Minnesota and North Dakota. From its origin, the Red River flows approximately 140 miles and descends about 172 feet to the northern boundary of the Grand Marais Creek Watershed near the town of Oslo. Covering an area of roughly 298,264 acres (466 mi^2) of land, the Grand Marais Creek Watershed serves as an important contribution to the Red River. Grand Marais Creek begins about 1.5 miles NW of Fisher, and parallels the Red Lake River for approximately 41 miles prior to its confluence with the Red River. Along its route, it receives surface water from its tributaries which are nearly all man-made ditches and or reaches which have been channelized to increase the drainage rate. Flow of these tributaries is primarily west in direction, as they drain the agricultural land to the east and eventually transport the surface water to Grand Marais Creek. These tributaries include County Ditch 2, County Ditch 126, and several unnamed ditches. The current outlet of Grand Marais Creek is a cut-off ditch built in the early 1900's as a State and County drainage project. This cut-off channel replaced the natural six mile meandering outlet which flows to the northwest. Since the construction of the cut-off channel, the area has seen increased erosion with estimates from the channel alone approaching 700 tons of sediment annually Board of Water and Soil Resources (BWSR). A project (Red Lake Watershed District [RLWD] Project 60F) has recently been completed to restore this abandoned six mile stretch of natural meandering outlet. In the far northern part of the watershed downstream of the confluence of Grand Marais Creek and the Red River, numerous small, ephemeral tributary streams flow directly into the main-stem of the Red River.

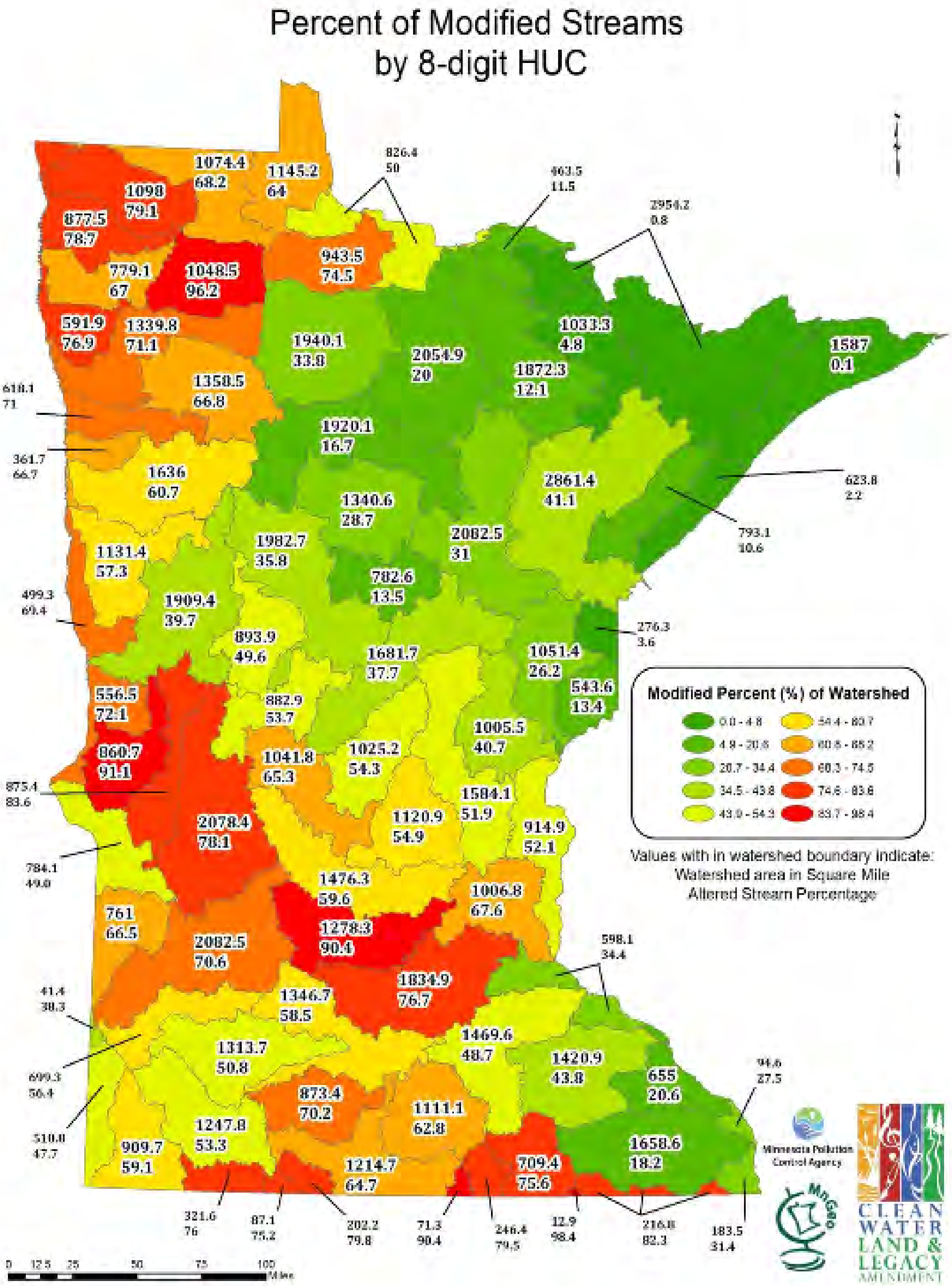

Figure 7. Percent modified streams by major watershed (8-HUC).

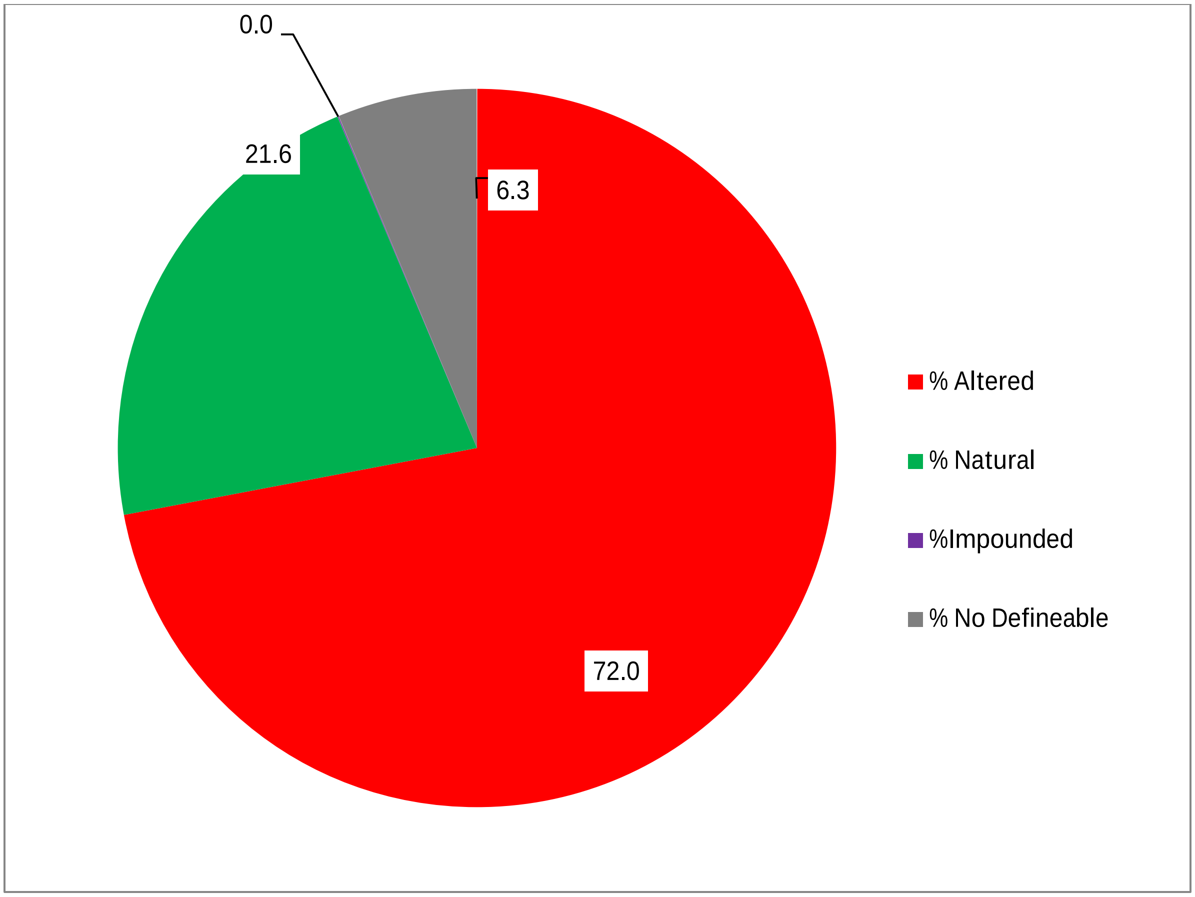

Figure 8. Comparison of natural to altered streams in the Grand Marais Creek Watershed (percentages derived from the state-wide Altered Water Course project).

Climate and precipitation

The ecoregion has a continental climate, marked by warm summers and cold winters. The mean annual temperature for Minnesota is 4.5°C; the mean summer temperature for the Grand Marais Creek watershed is 18.9°C; and the mean winter temperature is – 13.3°C (DNR State Climatology Office, 2003).

Precipitation is the source of almost all water inputs to a watershed. Figure 9 shows two representations of precipitation for calendar year 2012. On the left is total precipitation, showing the typical pattern of increasing precipitation toward the eastern portion of the state. According to this map, the Grand Marais Creek Watershed area received approximately 16 inches of precipitation in 2012. The display on the right shows the amount those precipitation levels departed from normal. For the Grand Marais Creek area it shows that precipitation ranged from four to six inches below normal.

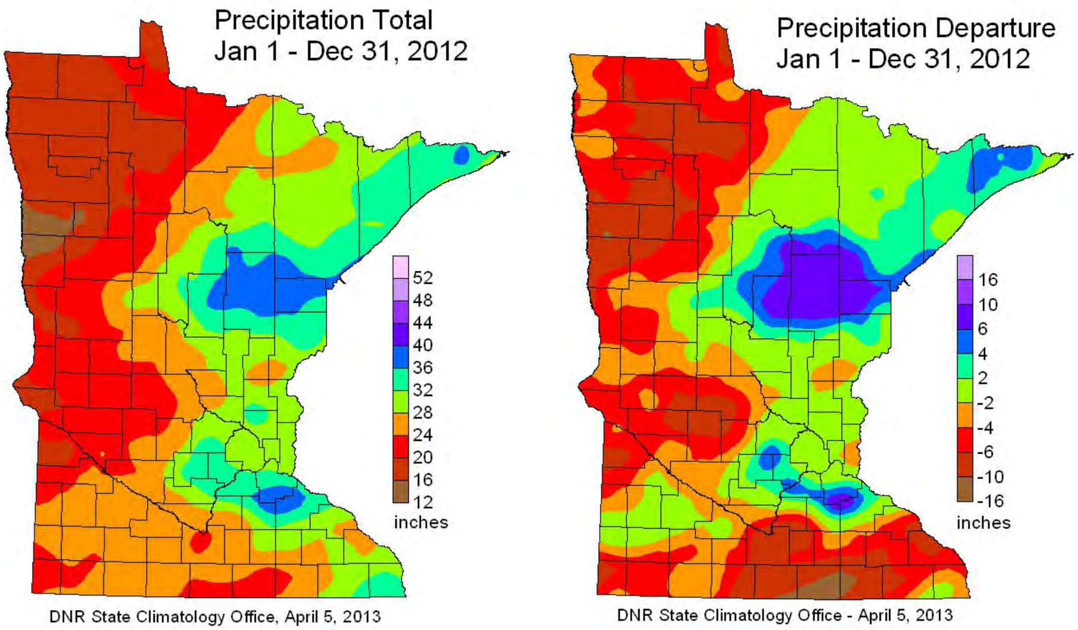

Figure 9. State-wide precipitation levels during the 2012 water year (Source: DNR State Climatology Office, 2003).

The Grand Marais Creek Watershed is located in the northwest precipitation region. Figure 10 and 11 (below) display the areal average representation of precipitation in northwest Minnesota for 20 and 100 years, respectively. An areal average is a spatial average of all the precipitation data collected within a certain area presented as a single dataset. This data is taken from the Western Regional Climate Center, available as a link off of the University of Minnesota Climate website. Though rainfall can vary in intensity and time of year, rainfall totals in the northwest region display no significant trend over the last 20 years.

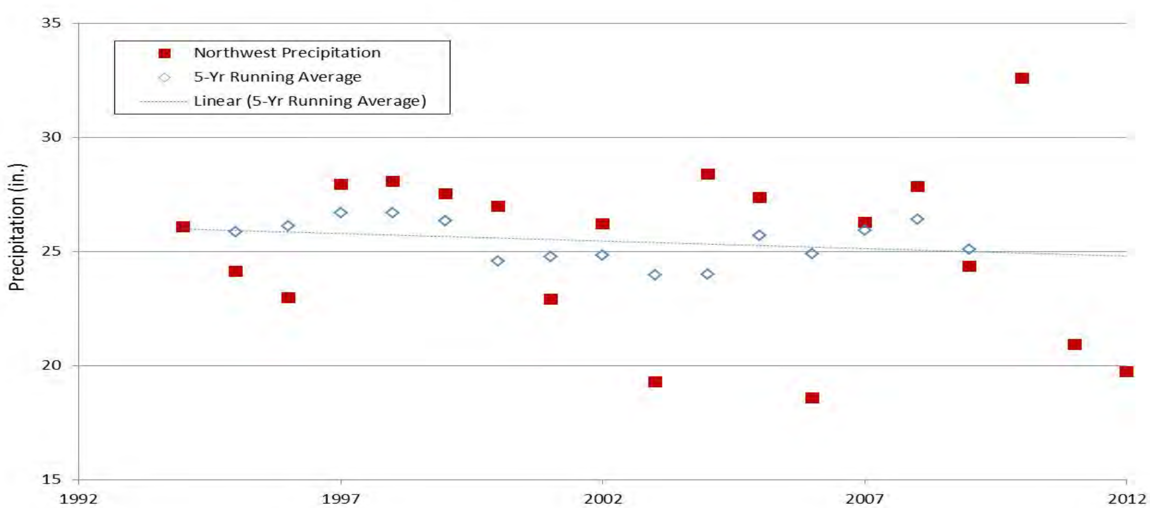

Figure 10. Precipitation trends in Northwest Minnesota (1993 - 2012) with five year running average.

However, precipitation in northwest Minnesota exhibits a statistically significant rising trend over the past 100 years (p=0.001). This is a strong trend and matches similar trends throughout Minnesota.

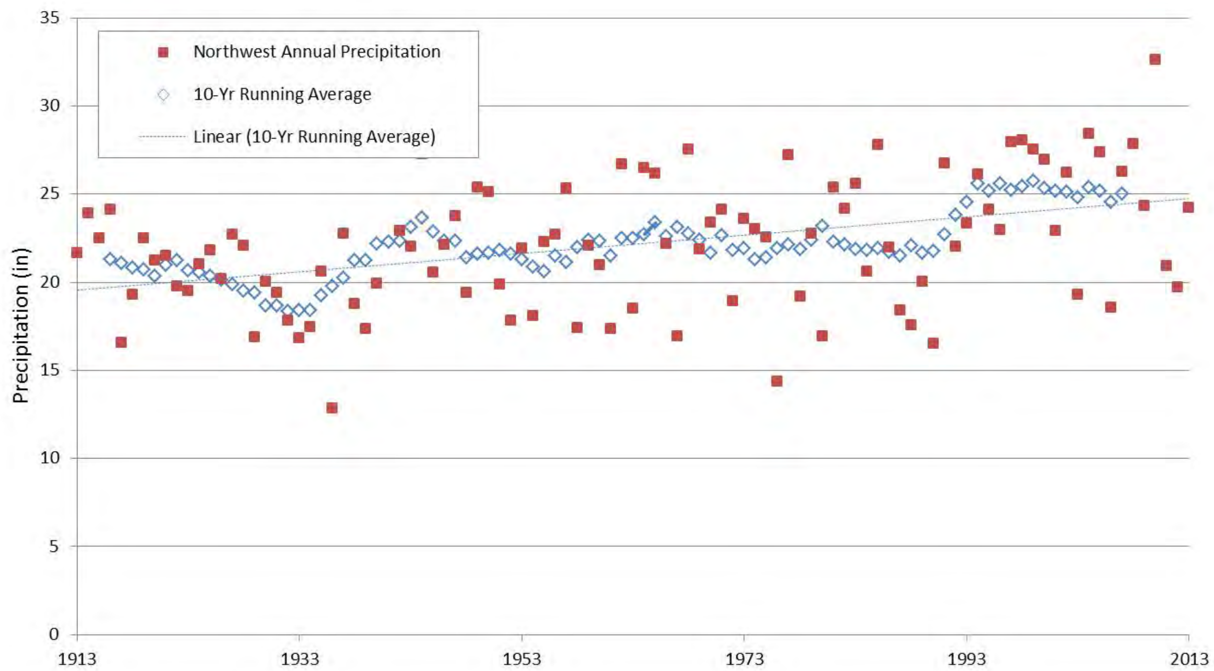

Figure 11. Precipitation trends in northwest Minnesota (1913-2013) with ten-year running average.

Hydrogeology

The Grand Marais Creek Watershed is located within the Red River of the North Basin in the Northwest Hydrogeologic region of Minnesota (Region 3). This basin is composed of thick lacustrine sediments, averaging 150 to 300 feet deep with up to 95 feet of silt and clay lacustrine deposits underneath left behind by Glacial Lake Agassiz (USGS, 2013). The lake was formed in the Hudson Bay drainage during the last de-glaciation, leaving behind two distinct hydrogeologic features – beach ridges and the lake plain. The beach ridges are remnants of the shorelines of Lake Agassiz, and are characterized by sandy, coarse-textured deposits and disjoined aquifers. In these disconnected aquifers, water will collect and move horizontally through the ridge and form wetlands and springs at the bases. The plain, also named Lake Agassiz Plain, is composed of glacial till overlying thick lacustrine sediments and is more specifically characterized by glacially-deposited, clay-rich sediments, poorly drained organic soils, peat and open and wooded wetlands (Lorenz & Stoner, 1996). The plain is extremely flat with few lakes, making it highly prone to flooding.

The Grand Marais Creek Watershed is also located within one of Minnesota's six Ground Water Provinces: the Western Province (Figure 12). This province is defined by the DNR and described geologically as "clayey glacial drift overlying Cretaceous and Precambrian bedrock" (2001).

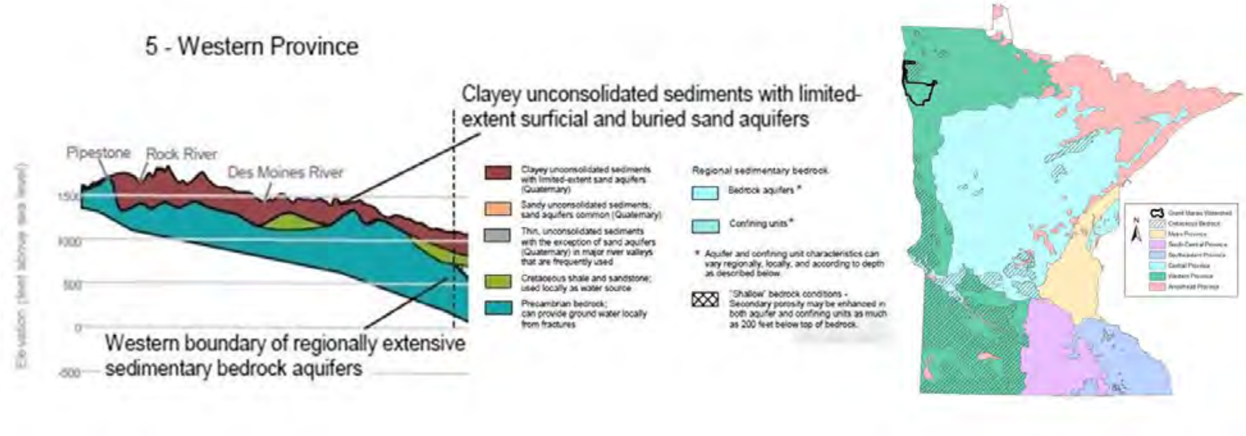

Figure 12. Western province generalized cross section (Source: DNR, 2001).

The lake plain aquifers are covered with thick lake deposits which are recharged primarily from areas with stagnation moraines to the east of the watershed. These areas are where glaciers “stagnated”; deposited coarse-grained material and left behind rough topography. These areas are important for regional groundwater recharge in the entire northwestern portion of the state; they average five inches of recharge per year, but can account for up to ten inches (MPCA, 1999)

Groundwater is available primarily through surficial sand and gravel aquifers, buried sand and gravel aquifers and deeper cretaceous aquifers. Recharge of these aquifers is limited to areas located at topographic highs, areas with surficial sand and gravel deposits, and those along the bedrock/surficial deposit interface. Typically, recharge rates in unconfined aquifers are estimated at 20 to 25% of precipitation received, but can be less than 10% of precipitation where glacial clays or till are present (USGS, 2007). For the Grand Marais Creek Watershed, the average annual recharge rate to surficial materials is zero to two inches per year for the majority of the watershed with some areas of two to four inches per year in the eastern reaches (Figure 13).

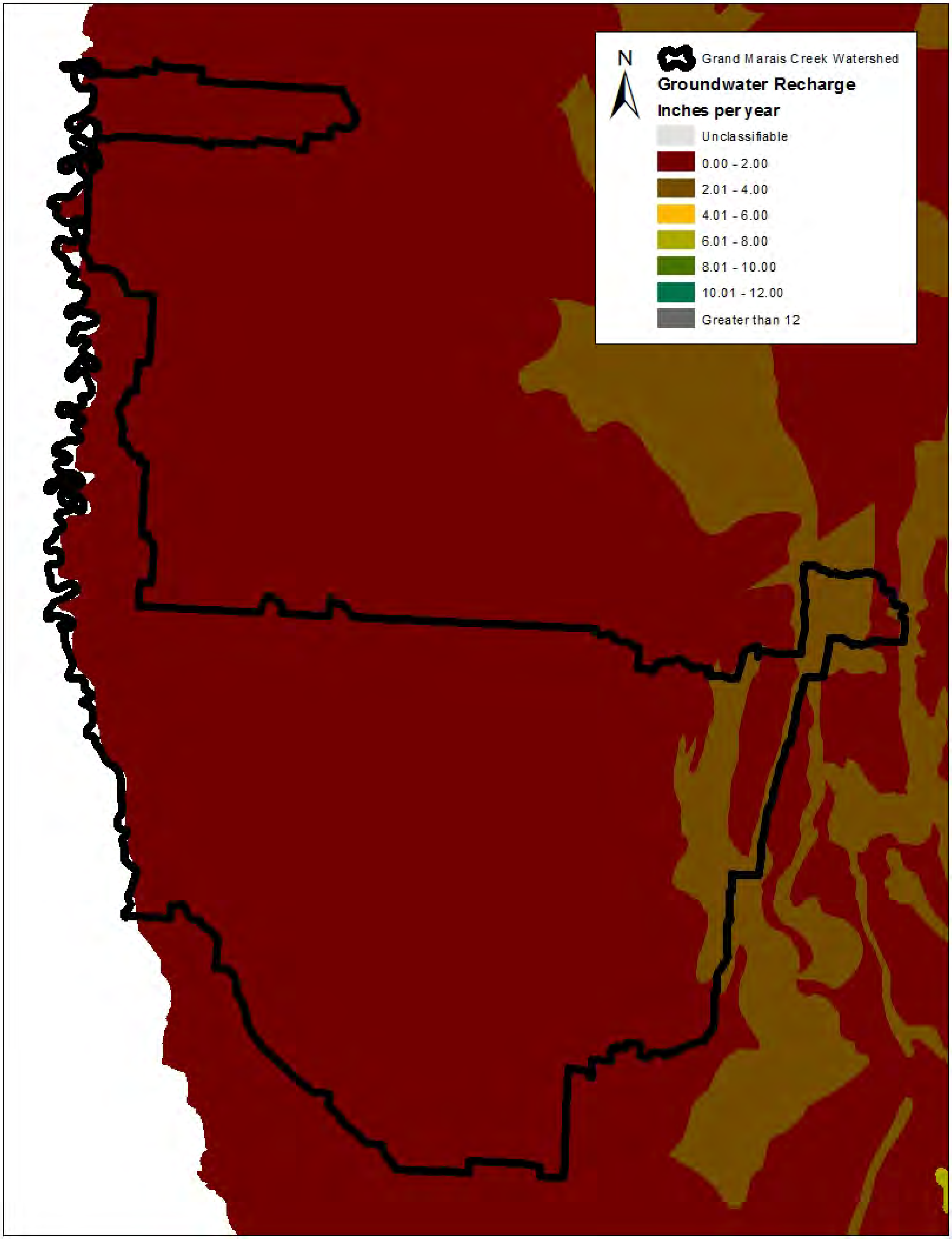

Figure 13. Average annual recharge rate to surficial materials in Grand Marais Creek Watershed (1971 - 2000).

High capacity withdrawals

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

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

The three largest permitted consumers of water in the state (in order) are municipalities, industry and irrigation. The withdrawals within the Grand Marais Creek Watershed are mostly for irrigation (major crop) and municipal use (waterworks).

Figure 14 displays total groundwater withdrawals from the watershed from 1991-2011 as blue diamonds with total surface water withdrawals as red squares. During this time period within the Grand Marais Creek Watershed, groundwater withdrawals exhibit a significant declining trend (p=0.01) while surface water withdrawals exhibit no trend.

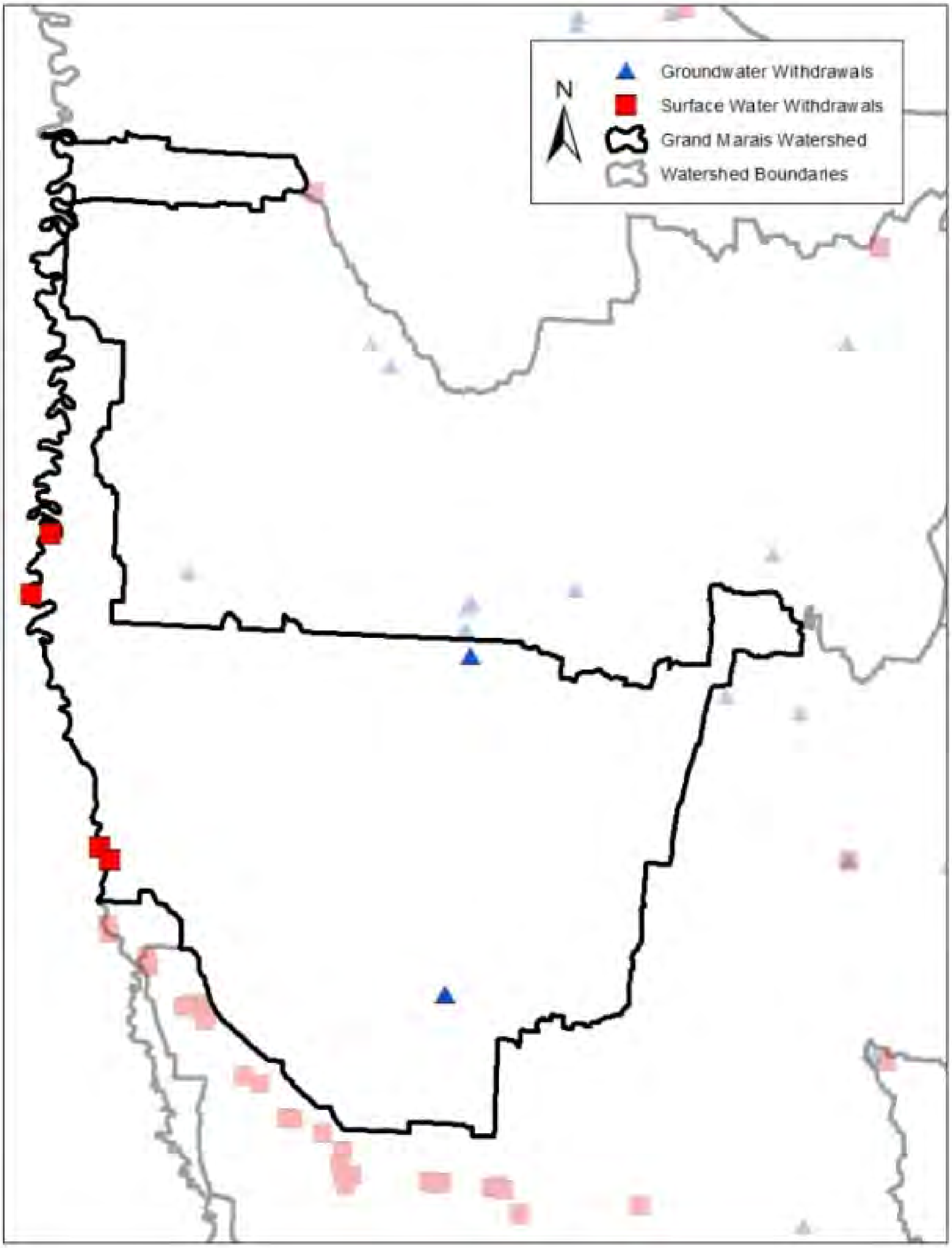

Figure 14. Locations of permitted groundwater withdrawals in the Grand Marais Creek Watershed.

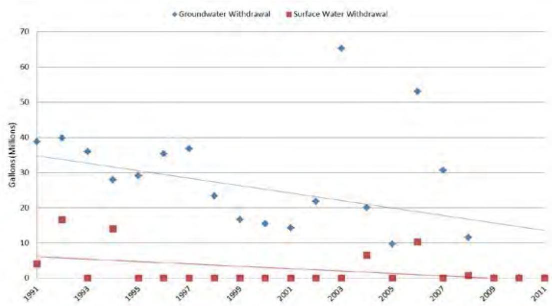

Figure 15. Total annual groundwater and surface water withdrawals in the Grand Marais Creek Watershed (1991 - 2011).

Wetlands

Wetlands are uncommon in the Grand Marais Creek Watershed. National Wetlands Inventory (NWI) data estimate 4,751 acres of wetland – which is approximately only 1% of the watershed area (Figure 16). This wetland extent is well below the state wetland coverage rate of 19% and below the 6% rate for the Temperate Prairies ecoregion (Kloiber and Norris 2013, MPCA *in prep*). Almost all of the wetlands present in the watershed are the Emergent wetland class (i.e., dominated by grasses, sedges, bulrushes, and/or cattails).

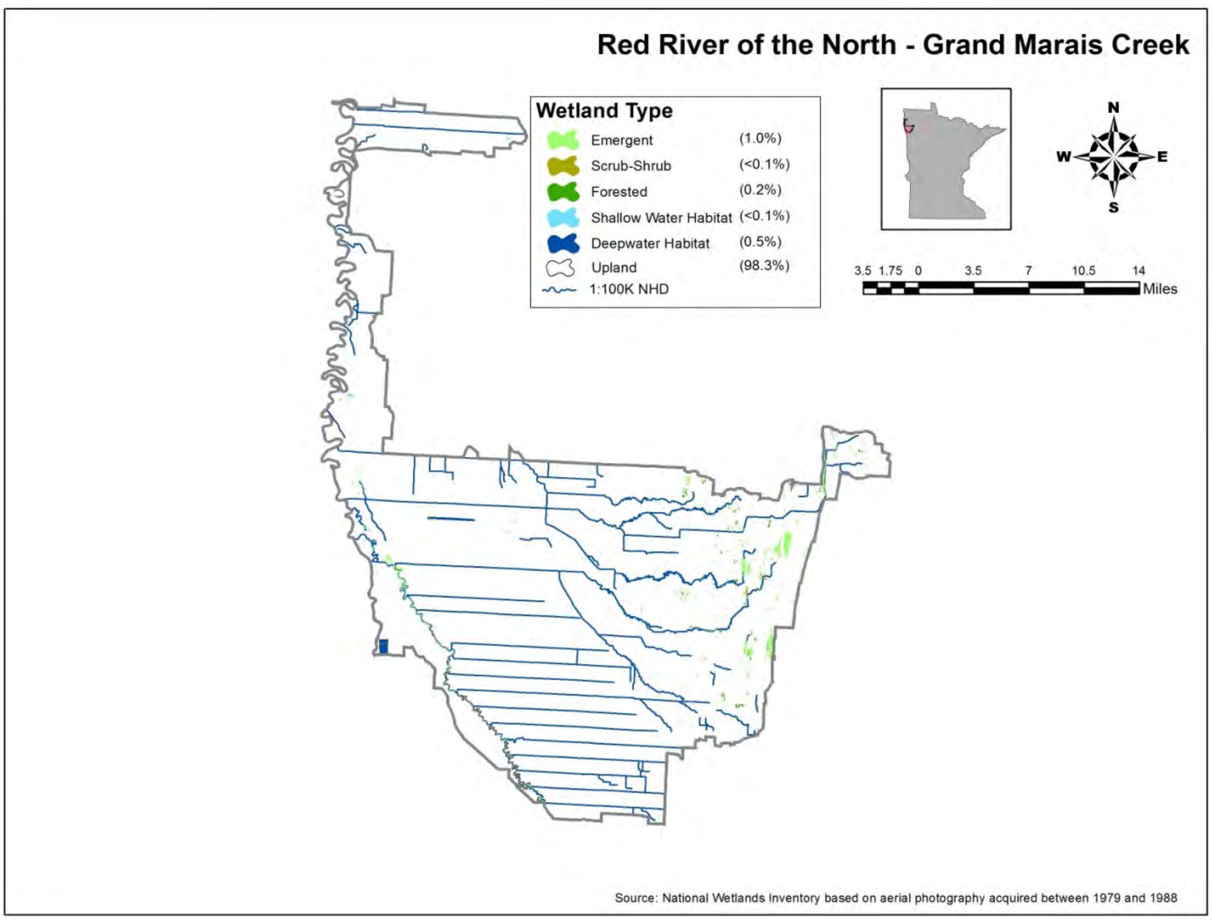

Figure 16. Wetlands and surface water in the Grand Marais Creek Watershed. Wetland data is from the National Wetlands Inventory.

Prior to settlement, wetlands were much more prevalent in the Grand Marias Creek Watershed. Soil features that persist even after artificial drainage can be used to estimate historical wetland extent. Mapped Poorly and Very Poorly drained soil drainage classes (which would typically support wetlands) equal 142,508 acres in the watershed – or approximately 38%. Comparing that total to the current NWI estimate reveals that approximately 96% of the historical wetland extent has been lost. There is also little variation in wetland loss rates between the six sub-watersheds – with loss rates ranging from 93%-98%.

Two glacial landforms present in the Grand Marais Creek Watershed (MNGS 1997) have largely dictated the current extent patterns; as well as the kinds of hydrogeomorphically (HGM; Smith et al. 1995) functioning types that are currently (or once) present. The western two-thirds of the watershed consists of a glacial lake plain landform. The extremely flat landscape that remained following the drainage of Glacial Lake Agassiz had little capacity to drain surface water – promoting saturated soil conditions over expansive areas. The mineral flat HGM type wetlands that formed due to these factors have in large part been effectively drained via surface ditching to increase agriculture production. The remainder of the watershed is made up of a relatively narrow band of sand and gravel glacial lake beach ridges that were formed on the shores of Glacial Lake Agassiz at various stages of lake depth. The majority of the watershed's current wetlands occur amongst these beach ridges – where drainage and agriculture is less practical. There are numerous areas of groundwater discharge along the beach ridge zone. Wetlands form where water accumulates behind downstream ridges (depressional HGM type); as well as, in areas on the ridge slopes where groundwater discharge saturates the soil surface and peat accumulates (slope HGM type). Calcareous fens – an uncommon wetland type with alkaline (pH > 6.7) peat that supports a number of rare plant species – form where the groundwater discharge is mineral-rich. Calcareous fens are state Outstanding Resource Value Waters (ORVW; Minn. R. ch. 7050 2008; https://www.revisor.leg.state.mn.us/rules/?id=7050. A single known-designated calcareous fen occurs in the watershed approximately two miles north of the intersection of the Pembina Trail and MN Hwy 1.

The MPCA is actively developing methods and building capacity to conduct wetland quality monitoring and assessment. Our primary approach is biological monitoring – where changes in biological communities may be indicating a response to human-caused stressors. The MPCA has developed macroinvertebrate and vegetation Indices of Biological Integrity (IBIs) for depressional wetlands and the Floristic Quality Assessment (FQA) to assess vegetation condition in all of Minnesota's wetland types. For more information about the wetland monitoring (including technical background reports and sampling procedures) please visit the MPCA Wetland monitoring and assessment webpage.

The MPCA currently does not monitor wetlands systematically by watershed. Alternatively, the overall status and trends of wetland quality in the state and by major ecoregion is being tracked through probabilistic monitoring. Probabilistic monitoring refers to the process of randomly selecting sites to monitor; from which, an unbiased estimate of the resource can be made. The MPCA is in process of publishing the results of an initial baseline survey of vegetation quality for all wetland types based on the FQA (MPCA *in prep*). While none of the survey sites were located within the watershed – the overall survey results may provide a reasonable approximation of current wetland conditions.

Wetland vegetation quality is high in Minnesota (Table 2) – with approximately 67% of the total wetland extent in Good to Exceptional condition. Wetlands in these condition categories have had few (if any) changes in expected native vegetation composition or abundance distribution. The high rates of Good to Exceptional wetlands at the statewide scale is being driven by the large proportion of wetlands (75%) that occur in the Mixed Wood Shield (i.e., northern forest) ecoregion – where there have been few human impacts. The Grand Marais Creek watershed, however, is located entirely within the Temperate Prairies ecoregion – where agriculture is the predominant land use and the vast majority of pre-settlement wetlands have been drained. Correspondingly, wetland vegetation quality in the ecoregion is largely degraded (Table 2) – with 82% of wetlands in Poor to Fair condition. Plant communities assessed as Poor to Fair have had moderate to extreme changes in expected species composition and abundance distributions. These changes are associated with a broad spectrum of human impacts such as physical and hydrological alterations – that most often promote increases in the abundance of non-native plant species such as Reed canary grass and/or Narrow leaved cattail. Wetlands with Poor vegetation condition often have had significant to complete replacement of native species by non-native invasives. Given the ecoregional setting of the Grand Marais Creek Watershed, it is very likely that the vegetation quality of the wetlands in the watershed is predominantly degraded.

Table 2. The relative proportions of wetland vegetation condition categories (Exceptional/Good/Fair/Poor) observed statewide and in the Temperate Prairies ecoregion for all wetland types. Proportions are based on the total wetland extent over the geographic area.

Condition Category	Statewide	Temperate Prairies
Exceptional	49%	7%
Good	18%	11%
Fair	23%	40%
Poor	10%	42%

Watershed-wide data collection methodology

Load monitoring

Water chemistry sampling and stream gaging on the Grand Marais Creek on CR64 near East Grand Forks, Minnesota (DNR/MPCA ID: 67014001; Environmental Quality Information System EQuIS ID: S002-126) started in late 2009. High flow events in 2010 and 2011 caused backwater issues at the site, making it impossible to measure flow volume. Reverse flow from the Red River was noted during one high flow event in early March 2010.

In addition, access during high water periods was not possible due to flooded roads. In 2012, there was little or no flow at the site for most of the year. Due to the difficulty in obtaining flow measurements, the site was removed from the WPLMN network after the 2012 monitoring season.

Grand Marais Creek received funds through the Lessard-Sams/Clean Water Fund in 2012 for a multipurpose flood damage reduction and habitat restoration project. The project restored the original characteristics of Grand Marais Creek and its floodplain, stabilized the stream channel (including the outlet to the Red River of the North), and installed an upstream control structure. The structure allows 1.25 year storm flows to pass through the restored cut-off drainage to the Red River. This project has recently been completed.

The flow period for 2010 was from 04/19/2010 to 12/31/2010. The flow period for 2011 was from 04/04/2011 to 12/31/2011. Because correlations between concentration and flow exist for many of the monitored analytes, sampling frequency is typically greatest during periods of moderate to high flow (Figure 17). Because these relationships can also 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.

Annual water quality and daily average flow 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 to compute pollutant loads for all WPLMN monitoring sites. 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 includes annual and daily pollutant loads and flow weighted mean concentrations (pollutant load/total flow volume). Loads and flow weighted mean concentrations are calculated for total suspended solids (TSS), total phosphorus (TP), dissolved orthophosphate (DOP), nitrate plus nitrite nitrogen (nitrate-N), and total Kjeldahl nitrogen (TKN).

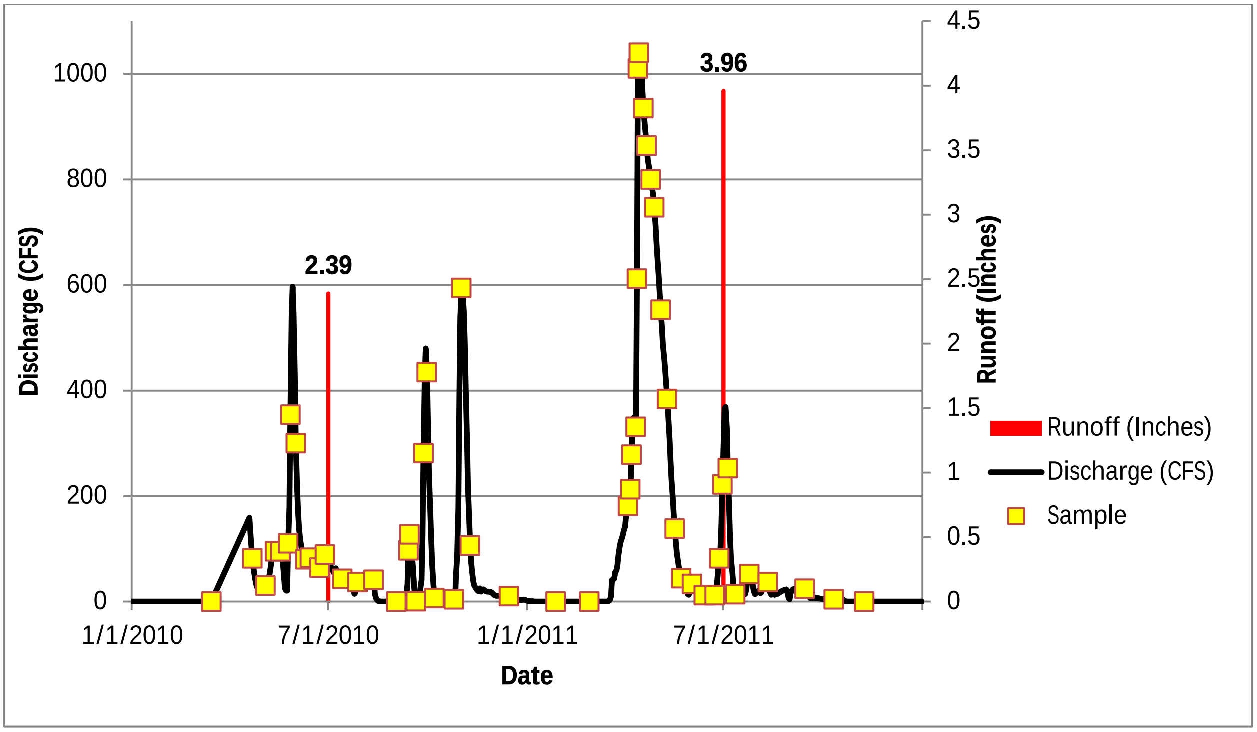

Figure 17. Hydrograph, sampling regime and annual runoff for the Grand Marais Creek near East Grand Forks, Minnesota.

Stream water sampling

Four water chemistry stations were sampled from May thru September in 2012, and again from June thru August of 2013, to provide sufficient data to assess aquatic life and aquatic recreation. Following the IWM design, water chemistry stations were placed at the outlet of each aggregated 12 HUC subwatershed that was >40 square miles in area (red circles and green circles/triangles in (Figure 3). A Surface Water Assessment Grant (SWAG) was awarded to the RLWD. Due to the highly temporal nature of many of the reaches within the Grand Marais Creek Watershed, water chemistry stations were only sampled at the outlet of four of the six subwatersheds; Judicial Ditch #75, County Ditch #2, Grand Marais Creek, and Judicial Ditch 1. Furthermore, only Judicial Ditch 75 and County Ditch #2 were able to be co-located with biological monitoring stations. The Grand Marais Creek water chemistry station was not assessed for biology or chemistry due to influence from the outlet restoration project.

Stream flow methodology

The United States Geological Survey (USGS) maintains real-time stream flow gaging stations across the United States. Measurements can be viewed at http://waterdata.usgs.gov/nwis/rt. Additionally, the MPCA and DNR cooperatively operate gaging stations across the state. Data from these stations is available at http://www.dnr.state.mn.us/waters/csg/index.html.

Stream biological sampling

Three new sites and two existing sites on five different stream reaches were sampled in the Grand Marais Creek Watershed during the summer of 2012. The sites were located near the outlets of minor HUC-14 watersheds. The existing sites were initially established as part of a random Red River Basin wide survey in 2005, or a 1996 survey of channelized streams with intact riparian zones. Data from the last 10 years was used in the 2014 assessments but the majority of data was collected in 2012. Sufficient data was available to assess aquatic life on four stream reaches. Biological information that was not used in the assessment process will be crucial to the stressor identification process and will also be used as a basis for long term trend results in subsequent reporting cycles.

Fish and invertebrate indices of IBIs were calculated to measure the health of aquatic life at each biological monitoring station. The IBI's are divided into seven distinct warm water classes and two cold water classes to account for natural variation in community structure due to geographic region, watershed drainage area, water temperature and stream gradient. Each IBI class uses a unique suite of metrics, scoring functions, impairment thresholds, and confidence intervals (CIs) (For IBI classes, thresholds and CIs, see Appendix 4.1). IBI scores that are 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 is examined to support an impairment decision. Examples of additional data used to support an assessment decision include potential local and watershed stressors and additional monitoring information (e.g., water chemistry, physical habitat, observations of local land use activities). For IBI results for each individual biological monitoring station, see Appendix 4.2 and 4.3.

Fish contaminants

No fish contaminant data was collected for the Grand Marais Creek Watershed. The Outlet Restoration Project (Project 60) altered the flow and made sampling at the pour point (required for this analysis) nearly impossible. The project has recently been completed and the watersheds natural six mile meandering outlet has been restored.

Lake water sampling

There are no lakes in the Grand Marais Creek Watershed.

Ground water 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 quantity

Monitoring wells from the DNR 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.

Wetland monitoring

The MPCA began developing biological monitoring methods for wetlands in the early 1990s, focusing on wetlands with emergent vegetation (i.e., marshes) in a depressional geomorphic setting. This work has resulted in the development of plant and macroinvertebrate (aquatic bugs, snails, leeches, and crustaceans) IBIs for the Temperate Prairies (TP), Mixed Wood Plains (MWP) and the Mixed Wood Shield (MWS) level II ecoregions in Minnesota. These IBIs are suitable for evaluating the ecological condition or health of depressional wetland habitats. All of the wetland IBIs are scored on a 0 to 100 scale with higher scores indicating better condition. Wetland sampling protocols can be viewed at: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/wetlands/wetland-monitoring-and-assessment.html. Today, these indicators are used in a statewide survey of wetland condition where results can be summarized statewide and for each of Minnesota's three level II ecoregions (Genet 2012).

Individual subwatershed results

Aggregated HUC-12 subwatersheds

Assessment results for aquatic life and recreation use are presented for each aggregated HUC-12 subwatershed within the Grand Marais Creek Watershed. The primary objective is to portray all the full support and impairment listings within an aggregated 12-HUC subwatershed resulting from the complex and multi-step assessment and listing process (Figure 4). 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 aggregated HUC-12 subwatersheds contain the assessment results from the 2014 Assessment Cycle as well as any impairment listings from previous assessment cycles. Discussion of assessment results focuses primarily on the 2012 intensive watershed monitoring effort, but also considers available data from the last ten years.

The proceeding pages provide an account of each aggregated HUC-12 subwatershed. 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) stream habitat quality c) channel stability, and where applicable d) water chemistry for the aggregated HUC-12 outlet, and e) lake aquatic recreation assessments. Following the tables is a narrative summary of the assessment results and pertinent water quality projects completed or planned for the subwatershed. A brief description of each of the summary tables is provided below.

Stream assessments

A table is provided in each section summarizing aquatic life and aquatic recreation assessments of all assessable stream reaches within the subwatershed (i.e., where sufficient information was available to make an assessment). Primarily, these tables reflect the results of the 2012 assessment process, 2014 Environmental Protection Agency (EPA) reporting cycle; however, impairments from previous assessment cycles are also included and are distinguished from new impairments via cell shading (see footnote section of each table). These tables also denote the results of comparing each individual aquatic life and aquatic recreation indicator to their respective criteria (i.e., standards); determinations made during the desktop phase of the assessment process (see Figure 5). Assessment of aquatic life is derived from the analysis of biological (fish and invert IBIs), dissolved oxygen, turbidity, chloride, pH and un-ionized ammonia (NH3) data, while the assessment of aquatic recreation in streams is based solely on bacteria (E. coli or fecal coliform) data. Included in each table is the specific aquatic life use classification for each stream reach: cold water community (CW); cool or warm water community (WW); 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, but are included in Appendix 3. Where applicable and sufficient data exists, assessments of other designated uses (e.g., class 7, drinking water, aquatic consumption) are discussed in the summary section of each aggregated HUC-12 subwatershed as well as in the watershed wide results and discussion section.

Stream habitat results

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

Stream stability results

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

Subwatershed outlet water chemistry results

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

No lakes are within the Grand Marais Creek Watershed.

Judicial Ditch 75 Subwatershed

HUC 0902030603-01

The Judicial Ditch 75 Subwatershed is in the north half of the watershed. Draining approximately 106 square miles, it's the second largest contributing subwatershed in the Grand Marais Creek system and includes portions of Marshall, Pennington, and Polk Counties. Reaches within this area include several unnamed ditches, County Ditch 44, and Judicial Ditch 75 (County Ditch 43). Flow is primarily in a westerly direction with surface water from all of the reaches going into Judicial Ditch 75. Judicial Ditch 75 empties into the Red River approximately six miles south of the town of Oslo. The land is primarily utilized for agricultural purposes as roughly 92% is cropland. Due to the temporal nature of the channelized reaches within this subwatershed, along with the dry year experienced in 2012, few stations were established and or sampled. This is true for the entire Grand Marais Creek Watershed.

The outlet of the Judicial Ditch No. 75 Subwatershed is represented by MPCA's STORET/EQuIS station S005-570 and biological station 12RD098, located upstream of County Road 22 and about 6 miles southeast of the town of Oslo.

Table 3. Aquatic life and recreation assessments on stream reaches: Judicial Ditch 75 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:								Aquatic Rec. Indicators:		Aquatic Life	Aquatic Rec.
					Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH3	Pesticides	Bacteria	Nutrients		
09020306-517 County Ditch 43 *Unnamed Ditch to County Ditch 7*	23.61	WWm	07RD023 2RD089 12RD087	Upstream of CSAH 8, 3 mi. SW of Carpenters Corner Upstream of 300th Ave NW, 0.5 mi. NE of Angus Upstream of 360th Ave NW, 2 mi. NE of Tabor	EXS	EXS	IF	IF	-	IF	-	-	-	-	IMP	NA
09020306-520 Judicial Ditch 75 *County Ditch 7 to Red River*	12.86	WWm	12RD098	Downstream of CSAH 22, 6 mi. SE of Oslo.	EXS	MTS	MTS	-	MTS	MTS	MTS	-	IF	-	IMP	IMP

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information

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

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

Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water

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

Table 4. Minnesota Stream Habitat Assessment (MSHA): Judicial Ditch 75 Subwatershed.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
2	07RD023	County Ditch 43	0	10.5	22	11	25	68.5	Good
	07RD023	County Ditch 43	3	8.5	10.8	15	15	52.3	Fair
1	12RD089	County Ditch 43	0	6.5	20	9	7	42.5	Poor
1	12RD087	County Ditch 43	0	6	7	5	7	25	Poor
1	12RD098	Judicial Ditch 75	0	7	12	10	13	42	Poor
Average Habitat Results: Judicial Ditch No. 75 Subwatershed			**.6**	**7.7**	**14.36**	**10**	**13.4**	**46.06**	**Fair**

Qualitative habitat ratings

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

Table 5. CCSI: Judicial Ditch 75 Subwatershed.

# Visits	Biological Station ID	Stream Name	Upper Banks (43-4)	Lower Banks (46-5)	Substrate (37-3)	Channel Evolution (11-1)	CCSI Score (137-13)	CCSI Rating
1	07RD023	County Ditch 43	22	15	12	4	53	Moderately Unstable
1	12RD089	County Ditch 43	23	14	15	2	54	Moderately Unstable
1	12RD087	County Ditch 43	30	17	22	2	71	Moderately Unstable
0	12RD098	Judicial Ditch 75	-	-	-	-	-	-
Average Stream Stability Results: *Judicial Ditch No. 75 Subwatershed*			**25**	**15.3**	**16.3**	**2.7**	**59.3**	**Moderately Unstable**

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 6. Outlet water chemistry results: Judicial Ditch 75 Subwatershed.

Station location:	**Judicial Ditch # 75 AT CSAH-22, 11 MI N OF EAST GRAND FORKS**						
STORET/EQuIS ID:	**S005-570**						
Station #:	**0902030603-01**						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	ug/L	14	0.63	15.0	3.9	40	0
Chloride	mg/L	16	5.6	43.5	22.5	230	0
Dissolved Oxygen (DO)	mg/L	45	5.5	13.8	8.4	5	0
pH		42	7.6	9.3	8.1	6.5 - 9	2
Secchi Tube	100 cm	26	1	45	20.6	10	7
Total suspended solids	mg/L	29	3	1040	79	65	4
Escherichia coli (geometric mean)	MPN/100ml	3	92	137	113	126	1
Escherichia coli	MPN/100ml	30	11	1203	217	1260	0
Chlorophyll-a, Corrected	ug/L	0					
Inorganic nitrogen (nitrate and nitrite)	mg/L	20	< 0.02	1.4	0.32		
Kjeldahl nitrogen	mg/L	10	1.18	2.43	1.6		
Orthophosphate	ug/L	0					
Pheophytin-a	ug/L	0					
Phosphorus	ug/L	20	60	800	250	150	12
Specific Conductance	uS/cm	45	322	1283	794		
Temperature, water	deg °C	45	7.6	27.7	19.6		
Sulfate	mg/L	10	72	394	247		
Hardness	mg/L	10	170	530	372		

[1]Secchi Tube standards are surrogate standards derived from the total suspended solids standard of 65 mg/L.
[2]Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Judicial Ditch 75 Subwatershed, a component of the IWM work conducted between May and September from 2004-2013. This specific data does not necessarily reflect all data that was used to assess the AUID.

Summary

Aquatic life surveys conducted within the Judicial Ditch 75 Subwatershed indicate that the aquatic communities are stressed. Four stations were sampled on two reaches.

Station 12RD098 on Judicial Ditch 75 (09020306-520) was designated as modified through a UAA due to ditching and poor habitat. The FIBI score was poor, consisting of only a few tolerant species. MIBI scores were above the applicable thresholds and therefore were passing, though they were also dominated by tolerant taxa. The poor fish communities may be the result of a series of small low head dams that inhibit fish passage. Water quality at this site, based on conventional parameters such a DO, pH, and unionized ammonia, suggests support of aquatic life. Nutrients (nitrogen and phosphorus) indicate that water quality is relatively good compared to other streams in this major watershed, and at expected levels, given the watershed's land use and the stream's morphology. The bacteria dataset was initially inconclusive regarding an assessment of aquatic recreational use. One summer month slightly exceeded the geometric mean standard (126 colonies per 100mL), however this was due to one individual sample. The reach was designated as impaired for aquatic recreation to stay consistent with other impairments within the major watershed Poor land use practices such as a lack of riparian buffers and wind breaks may contribute to the high bacteria concentrations in JD #75.

County Ditch 43 (09020306-517) was surveyed for fish and macroinvertebrates at three locations (07RD023, 12RD089, and 12RD087). This channelized reach was designated as modified through a UAA. The fish and macroinvertebrate communities were in poor condition, consisting of only a few relatively tolerant species. With the exception of monitoring station 07RD023, habitat scores (MSHA) indicated poor conditions at the other stations.

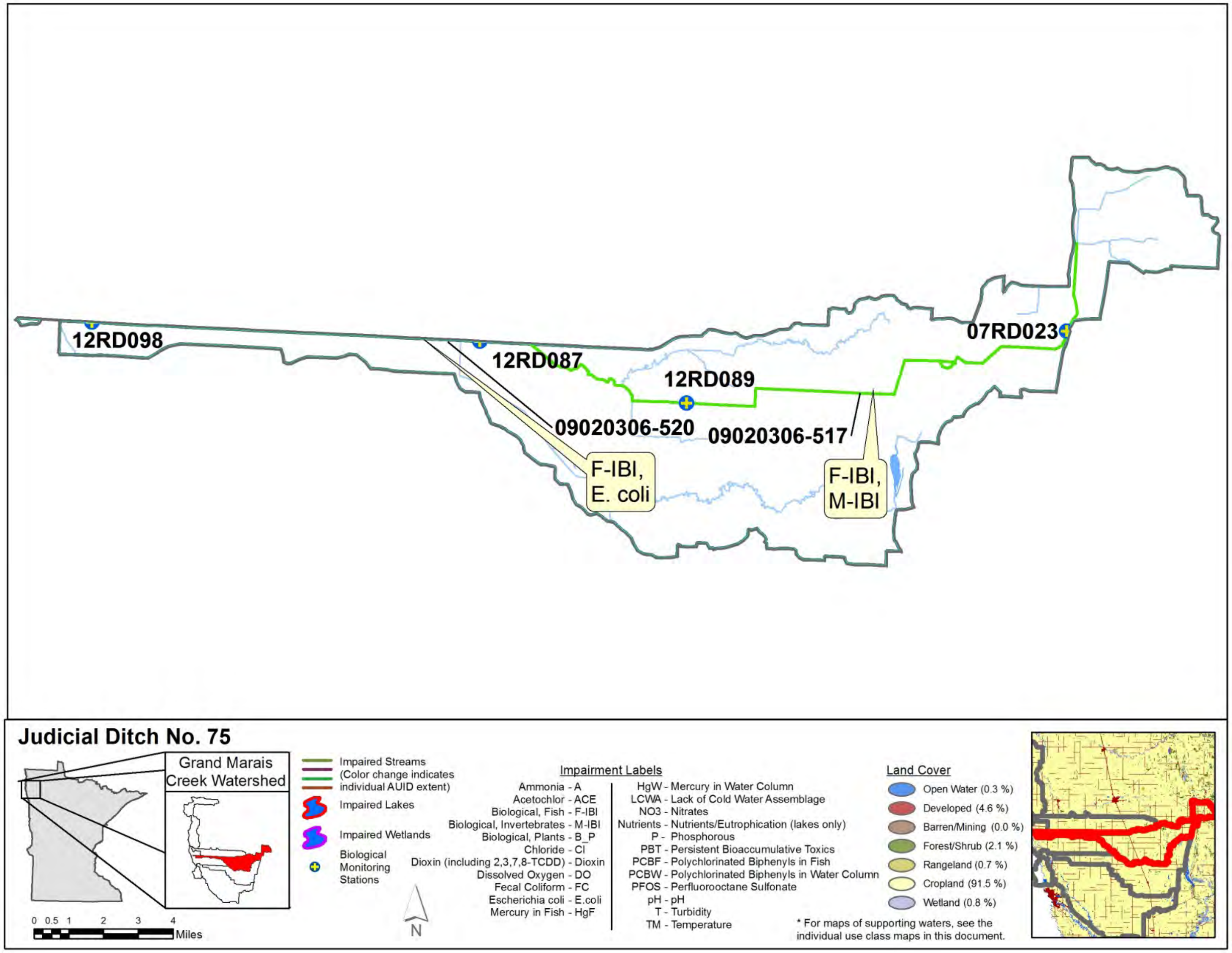

Figure 18. Currently listed impaired waters by parameter and land use characteristics in the Judicial Ditch 75 Subwatershed.

County Ditch 2 Subwatershed HUC 0902030601-01

The County Ditch 2 Subwatershed is located in the central portion of the Grand Marais Creek Watershed. Covering an area of approximately 104 square miles, it includes portions of Pennington and Polk Counties. Streams within this watershed include several unnamed ditches, County Ditch 66, Red Lake Watershed Ditch 15, and County Ditch 2. Streams flow in a westerly direction entering County Ditch 2 prior to its confluence with Grand Marais Creek approximately seven miles north of East Grand Forks. The land within this area is primarily utilized for agricultural purposes with roughly 92% being in some form of cropland.

The outlet of this subwatershed is represented by MPCA's STORET/EQuIS station S004-131 and biological station 12RD100, which is located upstream of County Road 62, about three miles SW of Tabor.

Table 7. Aquatic life and recreation assessments on stream reaches: County Ditch 2 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.**
09020306-515 County Ditch 2 D 66 to Grand Marais Cr	10.74	WWm	12RD100 05RD098	Upstream of CSAH 62, 3 mi. SW of Tabor Upstream of Hwy 220, 8 mi. N of East Grand Forks	EXP	EXS	MTS	MTS	MTS	IF	MTS	-	EX	IMP	IMP

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: = existing impairment, listed prior to 2014 reporting cycle; = new impairment; = full support of designated use; = insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water

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

Table 8. Minnesota Stream Habitat Assessment (MSHA): County Ditch 2 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	12RD100	County Ditch 2	0	7	6	15	7	35	Poor
3	05RD098	County Ditch 2	0	6	7	4	10	27	Poor
	05RD098	County Ditch 2	0	7	7	6	10	30	Poor
	05RD098	County Ditch 2	0	8	7	12	7	34	Poor
Average Habitat Results: *County Ditch 2 Subwatershed*			**0**	**7**	**6.75**	**9.25**	**8.5**	**31.5**	**Poor**

Qualitative habitat ratings

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

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

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

Table 9. CCSI: County Ditch 2 Subwatershed.

# Visits	Biological Station ID	Stream Name	Upper Banks (43-4)	Lower Banks (46-5)	Substrate (37-3)	Channel Evolution (11-1)	CCSI Score (137-13)	CCSI Rating
1	12RD100	County Ditch 2	19	17	20	2	58	Moderately Unstable
1	05RD098	County Ditch 2	9	5	6	1	21	Stable
Average Stream Stability Results: *County Ditch 2 Subwatershed*			**14**	**11**	**13**	**1.5**	**39.5**	**Fairly Stable**

Qualitative channel stability ratings

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

Table 10. Outlet water chemistry results: County Ditch 2 Subwatershed.

Station location:	**County Ditch 2, at CR-62, seven miles NE of East Grand Forks**						
STORET/EQuIS ID:	**S004-131**						
Station #:	**0902030601-01**						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	ug/L	20	0.1	27.5	7.5	40	0
Chloride	mg/L	15	5.6	23.7	15.0	230	0
Dissolved Oxygen (DO)	mg/L	109	3.3	16.5	9.2	5	2
pH		108	6.49	9.5	8.19	6.5 - 9	11
Secchi Tube	cm	39	5	58	29	10	3
Total suspended solids	mg/L	56	1	165	19.3	65	4
Escherichia coli (geometric mean)	MPN/100ml	3	68	273	177	126	2
Escherichia coli	MPN/100ml	31	10	1732	271	1260	2
Chlorophyll-a, Corrected	ug/L	0					
Inorganic nitrogen (nitrate and nitrite)	mg/L	51	< 0.03	5.38	0.69		
Kjeldahl nitrogen	mg/L	12	1.0	2.0	1.4		
Orthophosphate	ug/L	40	3	460	110		
Pheophytin-a	ug/L	0					
Phosphorus	ug/L	51	30	610	140	150	19
Specific Conductance	uS/cm	108	271	1398	732		
Temperature, water	deg °C	109	0	30.3	17.5		
Sulfate	mg/L	9	264	631	413		
Hardness	mg/L	10	170	530	372		

[1]Secchi Tube standards are surrogate standards derived from the total suspended solids standard of 65 mg/L.
[2]Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the County Ditch 2 Subwatershed, a component of the IWM work conducted between May and September from 2004-2013. This specific data does not necessarily reflect all data that was used to assess the AUID.

Summary

Biological surveys conducted within the County Ditch 2 Subwatershed indicate that the aquatic life is stressed. There were four fish and five macroinvertebrate surveys conducted at two monitoring stations on County Ditch 2 (09020306-515) between 2005 and 2012. The reach was designated as modified through a UAA. Station 12RD100 was dominated by tolerant species (e.g. fathead minnow, brook stickleback, central mudminnow, and black bullhead) resulting in a low (FIBI) score. MIBI scores were also poor. Both macroinvertebrate samples were numerically dominated by *Gyraulus*, a primarily air breathing snail tolerant of low dissolved oxygen. Further downstream, station 05RD098 was sampled for fish once in 2005 and twice in 2012. Both the initial 2005 and 2012 (July) samples were dominated by tolerant species. In August, a replicate fish sample was collected from this station and resulted in a FIBI score that was just above the threshold. The increase in the FIBI was due to an increase in the numbers of benthic insectivores combined with low numbers of other taxa. This resulted in an artificially inflated IBI score and is not representative of the observed poor fish communities. Station 05RD098 was sampled for macroinvertebrates twice in 2005, and once in 2011. These samples were dominated by tolerant taxa and scored poorly. Poor habitat conditions were present at all of the stations, which is detrimental to aquatic life. The overall assessment for aquatic life in this reach was non-support based on low fish and macroinvertebrate IBI scores.

The water chemistry site on County Ditch 2 was collocated with biological station 12RD100. Overall, the chemistry dataset was inconclusive to assess aquatic life use. The dissolved oxygen, unionized ammonia, and chloride standards were being met. Conversely, this reach of County Ditch 2 had several samples that exceeded the pH standard – (a 14% exceedance rate overall). Most exceedances of the pH standard took place in the summer of 2012 during a dry period, when biological productivity can raise the pH.

High bacteria levels indicated non-support for aquatic recreation. Two summer months exceeded the geometric mean standard, and there were a few individual samples with very high concentrations (> 1,700 colonies/ 100 mL).

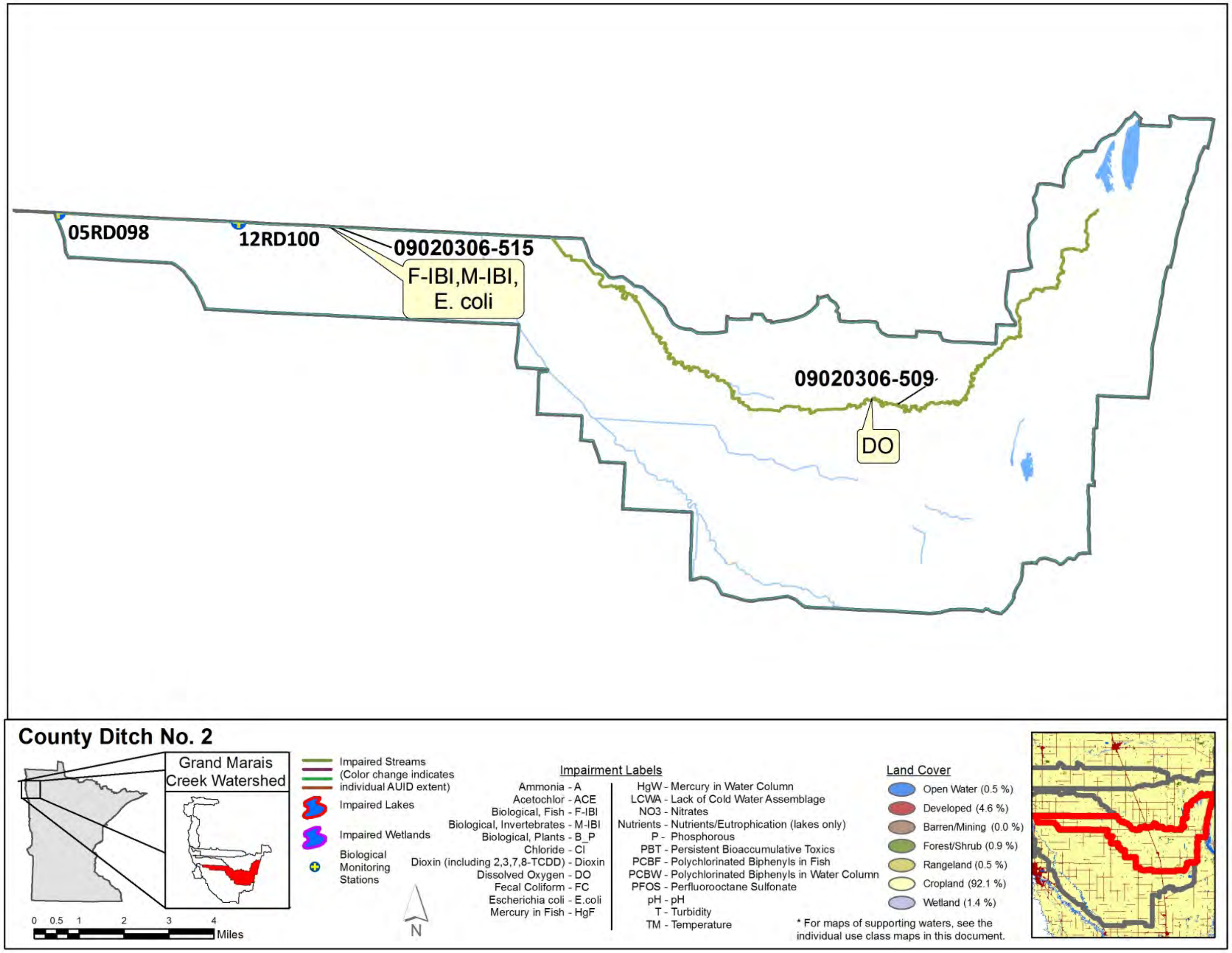

Figure 19. Currently listed impaired waters by parameter and land use characteristics in the County Ditch 2 Subwatershed.

Grand Marais Creek Subwatershed HUC 0902030602-01

The Grand Marais Creek Subwatershed is located in the southwestern portion of the drainage and is within Polk County. Covering an area of approximately 187 square miles, it is the largest subwatershed of the Grand Marais Creek Watershed. Streams within this subwatershed include several unnamed ditches, County Ditch 126, and Grand Marais Creek. Grand Marais Creek flows primarily in a northwest direction as it picks up surface water from its tributaries that originate from the east. Eventually Grand Marais Creek empties into the Red River of the North about 9 miles north of East Grand Forks. Land within this area is primarily utilized for agriculture with over 93% being cropland.

The outlet of this subwatershed is represented by MPCA's STORET/EQuIS station S002-126 and biological station 12RD097, located upstream of County Road 64 about 6.5 miles north of East Grand Forks.

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

					Aquatic Life Indicators:								Aquatic Rec. Indicators:			
AUID ***Reach Name,*** *Reach Description*	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Fish IBI**	**Invert IBI**	**Dissolved Oxygen**	**Turbidity**	**Chloride**	**pH**	**NH_3**	**Pesticides**	**Bacteria**	**Nutrients**	**Aquatic Life**	**Aquatic Rec.**
09020306-507 Grand Marais Creek Headwaters to CD 2	38.17	WWg			-	-	EXS	MTS	-	MTS	MTS	EXS	MTS	-	IMP	SUP

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: = existing impairment, listed prior to 2014 reporting cycle; = new impairment; = full support of designated use; = insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 12. Outlet water chemistry results: Grand Marais Creek Subwatershed

Station location:	**Grand Marais Creek AT CR-64, 9 MI N Of East Grand Forks**						
STORET/EQuIS ID:	**S002-126**						
Station #:	**0902030602-01**						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	ug/L	27	0.32	7.3	1.4	40	0
Chloride	mg/L	31	4.95	111	25	230	0
Dissolved Oxygen (DO)	mg/L	185	0.02	16.2	8.6	5	13
pH		184	7.2	8.9	7.9	6.5 - 9	0
Secchi Tube	100 cm	133	1	58	15	10	47
Total suspended solids	mg/L	156	3	2320	124	65	64
Escherichia coli (geometric mean)	MPN/100ml	3	85	123	105	126	0
Escherichia coli	MPN/100ml	32	12	461	144	1260	0
Chlorophyll-a, Corrected	ug/L	7	1	9	4.3		
Inorganic nitrogen (nitrate and nitrite)	mg/L	153	< 0.03	5.8	1.34		
Kjeldahl nitrogen	mg/L	104	0.57	5.8	1.6		
Orthophosphate	ug/L	143	10	620	350		
Pheophytin-a	ug/L	6	1	2	1.4		
Phosphorus	ug/L	153	60	1790	550	150	133
Specific Conductance	uS/cm	185	11	2436	809		
Temperature, water	deg °C	185	- 0.1	29.4	15.5		
Sulfate	mg/L	29	2	1810	300		
Hardness	mg/L	14	310	1080	655		

[1]Secchi Tube standards are surrogate standards derived from the total suspended solids standard of 65mg/L.
[2]Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Grand Marais Creek Subwatershed, a component of the IWM work conducted between May and September from 2004-2013. This specific data does not necessarily reflect all data that was used to assess the AUID.

Summary

Grand Marais Creek is the largest stream in the watershed. The monitoring station (chemistry and biology) was located on the 1.8 mile cutoff channel that had replaced the natural 6 mile outlet connection to the Red River. Fish and water chemistry samples were collected in 2012 but the reach was not assessed because, upon completion of Project 60, the channel receives water only during flow events greater than 1.25 year occurrence. Although there were no new assessments in 2014, the biological data indicate that the fish communities were in poor condition. Also, the chemistry data suggest that dissolved oxygen can at times exceed standards. DO samples collected during low flow periods were well below the 5 mg/l standard (< 0.3 mg/L). Bacteria levels were within normal ranges. The reach remains impaired for aquatic life due to exceedances of the turbidity standard; this reach was listed as impaired in 2006.

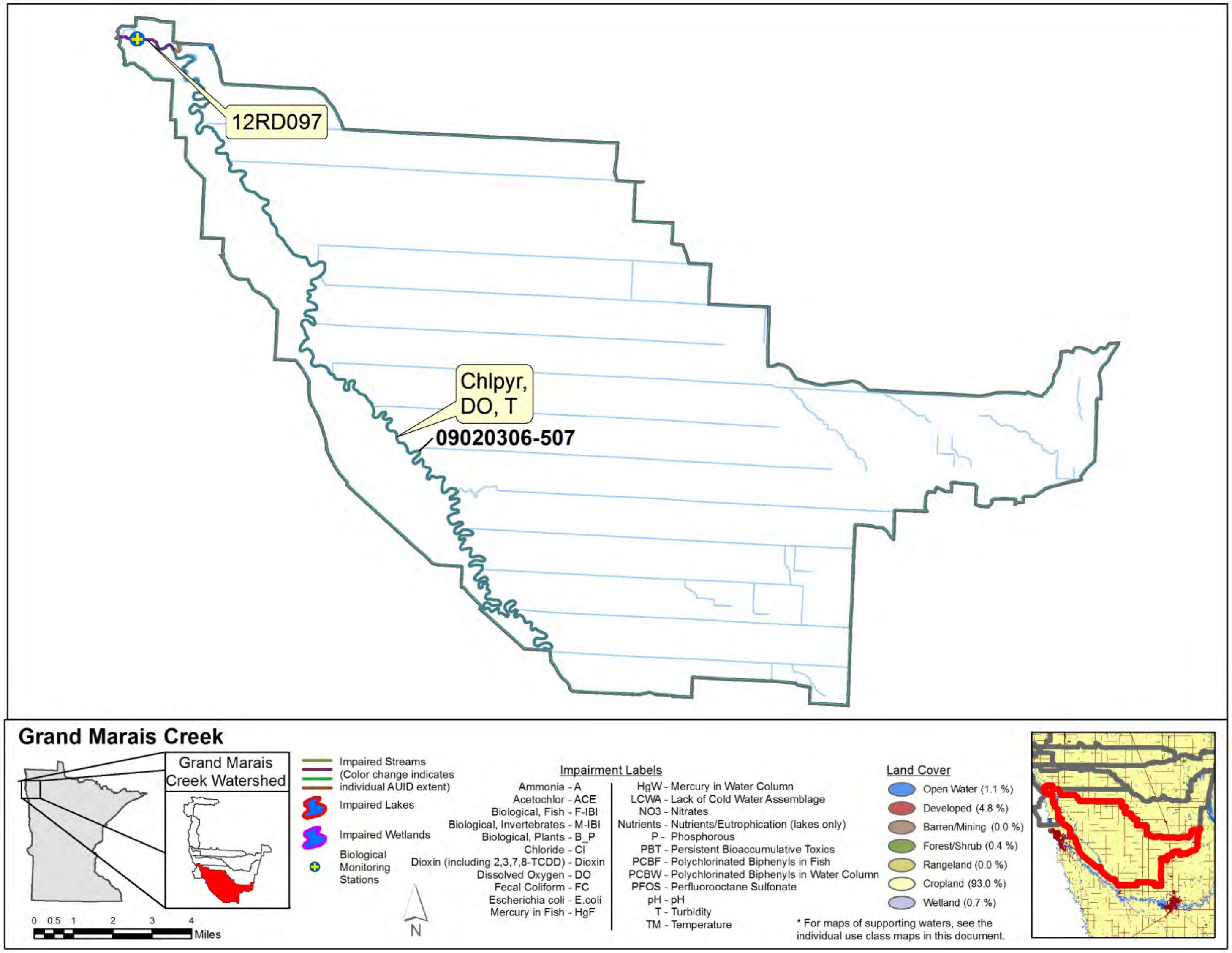

Figure 20. Currently listed impaired waters by parameter and land use characteristics in the Grand Marais Creek Subwatershed.

Judicial Ditch 68 Subwatershed HUC 0902030605-01

The Judicial Ditch 68 Subwatershed is a 73 square mile section of Polk County on the far western edge of the watershed. The Red River Mainstem, Judicial Ditch 68 and a few unnamed ditches are in this subwatershed. The subwatershed also includes a portion of the recently restored natural outlet of Grand Marais Creek. There was no biological or water chemistry data collected within this subwatershed in 2012 because none of the potential monitoring sites met the sampling guidelines. The land within this area is primarily used for agricultural purposes with approximately 86% being cropland.

Summary

The MPCA sampled biology, habitat, and water chemistry on the Red River mainstem during the summer of 2015. The results of that survey will be summarized in a watershed assessment report of the Red River that is scheduled to be completed in 2018.

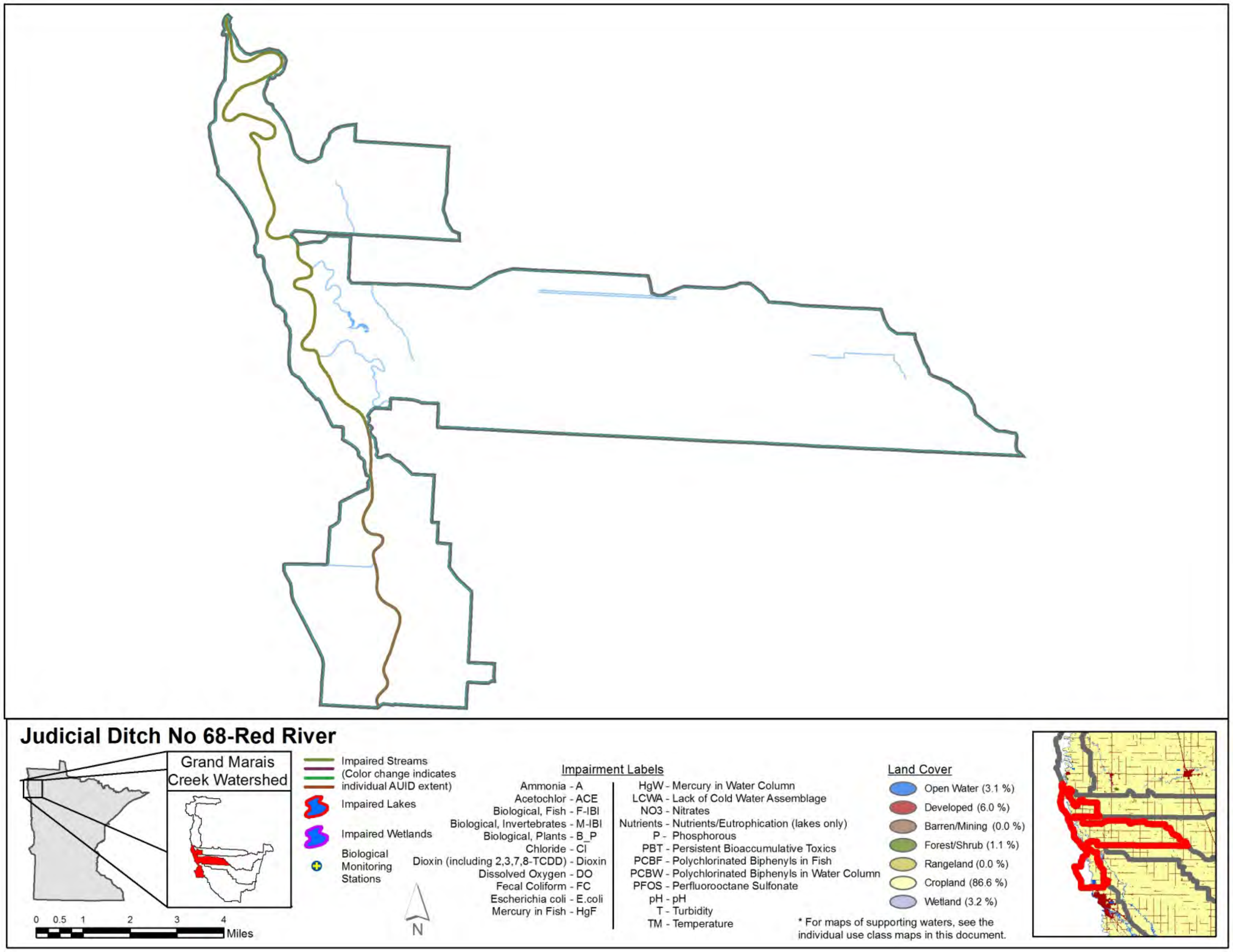

Figure 21. Currently listed impaired waters by parameter and land use characteristics in the Judicial Ditch 68 Subwatershed.

Judicial Ditch 1 Subwatershed — HUC 0902030604-01

The Judicial Ditch 1 Subwatershed is covers a 62 square mile area of Polk County in the northern part of the watershed. Judicial Ditch 1 flows primarily in a western direction. It receives flow from several unnamed ditches from the south as well as County Ditch 7 prior to reaching its confluence with the Red River approximately three miles south of Oslo. There was no biological data collected within this subwatershed in 2012 because none of the potential monitoring sites met the sampling guidelines. The land in this area is primarily utilized for agricultural purposes with almost 94% being in some form of cropland.

The outlet of this subwatershed is represented by MPCA's STORET/EQuIS station S005-571 and is located upstream of County Road 22, 4 miles south/southeast of Oslo.

Table 13. Aquatic life and recreation assessments on stream reaches: Judicial Ditch 1 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:							Aquatic Rec. Indicators:			Aquatic Life	Aquatic Rec.
					Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	Nutrients		
09020306-519 *Judicial Ditch 1* *County Ditch 7 to Red River*	10.67	2Bg,3C			-	-	MTS	IF	MTS	MTS	MTS	-	EXS	-	IF	IMP

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: = existing impairment, listed prior to 2014 reporting cycle; = new impairment; = full support of designated use; = insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 14. Outlet water chemistry results: Judicial Ditch 1 Subwatershed.

Station location:	Judicial Ditch #1, At CSAH-22, 14 Miles NE of East Grand Forks						
STORET/EQuIS ID:	S005 - 571						
Station #:	0902030604-01						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	ug/L	16	0.56	32.7	8.3	40	0
Chloride	mg/L	16	8.7	107	52.6	230	0
Dissolved Oxygen (DO)	mg/L	44	2.98	16.8	8.4	5	3
pH		43	7.6	9.2	8.2	6.5 - 9	1
Secchi Tube	cm	25	1.5	58	32	10	4
Total suspended solids	mg/L	29	1	1300	76	65	4
Escherichia coli (geometric mean)	MPN/100ml	3	79	128	111	126	2
Escherichia coli	MPN/100ml	28	6.3	1553	239	1260	2
Chlorophyll-a, Corrected	ug/L	0					
Inorganic nitrogen (nitrate and nitrite)	mg/L	20	< 0.02	0.96	0.47		
Kjeldahl nitrogen	mg/L	10	1.2	2.9	2.1		
Orthophosphate	ug/L	0					
Pheophytin-a	ug/L	0					
Phosphorus	ug/L	20	200	1100	610	150	20
Specific Conductance	uS/cm	44	272	4148	1524		
Temperature, water	deg °C	44	8.3	25.0	18.1		
Sulfate	mg/L	10	59	2574	667		
Hardness	mg/L	10	133	1952	773		

[1]Secchi Tube standards are surrogate standards derived from the total suspended solids standard of 65 mg/L.
[2]Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Judicial Ditch 1 Subwatershed, a component of the IWM work conducted between May and September from 2004-2013. This specific data does not necessarily reflect all data that was used to assess the AUID.

Summary

Overall, water quality is fair in this watershed but an overall assessment of aquatic life based on the chemistry dataset was inconclusive. Most conventional parameters such as DO, pH, and chloride had minimal exceedances of water quality standards. In regards to DO, there were an insufficient number of samples collected before 9:00 AM to make an assessment. Nitrogen and phosphorus levels were high in contrast to other subwatersheds. E. coli bacteria levels were also high indicating non-support for aquatic recreation. E. coli levels in two of three summer months exceeded the geometric mean water quality standard, and a few individual samples had very high concentrations of bacteria (> 1,500 colonies / 100 mL).

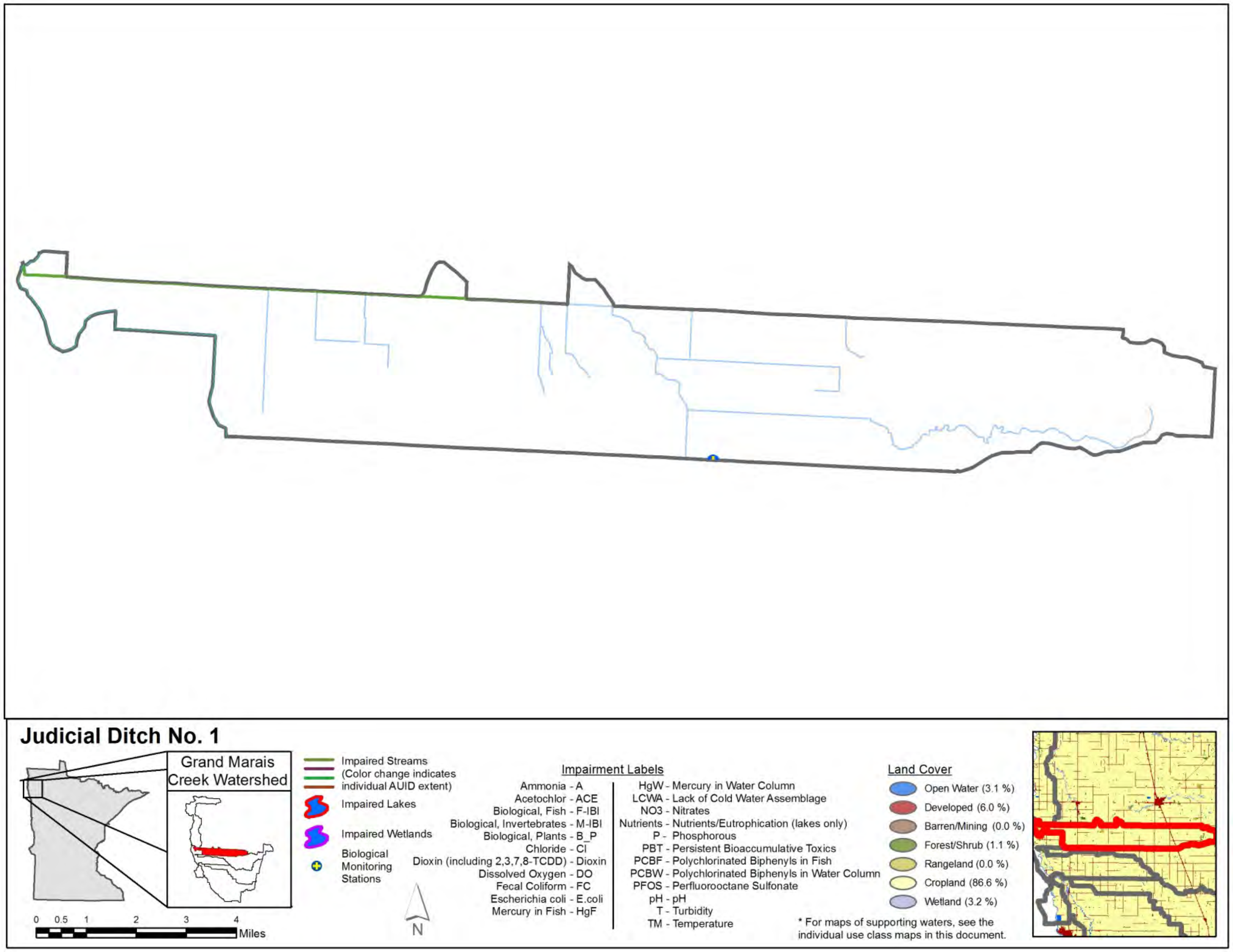

Figure 22. Currently listed impaired waters by parameter and land use characteristics in the Judicial Ditch No. 1 Subwatershed.

City of Oslo – Red River Subwatershed HUC 0902030606-01

The City of Oslo-Red River Subwatershed is located in the northwest corner of the Grand Marais Creek Watershed and includes portions of Polk and Marshall Counties. Covering an area of roughly 104 square miles, the subwatershed is rather oddly shaped, spanning approximately 23 miles long and four to five miles wide. The subwatershed includes the mainstem of the Red River and a network of ephemeral ditches that intermittently discharge into the Red River from the east. The land within this subwatershed is primarily utilized for agriculture as roughly 85% is in some form of cropland. The remaining land is about equally divided between open water (6%), developed (6%), and wetland (3%).

Summary

There was no biological data collected within this subwatershed in 2012 because none of the potential monitoring sites met the sample-able criteria.

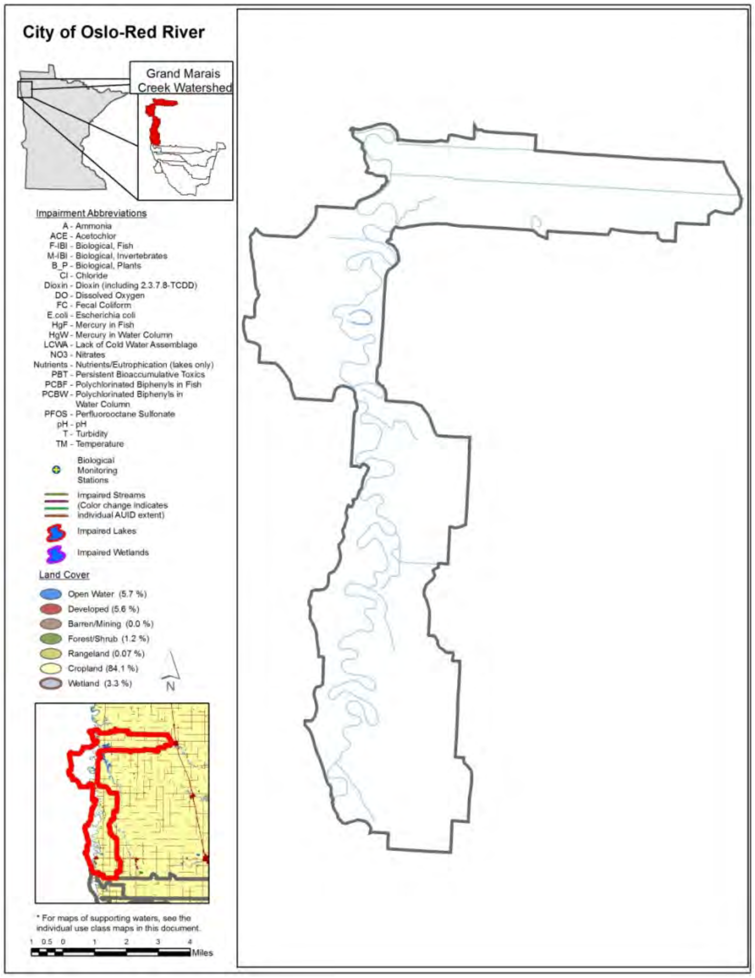

Figure 23. Currently listed impaired waters by parameter and land use characteristics in the City of Oslo-Red River Subwatershed.

Watershed-wide results and discussion

Assessment results and data summaries are included below for the Grand Marais Creek Watershed, grouped by sample type. Summaries are provided for load monitoring data results near the mouth of the watershed, and for aquatic life and recreation uses in streams and lakes throughout 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 Grand Marais Creek Watershed.

Pollutant load monitoring

Grand Marais Creek was monitored on CR64 near East Grand Forks, MN, approximately 0.5 miles above the confluence with the Red River of the North. 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, 2013). Of the state's three RNRs (North, Central, South), the Grand Marais' monitoring station is located within the South RNR.

Seasonal flow weighted mean concentrations (FWMCs) were calculated for years 2010-2011 (Figures 24-27) and compared to the RNR standards (only TP and TSS standards are available for the South RNR). It should be noted that while a FWMC exceeding 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, 2014). 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 TSS and nitrate + nitrite nitrogen ($NO_3 + NO_2$-N) are generally regarded as "non-point" source derived pollutants originating from many diffuse sources such as urban or agricultural runoff. Excess TP and DOP can be attributed to either "non-point" as well as "point" or end of pipe sources such as industrial or waste water treatment plants. Major "non-point" sources of phosphorus include dissolved phosphorus from fertilizers and phosphorus adsorbed to and transported with sediment during runoff.

Within a given watershed, pollutant sources and source contributions can also be quite variable from one runoff event to the next depending on factors such as: canopy development, soil conditions (frozen/unfrozen, saturation level, etc.) 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 plant canopy development when compared to 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 flow, shallow and deep groundwater, and/or subsurface drainage tile. Runoff pathways, discharge levels, total flow volume and 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. 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 $NO_3 + NO_2$-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, $NO_3 + NO_2$-N levels tend to be elevated.

Total Suspended Solids (TSS)

Water clarity refers to the transparency of water. Turbidity is a measure of the lack of transparency or "cloudiness" of water due to the presence of suspended and colloidal materials such as clay, silt, finely divided organic and inorganic matter, and plankton or other microscopic organisms. By definition, turbidity is caused primarily by suspension of particles that are smaller than one micron in diameter in the water column.

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

Minnesota's water quality standards for river eutrophication and TSS were adopted into State Rule Ch. 7050 in 2014 and approved by the EPA in January 2015. Within the South RNR, a river is considered impaired when greater than 10% of the individual samples exceed the TSS standard of 65 mg/L (MPCA, 2011). From 2010-2011, 23% and 37% of the samples exceeded the 65 mg/L standard, respectively.

Table 15 displays the total seasonal loads which indicate TSS loads to be slightly lower in 2011 which also had the lowest FWMC for the two years. Often, there is a strong positive correlation between pollutant loads and annual runoff volume (Figure 17). For Grand Marais Creek, this was not the case in 2010 and 2011. A large part of this was due to an extremely high TSS sample of 2,320 mg/L on May 25, 2010. Also, in 2011, samples were collected upstream on the main-stem due to flooding and backwater conditions, which excluded County Ditch 2. This drainage often carries additional sediment to the Grand Marais Creek.

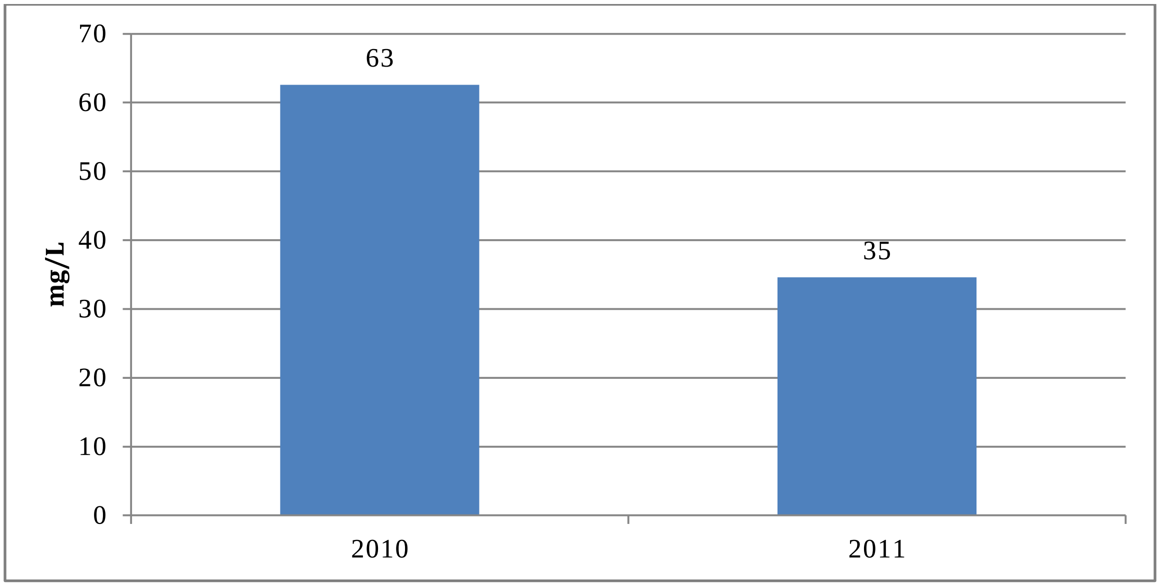

Figure 24. Total Suspended Solids (TSS) flow weighted mean concentrations in Grand Marais Creek.

Table 15. Seasonal pollutant loads by parameter for Grand Marais Creek.

	2010	2011
Parameter	**Mass (kg)**	**Mass (kg)**
Total Suspended Solids	2,868,426	2,623,935
Total Phosphorus	16,201	18,665
Dissolved Orthophosphate	13,582	9,811
Nitrate + Nitrite Nitrogen	14,594	350,159

Total Phosphorus (TP)

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.

Within the South RNR, the TP standard is 0.150 mg/L as a summer average (June through September). Summer average violations of one or more “response” variables (pH, biological oxygen demand, dissolved oxygen flux, chlorophyll-a) must also occur along with the numeric TP violation for the water to be considered impaired. A comparison of the 2010 and 2011 data collected during the summer indicate that TP exceedences occurred 85 and 86% of the time, respectively. The summer averages also exceeded the standard (0.334 mg/L and 0.450 mg/L, respectively). Figure 25 illustrates FWMCs greater than the standard (2010 and 2011), albeit this includes all data throughout the year (not just summer values). Table 15 shows annual loads with 2011 having a slightly larger TP load when compared to 2010 despite 2011 having a lower TP FWMC. In this case, the increased 2011 load can be attributed to differences in annual runoff volume (Figure 17).

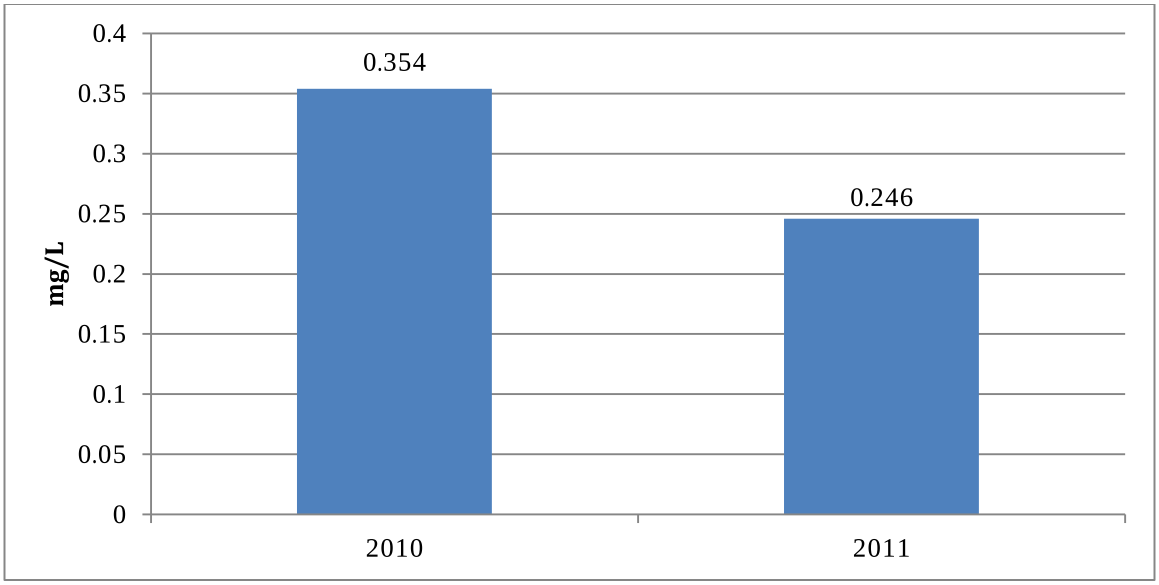

Figure 25. TP flow weighted mean concentrations for Grand Marais Creek.

Dissolved Orthophosphate (DOP)

DOP 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 2010 and 2011 were between 84% and 52%, respectively. Figure 26 and Table 15 show a similar pattern to the TSS results. A 28% reduction in the DOP load in Grand Marais Creek occurred between 2010 and 2011, despite a 1.5 inch increase in total flow volume over the same time period. Because pollutant loads are the product of flow and concentration, this reduction is due to the decrease in the DOP flow weighted mean concentration between 2010 and 2011 (0.297 and 0.129 mg/L respectively). Large between-year shifts of flow weighted mean concentrations can often be attributed to between year differences in primary runoff source; surface runoff from snowmelt vs groundwater from low intensity storms for example. In this example, surface runoff, especially during snowmelt will contain more phosphorus than runoff derived from groundwater.

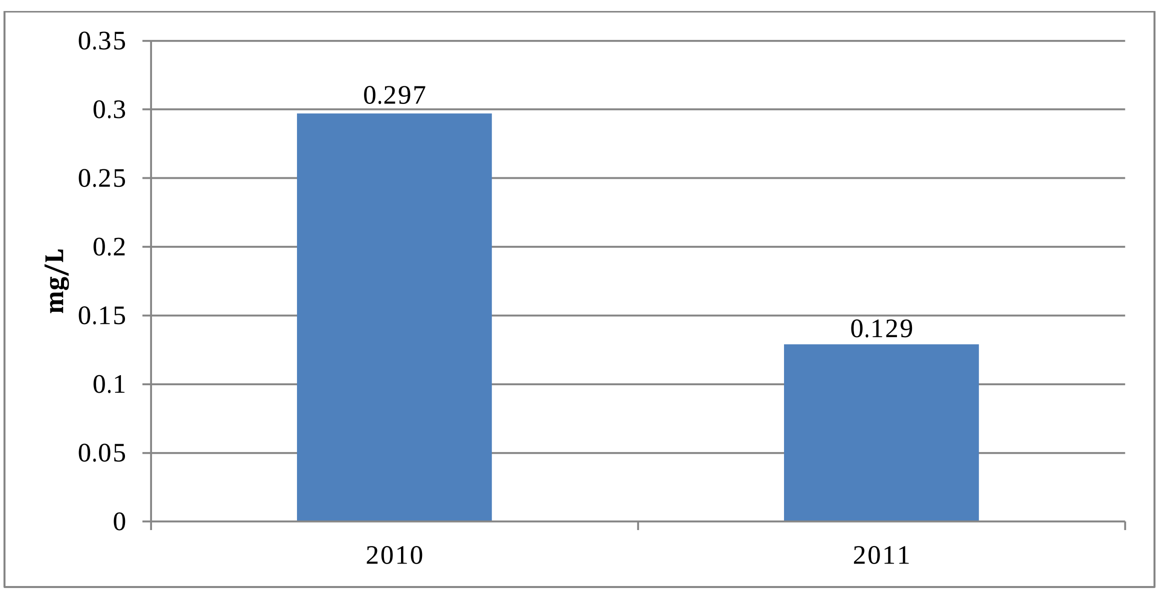

Figure 26. DOP flow weighted mean concentrations for Grand Marais Creek.

Nitrate plus Nitrite-Nitrogen

Nitrate and nitrite-nitrogen are inorganic forms of nitrogen present within the environment that are formed through the oxidation of ammonia-nitrogen by nitrifying bacteria (nitrification). Ammonia-nitrogen is found in fertilizers, septic systems, and animal waste. Once converted from ammonia-nitrogen to nitrate and nitrite-nitrogen, they too, like phosphorus, can stimulate excessive levels of some algae species in streams (MPCA, 2013). 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. Environmentally, studies have shown that the elevated nitrate-nitrogen levels in the Minnesota River basin contribute to hypoxia (low levels of dissolved oxygen) in the Gulf of Mexico. This occurs by nitrate-nitrogen stimulating the growth of algae which, through death and biological decomposition, consume large amounts of dissolved oxygen and thereby threaten aquatic life (MPCA and MSUM, 2009).

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 27 shows the $NO_3 + NO_2$-N FWMCs over the two-year period for the Grand Marais Creek monitoring site. The FWMCs for both years were below the draft acute and draft chronic Class 2B standards. Between 2010 and 2011, there were no exceedances of the draft acute standard and no exceedances of the draft chronic Class 2B standard. The annual loads increased greatly from 2010 to 2011 (Table 15) corresponding to the large increase in the FWMC and runoff volume (Figure 24).

The large increase was primarily due to samples collected during the early snow melt event which exhibited high NO3 + NO2-N concentrations. Also, in 2011, samples were collected upstream on the main-stem due to flooding and backwater conditions.

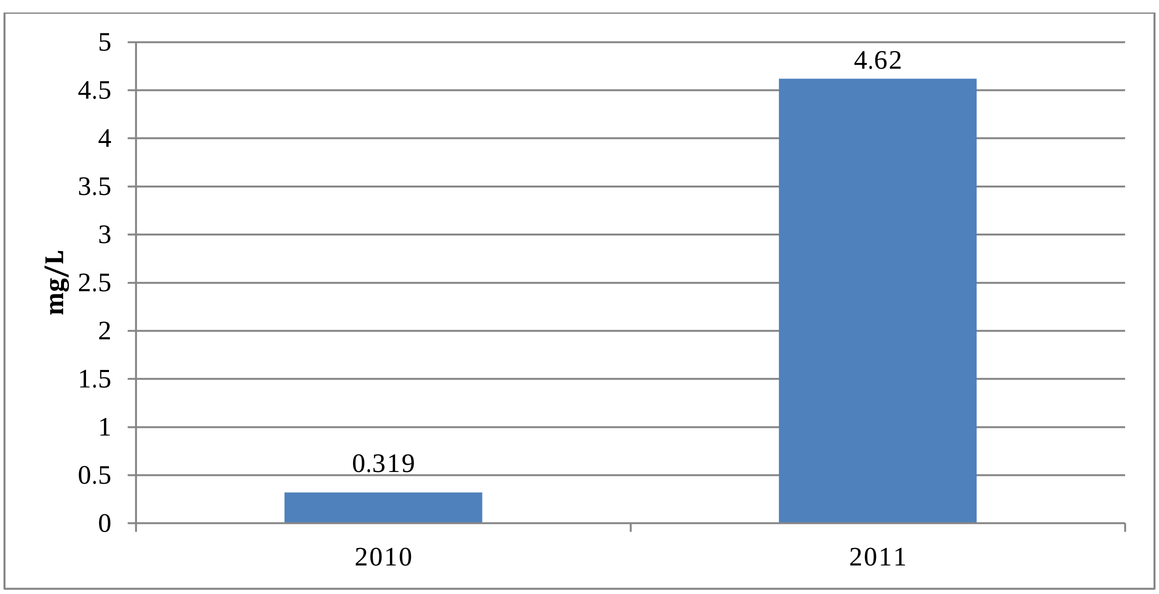

Figure 27. Nitrate + Nitrite Nitrogen (Nitrate-N) flow weighted mean concentrations for Grand Marais Creek.

Stream water quality

Eight of twenty stream reaches were assessed (Table 16) for aquatic life and/or aquatic recreation. Of the stream reaches assessed for aquatic life, no reaches were fully supporting and five reaches were non-supporting. Of the streams assessed for aquatic recreation, two streams were fully supporting and three were non-supporting.

Table 16. Assessment summary for stream water quality in the Grand Marais Creek Watershed.

				Supporting		Non-supporting			
Watershed	**Area (acres)**	**# Total AUIDs**	**# Assessed AUIDs**	**# Aquatic Life**	**# Aquatic Recreation**	**# Aquatic Life**	**# Aquatic Recreation**	**Insufficient Data**	**# Delistings**
Grand Marais Creek HUC 8	298,264	20	8	0	2	5	3	5	0
0902030603-01	67,733	4	2	0	0	2	1	2	0
0902030601-01	66,516	4	2	0	0	2	1	3	0
0902030602-01	119,625	6	2	0	2	1	0	2	0
0902030605-01	46,803	1	0	0	0	0	0	0	0
0902030604-01	39,418	1	1	0	0	0	1	1	0
0902030606-01	66,190	4	0	0	0	0	0	1	0

Fish contaminant results

No fish were collected at the outlet of the Grand Marais Creek Watershed for contaminant analysis in spite of a significant effort to obtain a sample.

Ground water monitoring

Groundwater quality

There are currently no MPCA Ambient Groundwater Monitoring wells in or near the Grand Marais Creek Watershed. However, a baseline study of groundwater conditions across the state, conducted by the MPCA, found that the median concentrations of most chemicals in the sand and gravel aquifers in this region were slightly higher, while iron and sulfate were much higher, than concentrations in similar aquifers statewide (MPCA, 1999).

The results of this study identified exceedances of drinking water criteria in the three different aquifers found in the region. The study also identified that there are two factors that control ground water quality: the presence of Cretaceous bedrock and location. While water quality in Cretaceous bedrock is typically poor, the location can dictate higher levels of contamination, such as higher arsenic concentrations in buried sand and gravel aquifers along stagnation moraines.

The Minnesota Department of Agriculture (MDA) monitors pesticides and nitrate on an annual basis in groundwater across agricultural areas in the state. The Grand Marais Creek Watershed lies within MDA's Pesticide Monitoring Region 1 (PMR 1), also referred to as the Northwest Red River region. According to the MDA's Water Quality Monitoring Report, there were no pesticides detected in 2013 (MDA, 2014). However, nitrates were detected in 57% of the samples collected from PMR 1 with a median concentration of 0.08 milligrams per liter (mg/L). Of those samples, 36% were at or below background level of 3 mg/L, 7% were within 3.01 to 10.00 mg/L, and 14% were above the drinking water standard of 10.00 mg/L (MDA, 2014).

Another source of information on groundwater quality comes from the Minnesota Department of Health (MDH). Mandatory testing for arsenic of all newly constructed wells has found that 10.4% of all wells installed from 2008 to 2013 have arsenic levels above the maximum contaminant level (MCL) for drinking water of 10 mg/L (MDH). In Northwest Minnesota, the majority of new wells are within the water quality standards for arsenic levels, but there are some exceedances (Figure 28).

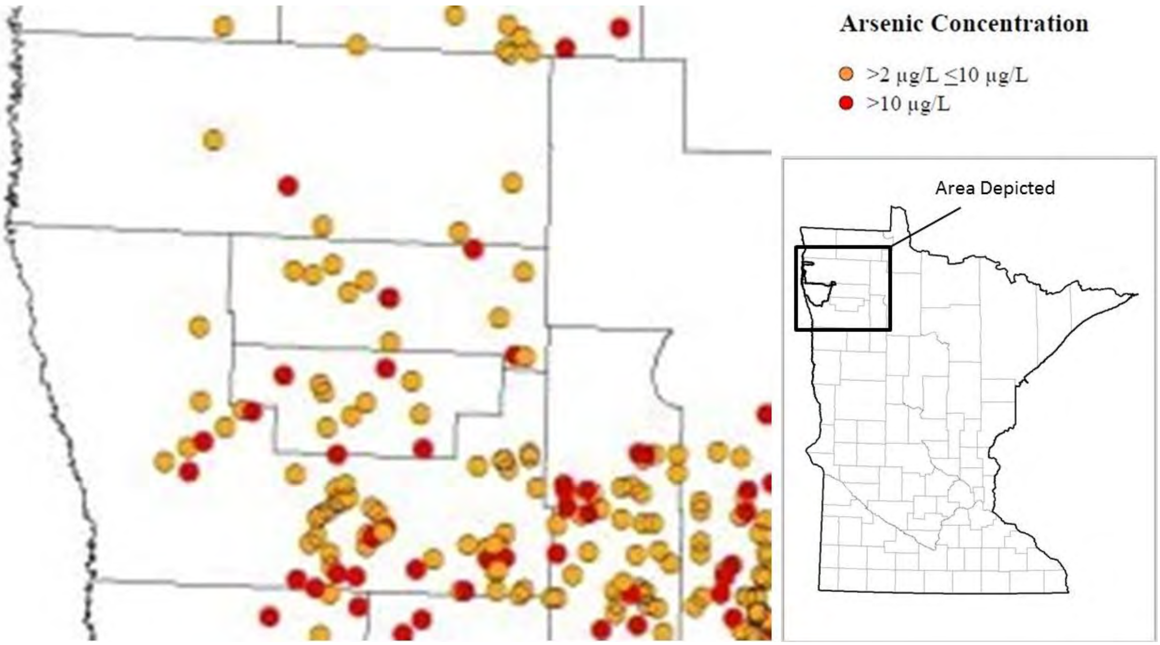

Figure 28. Arsenic occurrence in new wells in Grand Marais Creek Watershed area (2008-2012) (Source: MDH).

Groundwater quantity

Monitoring wells from the DNR 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.

One DNR Observation Well (57002) located in the Grand Marais Creek Watershed was chosen based on data availability and geologic location within the watershed. The observation well does not exhibit a statistically significant trend in groundwater elevation change (Figure 29).

Information regarding the ground water conditions in the Grand Marais Creek Watershed is limited due to the lack of monitoring wells. In addition, with so few high capacity groundwater withdrawals in the watershed, it is difficult to draw correlations between them and any decrease in surficial water quantity. However, the surficial geology of the Red River Valley is such that conditions for groundwater recharge are ideal in only a few areas; around topographic highs and in the presence of surficial sand and gravel deposits. Preservation of these areas is critical to maintaining sufficient groundwater availability for consumptive use.

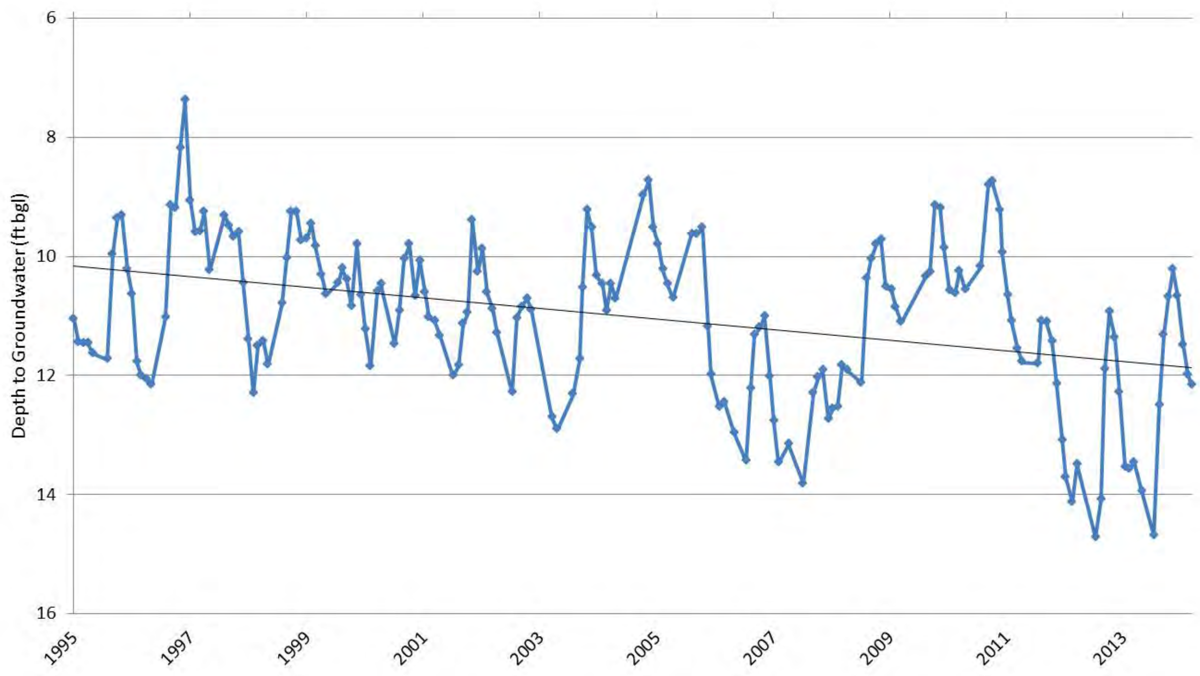

Figure 29.Observation well 57002, located in the eastern part of the Grand Marais Creek Watershed near Dorothy, Minnesota (1995-2014).

Stream flow

The DNR and MPCA cooperatively maintain a gaging station on Grand Marais Creek near East Grand Forks, Minnesota (site # 67014001). Two years of data, 2010 and 2011 are available and are shown below in Figure 30.

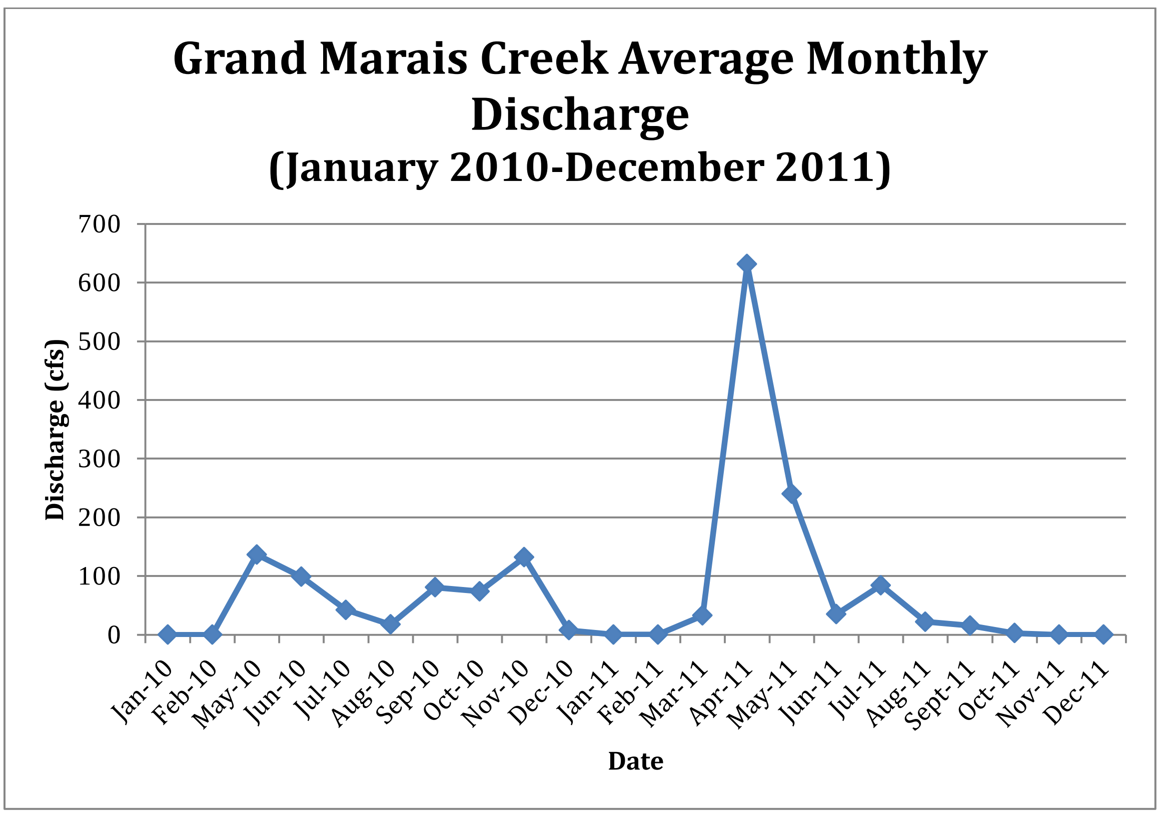

Figure 30. Grand Marais Creek average monthly discharge near East Grand Forks, Minnesota (site # 67014001).

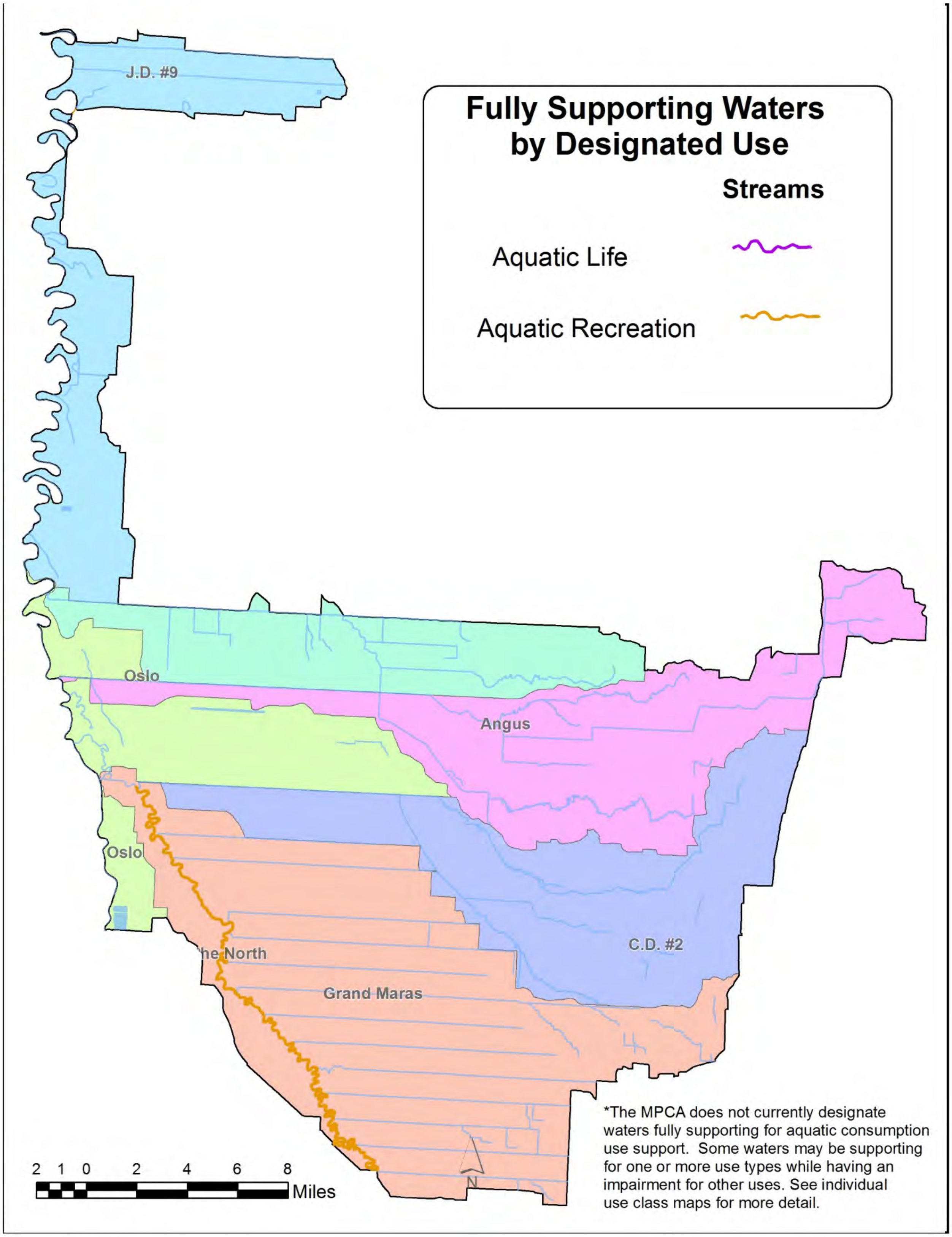

Figure 31. Fully supporting waters by designated use in the Grand Marais Creek Watershed.

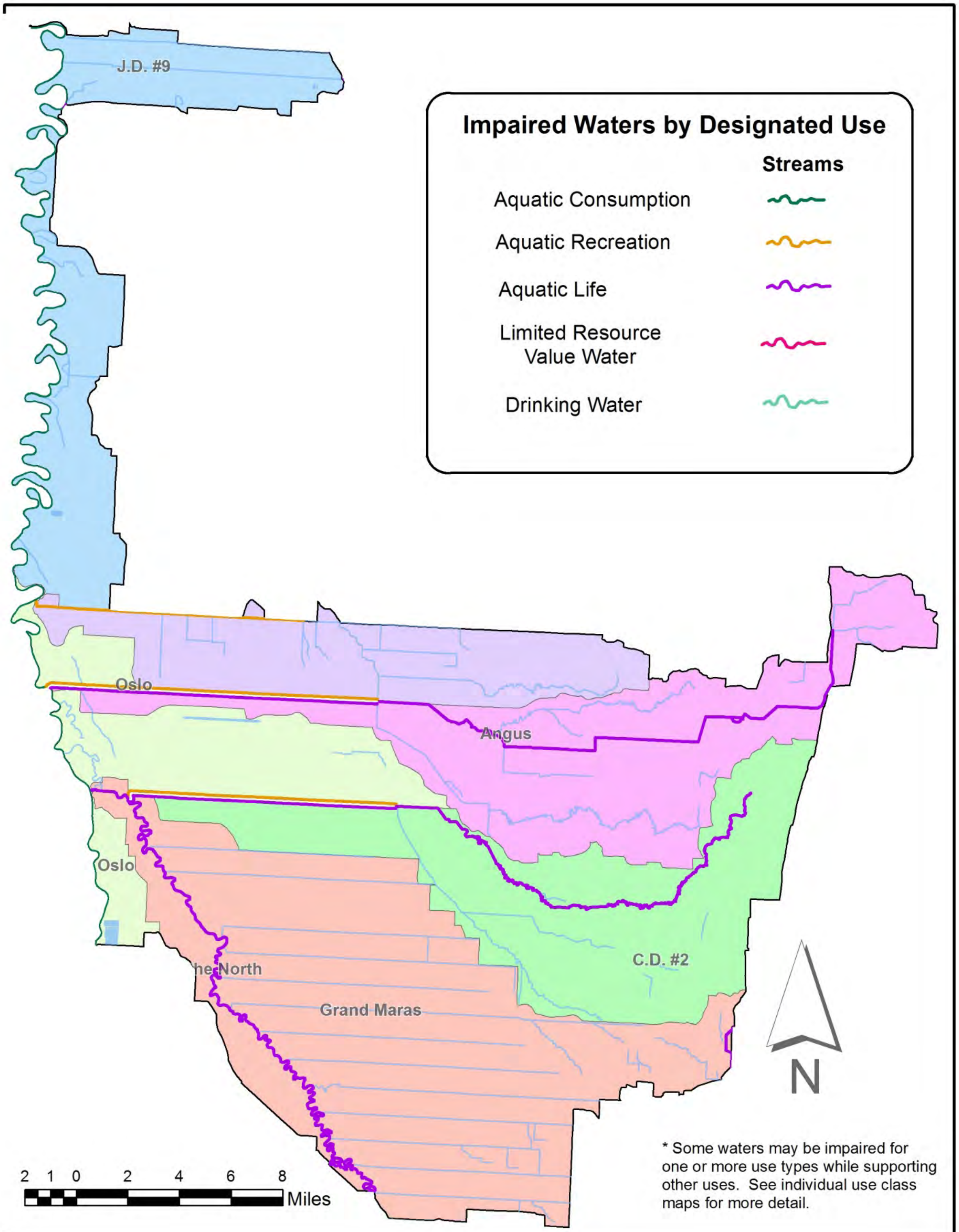

Figure 32. Impaired waters by designated use in the Grand Marais Creek Watershed.

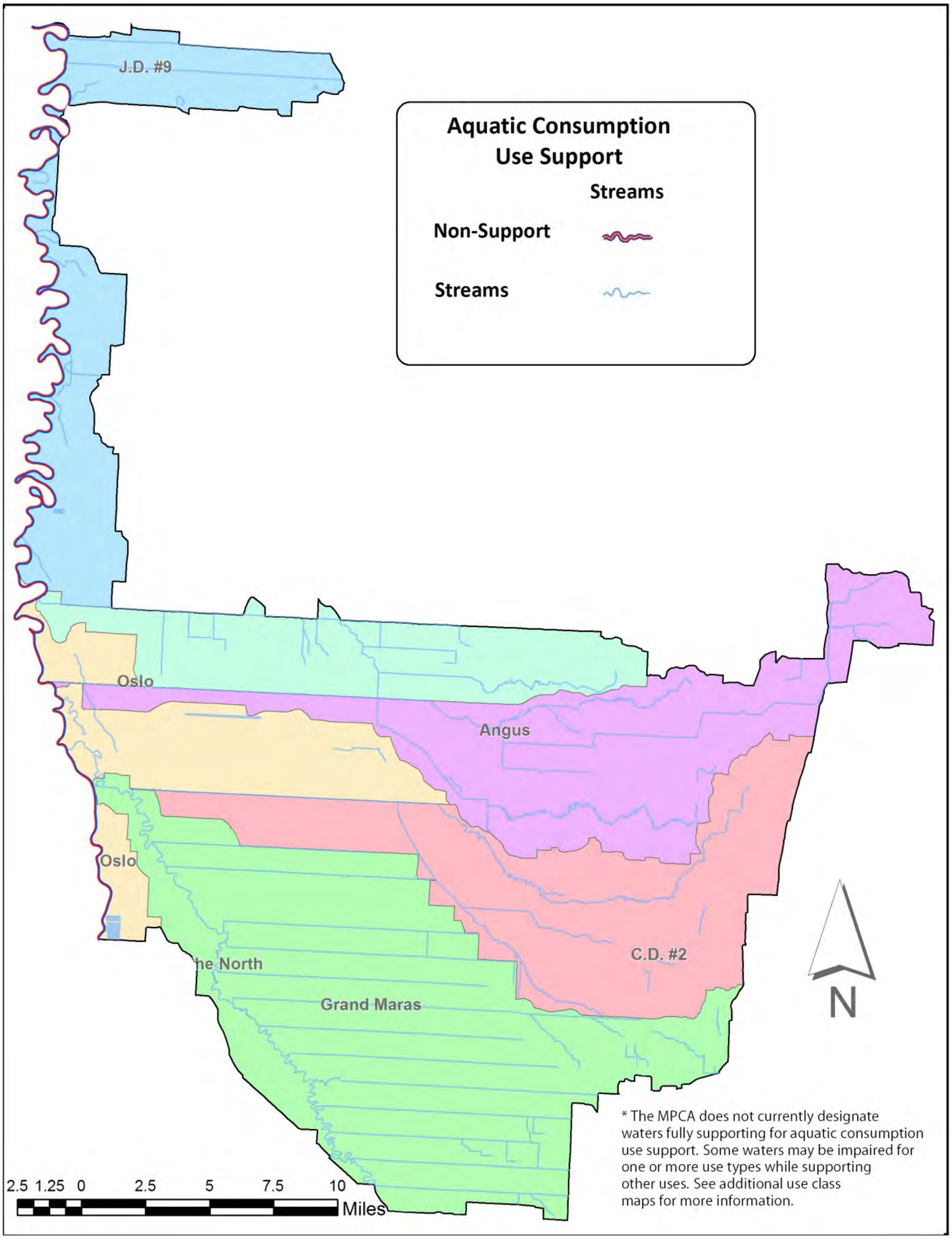

Figure 33. Aquatic consumption use support in the Grand Marais Creek Watershed.

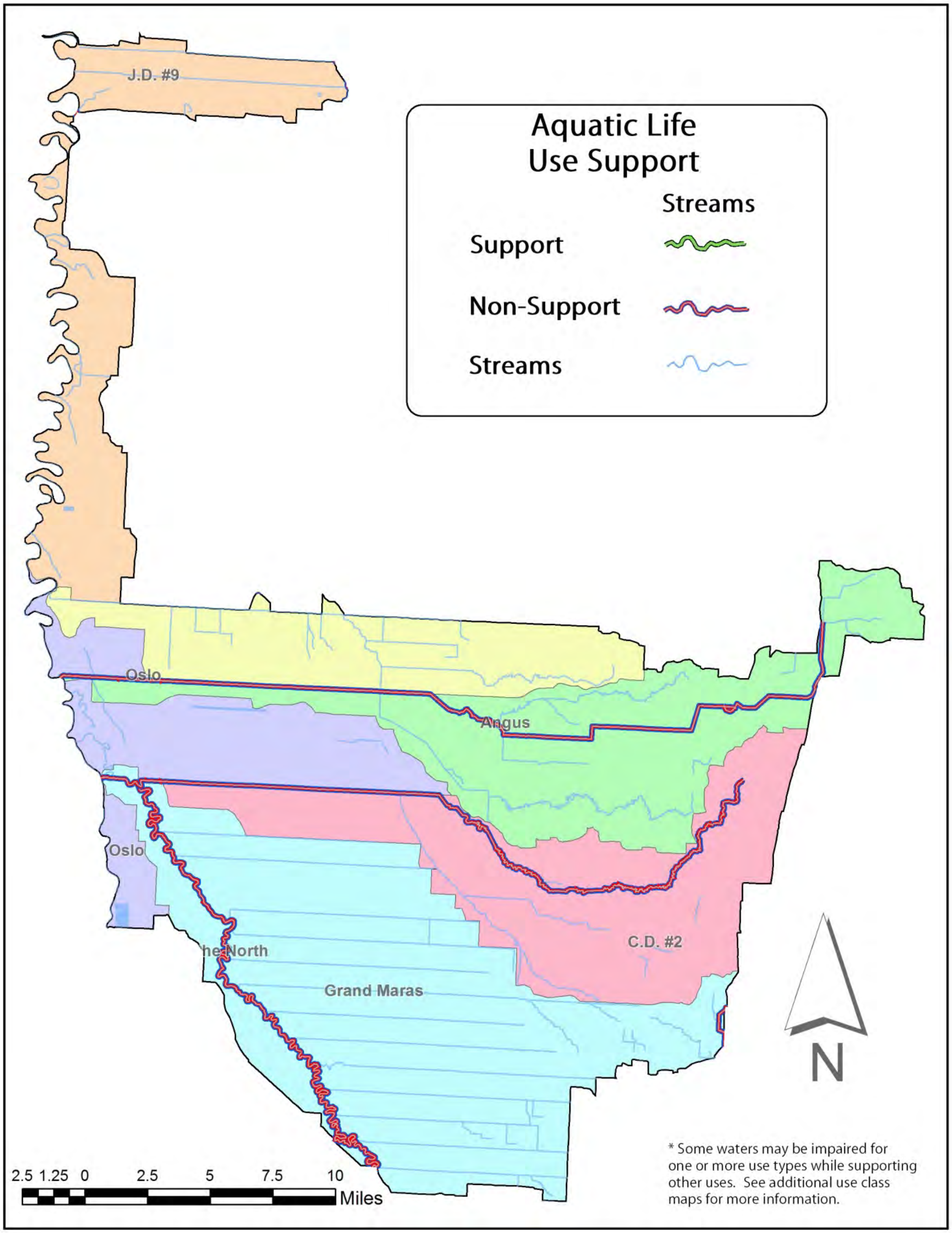

Figure 34. Aquatic life use support in the Grand Marais Creek Watershed.

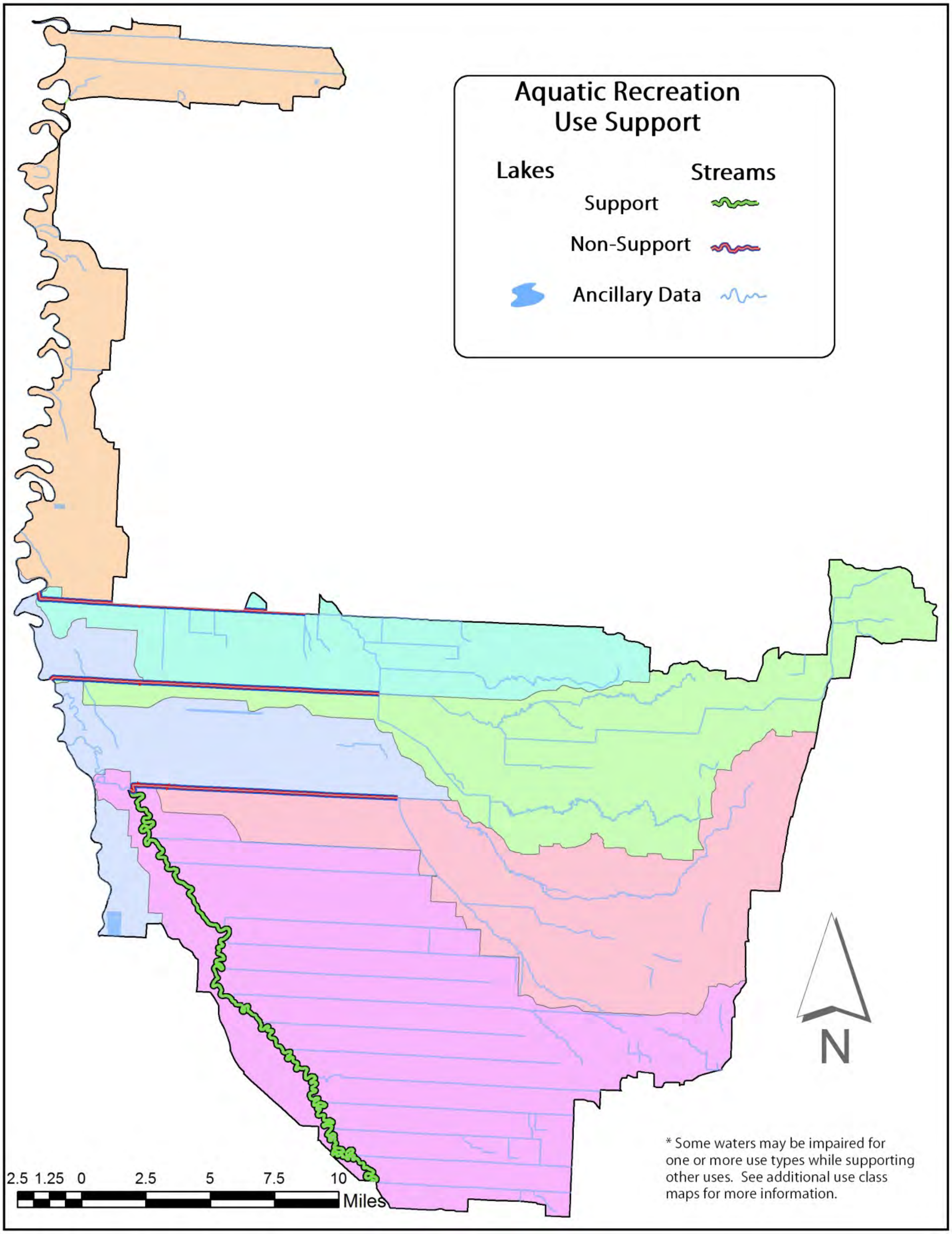

Figure 35. Aquatic recreation use support in the Grand Marais Creek Watershed.

Pollutant Trends for the Grand Marais Creek Watershed

Water quality trends at long-term monitoring stations

There is no available trend data for the Grand Marais Creek Watershed.

Summaries and Recommendations

The Grand Marais Creek Watershed is dominated by agriculture, with nearly 92% of the land in crop production. Historically, the watershed was dominated by tall-grass prairie with natural low gradient streams. Today, approximately 72% of the streams in the watershed have been channelized to increase drainage rates for agriculture. These alterations have fundamentally changed the in-stream habitat resulting in changes in the abundance and diversity of the fish and macroinvertebrate communities. Only one site had a passing macroinvertebrate IBI score in surveys conducted from 2005 – 2013. Dominate macroinvertebrate taxa within the watershed include Gyraulus, Physa, Coenagrionidae, Hyalella, and Corixida, which are highly tolerant of disturbance. Fish survey results corroborated the poor biological conditions indicated by the macroinvertebrate communities. Tolerant fish species such as fathead minnow and brook stickleback dominated the fish samples. The dominance of tolerant species throughout the watershed is most likely a result of poor habitat and water quality conditions. The instream habitat was understandably rather homogenous given the extent of channelization in the watershed. Most streams had habitat that was characterized by poor channel development, excessive sedimentation, and a lack of coarse substrates. The highly altered condition of the streams could plausibly explain the low dissolved oxygen readings as channelization increases flow variability and reduces flow permanence leading to low flow or even stagnant conditions during dry periods. Of the six fish surveys that were used to assess aquatic life, none of the FIBI scores were above the designated thresholds (general or modified use), and therefore indicated non-support for these communities. Similarly, macroinvertebrates are also signaling stressed aquatic communities as all 10 MIBI scores since 2005 for this watershed are poor.

Though streams in the Grand Marais Creek Watershed are largely impaired, there were a few sensitive macroinvertebrate taxa collected during sampling such as mayflies from the genera Leptophlebiidae and Procloeon, and a sensitive midge from the genus Psectrocladius. There are likely additional source populations of other sensitive macroinvertebrates that were not sampled that would repopulate if stream habitat and water quality was improved. It is important to recognize that many of the reaches within this watershed are man-made ditches and or natural streams which have been modified. For the man-made ditches in particular, it's difficult to expect many of them to maintain an adequate flow regime, which is required to support healthy fish and invertebrate communities. Many of these ditches really have no sustained base-flow, and the water level within them at any given time is dependent on recent precipitation levels and therefore this level can fluctuate greatly. Farmers are strongly encouraged to increase riparian buffer zones and utilize crop rotation practices as this should help the biology by minimizing erosion and decreasing nutrient contamination.

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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 Grand Marais Creek Watershed

Biological Station ID	STORET/ EQuIS ID	Waterbody Name	Location	12-digit HUC
12RD098	S005-570	Judicial Ditch #75	At CR 22, 11 miles N of East Grand Forks	0902030604-01
12RD100	S004-131	County Ditch #2	At CR 62, 7 miles NE of East Grand Forks	0902030601-01
12RD097	S002-126	Grand Marais Creek	At CR 64, 9 miles N of East Grand Forks	0902030602-01
12RD099	S005-571	Judicial Ditch 1	At CR 22, 14 miles NE of East Grand Forks	0902030604-01

Appendix 3 – AUID table of stream assessment results (by parameter and beneficial use)

AUID Descriptions					Uses					Water quality standards									
										Aquatic Life Indicators:								Aquatic Rec. Indicators:	
Assessment Unit ID (AUID)	**Stream Reach Name**	**Reach Description**	**Reach Length (Miles)**	**Use Class**	**Aquatic Life**	**Aquatic Recreation**	**Aquatic Consumption**	**303d listed impairments YEAR**		**Fish**	**Macroinvertebrates**	**Dissolved Oxygen**	**Turbidity**	**Chloride**	**pH**	**NH3**	**Pesticides**	**Bacteria**	**Nutrients**
HUC 12: 0902030603-01 (Judicial Ditch No 75)																			
09020306-516	Unnamed creek (County Ditch 44)	Headwaters to CD 7	30.10	2Bg, 3C	NA	NA	NA											MTS	
09020306-517	County Ditch 43 (Judicial Ditch 75)	Unnamed ditch to CD 7	23.61	2Bm, 3C	NS	NA	NA			EXS	EXS	IF	IF		IF				
09020306-518	County Ditch 7	CD 43 to Unnamed ditch	5.38	2Bg, 3C	NA	NA	NA												
09020306-520	Judicial Ditch 75	County Ditch 7 to Red River	12.86	2Bm, 3C	NS	NS	NA			EXS	MTS	MTS	IF	MTS	MTS	MTS		IF	
HUC 12: 0902030601-01 (County Ditch No 2)																			
09020306-509	Unnamed creek (Red Lake Watershed Ditch 15)	Headwaters to CD 66	24.69	2Bg, 3C	NS	NA	NA					IF	MTS		MTS				
09020306-510	Unnamed ditch	Headwaters to CD 66	6.71	2Bg, 3C	IF	NA	NA					IF	IF		MTS				
09020306-514	County Ditch 66	Headwaters to CD 2	14.85	2Bg, 3C	NA	NA	NA												
09020306-515	County Ditch 2	CD 66 to Grand Marais Cr	10.74	2Bm, 3C	NS	NS	NA			EXP	EXS	MTS	MTS	MTS	IF	MTS		EX	
HUC 12: 0902030602-01 (Grand Marais Creek)																			
09020306-507	Grand Marais Creek	Headwaters to CD 2	38.17	2Bg, 3C	NS	FS	NA					EX	MTS		MTS	MTS		MTS	
09020306-511	County Ditch 126	Unnamed cr to Grand Marais Cr	11.91	2Bg, 3C	IF	NA	NA					IF			IF				

AUID Descriptions					Uses				Water quality standards									
									Aquatic Life Indicators:								Aquatic Rec. Indicators:	
Assessment Unit ID (AUID)	Stream Reach Name	Reach Description	Reach Length (Miles)	Use Class	Aquatic Life	Aquatic Recreation	Aquatic Consumption	303d listed impairments YEAR	Fish	Macroinvertebrates	Dissolved Oxygen	Turbidity	Chloride	pH	NH3	Pesticides	Bacteria	Nutrients
09020306-512	Grand Marais Creek	CD 2 to Red R	1.80	2Bg, 3C	IF	FS	NA				IF		MTS	MTS	MTS		MTS	
09020306-513	Grand Marais Creek	Diversion ditch to Red R	6.03	2Bg, 3C	NA	NA	NA											
09020306-521	Grand Marais Creek	CD 2 to diversion ditch	0.66		NA	NA	NA											
09020306-522	Grand Marais Cutoff Channel	Grand Marais Cr to Red R	1.14	2Bg, 3C	NA	NA	NA											

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 2014 reporting cycle; ☐ = new impairment; ☐ = full support of designated use.

AUID Descriptions				Uses							Water Quality Standards: Life Indicators:							Aquatic Rec. Indicators:	
Assessment Unit ID (AUID)	Stream Reach Name	Reach Description	Reach Length (Miles)	Use Class	Aquatic Life	Aquatic Recreation	Aquatic Consumption	303d listed impairments YEAR		Fish	Macroinvertebrates	Dissolved Oxygen	Turbidity	Chloride	pH	NH3	Pesticides	Bacteria	Nutrients
HUC 12: 0902030605-01 (Judicial Ditch No 68)																			
09020306-502	Red River of the North	English Coulee (ND) to Grand Marais Cr	6.88	1C, 2Bdg, 3C	NA	NA	NA												
HUC 12: 0902030604-01 (Judicial Ditch No. 1)																			
09020306-519	Judicial Ditch No. 1	County Ditch 7 to Red River	10.67	2Bg, 3C	IF	NS	NA					MTS	IF	MTS	MTS	MTS		EX	
HUC 12: 0902030606-01 (City of Oslo-Red River)																			
09020306-501	Red River of the North	Grand Marais Cr to North Marais R (ND)	41.82	1C, 2Bdg, 3C	IF	NA	NA					IF	IF		IF	IF			
09020306-503	Red River of the North	North Marais R (ND) to Forest R (ND)	3.68	1C, 2Bdg, 3C	NA	NA	NA												
09020306-504	Red River of the North	Forest R (ND) to Snake R	13.56	1C, 2Bdg, 3C	NA	NA	NA												
09020306-505	Red River of the North	Snake R to Park R (ND)	8.05	1C, 2Bdg, 3C	NA	NA	NA												

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 2014 reporting cycle; ☐ = new impairment; ☐ = full support of designated use.

Appendix 4.1 – Minnesota statewide IBI thresholds and confidence limits

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

Appendix 4.2 – Biological monitoring results – fish IBI (assessable reaches)

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi2	Fish Class	Threshold	FIBI	Visit Date
HUC 12: 0902030603-01 (Judicial Ditch No. 75)							
09020306-517	07RD023	County Ditch 43	12.66	6	23	0.6	08/09/2007
09020306-517	07RD023	County Ditch 43	12.66	6	23	0	06/13/2012
09020306-517	12RD089	County Ditch 43	31.18	2	35	12.5	06/13/2012
09020306-517	12RD087	County Ditch 43	64.11	2	35	12.5	07/19/2012
09020306-520	12RD098	Judicial ditch No. 75	108.25	2	35	0	06/19/2012
HUC 12: 0902030601-01 (County Ditch No. 2)							
09020306-515	12RD100	County Ditch 2	93.65	2	35	19.2	06/14/2012
09020306-515	05RD098	County Ditch 2	101.36	2	35	21.8	08/23/2005
09020306-515	05RD098	County Ditch 2	101.36	2	35	12.5	07/18/2012
09020306-515	05RD098	County Ditch 2	101.36	2	35	50.9	08/16/2012
HUC 12: 0902030602-01 (Grand Marais Creek)							
No Assessable Fish Data							
HUC 12: 0902030605-01 (Judicial Ditch No. 68)							
No Assessable Fish Data							
HUC 12: 0902030604-01 (Judicial Ditch No. 1)							
No Assessable Fish Data							
HUC 12: 0902030606-01 (City of Oslo-Red River)							
No Assessable Fish Data							

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

	Biological Station ID	Stream Segment Name	Drainage Area Mi2	Invert Class	Threshold	MIBI	Visit Date
0902030603-01 Judicial Ditch No. 75							
09020306-517	07RD023	County Ditch 43	12.66	7	41	11.19	8/14/2007
09020306-517	12RD087	County Ditch 43	64.11	7	41	4.90	8/1/2012
09020306-517	12RD089	County Ditch 43	31.18	7	41	12.92	8/1/2012
09020306-517	07RD023	County Ditch 43	12.66	7	41	17.37	8/6/2013
09020306-520	12RD098	Judicial Ditch 75	108.25	7	41	32.34	8/1/2012
0902030601-01 County Ditch No. 2							
09020306-515	05RD098	County Ditch 2	101.36	7	41	12.73	9/12/2005
09020306-515	05RD098	County Ditch 2	101.36	7	41	19.61	9/27/2005
09020306-515	05RD098	County Ditch 2	101.36	7	41	11.91	8/8/2012
09020306-515	12RD100	County Ditch 2	93.65	7	41	11.18	8/1/2012
09020306-515	12RD100	County Ditch 2	93.65	7	41	5.76	8/1/2012

Appendix 5 – 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 6 – Fish species found during biological monitoring surveys

Common Name	Quantity of Stations Where Present	Quantity of Individuals Collected
bigmouth buffalo	2	2
black bullhead	4	747
blackside darter	1	4
brook stickleback	3	81
burbot	1	1
central mudminnow	2	20
channel catfish	2	23
common carp	3	46
common shiner	2	66
fathead minnow	6	923
freshwater drum	2	11
goldeye	1	31
Iowa darter	1	7
northern pike	6	45
quillback	1	5
rock bass	1	1
sand shiner	2	17
sauger	1	5
shorthead redhorse	1	33
silver chub	1	2
silver redhorse	1	2

Common Name	Quantity of Stations Where Present	Quantity of Individuals Collected
spotfin shiner	1	7
stonecat	1	2
trout-perch	1	2
walleye	1	1
white bass	2	9
white sucker	6	71

Appendix 7 – Macroinvertebrate Species Found During Biological Monitoring Surveys

Taxonomic Name	Quantity of Stations Where Present	Quantity of Individuals Collected
ACARI		
Acari	7	16
AMPHIPODA		
Hyalella	9	307
BRANCHIOBDELLIDA		
Branchiobdellida	1	1
COLEOPTERA		
Acilius	1	3
Anacaena	1	2
Berosus	2	2
Dubiraphia	3	21
Dytiscidae	4	9
Dytiscus	1	1
Gyrinus	2	12

Taxonomic Name	Quantity of Stations Where Present	Quantity of Individuals Collected
Haliplus	9	40
Hydrophilidae	1	1
Hygrotus	1	1
Laccophilus	6	45
Liodessus	2	57
Macronychus	1	1
Neoporus	1	1
Ochthebius	1	2
Peltodytes	4	19
Rhantus	1	1
Stenelmis	1	1
Tropisternus	1	12
DECAPODA		
Orconectes	2	2
DIPTERA		
Ablabesmyia	4	17
Acricotopus	1	2
Anopheles	1	1
Bezzia/Palpomyia	1	1
Ceratopogonidae	1	1
Ceratopogoninae	2	3
Chironomini	2	4
Chironomus	3	9
Corynoneura	6	17
Cricotopus	4	16
Cryptochironomus	1	1
Culex	1	2

Taxonomic Name	Quantity of Stations Where Present	Quantity of Individuals Collected
Culicidae	1	1
Dasyhelea	1	1
Dicrotendipes	6	38
Endochironomus	7	74
Ephydridae	1	3
Glyptotendipes	3	78
Labrundinia	2	8
Limonia	1	1
Mallochohelea	1	1
Nanocladius	1	1
Odontomyia /Hedriodiscus	1	1
Paramerina	2	11
Paratanytarsus	6	131
Paratendipes	1	5
Polypedilum	3	5
Probezzia	1	3
Procladius	2	2
Psectrocladius	2	15
Sciomyzidae	1	1
Tanypodinae	3	4
Tanytarsini	1	1
Tanytarsus	5	24
Thienemannimyia Gr.	1	1
EPHEMEROPTERA		
Anafroptilum	1	47
Anthopotamus	1	1
Baetidae	1	1

Taxonomic Name	Quantity of Stations Where Present	Quantity of Individuals Collected
Baetis	1	1
Caenis	10	119
Caenis diminuta	3	20
Callibaetis	5	14
Heptagenia	1	1
Heptageniidae	1	10
Hexagenia bilineata	1	1
Leptophlebiidae	1	3
Leucrocuta	1	1
Procloeon	1	2
Stenacron	1	2
Stenonema	2	6
Tricorythodes	1	2
GASTROPODA		
Fossaria	1	4
Gyraulus	7	682
Lymnaeidae	3	10
Physa	10	584
Planorbella	2	6
Planorbidae	2	72
Promenetus	1	1
Stagnicola	3	149
HEMIPTERA		
Belostoma	2	6
Belostoma flumineum	3	3
Belostomatidae	2	3
Callicorixa	1	1

Taxonomic Name	Quantity of Stations Where Present	Quantity of Individuals Collected
Corixidae	4	215
Hesperocorixa	1	1
Merragata	1	1
Neoplea striola	2	2
Notonecta	7	17
Palmacorixa	1	17
Sigara	3	16
Trichocorixa	2	4
HIRUDINEA		
Hirudinea	5	12
HYDROZOA		
Hydrozoa	1	4
LEPIDOPTERA		
Crambidae	3	12
MEGALOPTERA		
Sialis	1	1
NEMATODA		
Nematoda	1	1
ODONATA		
Aeshna	1	1
Anax	2	5
Anax junius	6	6
Coenagrionidae	7	340
Enallagma	7	51
Gomphus	1	1
Ischnura	1	2
Leucorrhinia	1	1

Taxonomic Name	Quantity of Stations Where Present	Quantity of Individuals Collected
Libellula	1	1
Libellulidae	2	8
Somatochlora	1	1
OLIGOCHAETA		
Oligochaeta	7	85
TRICHOPTERA		
Ceraclea	1	1
Hydroptila	1	4
Leptoceridae	1	1
Oecetis	1	1
Oecetis testacea	1	1
VENEROIDA		
Pisidiidae	5	24