Snake River Watershed Monitoring and Assessment Report

Minnesota Pollution Control Agency

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List of Acronyms

AUID Assessment Unit Identification Determination

CCSI Channel Condition and Stability Index

CD County Ditch

Chl-*a* Chlorophyll-*a*

CI Confidence Interval

CLMP Citizen Lake Monitoring Program

CR County Road

CSAH County State Aid Highway

CSMP Citizen Stream Monitoring Program

CWA Clean Water Act

CWLA Clean Water Legacy Act

DO Dissolved Oxygen

DOP Dissolved Orthophosphate

E Eutrophic

EPA U.S. Environmental Protection Agency

EQuIS Environmental Quality Information System

E. coli *Escherichia coli*

EXS Exceeds Criteria, Potential Severe Impairment

F-IBI Fish Index of Biotic Integrity

FS Full Support

FQA Floristic Quality Assessment

FWMC Flow Weighted Mean Concentration

H Hypereutrophic

HGM Hydrogeomorphically

HUC Hydrologic Unit Code

IBI Index of Biotic Integrity

IWI International Water Institute

IWM Intensive Watershed Monitoring

IF Insufficient Information

K Potassium

LAP Lake Agassiz Plain

LRVW Limited Resource Value Water

M Mesotrophic

MCES Metropolitan Council Environmental Services

MDA Minnesota Department of Agriculture

MDH Minnesota Department of Health

M-IBI Macroinvertebrate Index of Biotic Integrity

MLRA Major Land Resource Area

MNDNR Minnesota Department of Natural Resources

MPCA Minnesota Pollution Control Agency

MSHA Minnesota Stream Habitat Assessment

MTS Meets the Standard

MWP Mixed Wood Plains

MWS Mixed Wood Shield

N Nitrogen

Nitrate-N Nitrate Plus Nitrite Nitrogen

NA Not Assessed

NHD National Hydrologic Dataset

NH_3 Ammonia

NPDES National Pollution Discharge Elimination System

NS Not Supporting

NT No Trend

OP Orthophosphate

P Phosphorus

PCB Polychlorinated Biphenyl

PFC Perfluorochemicals

PFOS Perfluorooctane Sulfonate

PMR Pesticide Monitoring Region

PWI Protected Waters Inventory

RNR River Nutrient Region

SWAG Surface Water Assessment Grant

SWCD Soil and Water Conservation District

TALU Tiered Aquatic Life Uses

TKN Total Kjeldahl Nitrogen

TMDL Total Maximum Daily Load

TP Total Phosphorus

TSS Total Suspended Solids

UAA Use Attainability Analysis

USGS United States Geological Survey

WMA Wildlife Management Area

WPLMN Watershed Pollutant Load Monitoring Network

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Executive summary

The Snake River Watershed (09020309) lies within Marshall, Polk, and Pennington Counties in the northwest portion of Minnesota. The Snake River originates approximately six miles west of the town of Newfolden where it flows southwest collecting the Snake River, South Branch and passes through the towns of Warren and Alvarado. Downstream of Alvarado, the river turns northwest and collects the Middle River approximately five miles upstream of its confluence with the Red River of the North. The watershed drains approximately 611,800 acres (956 mi^2) and includes 39 named stream assessment units (AUIDs).

The Snake River provides habitat for aquatic life, riparian corridors for wildlife, and recreational opportunities such as fishing, swimming and canoeing. Today, roughly 79% of the watersheds landscape is utilized for cropland, 7% wetlands, 6% forested, 3% rangeland, 5% is developed land used for housing, business and industrial complexes, county roads and city streets, and less than 1% is open water (Figure 9).

In 2013, the Minnesota Pollution Control Agency (MPCA) initiated an intensive watershed monitoring (IWM) effort of the Snake River Watershed's surface waters. Thirty-four stream sites were sampled for biology at the outlets of variable sized subwatersheds which included the mainstem Snake River, outlets of major tributaries, and the headwaters of smaller streams. As part of this effort, MPCA staff joined with the International Water Institute (IWI) and the Middle-Snake-Tamarac Watershed District to complete stream water chemistry sampling. In 2015, a holistic approach was taken to assess all of the watershed's surface waterbodies for support or non-support of aquatic life, recreation, and fish consumption, where sufficient data was available. Twenty-two stream segments (e.g., AUIDs) were assessed in this effort however no lakes were assessed (not all stream AUIDs were able to be assessed due to insufficient data, data was unable to be collected, or their status as limited resources waters).

Throughout the watershed, four streams fully support aquatic life and seven fully support aquatic recreation (Appendix 3). Sixteen streams do not support aquatic life and four do not support aquatic recreation. Aquatic recreation impairments are due to high bacteria levels.

The main resource concerns in the watershed are wind and water erosion, nutrient management, wetland management, surface water quality, flood damage reduction, and connectivity (dams). Many of the resource concerns relate directly to flooding, increased sediment, and pollutant loadings to surface waters (MPCA, Snake River Webpage). Changes in land use patterns including wetland removal and the conversion of tallgrass prairie into agriculture have likely contributed to sediment and pollutant loadings to surface waters, leading to decreased habitat and water quality, thus reducing populations of sensitive aquatic species.

Introduction

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

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

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

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

This watershed-wide monitoring approach was implemented in the Snake River Watershed beginning in the summer of 2013. This report provides a summary of all water quality assessment results in the Snake River Watershed and incorporates all data available for the assessment process including watershed monitoring, volunteer monitoring and monitoring conducted by local government units.

I. The watershed monitoring approach

The watershed approach is a 10-year rotation for monitoring and assessing waters of the state on the level of Minnesota's 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 three 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

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 (MNDNR) flow gaging stations with water quality data collected by the Metropolitan Council Environmental Services (MCES), local monitoring organizations, and MPCA to compute pollutant loads for 199 stream and river monitoring sites 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:

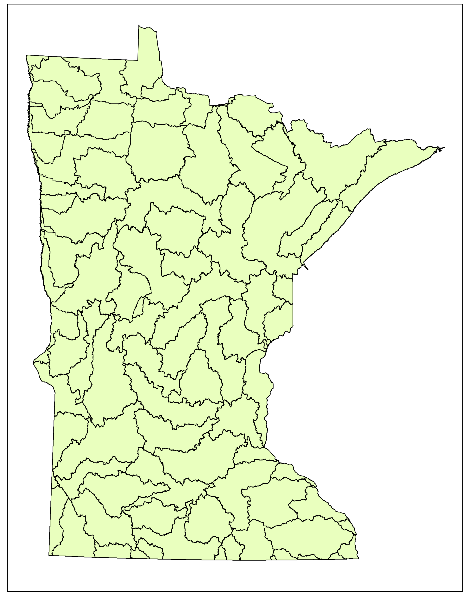


Figure 1. Minnesota's 80 major watersheds (8 Digit HUC Scale).

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

Major Watershed – tributaries draining to basin rivers with an average drainage area of 1,350 mi^2 (8-digit HUC scale).

Subwatershed – major branches or nodes within major watersheds with average drainage areas of approximately 300-500 mi^2. 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 including a map of the sites.

The Snake River station near Bigwoods on MN220 (DNR/MPCA ID H68011001, EQuIS ID S000-185) is the furthest downstream WPLMN monitoring site in the Snake River Watershed and drains an area of approximately 766 mi^2 (Figure 2). The gage is operated by the MNDNR and is located approximately three river miles above the confluence of the Snake with the Red River near Bigwoods, Minnesota. An average of 30 mid-stream grab samples per year were collected from this site between 2009 and 2013. Two subwatershed sites were also established in the watershed during 2013, the Snake River above Warren, CSAH34 (DNR/MPCA ID 68031002, USGS ID 05085450, EQuIS ID S003-101) and the Middle River near Argyle, CSAH4 (DNR/MPCA ID 68017001, USGS ID 05087500, EQuIS ID S000-700).

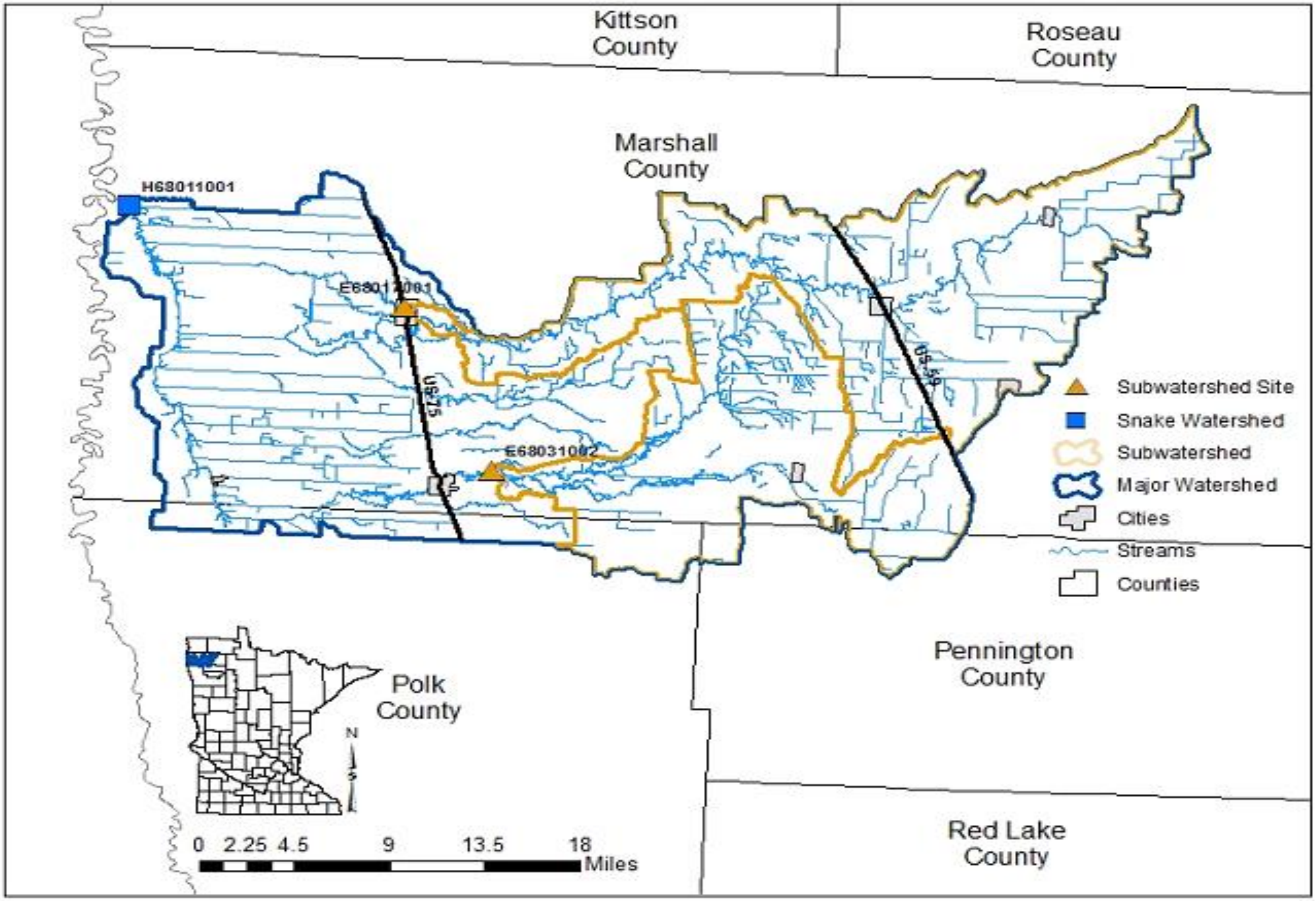


Figure 2. WPLMN monitoring sites in the Snake River Watershed.

Intensive watershed monitoring

The IWM strategy utilizes a nested watershed design allowing the sampling of streams within watersheds from a coarse to a fine scale (Figure 3). 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 (HUC-8) 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, HUC-8, HUC-11, and HUC-14 (Figure 3). 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 HUC-8 scale. The outlet of the major HUC-8 watershed (purple dot in Figure 4) 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 HUC-11 is the next smaller subwatershed scale which generally consists of major tributary streams with drainage areas ranging from 75 to 150 mi^2. Each HUC-11 outlet (green dots in Figure 4) is sampled for biology and water chemistry for the assessment of aquatic life and aquatic recreation use support. Within each HUC-11, smaller watersheds (14-HUCs, typically 10-20 mi^2), are sampled at each outlet that flows into the major HUC-11 tributaries. Each of these minor subwatershed outlets is sampled for biology to assess aquatic life use support (red dots in Figure 4). Specific locations for sites sampled as part of the intensive monitoring effort in the Snake River Watershed are shown in Figure 4 and are listed Appendix 2, Appendix 4.2, and Appendix 4.3.

Within the IWM 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 were no assessable lakes within the Snake River Watershed.

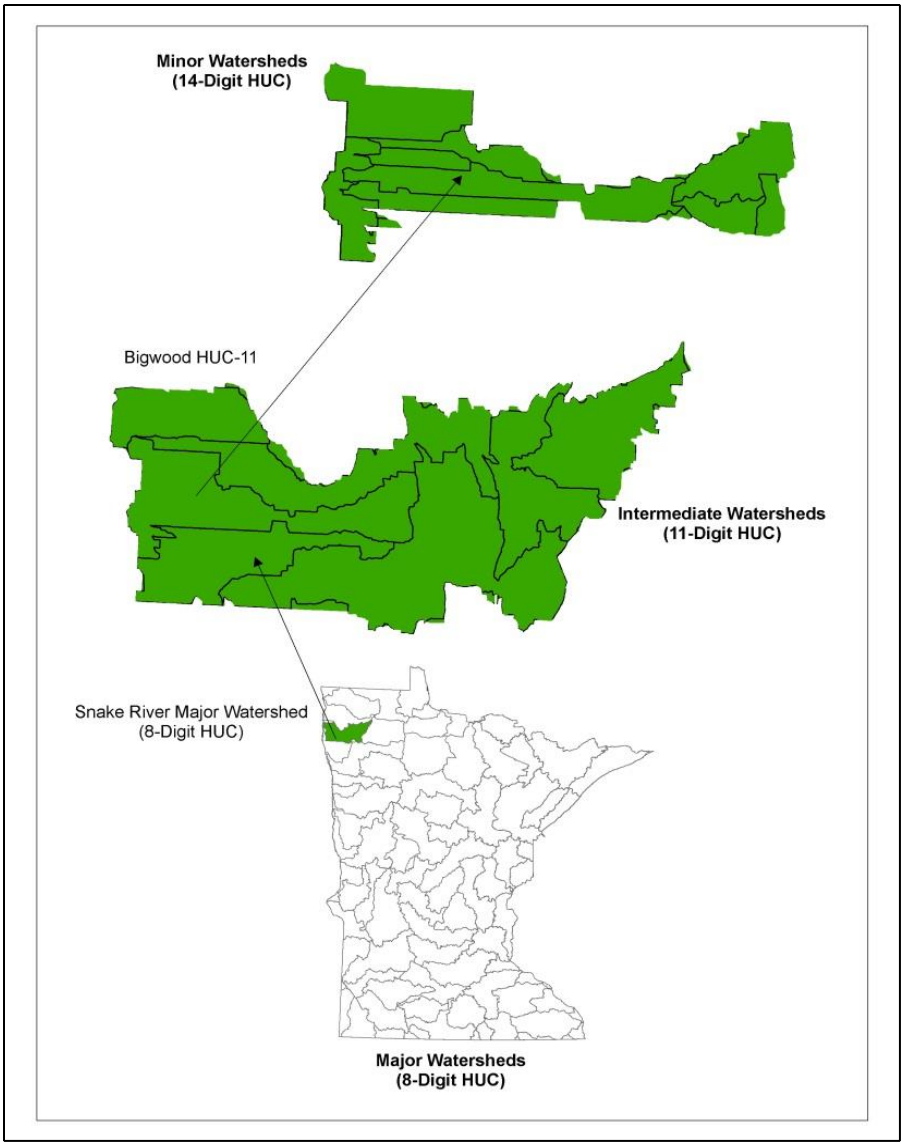


Figure 3. The IWM design.

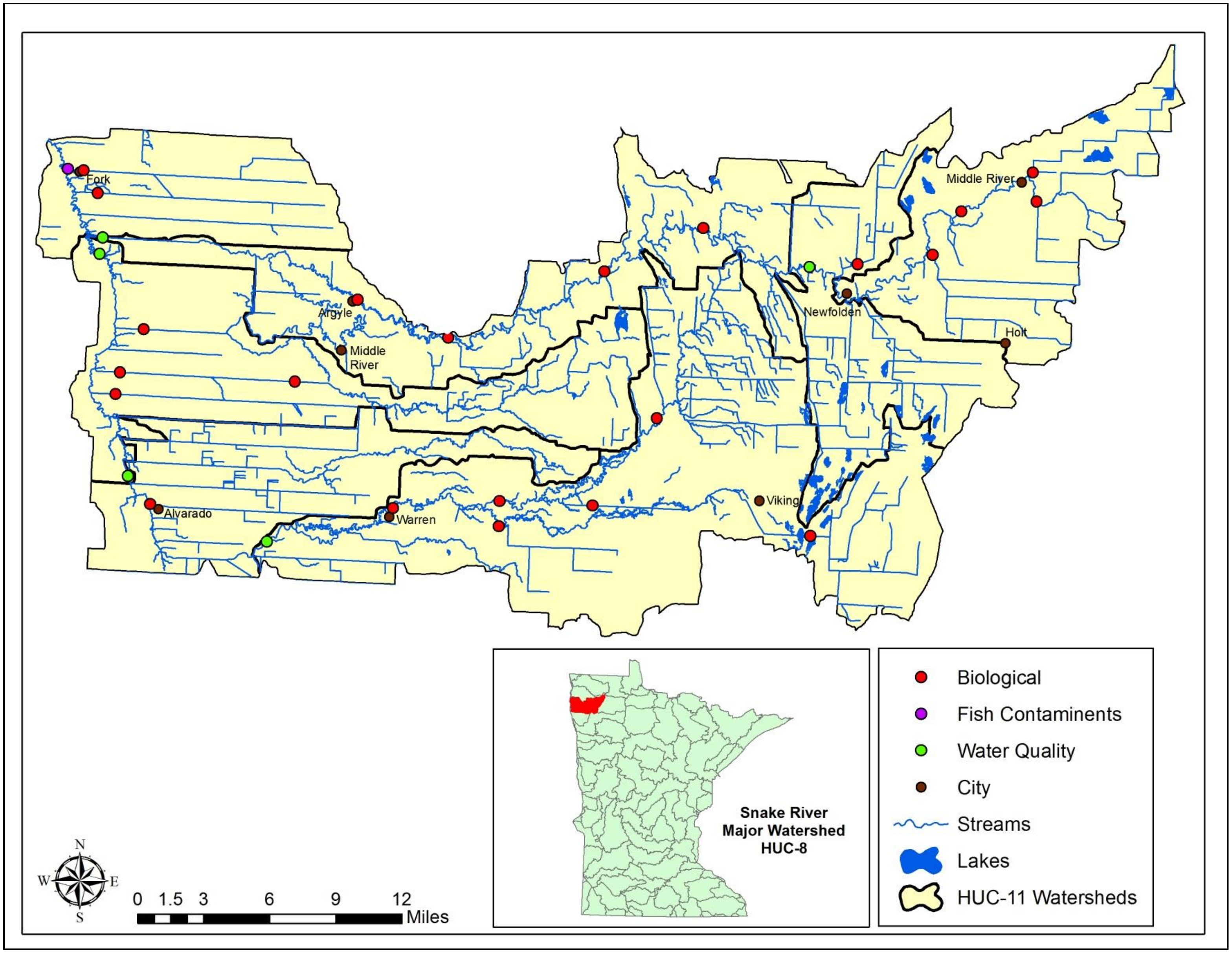


Figure 4. IWM sites for streams in the Snake River Watershed.

Citizen and local monitoring

Citizen and local monitoring is an important component of the watershed approach. The MPCA and its local partners jointly select the stream sites and lakes to be included in the IWM 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: Citizen Lake Monitoring Program (CLMP) and the Citizen Stream Monitoring Program (CSMP). Like the permanent load monitoring network, having citizen volunteers monitor a given lake or stream site monthly and from year to year can provide the long-term picture needed to help evaluate current status and trends. Citizen monitoring is especially effective at helping to track water quality changes that occur in the years between intensive monitoring years. Figure 5 provides an illustration of the locations where citizen monitoring data were used for assessment in the Snake River Watershed.

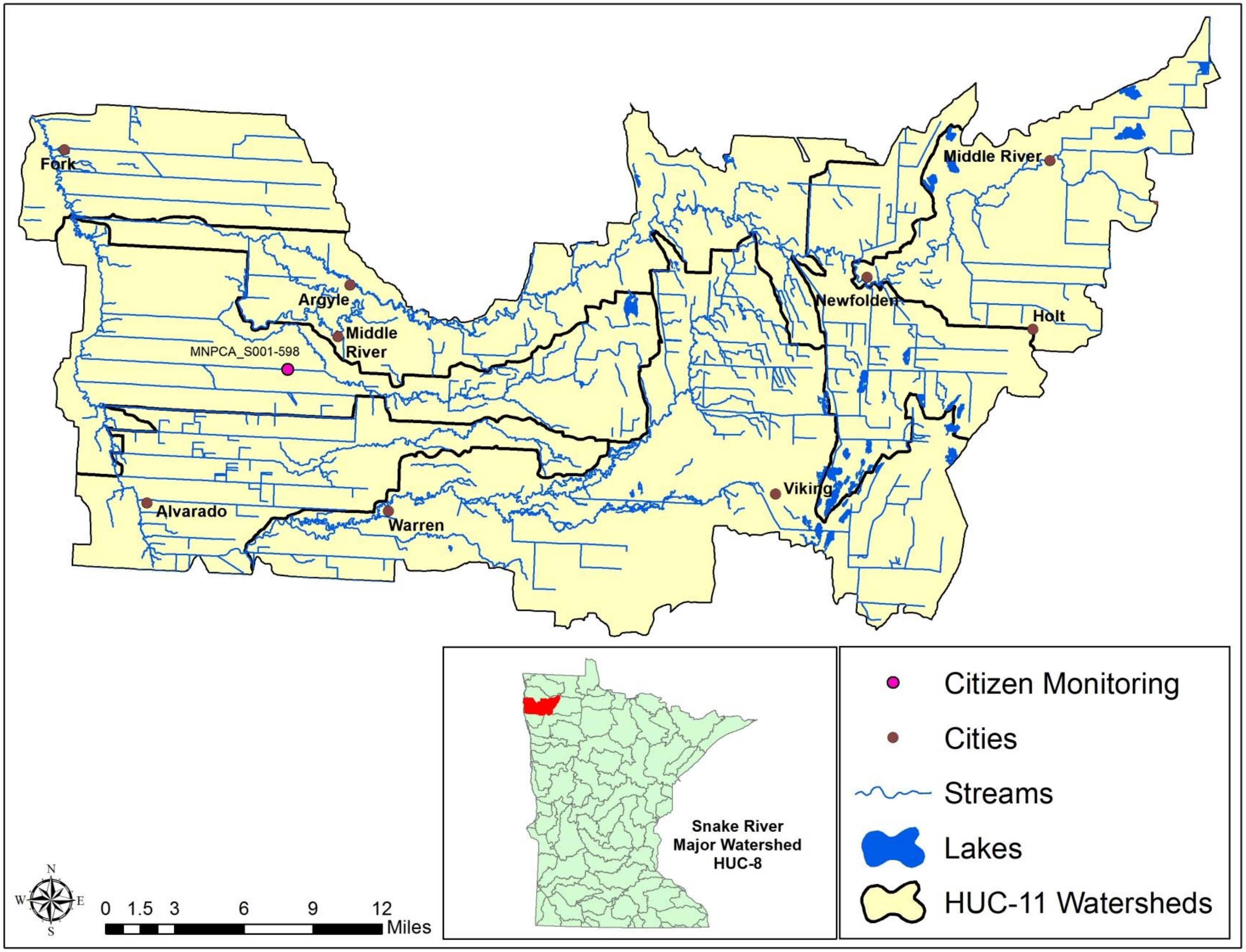


Figure 5. Monitoring location of local groups and citizens in the Snake River Watershed.

II. Assessment methodology

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

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, macroinvertebrates, 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 IBIs 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 IBIs 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 biocriteria against which an IBI score can be compared within a given stream class. In general, an IBI score above this threshold is indicative of aquatic life use support, while a score below this threshold is indicative of non-support. Additionally, chemical parameters are measured and assessed against numeric standards developed to be protective of aquatic life, including pH, dissolved oxygen (DO), un-ionized ammonia nitrogen, chloride and turbidity.

Protection for aquatic life uses are divided into three tiers: Exceptional, General, and Modified. Exceptional Use waters support fish and macroinvertebrate communities that have minimal changes in structure and function from the natural condition. General Use waters harbor "good" assemblages of fish and macroinvertebrates that are balanced and that have retained their ecosystem functions. Modified Use waters have been extensively altered through legacy (i.e., prior to the CWA) physical modifications which limit the ability of the biological communities to attain the General Use. Currently the Modified Use is only applied to some rivers and streams with poor biology due to habitat limitations resulting from channelization and ditching practices. These tiered uses are determined before assessment based on the attainment of the applicable biological criteria and/or an assessment of the habitat. For additional information, see: https://www.pca.state.mn.us/water/tiered-aquatic-life-use-talu-framework.

Table 1. Table of proposed Tiered Aquatic Life Use (TALU) Standards.

Proposed TALU	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 coldwater 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 coldwater 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 *Escherichia coli* (*E. coli*) bacteria in the water. To determine if a lake supports aquatic recreational activities its trophic status is evaluated, using total phosphorus (TP), Secchi depth, and chlorophyll-*a* (chl-*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, DO 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 (HUC-8) plus a three-character code that is unique within each HUC. Lake and wetland identifiers are assigned by the MNDNR. The Protected Waters Inventory (PWI) provides the identification numbers for lake, reservoirs and wetlands. These identification numbers serve as the AUID and are composed of an eight-digit number indicating county, lake and bay for each basin.

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

Determining use attainment

For beneficial uses related to human health, such as drinking water or aquatic recreation, the relationship is well understood and thus the assessment process is a relatively simple comparison of monitoring data to numeric standards. In contrast, assessing whether a waterbody supports a healthy aquatic community is not as straightforward and often requires multiple lines of evidence to make use attainment decisions with a high degree of certainty. Incorporating a multiple lines of evidence approach into MPCA's assessment process has been evolving over the past few years. The current process used to assess the aquatic life use of rivers and streams is outlined below and in Figure 6.

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).

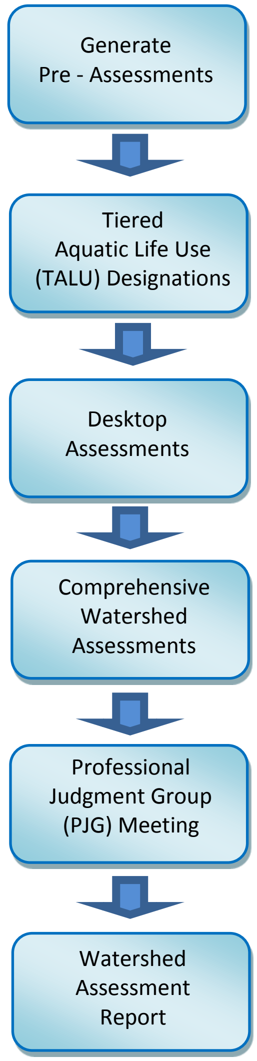


Figure 6. Flowchart of aquatic life use assessment process.

The next step in the process is a Comprehensive Watershed Assessment meeting where reviewers convene to discuss the results of their desktop assessments for each individual waterbody. Implementing a comprehensive approach to water quality assessment requires a means of organizing and evaluating information to formulate a conclusion utilizing multiple lines of evidence. Occasionally, the evidence stemming from individual parameters are not in agreement and would result in discrepant assessments if the parameters were evaluated independently. However, the overall assessment considers each piece of evidence to make a use attainment determination based on the preponderance of information available. See the *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment 305(b) Report and 303(d) List* (MPCA, 2012) https://www.pca.state.mn.us/water/minnesotas-impaired-waters-list 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 data system and are also uploaded to the U.S. Environmental Protection Agency (EPA) data warehouse. Data for monitoring projects with federal or state funding are required to be stored in EQuIS (e.g., Clean Water Partnership, CWLA SWAGs 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.

III. Watershed overview

Physical setting

From its source approximately six miles west of the town of Newfolden the Snake River flows southwest collecting the South Fork Snake River and passes through the towns of Warren and Alvarado. Downstream of Alvarado, the river turns northwest and collects the Middle River approximately 5 miles upstream of its confluence with the Red River of the North, in total, flowing about 93 miles. The watershed covers 955 mi^2 and drains approximately 611,800 acres, nearly all of which is encompassed within Marshall County with small portions in Pennington and Polk Counties.

The watershed is fully contained within the Lake Agassiz Plain (LAP) ecoregion which covers approximately 15,690 mi^2 (Figure 7). The LAP was formed approximately ten thousand years ago when great continental glaciers of North America started to recede to the north (USGS, Webpage). The melting ice formed many large glacial lakes, the last of which was Glacial Lake Agassiz which filled the Red River Valley. Today, what remains is an extremely flat lake plain, with an average gradient of about six inches per mile and gently rolling uplands along the eastern and western edges of the Red River Valley (USGS, Webpage). The watershed is largely comprised within the Red River of the North Major Land Resource Area (MLRA) with a small portion in the northeast corner being in the Northern Minnesota Gray Drift MLRA (Figure 8).

The flat terrain combined with the rich and loamy soils enable the Red River Valley to be one of the most productive agricultural regions in the Great Plains (USGS, Webpage). The very flat and poorly defined floodplains however, lead to the region experiencing numerous major floods over the years.

These floods led to the creation of extensive man-made drainage networks designed to remove surface water quickly from agricultural lands. Today, rapid surface water removal from agricultural fields continues to be a focus with underground tile piping becoming widely used within the region.

History

Native Americans were the first to occupy the region, long before the first white settlers began arriving in the area. Fur traders and other European settlers began arriving in the area around 1820 via ox cart trails that ran between settlements in Winnipeg, the Mississippi River, and/or St. Paul. The first white settler to the region homesteaded in 1868; however, major waves of immigration did not begin until 1872 and 1873 when railroads were built (MSUM, Webpage). Although agricultural lands were planted by the Native Americans, major agricultural development did not begin until the immigration of settlers began in the region. Roads and bridges were constructed beginning in 1880 and by 1881 nearly all of the land was occupied by homesteads, with one-third of the farms averaging over 1,000 acres (NRDC, Webpage). In the years that followed, most of the native grasslands were replaced by row crop agriculture which still dominates the landscape today. The population in the region that began with only a few families in 1878 increased to 992 in 1830, and to 17,003 in 1930 (NRDC, Webpage). Although the landscape remains similar, over the years the average size of family farms in this region has continued to decrease with the average farm being 122 acres (NRCS, 2007).

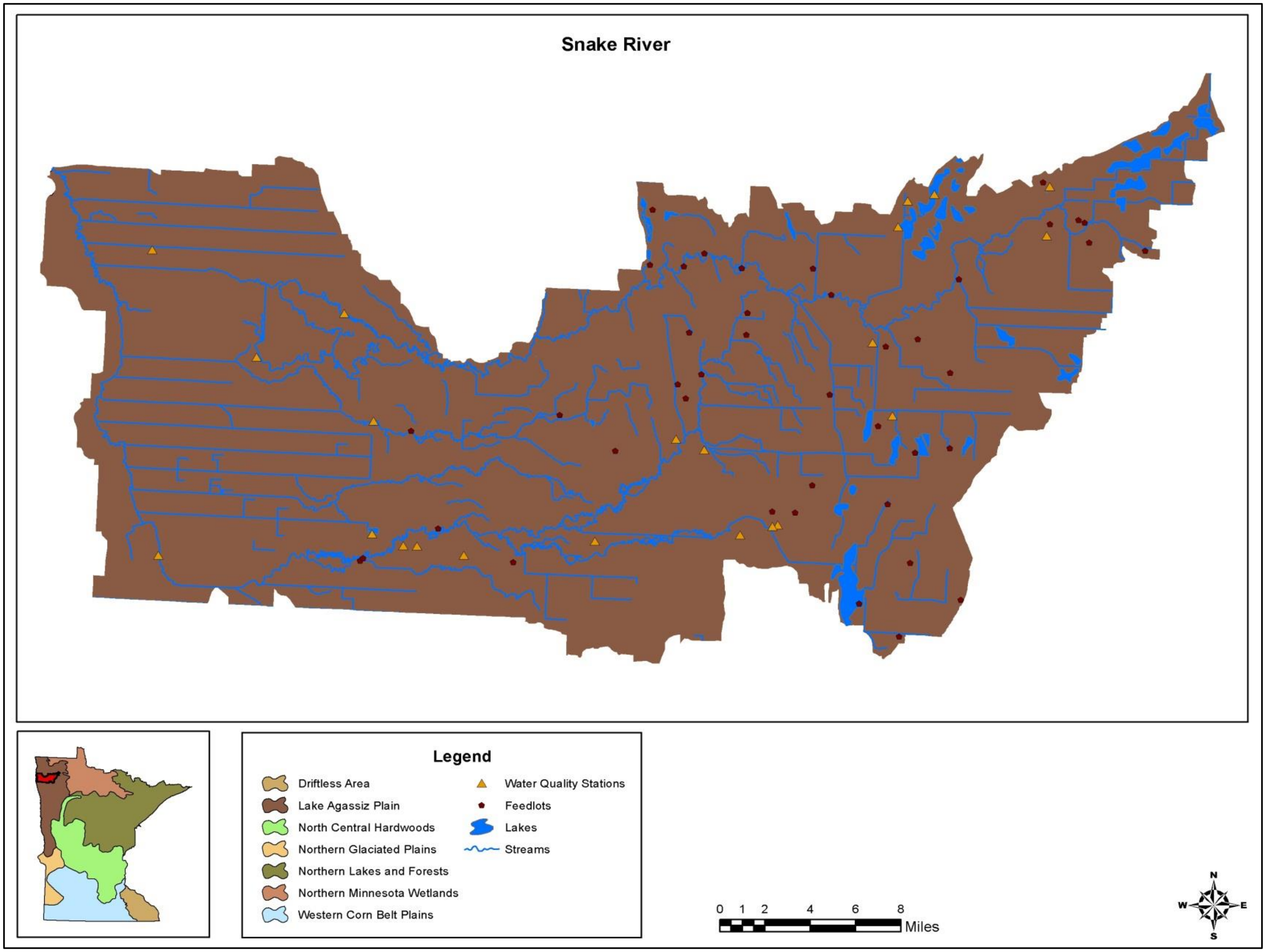


Figure 7. **Permitted feedlots and NPDES discharges within the Snake River Watershed, Lake Agassiz Plain ecoregion of northwest Minnesota.**

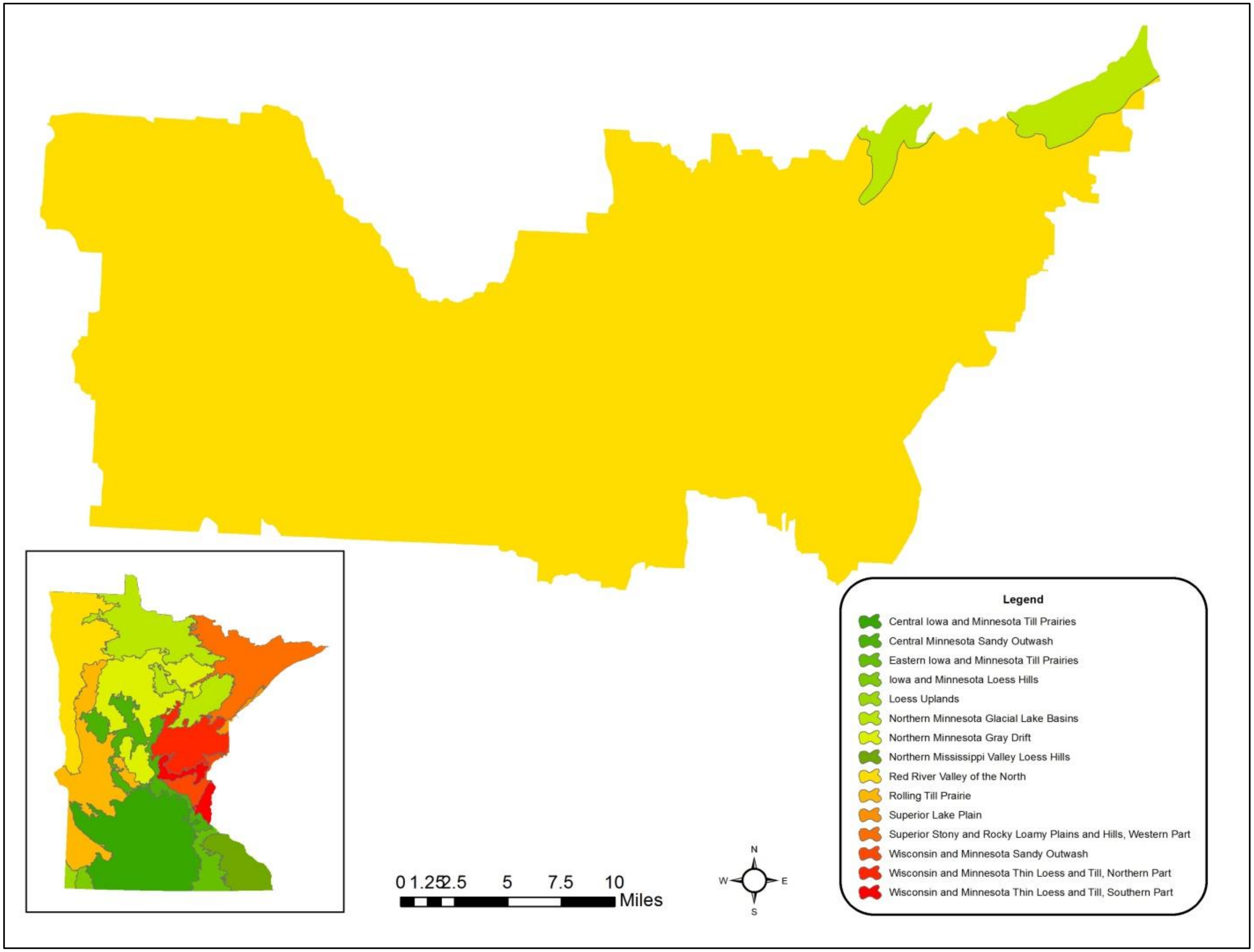


Figure 8. MLRA in the Snake River Watershed.

Land use summary

The Snake River Watershed is dominated by an agricultural landscape with areas of grassland, wetland, and forest scattered throughout the eastern portion of the watershed. The western portion of the watershed is nearly completely covered in agricultural lands except for wooded areas lining streams and homesteads.

Land cover in the watershed is distributed as follows: 78.7% cropland, 7.2% wetland, 5.7% forest, 4.9% developed, 3.1% rangeland, and 0.4% open water (Figure 9). Approximately 97% of the watershed's acreage is privately owned (NRCS, 2007). Area farms are largely comprised of family farms with 63% earning their living entirely off the land and are not dependent on off-farm income. Thirty-seven percent of the operations are less than 180 acres, 26% are from 180 to 500 acres, 15% are from 500-1,000 acres, and 22% are greater than 1,000 acres in size (NRCS, 2007).

Six thousand five hundred and twenty-two people reside within the Snake River Watershed (NRCS, 2007), equating to roughly seven people per square mile. The largest population centers are located in the towns of Alvarado, Warren, Argyle, Newfolden, and Middle River.

Terrain: The LAP ecoregion consists of a lacustrine plain to the west and reworked till plain on the east. Portions of the lacustrine lake plain are level, but there are also small dunes and a series of low beach ridges and swales. The beach ridges are commonly gravelly and swales often contain abundant cobbles and boulders while the water-worked till plain has low relief with less course substrate (MNDNR, 2015).

Soils of the lacustrine plain range from loams and silts to sands and gravels. Calcareous fens and saline seeps occur at the base of sand dunes and beach ridges. On the water-worked till plain, soils are generally loamy. The till often contains large boulders that restrict land use. In places, till is partially mantled with lacustrine sands, silts, and clays (MNDNR, 2015). The growing season is generally shorter and cooler, averaging roughly 120 days (MNDNR, 2015).

Vegetation: The LAP ecoregion consists primarily of agricultural lands but where natural grasses are present, combinations of aspen savannas, tallgrass prairie, wet prairie, and dry gravel prairie exist. In areas where hardwoods are present (mostly along streams and floodplains) species such as silver maple, elm, cottonwood and ash are most common (MNDNR, 2015). Although rarely found within the watershed, small areas of herbaceous wetlands do exist.

Wildlife: Whitetail deer, rabbits, squirrels, coyote, fox, multiple hawk species, sandhill cranes, bald eagles and a variety of waterfowl species are common wildlife within the ecoregion (FWS, 2005). Common fish species include northern pike, walleye, sauger, channel catfish, and many minnow species.

Land use/human activities: Private landowners make up nearly the entire watershed (97%) with agriculture making up a majority of the private land use. State owned lands are the second largest ownership (2.7%) followed by small tracts of federal lands (NRCS, 2007). Hunting for big and small game, upland birds, and waterfowl commonly take place within the watershed.

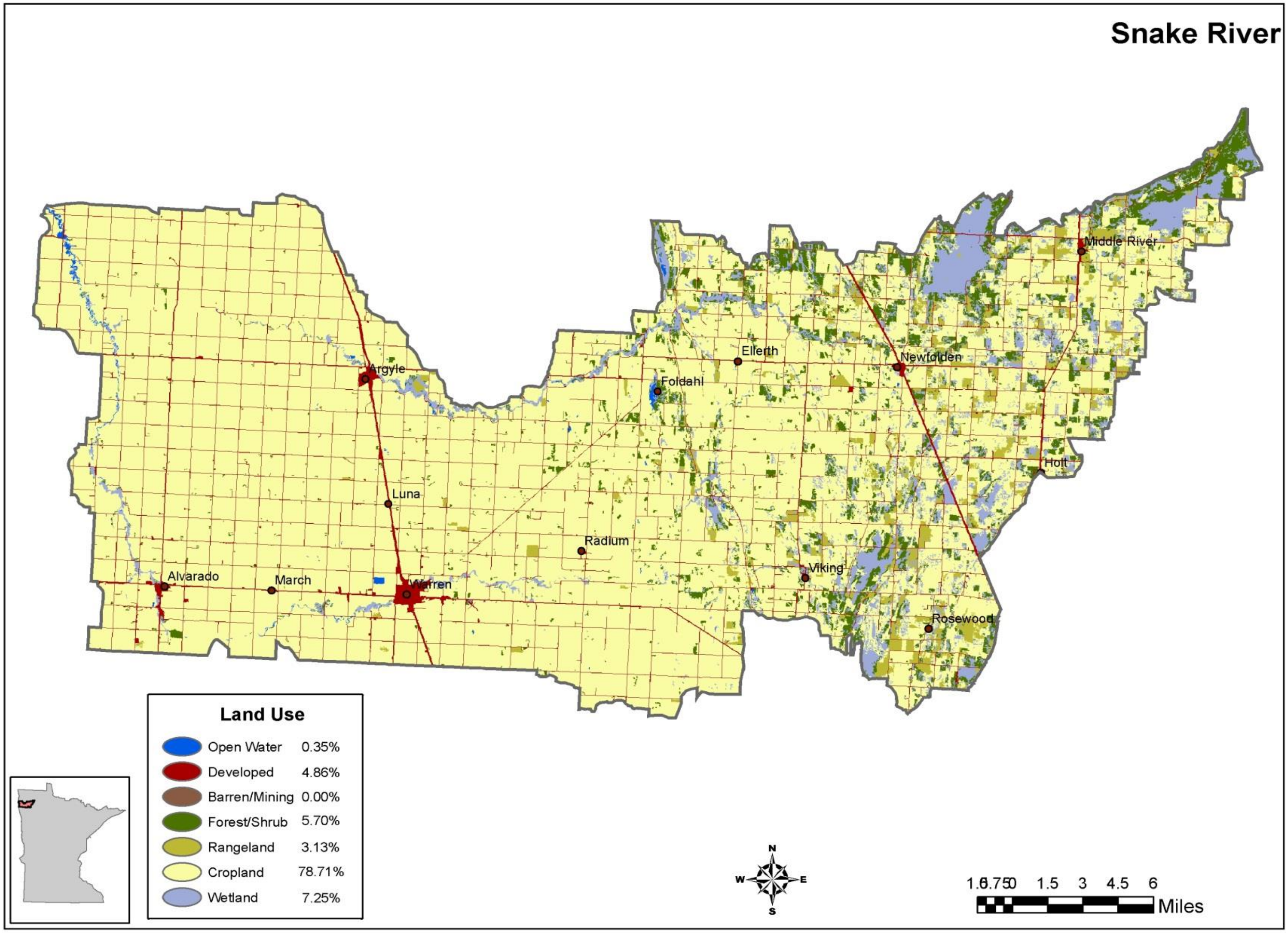


Figure 9. Land use in the Snake River Watershed.

Surface water hydrology

The Snake River originates approximately six miles west of the town of Newfolden where it flows southwest collecting the South Fork Snake River and passes through the towns of Warren and Alvarado. Downstream of Alvarado, the river turns northwest and collects the Middle River approximately five miles upstream of its confluence with the Red River of the North.

The highest elevation of the Snake River Watershed is approximately 1,211 feet above sea level found in the northeast portion of the watershed, with decreasing elevations as the watershed progresses westerly. Throughout its course, the river drops approximately 421 feet to an elevation of 790 feet above sea level with an overall mean gradient decrease of 4.5 feet per river mile. Several tributaries feed into the Snake River mainstem including the Snake River, South Branch; Middle River; and numerous smaller ditches and streams.

The streams within the Snake River Watershed are highly human impacted similar to other watersheds in surrounding areas (Figure 10). Overall, over 67% of the streams within the watershed have been altered through channelization and ditching (Figure 11). Those waterways with non-definable channels (i.e., wetlands without a visible channel, channels through fields that are planted over, and/or channels that are dry most years) were not included in these calculated percentages which totaled 234 miles. In addition to stream channel alteration, the creation of dams within the watershed also affects the hydrology and biological communities within the watershed. There are three MNDNR dams within the Snake River Watershed, two other dams have been removed. The dams that were removed were considered historical and were both located on the Middle River. One was located within Old Mill State Park and the other on the east edge of Argyle. They consisted mostly of boulders across the river, and were utilized for recreation purposes such as fishing and swimming and for aquatic species habitat. The remaining three dams are located on impoundments and/or diversion channels and are utilized for flood mitigation as well as waterfowl habitat.

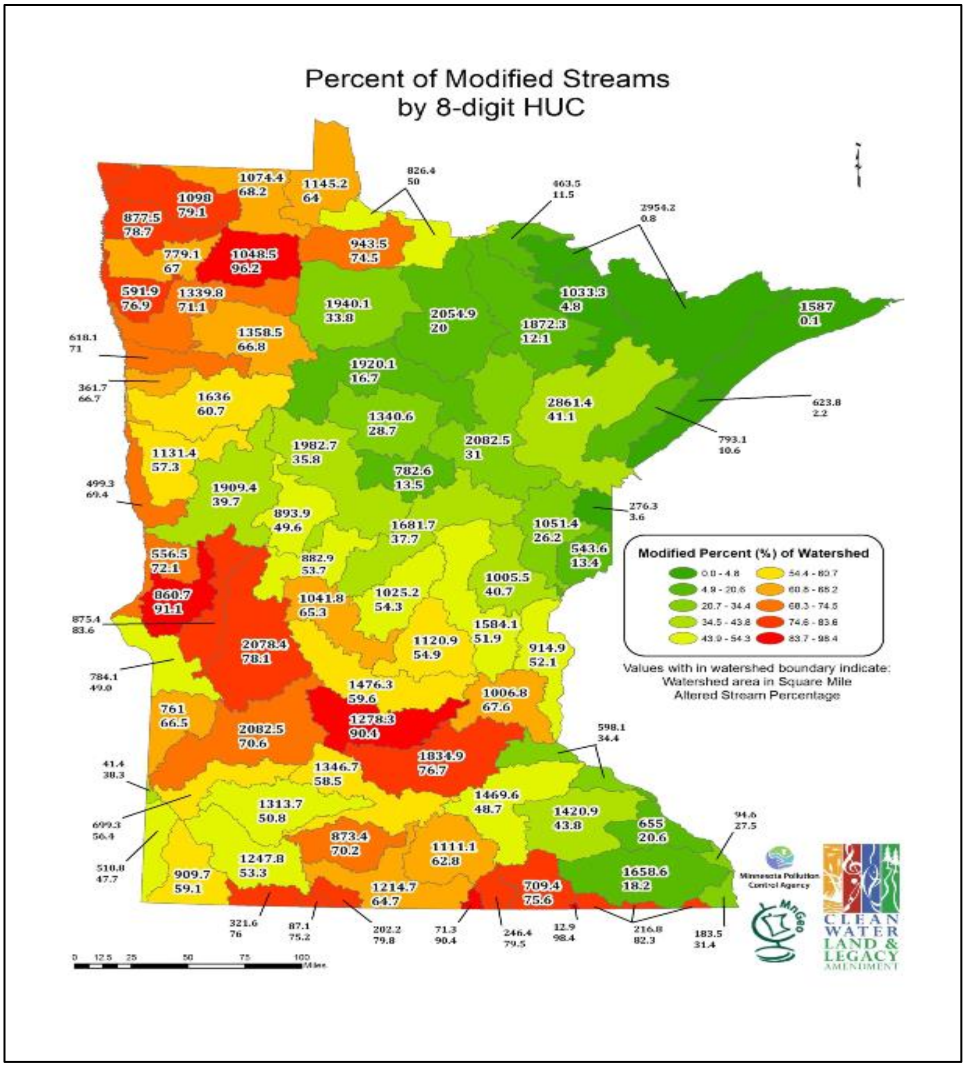


Figure 10. Map of percent modified streams by major watershed (HUC-8).

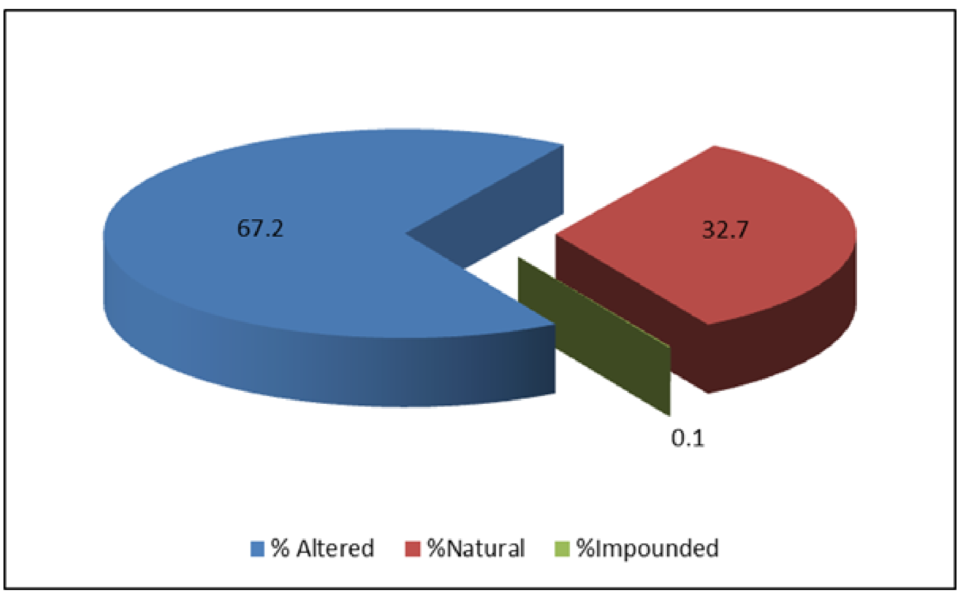


Figure 11. Comparison of natural to altered streams in the Snake River Watershed (percentages derived from the State-wide Altered Water Course project).

Climate and precipitation

The ecoregion has a continental climate, marked by warm summers and cold winters. The mean annual temperature for Minnesota is 5.1˚C. The mean summer temperature for the Snake River Watershed is 18.9˚C and the mean winter temperature is -13.8˚C (High Plains Regional Climate Center Webpage, 2013), with a mean annual temperature of 2.6°C.

Precipitation is the source of almost all water inputs to a watershed. The Snake River Watershed area received 20-24 inches of precipitation in water year 2013 resulting in annual runoff that ranged from normal to two inches above normal (Figure 12).

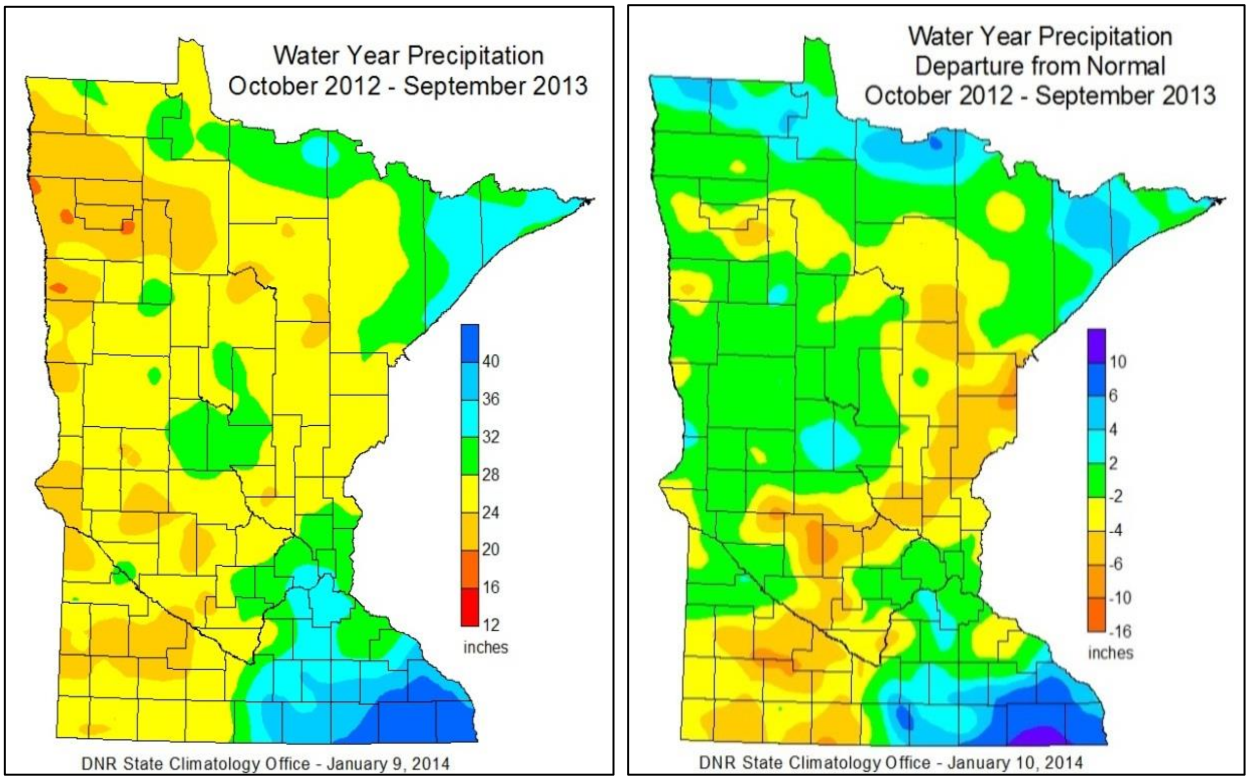


Figure 12. State-wide precipitation levels during the 2013 water year.

Figure 13 displays the areal average representation of precipitation in west-central Minnesota. An aerial 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 on the University of Minnesota Climate website: http://www.wrcc.dri.edu/spi/divplot1map.html. Though rainfall can vary in intensity and time of year, rainfall totals in the west-central region display no significant trend over the last 20 years. However, precipitation in west central Minnesota exhibits a statistically significant rising trend over the past 100 years, p=0.001 (Figure 14). This is a strong trend and matches similar trends throughout Minnesota.

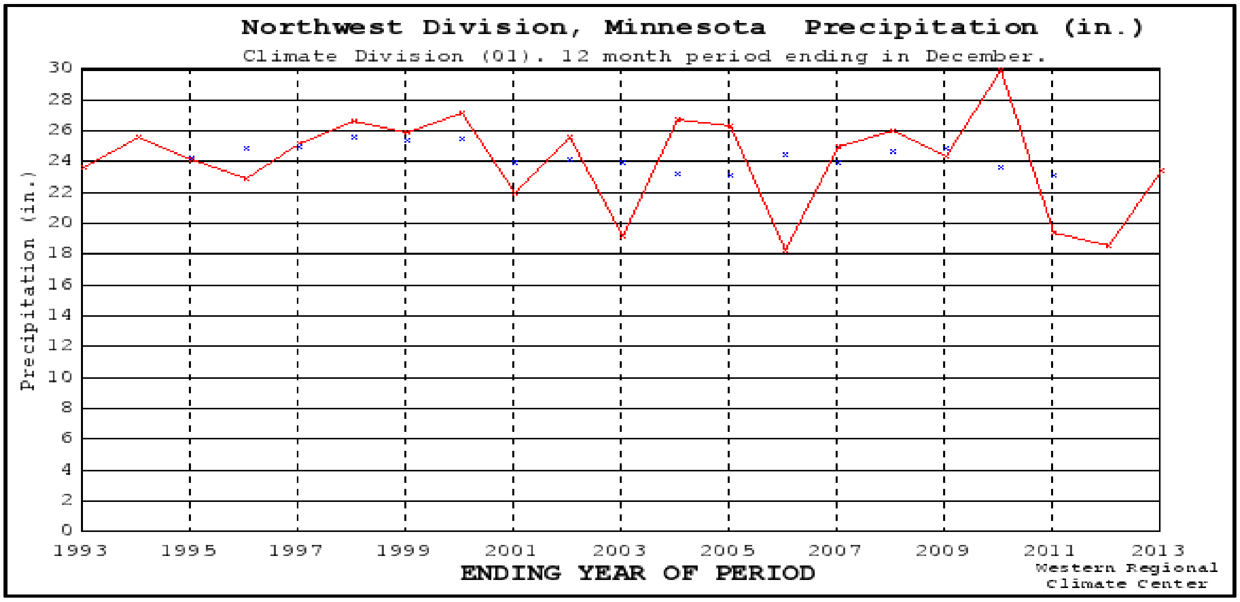


Figure 13. Precipitation trends in west central Minnesota (1993-2013) with five year running average.

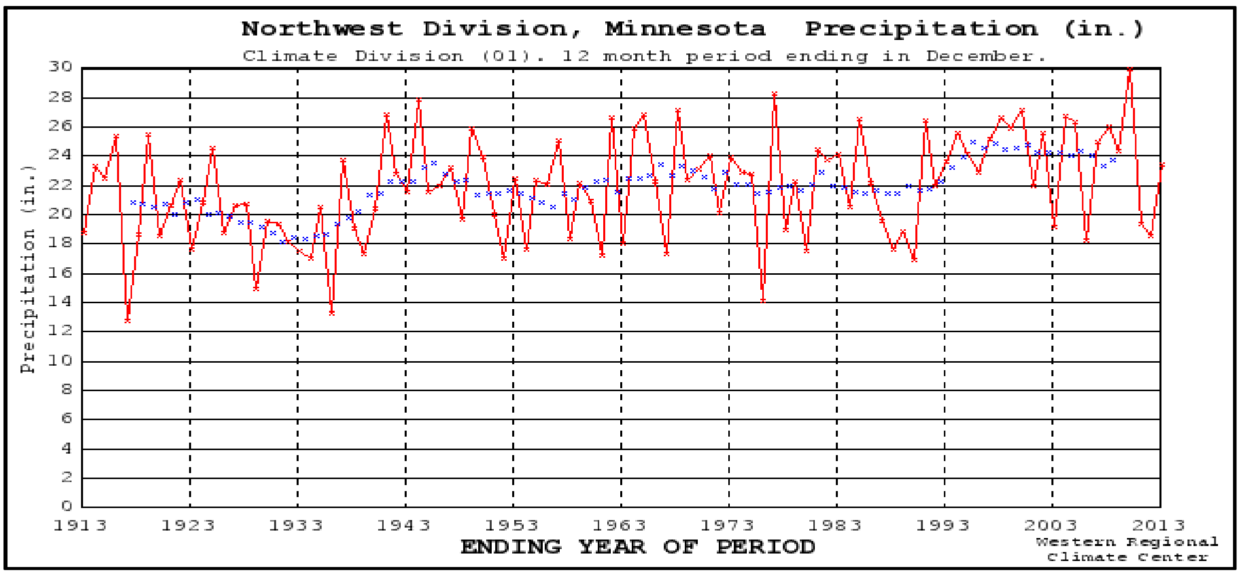


Figure 14. Precipitation trends in west central Minnesota (1913-2013) with 10- year running average.

Hydrogeology and groundwater quality

The Snake River 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 deglaciation, 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 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 Snake River Watershed is also located within one of Minnesota's six Ground Water Provinces: the Western Province (Figure 15). This province is defined by the MNDNR and described geologically as "clayey glacial drift overlying Cretaceous and Precambrian bedrock" (MNDNR, 2001). The western portion of the watershed also contains cretaceous bedrock, which is characterized by sandstone layers interbedded with thick layers of shale, often used locally as water sources (MNDNR, 2001).

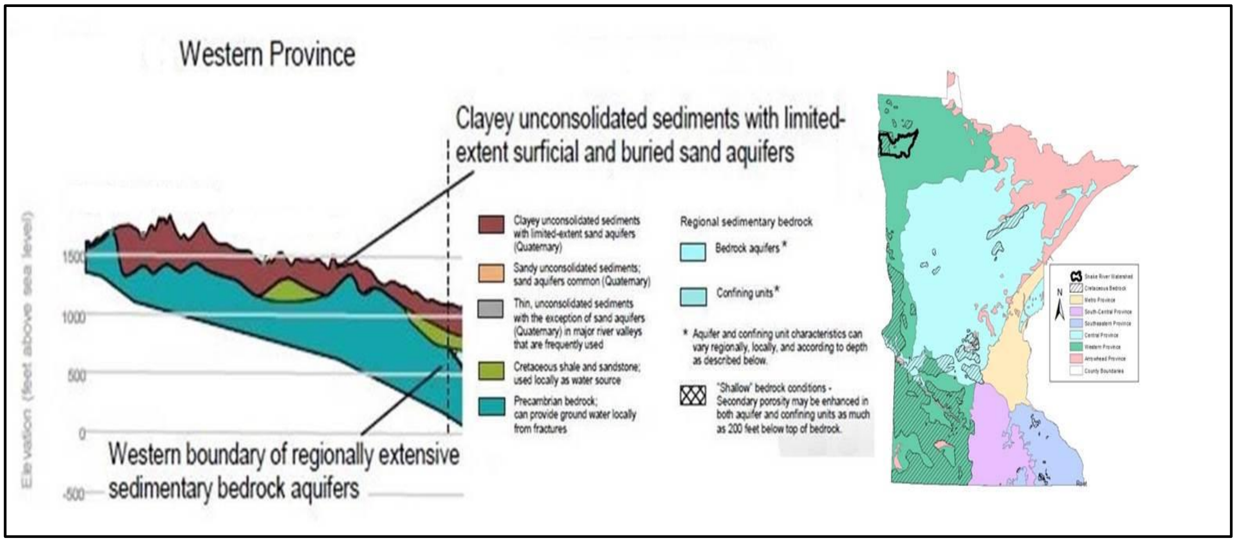


Figure 15. Western Province Generalized cross section (Source: MNDNR, 2001).

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 10 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 Snake River Watershed, the average annual recharge rate to surficial materials is zero to four inches per year for the majority of the watershed (Figure 16).

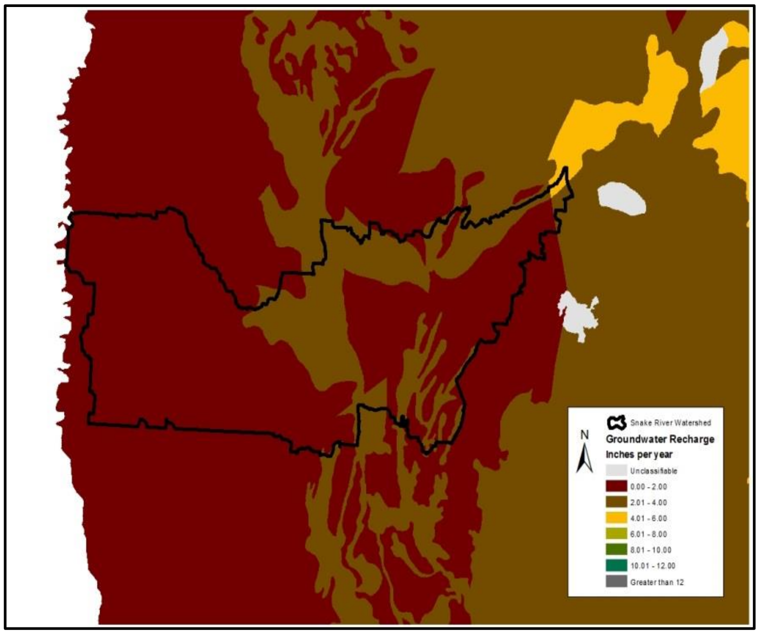


Figure 16. Average annual recharge rate to surficial materials in Snake River Watershed (1971-2000).

IV. Watershed-wide data collection methodology

Watershed Pollutant Load Monitoring Network

Intensive water quality sampling occurs at all WPLMN sites. Thirty-five samples per year are allocated for basin and major watershed sites and 25 samples per season (ice out through Oct. 31) for subwatershed sites. 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 (FWMCs) (pollutant load/total flow volume). Loads and FWMCs are calculated for total suspended solids (TSS), TP, dissolved orthophosphate (DOP), nitrate plus nitrite nitrogen (NO_2+NO_3-N), and total Kjeldahl nitrogen (TKN).

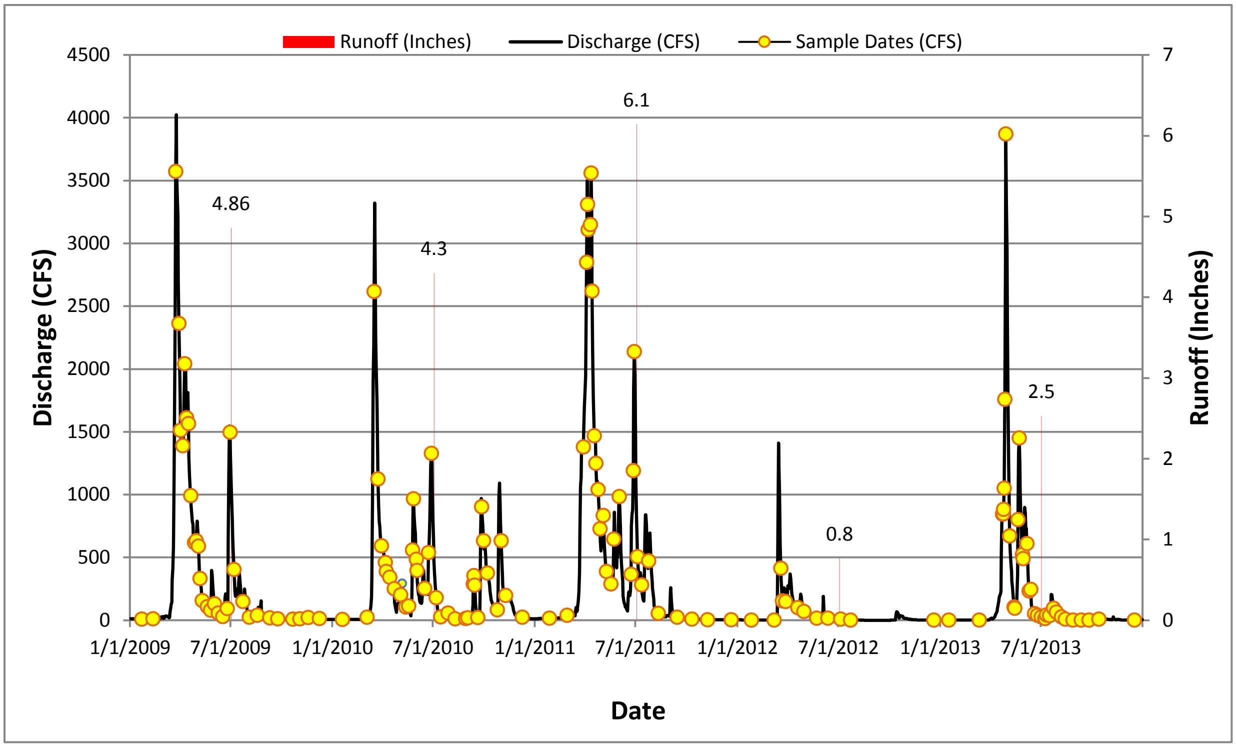


Figure 17. 2009-2013 Hydrograph, sampling regime and annual runoff for the Snake River near Bigwoods, Minnesota.

Stream water sampling

Seven water chemistry stations were sampled from May thru September in 2013, and again June thru August of 2014, to provide sufficient water chemistry data to assess many components of the aquatic life and recreation use standards. Following the IWM design, water chemistry stations were placed at the outlet of each HUC-11 subwatershed that was 75-150 mi^2 in area. A SWAG was awarded to the International Water Institute (IWI) in partnership with the Middle-Snake-Tamarac Rivers Watershed District to conduct the sampling.

Stream flow methodology

MPCA and the MNDNR joint stream water quantity and quality monitoring data for dozens of sites across the state on major rivers, at the mouths of most of the state's major watersheds, and at the mouths of some aggregated HUC-11 subwatersheds are available at the MNDNR/MPCA Cooperative Stream Gaging webpage at: http://www.dnr.state.mn.us/waters/csg/index.html.

Stream biological sampling

The biological monitoring component of the IWM in the Snake River Watershed was completed during the summer of 2013. A total of 34 sites (6 existing and 28 new) were established across the watershed and sampled for fish and macroinvertebrates. These sites were located near the outlets of most minor HUC-14 watersheds. In addition, seven of the biological monitoring stations within the watershed were revisited in 2014. While data from the last 10 years contributed to the watershed assessments, the majority of data utilized for the 2015 assessment was collected in 2013. A total of 20 AUIDs were sampled and assessed for aquatic life.

To measure the health of aquatic life at each biological monitoring station, IBIs, specifically Fish-index of biotic integrity (F-IBI) and Macroinvertebrate-index of biotic integrity (M-IBI), were calculated based on monitoring data collected for each of these communities. A fish and macroinvertebrate classification framework was developed to account for natural variation in community structure which is attributed to geographic region, watershed drainage area, water temperature and stream gradient. As a result, Minnesota's streams and rivers were divided into seven distinct warmwater classes and two coldwater classes, with each class having its own unique F-IBI and M-IBI. Each IBI class uses a unique suite of metrics, scoring functions, impairment thresholds, and confidence intervals (CIs) (for IBI classes, thresholds and CIs, see Appendix 4.1. IBI scores higher than the impairment threshold and upper CI indicate that the stream reach supports aquatic life. Contrarily, scores below the impairment threshold and lower CI indicate that the stream reach does not support aquatic life. When an IBI score falls within the upper and lower confidence limits additional information may be considered when making the impairment decision such as the consideration of potential local and watershed stressors and additional monitoring information (e.g., water chemistry, physical habitat, observations of local land use activities). For IBI results for each individual biological monitoring station, see Appendix 4.2 and Appendix 4.3.

Fish contaminants

When fish are collected as part of the MPCA's IWM, the MPCA biological monitoring staff attempt to collect up to five piscivorous (top predator) fish and five forage fish for contaminant analysis. All fish collected by the MPCA are analyzed for mercury, some for perfluorochemicals (PFCs), and the two largest individual fish are analyzed for PCBs. Monitoring of fish contaminants in the 1970s and 1980s showed high concentrations of PCBs were primarily a concern downstream of large urban areas in large rivers, such as the Mississippi River, and in Lake Superior. Therefore, PCBs are currently tested where high concentrations were found in the past. In addition, major watersheds are screened for PCBs during the watershed monitoring collections.

Captured fish are wrapped in aluminum foil and frozen until they were thawed, scaled (or skinned), filleted, and ground to a homogenized tissue sample. Homogenized fillets were placed in 125 mL glass jars with Teflon™ lids and frozen until thawed for lab analysis. The Minnesota Department of Agriculture (MDA) Laboratory analyzed the samples for mercury and PCBs. If fish were tested for PFCs, whole fish were shipped to AXYS Analytical Laboratory, which analyzed the homogenized fish fillets for 13 PFCs. Of the measured PFCs, only perfluorooctane sulfonate (PFOS) is reported because it bioaccumulates in fish to levels that are potentially toxic and a reference dose has been developed.

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

Before 2006, mercury in fish tissue was assessed for water quality impairment based on MDH's fish consumption advisory. An advisory more restrictive than a meal per week was classified as impaired for mercury in fish tissue. Since 2006, a waterbody has been classified as impaired for mercury in fish tissue if 10% of the fish samples (measured as the 90th percentile) exceed 0.2 mg/kg of mercury, which is one of Minnesota's water quality standards for mercury. At least five fish samples per species are required to make this assessment and only the last 10-years of data are used for statistical analysis. MPCA's Impaired Waters List includes waterways that were assessed as impaired prior to 2006 as well as more recent impairments.

Lake water sampling

No lakes were sampled in the Snake River Watershed. The open water basins in the watershed are wetlands, intermittent lakes, or short-term water storage impoundments (flood damage reduction projects). These bodies of water would not meet the criteria to be assessed as lakes. Consequently, there are currently no volunteers enrolled in the MPCA CLMP that are conducting lake monitoring within the watershed. Lake sampling methods commonly used among monitoring groups are described in the document entitled "*MPCA Standard Operating Procedure for Lake Water Quality*" found at http://www.pca.state.mn.us/publications/wq-s1-16.pdf. The lake water quality assessment standard requires eight observations/samples within a 10-year period for phosphorus, chl-*a*, and Secchi depth. No further discussion of lakes will be included in the report.

Groundwater monitoring

Groundwater quality

The MPCA's Ambient Groundwater Monitoring Program monitors trends in statewide groundwater quality by sampling for a comprehensive suite of chemicals including nutrients, metals, and volatile organic compounds. These ambient wells represent a mix of deeper domestic wells and shallow monitoring wells. The shallow wells interact with surface waters and exhibit impacts from human activities more rapidly. Available data from federal, state, and local partners are used to supplement reviews of groundwater quality in the region.

Groundwater quantity

Monitoring wells from the MNDNR 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.

Groundwater/surface water withdrawals

The MNDNR permits all high capacity water withdrawals where the pumped volume exceeds 10,000 gallons/day or 1 million gallons/year. Permit holders are required to track water use and report back to the MNDNR 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 MNDNR 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.

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).

V. Individual HUC-11 subwatershed results

Assessment results for aquatic life and recreation use are presented for each HUC-11 subwatershed within the Snake River Watershed. The primary objective is to portray all the full support and impairment listings within a HUC-11 subwatershed resulting from the complex and multi-step assessment and listing process. (A summary table of assessment results for the entire HUC-8 watershed, including aquatic consumption and drinking water assessments (where applicable), is included in Appendix 3. This scale provides a robust assessment of water quality condition at a practical size for the development, management, and implementation of effective TMDLs and protection strategies. The graphics presented for each of the HUC-11 subwatersheds show the assessment results from the 2015 assessment cycle as well as any impairment listings from previous assessment cycles. Discussion of assessment results focuses primarily on the 2013 IWM effort, but also considers available data from the last 10 years.

The proceeding pages provide an account of each HUC-11 subwatershed. Each account includes a brief description of the HUC-11 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 HUC-11 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 HUC-11 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 HUC-11 subwatershed (i.e., where sufficient information was available to make an assessment). Primarily, these tables reflect the results of the 2015 assessment process as part of the 2016 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 6). Assessment of aquatic life is derived from the analysis of biological (F-IBI and M-IBIs), DO, TSS, chloride, pH and un-ionized ammonia (NH_3) 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: coldwater community (2A); cool or warmwater community (2B); or indigenous aquatic community (2C). Stream reaches that do not have sufficient information for either an aquatic life or aquatic recreation assessment (from current or previous assessment cycles) are not included in these tables, 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 HUC-11 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 HUC-11 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 HUC-11 subwatershed.

Stream stability results

Stream channel stability information evaluated during each invert sampling visit is provided in each HUC-11 subwatershed section. These tables display the results of the Channel Condition and Stability Index (CCSI) which rates the geomorphic stability of the stream reach sampled for biology. The CCSI rates three regions of the stream channel (upper banks, lower banks, and bottom) which may provide an indication of stream channel geomorphic changes and loss of habitat quality which may be related to changes in watershed hydrology, stream gradient, sediment supply, or sediment transport capacity. The CCSI was recently implemented in 2008, and is collected once at each biological station. Consequently, the CCSI ratings are only available for biological visits sampled in 2010 or later. The final row in each table displays the average CCSI scores and a rating for the HUC-11 subwatershed.

HUC-11 subwatershed outlet water chemistry results

These summary tables display the water chemistry results for the monitoring station representing the outlet of the HUC-11 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 Snake River Watershed are compared to expectations developed by McCollor and Heiskary (1993) that were based on the 75th percentile of a long-term dataset of least impacted streams within each ecoregion.

Lake assessments

There were no lake assessments within the Snake River Watershed.

Snake River Subwatershed HUC 09020309010

The Snake River Subwatershed is located in southern Marshall County, with small portions in extreme northwest Pennington and northeast Polk Counties. It is the largest of the subwatersheds, draining an area of 218.5 mi^2. This subwatershed contains the headwaters of the Snake River which originates from a small line of wetlands and flows 52 miles through a mostly natural watercourse. As the river flows southwest, it receives water from many smaller ditch and stream tributaries as well as one major tributary, the Snake River, South Branch (old channel). Unlike the Snake River mainstem, the Snake River, South Branch (old channel) has been greatly modified and straightened. These two rivers converge roughly three miles east of Warren, where the mainstem Snake River then turns and flows west. Land use transitions significantly from a mixture of wetland, forest, and pasture in the eastern Agassiz Beach Ridge region of the subwatershed to primarily cropland in the Agassiz Lake Plain to the west. Overall, cropland dominates this subwatershed by comprising 80% of the total land use, followed by wetland, development, forest, and rangeland each comprising 6%, 5%, 5%, and 4%, respectively (Figure 21). The subwatershed contains water chemistry data available from 7 stream AUIDs and 11 biological monitoring stations. The water chemistry monitoring station is located on the Snake River at County Road 21, five miles west of Warren.

Table 2. Aquatic life and recreation assessments on stream reaches: Snake River Subwatershed. Reaches are organized upstream to downstream in the table.

					Aquatic life indicators:								Aquatic recreation indicators:			
AUID ***reach name,*** *reach description*	**Reach length (miles)**	**Use class**	**Biological station ID**	**Location of biological station**	**F-IBI**	**I-IBI**	**DO**	**TSS**	**Chloride**	**pH**	**NH_3**	**Pesticides**	**Bacteria**	**Nutrients**	**Aquatic life**	**Aquatic recreation**
09020309-543 ***Snake River*** *Unnamed creek to S Br Snake River*	29.09	WWg	13RD104 13RD036	4 mi NW of Viking, US of County Hwy 14 Upstream of 285th Ave NW, 3 mi. SW of Radium	EXS	EXS	IF	IF	MTS	MTS	MTS	-	EXS	-	IMP	IMP
09020309-504 ***Snake River*** *S Br Snake River (old channel) to Cty Ditch 7*	22.88	WWg	13RD108 93RD416 05RD175 13RD004	Upstream of Cty Hwy 34, 2 mi ENE of Warren 5th Street bridge, 0.125 mi NW Warren Downstream of CR 15, just W of Warren Upstream of CR 21, 5 mi. W of Warren	EXS	EXS	IF	EXS	MTS	MTS	MTS	-	EXS	-	IMP	IMP
09020309-546 ***Snake River, South Branch (new channel)*** *Headwaters to Snake River*	14.60	WWg	13RD034 13RD106 13RD105 13RD099	Upstream of Lilac Ridge Rd., 3 mi. SE of Viking 2.4 mi W of Viking, US of County Hwy 38 1.5 mi S of Viking, US of 165th Ave NW Downstream of 230th, 7.7 mi W of Viking on 230th St. NW, 0.25 mi W of 240th Ave.	EXS	MTS	IF	IF	-	IF	IF	-	-	-	IMP	NA
09020309-518 ***Unnamed ditch*** *Unnamed ditch to S Br Snake River*	2.01	WWm	05RD011	Downstream of County Road 36, 6.5 miles SE of Warren	-	MTS	IF	IF	IF	IF	IF	-	-	-	SUP	NA
09020309-514 ***Unnamed ditch*** *Unnamed ditch to S Br Snake River*	2.01	WWg			-	-	MTS	MTS	-	MTS		-	-	-	NA	NA
09020309-544 ***Snake River, South Branch (old channel)*** *Unnamed ditch to Snake River*	2.63	WWg	13RD035	Upstream of Hwy 1, 4.5 mi. E of Warren	EXS	EXS	IF	IF	-	IF	IF	-	-	-	IMP	NA

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

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

Key for Cell Shading: ☐ = existing impairment, listed prior to 2015 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐ = insufficient information.

Abbreviations for Use Class: **WWg** = Warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = Limited Resource Value Water

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

Table 3. MSHA: Snake River Subwatershed.

# Visits	Biological station ID	Reach name	Land use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish cover (0-17)	Channel morph. (0-36)	MSHA score (0-100)	MSHA rating
2	13RD104	Snake River	1.75	8.75	17.3	11	7.5	46.3	Fair
2	13RD036	Snake River	0	9	16.25	13.5	20.5	59.25	Fair
1	13RD108	Snake River	0	9	20	14	22	65	Fair
1	93RD416	Snake River	2	6	15.25	17	21	61.25	Fair
1	05RD175	Snake River	2.5	8	13	8	8	39.5	Poor
1	13RD004	Snake River	0	7	11	14	16	48	Fair
1	13RD034	Snake River, South Branch (new channel)	5	8	18.6	10	13	54.6	Fair
1	13RD106	Snake River, South Branch (new channel)	3	11	18.4	12	20	64.4	Fair
1	13RD105	Snake River, South Branch (new channel)	0	9	19.1	16	14	58.1	Fair
2	13RD099	Snake River, South Branch (new channel)	0	6	18.5	11	14	49.5	Fair
1	13RD035	Snake River, South Branch (old channel)	2.5	9	8	15	14	48.5	Fair
Average habitat results: *Snake River Subwatershed*			**1.52**	**8.25**	**15.95**	**12.86**	**15.45**	**54.04**	**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 4. CCSI: Snake River Subwatershed.

# Visits	Biological station ID	Stream name	Upper banks (43-4)	Lower banks (46-5)	Substrate (37-3)	Channel evolution (11-1)	CCSI score (137-13)	CCSI Rating
1	13RD104	Snake River	32	27	21	3	83	Severely Unstable
1	13RD108	Snake River	21	19	8	3	51	Moderately Unstable
1	13RD106	Snake River, South Branch	6	16	4	3	29	Fairly Stable
Average stream stability results: *Snake River Subwatershed*			**19.67**	**20.67**	**11**	**3**	**54.33**	**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 5. Outlet water chemistry results: Snake River Subwatershed.

Station location:	Snake River at CSAH21, 5 miles west of Warren						
STORET/EQuIS ID:	S004-214						
Station #:	13RD004						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances**
Ammonia-nitrogen	ug/L	10	<40	131	50	40	2
Chloride	mg/L	10	7.5	21.3	13.1	230	
DO	mg/L	22	3.84	10.99	7.89	5	1
pH		22	7.06	8.30	8.04	6.5 - 9	
Secchi tube	100 cm	22	10.4	47.5	26.5	10	
TSS	mg/L	10	9.0	63.0	26.2	65	
Phosphorus	ug/L	10	69	193	120	150	3
Chl-*a*, corrected	ug/L	-	-	-	-	35	
***E. coli* (geometric mean)**	MPN/ 100ml	3	49	85	-	126	
E. coli	MPN/ 100ml	15	19	228	-	1260	
Inorganic nitrogen (nitrate and nitrite)	mg/L	10	<0.03	1.01	0.24		
Kjeldahl nitrogen	mg/L	10	1.07	1.98	1.38		
Orthophosphate	ug/L	-	-	-	-		
Pheophytin-a	ug/L	-	-	-	-		
Specific conductance	uS/cm	22	457	884	638		
Temperature, water	deg °C	22	13.92	24.44	19.25		
Sulfate	mg/L	10	83.7	200.0	132.6		
Hardness	mg/L	10	222	362	282		

[1]Secchi Tube standards are surrogate standards derived from the TSS standard of 65 mg/L.

**Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Snake River Subwatershed, conducted from 2013 to 2014 (IWM work was conducted between May and September from 2013 to 2014). This specific data does not necessarily reflect all data that was used to assess the AUID.

Summary

The Snake River (AUID 09020309-542) originates about 7.5 miles west of Newfolden on the Agassiz Beach Ridge where the landscape is a mixture of wetlands and cropland. The river flows southwest where after 2.14 miles the reach splits into AUID 09020309-543. The AUID was split from the now-retired parent AUID 09020309-506, with the DO impairment (2008) being carried-forward to both AUIDs. No biological monitoring stations or water chemistry data existed on this reach in 2013.

Snake River (AUID 09020309-543) flows 27 miles to its confluence with the Snake River, South Branch (old channel) (AUID 09020309-544). The upstream portion of this reach begins in a landscape similar to its headwaters; however, the lower half of the reach flows through the flat, rich soils of the Agassiz Lake Plain and land use is dominated by crops. This reach contains two biological monitoring stations, 13RD104 was upstream of the confluence with the Snake River, South Branch (new channel) and 13RD036 was downstream of the confluence.

This reach is characterized by poor biological communities which likely stem from the poor water quality, specifically DO. Both biological stations were sampled for fish in 2013 and 2014, resulting in poor F-IBI scores which were dominated by tolerant species such as fathead minnow, white sucker, and central mudminnow. Both stations were sampled for macroinvertebrates in 2013 with 13RD104 scoring well below the impairment threshold and 13RD036 scoring slightly above the threshold. Though MSHA scores at both sites were fair, both fish and macroinvertebrate community composition was stronger at 13RD036 than 13RD104. Hydrological issues (extremely variable water levels) exist at both sites; however, it is likely that input from the Snake River, South Branch (new channel) is contributing to more consistent flows at 13RD036, thus improving abiotic conditions.

Un-ionized ammonia, chloride, and pH were all meeting aquatic life standards within this AUID. Out of those three parameters, only one pH exceedance (5.60) was observed. DO values exceeded the standard in 10.5% of measurements over 7 years, so the existing DO impairment will remain. The range of DO concentrations over the assessment period was large, from 2.80 mg/L to 15.20 mg/L, suggesting that DO flux may be an issue on this reach. The low DO concentrations likely are a contributing factor to the poor biological communities and high numbers of low DO tolerant species. There was limited TSS data, though no values exceeded the 65 mg/L standard. Secchi tube can serve as a surrogate for TSS – no exceedances were found out of 34 samples during the assessment period, thus, TSS is meeting aquatic life standards. TP and one response variable (chl-*a*) had data available for river eutrophication assessment on this AUID. TP had an average concentration of 109.2 ug/L, which meets the South Nutrient Region standard. Limited chl-a data was available, but with a mean concentration of 4.4 ug/L it is meeting the standard (35 ug/L). The river eutrophication standard is met on this reach. *E. coli* samples yielded one individual and two geometric monthly mean exceedances (standards of 1260 MPN/100mL and 126 MPN/100mL, respectively) during the assessment period. Since there is at least one month exceeding the geometric monthly mean (in this instance 276/100mL for July and 173/100mL for August), the reach does not support for aquatic recreation.

Snake River (AUID 09020309-504) is a 22.88-mile reach which begins at the confluence with the Snake River, South Branch (old channel) and flows west through the city of Warren, to the confluence of Polk County Ditch #7 about 4.5 miles southeast of Alvarado. Land use along this reach of the Snake River is primarily cropland. This AUID has existing impairments for turbidity (2008) and F-IBI (2002). The reach contains biological monitoring stations 13RD108, 93RD416, 05RD175, 04RD002 and 13RD004 from upstream to downstream.

The biological communities within this reach were poor, confirming the existing F-IBI impairment and creating a new M-IBI impairment. These impairments may be linked to high suspended sediment concentrations as indicated by the existing turbidity impairment. F-IBI scores were all below the impairment threshold and showed a negative relationship with habitat at all sites within this reach. 13RD108 and 93RD416 had good habitat scores but had very poor F-IBI scores, whereas 05RD175 had the highest F-IBI score (still poor) but the lowest habitat score. 13RD004 scored fair for habitat, particularly for fish cover, but yet had the lowest F-IBI score. The fish communities may be influenced by a dam located between 93RD416 and 13RD108, roughly one mile east of Warren. During high flows, this dam holds back water and diverts the flow into a man-made channel which is 16 feet deep and 160 feet wide (MSTRWD, 2009). The dam does have a fish ladder which allows for fish passage during high flows; however, during lower flows, this passage is completely out of the water, prohibiting fish passage (Figure 18). In addition to the dam, an off channel flood control impoundment exists between stations 13RD036 and 13RD104, roughly 10 miles northeast of Warren (Figure 19). Although this does not directly block fish passage, it may effect stream flow as well as stream water quality such as DO. The impoundment can store roughly 6,700 acre-feet of water which reduces flow by approximately 1,400 cubic feet per second (MSTRWD, 2009). M-IBI scores on this reach were also poor, with only 13RD004 scoring above the impairment threshold. Bank erosion and sedimentation are likely drivers of the low F-IBI and M-IBI scores. Sample pictures and habitat scores indicate that the stream riparian, substrate, and habitat begins to transition within this reach. At 13RD108, the substrates consist of gravel and cobble with riffles present while 93RD416 had only small areas of gravel with increased sand and silt. The amount of coarse substrate continues to decline to nearly complete sand and silt with the only coarse substrate being scattered boulders at the downstream stations. In addition, bank erosion and woody debris increase while water clarity decreases from upstream to downstream.

Un-ionized ammonia and chloride are meeting the standard on this AUID, neither parameter yielded an exceedance. There was a large pH data set, 150 samples over the assessment window, with only one sample slightly exceeding the standard (6.30) – pH is meeting aquatic life standards. DO measurements yield only two exceedances in 95 samples. With the low exceedance frequency, DO does not appear to be stressing aquatic life. Secchi tube exceeded the surrogate standard only 4 times in 110 measurements, but TSS had a 12.5% exceedance rate – this confirms the existing turbidity impairment. TP had an average concentration of 141.7 ug/L, which meets the South Nutrient Region standard while one response variable (chl-*a*) had limited data available, but with a mean concentration of 15.3 ug/L it is meeting the standard meaning the river eutrophication standard is met on this reach. *E. coli* samples resulted in one individual exceedance of 2419/100mL and one geometric monthly mean exceedance 134/100mL for July. August geometric mean is also close to the standard, being 92/100mL. This reach is therefore not supporting for aquatic recreation.

Snake River, South Branch (new channel) (AUID 09020309-546), is a 14.60 mile reach that flows from east to west beginning at its headwaters about 3.5 miles southeast of Viking to its confluence with the Snake River about 7.5 miles east of Warren. The surrounding landscape is a mixture of wetlands, forest, and pasture which transitions going westward to mostly cropland. The AUID was split from the now-retired parent AUID 09020309-510 and is the new watercourse for the Snake River, South Branch. No impairments were carried forward. The new channel is primarily ditched, and diverts flow from the original, natural channel. Water chemistry data was limited and was not used in the assessment of aquatic life or recreation. This reach contains biological monitoring stations 13RD034, 13RD106, 13RD105, and 13RD099 from upstream to downstream. All stations were sampled once for fish in 2013 with 13RD099 having an additional fish sample in 2014. Each station was sampled for macroinvertebrates in 2013 except 13RD105 which was too deep to wade.

Aquatic life is impaired on this reach based on F-IBI scores which were all below the impairment threshold except 13RD106 which scored slightly above the threshold. Although habitat scores were fair, the communities are likely being affected by stream alteration. Sample pictures and sinuosity scores show nearly straight channels with only slight bends at all stations. The lack of sinuosity is limiting the streams ability to provide various flows types, transport sediment, and provide diverse cover types which are crucial for healthy fish communities. Contrary to the poor fish communities, the reach did support a good macroinvertebrate community at nearly all locations. The two upstream stations 13RD034 and 13RD106 had strong M-IBI scores which corresponded with a relatively intact riparian buffer and an immediate watershed dominated by prairie grasses. Downstream at 13RD009, the M-IBI was fair. At 13RD009, surrounding land use shifts to row crops and riparian zones shrink, and many of the sensitive macroinvertebrate taxa that were observed upstream disappear as well. 13RD009 is at a vulnerable state and should be protected to maintain existing taxa and allow for recolonization of more sensitive taxa. Water chemistry data was limited on this reach, so there was insufficient data to assess for aquatic life. However, no water chemistry values exceeded their respective standards (un-ionized ammonia, chloride, pH, TSS, and S-tube).

Unnamed Ditch (AUID 09020309-518), is a two mile modified use reach that flows from east to west and ends at AUID 09020309-514 about six miles east-southeast of Warren. Land use near this AUID is primarily cropland except for the open water Agassiz Valley Impoundment to the south. One biological monitoring station, 05RD011, was sampled in 2005 for macroinvertebrates; however, neither fish nor macroinvertebrates were sampled in 2013 as the reach was dry. The M-IBI sample taken in 2005 did score above the impairment threshold. No water chemistry data was collected on this reach.

Unnamed Ditch (AUID 09020309-514), is a two-mile reach which collects water from AUID -518 mentioned above. The stream flows from east to west about a mile, then south to north one mile, ending at AUID 09020309-544 (Snake River, South Branch (old channel)). No biological monitoring stations existed on this reach. DO, TSS, and pH were all meeting aquatic life standards. The mean TP (152.6 ug/L) exceeds the South Nutrient Region standard of 150 ug/L. After further investigation; however, the only chemistry monitoring site on this reach (S002-108) was found to be on the outlet of the Agassiz Valley Impoundment. Therefore, the chemistry observed here would not be characteristic of stream conditions, but instead operations of the impoundment, so the reach was deemed non-assessable for aquatic life.

Snake River, South Branch (old channel) (AUID 09020309-544), flows 2.63 miles northwesterly to its confluence with the Snake River about four miles east of Warren. The AUID was split from the now-retired parent AUID 09020309-510. No impairments were carried-forward. This reach is the end of the old channel of the Snake River, South Branch and collects water from both AUIDs -518 and -514 mentioned above. The surrounding land use is cropland with some small pockets of forest along the river. Biological communities within this reach are poor and appear to be effected by excessive sediment in the channel. Biological monitoring station 13RD035 is located two stream miles prior to its confluence with the Snake River mainstem. Although the F-IBI and M-IBI scores were poor, cover does not appear to be the limiting factor as emergent and submergent vegetation, deep pools, and woody debris were all present. However, sample notes and substrate scores indicate that this stream consists of nearly all fine sediments and severe embeddedness of coarse substrates. These factors may be why mostly tolerant species and few lithophilic spawners were sampled. Additionally, macroinvertebrate sample notes/pictures show long filamentous algae present and low DO concentrations, suggesting nutrients and DO are likely stressors to aquatic life.

Data from the Middle-Snake-Tamarack Rivers Watershed District show that excess sediment has been an issue in this stream for many years, specifically since severe flooding in 1996 and 1997 when the reach was found to have an average of two feet of excess sediment throughout. Since that time, sediment removal projects have occurred in fall 2009, fall 2010, and spring 2014. In 2014, riprap and an additional 18” culvert was installed to inhibit sediment transport and all post-project exposed dirt was seeded in addition to erosion control blankets set to reduce erosion (Danny Omdahl, Personnel Communication). If these changes allow for sediment to travel through the system and not build up, it is possible that fish communities could benefit from available course substrate and increased beneficial habitat. That being said, a large proportion of the flow in this reach is from the Agassiz Valley Impoundment located roughly five miles southeast of Warren (Figure 20). This impoundment captures the water from approximately 32 square miles of drainage and can store up to 10,670 acre feet of water and can be released and various times during the year depending on water levels (MSTRWD, 2009). It is possible that if more consistent higher flows existed in this reach, fine sediments may not settle out covering course substrates. Chemistry data on this AUID was limited to the biological visits so there is insufficient information to assess for aquatic life and recreation (also addressed in AUID -514 below).

Overall, the fish communities within this subwatershed are very poor and weakly associated habitat quality. Whether sites had good, fair, or poor available habitat, fish communities struggled. Macroinvertebrate communities however were poor on the Snake River mainstem, good on the Snake River, South Branch (new channel), and variable on the smaller tributaries. Poor water quality does generally exist on most systems and appears to be having a negative effect on biological communities. Beginning upstream on the Snake River mainstem in AUIDs -542 and -543, low DO concentrations appears to be the largest factor however low water levels upstream of the confluence with the Snake River, South Branch (new channel) may be contributing to poor biological communities as well. The next downstream AUID (-504) is where turbidity concentrations begin to increase, specifically downstream of 93RD416. Increased flow in this stretch has led to extensive erosion in turn causing bank failures that result in soil and trees falling into the stream. Extremely high amounts of sediment were found in the Snake River, South Branch (old channel) which was covering coarse substrate for fish spawning and macroinvertebrate habitat. If erosion and sediment rates within this subwatershed can be reduced, it is possible that coarse substrates could be more readily available to the biological communities. Lastly, the large off channel storage area and the dam near Warren may also be having negative effects on the biological communities both on the Snake River mainstem and its tributaries. Both structures are likely altering flow during certain times of the year and the dam may be prohibiting fish passage.

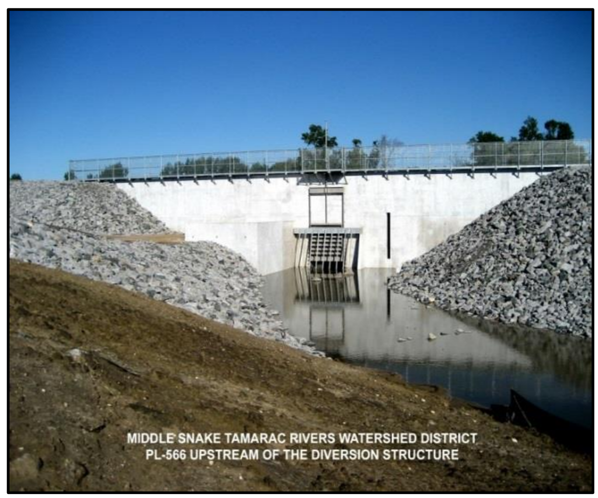


Figure 18. Dam on the Snake River upstream of Warren during high (left) and low flows (right) and the location of the fish ladder (photos courtesy of MSTWD 2009).

Figure 19. Snake River PL-566 Flood Control impoundment located roughly 10 miles northeast of Warren (Photos courtesy of MSTWD 2009).

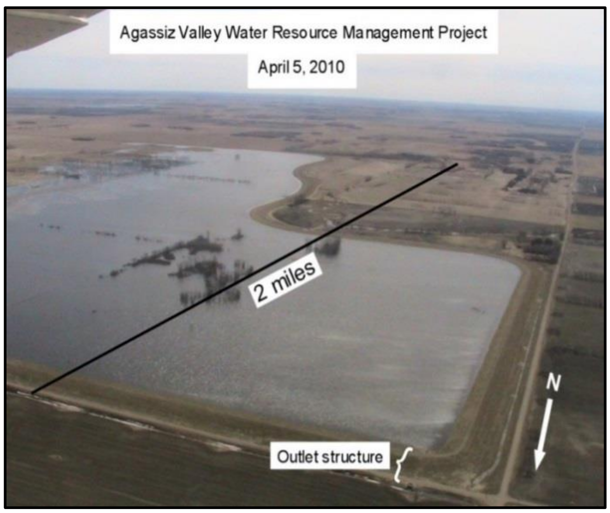


Figure 20. Agassiz Valley Impoundment during high flows (left) and low water levels (right) (Photos courtesy of MSTWD 2009).

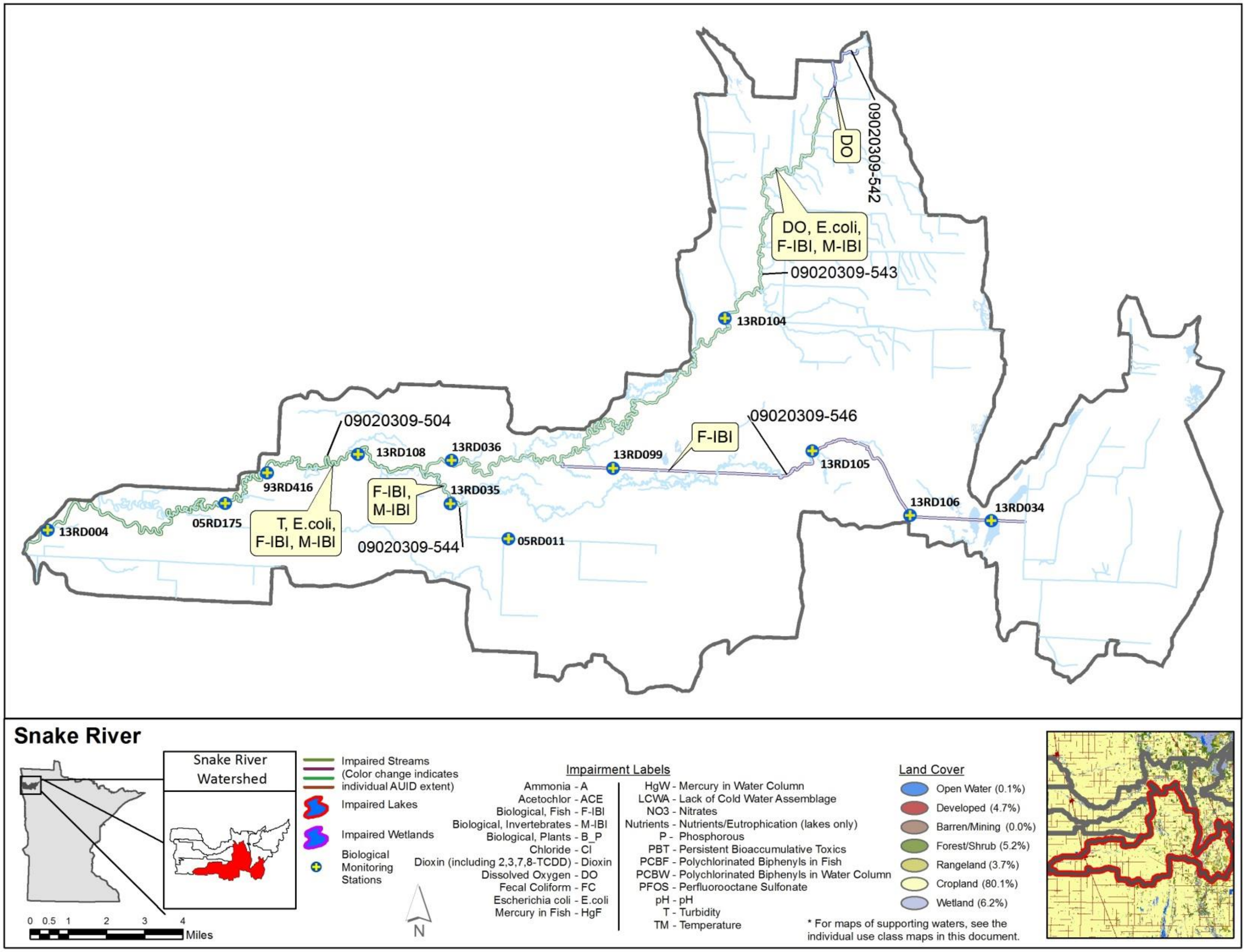


Figure 21. Currently listed impaired waters by parameter and land use characteristics in the Snake River Subwatershed.

Vega Subwatershed HUC 09020309030

The Vega Subwatershed is located in southwest Marshall County with a small portion in extreme northern Polk County. It drains an area of 86.5 mi^2 and is directly downstream of the Snake River Subwatershed. The subwatershed contains the Snake River mainstem which turns and flows north approximately two miles south of Alvarado where it receives water from several County and Judicial Ditches along the way. This subwatershed is nearly all cropland, comprising 93% of the land use, followed by developed lands at 6% while forest and wetlands comprise less than 1% each (Figure 23). The watershed contains one AUID with one biological monitoring station and water chemistry station. The water chemistry monitoring station for this subwatershed is on the Snake River at State Highway 1 on the west edge of Alvarado.

Table 6. Aquatic life and recreation assessments on stream reaches: Vega 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: F-IBI	I-IBI	DO	TSS	Chloride	pH	NH_3	Pesticides	Aquatic recreation indicators: Bacteria	Nutrients	Aquatic life	Aquatic recreation
09020309-537 ***Snake River*** *T154 R49W S17 east line to County Ditch 3*	14.91	WWg	94RD511	USGS site on west edge of Alvarado	EXS	EXS	IF	IF	MTS	MTS	MTS	-	EXS	-	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 2015 reporting cycle; = new impairment; = full support of designated use; = insufficient information.

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

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

Table 7. Minnesota Stream Habitat Assessment (MSHA): Vega 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	94RD511	Snake River	0.5	10	8.5	9.5	6	34.5	Poor
		Average habitat results: *Vega Subwatershed*	**0.5**	**10**	**8.5**	**9.5**	**6**	**34.5**	**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 8. Outlet water chemistry results: Vega Subwatershed.

Station location:	Snake River at MN Hwy 1 in Alvarado						
STORET/EQuIS ID:	S004-142						
Station #:	13RD006						
Parameter	Units	# of Samples	Minimum	Maximum	Mean	WQ Standard[1]	# of WQ Exceedances
Ammonia-nitrogen	ug/L	22	<3	500	74	40	10
Chloride	mg/L	18	8.3	33.0	17.9	230	
DO	mg/L	87	1.24	13.53	8.80	5	2
pH		86	6.23	8.59	8.00	6.5 - 9	1
Secchi tube	100 cm	30	3.5	41.8	19.7	10	7
TSS	mg/L	59	2.0	448.0	94.7	65	29
Phosphorus	ug/L	58	33	503	214	150	35
Chl-a, Corrected	ug/L	8	4.0	57.0	23.4	35	3
E. coli (geometric mean)	MPN/100ml	3	67	215	-	126	1
E. coli	MPN/100ml	33	8	>2419	-	1260	1
Inorganic nitrogen (nitrate and nitrite)	mg/L	58	<0.02	6.60	0.58		
Kjeldahl nitrogen	mg/L	56	0.84	2.26	1.27		
Orthophosphate	ug/L	2	117	211	164		
Pheophytin-a	ug/L	-	-	-	-		
Specific conductance	uS/cm	87	238	1038	592		
Temperature, water	deg °C	87	-0.01	23.88	13.12		
Sulfate	mg/L	11	25.4	143.0	94.9		
Hardness	mg/L	11	161	422	272		
Total volatile solids	mg/L	33	<1.0	44.0	14.6		

[1]Secchi tube standards are surrogate standards derived from the TSS standard of 65mg/L.

**Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Vega Subwatershed, conducted from 2006 to 2014 (IWM work was conducted between May and September from 2013 to 2014). This specific data does not necessarily reflect all data that was used to assess the AUID.

Summary

The Vega subwatershed consists of three AUIDs, all of which are on the Snake River mainstem. Beginning upstream, AUID 09020309-504 is the downstream end of the 22.88-mile reach addressed above in the Snake River Subwatershed; no biological monitoring or water chemistry stations exist on this AUID within this subwatershed; however, all impairments previously addressed still apply. Similarly, AUID 09020309-536 does not have any biological or water chemistry stations in this subwatershed. This AUID is 2.27 miles and was split from the now-retired parent AUID 09020309-503 to form AUID 09020309-537. There were existing DO and F-IBI impairments on this reach which will carry-forward to both AUIDs.

The most downstream AUID (09020309-537) within this subwatershed is a 14.91-mile reach that begins about 2.5 miles southeast of Alvarado and winds northwest to the confluence with Marshall County Ditch #3 about 2.5 miles southeast of Bigwoods. This reach of the Snake River lies completely within the Agassiz Lake Plain with land use here being primarily cropland. The lone biological monitoring station, 94RD511, was located on the west edge of Alvarado roughly 1.5 miles prior to the outlet of this subwatershed.

The biological communities within this reach are struggling and are likely being affected by poor water quality such as low DO, slow flow, and excess sedimentation. The F-IBI score was very poor with a low number of individuals, most of which were tolerant species. The M-IBI score was above the general use threshold but was dominated by species that are considered tolerant of elevated TSS and variable flow. The habitat score at this station was poor with steep banks and bottom substrate consisting of non-cohesive soils (primarily clay and silt) and no course substrate within the reach. Cover was sporadic, consisting of some deep pools, scattered sparse vegetation, and random woody debris. In addition to a lack of habitat, water levels and flow may also be an issue. Although water levels were "normal" at time of sampling, the flow was very slow and the presence of duckweed indicated very little flow had been present prior to sampling. However, based on the amount of erosion, sloughing trees (Figure 22), presence of log jams, and random woody debris, it is clear that at certain times of year the water level and flow increase significantly. The lack of suitable cover, no coarse substrate, and variable flow regime may all be playing a factor in the poor fish community at this site.

The water chemistry station for this subwatershed is located in the next subwatershed however its position is suitable to characterize the water chemistry within this subwatershed (Table 8). Un-ionized ammonia, chloride, and pH were all meeting aquatic life standards. Only two exceedances were found in 66 DO readings over 7 years of sampling. However, there were not enough early morning samples taken on this AUID, so the existing DO impairment will carry forward. TSS and surrogate Secchi tube both exceeded the standard in 48.2% and 25.6% of samples, respectively. These parameters look to be heavily biased towards event-based sampling. If these event-based samples are excluded from consideration, then TSS would have a 9.0% exceedance rate and S-tube would have a 4.0% exceedance rate. Therefore, there is insufficient information for assessing TSS for aquatic life use. TP and one response variable (chl-*a*) were available for river eutrophication assessment. TP has an average concentration of 200.3 ug/L, which exceeds the eutrophication standard (150 ug/L) for the South Nutrient Region. Limited chl-*a* data was available, but with a mean concentration of 23.4 ug/L it is meeting the standard (35 ug/L). Since no response was noted between TP and chl-*a*, there is insufficient information that eutrophication is impacting aquatic life. *E. coli* exceeded the geometric monthly mean for August, being 214/100mL and the July geometric mean was also close to the standard, being 115/100mL. With at least one geometric monthly mean exceeding the standard, this reach does not support aquatic recreation.

The northern half of this subwatershed consists of three county and judicial ditches which all flow into the Snake River downstream of this subwatershed. Biological monitoring could not be conducted in any of them because they were all dry at the time of sampling. These ditches appear to be ephemeral, containing water only sporadically during rain events or spring snow melt. Any water chemistry information coming from these ditches will be captured in the next downstream subwatershed (Bigwood).

Figure 22. Sloughing trees and bank erosion at 94RD511.

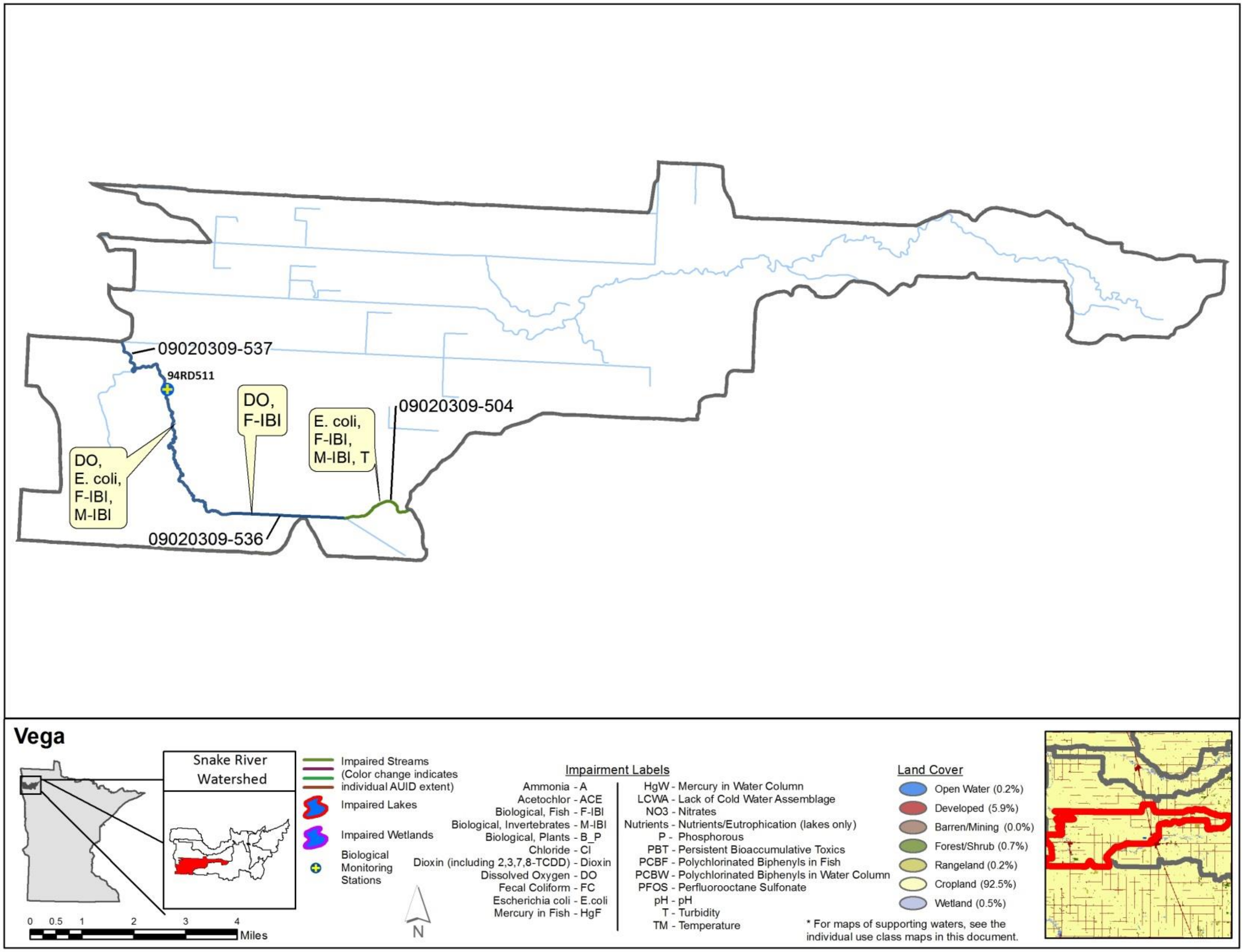


Figure 23. Currently listed impaired waters by parameter and land use characteristics in the Vega Subwatershed.

Bigwood Subwatershed HUC 09020309040

The Bigwood Subwatershed begins in central Marshall County, flowing to the west-central edge of the watershed. It is the second largest of the subwatersheds, draining an area of 121.4 mi^2. This subwatershed contains predominantly altered tributaries which flow east to west, directly into the Snake River mainstem. The Bigwood Subwatershed is nearly all cropland, comprising 92% of the land use, followed by development, forest, and wetlands at 5%, 2%, and 1%, respectively (Figure 25). With the high amount of cropland, most of the watercourses are altered or ditched to promote drainage. There is water chemistry data available from three stream AUIDs and three biological monitoring sites. The water chemistry monitoring station for this subwatershed is on the Snake River at County Road 17, four miles southeast of Fork.

Table 9. Aquatic life and recreation assessments on stream reaches: Bigwood 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 recreation indicators:		Aquatic life	Aquatic recreation
					F-IBI	I-IBI	DO	TSS	Chloride	pH	NH_3	Pesticides	Bacteria	Nutrients		
09020309-537 ***Snake River*** *T154 R49W S17, east line to County Ditch 3*	14.91	WWg	13RD006 13RD080	Downstream of CR 144, 1 mi. NW of Alvarado Upstream of 280th St., 6.6 Miles NNW of Alvarado	EXS	EXS	IF	IF	MTS	MTS	MTS	-	EX	-	IMP	IMP
09020309-502 ***Snake River*** *County Ditch 3 to Middle River*	11.16	WWg	13RD007	Downstream of CR 17, 4 mi. SE of Fork	EXS	EXS	EXS	EXS	MTS	MTS	MTS	-	MTS	-	IMP	SUP
09020309-511 ***Swift Coulee (County Ditch 3)*** *Headwaters to Snake River*	27.31	WWg			-	-	IF	MTS	-	IF	IF	-	-	-	IF	NA

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **-** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: = existing impairment, listed prior to 2015 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 10. MSHA: Bigwood 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	13RD006	Snake River	0	8	10	11	1	30	Poor
1	13RD080	Snake River	0	8	9.7	11	3	31.7	Poor
1	13RD007	Snake River	0	10	7	11	13	41	Poor
Average habitat results: *Bigwood Subwatershed*			**0.0**	**8.67**	**8.9**	**11**	**5.67**	**34.23**	**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 11. CCSI: Vega 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	13RD080	Snake River	13	12	11	2	38	Fairly Stable
Average stream stability results: *Vega Subwatershed*			**13**	**12**	**11**	**2**	**38**	**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 12. Outlet water chemistry results: Bigwood Subwatershed.

Station location:	Snake River at CSAH 17, 12 mi W of Argyle						
STORET/EQuIS ID:	S003-692						
Station #:	13RD007						
Parameter	Units	# of Samples	Minimum	Maximum	Mean	WQ Standard[1]	# of WQ Exceedances
Ammonia-nitrogen	ug/L	26	<3	225	59	40	13
Chloride	mg/L	21	6.6	40.3	22.5	230	
DO	mg/L	73	2.22	12.50	6.74	5	16
pH		74	4.40	8.97	7.90	6.5 - 9	2
Secchi tube	100 cm	21	10.0	58.0	24.7	10	
TSS	mg/L	38	2.0	206.0	56.5	65	11
Phosphorus	ug/L	38	77	672	284	150	34
Chl-*a*, corrected	ug/L	8	16.0	43.0	32.6	35	4
E. coli (geometric mean)	MPN/100ml	3	27.4	47.6	-	126	
E. coli	MPN/100ml	33	4	218	-	1260	
Inorganic nitrogen (nitrate and nitrite)	mg/L	38	<0.01	4.69	0.25		
Kjeldahl nitrogen	mg/L	17	0.99	2.30	1.55		
Orthophosphate	ug/L	-	-	-	-		
Pheophytin-a	ug/L	-	-	-	-		
Specific conductance	uS/cm	74	317	1204	735.8		
Temperature, water	deg °C	74	6.40	26.10	18.33		
Sulfate	mg/L	10	42.5	220.0	122.1		
Hardness	mg/L	10	177	451	304		
Total dissolved solids	mg/L	12	152	776	400		

[1]Secchi tube standards are surrogate standards derived from the TSS standard of 65 mg/L.

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Bigwood Subwatershed, conducted from 2004 to 2014 (IWM work was conducted between May and September from 2013 to 2014). This specific data does not necessarily reflect all data that was used to assess the AUID.**

Summary

The Snake River (AUID 09020309-537) is a continuation of the same AUID previously reported within the Vega Subwatershed, with all impairments also applying to this reach (F-IBI and DO). The biological communities within this reach were very poor which coincided with the poor habitat attributes. Two biological monitoring stations existed, 13RD006 and 13RD080 from upstream to downstream. The F-IBI score at 13RD006 was very poor. Although significantly higher, the score at 13RD080 was still below the impairment threshold, further confirming the F-IBI impairment. Neither sample consisted of many fish; with the sample at 13RD006 consisting of mostly of tolerant minnows (i.e., fathead minnow) in addition to several other tolerant species such as common carp and bigmouth buffalo. The 13RD080 sample consisted of mostly longer lived species such as goldeye, channel catfish, and sauger with fewer common carp and no bigmouth buffalo or minnow species. M-IBI scores were abysmal. Very few unique taxa were collected at either sampling station, and taxa that were collected were tolerant of disturbance. Significant hydrologic stressors are present at these stations, sediment bars and eroded banks dominated these sampling reaches. Habitat appears to be the limiting factor as both sites had very similar (poor) scores and were dominated by fine substrates (clay and silt) and only sporadic fish cover consisting mostly of scattered vegetation and woody debris. Water chemistry was limited to the biological samples and was not used to assess aquatic life or recreation. Secchi tube readings at the time of fish samples indicated that the water was more turbid at 13RD006 (35 cm) versus 13RD080 (58 cm) which is also confirmed by sample pictures. In addition, lab water chemistry results indicate elevated nutrients. TSS and nitrogen levels were four times as high and TP was three times as high at 13RD006 versus 13RD080.

Snake River (AUID 09020309-502) begins at the Swift Coulee confluence and flows north 11.16 miles to the confluence with the Middle River about 2.25 miles southeast of Fork. The surrounding landscape is mostly cropland, but there are wetlands and forest present especially in the immediate floodplain of the river. There are existing impairments from 2010 on this AUID for DO and turbidity. One biological monitoring station, 13RD007, existed on this reach.

Biological indicators on this reach were poor, again reflecting the poor habitat, high turbidity, and low DO concentrations. Although the F-IBI sample consisted of 13 species, the community was comprised of all tolerant species including a high abundance of carp and buffalo species resulting in a very poor F-IBI score. Macroinvertebrates also scored poorly, with the sample dominated by a few tolerant taxa. The lone in-stream habitat attribute to score fairly was fish cover as vegetation and woody debris were present but all other attributes scored very low. Sample comments and pictures indicate that the substrate consisted of excess clay and silt with no coarse substrate. In addition, very slow flow was noted during the sample. The pictures taken during the sampling event show duckweed present and little indication of flow (Figure 24). However, high flows likely exist during major precipitation events or spring snowmelt runoff as large logjams and scattered large trees/wood were present throughout the reach (Figure 24).

Water chemistry was taken at biological monitoring station 13RD007 and is summarized in Table 12. Un-ionized ammonia, chloride, and pH were all meeting aquatic life standards. DO exceeded the standard in 25% of samples, with readings as low as 2.20 mg/L, which confirms the existing DO impairment. S-tube exceeded the 10cm surrogate standard in 9.7% of cases, which is very close to the exceedance threshold. TSS exceeded the standard in 31.4% of samples, also confirming the existing turbidity impairment. TP and one response variable (chl-*a*) were available for and assessment of river eutrophication. Phosphorus had an average concentration of 333.6 ug/L which exceeds the South Nutrient Region eutrophication standard of 150 ug/L. Limited chl-*a* data was available, but with a mean concentration of 32.6 ug/L it is meeting the standard (35 ug/L). Since no response was noted between TP and chl-*a*, there is insufficient information that eutrophication is impacting aquatic life. No individual or geometric monthly mean exceedances were found when comparing *E. coli* concentrations to aquatic recreation standards. The highest individual *E. coli* concentration was 218/100mL, and the highest geometric monthly mean was 48/100mL for July. Therefore, the reach supports aquatic recreation.

Swift Coulee (AUID 09020309-511) begins about seven miles southwest of Old Mill State Park and flows west 27.31 miles to its confluence with the Snake River. This reach is also known as Marshall County Ditch #3. With the exception of a few sporadic wetlands and pastures along the upper end of this AUID, cropland dominates the landscape surrounding this reach. Two biological monitoring stations were established on this reach, however neither were able to be sampled for fish or macroinvertebrates due to stagnant water, no definable channels, and choking vegetation. A large Secchi tube data set was available for review and will serve as a surrogate for TSS on this AUID. There was a 3.4% exceedance rate out of 145 measurements over 10 years of monitoring –therefore, aquatic life standards are being met for TSS. Data from other parameters on this reach were limited; no bacteria data was available so there is insufficient information to assess for aquatic recreation.

Overall, this Snake River mainstem in this subwatershed is similar to the upstream portions mentioned previously. These reaches are characterized by poor biological communities which likely stem from the poor water quality and habitat surrounding them. Throughout the system, low DO concentrations, increased turbidity, and variable flows likely also play a large factor in the poor aquatic communities. In addition, although cover/habitat was not completely absent, limited types of sporadic cover were found throughout the watershed. It appears that flow increases to such high rates within this portion of the stream that vegetation is ripped out and most woody debris (besides large log jams) are carried downstream. These negative characteristics all likely contribute to the poor biological communities within this reach.

Figure 24. Log jam, duckweed, and low flow at 13RD007.

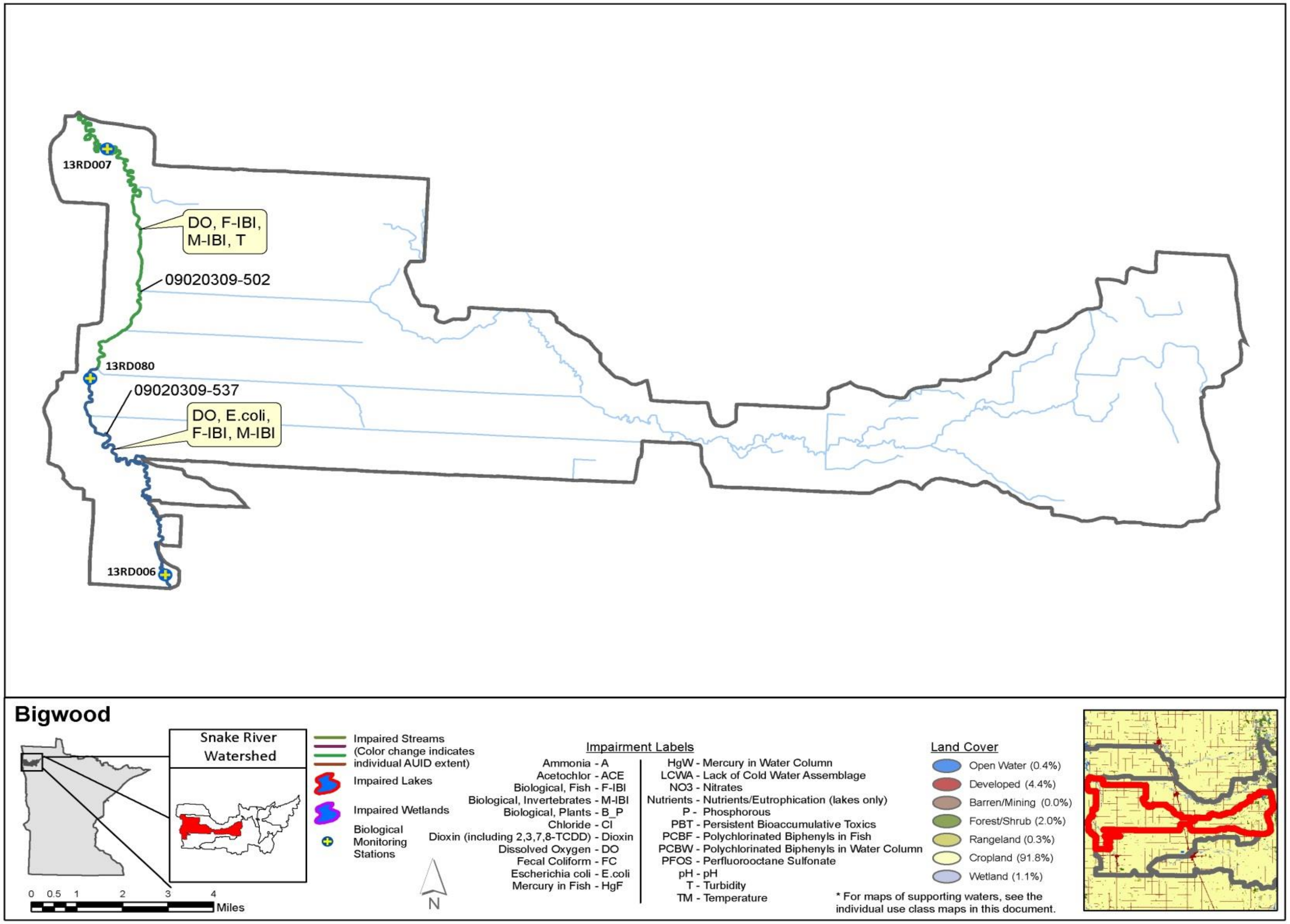


Figure 25. Currently listed impaired waters by parameter and land use characteristics in the Bigwood Subwatershed.

East Middle River Subwatershed HUC 09020309050

The East Middle River Subwatershed is located in east-central Marshall County and drains an area of 97.6 mi^2. This subwatershed contains the headwaters of the Middle River, originating from a small wetland/forest complex approximately five miles southeast of the town of Middle River. The river meanders northwest through the town of Middle River where it then turns and flows southwest to the outlet of the subwatershed near Newfolden. Along its path the river collects water from many small stream and ditch tributaries. The subwatershed has the lowest percentage of agricultural land in the watershed, comprising only 54% of the landscape. In contrast, this subwatershed has the highest amount of wetland and forest land cover within the watershed at 18% and 14%, respectively Rangeland and development make up the remaining land use with 8% and 5%, respectively (Figure 27). This subwatershed consists of four AUIDs and six biological monitoring stations. The water chemistry monitoring station for this subwatershed is on the Middle River at County Road 28, one mile east of Newfolden.

Table 13. Aquatic life and recreation assessments on stream reaches: East Middle River Subwatershed. Reaches are organized upstream to downstream in the table.

AUID *reach name*, *reach description*	Reach length (miles)	Use class	Biological station ID	Location of biological station	Aquatic life indicators:								Aquatic recreation indicators:		Aquatic life	Aquatic recreation
					Fi-IBI	I-IBI	DO	TSS	Chloride	pH	NH_3	Pesticides	Bacteria	Nutrients		
09020309-538 ***Middle River*** *Headwaters to -96.171 48.4349*	6.82	WWm	13RD026	Downstream of 150th Ave NE, 1 mi. SE of Middle River	EXS	-	IF	IF	-	IF	IF	-	-	-	IMP	NA
09020309-539 ***Middle River*** *-96.171 48.4349 to County Rd 114*	37.91	WWg	13RD103 05RD095 13RD001	Upstream of 370th St., 3mi SW of Middle River Upstream of CR 30, 3.5 mi. NE of Newfolden Downstream of CR 28, 1 mile E of Newfolden	MTS	MTS	IF	IF	MTS	MTS	MTS	-	MTS	-	IMP	SUP
09020309-529 ***Unnamed ditch*** *Unnamed ditch to Middle River*	7.59	WWm	13RD027	Downstream of County Hwy 6, 1 mi NE of Middle River	MTS	EXS	IF	IF	-	IF	IF	-	-	-	IMP	NA
09020309-534 ***Unnamed ditch*** *Unnamed ditch to Middle River*	1.55	WWg	13RD025	Downstream of County Hwy 30, 4 mi. E of Newfolden	MTS	MTS	IF	IF	-	IF	IF	-	-	-	SUP	NA

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **-** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: = existing impairment, listed prior to 2015 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. Minnesota Stream Habitat Assessment (MSHA): East Middle River Subwatershed.

# Visits	Biological station ID	Reach name	Land use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish cover (0-17)	Channel morph. (0-36)	MSHA score (0-100)	MSHA rating
1	13RD026	Middle River	0	8	7	11	10	36	Poor
1	13RD103	Middle River	0	7	17	13	15	52	Fair
1	13RD027	Unnamed Ditch	1.75	10	15.1	10	11	47.85	Fair
1	13RD025	Unnamed Ditch	1.5	4	16.2	13	21	55.7	Fair
Average habitat results: *East Middle River Subwatershed*			**0.81**	**7.25**	**13.83**	**11.75**	**14.25**	**47.89**	**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 15. Outlet water chemistry results: East Middle River Subwatershed.

Station location:	Middle River at CSAH28, 0.5 mi E of Newfolden						
STORET/EQuIS ID:	S004-106						
Station #:	13RD001						
Parameter	Units	# of Samples	Minimum	Maximum	Mean	WQ Standard [1]	# of WQ Exceedances
Ammonia-nitrogen	ug/L	10	<40	<40	<40	40	
Chloride	mg/L	10	6.1	15.1	9.5	230	
DO	mg/L	24	1.23	8.94	5.64	5	9
pH		24	6.26	8.24	7.79	6.5 - 9	1
Secchi tube	100 cm	24	65.3	>100.0	97.0	25	
TSS	mg/L	12	1.0	13.1	4.2	30	
Phosphorus	ug/L	10	38	127	74	150	
Chl-*a*, Corrected	ug/L	-	-	-	-	35	
E. coli (geometric mean)	MPN/100ml	3	43.9	76.9	-	126	
E. coli	MPN/100ml	15	8	238	-	1260	
Inorganic nitrogen (nitrate and nitrite)	mg/L	10	<0.03	0.131	0.05		
Kjeldahl nitrogen	mg/L	10	1.15	2.01	1.41		
Orthophosphate	ug/L	-	-	-	-		
Pheophytin-a	ug/L	-	-	-	-		
Specific Conductance	uS/cm	24	366	643	534		
Temperature, water	deg °C	24	2.55	24.02	18.31		
Sulfate	mg/L	10	32.3	67.5	51.9		
Hardness	mg/L	10	257	298	271		

[1]Secchi tube standards are surrogate standards derived from the TSS standard of 30 mg/L.

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the East Middle River Subwatershed, from 2006 to 2014 (IWM work was conducted between May and September from 2013 to 2014). This specific data does not necessarily reflect all data that was used to assess the AUID.**

Summary

Middle River (AUID 09020309-538) is a 6.82 mile modified reach that begins at the headwaters and flows northwest to the town of Middle River, and ends just west of MN Highway 32. The landscape is mostly cropland with interspersed forests and pasture. Aquatic life was assessed based on the fish sample as invertebrates were unable to be sampled do to a lack of flow. One biological monitoring station exists on this reach, 13RD026. The F-IBI score was slightly below the impairment threshold and consisted of a low number of individuals collected (19). This community is likely being affected by poor habitat which consisted of low flow, poor substrate, excess sedimentation, and although fish cover was extensive, it consisted only of thick vegetation. Similar to the upstream portions of the Middle River, this reach may be affected by beaver dams upstream of this station. Although water chemistry data on this AUID was limited to the biological visits, the existing DO and turbidity impairments from the now-retired parent AUID 09020309-505 will carry forward.

Middle River (AUID 09020309-539) begins just west of the town of Middle River and flows west 37.91 miles to Marshall County Road 114 about 1.5 miles northeast of Old Mill State Park. A portion of this AUID flows through a mixture of cropland, wetlands, and pasture. There's a large wetland just north of the reach, within the New Maine Wildlife Management Area (WMA). There are existing DO and turbidity impairments (2008) on this reach that carried forward from the now-retired parent AUID 09020309-505. Although multiple biological monitoring stations exist on this reach within this subwatershed, each aquatic life and recreation assessment were made using data from a different station. Fish were assessed using data from 13RD103 as the site was beaver impounded at time of macroinvertebrate sampling. Invertebrates were assessed using data from 05RD095 as fish were not collected, and water chemistry was assessed using data collected at the 13RD001 location as the site was beaver impounded during each biological monitoring visit. Although the biological communities are not impaired, it is clear based on sampling notes and the amount of beaver impoundments that this reach is experiencing connectivity and water level issues due to the beaver dams. This reach flows through the East Middle River Subwatershed and ends past the outlet of the next downstream subwatershed, Center Middle River.

The F-IBI score at 13RD103 was well above the impairment threshold consisting of 10 species, including three sensitive species (pearl, northern redbelly, and finescale dace) in addition to the presence of several lithophilic spawning species. Although the habitat score was fair, coarse substrates were found throughout the reach with very little fine sediments. There is evidence that beavers are affecting this section of stream. We were unable to sample the site for fish in 2013 due to a beaver dam at the upstream end of the reach. In 2014 the flow was very slow at the time of fish sampling and impounded during macroinvertebrate sampling, perhaps suggesting a possible beaver impoundment downstream of the site. The macroinvertebrate sample was good at 05RD095, with a mix of both tolerant and intolerant taxa. 13RD001 was visited multiple times during 2013 and 2014 but was not sampled for fish or macroinvertebrates due to a beaver impoundment downstream causing a lack of flow at the site, however water chemistry samples were taken.

Unnamed Ditch (AUID 09020309-529) is a 7.59 mile modified reach that flows east from the very upper end of the subwatershed to its confluence with the Middle River in the town of Middle River. The reach flows through a large wetland complex and is primarily surrounded by wetlands and forested land. One biological monitoring station existed, 13RD027. Although not many fish were sampled at this site (42) the F-IBI was well above the impairment threshold due to the high percentage of sensitive species such as northern redbelly, pearl, and finescale dace in comparison to the overall number of fish sampled. Given the high F-IBI score, the lack of flow and water depth may be prohibiting the fish community from being more robust. Conversely, the macroinvertebrate community was very poor and dominated by tolerant taxa (Oligochaeta and Physa). Habitat was limited to overhanging vegetation and woody debris, riffle habitats did not contain significant coarse substrate to allow for a sample to be taken. The greatest water depth found within the reach during both samples was 6 inches, with much of the available cover and habitat existing out of the water. Though the stream was flowing, the possibility of beaver dams upstream holding back water from this reach may be contributing to the low water levels, slow flow, and thus the lack of suitable habitat (see AUID -534 below). In addition, excess amount of fine sediments in the stream may affect the biological communities. An active cattle pasture exists directly upstream on the opposite side of the road (Figure 26). Management of cattle access to the stream may improve the overall water quality and habitat within this reach. Chemistry data on this AUID was limited to the biological visits, so there is insufficient information to assess for aquatic life and recreation.

Unnamed Creek (AUID 09020309-534) flows from south to north 1.55 miles to its confluence with the Middle River just north of Marshall CSAH 30. The land use along the reach is cropland, pasture, and wetlands. This reach contained biological monitoring station 13RD025 which was similar to 13RD027 in that they have nearly the same drainage areas, fair habitat, and are located near active pastures. Biological communities in this stream appear to be thriving which may be a result of faster flow, greater water depth, and the presence of coarse substrate. The fish community here was nearly exceptional and consisted of three more species (10) as well as an increased number of individuals (261) than at 13RD027, including sensitive and riffle dwelling species. The macroinvertebrate community was also above the impairment threshold, with several intolerant taxa present. Increased flow was evident as deep scour pools and clean coarse substrates were found throughout much of the reach. However, similar to 13RD027 animal access to the stream is contributing to decreased habitat scores and causing erosion which is evident by sample photos (Figure 26). As stated above, it would benefit this stream if cattle access to the stream was managed in an environmentally sustainable way. Chemistry data on this AUID was limited to the biological visits, so there is insufficient information to assess for aquatic life and recreation.

Overall, the biological communities within this subwatershed appear to be dependent on continuous flow and low amounts of sediment. One large issue within this subwatershed appears to be the presence of beaver impoundments which are likely affecting the biological communities and water quality. Beaver impoundments made it difficult to sample may reaches. Where beaver impoundments were present, flows were decreased and higher amounts of sediment were noted in comparison to those stations without impoundment issues. The low flow/high sediment locations coincided with poor F-IBI scores while stations where good flow and little sediment were noted, fish communities appeared to thrive. Although DO and turbidity impairments do exist on AUID -538 and -539, biological communities are above their respective thresholds.

Figure 26. Cattle access to stream at 13RD027 (left) and animal trampling at 13RD025 (right).

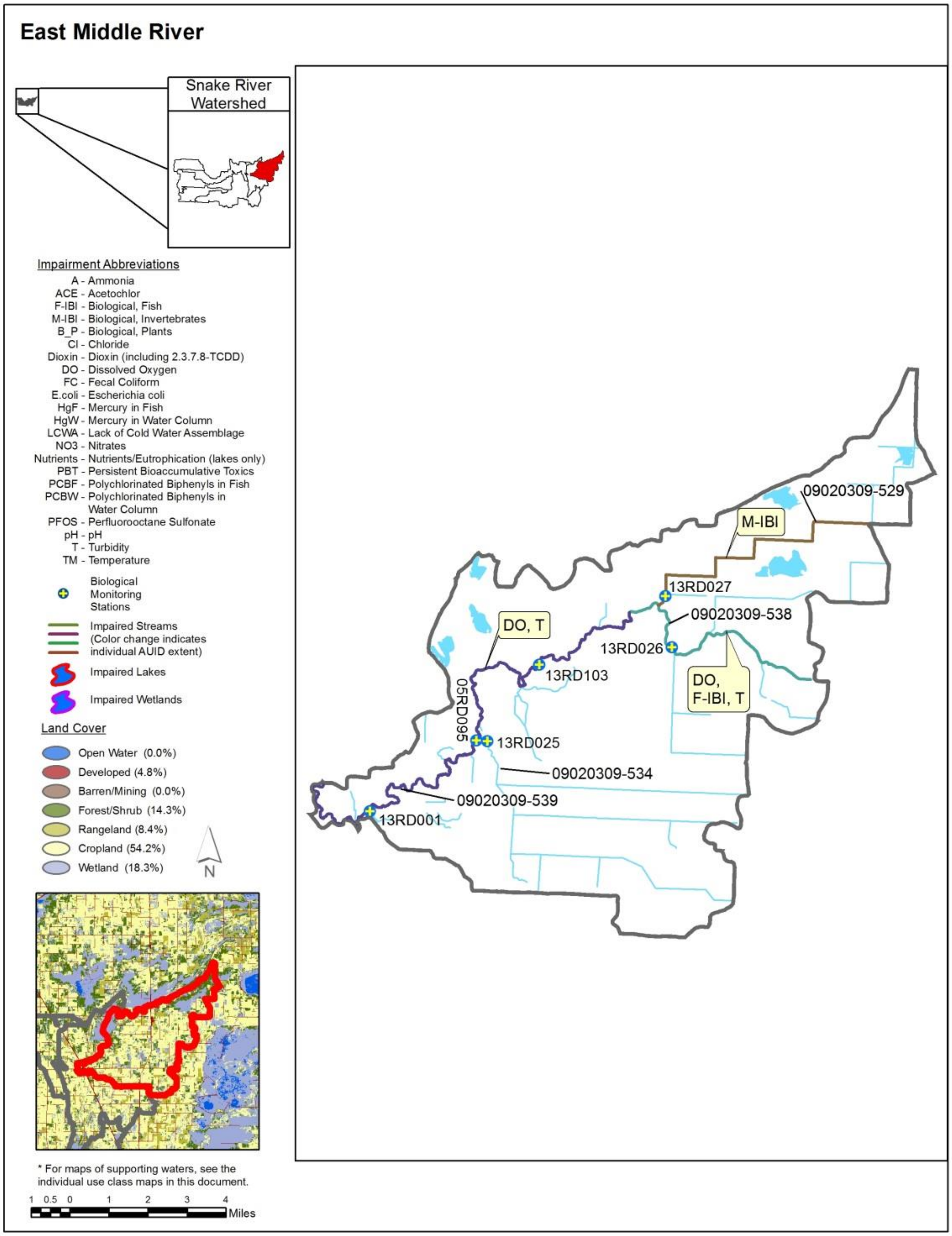


Figure 27. Currently listed impaired waters by parameter and land use characteristics in the East Middle River Subwatershed.

Center Middle River Subwatershed HUC 09020309060

The Center Middle River Subwatershed is located in central Marshall County and drains an area of 79.5 mi^2. The subwatershed contains a short reach of the Middle River mainstem connecting the east and west Middle River Subwatersheds. A vast majority of the waterways in the subwatershed are small state and Judicial Ditches located to the north and south of the town of Newfolden. The subwatershed is on the Agassiz Beach Ridge and is largely comprised of cropland, covering 57% of the landscape. Wetland and forest land uses are less common, occurring on 18% and 12% of the land in the watershed, respectively. Rangeland and development make up the remainder of the land use at 8% and 5%, respectively (Figure 28). There are large wetland complexes on the northern- and southern-most ends of the subwatershed. There is water chemistry data available for three AUIDs with one biological monitoring station on each. The water chemistry monitoring station for this subwatershed is on the Middle River at 150th Ave. NW, two miles NW of Newfolden.

Table 16. Aquatic life and recreation assessments on stream reaches: Center Middle River Subwatershed. Reaches are organized upstream to downstream in the table.

AUID *reach name*, *reach description*	Reach length (miles)	Use class	Biological station ID	Location of biological station	Aquatic life indicators:								Aquatic recreation indicators:		Aquatic life	Aquatic recreation
					F-IBI	I-IBI	DO	TSS	Chloride	pH	NH_3	Pesticides	Bacteria	Nutrients		
09020309-539 ***Middle River*** *-96.171 48.4349 to Co Rd 114*	37.91	WWg	13RD002	Downstream of 150th Ave. NW, 2 mi. NW of Newfolden	MTS	MTS	IF	IF	MTS	MTS	MTS	-	MTS	-	IMP	SUP
09020309-515 ***Unnamed Ditch*** *Headwaters to County Ditch 15*	2.22	WWm	05RD020	1.5 mi. upstream of CR 141, 2 miles NW of Holt	MTS	MTS	IF	IF	-	IF	IF	-	-	-	SUP	NA
09020309-530 ***Judicial Ditch 21*** *380th St to Middle River*	5.23	WWg	13RD023	Upstream of CR 8, 1.5 mi. N of Newfolden	MTS	MTS	IF	IF	-	IF	IF	-	-	-	SUP	NA

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **-** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: ☐ = existing impairment, listed prior to 2015 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐ = insufficient information.
Abbreviations for Use Class: **WWg** = Warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 17. MSHA: Center Middle River Subwatershed.

# Visits	Biological station ID	Reach name	Land use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish cover (0-17)	Channel morph. (0-36)	MSHA score (0-100)	MSHA rating
1	13RD002	Middle River	2.5	13	21.1	14	26	76.6	Good
1	05RD020	Unnamed Ditch	2.5	9	3	10	10	34.5	Poor
1	13RD023	Judicial Ditch 21	3.5	11	15	12	10	51.5	Fair
Average habitat results: *Center Middle River Subwatershed*			**2.83**	**11**	**13.03**	**12**	**15.33**	**54.2**	**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 18. Outlet water chemistry results: Center Middle River Subwatershed.

Station location:	**Middle River at 150th Ave NW, 2 mi NW of Newfolden**						
STORET/EQuIS ID:	**S007-440**						
Station #:	**13RD002**						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances**
Ammonia-nitrogen	ug/L	10	<40	<40	<40	40	
Chloride	mg/L	10	5.2	13.3	10.1	230	
DO	mg/L	22	3.11	11.31	8.31	5	1
pH		21	7.63	8.47	7.99	6.5 - 9	
Secchi tube	100 cm	22	77.0	>100.0	97.2	25	
TSS	mg/L	10	1.0	9.0	4.2	30	
Phosphorus	ug/L	10	36	67	51	150	
Chl-*a*, corrected	ug/L	-	-	-	-	35	
***E. coli* (geometric mean)**	MPN/100ml	3	68.3	133.4	-	126	1
E. coli	MPN/100ml	15	17	190	-	1260	
Inorganic nitrogen (nitrate and nitrite)	mg/L	10	<0.03	0.41	0.13		
Kjeldahl nitrogen	mg/L	10	0.52	2.51	1.24		
Orthophosphate	ug/L	-	-	-	-		
Pheophytin-a	ug/L	-	-	-	-		
Specific conductance	uS/cm	22	379	741	562		
Temperature, water	deg °C	22	15.22	24.13	19.13		
Sulfate	mg/L	10	41.2	67.3	57.5		
Hardness	mg/L	10	189	364	280		

[1]Secchi tube standards are surrogate standards derived from the TSS standard of 30 mg/L.

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Center Middle River Subwatershed, conducted from 2013 to 2014 (IWM work was conducted between May and September from 2013 to 2014). This specific data does not necessarily reflect all data that was used to assess the AUID.**

Summary

Middle River (AUID 09020309-539) begins just west of the town of Middle River and flows west 37.91 miles to Marshall County Road 114 about 1.5 miles northeast of Old Mill State Park. There are existing DO and turbidity impairments (2008) that carried forward from the now-retired parent AUID 09020309-505. The more recent data suggests that the DO impairment will remain unchanged. DO exceeded the standard in 25.9% of samples over the assessment period. All of the exceedances were observed in 2013 and 2014, and the lowest recorded concentration was 1.20 mg/L. Newer TSS data indicates that the existing turbidity impairment may be delisted. Only 15 TSS samples (20 is the minimum) were taken over the assessment window, but none exceeded the Central TSS Region standard of 30 mg/L. S-tube can serve as a surrogate when TSS measurements are lacking; of the 47 S-Tube measurements only two exceeded the standard of 25 cm. With a mean concentration of 68.3 ug/L, TP data meets the South Nutrient Region standard (150 ug/L). Since TP concentrations are below the standard and there is no response variable, then the reach is meeting the river eutrophication standard. Un-ionized ammonia, chloride, and pH were meeting aquatic life standards. *E. coli* concentrations resulted in no individual or geometric monthly mean exceedances. The highest individual *E. coli* concentration was 338/100mL, and the highest geometric monthly mean was 102/100mL for July, so the reach is supporting for aquatic recreation use.

There is one biological monitoring location on this reach, 13RD002. The fish community scored above the impairment threshold consisting of 10 species including 2 sensitive and multiple lithophilic spawning species. The macroinvertebrate community was fair, though there were many low DO tolerant taxa present. Although low DO does exist within this reach, positive habitat attributes appear to be driving the biological communities on this reach. The habitat score (good) and sample pictures indicate abundant coarse substrate, little sediments, good flow, and abundant cover types throughout the channel.

Unnamed Ditch (AUID 09020309-515) is a 2.22 mile modified reach that flows from its headwaters northward to its confluence with Marshall County Ditch #15 about two miles northwest of Holt. The landscape bordering this reach is primarily cropland and wetlands. There was one biological monitoring location, 05RD020, which was sampled for both fish and macroinvertebrates in 2005. The F-IBI score was above the modified use threshold but consisted of a low number of species. Two sensitive species were present although in low abundance as over 90% of the sample was made up of tolerant species (mostly brook stickleback). Macroinvertebrate taxa were dominated by low DO tolerant taxa. The habitat score for this station was poor, specifically channel morphology and substrate which consisted of only silt and detritus and no coarse substrate. Chemistry data on this AUID was limited to the biological visits, so there is insufficient information to assess for aquatic life and recreation. However, at the time of fish sampling the DO concentrations were very low (3.0 mg/L) which may be causing stress on the biological communities.

Judicial Ditch #21 (AUID 09020309-530) flows south, then southwest, roughly five miles where it enters the Middle River just one half mile north of Newfolden. Land use is primarily wetland and forest with a few pastures and cropland near the downstream end of the reach. There are small impoundments upstream and along this reach including the New Maine WMA, which all drain into this AUID. There is one biological monitoring station on this reach, 13RD023. Biological communities appear to do well on this reach, however they are likely dependent on flow which appears variable as one attempted fish visit was unsuccessful due to no flow and choking vegetation.

There was no flow and choking vegetation in the stream during the initial fish visit in July of 2013, so the stream was not sampled during that time. However, only a month later in August a macroinvertebrate sample was able to be taken due to improved conditions with good flow through the stream. In June 2014, the flow conditions were good and a fish sample was obtained which resulted in an F-IBI score above the impairment threshold. Although the number of individuals sampled was low (29), it was comprised of a high percentage of sensitive individuals and taxa (three sensitive species out of nine total) as well as multiple lithophilic spawning species. The macroinvertebrate score was fair, with a mix of tolerant and intolerant taxa in the sample. The F-IBI and M-IBI scores coincided with a habitat score that was fair with abundant coarse substrates and high a high amount of fish cover. Aerial photography shows that the watershed upstream of this station has been altered significantly. There are multiple man-made water retention areas which appear to hold water only during certain times of the year. The creation of these areas appears to coincide with two gravel pits established near the water retention areas. If water is being held back in these water retention structures, it may result in a lower water level and flow within the stream. It is possible that during periods of low flow, fish are able to migrate out of the more stressful conditions, whereas the macroinvertebrates cannot which may explain why there was a high F-IBI score and a mediocre M-IBI score. Water chemistry data on this AUID was limited to the biological visit which showed slightly elevated levels of nitrogen within the stream (1.29 mg/L). However, there was not enough information to assess for aquatic life and recreation.

Overall, both the fish and macroinvertebrate communities within this subwatershed are doing well. Although low DO concentrations do exist on the Middle River in the reach, the biological communities appear to benefit from the presence of good flow and habitat, specifically coarse substrates. In this way this watershed is similar to the upstream portions of the Middle River and some smaller tributaries (e.g., AUID -530).

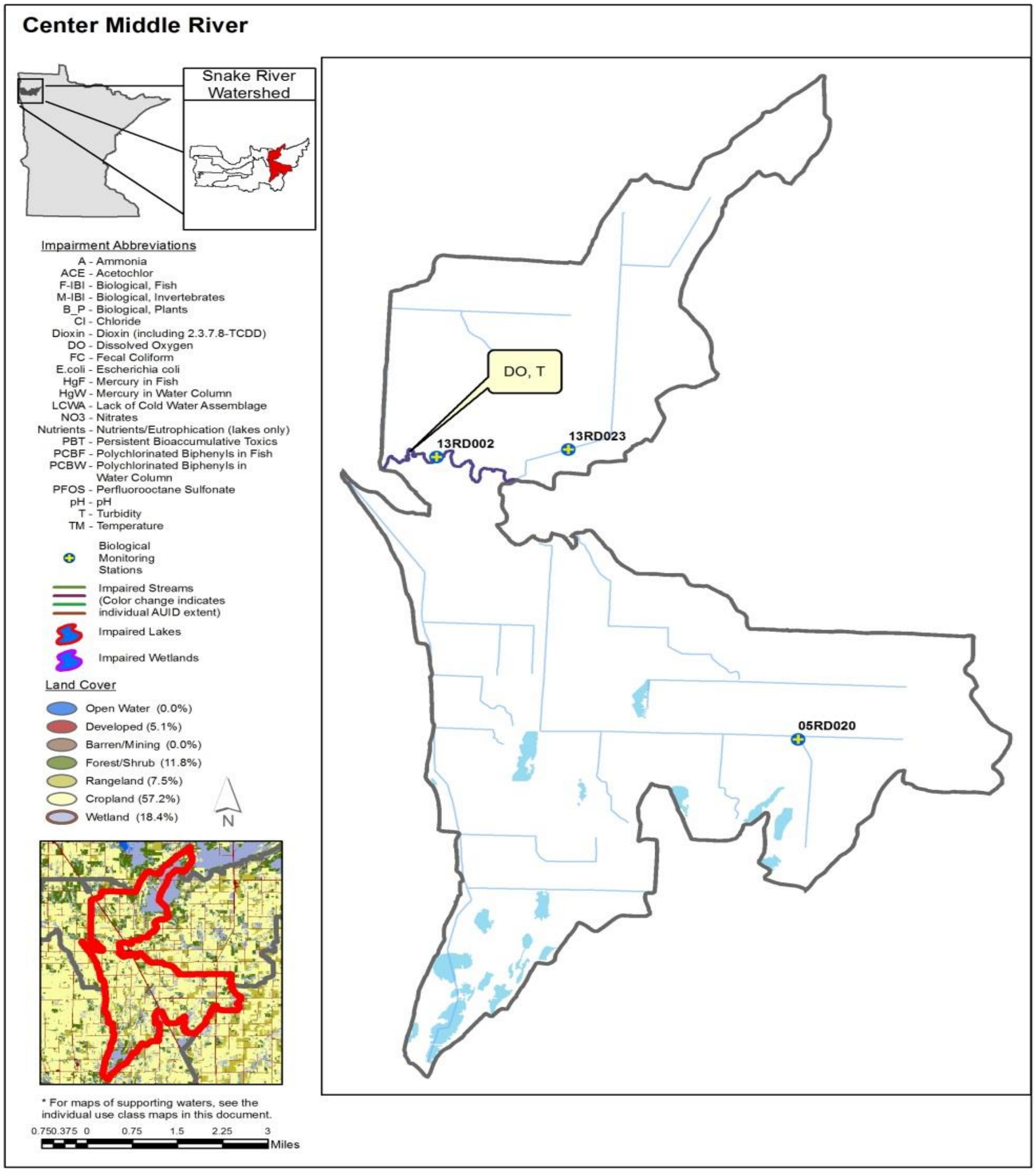


Figure 28. Currently listed impaired waters by parameter and land use characteristics in the East Middle River Subwatershed.

West Middle River Subwatershed HUC 09020309070

The West Middle River Subwatershed is located in central and west-central Marshall County draining an area of 117.3 mi^2. This subwatershed contains over half of the Middle River mainstem. The watershed begins roughly three miles northwest of Newfolden. As the river flows westerly towards Argyle it receives water from many small tributaries including many state and Judicial Ditches before its confluence with the Snake River. The upstream portion of the subwatershed begins as a mixture of wetlands (including the Florian WMA), forest, pasture, and cropland on the Agassiz Beach Ridge before transitioning further west to primarily cropland down on the Agassiz Lake Plain. Overall the land is dominated by cropland which comprises 79%of the landscape. The remainder is made up of wetland and forest both of which cover 7%, development 5%, and rangeland 2% (Figure 31). The West Middle River Subwatershed has water chemistry data available from three stream AUIDs and seven biological monitoring stations. These stream AUIDs are all reaches of the Middle River. The water chemistry monitoring station for this subwatershed is on the Middle River at County Road 17, three miles East of Fork.

Table 19. Aquatic life and recreation assessments on stream reaches: West Middle River Subwatershed. Reaches are organized upstream to downstream in the table.

AUID *reach name*, *reach description*	Reach length (miles)	Use class	Biological station ID	Location of biological station	Aquatic life indicators: F-IBI	I-IBI	DO	TSS	Chloride	pH	NH_3	Pesticides	Aquatic recreation indicators: Bacteria	Nutrients	Aquatic life	Aquatic recreation
09020309-539 ***Middle River*** *-96.171 48.4349 to County Rd 114*	37.91	WWg	13RD100	Upstream of 200th Ave., 10 mi. N of Newfolden	MTS	MTS	IF	IF	MTS	MTS	MTS	-	MTS	-	IMP	SUP
09020309-540 ***Middle River*** *County Rd 114 to T156 R49W S3, N line*	45.54	WWg	13RD022 05RD014 13RD079 93RD417 13RD098	Downstream of CR 39, 11 mi. W of Newfolden Downstream of Cty Route 1, 10 miles NE of Warren Downstream of Cty Hwy 34, 4.8 mi east of Argyle CR 4 bridge, 0.25 mi E of Argyle Downstream of 380th St., N of 330th Ave., 2 mi. NW of Argyle	MTS	EXS	IF	EXS	MTS	MTS	MTS	-	MTS	-	IMP	SUP
09020309-541 ***Middle River*** *T157 R49W S34, S line to Snake River*	5.91	WWm	13RD008	Upstream of County Rd 17, 3 mi. E of Fork, 1 mi S of 350th St.	MTS	-	IF	EXS	MTS	MTS	MTS	-	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 2015 reporting cycle; = new impairment; = full support of designated use; = insufficient information.

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

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

Table 20. MSHA: West Middle River Subwatershed.

# Visits	Biological station ID	Reach name	Land use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish cover (0-17)	Channel morph. (0-36)	MSHA score (0-100)	MSHA rating
2	13RD100	Middle River	2.5	11.25	20.2	14	23.5	71.45	Good
2	13RD022	Middle River	2.5	8.25	20.75	12	22.5	66	Good
1	05RD014	Middle River	5	8.5	17	7	18	55.5	Fair
1	13RD079	Middle River	2.5	8.5	11.5	12	12	46.5	Fair
1	93RD417	Middle River	0	11	17.4	13	28	69.4	Good
1	13RD098	Middle River	0	8	11.3	17	19	55.3	Fair
1	13RD008	Middle River	0	7	12	6	11	36	Poor
Average habitat results: *West Middle River Subwatershed*			**1.79**	**8.93**	**15.74**	**11.57**	**19.14**	**57.16**	**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 21. Outlet water chemistry results: West Middle River Subwatershed.

Station location:	**Middle River at CSAH17, 12 mi W of Argyle**						
STORET/EQuIS ID:	**S003-691**						
Station #:	**13RD008**						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances**
Ammonia-nitrogen	ug/L	19	<3	90	32	40	3
Chloride	mg/L	20	5.1	17.1	11.4	230	
DO	mg/L	79	1.04	12.43	8.65	5	5
pH		80	4.56	8.62	8.13	6.5 - 9	1
Secchi tube	100 cm	21	6.0	21.0	12.9	10	2
TSS	mg/L	45	4.0	295.0	83.4	65	23
Phosphorus	ug/L	34	27	575	178	150	18
Chl-*a*, corrected	ug/L	-	-	-	-	35	
***E. coli* (geometric mean)**	MPN/100ml	3	48.7	66.0	-	126	
E. coli	MPN/100ml	33	4	435	-	1260	
Inorganic nitrogen (nitrate and nitrite)	mg/L	34	<0.01	1.76	0.12		
Kjeldahl nitrogen	mg/L	10	0.76	1.32	1.06		
Orthophosphate	ug/L	-	-	-	-		
Pheophytin-a	ug/L	-	-	-	-		
Specific conductance	uS/cm	80	241	916	593		
Temperature, water	deg °C	80	2.57	26.50	18.29		
Sulfate	mg/L	10	35.2	68.1	56.6		
Hardness	mg/L	10	38	353	270		
Total dissolved solids	mg/L	14	119.0	503.0	313.4		
Total volatile solids	mg/L	2	3.0	8.0	5.5		

[1]Secchi tube standards are surrogate standards derived from the TSS standard of 65 mg/L.

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the West Middle River Subwatershed, conducted from 2004 to 2014 (IWM work was conducted between May and September from 2013 to 2014). This specific data does not necessarily reflect all data that was used to assess the AUID.**

Summary

Middle River (AUID 09020309-539) is roughly 13.5 miles and is the tail-end of this AUID which was also mentioned in the Center Middle River Subwatershed where the water chemistry for this reach was addressed. All water chemistry information carries through to this subwatershed, including the exiting DO impairment and the proposed delisting of the turbidity impairment. There is one biological monitoring station on this AUID within this subwatershed, 13RD100. Two samples were taken in 2013, the first sample taken in June was above the impairment threshold and the second sample in mid-July was right at the impairment threshold. The June sample consisted of roughly 225 individuals and the July sample had over 2,000 individuals. However, both samples had three sensitive taxa as well as multiple lithophilic spawning species. Reasons for the large increase in the number of individuals in unclear, as water levels were nearly equal and gear type was the same. The only noticeable difference was water temperature which was 16.3°C in June and 22.7°C in July. Same day macroinvertebrate replicate samples were collected in August 2013, and both samples were good. However, the taxa present did suggest that increased sedimentation, likely from bank erosion was a likely stressor. The high habitat scores in each category (highest in the HUC-8 watershed), availability of clean coarse substrate, and abundant cover were all contributing factors to the robust biological communities found within this reach. Bank erosion was found within the reach but swift flows likely wash most sediment downstream and out of the reach. In addition to the good habitat, the water chemistry results (although limited to the biological visits) indicated good water quality at the time the samples were taken.

Middle River (09020309-540) is a long, 45.54-mile reach that begins about 2.5 miles northwest of Newfolden, flows west through Old Mill State Park to the city of Argyle, and ends about 6.5 miles southwest of Stephen. This is a natural, unaltered reach of the Middle River where although much of the landuse is cropland, the riparian zone is nearly all wooded. There are existing DO and turbidity impairments (2008) that carried forward from the now-retired parent AUID 09020309-505. Five biological monitoring stations were located within this reach, 13RD022, 05RD014, 13RD079, 93RD417, and 13RD098 from upstream to downstream. The F-IBI scores were all fair to good along the entire reach while the M-IBI were variable and inconsistent between site locations. The habitat scores ranged from poor to good with generally decreasing habitat quality from upstream to downstream.

Although the fish communities were all at or above their respective impairment thresholds, populations are better upstream where coarse substrate is not only present but clean of sediment. Extensive boulders, cobble, gravel, and riffles were present at 13RD022 and 05RD014 which coincided with the highest number of species (15 and 19, respectfully) and individuals (2,000+ at each site). In addition, the highest numbers of sensitive species were found at these stations such as burbot, rock bass, and stonecat in addition to many lithophilic spawning species including three different redhorse species. At the next downstream site (13RD079) however, the habitat decreases with increased erosion and sediment, less coarse substrate, and fewer riffles. Here, the number of species (8) and individuals (27) decreased dramatically. Although the habitat score increased to good at the next downstream site (93RD417), erosion and sedimentation were still high with the only area of coarse substrate being a small section where an old dam was located. Here, the number of species and individuals was still poor (9 species and 84 individuals) with only one sensitive species and one redhorse species. Sedimentation and erosion continued to increase further downstream at 13RD098, however there were small riffles present. Species composition increased to 12 but the number of individuals was still low (102) in comparison to upstream stations. Several longer lived species were sampled here that were not present upstream including smallmouth bass, sauger, and goldeye (all in low density). Macroinvertebrate scores vary along this stream reach. The upstream station, 13RD022, was visited twice in 2013 and scored very poorly at both visits. 05RD014 was sampled in 2005 and had a good IBI score, and high quality clean substrate was noted. 13RD079 scored poorly, dominated by tolerant snails. This site in particular has been severely degraded by hydrologic stress with many trees falling into the stream and sloughing banks adding sediment to the reach. 93RD417 and 13RD098 had fair IBI scores, both sites had some good habitat attributes but communities show signs of degradation.

Un-ionized ammonia and chloride were meeting aquatic life standards. The pH data set is robust, with 205 samples taken over the assessment window. Only one pH single exceedance of 5.50 was observed early in the assessment window (2005), so pH is meeting aquatic life standards. There was also a large DO dataset available for this AUID. Only four DO measurements exceeded the 5 mg/L standard out of 115 samples. The exceedances were minor, being between 3.00 and 4.60 mg/L. However, there were not enough early morning DO samples to render a judgement, thus the DO impairment remains. S-tube only exceeded the surrogate standard five times in 140 samples during the assessment window, but TSS exceeded the 65 mg/L standard in 27.7% of samples. Many samples in this dataset were event-based, likely biasing the results. So, the event-based measurements were excluded; however, TSS was still exceeding the standard, confirming the turbidity impairment. With a mean concentration of 134.8 ug/L, TP data meets the South Nutrient Region standard (150 ug/L). Since TP meets and there is no response variable, then the reach is meeting the river eutrophication standard. *E. coli* concentrations resulted in no individual or geometric monthly mean exceedances. The highest individual *E. coli* concentration was 365/100 mL, and the highest geometric monthly mean was 70/100 mL for July, so the reach is supporting for aquatic recreation use.

Middle River (09020309-541) is a 5.91 mile modified (i.e. ditched) reach which begins about 6.5 miles southwest of Stephen, flows west and ends with its confluence with the Snake River about two miles southeast of Fork. There are existing DO and turbidity impairments (2008) that carried forward from the now-retired parent AUID 09020309-505. There was one biological monitoring station, 13RD008.

The fish community was robust consisting of 19 species and roughly 900 individuals, scoring slightly above the modified impairment threshold. Nearly the entire community was made up of tolerant species, two-thirds of which were common carp, smallmouth buffalo, and bigmouth buffalo. The high number of species, particularly large bodies species, found here may be in part due to the to the stations close proximity to the Snake River (one river mile away) as some species may be swimming upstream but may be blocked from going further (see subwatershed conclusion) depending on flow. The high number of tolerant species is indicative of the poor habitat found within this reach which is characterized by no coarse substrate, little cover and high amount of sediment. Macroinvertebrates were not sampled because there was a lack of habitat to sample, only clay and sand banks were present.

Un-ionized ammonia, chloride, and pH are meeting aquatic life standards. DO exceeded the 5 mg/L standard in 5.8% of samples over the assessment window. Some of the exceedances were very low – the lowest measured concentration was 1.00 mg/L. There were not enough early-morning samples to make a recommendation for aquatic life use, so the existing DO impairment will remain. Secchi tube was exceeding the surrogate threshold in 22.4% of cases and TSS exceeded the 65 mg/L standard in 52.5% of samples over the assessment window; therefore, the existing turbidity impairment is confirmed. TP data exceeds the South Nutrient Region standard with a mean concentration of 172 ug/L. There is no data available from response variables (i.e., chl-a, BOD5), so a judgement cannot be determined if the reach is supporting aquatic life based on eutrophication. No individual or geometric monthly mean exceedances were found when comparing *E. coli* concentrations to aquatic recreation standards. The highest individual *E. coli* concentration was 435/100 mL, and the highest geometric monthly mean was 66/100 mL for June. Therefore, this reach supports aquatic recreation.

Overall, the presence of coarse substrates and low TSS concentrations appear to be driving the fish communities within this subwatershed. At stations where coarse substrates were present, even in small areas, the number of lithophilic spawning species increased significantly which often lead to higher F-IBI scores. Coarse substrates appeared to be associated with low TSS concentrations and an increase in sensitive species. Based on MSHA scores, sample pictures, and notes it is clear that coarse substrates and riffles are abundant at and upstream of 05RD014 but decline to only small areas or are completely absent downstream from this location. In addition to the decrease in coarse substrates downstream of 05RD014, bank erosion and fine sediments dramatically increase leading to decreased water clarity/quality. This is confirmed by the water chemistry samples taken at the time of fish sampling where TSS concentrations increased from 4.0 mg/L at 13RD022 to 15.8 mg/L at 13RD098 to 38.4 mg/L at 13RD008.

In addition to coarse substrates and TSS concentrations, two dams had previously existed on the Middle River within this subwatershed but have been removed in an effort to restore river conditions and allow fish passage. The most downstream dam was located on the east edge of Argyle and was removed in 2007 (Figure 29). The upstream dam was located within the Old Mill State Park and was removed in 2001 (Figure 30). Although these dams are removed connectivity issues may still limit fish migration during certain times of the year. Based on aerial photography there still appears to be obstructions within this subwatershed (both man-made and natural) that may be limiting flow and fish passage. First, a private driveway located roughly three miles northeast of Old Mill State Park appears to cut the natural flow of the river down into a small culvert while pooling up water on the upstream side of the driveway. Second, a shallow rock "crossing" is located roughly three miles southeast of Argyle which appears to allow farming equipment to cross the river and third, there is a rock "wall" across the stream under the road crossing at 13RD008. All of these blockages are likely causing a reduction in flow throughout the stream in addition to prohibiting fish passage at certain times of the year, specifically during low flows. If possible, these areas should be examined to determine if they are truly causing connectivity issues. In addition, there also appears to be many areas with large beaver dams and/or log jams which are likely slowing the flow of the river and possibly prohibiting fish passage. These areas begin downstream of 05RD014, similar to the erosion and sedimentation issues mentioned above.

Figure 29. Before and after pictures of the Middle River Dam in Argyle, Minnesota (Photos courtesy of MNDNR).

Figure 30. Before (left) and after (right) pictures of the Middle River Dam in Old Mill State Park, Minnesota (Photos courtesy of MNDNR).

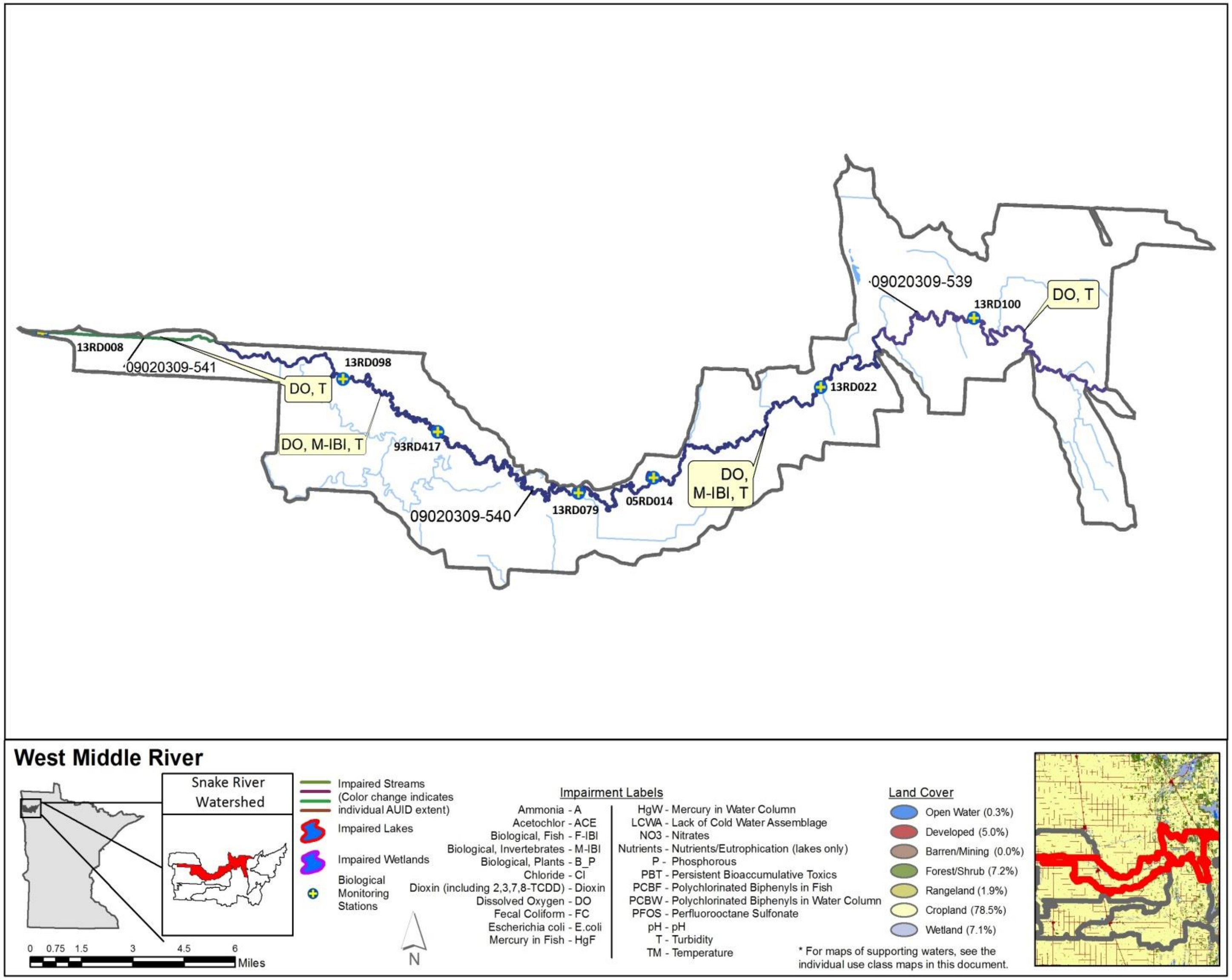


Figure 31. Currently listed impaired waters by parameter and land use characteristics in the West Middle River Subwatershed.

Judicial Ditch #29 Subwatershed HUC 09020309080

The Judicial Ditch #29 Subwatershed is located in western Marshall County and is the smallest of the subwatersheds, draining an area of 64.2 mi^2. This subwatershed is the outlet of the Snake River Watershed which receives water from all other streams and ditch systems within this subwatershed. All of this water eventually flows into the Red River of the North approximately four miles north of the town of Fork. The subwatershed is nearly all cropland, comprising 94% of the watershed, development 5% and open water 1% (Figure 32). The water chemistry monitoring station for this subwatershed is also the fish contaminants station for the HUC-8 watershed, located on the Snake River at Highway 220, two miles north of Fork.

Table 22. Aquatic life and recreation assessments on stream reaches: Judicial Ditch #29 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: F-IBI	I-IBI	DO	TSS	Chloride	pH	NH_3	Pesticides	Aquatic recreation indicators: Bacteria	Nutrients	Aquatic life	Aquatic recreation
09020309-501 ***Snake River*** *Middle River to Red River of the North*	10.35	WWg	13RD009	Upstream of Hwy 220, 2 mi. N of Fork	EXS	-	EX	EX	MTS	MTS	MTS	-	MTS	-	IMP	SUP
09020309-519 ***Judicial Ditch #29*** *Headwaters to Snake River*	10.94	WWg	13RD010	Downstream of 480th Ave NW, 2 mi. NE of Fork	EXS	-	IF	IF	IF	IF	IF	-	IF	-	IMP	IF

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

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

Key for Cell Shading: = existing impairment, listed prior to 2015 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 23. Minnesota Stream Habitat Assessment (MSHA): Judicial Ditch #29 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
	13RD009	Snake River	0	4	7	3	11	25	Poor
	13RD010	Judicial Ditch #29	0	5	6.6	4	16	31.6	Poor
Average habitat results: *Judicial Ditch #29 Subwatershed*			**0**	**4.5**	**6.8**	**3.5**	**13.5**	**28.3**	**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 24. Outlet water chemistry results: Judicial Ditch #29 Subwatershed.

Station location:	**Snake River at MN220, N of Bigwoods**						
STORET/EQuIS ID:	**S000-185**						
Station #:	**13RD009**						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances**
Ammonia-nitrogen	ug/L	79	<3	720	88	40	50
Chloride	mg/L	67	5.2	70.6	18.5	230	
DO	mg/L	252	0.85	15.38	7.76	5	33
pH		256	5.92	8.72	8.03	6.5 - 9	1
Secchi tube	100 cm	72	0.9	70.0	12.2	10	35
TSS	mg/L	232	<1.0	2640.0	110.6	65	102
Phosphorus	ug/L	225	37	1910	280	150	182
Chl-*a*, Corrected	ug/L	33	<1.0	43.0	15.0	35	2
BOD	mg/L	12	1.4	3.3	2.2	3	1
***E. coli* (geometric mean)**	MPN/100ml	4	5.8	64.1	-	126	
E. coli	MPN/100ml	52	1	2400	-	1260	2
Inorganic nitrogen (nitrate and nitrite)	mg/L	230	<0.02	10.9	0.597		
Kjeldahl nitrogen	mg/L	173	0.65	8.76	1.50		
Orthophosphate	ug/L	9	52	517	265		
Pheophytin-a	ug/L	31	<1.0	14.0	4.3		
Specific conductance	uS/cm	258	197	2098	660		
Temperature, water	deg °C	255	-0.46	28.85	14.66		
Sulfate	mg/L	65	<1	224	80.39		
Hardness	mg/L	28	89	595	342		
Color		8	110	200	149		
Total volatile solids	mg/L	92	<1.0	180.0	13.8		

[1]Secchi tube standards are surrogate standards derived from the TSS standard of 65 mg/L.

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Judicial Ditch #29 Subwatershed, conducted from 2004 to 2014 (IWM work was conducted between May and September from 2013 to 2014). This specific data does not necessarily reflect all data that was used to assess the AUID.**

Summary

The Judicial Ditch #29 subwatershed has water chemistry data available from two stream AUIDs and two biological monitoring stations. This subwatershed is entirely within the Agassiz Lake Plain and land use is dominated by cropland.

Snake River (09020309-501) is a 10.35 mile reach that begins at the confluence with the Middle River, flows northwest, and ends with its confluence with the Red River of the North. This AUID has existing impairments for DO and turbidity (2002). The lone biological monitoring station on this reach is located one mile prior to the confluence with the Red River of the North. Water levels at this site were high for much of the early part of the summer in 2013 due to heavy precipitation. There was also backflow from the Red River of the North during certain times of the year restricting flow from the Snake River. A fish sample from early August scored below the impairment threshold. Although the sample did consist of the highest number of species in the entire watershed (22) including a good mix of minnow and longer lived species, nearly all were tolerant species. In addition, most species were found in very low abundance with 19 of the 22 species having six or less individuals. This high proportion of tolerant species is likely due to the very poor habitat conditions within this reach. Extremely high amounts of fine sediment were present within the reach. Notes taken during the habitat assessment indicate that the sediment was "like quicksand" with no coarse substrates present. In addition, physical cover was nearly absent, with only small sticks being scattered throughout. The high number of species at this station cannot be attributed to flow or habitat but likely to its proximity to the Red River of the North. Macroinvertebrates were not sampled as there was no habitat available, only sediment lined banks with very little aquatic vegetation.

Un-ionized ammonia and chloride had large datasets (78 and 67 samples, respectively) over the assessment window. Neither parameter yielded a sample that exceeded standards, as a result they are both meeting aquatic life standards. There was a very robust pH dataset for this reach, 262 samples over the assessment window, and only one exceedance was observed indicating that pH is meeting aquatic life standards. DO measurements exceeded the 5 mg/L standard in 14.2% of samples over 10-years of sampling. Some DO concentrations were extreme, the lowest reading being 0.80 mg/L, confirming the existing DO impairment. TSS and surrogate Secchi tube far exceeded their standards (65 mg/L and 10cm) with exceedance rates of 52.3% and 53.2%, respectively, confirming the existing turbidity impairment. TP and two response variables (chl-*a* and BOD 5) had data available for comparison to the eutrophication standard. TP has a large data set with an average concentration of 286.1 ug/L which exceeds South Nutrient Region standard of 150 ug/L. Chl-a has a data set that shows a few exceedances, but with an average concentration 15.2 ug/L is meeting the eutrophication standard. BOD5 had a mean concentration of 2.2 mg/L, also below the eutrophication standard of 3 mg/L. This shows there is no response between TP and chl-*a* or BOD_5 and the data indicates that eutrophication (based on suspended algae) is not impacting aquatic life on this reach. A large *E. coli* data set (52 samples) was available for review when comparing to aquatic recreation standards. Two individual exceedances were observed during the assessment window; both were in 2006 with concentrations of 2400/100 mL and 2000/100 mL. The rest of the measurements were well below the individual standard of 1260/100 mL. No geometric monthly means exceeded the standard on this reach with the highest geometric mean being 64/100 mL for July, well below the 126/100 mL standard. Consequently, this AUID supports aquatic recreation.

Judicial Ditch #29 (09020309-519) is a 10.94 mile reach that flows from east to west beginning at US Highway 59, following 370^{th} Street NW, ending with its confluence with the Snake River. The reach is entirely channelized. The stream flows through a landscape of complete cropland until shortly before it confluence with the Snake River where it is surrounded by marsh/woods. There was one biological monitoring station on this reach, 13RD010. The fish community here was extremely poor consisting of

33 fathead minnows and one northern pike, both tolerant species. It appears that this reach often dries up in late summer each year. Habitat was poor as well, scoring low in each category with little coarse substrate or habitat. Chemistry data on this AUID was limited to the biological visits, so there is insufficient information to assess for aquatic life and recreation.

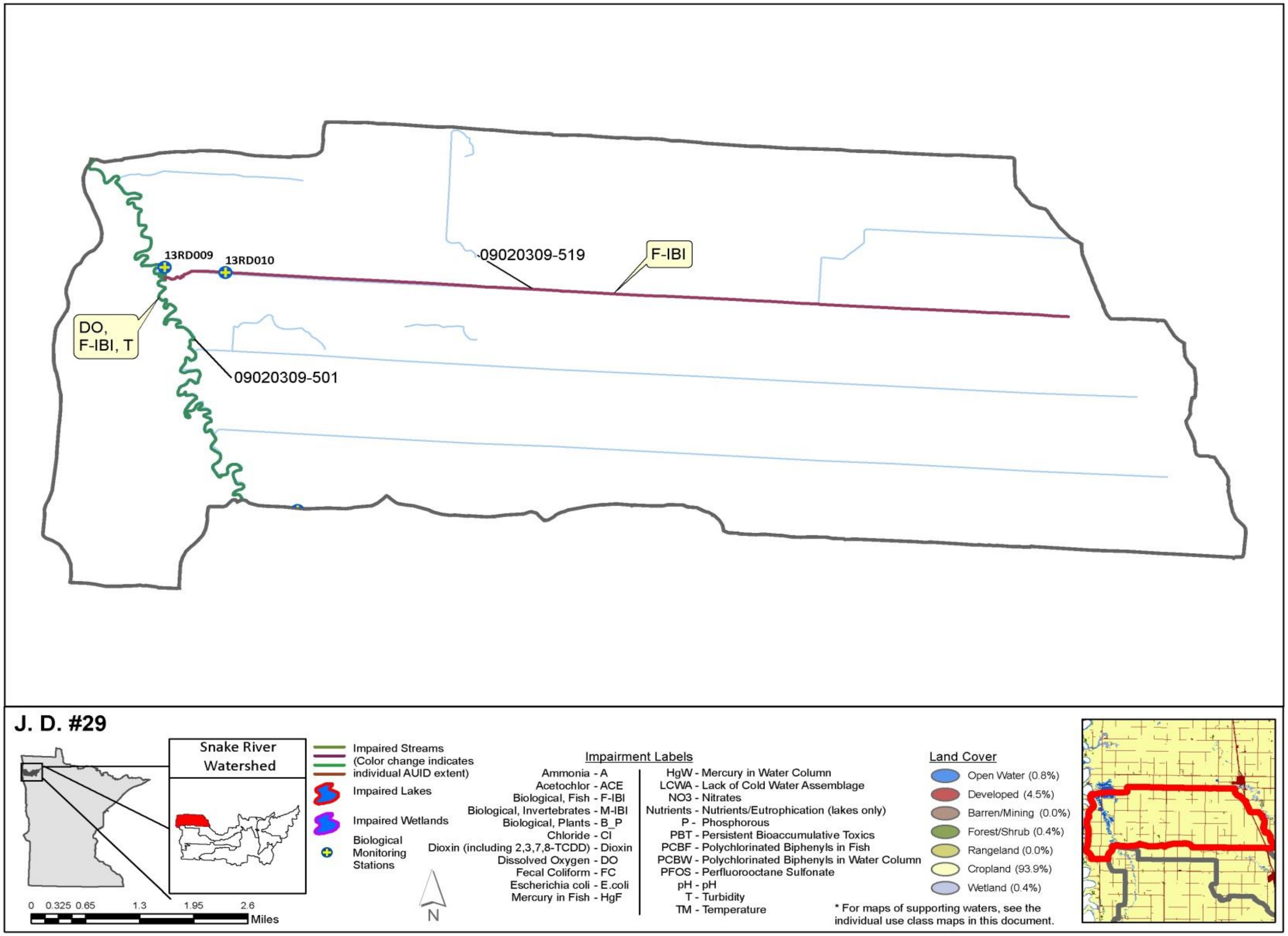


Figure 32. Currently listed impaired waters by parameter and land use characteristics in the Judicial Ditch #29 Subwatershed.

VI. Watershed-wide results and discussion

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

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

Watershed Pollutant Load Monitoring Network

Samples have been collected and loads calculated for the Snake River near Bigwoods, MN220 beginning in 2009. Two subwatershed sites were established in 2013 (Table 25); however, due to their recent establishment, subwatershed data was not available at the time of this report. Analysis and results within this report are limited to the data collected at the Snake River near Bigwoods.

Table 25. WPLMN stream monitoring sites for the Snake River Watershed.

Site type	Stream name	USGS	DNR/MPCA	EQuIS
Major Watershed	Snake River near Bigwoods, MN220	NA	H68011001	S000-185
Subwatershed	Snake River above Warren, CSAH34	05085450	E68031002	S003-101
Subwatershed	Middle River at Argyle, CSAH4	05087500	E68017001	S000-700

Pollutant loads are influenced by land use, land management, watershed size, hydrology, climate, and other factors. Watershed size and differences in flow volume greatly influence pollutant loads. Therefore, when comparing watersheds across a region or state, it is often useful to normalize the results for these differences. The FWMC is calculated by dividing the total load (mass) by the total flow volume, which normalizes load data for both spatial and volumetric difference in flow between watersheds. The FWMC is an estimate of the average concentration (mg/L) of a pollutant for the entire flow volume that passed the monitoring location over the monitoring season. This allows for the direct comparison of water quality between watersheds regardless of watershed size or annual discharge volume. In this report, WPLMN data will be expressed primarily as loads and FWMCs.

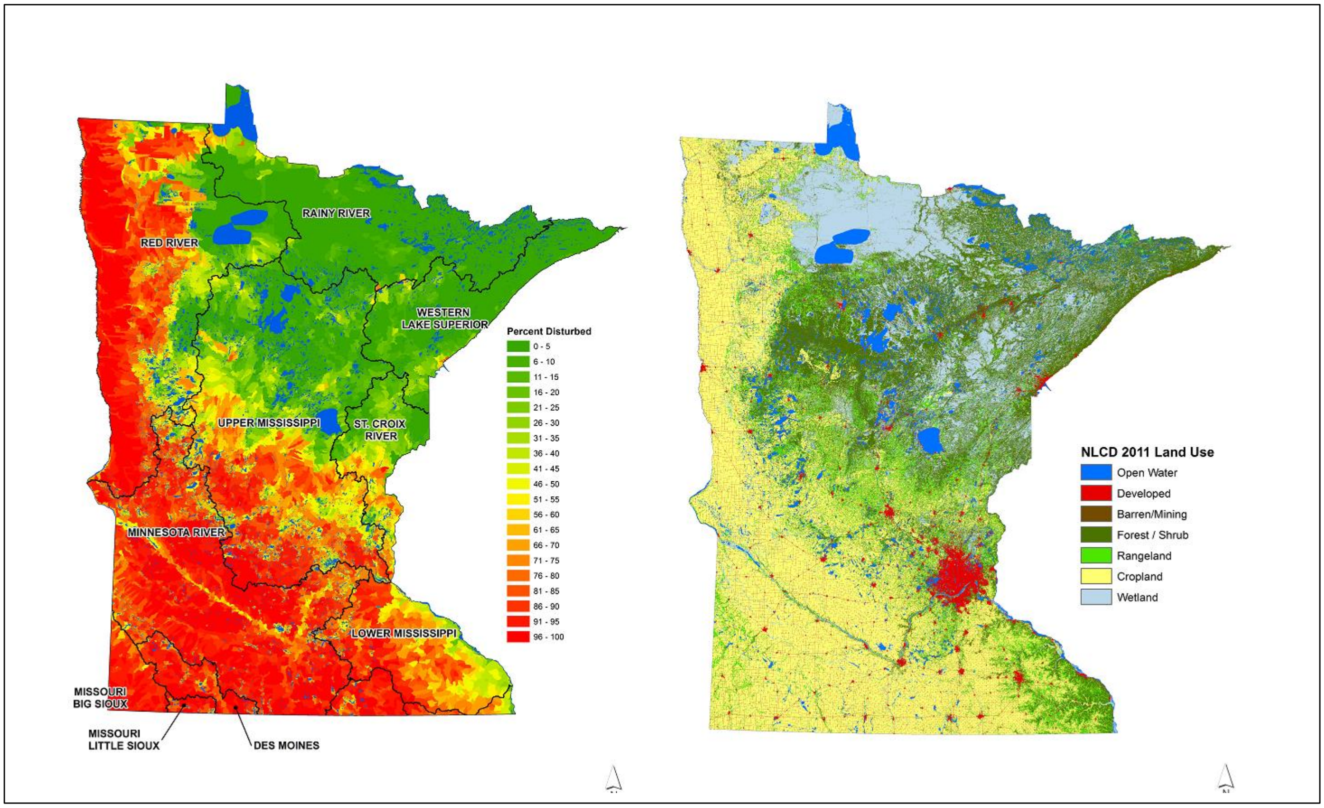
Many years of water quality data from throughout Minnesota, combined with the previous analysis of Minnesota's ecoregion patterns, resulted in the development of three "River Nutrient Regions" (RNR), each with unique nutrient standards (MPCA, 2013a). Of the state's three RNRs (north, central, south), the Snake River's monitoring stations are located within the south RNR.

Annual FWMCs for the Snake River near Bigwoods were calculated for 2009 to2013 and compared with South RNR standards (only TP and TSS river standards exist for Minnesota at this time) to give an indication of the overall water quality of the watershed and contrast year to year variability. See below for specific parameter results and discussion. It should be noted that while a FWMC exceeding water quality standards is generally a good indicator that the water body is out of compliance with the RNR standard, the rule may 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 10-year period (MPCA, 2014) and not based on comparisons with FWMCs. A river with a

FWMC above a water quality standard, for example, would not be listed as impaired if less than 10% of the individual samples collected over the assessment period exceeded the standard.

Pollutant sources and source contributions affecting rivers can be diverse from one watershed to the next depending on land use, climate, soils, slopes, and other watershed factors. Regional correlations between land use, percent land disturbance, and water quality can be observed with Figure 33 and Figure 34. Elevated nutrient and sediment levels in streams and rivers can occur naturally in landscapes composed of young glacial soils, steep slopes or other natural factors; however, land use, percent disturbance and other anthropogenic influences also strongly influence measured water quality. As a general rule, elevated levels of TSS and nitrate plus nitrite-nitrogen (NO_3+NO_2-N) are regarded as "non-point" source derived pollutants originating from many small diffuse sources such as urban or agricultural runoff. Excess TP and DOP can be attributed to both non-point as well as point sources such as industrial or wastewater treatment plants. Major "non-point" sources of phosphorus include dissolved phosphorus from fertilizers and phosphorus adsorbed to and transported with sediment during runoff.

Figure 33. Percent land disturbance and NLCD 2011 landuse for the state of Minnesota.



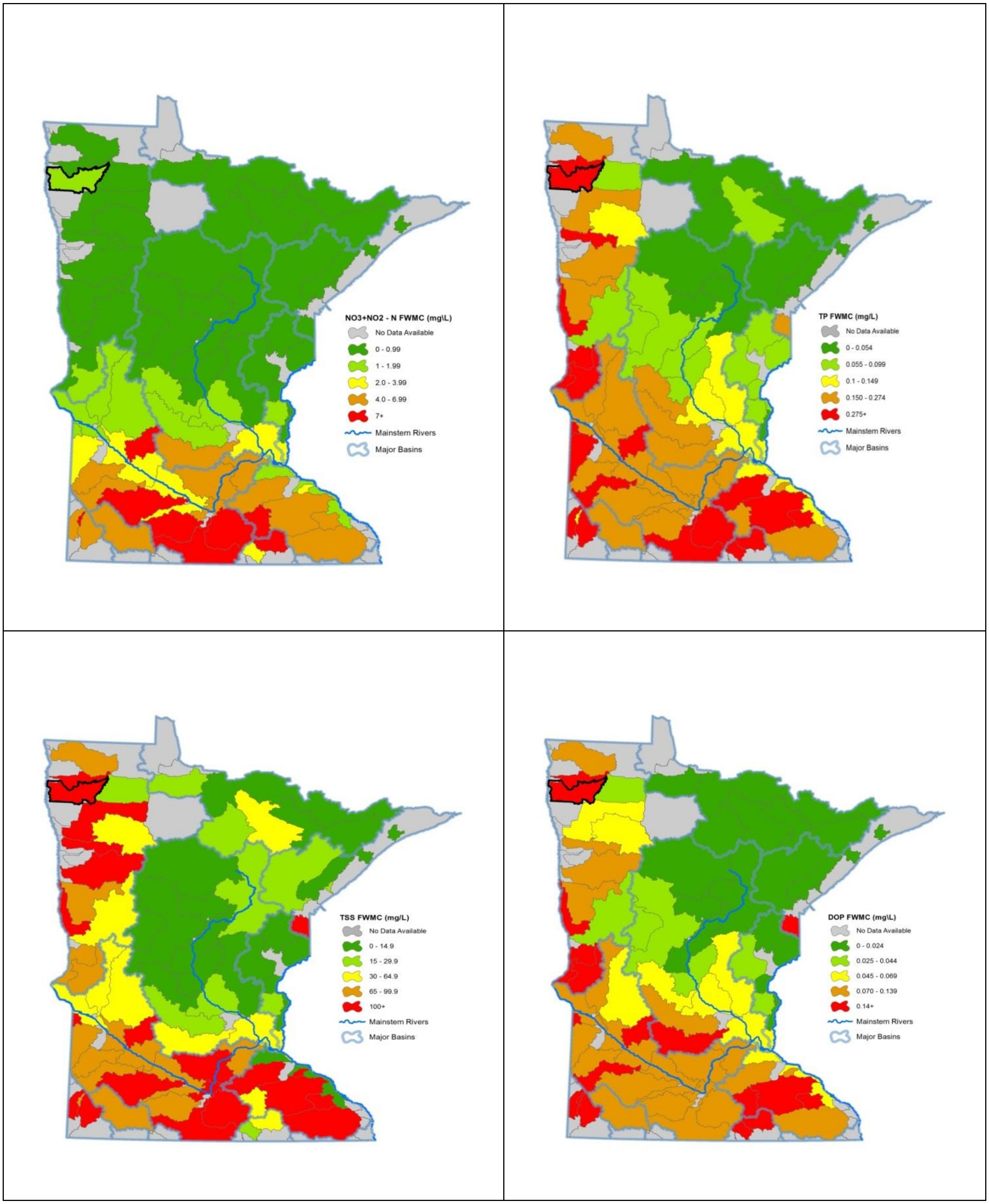


Figure 34. 2007-2013 WPLMN average annual TSS, TP, NO3-NO2-N and DOP FWMCs by major watershed.

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: vegetative canopy development, soil conditions (frozen/unfrozen saturation level, etc.), and precipitation type, intensity, and amount. Surface erosion and in-stream sediment concentrations, for example, will typically be much higher following high intensity rain events prior to canopy development when compared to post-canopy events where soils are more protected and less surface runoff and more infiltration occur. Precipitation type and intensity can influence the major course of storm runoff, routing water through several potential pathways including overland, shallow and deep groundwater, or through artificial agricultural and urban drainage networks. Runoff pathways along with other factors determine the type and levels of pollutants transported in runoff to receiving waters and help explain between-storm and temporal differences in in-stream pollutant concentrations. Pollutant loads, the product of concentration and flow, are influenced not only by in-stream pollutant concentrations but also the volume of runoff delivered to the stream. During years when high intensity rain events provide the greatest proportion of total annual runoff, FWMCs of TSS 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 FWMCs tend to be lower while DOP, and NO3+NO2-N levels tend to be elevated. TP concentrations can be high from both runoff sources although storm generated runoff will typically have a greater proportion of sediment bound phosphorus resulting in lower DOP/TP ratios when compared to snowmelt runoff. Years with larger runoff volumes will typically have larger loads when compared to years with lesser runoff volumes. Table 26 for example, shows the 2011 TSS load to be approximately six times higher than the following year's load, largely because of differences in runoff volume.

Table 26. Annual pollutant loads (kg) for the Snake River near Bigwoods, Minnesota.

Parameter	2009	2010	2011	2012	2013
TSS	29,707,047	26,827,640	35,613,760	5,946,803	17,816,720
TP	67,478	59,664	70,891	10,695	43,222
DOP	35,493	35,008	35,649	9,108	22,212
NO_3+NO_2-N	114,594	131,232	528,116	119,318	70,478

Total suspended solids

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

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

Minnesota's water quality standards for river eutrophication and TSS were adopted into Minn. R. 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). Figure 34 shows the average annual TSS FWMC to be several times higher for the Snake River Watershed compared to other HUC-8 watersheds in north central and northeast Minnesota but in line with the agriculturally rich watersheds found in northwest, north central, and southern regions of the state. From 2009 through 2013, 55% of the 144 water quality samples collected at the Snake River near Bigwoods monitoring site exceeded this standard. TSS FWMCs for this site also exceeded the 65 mg/L standard all five years as shown in Figure 35. Seasonality and climate influence the timing and size of TSS loads. Figure 36 illustrates the majority of the average annual flow volume (82%) and average annual

TSS load (88%) pass through the watershed beginning in March and runs through the end of June, the period when vegetative canopy is lacking or minimal.

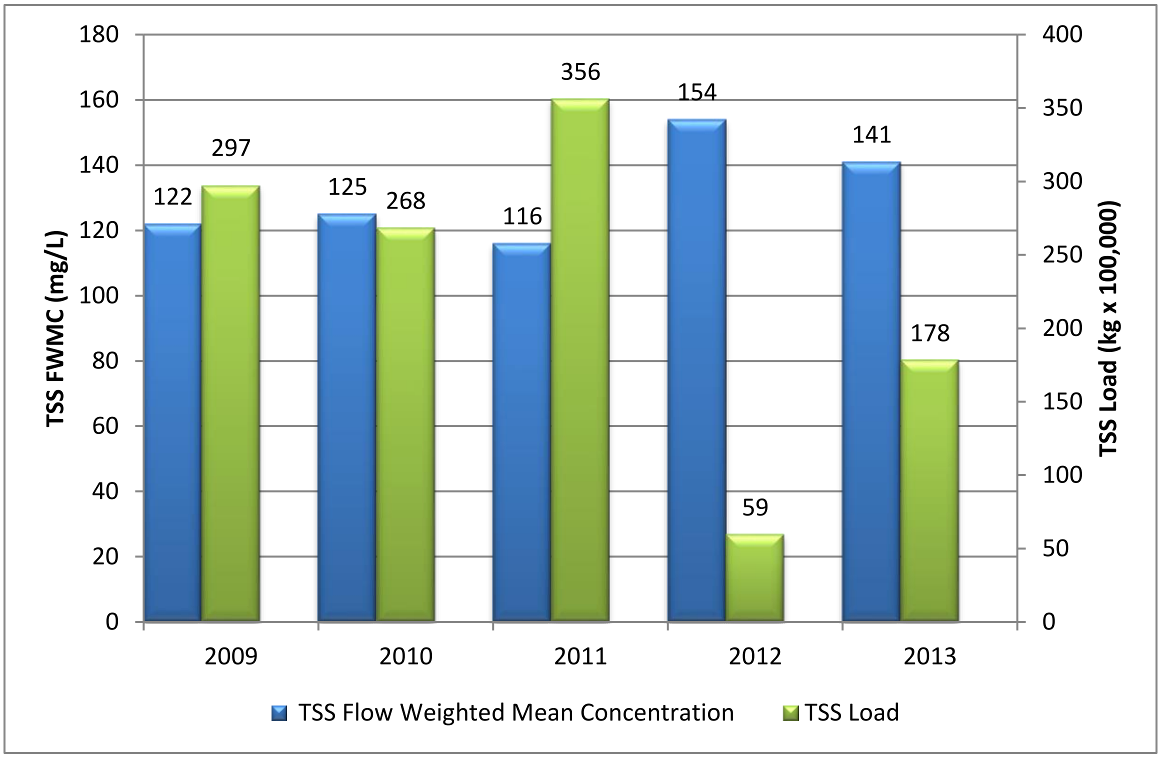


Figure 35. TSS FWMCs and Loads for the Snake River near Bigwoods, Minnesota.

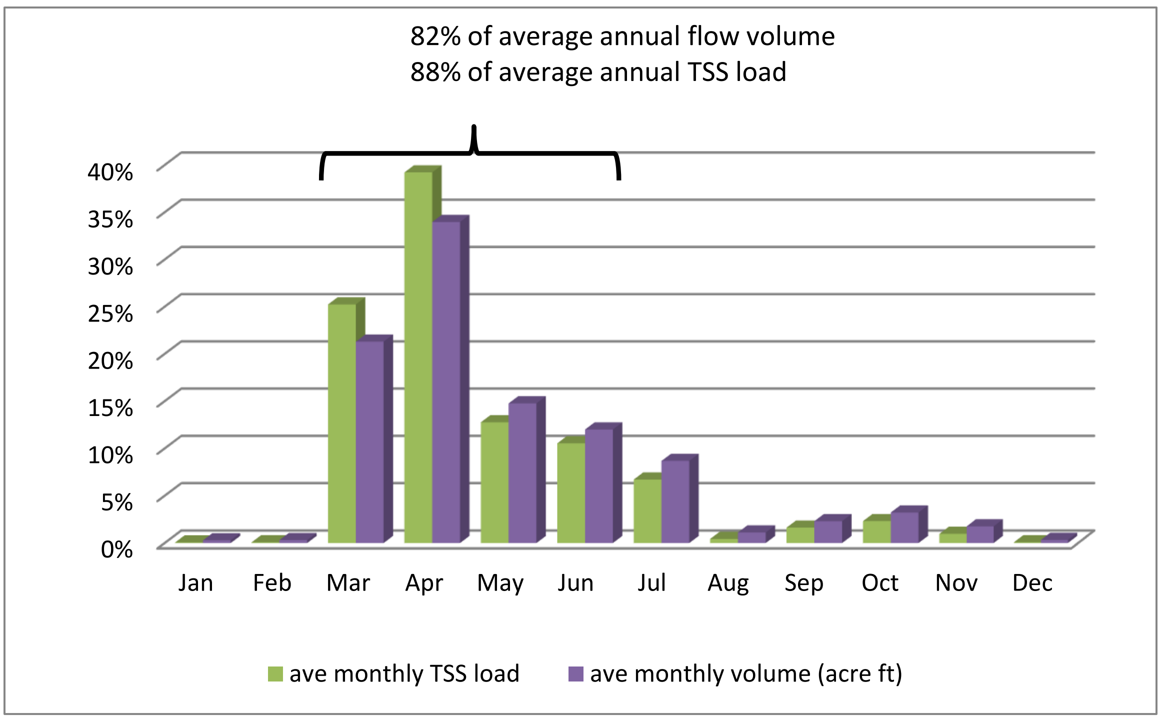


Figure 36. Monthly percentages of the average annual TSS load for the Snake River near Bigwoods, 2009-2013.

Total phosphorus

Nitrogen, phosphorus, and potassium (K) are essential macronutrients and are required for growth by all animals and plants. Lack of sufficient nutrient levels in surface water often restricts the growth of aquatic plant species (University of Missouri Extension, 1999). In freshwaters such as lakes and streams, phosphorus is typically the nutrient limiting growth; increasing the amount of phosphorus entering a stream or lake will increase the growth of aquatic plants and other organisms. Although phosphorus is a necessary nutrient, excessive levels overstimulate aquatic growth in lakes and streams resulting in reduced water quality. The progressive deterioration of water quality from overstimulation of nutrients is called eutrophication where, as nutrient concentrations increase, the surface water quality is degraded (University of Missouri Extension, 1999). Elevated levels of phosphorus in rivers and streams can result in: increased algae growth, reduced water clarity, reduced oxygen in the water, fish kills, altered fisheries, and toxins from cyanobacteria (blue green algae) which can affect human and animal health (University of Missouri Extension, 1999).

Within the south RNR, a violation of Minnesota's water quality standard for river eutrophication occurs when the TP summer mean concentration (June through September) is at or above 0.150 mg/L along with a summer average violation of one or more "response" variables (pH, biological oxygen demand, DO flux, chl-*a*). A comparison of 2009 through 2013 TP data collected for the Snake River near Bigwoods shows TP concentrations at or above the 0.150 mg/L south RNR TP standard 61% of the time. The summer TP averages were above the standard in all years. TP FWMCs were also greater than the standard in all years (Figure 37).

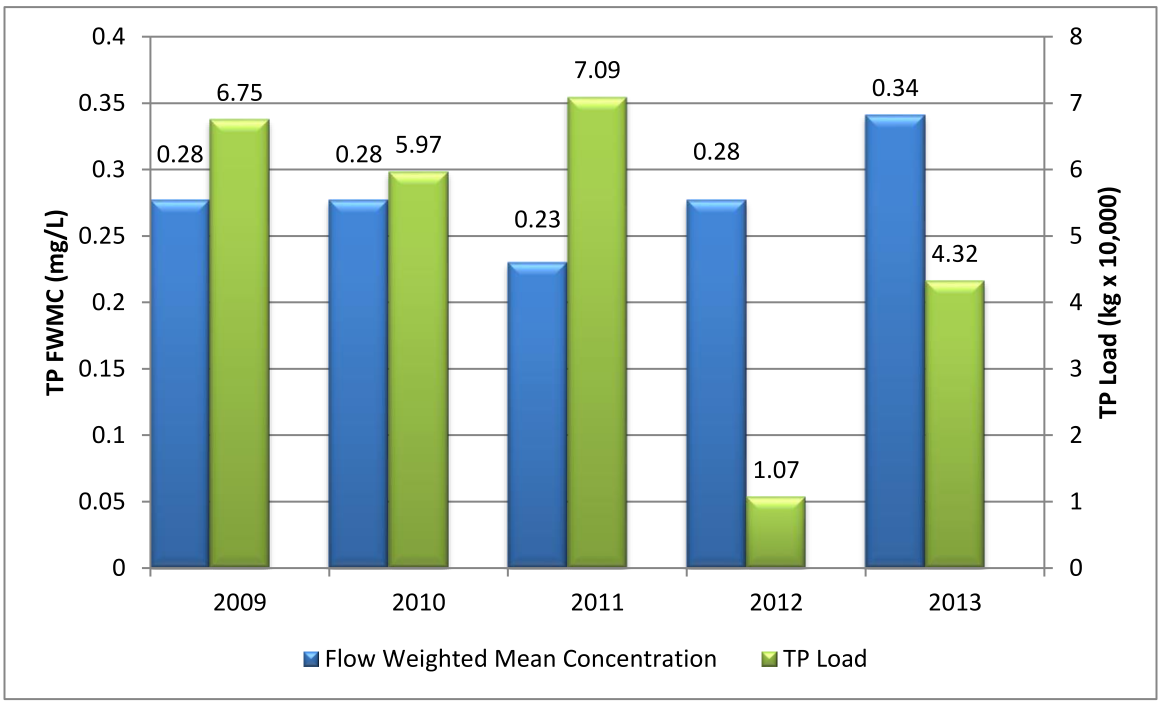


Figure 37. TP FWMCs and Loads for the Snake River near Bigwoods, Minnesota.

Similar to TSS, NO_3+ NO_2-N, and flow, Figure 38 illustrates the majority of the average annual TP load (85%) passes through the system beginning in March and runs through the end of June. Interestingly, 58% of the average annual load is carried through the system during the months of March and April alone, a period largely dominated by snowmelt runoff and spring showers.

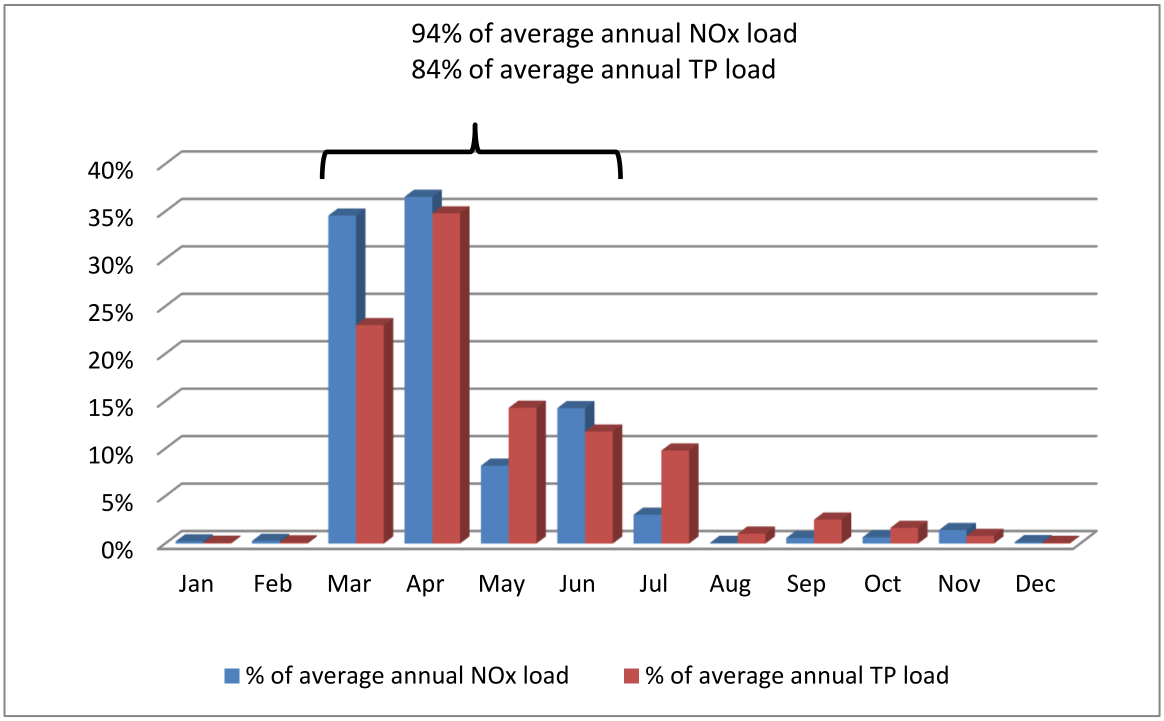


Figure 38. Monthly percentages of the average annual NO3-NO2-N and TP loads for the Snake River near Bigwoods, 2009-2013.

Due to soil frost and snow packed ditches, melt water can be trapped on the landscape for days or weeks at a time allowing for desorption of phosphorus from agricultural soils and plant residue resulting in elevated DOP concentrations. During years with sudden spring thaws, surface soils can also be eroded when surface frost thaws, allowing the transport of sediment bound phosphorus to receiving streams. Further analysis of 151 water quality samples show the month of July to have the highest mean TP concentration at 0.340 mg/L (Table 27), 36% in the form of DOP. The average TP concentration for the other 11 months of the year is about half the July average at 0.179 mg/L, 69% in the form of DOP. Orthophosphate is a form of phosphorus directly available for biological uptake.

Table 27. Mean TP and DOP concentrations during July and the remainder of the year for the Snake River near Bigwoods.

	Mean TP (mg/L)	Mean DOP (mg/L)	DOP/TP ratio
July	0.340	0.184	36%
August-June	0.179	0.123	69%

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 DO) 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 DO and thereby threaten aquatic life (MPCA and MSUM, 2009).

Nitrate-N can also be a common toxicant to aquatic organisms in Minnesota 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. A 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 (warmwater) surface waters is 4.9 mg/L nitrate-N for a four-day duration. In addition, a draft chronic value of 3.1 mg/L nitrate-N (four-day duration) was determined for protection of Class 2A (coldwater) surface waters (MPCA, 2010a).

Infants less than six months old who drink water with high levels of nitrate can become critically ill and develop methemoglobinemia, which is also known as "Blue Baby Syndrome". As such, the MDH has set a standard of 10 mg/L for nitrate in drinking water. For means of this discussion, data comparisons will be limited to MDH Drinking Water Standard.

From a statewide perspective, Figure 38 shows the average annual NO_3+NO_2-N FWMCs to be highest in the southern part of the state. These FWMCs are several times higher than watersheds north of the Twin Cities Metropolitan Area. Watersheds characterized as having low or medium levels of nitrate generally have more land in forest or grasses, more in wetlands, more in small grains, and less land in row crops and tile drainage (MPCA, 2013b).

Figure 39 shows the NO_3+ NO_2-N FWMCs over the five-year period for the Snake River near Bigwoods. FWMCs for the site ranged from 0.47 to 3.1 mg/L over the monitoring period with a 5-year average of 1.3 mg/L. Of the 148 individual samples collected between 2009 and 2013, less than 1% exceeded the nitrate drinking water standard.

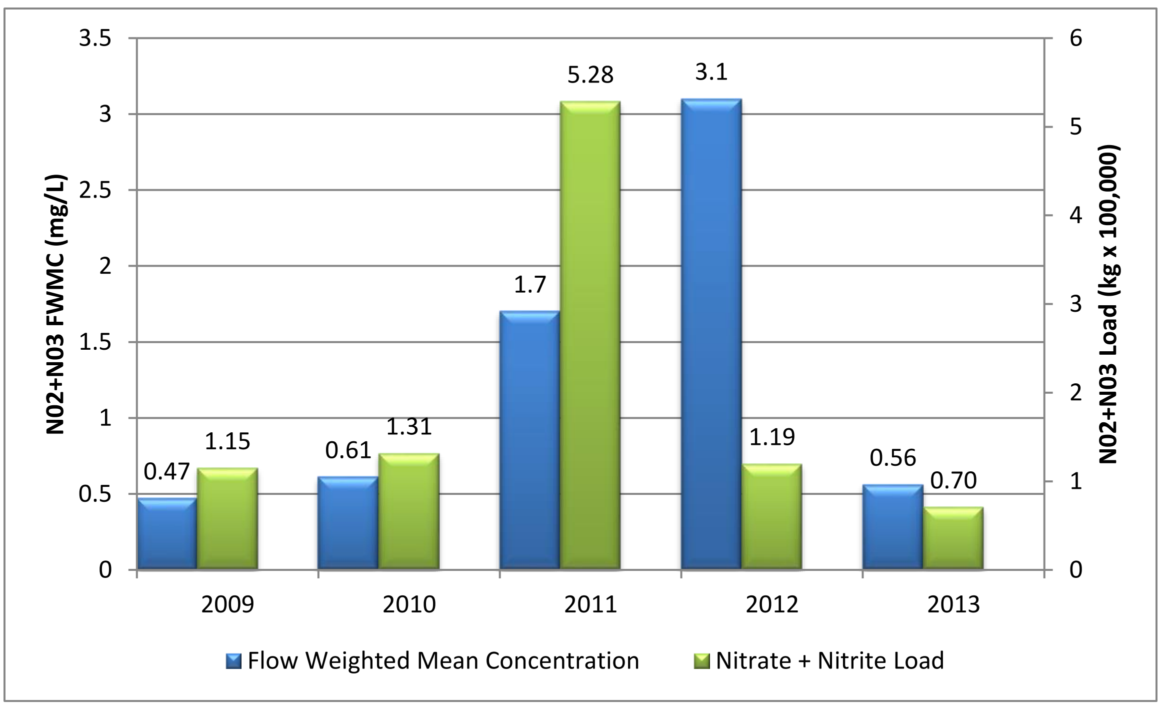


Figure 39. NO3+NO2-N FWMCs and Loads for the Snake River near Bigwoods, Minnesota.

Seasonal NO_3+ NO_2-N load dynamics for the Snake River are similar to TSS, TP and runoff with 94% of the load (Figure 38) passing through the system beginning in March and running through the end of June when vegetative canopy is lacking or in the early stages of development and transpiration rates are low.

Figure 39 shows the influence annual runoff volume has on annual NO_3+ NO_2-N loads. For example, the load associated with the year of the highest runoff volumes (2011), makes up 37% of the entire load over the five-year period.

Stream water quality

Twenty-two of the 39 stream AUIDs were assessed (Table 28), as 17 were either unable to be sampled or had insufficient data for assessment. Of the 22 assessed streams, 11 streams had bacteria data available leaving 11 AUIDs not assessed due to no available data. Throughout the Snake River Watershed, 4 AUIDs support aquatic life and 16 are impaired for aquatic life while 7 are supporting aquatic recreation and 4 are impaired for aquatic recreation.

Table 28. Assessment summary for stream water quality in the Snake River Watershed.

				Supporting		Non-supporting			
Watershed	Area (acres)	# Total AUIDs	# Assessed AUIDs	# Aquatic life	# Aquatic recreation	# Aquatic life	# Aquatic recreation	Insufficient data	# Delistings
09020309 (HUC 8)	**502,400**	**39**	**22**	**4**	**7**	**16**	**4**	**2 AQL, 11 AQR**	**1**
09020309010	139,840	10	6	1	0	4	2	1 AQL, 4 AQR	0
09020309030	55,360	8	1	0	0	1	1	0 AQL, 0 AQR	0
09020309040	77,696	5	3	0	1	2	1	1 AQL, 1 AQR	0
09020309050	62,464	3	4	1	1	3	0	0 AQL, 3 AQR	0
09020309060	50,880	6	3	2	1	1	0	0 AQL, 2 AQR	1
09020309070	75,072	4	3	0	3	3	0	0 AQL, 0 AQR	0
09020309080	41,088	3	2	0	1	2	0	0 AQL, 0 AQR	0

Stream biological monitoring

Fish

Historically, throughout the Red River Basin, there have been 86 different species of fish sampled. Although the Snake River Watershed only encompasses a small portion of the Red River Basin, 43 fish species were sampled during this survey. This watershed does not have any fish species identified by the MNDNR as endangered; however, it does have one threatened species (pugnose shiner) and two species of special concern (least darter and lake sturgeon), none of which were sampled in the Snake River Watershed. The MNDNR has also identified one aquatic invasive species that exist within this watershed, Eurasian watermilfoil.

Some species of fish were found at many sites with high densities, while other species were found at limited sites in low numbers. The most commonly found fish species within the watershed were the fathead minnow and white sucker, which were both sampled at 31 of 34 sites. However, the species sampled in the highest numbers was the common shiner, totaling 4,127 individuals (found at 20 of 34 sites). Other species that were commonly found throughout the watershed included brook stickleback, creek chub, and pearl dace, all of which were sampled at roughly 50% of the sites. A number of species were only sampled at one site and in low numbers such as black crappie, burbot, hornyhead chub, Iowa darter, silver chub, smallmouth bass, and white bass. A list of the species sampled, how many sites each species were sampled at, and the total number of individuals can be found in Appendix 5.

Macroinvertebrates

During macroinvertebrate sampling in the Snake River watershed, 225 unique macroinvertebrate taxa were collected. The Snake River watershed's macroinvertebrate community is subject to a great deal of anthropogenic stress as a result of land use practices. Localized stressors such as low DO, high nutrient levels, excess sediment, stream instability, and lack of permanent flow were common through much of the watershed. The most abundant taxa in the watershed were all tolerant to disturbance including; midges, *Polypedilum* and *Dicrotendipes*, black flies, *Simulium*, a snail, *Physa*, and an amphipod, *Hyalella*. Though the majority of the watershed is dominated by tolerant taxa, there are portions of the watershed that have pockets of more sensitive taxa. These areas were generally associated with less disturbed stream channels and substantial buffers. Some of the notable less tolerant taxa observed included *Gomphus* a dragonfly, *Chimarra* and *Ceraclea* both Caddisflies. A list of species sampled, how many occurrences were observed, and the total number of individuals collected can be found in Appendix 6.

Groundwater quality

The Snake River Watershed is located in northwest Minnesota with three types of aquifers: Cretaceous, buried sand and gravel, and surficial sand and gravel aquifers. A baseline study 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 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 MDA monitors pesticides and nitrate on an annual basis in groundwater across agricultural areas in the state. The Snake River Watershed lies within MDA's Pesticide Monitoring Region (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 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 MCL for drinking water of 10 micrograms per liter. In northwest Minnesota, the majority of new wells are within the water quality standards for arsenic levels, but there are some exceedances (Figure 40).

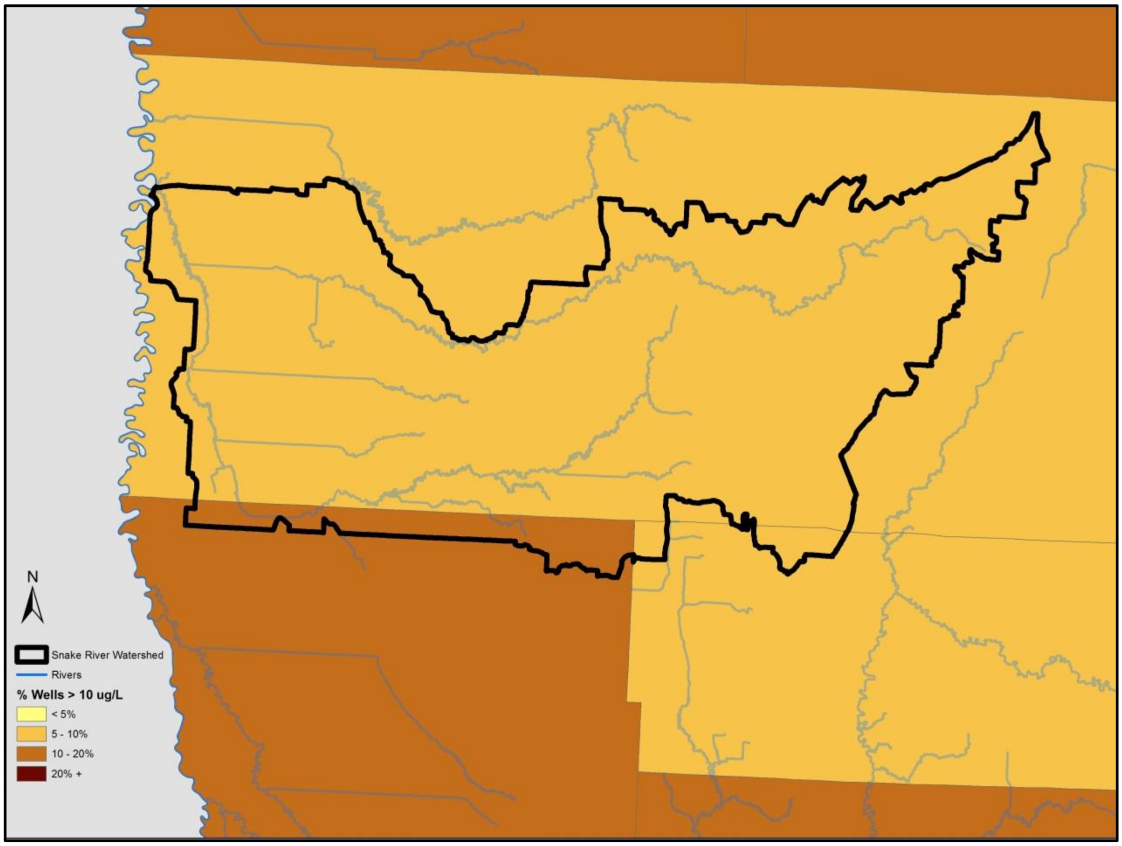


Figure 40. Arsenic occurrence in new wells in Snake River Watershed Area (2008-2012) (Source: MDH, 2012).

Groundwater quantity

Monitoring wells from the MNDNR 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.

Two MNDNR Observation Well (45006 and 57008) located in the Snake River Watershed were chosen based on data availability and geologic location within the watershed. The observation wells do not exhibit a statistically significant trend in groundwater elevation change Figure 41 and Figure 42.

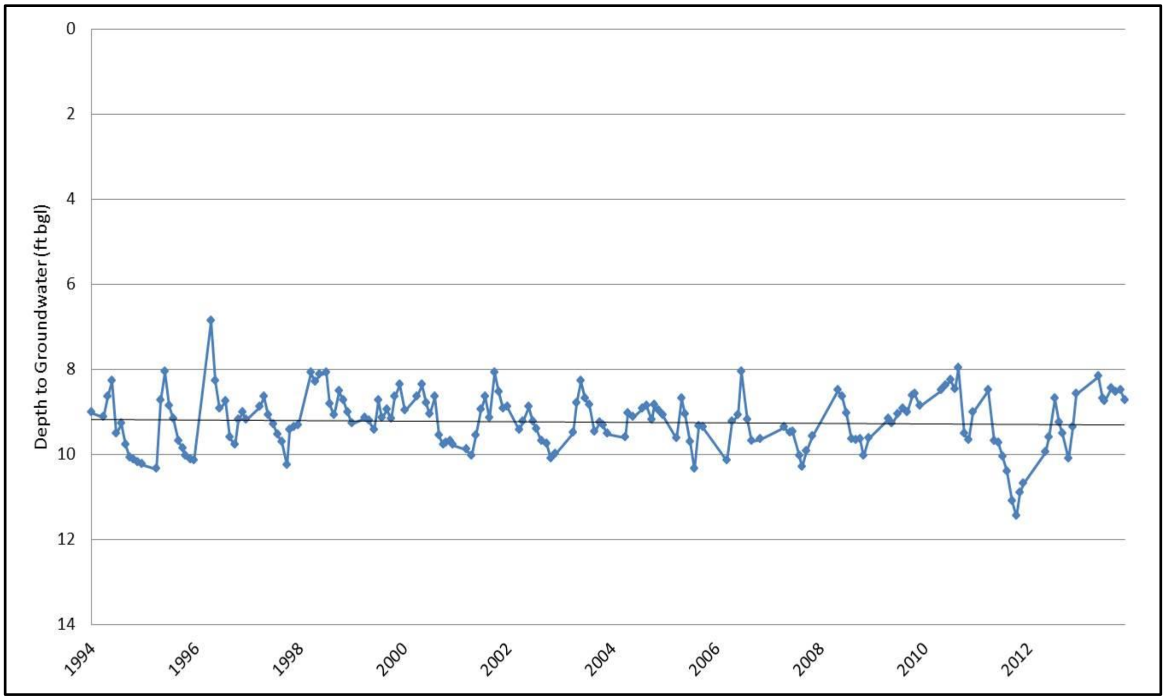


Figure 41. Observation Well 45006, located in the central part of the Snake River Watershed near Alma, Minnesota (1994-2014).

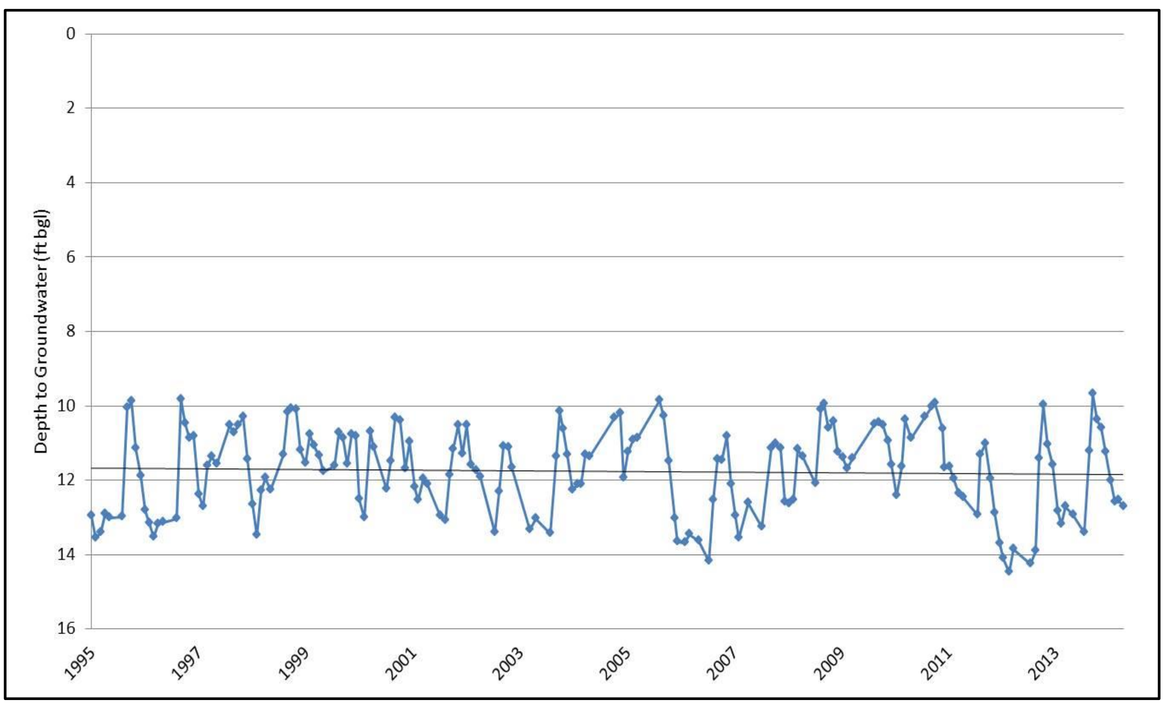


Figure 42. Observation Well 57008, located in the southeastern part of the Snake River Watershed near Thief River Falls, Minnesota (1995-2014).

High-capacity withdrawals

The MNDNR 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 MNDNR 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 MNDNR 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 groundwater resources.

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

Groundwater (blue diamonds) and surface water (red square) withdrawal locations from 1991-2011 are displayed in Figure 43 below. Figure 44 displays total groundwater and surface water withdrawals within the watershed during the same timeframe. During this time period within the Snake River Watershed, groundwater withdrawals exhibit a significant rising trend (p=0.01) while surface water withdrawals exhibit no trend.

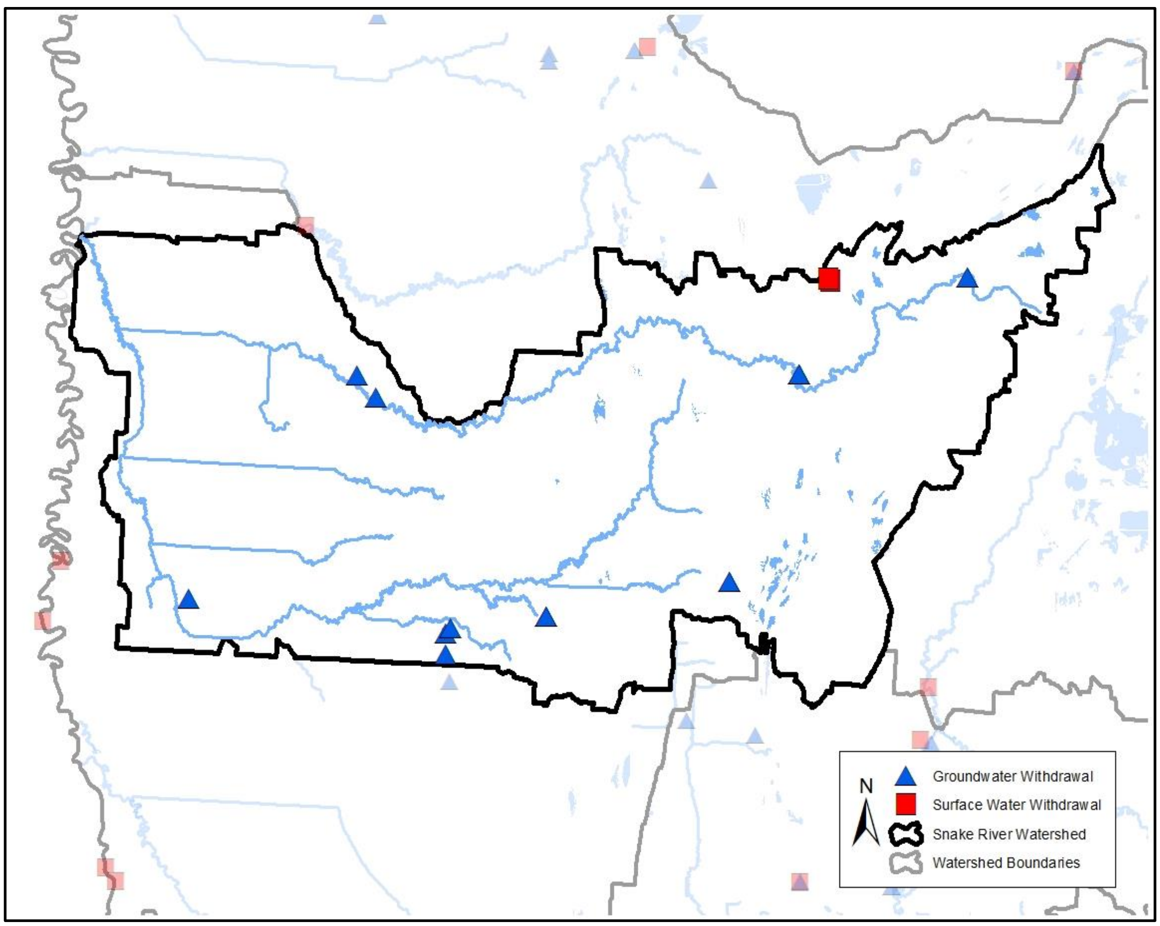


Figure 43. Locations of permitted groundwater withdrawals in the Snake River Watershed.

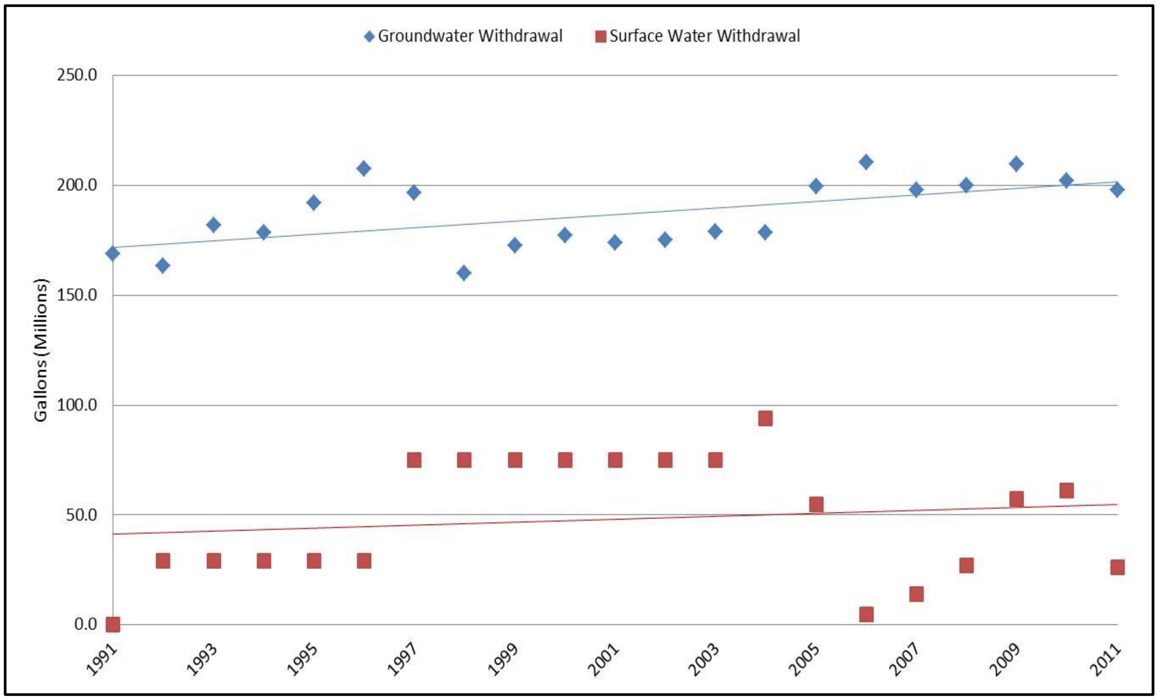


Figure 44. Total annual groundwater and surface water withdrawals in the Snake River Watershed (1991-2011).

Stream flow

Figure 45 and Figure 46 display mean annual discharge for the Middle River from 1993-2013 and mean monthly discharge for the months of July and August over the same time period. Analysis of both datasets indicates there is no significant trend in discharge.

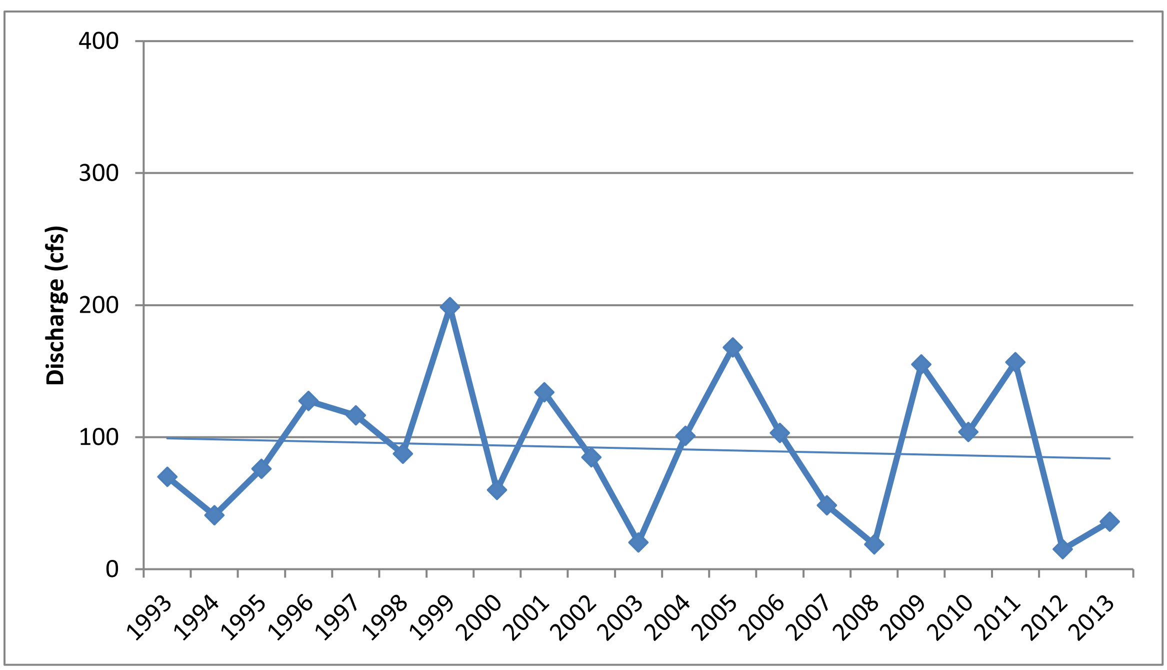


Figure 45. Mean annual discharge, Middle River (1993-2013).

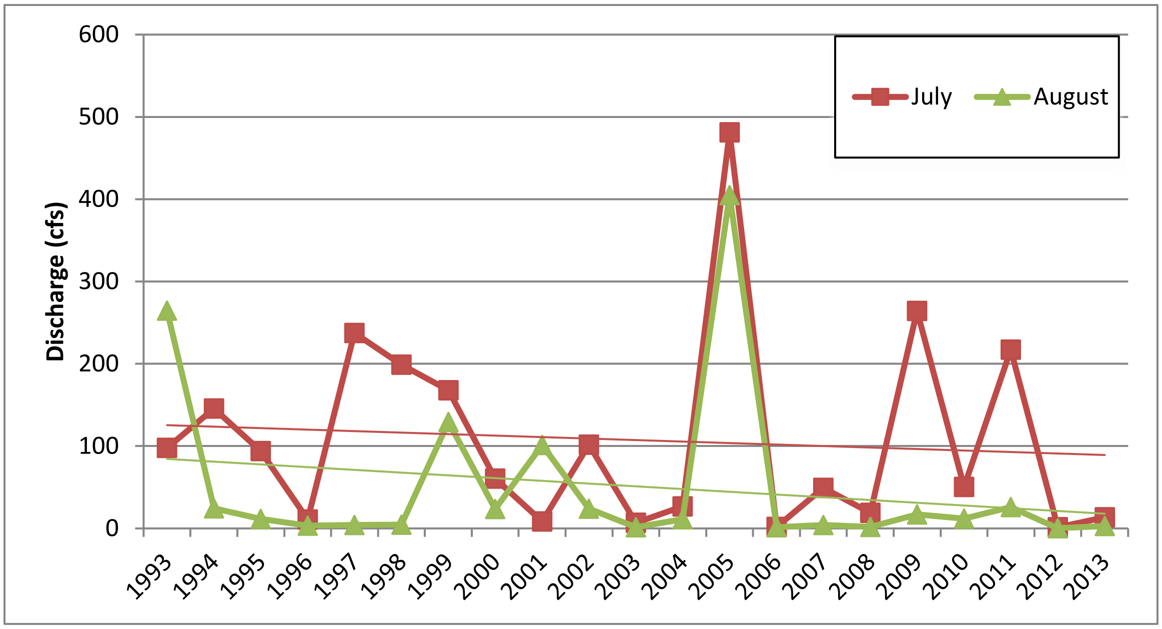


Figure 46. Middle River - mean Annual and July/August discharge measurements (1993-2013).

Wetland condition

Currently, wetlands are relatively uncommon in the Snake River Watershed. National Wetlands Inventory (NWI) data estimates 26,957 acres of wetland—which is approximately 5% of the watershed area (Figure 47). This wetland extent is well below the state wetland coverage rate of 19% and slightly below the 6% rate for the Temperate Prairies Ecoregion (Kloiber and Norris 2013; MPCA, 2015). The predominant wetland type present in the watershed is the Emergent wetland class (i.e., dominated by grasses, sedges, bulrushes, and/or cattails) which comprises roughly 61% of the wetlands in the Snake River Watershed).

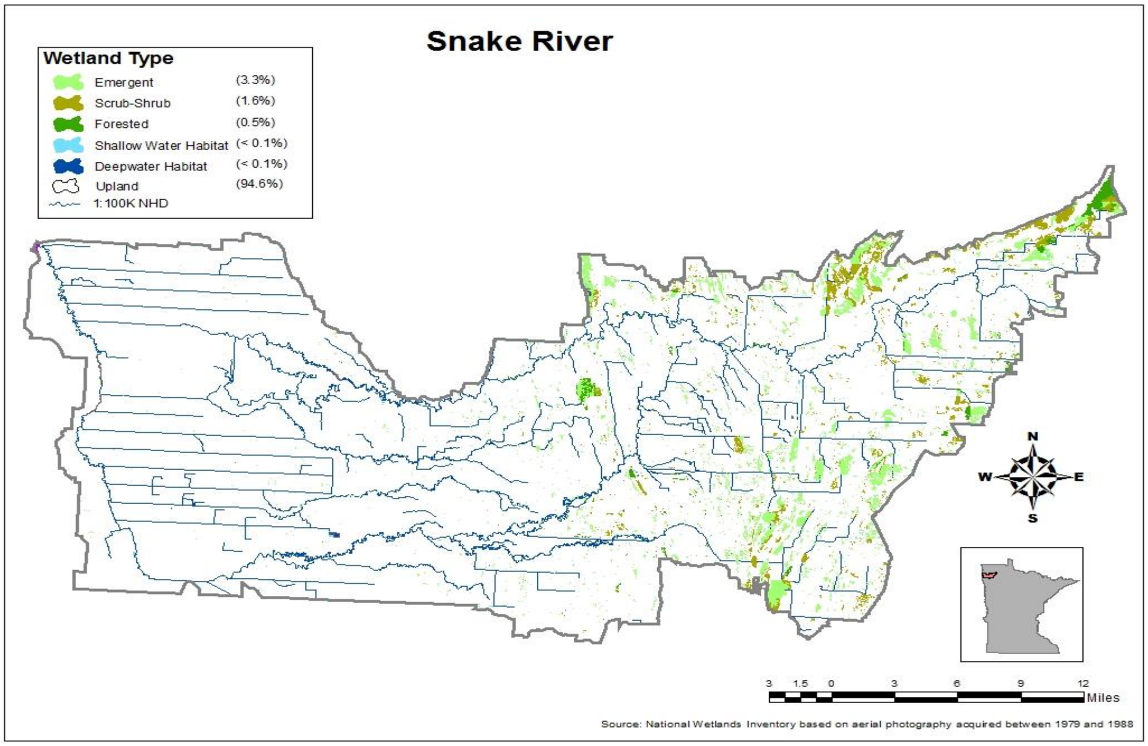


Figure 47. Wetlands and surface water in the Snake River watershed. Wetland data are from the National Wetlands Inventory.

Prior to European settlement, wetlands were much more prevalent in the Snake River Watershed. As wetland soil features persist after artificial drainage, soil survey data can be used to estimate historical wetland extent. Mapped Poorly and Very Poorly drained soil drainage classes (which would typically support wetlands if not artificially drained) equal 307,514 acres—or approximately 62% of the watershed. Comparing that total to the current NWI estimate reveals that approximately 91% of the historical wetland extent has been lost. The remaining wetlands are not distributed evenly, with the majority located in the eastern (or upper) half of the watershed (Figure 47). The Upper Middle River and Snake River, South Branch (New Channel) Subwatersheds have historical loss rates between 75% – 90%; whereas, all of the subwatersheds in the western (or lower) half of the watershed have loss rates > 90% (Figure 48). The Lower Snake River Subwatershed (which is located on the lowest plain of the Red River Valley) has an estimated historical wetland loss rate of > 99%.

Two glacial landforms are present in the Snake River Watershed (MNGS 1997) that have largely dictated the current wetland extent patterns; as well as, the kinds of hydrogeomorphically (HGM) (Smith et al. 1995) functioning wetland types that are currently (or were once) present. The western half 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 (and more recently subsurface tile drainage) to increase agriculture production. Two relatively narrow bands (approximately five to eight miles in width) of sand and gravel glacial lake beach ridges that were formed on the shores of Glacial Lake Agassiz at various stages of lake depth run north-south through the watershed. The western most beach ridge occurs at the approximate east-west midpoint of the watershed. The other beach ridge forms upper (easternmost) portion of the watershed. A glacial lake plain occurs in between the two beach ridges. The majority of the remaining wetlands in the watershed occur amongst these beach ridges (Figure 47)—where agriculture and drainage is less practical. Wetlands occur where water accumulates behind down-gradient ridges or in shallow depressions between ridges (i.e., depressional HGM wetland type); as well as, in areas on the ridge slopes where groundwater discharge saturates the soil surface and peat accumulates (slope HGM wetland 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) and two known-state designated calcareous fens occur in the watershed, on the westernmost beach ridge.

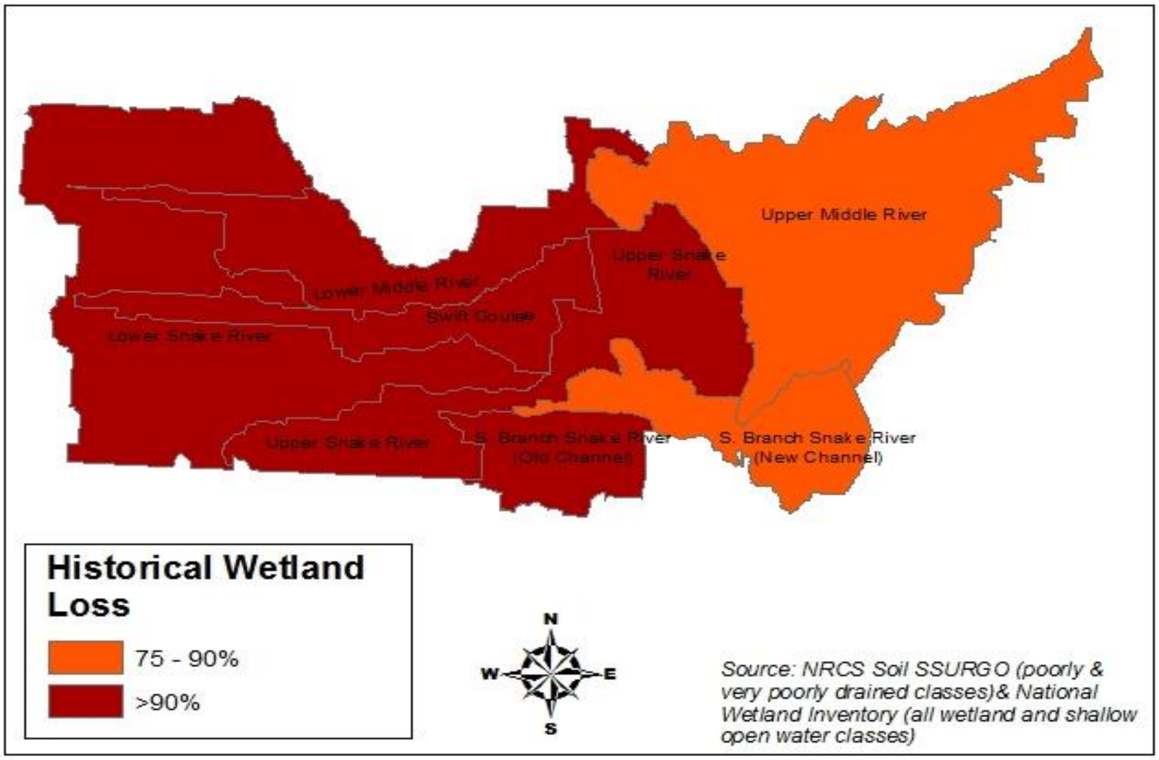


Figure 48. Historical wetland loss by sub-watershed in the Snake River Watershed.

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 IBIs to monitor the macroinvertebrate condition of depressional wetlands that have open water and the Floristic Quality Assessment (FQA) to assess vegetation condition in all of Minnesota 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. Probabilistic survey results may provide a reasonable approximation of the current wetland quality in the watershed. As few open water depressional wetlands exist in the watershed due to the lake plain and beach ridge geomorphology and drainage history, the focus will be on vegetation quality results of all wetland types.

Wetland vegetation quality is high in Minnesota (Table 29)—with approximately 67% of the total wetland extent in exceptional-good condition statewide. Wetlands in exceptional-good condition have had few (if any) changes in expected native vegetation composition or abundance distribution. The high rates of exceptional-good condition 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.

Table 29. 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%

The Snake River 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 29)—with 82% of wetlands having fair-poor condition. Plant communities assessed as fair-poor 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 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 either of these non-native invasives (MPCA 2015). Given the ecoregion results, it is very likely that the vegetation quality of the few remaining wetlands in the Snake River Watershed is predominantly in a degraded state.

Pollutant trends for the Snake River Watershed

Table 30. Snake River at bridge on MN-200 N of Bigwoods (S000-185) (SK-1.8) (period of record 1971-2010).

	TSS	TP	Nitrate	Nitrite/ Ammonia	BOD	Chloride
Overall trend	No trend	Decrease	No trend	Decrease	Decrease	No trend
Estimated average annual change		-0.7%		-5.3%	-1.7%	
Estimated total change		-24.0%		-88.0%	-49.0%	
1995 - 2010 trend	No trend	Decrease	No trend	No trend	No trend	Decrease
Estimated average annual change		-1.3%				-4.80%
Estimated total change		-22.0%				-60%
Median concentrations first 10 years	47	0.3	<0.01	0.25	4	22
Median concentrations most recent 10 years	70	0.3	<0.05	<0.05	2	14

(Analysis was performed using the Seasonal Kendall Test for Trends. Trends shown are significant at the 90% confidence level. Percentage changes are statistical estimates based on the available data. Actual changes could be higher or lower. A designation of "no trend" means that a statistically significant trend has not been found; this may simply be the result of insufficient data).
(Concentrations are median summer (Jun-Aug) values, except for chlorides, which are median year-round values. All concentrations are in mg/L.).

Water clarity trends at citizen monitoring sites

MPCA CSMP has volunteer data available from only one stream, Swift Coulee, in the Snake River Watershed. Water clarity has shown no trend at the Swift Coulee citizen monitoring site S001-598. Important to note, the River Watch Citizen Monitoring Program (in partnership with IWI) is conducted throughout the Red River Basin. This citizen program also has water chemistry data available from streams and ditches within this watershed. Information on these sites can be found at http://riverwatch.wq.io/.

Table 31. Water clarity trends at citizen stream monitoring sites.

Snake River HUC 09020309	**Citizen Stream Monitoring Program**
Number of sites w/ increasing trend	0
Number of sites w/ decreasing trend	0
Number of sites w/ no trend	1

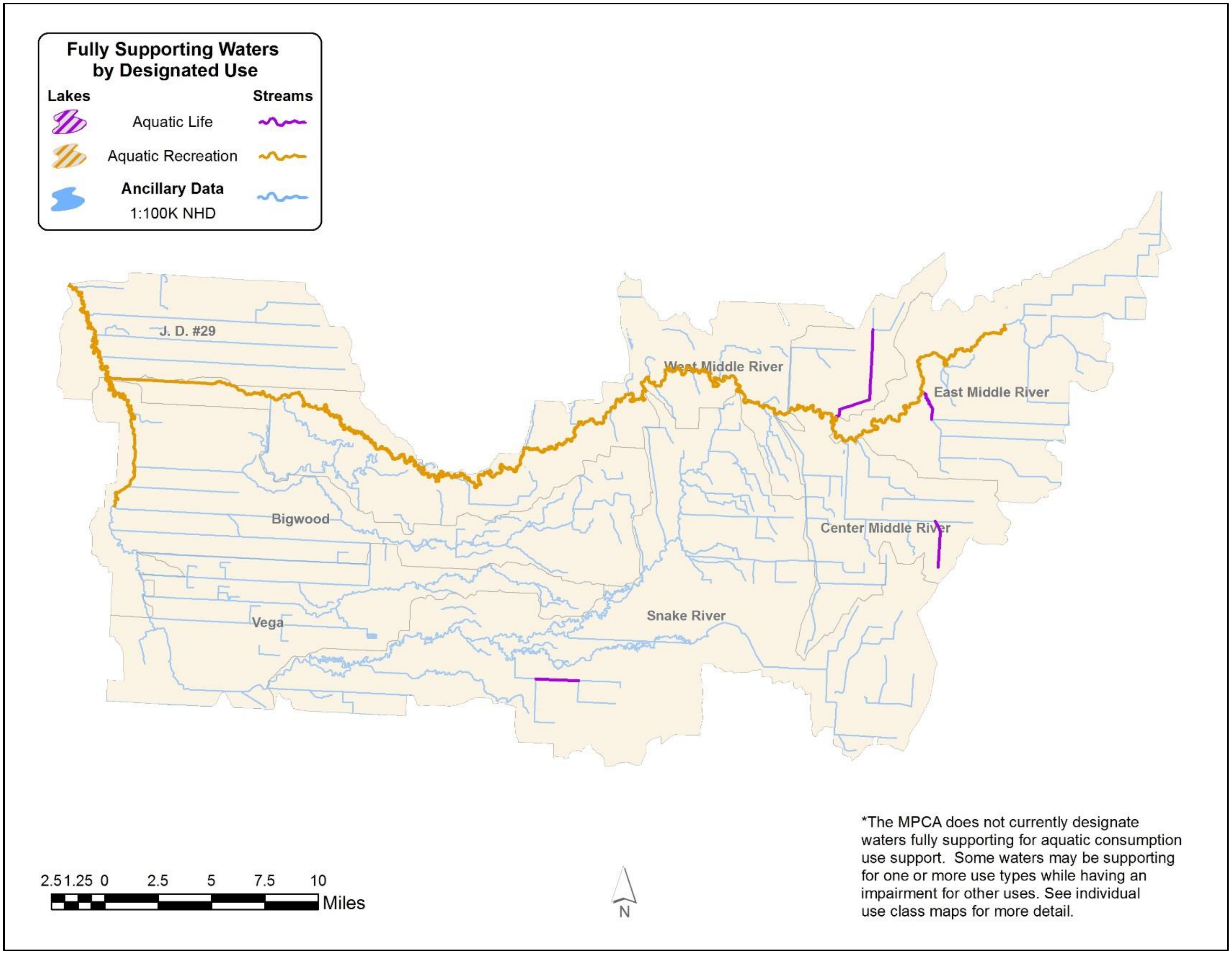


Figure 49. Fully supporting waters by designated use in the Snake River Watershed.

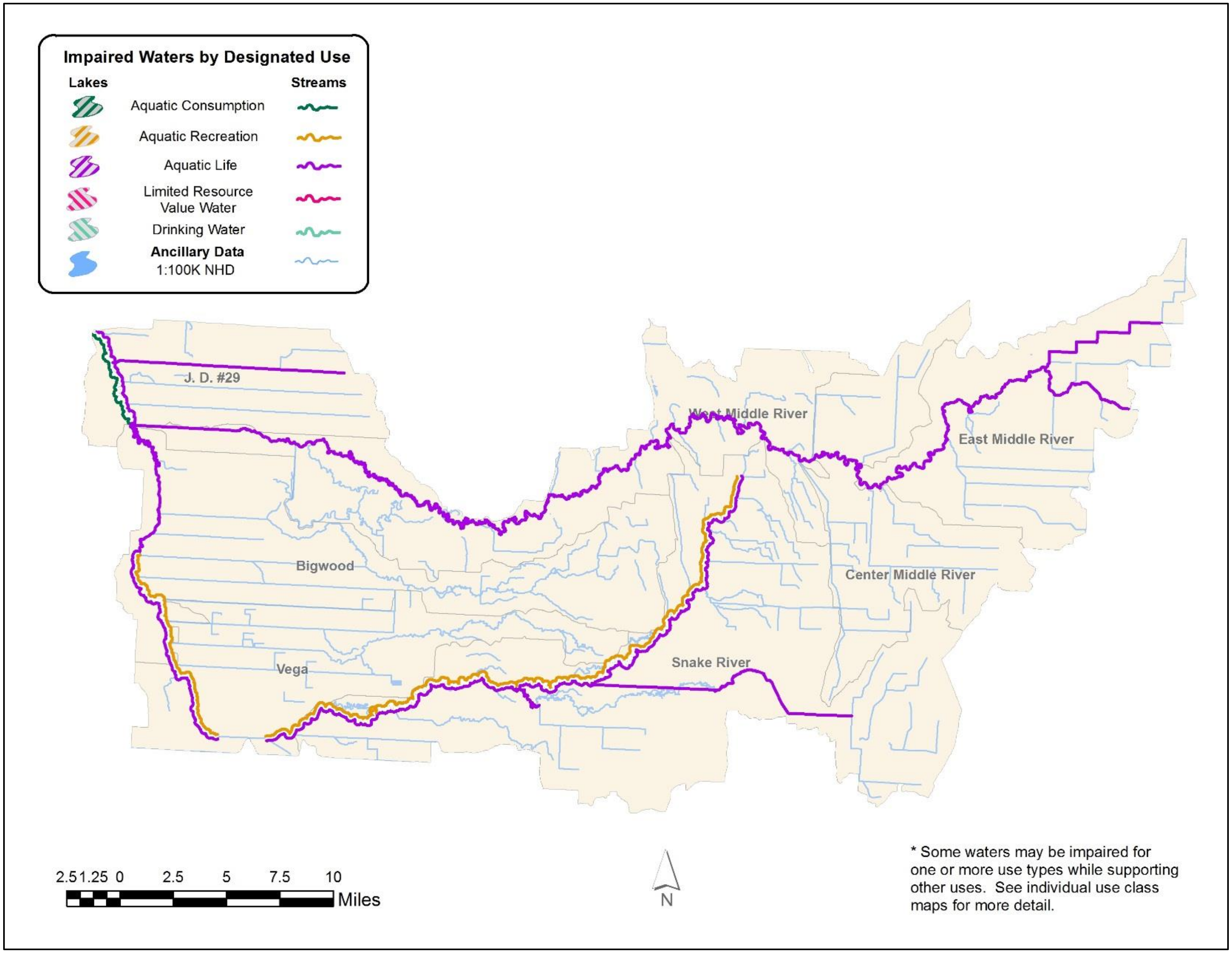


Figure 50. Impaired waters by designated use in the Snake River Watershed.

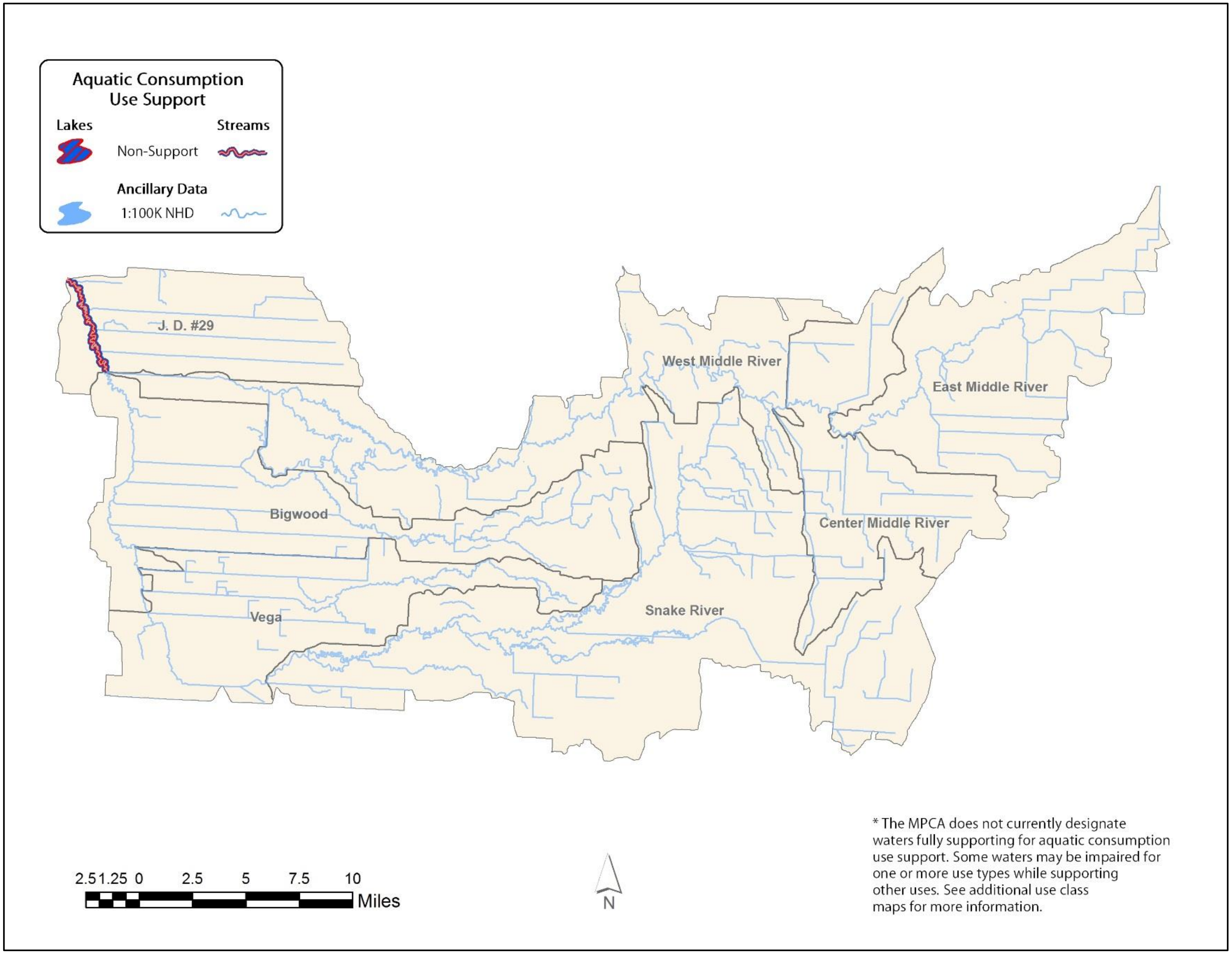


Figure 51. Aquatic consumption use support in the Snake River Watershed.

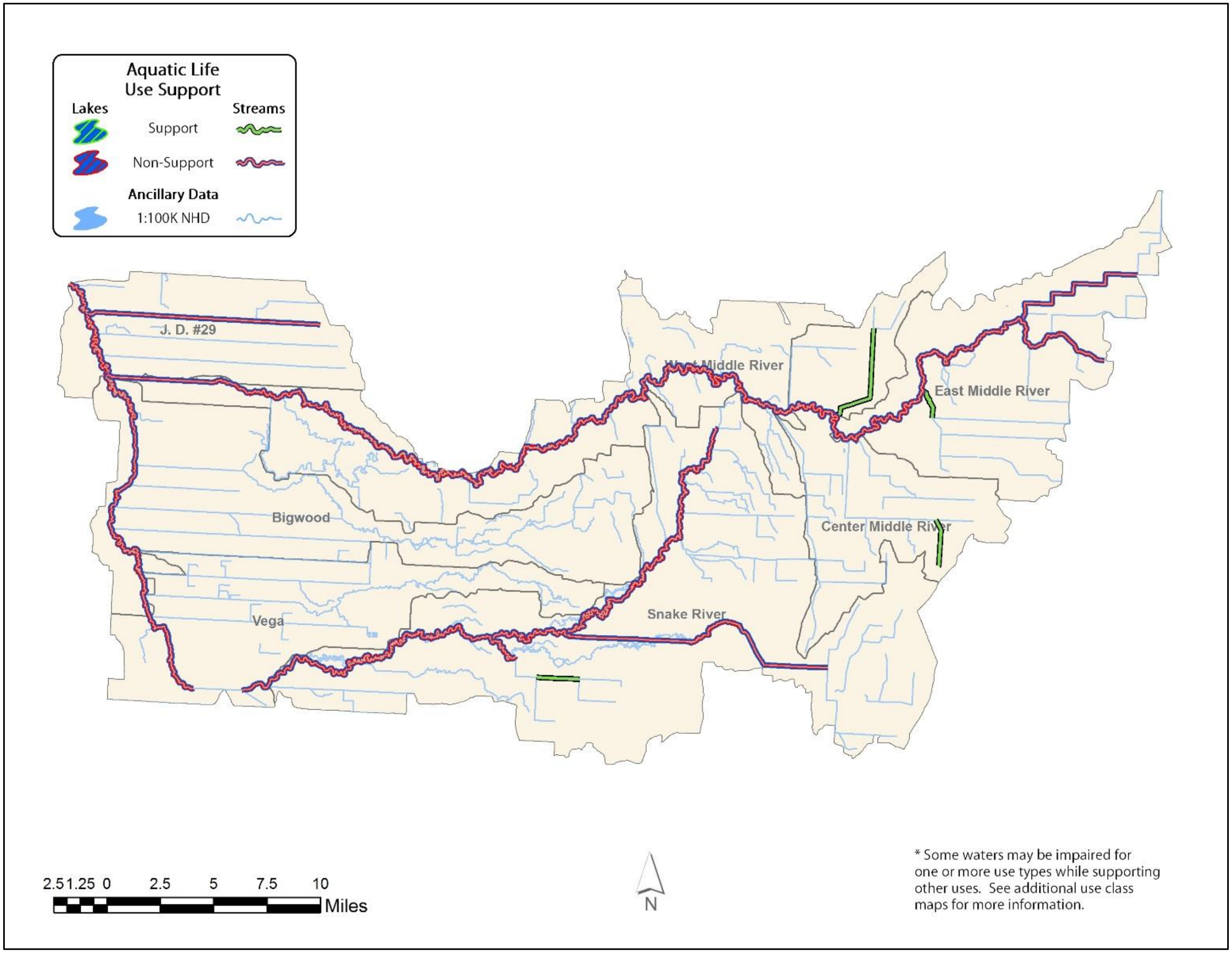


Figure 52. Aquatic life use support in the Snake River Watershed.

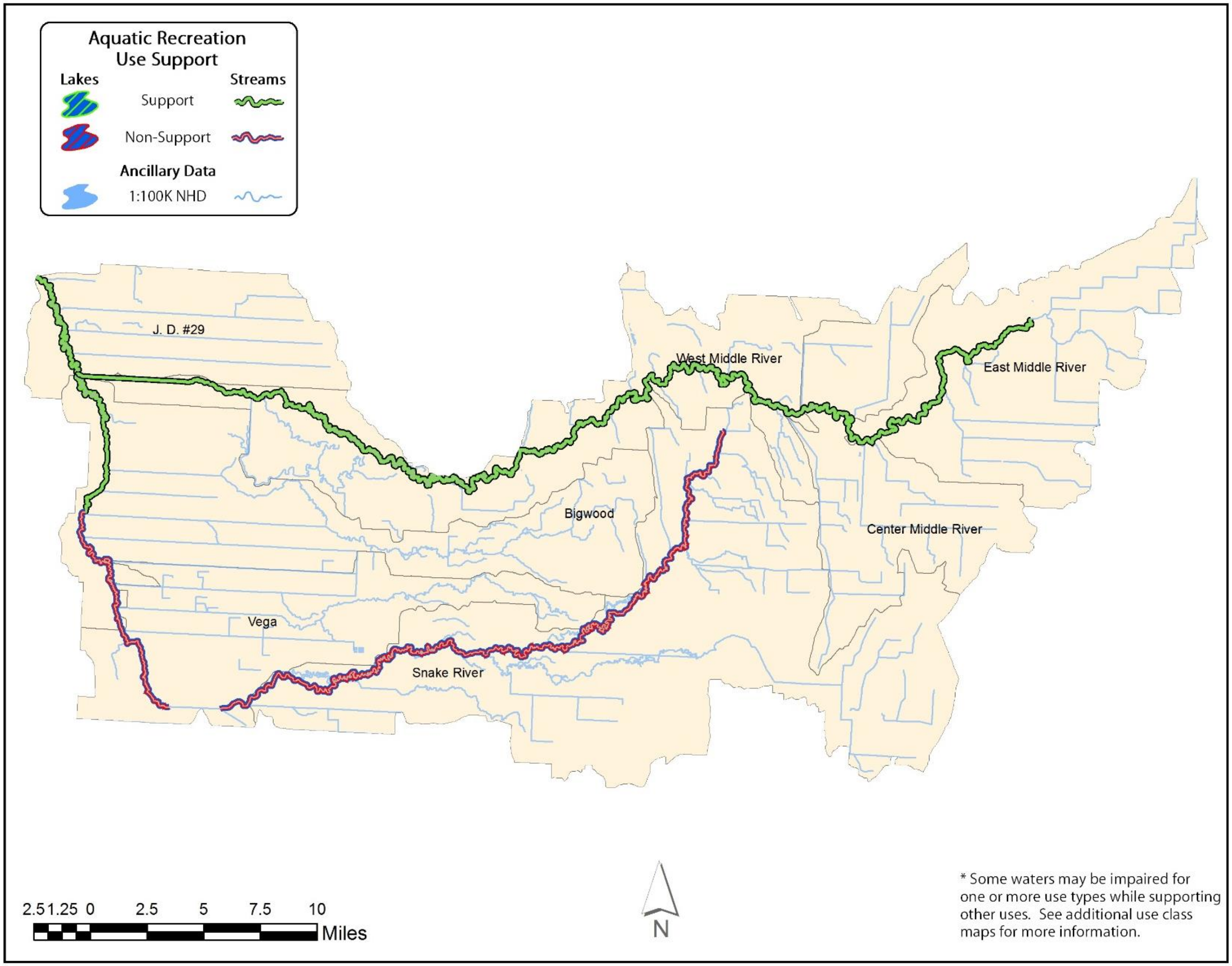


Figure 53. Aquatic recreation use support in the Snake River Watershed.

VII. Summaries and recommendations

Although the Snake River Watershed consists of scattered woodland and wetland areas near the headwaters, these areas are nearly completely absent throughout the remainder of the watershed. Outside of tree lined banks along rivers and streams, the watershed is dominated by cropland and rangeland commonly combining to make up over 80% of individual HUC-11 watersheds. Due to the high degree of channelization, inadequate riparian buffers, and high levels of water discharge, many of the streams in the watershed have become destabilized. As a result, dramatic fluctuations of water levels are leading to high erosion rates along stream banks, loss of coarse substrate, and poor water quality (e.g., high TSS).

As a result of the channel manipulation, flow regimes, and intensive land use within the watershed, eight AUIDs on the Snake and Middle Rivers are not meeting the state's turbidity standard. Although present in upstream portions of the watershed, the turbidity impairments increase drastically in the downstream two-thirds of the watershed where additional water from ditched tributaries is overwhelming both rivers. The upstream stations on these rivers both have bottom substrates consisting of sand and gravel with scattered cobble and boulders throughout. However, shortly downstream the erosion increases which coincides with bottom substrates transitioning to clay and silt and any coarse substrate being embedded under the fine sediments or completely absent. These habitat factors often coincided with the fish communities as well. In areas where coarse substrates and less turbid waters were present, a higher abundance of riffle dwelling and lithophilic spawning species (i.e., blackside darter and blacknose dace) were generally found. In downstream sections of these streams where coarse substrate was absent and turbidity concentrations increased, the concentration of tolerant species increased (i.e., common carp and bigmouth buffalo).

In addition to the increased turbidity, DO concentrations are also an area of concern as 10 AUIDs were exceeding the state DO standard. Concentrations were extremely variable, ranging between 0.85 mg/L and 15.38 mg/L, with most HUC-11 subwatersheds dipping below 3.3 mg/L and exceeding 11 mg/L. The high DO fluctuations are indicative of nutrient enriched stream systems. The nutrients form algae that contribute to high DO levels during the day and low levels over night. The highly variable DO levels are likely also having a negative effect on the fish communities as many fish species can be sensitive to such low concentrations of DO, specifically for extended periods of time.

Habitat within the watershed varied depending on the stream as well as the station location on those streams. The ditches and tributaries feeding into the major waterways had poor habitat (average MSHA score of 45), specifically for channel morphology (due to channelization) and cover. The habitat on the Snake River mainstem was poor as a whole (average score 44) and declined from upstream to downstream. The upstream stations scored highly for substrate, cover, and channel morphology however downstream of 93RD416 near Warren, erosion rates increase, coarse substrates begin to disappear, and MSHA scores begin to decline. From this location downstream, MSHA scores are specifically poor for substrate and cover. In addition to high sediment concentrations, flows increase to such high levels that much of the available cover with the system (i.e., wood and vegetation) are flushed downstream. The Middle River and Snake River, South Branch (both old and new) scored fair for habitat with higher concentrations of coarse substrates (specifically towards their headwaters), good channel morphology, as well as more abundant fish cover. The only consistent scoring attribute in the watershed was land use which scored poorly at nearly every site.

In addition to habitat, it is possible that flow instability (particularly in headwater areas) had a large effect on the biological communities as well. Locations existed where fair to good habitat was present during early summer fish samples but the stream was dry during the late summer macroinvertebrate sampling period. Although fish can migrate downstream to avoid areas with depleting water levels, the areas they migrate to may not be ideal living conditions. These areas may not provide spawning habitat and/or areas to escape from high flows or predation. Macroinvertebrates however, cannot as easily escape the receding water levels. Many macroinvertebrate species do not have the ability to migrate and thus are forced to live in very little water or if the stream goes completely dry, these organisms often end up perishing from the conditions. Unfortunately, the lack of consistent flow in many systems within the watershed negates the positive habitat attributes some stream may have. The effects of inconsistent flows were seen in both fish and macroinvertebrates as where streams went dry or had very little water, species compositions were often comprised of mostly tolerant species.

Dams are a large component of hydrology which can both positively and negatively impact waterways. Dams can create recreational opportunities such as areas for fishing and camping and can also aid in water storage and flood control. Conversely, dams can also restrict water flow to downstream areas, create impoundments upstream, alter stream flow and water quality, and prevent fish passage, among other impacts. Certain species of fish migrate upstream to reach suitable spawning habitat; however, dams create barriers which restrict fish from reaching these areas. Within the Snake River Watershed there is one dam located on the Snake River just upstream of Warren. During high flows this dam diverts the rivers natural flow into a man-made channel which flows around town. In addition, there is also an off channel storage area upstream which fills with water from the Snake River when flows are high. Both of these are discussed within the Snake River Subwatershed summary. Two previously existing dams have been removed within this watershed, both on the Middle River and are discussed in the West Middle River Subwatershed summary. Aerial photos also show several areas on the Middle River where fish passage may be prohibited such as rock dams, private culverts, and private “crossings” which are discussed in the subwatershed summaries. These areas should be investigated to determine their effect on flow and fish passage. Lastly, natural dams (i.e., beaver dams) can also have negative impacts on waterways similar to man-made dams. Several waterways within this watershed have beaver impoundments that are clearly affecting the flow regime of the streams and may hamper fish migration.

The high volumes of sediment found within the Snake River Watershed pose negative impacts to not only the river’s aesthetic and recreational aspects, but also to downstream waters and the biological communities that reside there. In order to reduce turbidity concentrations and possibly bring them back into compliance with the state standard, considerable measures must be taken on a watershed wide scale to stabilize stream flows as well as improve the instream habitat and riparian buffers.

The primary concerns for groundwater within the watershed are preserving areas of groundwater recharge, and naturally-occurring arsenic in drinking water. The geology of the watershed limits recharge to areas of topographic highs and those with surficial sand and gravel deposits. With regard to arsenic, the MDH is continually monitoring arsenic in drinking water supplies and in all new wells. Groundwater supply and its potential impacts on surface water bodies can be tracked by two MNDNR efforts; the cooperative stream gauging effort to define trends in flow, and annual reporting of high-capacity withdrawals to determine if and how they change over time.

Examples of actions that could help improve the issues listed above include:

- Establish or repair riparian zones using native vegetation and/or trees
- Protect any current riparian buffer zones and quality stream habitat
- Establish best management practices to improve current sedimentation and erosion issues and to prevent additional sedimentation
- Reduce and/or limit the amount of channelization, drainage, and tiling occurring within the watershed
- Reduce the amount of agricultural runoff and livestock access to streams

- Improve fish and macroinvertebrate habitat within the waterways
- Protect current waterways with existing good stream habitat
- Evaluate dam near Warren, small rock dams, and private culverts and crossing locations and possible negative effects on fish/macroinvertebrate communities
- Install DO meters at the site locations that had excess or insufficient amounts of DO to compare night concentrations
- Continued monitoring to evaluate and document declining or improving conditions

Progress is currently being made to complete a watershed-wide TMDL and Water Restoration and Protection Strategy, with an anticipated completion date of early 2016. The TMDL will primarily focus on the ongoing turbidity and DO impairments within the watershed. Since over 80% of the watershed is agricultural lands and nearly all sources of suspended sediment are from runoff and erosion, the TMDL will focus on the reduction of runoff to waterways. The TMDL should incorporate additional monitoring along the Snake and Middle Rivers, to monitor potential downstream effects of mitigations efforts that will be installed on the landscape in the future as a result of TMDL implementation activities.

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Appendix 1 - Water chemistry definitions

Dissolved oxygen (DO) - Oxygen dissolved in water required by aquatic life for metabolism. DO enters into water from the atmosphere by diffusion and from algae and aquatic plants when they photosynthesize. DO 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 does air temperature.

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

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

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

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

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

Unnionized Ammonia (NH_3) - 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 Snake River Watershed

Biological station ID	STORET/ EQuIS ID	Waterbody name	Location	HUC-11
13RD004	S004-214	Snake River	Snake River at CSAH21, 5 mi W of Warren	09020309010
13RD006	S004-142	Snake River	Snake River at MN1 in Alvarado	09020309030
13RD007	S003-692	Snake River	Snake River at CSAH17, 12 mi W of Argyle	09020309040
13RD001	S004-106	Middle River	Middle River at CSAH28, 0.5 mi E of Newfolden	09020309050
13RD002	S007-440	Middle River	Middle River at 150th Ave NW, 2 mi NW of Newfolden	09020309060
13RD008	S003-691	Middle River	Middle River at CSAH17, 12 mi W of Argyle	09020309070
13RD009	S000-185	Snake River	Snake River at MN220, N of Bigwoods	09020309080

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

				USES				WATER QUALITY STANDARDS								
								Aquatic life indicators							Aquatic recreation indicators	
Assessment Unit ID (AUID)	**Stream reach name**	**Reach description**	**Reach length (miles)**	**Use class**	**Aquatic life**	**Aquatic recreation**	**303(d) listed impairments year**	**Fish**	**Macroinvertebrates**	**DO**	**TSS**	**Chloride**	**pH**	**NH_3**	**Bacteria**	**Nutrients**
HUC 11: 09020309010(Snake River Subwatershed)																
09020309-543	Snake River	Unnamed Creek to S Br Snake River	29.09	WWg	IMP	IMP	2008	EX	EX	IF	IF	MTS	MTS	MTS	EX	-
09020309-546	Snake River, South Branch (new channel)	Headwaters to Snake River	14.6	WWg	IMP	NA		EX	MTS	IF	IF	-	IF	IF	-	-
09020309-544	Snake River, South Branch (old channel)	Unnamed Ditch to Snake River	2.63	WWg	IMP	NA		EX	EX	IF	IF	-	IF	IF	-	-
09020309-504	Snake River	S Br Snake River (old channel) to Cty Ditch 7	22.88	WWg	IMP	IMP	2002/2008	EX	EX	IF	EX	MTS	MTS	MTS	EX	

				USES				WATER QUALITY STANDARDS								
								Aquatic life indicators							Aquatic recreation indicators	
Assessment Unit ID (AUID)	Stream reach name	Reach description	Reach length (miles)	Use class	Aquatic life	Aquatic recreation	303(d) listed impairments year	Fish	Macroinvertebrates	DO	TSS	Chloride	pH	NH_3	Bacteria	Nutrients
09020309-518	Unnamed Ditch	Unnamed Ditch to S Br Snake River	2.01	WWm	SUP	NA		-	MTS	IF	IF	IF	IF	IF		-
09020309-514	Unnamed Ditch	Unnamed Ditch to S Br Snake River	2.01	WWg	NA	NA		-	-	MTS	MTS	-	MTS	-	-	-
HUC 11: 09020309030(Vega Subwatershed)																
09020309-537	Snake River	T154 R49W S17 east line to Cty Ditch 3	14.91	WWg	IMP	IMP	2008	EX	EX	IF	IF	MTS	MTS	MTS	EX	-
HUC 11:09020309040 (Bigwood Subwatershed)																
09020309-537	Snake River	T154 R49W S17 east line to Cty Ditch 3	14.91	WWg	IMP	IMP		EX	EX	IF	IF	MTS	MTS	MTS	EX	-
09020309-502	Snake River	County Ditch 3 to Middle River	11.16	WWg	IMP	SUP	2010	EX	EX	EX	EX	MTS	MTS	MTS	MT S	-

				USES				WATER QUALITY STANDARDS								
								Aquatic life indicators							Aquatic recreation indicators	
Assessment Unit ID (AUID)	Stream reach name	Reach description	Reach length (miles)	Use class	Aquatic life	Aquatic recreation	303(d) listed impairments year	Fish	Macroinvertebrates	DO	TSS	Chloride	pH	NH_3	Bacteria	Nutrients
09020309-511	Swift Coulee (County Ditch 3)	Headwaters to Snake River	27.31	WWg	IF	NA		-	-	IF	MTS	-	IF	IF	-	-
HUC 11: 09020309050(East Middle River Subwatershed)																
09020309-529	Unnamed Ditch	Unnamed Ditch to Middle River	7.59	WWm	IMP	NA		MTS	EX	IF	IF	-	IF	IF	-	-
09020309-539	Middle River	96.1710 48.4349 to Cty Rd E36114	37.91	WWg	IMP	SUP	2008	MTS	MTS	IF	IF	MTS	MTS	MTS	MTS	-
09020309-538	Middle River	Headwaters to 96.171 48.4349	6.82	WWm	IMP	NA		EX	-	IF	IF	-	IF	IF	-	-
09020309-534	Unnamed Ditch	Unnamed Ditch to Middle River	1.55	WWg	SUP	NA		MTS	MTS	IF	IF	-	IF	IF	-	-

				USES					WATER QUALITY STANDARDS								
									Aquatic life indicators							Aquatic recreation indicators	
Assessment Unit ID (AUID)	Stream reach name	Reach description	Reach length (miles)	Use class	Aquatic life	Aquatic recreation	303(d) listed impairments year		Fish	Macroinvertebrates	DO	TSS	Chloride	pH	NH3	Bacteria	Nutrients
HUC 11: 09020309060(Center Middle River Subwatershed)																	
09020309-515	Unnamed Ditch	Headwaters to County Ditch 15	2.22	WWm	SUP	NA			MTS	MTS	IF	IF	-	IF	IF	-	-
09020309-530	Judicial Ditch 21	380th St. to Middle River	5.23	WWg	SUP	NA			MTS	MTS	IF	IF	-	IF	IF	-	-
09020309-539	Middle River	96.171 48.4349 to Cty Rd 114	37.91	WWg	IMP	SUP	2008		MTS	MTS	IF	IF	MTS	MTS	MTS	MTS	-
HUC 11: 09020309070(West Middle River Subwatershed)																	
09020309-539	Middle River	96.171 48.4349 to Cty Rd 114	37.91	WWg	IMP	SUP	2008		MTS	MTS	IF	IF	MTS	MTS	MTS	MTS	-
09020309-540	Middle River	Cty Rd 114 to T156 R49WS3, N Line	45.54	WWg	IMP	SUP	2008		MTS	EX	IF	EX	MTS	MTS	MTS	MTS	-

				USES				WATER QUALITY STANDARDS								
								Aquatic life indicators							Aquatic recreation indicators	
Assessment Unit ID (AUID)	**Stream reach name**	**Reach description**	**Reach length (miles)**	**Use class**	**Aquatic life**	**Aquatic recreation**	**303(d) listed impairments year**	**Fish**	**Macroinvertebrates**	**DO**	**TSS**	**Chloride**	**pH**	**NH_3**	**Bacteria**	**Nutrients**
09020309-541	Middle River	T157 R49W S34, S Line to Snake River	5.91	WWm	IMP	SUP	2008	MTS	-	IF	EX	MTS	MTS	MTS	MTS	-
HUC 11: 09020309080 (Judicial Ditch #29 Subwatershed)																
09020309-501	Snake River	Upstream of Hwy 200, 2 mi. N of Fork	10.35	WWg	IMP	SUP	2002	EX	-	EX	EX	MTS	MTS	MTS	MTS	-
09020309-519	Judicial Ditch #29	Downstream of 480th Ave NW, 2 mi. NE of Fork	10.94	WWg	IMP	IF		EX	-	IF	IF	IF	IF	IF	IF	-

Full Support (FS); Not Supporting (NS); Insufficient Data (IF); Not Assessed (NA); Meets standards or ecoregion expectations (MTS), Exceeds standards or ecoregion expectations (EX).
Key for Cell Shading: = existing impairment, listed prior to 2016 reporting cycle; = new impairment; = full support of designated use; =Insufficient Information

Appendix 4. Snake River Watershed IBI thresholds and results.

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 – F-IBI (assessable reaches)

National Hydrologic Dataset (NHD) Assessment segment AUID	Biological station ID	Stream segment name	Drainage area miles²	Fish class	Threshold	F-IBI	Visit date
HUC 11: 09020309010 (Snake River Subwatershed)							
09020309-543	13RD104	Snake River	54.49	5	47	25.10	10-Jun-14
09020309-543	13RD104	Snake River	54.49	5	47	23.95	11-Jun-13
09020309-543	13RD036	Snake River	131.80	5	47	29.12	05-Aug-13
09020309-543	13RD036	Snake River	131.80	5	47	26.76	09-Jun-14
09020309-504	13RD108	Snake River	177.49	2	50	33.02	24-Jun-13
09020309-504	93RD416	Snake River	182.48	2	50	28.41	27-Jun-13
09020309-504	05RD175	Snake River	183.84	2	50	47.95	24-Jul-06
09020309-504	13RD004	Snake River	206.91	2	50	1.29	25-Jun-13
09020309-546	13RD034	Snake River, South Branch	33.95	6	42	37.49	09-Jul-13
09020309-546	13RD106	Snake River, South Branch	2.00	6	42	43.14	13-Jun-13
09020309-546	13RD105	Snake River, South Branch	46.92	6	42	23.87	09-Jul-13
09020309-546	13RD099	Snake River, South Branch	60.08	5	47	31.68	10-Jun-13
09020309-546	13RD099	Snake River, South Branch	60.08	5	47	37.66	10-Jun-14
09020309-544	13RD035	Snake River, South Branch	41.97	7	42	31.36	05-Aug-13
HUC 11: 09020309030 (Vega Subwatershed)							
09020309-537	94RD511	Snake River	226.43	2	50	26.90	02-Sep-14
HUC 11: 09020309040 (Bigwood Subwatershed)							
09020309-537	13RD006	Snake River	252.97	2	50	26.62	25-Jun-13

National Hydrologic Dataset (NHD) Assessment segment AUID	Biological station ID	Stream segment name	Drainage area miles^2	Fish class	Threshold	F-IBI	Visit date
09020309-537	13RD080	Snake River	326.05	1	49	46.73	25-Jun-13
09020309-502	13RD007	Snake River	422.19	1	49	20.28	11-Jul-13
HUC 11: 09020309050 (East Middle River Subwatershed)							
09020309-538*	13RD026	Middle River	20.05	7	15	39.30	12-Jun-13
09020309-539	13RD103	Middle River	46.28	6	42	64.63	11-Jun-14
09020309-529*	13RD027	Unnamed ditch	15.21	6	23	58.67	09-Jun-14
09020309-534	13RD025	Unnamed creek	19.6	6	42	66.12	09-Jul-13
HUC 11: 03020312060 (Center Middle River Subwatershed)							
09020309-539	13RD002	Middle River	143.17	5	47	51.59	10-Jun-13
09020309-515*	05RD020	Unnamed ditch	8.25	6	23	37.89	23-Jun-05
09020309-530	13RD023	Judicial Ditch 21	9.73	6	42	60.60	09-Jun-14
HUC 11: 09020309070 (West Middle River Subwatershed)							
09020309-539	13RD100	Middle River	199.98	5	47	55.06	11-Jun-13
09020309-539	13RD100	Middle River	199.98	5	47	46.58	18-Jul-13
09020309-540	13RD022	Middle River	222.84	5	47	49.39	29-Jul-13
09020309-540	13RD022	Middle River	222.84	5	47	53.97	11-Jun-13
09020309-540	05RD014	Middle River	236.22	5	47	54.92	12-Jul-06
09020309-540	13RD079	Middle River	238.97	2	50	56.25	12-Jun-13
09020309-540	93RD417	Middle River	252.24	2	50	49.78	24-Jun-13
09020309-540	13RD098	Middle River	261.12	2	50	61.56	25-Jun-13
09020309-541*	13RD008	Middle River	292	2	35	54.04	17-Jul-13
HUC 11: 09020309080 (Judicial Ditch #29 Subwatershed)							
09020309-501	13RD009	Snake River	767.57	1	49	44.19	07-Aug-13

*Indicates this reach is designated modified use

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

National Hydrologic Dataset (NHD) Assessment segment AUID	Biological station ID	Stream segment name	Drainage area Mi^2	Invert class	Threshold	M-IBI	Visit date
HUC 11: 09020309010 (Snake River Subwatershed)							
09020309-543	13RD104	Snake River	54.49	5	37	13.73	06-Aug-13
09020309-543	13RD036	Snake River	131.80	5	37	42.44	01-Aug-13
09020309-504	13RD108	Snake River	177.49	5	37	20.23	07-Aug-13
09020309-504	93RD416	Snake River	182.48	7	41	37.22	06-Aug-13
09020309-504	05RD175	Snake River	183.84	7	41	16.78	15-Aug-06
09020309-504	13RD004	Snake River	206.91	7	41	58.74	07-Aug-13
09020309-546	13RD034	Snake River, South Branch	33.95	5	37	50.90	01-Aug-13
09020309-546	13RD106	Snake River, South Branch	2.00	5	37	47.15	01-Aug-13
09020309-546	13RD099	Unnamed Ditch	60.08	5	37	32.53	06-Aug-13
09020309-518*	05RD011	Unnamed Ditch	16.84	7	22	24.24	27-Sep-05
09020309-544	13RD035	Snake River, South Branch	41.97	5	37	15.36	01-Aug-13
HUC 11: 09020309030 (Vega Subwatershed)							
09020309-537	94RD511	Snake River	226.43	7	41	56.99	06-Aug-13
HUC 11: 09020309040 (Bigwood Subwatershed)							
09020309-537	13RD006	Snake River	252.97	7	41	8.22	06-Aug-13
09020309-537	13RD080	Snake River	326.05	7	41	18.96	06-Aug-13
09020309-502	13RD007	Snake River	422.19	7	41	30.29	06-Aug-13
HUC 11: 09020309050 (East Middle River Subwatershed)							
09020309-539	05RD095	Middle River	83.85	7	41	45.81	28-Sep-05
09020309-529*	13RD027	Unnamed ditch	15.21	5	24	12.99	06-Aug-13
09020309-534	13RD025	Unnamed creek	19.6	5	37	43.17	06-Aug-13

National Hydrologic Dataset (NHD) Assessment segment AUID	Biological station ID	Stream segment name	Drainage area Mi^2	Invert class	Threshold	M-IBI	Visit date
HUC 11: 03020312060 (Center Middle River Subwatershed)							
09020309-539	13RD002	Middle River	143.17	5	37	40.86	29-Jul-13
09020309-515*	05RD020	Unnamed ditch	8.25	7	22	29.01	24-Aug-05
09020309-530	13RD023	Judicial Ditch 21	9.73	5	37	36.48	06-Aug-13
HUC 11: 09020309070 (West Middle River Subwatershed)							
09020309-539	13RD100	Middle River	199.98	5	37	47.44	06-Aug-13
09020309-539	13RD100	Middle River	199.98	5	37	36.86	06-Aug-13
09020309-540	13RD022	Middle River	222.84	5	37	30.79	06-Aug-13
09020309-540	13RD022	Middle River	222.84	5	37	22.55	29-Jul-13
09020309-540	05RD014	Middle River	236.22	7	41	60.03	27-Sep-05
09020309-540	13RD079	Middle River	238.97	5	37	26.76	07-Aug-13
09020309-540	93RD417	Middle River	252.24	7	41	56.70	06-Aug-13
09020309-540	93RD417	Middle River	252.24	7	41	54.44	06-Aug-13
09020309-540	13RD098	Middle River	261.12	5	37	36.00	06-Aug-13

*Indicates this reach is designated modified use

Appendix 5 – Fish species found during biological monitoring surveys

Common name	Quantity of stations where present	Quantity of individuals collected
Bigmouth buffalo	3	254
Black bullhead	3	21
Black crappie	1	2
Blacknose dace	14	1233
Blackside darter	10	283
Brassy minnow	8	145
Brook stickleback	16	903
Burbot	1	1
Central mudminnow	18	77
Channel catfish	2	2
Common carp	9	383
Common shiner	20	4127
Creek chub	20	2259
Fathead minnow	28	2411
Finescale dace	5	7
Freshwater drum	1	6
Gen: redhorses	1	9
Golden redhorse	6	110
Goldeye	5	31
Hornyhead chub	1	2
Iowa darter	1	1
Johnny darter	15	1810
Northern pike	10	22
Northern redbelly dace	14	134
Pearl dace	16	219
Quillback	2	5
River shiner	2	13
Rock bass	5	60
Sand shiner	7	346
Sauger	3	6
Shorthead redhorse	6	21
Silver chub	1	3
Silver redhorse	3	20
Smallmouth bass	1	1
Smallmouth buffalo	3	192
Spotfin shiner	7	363
Stonecat	3	20
Tadpole madtom	2	3
Trout-perch	2	5

Common name	Quantity of stations where present	Quantity of individuals collected
Walleye	4	21
White bass	1	1
White sucker	28	2244
Yellow perch	2	2

Appendix 6 – Macroinvertebrate species found during biological monitoring surveys.

Taxonomic name	Number of stations where present	Quantity of individuals collected
Amphipoda		
Amphipoda	1	1
Hyalella	21	781
Basommatophora		
Ferrissia	9	45
Fossaria	3	6
Gyraulus	8	105
Helisoma anceps	3	7
Lymnaea	1	3
Lymnaea stagnalis	2	5
Lymnaeidae	5	11
Physa	31	777
Physella	1	8
Planorbella	6	16
Planorbidae	7	13
Stagnicola	8	42
Coleoptera		
Anacaena	1	1
Berosus	1	1
Colymbetes	1	1
Dubiraphia	18	236
Dytiscidae	2	4
Elmidae	1	1
Enochrus	4	4
Gyrinus	3	3
Haliplidae	1	2
Haliplus	16	61
Helichus	4	6
Helophorus	3	3
Hydraena	10	48
Hydrochus	4	5
Hydrophilidae	3	4
Hygrotus	1	1
Laccophilus	4	5
Liodessus	10	51
Macronychus glabratus	1	2
Neoporus	2	5
Ochthebius	5	6

Taxonomic name	Number of stations where present	Quantity of individuals collected
Optioservus	7	45
Paracymus	3	3
Peltodytes	3	6
Rhantus	1	1
Stenelmis	4	24
Tropisternus	2	8
Decapoda		
Orconectes	19	41
Diptera		
Ablabesmyia	25	104
Atherix	5	15
Atrichopogon	2	2
Bezzia	1	1
Bezzia/Palpomyia	5	10
Brillia	4	12
Ceratopogonidae	4	9
Ceratopogoninae	5	10
Chaoborus	1	1
Chironomini	11	40
Chironomus	5	11
Chrysops	1	1
Cladotanytarsus	13	59
Conchapelopia	4	6
Corynoneura	11	33
Cricotopus	27	356
Cryptochironomus	10	19
Cryptotendipes	2	4
Culicidae	1	1
Dicranota	1	2
Dicrotendipes	29	506
Endochironomus	10	31
Ephydridae	13	22
Glyptotendipes	20	161
Hemerodromia	1	3
Hydrobaenus	3	4
Labrundinia	17	54
Labrundinia becki	1	1
Limnophyes	4	13
Limonia	2	2
Micropsectra	5	19
Microtendipes	10	16
Nanocladius	14	16

Taxonomic name	Number of stations where present	Quantity of individuals collected
Nilotanypus	3	4
Nilothauma	3	4
Ormosia	2	2
Orthocladiinae	12	64
Orthocladius	6	15
Parachironomus	5	8
Parakiefferiella	3	3
Paralauterborniella nigrohalterale	1	1
Paramerina	2	2
Parametriocnemus	3	4
Paratanytarsus	22	327
Paratendipes	8	32
Pentaneura	1	1
Phaenopsectra	16	48
Polypedilum	30	934
Procladius	12	25
Psectrocladius	2	2
Rheocricotopus	6	12
Rheotanytarsus	15	101
Saetheria	7	12
Simulium	22	597
Stempellinella	8	15
Stenochironomus	13	59
Stictochironomus	5	6
Stratiomyidae	3	4
Tabanidae	2	2
Tanypodinae	9	13
Tanytarsini	12	69
Tanytarsus	26	281
Thienemanniella	11	31
Thienemannimyia Gr.	26	147
Tipula	2	3
Tipulidae	1	1
Tvetenia	6	17
Xenochironomus xenolabis	3	6
Zavreliella marmorata	1	1
Ephemeroptera		
Acentrella	3	28
Acentrella parvula	7	26
Acentrella turbida	2	4
Acerpenna	9	20

Taxonomic name	Number of stations where present	Quantity of individuals collected
Acerpenna pygmaea	2	2
Anafroptilum	1	1
Baetidae	12	32
Baetis	5	40
Baetis flavistriga	4	10
Baetis intercalaris	15	188
Caenis	9	284
Caenis diminuta	18	229
Caenis hilaris	3	38
Callibaetis	1	4
Ephoron	1	6
Heptagenia	6	15
Heptageniidae	6	11
Hexagenia	2	21
Hexagenia bilineata	1	2
Hexagenia limbata	1	4
Isonychia	5	15
Iswaeon	5	17
Labiobaetis	4	14
Labiobaetis dardanus	4	48
Labiobaetis frondalis	4	26
Labiobaetis propinquus	6	10
Leptophlebia	1	20
Leptophlebiidae	1	2
Leucrocuta	6	30
Maccaffertium	9	28
Maccaffertium exiguum	2	2
Maccaffertium mediopunctatum	2	2
Paracloeodes minutus	1	3
Plauditus	10	47
Procloeon	13	37
Pseudocloeon	2	4
Stenacron	9	75
Stenonema	2	30
Stenonema femoratum	2	3
Tricorythodes	10	95
Haplotaxida		
Aulodrilus	1	1
Oligochaeta	23	447
Hemiptera		

Taxonomic name	Number of stations where present	Quantity of individuals collected
Belostoma	5	5
Belostoma flumineum	1	3
Callicorixa	3	8
Corixidae	13	58
Hesperocorixa	2	10
Limnoporus	1	1
Mesovelia	1	1
Neoplea	1	1
Notonecta	4	4
Ranatra	1	1
Sigara	11	53
Trichocorixa	4	4
Hydroida		
Hydridae	1	1
Nematoda		
Nemata	4	4
Nematoda	1	8
Neotaenioglossa		
Hydrobiidae	1	9
Odonata		
Aeshna	4	5
Aeshna umbrosa	3	3
Aeshnidae	2	3
Anax junius	2	2
Anisoptera	1	2
Calopterygidae	1	1
Calopteryx	2	2
Calopteryx aequabilis	1	1
Coenagrionidae	17	118
Corduliidae	5	6
Enallagma	1	3
Gomphidae	1	2
Gomphus	2	2
Gomphus graslinellus	1	1
Ischnura	1	1
Libellula	1	1
Somatochlora	6	8
Sympetrum	1	1
Oligochaeta		
Tubificinae	1	3
Plecoptera		
Acroneuria	1	3

Taxonomic name	Number of stations where present	Quantity of individuals collected
Acroneuria lycorias	3	5
Perlesta	1	4
Perlidae	1	2
Pteronarcys	2	2
Taeniopteryx	1	2
Trichoptera		
Ceraclea	3	13
Ceratopsyche	3	14
Ceratopsyche morosa	3	15
Cheumatopsyche	15	132
Chimarra	2	2
Helicopsyche	1	2
Helicopsyche borealis	4	26
Hydropsyche	2	2
Hydropsyche betteni	1	1
Hydropsychidae	8	75
Hydroptila	18	310
Hydroptilidae	8	23
Lepidostoma	1	1
Leptoceridae	4	5
Limnephilidae	2	11
Nectopsyche	1	2
Nectopsyche diarina	8	16
Neureclipsis	2	6
Oecetis	1	1
Oecetis avara	2	3
Oecetis furva	1	1
Phryganeidae	3	5
Polycentropus	1	1
Ptilostomis	3	4
Triaenodes	2	7
Trichoptera	2	2
Unclassified		
Acari	26	109
Hirudinea	19	59
Hydrozoa	1	1
Turbellaria	1	6
Veneroida		
Pisidiidae	20	119