Bois de Sioux River Watershed Monitoring and Assessment Report

Minnesota Pollution Control Agency

November 2013

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List of acronyms

AUID Assessment Unit Identification Determination

CCSI Channel Condition and Stability Index

CD County Ditch

CI Confidence Interval

CLMP Citizen Lake Monitoring Program

CR County Road

CSAH County State Aid Highway

CSMP Citizen Stream Monitoring Program

CWA Clean Water Act

CWLA Clean Water Legacy Act

DOP Dissolved Orthophosphate

E Eutrophic

EQuIS Environmental Quality Information System

EX Exceeds Criteria (Bacteria)

EXP Exceeds Criteria, Potential Impairment

EXS Exceeds Criteria, Potential Severe Impairment

FS Full Support

FWMC Flow Weighted Mean Concentration

H Hypereutrophic

HUC Hydrologic Unit Code

IBI Index of Biotic Integrity

IF Insufficient Information

K Potassium

LRVW Limited Resource Value Water

M Mesotrophic

MCES Metropolitan Council Environmental Services

MDA Minnesota Department of Agriculture

MDH Minnesota Department of Health

MDNR Minnesota Department of Natural Resources

MINLEAP Minnesota Lake Eutrophication Analysis Procedure

MPCA Minnesota Pollution Control Agency

MSHA Minnesota Stream Habitat Assessment

MTS Meets the Standard?

N Nitrogen

Nitrate-N Nitrate Plus Nitrite Nitrogen

NA Not Assessed

NHD National Hydrologic Dataset

NH3 Ammonia

NS Not Supporting

NT No Trend

OP Orthophosphate

P Phosphorous

PCB Poly Chlorinated Biphenyls

PWI Protected Waters Inventory

RNR River Nutrient Region

SWAG Surface Water Assessment Grant

SWCD Soil and Water Conservation District

SWUD State Water Use Database

TALU Tiered Aquatic Life Uses

TKN Total Kjeldahl Nitrogen

TMDL Total Maximum Daily Load

TP Total Phosphorous

TSS Total Suspended Solids

USGS United States Geological Survey

WPLMN Water Pollutant Load Monitoring Network

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Executive summary

The Bois de Sioux River Watershed lies within the headwaters region of the Red River Basin. Encompassing an area of 718,685 acres, the watershed lies within west-central Minnesota, southeastern North Dakota, and northeastern South Dakota. Only the portion of the watershed located in Minnesota is addressed in this report. The land within the watershed is used predominately for agricultural row crop production. Extensive hydrologic alterations such as stream channelization and ditching have been made throughout the Bois de Sioux River Watershed to promote soil drainage. Flooding occurs frequently within the watershed due to the low gradient nature of the watershed, broad flood plains, and often saturated soil conditions during spring snowmelt. Major rivers and streams include the Bois de Sioux River, Rabbit River, and Doran Slough. Numerous small unnamed creeks and ditches occur throughout the watershed. There are also 325 lakes greater than 10 acres in surface area within the Bois de Sioux River Watershed. Major lakes within the watershed include Lake Traverse, Upper Lightning, and Mud Lake.

In 2010 the Minnesota Pollution Control Agency (MPCA) began an intensive watershed monitoring (IWM) effort of surface waters within the Bois de Sioux River Watershed. Twelve sites were sampled for biology at the outlet of variable sized sub-watersheds. In 2012 the surface water bodies within the watershed were assessed for aquatic life, aquatic recreation, and aquatic consumption use support. Seven stream segments (AUIDs) and three lakes were assessed. Ten stream segments were not assessed due to insufficient data, modified channel condition, or their status as limited resource waters. Also, numerous lakes were not assessed due to insufficient data.

Every stream segment assessed within the Bois de Sioux River Watershed failed to meet aquatic life use standards. Only one assessed stream segment fully supported aquatic recreation use. Most aquatic life impairments were the result of low dissolved oxygen and/or excess turbidity. Poor fish and macro-invertebrate communities also resulted in aquatic life impairment designations. Excessive bacteria levels resulted in all aquatic recreation impairments. Lakes with enough data to be assessed failed to support aquatic recreation. All lakes had high total phosphorus (TP) levels and most had low transparencies.

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 identifying all pollution sources causing or contributing to impairment and an estimation of the reductions needed to restore a water body so that it can once again support its designated use.

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

The passage of Minnesota's Clean Water Legacy Act in 2006 provided a policy framework and the initial resources for state and local governments to accelerate efforts to monitor, assess, restore, and protect surface waters. This work is implemented 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. This strategy provides an opportunity to more fully integrate MPCA water resource management efforts in cooperation with local government and stakeholders 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. A watershed approach will more effectively address multiple impairments resulting from the cumulative effects of point and non-point sources of pollution and further the CWA goal of protecting and restoring the quality of Minnesota's water resources.

This watershed-wide monitoring approach was implemented in the Bois de Sioux River Watershed beginning in the summer of 2010. This report provides a summary of all water quality assessment results in the Bois de Sioux 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 81 major watersheds (Figure 1). The primary feature of the watershed approach is that it provides a unifying focus on the water resources within a watershed as the starting point for water quality assessment, planning, implementation, and result measures. 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 and protection strategies. The following paragraphs provide details on each of the four principal monitoring components of the watershed approach. For additional information see: *Watershed Approach to Condition Monitoring and Assessment* (MPCA 2008) (http://www.pca.state.mn.us/publications/wq-s1-27.pdf).

Load monitoring network

Funded with appropriations from Minnesota's Clean Water Legacy Fund, the Watershed Pollutant Load Monitoring Network (WPLMN) is a long-term program designed to measure and compare regional differences and long-term trends in water quality among Minnesota's major rivers including the Red, Rainy, St. Croix, Mississippi, and Minnesota, as well as outlets of 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 (MDNR) flow gaging stations with water quality data collected by the Metropolitan Council Environmental Services, local monitoring organizations and MPCA WPLMN staff to compute annual pollutant loads at 79 river monitoring sites across Minnesota. Intensive water quality sampling occurs year round at all WPLMN sites. Data will also be used to assist with TMDL studies and implementation plans, watershed modeling efforts, and watershed research projects.

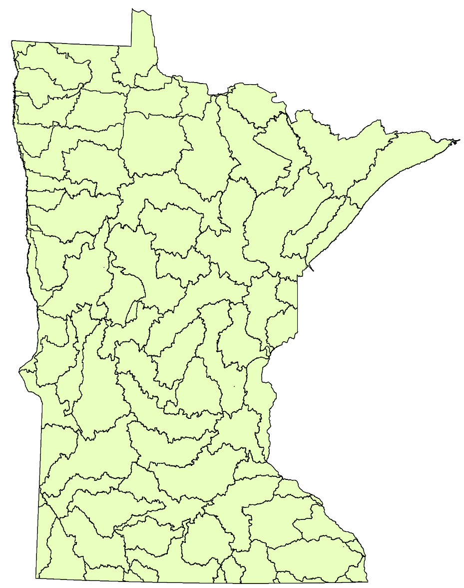


Figure 1. Major watersheds within Minnesota (8-Digit HUC)

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, 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. Pre-planning and coordination of sampling with local citizens and governments helps focus monitoring where it will be most effective for assessment and observing long-term trends. This allows citizens/governments the ability to see how their efforts are used to inform water quality decisions and track how management efforts affect change. Many SWAG grantees invite citizen participation in their monitoring projects and their combined participation greatly expand our overall capacity to conduct sampling.

The MPCA also coordinates two programs aimed at encouraging long term citizen surface water monitoring: the Citizen Lake Monitoring Program (CLMP) and the Citizen Stream Monitoring Program (CSMP). Like the permanent load monitoring network, having citizen volunteers monitor a given lake or stream site monthly, and from year to year, can provide the long-term picture needed to help evaluate current status and trends. Citizen monitoring is especially effective at helping to track water quality changes that occur in the years between intensive monitoring years. Figure 2 provides an illustration of the locations where citizen monitoring data were used for assessment in the Bois de Sioux River Watershed.

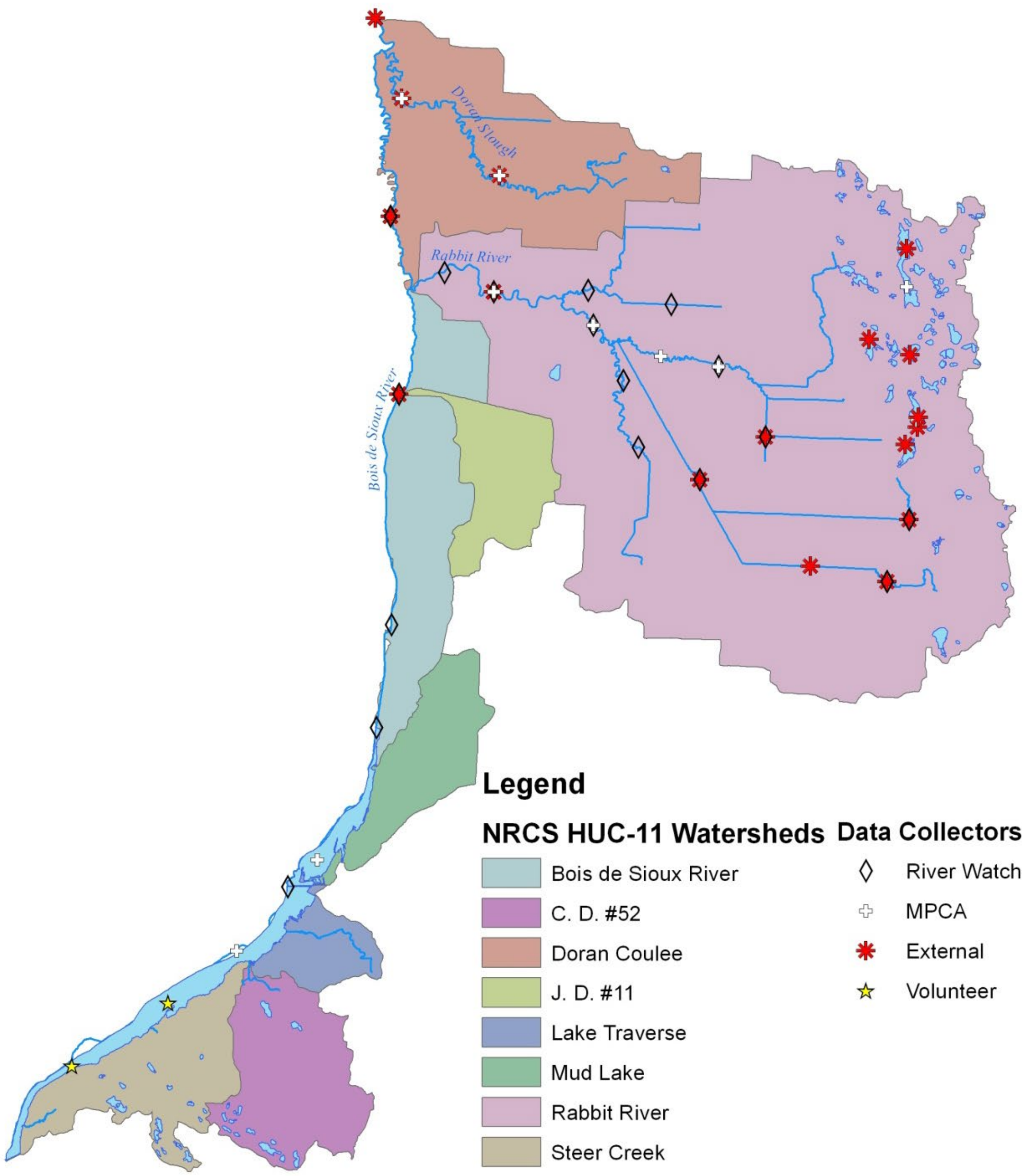


Figure 2. Monitoring locations of local groups, citizens and the MPCA lake monitoring staff in the Bois de Sioux River Watershed

Intensive watershed monitoring

The IWM strategy utilizes a nested watershed design allowing the sampling of streams within watersheds from a coarse scale 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 81 major watersheds (8-HUC) within Minnesota. Using this approach many of the smaller headwaters and tributaries to the main stem river are sampled in a systematic way so that a more holistic assessment of the watershed can be conducted and problem areas identified without monitoring every stream reach. Each major watershed is the focus of attention for at least one year within the 10-year cycle.

River/stream sites are selected near the outlet of each of three watershed scales, 8-HUC, 11-HUC and 14-HUC (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 8-HUC scale. The outlet of the major 8-HUC watershed (purple dot in Figure 4) is sampled for biology (fish and macro invertebrates), water chemistry and fish contaminants to allow for the assessment of aquatic life, aquatic recreation and aquatic consumption use support. The 11-HUC is the next smaller watershed scale which generally consists of major tributary streams with drainage areas ranging from 75 to 150 mi^2. Each 11-HUC outlet (green triangles in Figure 4) is sampled for biology and water chemistry for the assessment of aquatic life and aquatic recreation use support. Within each 11-HUC, smaller watersheds (14 HUCs, typically 10-20 mi^2) are sampled at each outlet that flows into the major 11-HUC tributaries. Each of these minor watershed outlets is sampled for biology to assess aquatic life use support (red dots in Figure 4.)

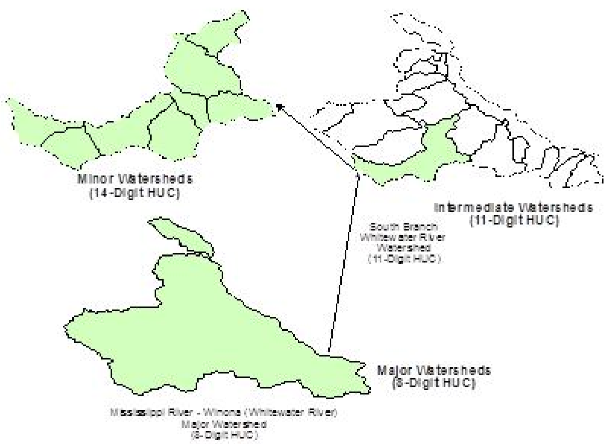


Figure 3. Example of the intensive watershed monitoring design

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

Specific locations for sites sampled as part of the intensive monitoring effort in the Bois de Sioux River Watershed are shown in Figure 4 and are listed in Appendix 2, Appendix 4.2, Appendix 4.3, Appendix 5.2 and Appendix 5.3.

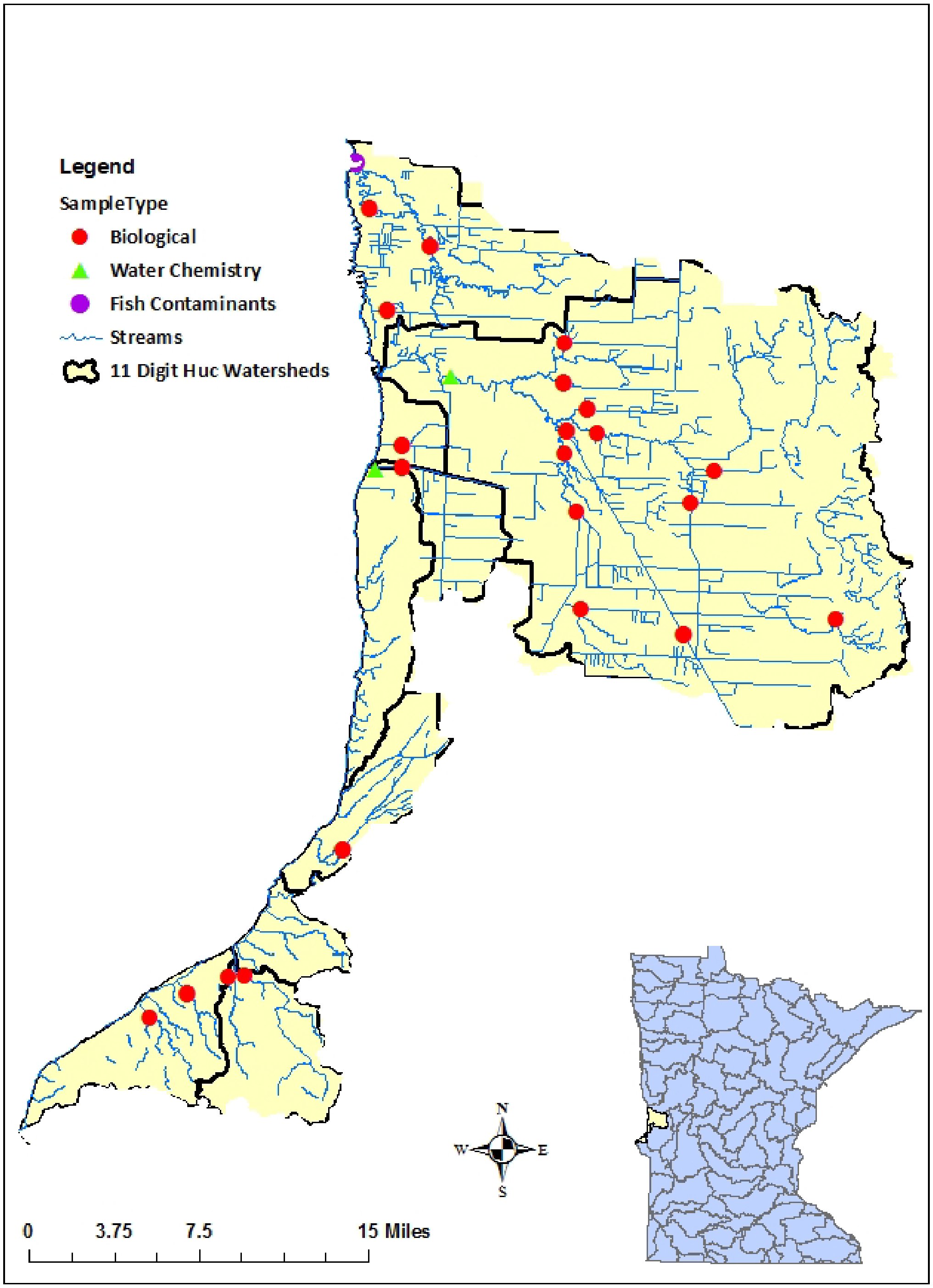


Figure 4. Intensive watershed monitoring sites for streams in the Bois de Sioux River Watershed

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. ch. 7050 2008; https://www.revisor.leg.state.mn.us/rules/?id=7050). The assessment and listing process involves dozens of MPCA staff, other state agencies and local partners. The goal of this effort is to use the best data and best science available to assess the condition of Minnesota's water resources. For a thorough review of the assessment methodologies see: *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment 305(b) Report and 303(d) List (MPCA 2012*). http://www.pca.state.mn.us/index.php/view-document.html?gid=16988.

Water quality standards

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

Protection of aquatic life means the maintenance of a healthy aquatic community, including fish, invertebrates and plants. The sampling of aquatic organisms for assessment is called biological monitoring. Biological monitoring is a direct means to assess aquatic life use support, as the aquatic community tends to integrate the effects of all pollutants and stressors over time. Interpretations of narrative criteria for aquatic life in streams are based on multi-metric biological indices including the Fish Index of Biological Integrity (Fish IBI), which evaluates the health of the fish community, and the Macroinvertebrate Index of Biological Integrity (MIBI), which evaluates the health of the aquatic invertebrate community. Additionally, chemical parameters are measured and assessed against numeric standards developed to be protective of aquatic life, including pH, dissolved oxygen, un-ionized ammonia nitrogen, chloride and turbidity.

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

Protection of consumption means protecting citizens who eat fish from Minnesota waters or receive their drinking water from water bodies 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. LRVW's 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, LRVW's have standards for bacteria, pH, dissolved oxygen and toxic pollutants.

Assessment units

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

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

Determining use attainment

For beneficial uses related to human health, such as drinking water or aquatic recreation, the relationship is well understood and thus the assessment process is a relatively simple comparison of monitoring data to numeric standards. In contrast, assessing whether a waterbody supports a healthy aquatic community is not as straightforward and often requires multiple lines of evidence to make use attainment decisions with a high degree of certainty. Incorporating a multiple lines of evidence approach into MPCA's assessment process has been evolving over the past few years. The current process used to assess the aquatic life use of rivers and streams is outlined below and in Figure 5.

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

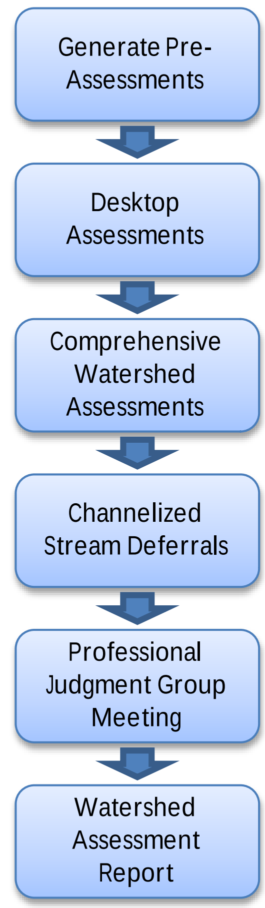


Figure 5. Flowchart of aquatic life use assessment process

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

Any new impairment (i.e., waterbody not attaining its beneficial use) is first reviewed using GIS to determine if greater than 50% of the assessment unit is channelized. Currently, the MPCA is deferring any new impairments on channelized reaches until new aquatic life use standards have been developed as part of the Tiered Aquatic Life Use (TALU) framework. For additional information, see: http://www.pca.state.mn.us/index.php/view-document.html?gid=18309. However, in this report, channelized reaches with biological data are evaluated on a "good-fair-poor" system to help evaluate their condition (see Section IV and Appendix 5.1).

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

Data management

It is MPCA policy to use all credible and relevant monitoring data to assess surface waters. The MPCA relies on data it collects along with data from other sources, such as sister agencies, local governments and volunteers. The data must meet rigorous quality assurance protocols before being used. All monitoring data required or paid for by MPCA are entered into EQuIS (Environmental Quality Information System), MPCA's data system and are also uploaded to the U.S. Environmental Protection Agency's (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 Surface Water Assessment Grants and TMDL program). Many local projects not funded by MPCA also choose to submit their data to the MPCA in an

EQuIS-ready format so that the monitoring data may be utilized in the assessment process. Prior to each assessment cycle, the MPCA sends out a request for monitoring data to local entities and partner organizations.

Period of record

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

III. Watershed overview

The Bois de Sioux River Watershed occupies a cumulative total of 718,685 acres of land distributed within Minnesota, North Dakota, and South Dakota (MPCA 2011). Approximately 361,222 acres of the watershed area lies within Minnesota. Early in its course the Bois de Sioux River forms the boundary between Minnesota and South Dakota. Further northward the river forms the boundary between Minnesota and North Dakota. Originating from Lake Traverse, the river flows north through Mud Lake along the western edge of Traverse County. The Bois de Sioux continues north into Wilkin County where it is joined by a primary tributary called the Rabbit River. Continuing northward the river enters the communities of Wahpeton and Breckenridge to join the Ottertail River and form the Red River of the North.

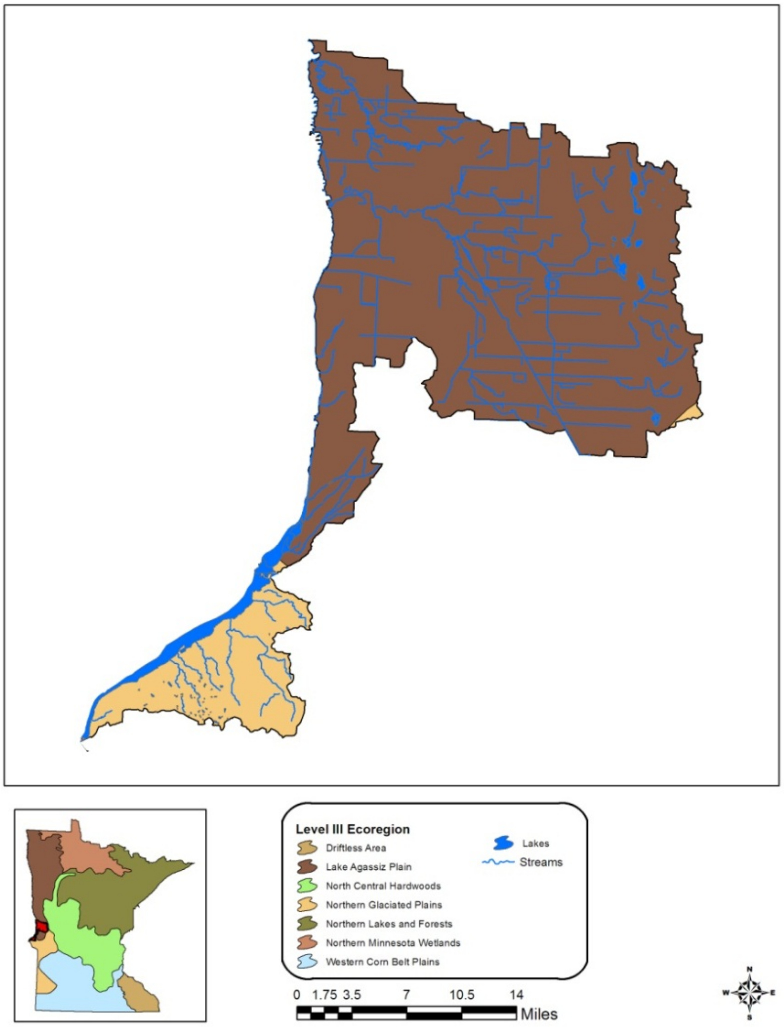


Figure 6. The Bois de Sioux River Watershed within the Lake Agassiz Plain ecoregion of western Minnesota

The Bois de Sioux River Watershed lies within two of Minnesota's level three ecoregions. The majority of the watershed lies within the Lake Agassiz Plain (LAP) ecoregion. Glacial Lake Agassiz deposited thick layers of silt and clay to form the soils of the LAP ecoregion (Krenz 1993). Similar to most remnant lake beds, the LAP ecoregion is very flat and featureless, with slopes of 0 – 2 % (Krenz 1993). The headwaters region of the watershed lies within the Northern Glaciated Plains ecoregion. Soils within this ecoregion are generally very fertile (Omernik et al. 1988). The terrain varies from flat to gently rolling hills within this ecoregion (Omernik et al. 1988).

Land use summary

Historically much of the Bois de Sioux River Watershed was covered in tall grass prairie and featured large areas of permanent and temporary wetlands (Krenz 1993).Throughout the mid to late1800s steamboats and railroads fostered settlement within the area (Krenz 1993). Settlers could purchase cheap land from the railroads or acquire it through government programs such as the Homestead Act (Krenz 1993). Most early residents settled along waterways in well drained areas due to the availability of natural resources and fertile river bottom soil (Krenz 1993). Eventually a shortage of well drained land occurred and attention was directed towards the flat saturated lands within the Red River Valley (Krenz 1993). Agricultural land drainage began as early as the mid 1800s to make more land within the Red River Basin available for agricultural production.

Today approximately 86% of the Bois de Sioux River Watershed acreage is used for agricultural purposes. Most of the original wetlands have been lost to agricultural drainage. "Wilkin County was, at one time, prime habitat for both waterfowl and upland birds. Most of the fish and wildlife habitat in the county has been lost due to land use changes, drainage and channel modifications (Wilkin County 2008)." Primary crops include corn, soybeans, sugar beets, and small grains. The abundant cultivated land combined with the flat topography of the watershed allows for considerable soil losses due to wind (Wilkin County 2008). Soil displaced by the wind enters road side ditches and field drainage systems, causing excessive sediment loads to enter surface water (Wilkin County 2008). Water erosion is also a problem due to the increased use of drainage equipment within the watershed (Wilkin County 2008). Urban development accounts for only 5% of land use within the Bois de Sioux River Watershed. Wetlands and open water account for the majority of the remaining land use within the watershed.

Cities and towns within the Bois de Sioux River Watershed include Breckenridge, Browns Valley, Campbell, Tintah, and Wahpeton.

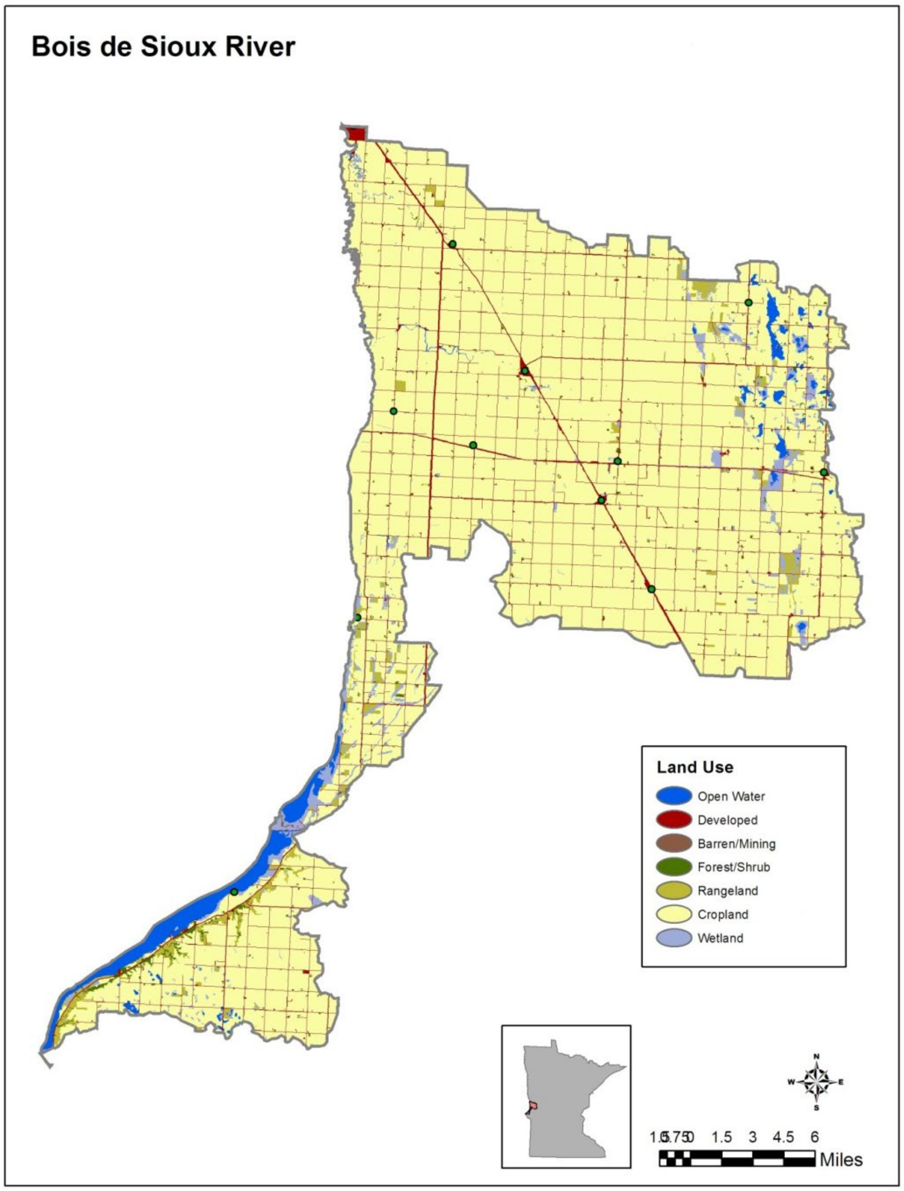


Figure 7. Land use in the Bois de Sioux River Watershed

Surface water hydrology

The Bois de Sioux River begins its 41 mile course at the dam on the north end of Lake Traverse. The river briefly flows north before entering Mud Lake. Roberts County, South Dakota lies on the west bank of the river and Traverse County, Minnesota on the east bank. The Bois de Sioux flows through White Rock Dam on the north end of Mud Lake and continues north. Eventually the river crosses into Richland County, North Dakota on its western side and Wilkin County, Minnesota on its eastern side. The Rabbit River, a major tributary, joins the Bois de Sioux River in Wilkin County. Originating near the source of the Mustinka River, the Rabbit River drains approximately 327 square miles of land and flows east to west within the Bois de Sioux River Watershed. The Bois de Sioux River continues north into the adjacent communities of Breckenridge, Minnesota and Wahpeton, North Dakota. At this location, the Otter Tail River joins with Bois de Sioux River to form the Red River of the North. Numerous small ditches and streams enter the Bois de Sioux at various locations throughout its entire course. Sections of the Bois de Sioux River have been channelized at various locations also.

Extensive drainage modifications have occurred within the Bois de Sioux River Watershed and throughout the entire Red River of the North Basin. The flat topography and poor natural drainage within the watershed necessitated the removal of excess water for agricultural production. Drainage activities began to occur within the Bois de Sioux River Watershed during the mid to late nineteenth century. Most early drainage activities consisted of digging ditches to move water from one location to another (Krenz 1993). Today hundreds of miles of drainage ditches exist within the watershed. The Bois de Sioux Watershed District legal ditch system contains four hundred lineal miles of ditch (Bois de Sioux Watershed District 2011), covering both the Bois de Sioux and Mustinka River watersheds. Routine maintenance, such as brush and sediment removal, is performed on most ditches within the watershed (Bois de Sioux Watershed District 2011). Another artificial drainage method increasingly used on agricultural lands within the Bois de Sioux Watershed is tiling. Lien and Orrick (2012) state that "In 1999, the Bois de Sioux Watershed District approved permits for 2.9 miles of subsurface tile, an artificial way to drain water from land. In 2009, it permitted 779.3 miles of drainage tile. Last year, it signed off on 1,558.3 miles. By mid-April, the total was approaching 1,000 miles, on pace to surpass 2011." As a result of extensive ditching and tiling, the natural hydrologic functions of the Bois de Sioux River Watershed have been radically altered.

Spring and summer flooding is a major concern within the Bois de Sioux River Watershed and the entire Red River of the North Basin. Most flooding occurs due to spring snowmelt but some flooding also occurs as a result of heavy summer rains. Level slopes within the watershed result in prolonged floods due to slow runoff (Krenz 1993). Urban flooding has caused damage to most cities within the watershed, especially the floods of 1993, 1996, 1997, and 2011. Flooding due to spring runoff causes damage to infrastructure throughout the watershed on an annual basis. Constructing large retention basins, channelizing streams, and building levees are some of the methods utilized to reduce flooding in the watershed (Krenz 1993). The North Ottawa Impoundment Project was constructed within the Rabbit River Watershed to reduce flooding. The impoundment is designed to store excess runoff on 1,920 acres of land and provide 16,000 acre feet of gate controlled storage (Bois de Sioux Watershed District 2011). The North Ottawa Project reduces peak flows in the Bois de Sioux River, controls excess nutrients through utilization of wetland plants, and reduces sedimentation (Bois de Sioux Watershed District 2011). Numerous other impoundments similar to the North Ottawa Impoundment may be constructed within the Red River Basin to reduce flooding.

Climate and precipitation

Precipitation is the source of almost all water inputs to a watershed. Figure 8 shows two representations of precipitation for water year 2012 (October – September). On the left is total precipitation, which shows that the watershed received between 16 to 24 inches. The display on the right shows the amount that the precipitation levels in water year 2012 departed from normal. Within the Bois de Sioux River Watershed precipitation varied from 4 - 10 inches below normal. Most of Minnesota shows the effect of persistent drought for this period.

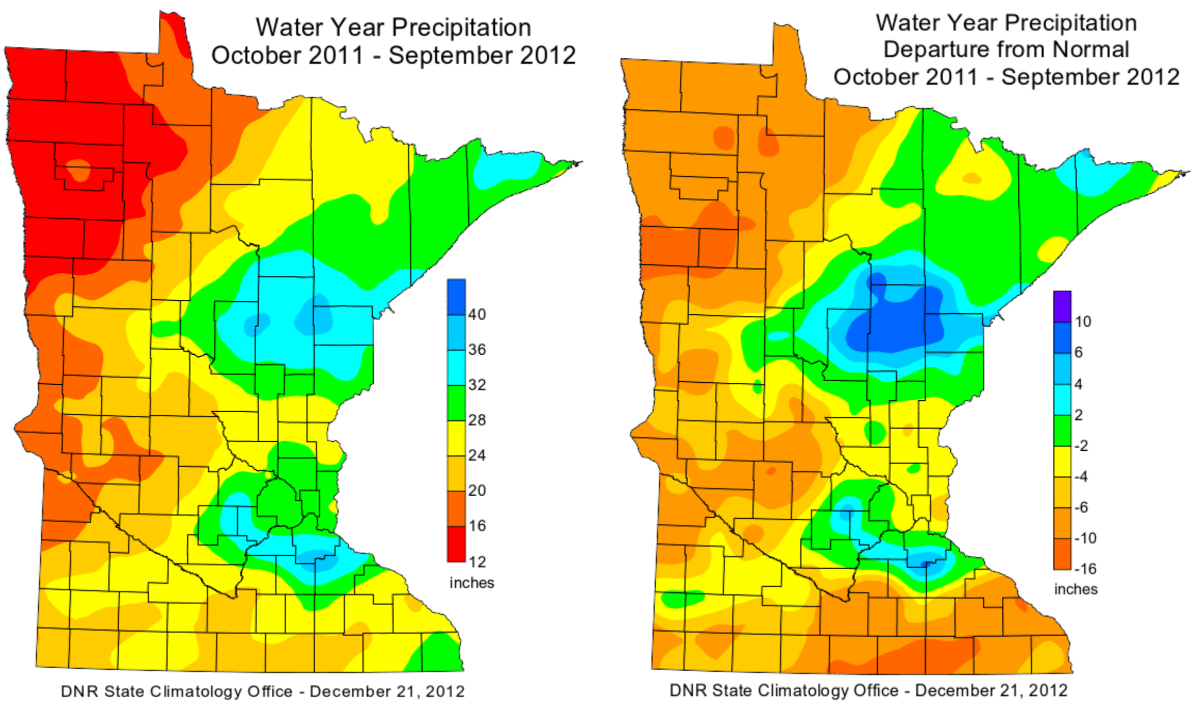


Figure 8. State-wide precipitation levels during the 2011-2012 water year

Figure 9 displays the areal average representation of precipitation in West Central Minnesota. An areal average is a spatial average of all the precipitation data collected within a certain area presented as a single dataset. This data is taken from the Western Regional Climate Center, available as a link off of the University of Minnesota Climate website: http://www.wrcc.dri.edu/spi/divplot1map.html.

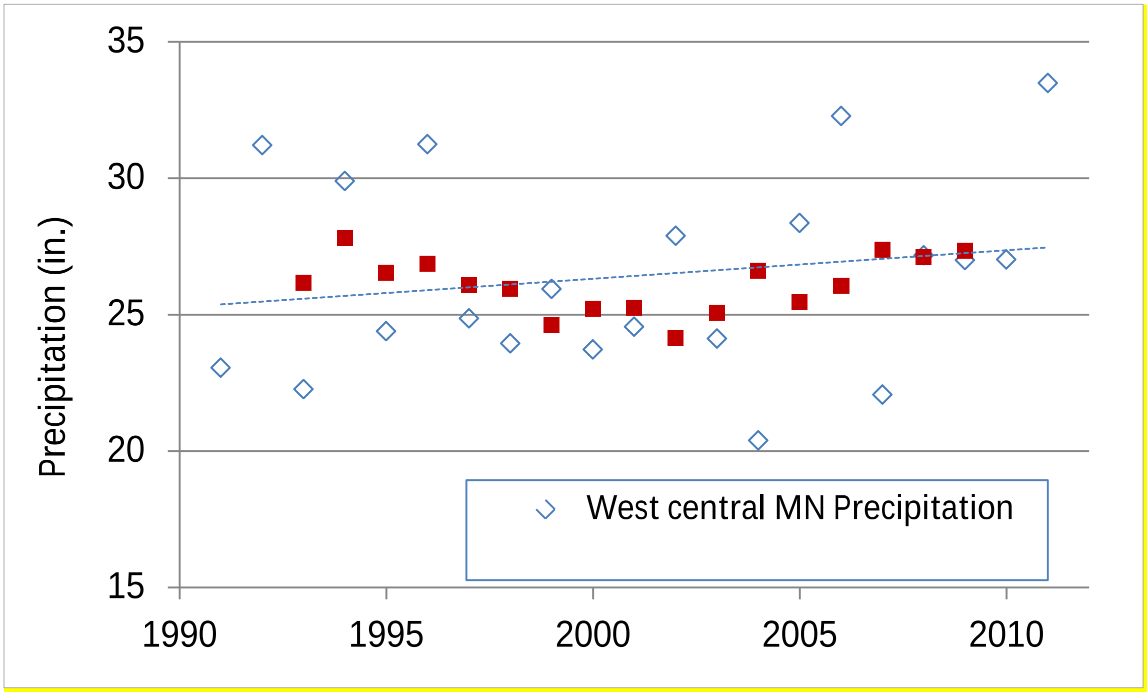


Figure 9. Precipitation trends in West Central Minnesota (1990-2010) with five year running average

Rainfall in the west central region displays no statistically significant trend over the last 20 years. Though rainfall can vary in intensity and time of year, it would appear that west-central Minnesota precipitation has not changed dramatically over this time period. However, precipitation in west-central Minnesota does exhibit a statistically significant rising trend over the past 100 years, $p = 0.001$ (Figure 10). This is a strong trend and matches similar trends throughout Minnesota for this time period.

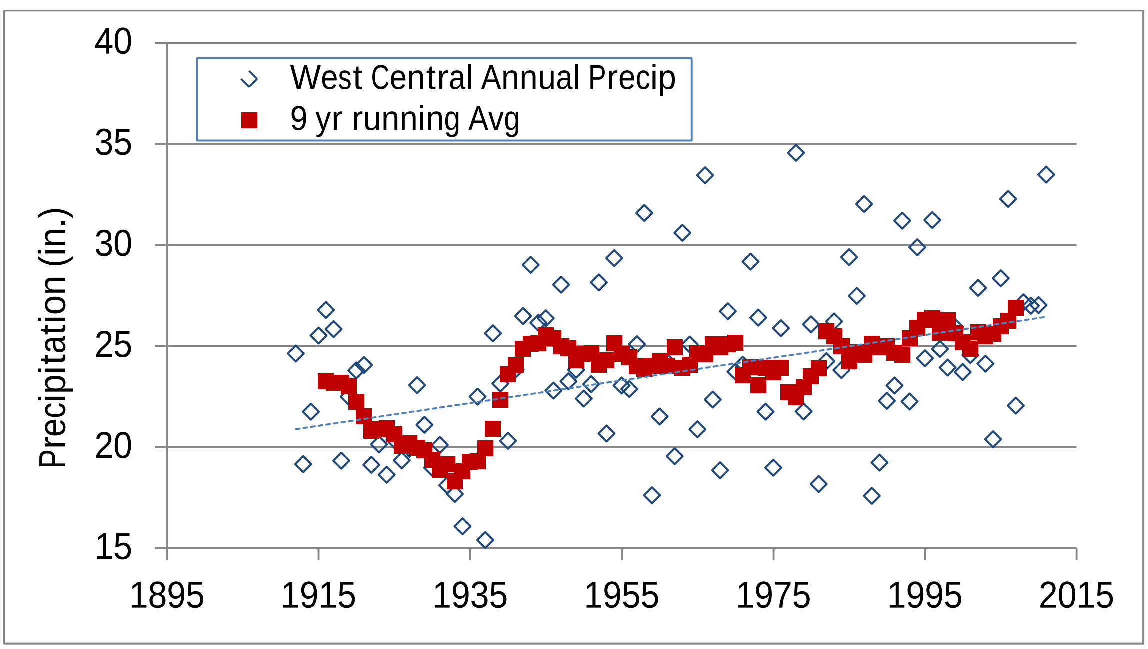


Figure 10. Precipitation trends in west central Minnesota (1895-2015) with nine year running average

Hydrogeology and groundwater quality

Hydrogeology encompasses the movement and distribution of groundwater in the subsurface, incorporating both the geology and its influence on the storage or movement of groundwater.

Surface topography

Figure 11 superimposes three different map coverages: the outline of the Bois de Sioux River Watershed, the newly available LiDAR (light detection and ranging) digital elevation display, and surface water features. The LIDAR data reveals previously unavailable detail on the drainage patterns off the highlands to the east. This data is collected using optical remote sensing technology.

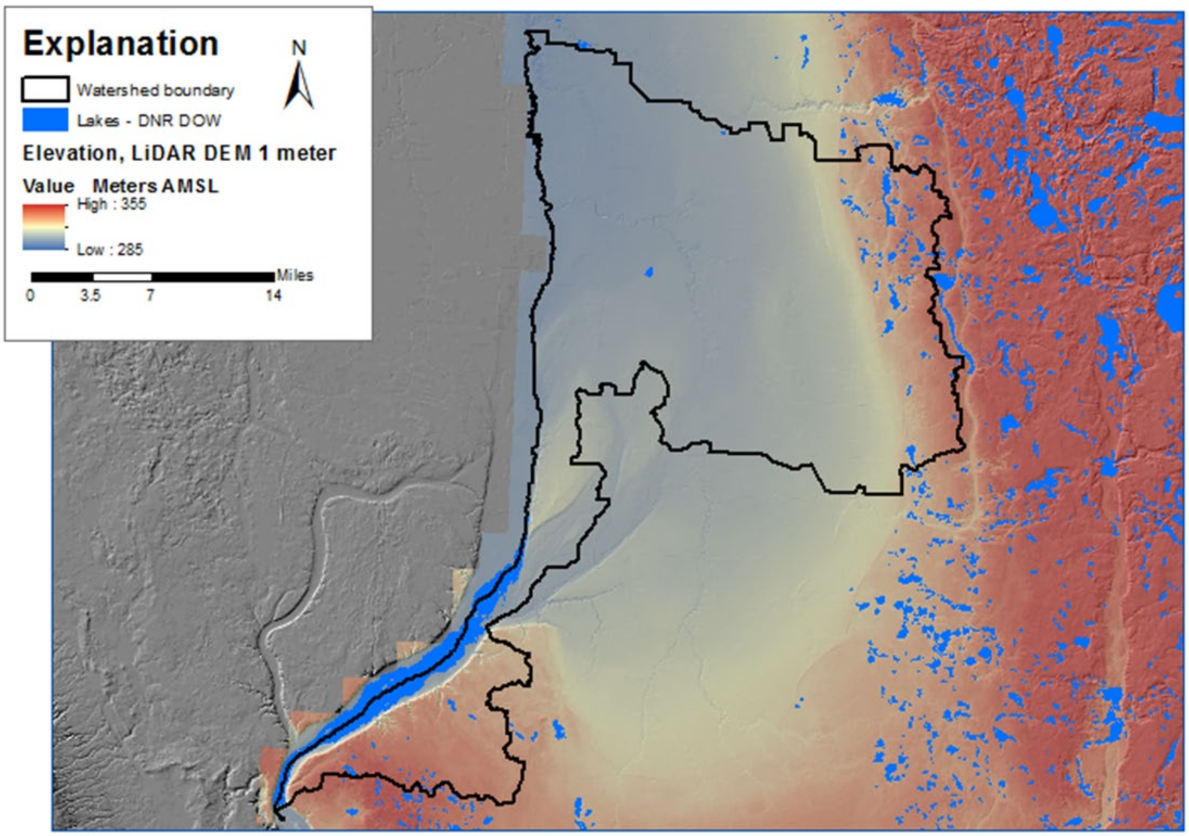


Figure 11. Topography of the Bois de Sioux River Watershed

High capacity withdrawals

The MDNR permits all high capacity water withdrawals where the pumped volume exceeds 10,000 gallons/day or one million gallons/year (See Figure 12 for locations of permitted groundwater and surface water withdrawals). Permit holders are required to track water use and report back to the MDNR yearly. Information on the program and the program database are found at: http://www.dnr.state.mn.us/waters/watermgmt_section/appropriations/wateruse.html.

Displayed below are the locations of these permitted groundwater and surface water withdrawals in the Bois de Sioux River Watershed, and neighboring area. Blue symbols are groundwater withdrawals and red are surface water, taken from lake, stream or other surface water feature.

The three largest permitted consumers of water in the state (in order) are municipalities, industry, and irrigation. The Bois de Sioux River Watershed high-capacity withdrawals are mostly municipal with a few for agricultural use. The Bois de Sioux River Watershed has relatively little crop irrigation compared to other watersheds in farm country.

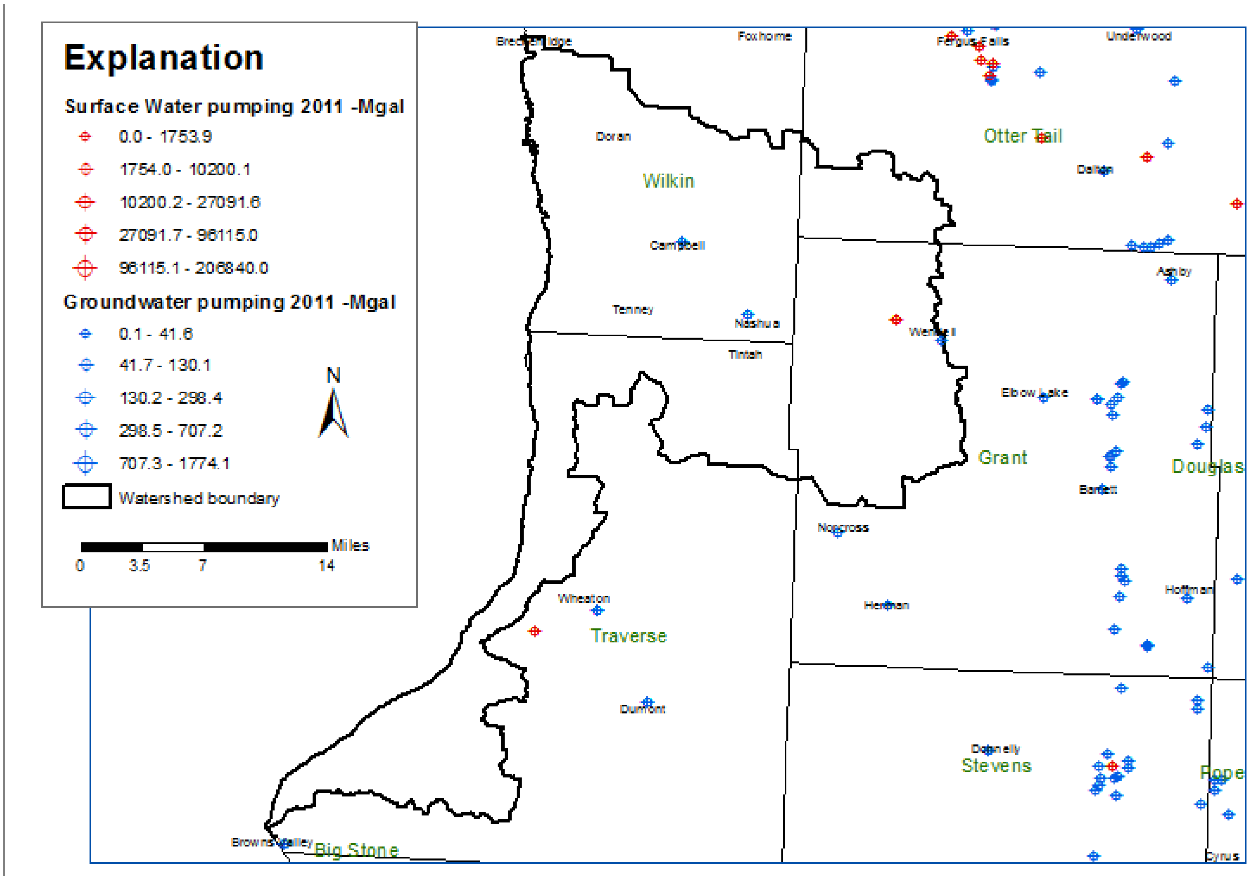


Figure 12. Locations of permitted groundwater withdrawals in the Bois de Sioux River Watershed

Total groundwater withdrawals for the watershed from 1991-2010 are displayed in Figure 13 as blue diamonds. The data is taken from the MDNR State Water Use Database. Groundwater withdrawals do not show a statistically significant trend over that time. Surface water withdrawals are limited to temporary MDNR lake level maintenance projects.

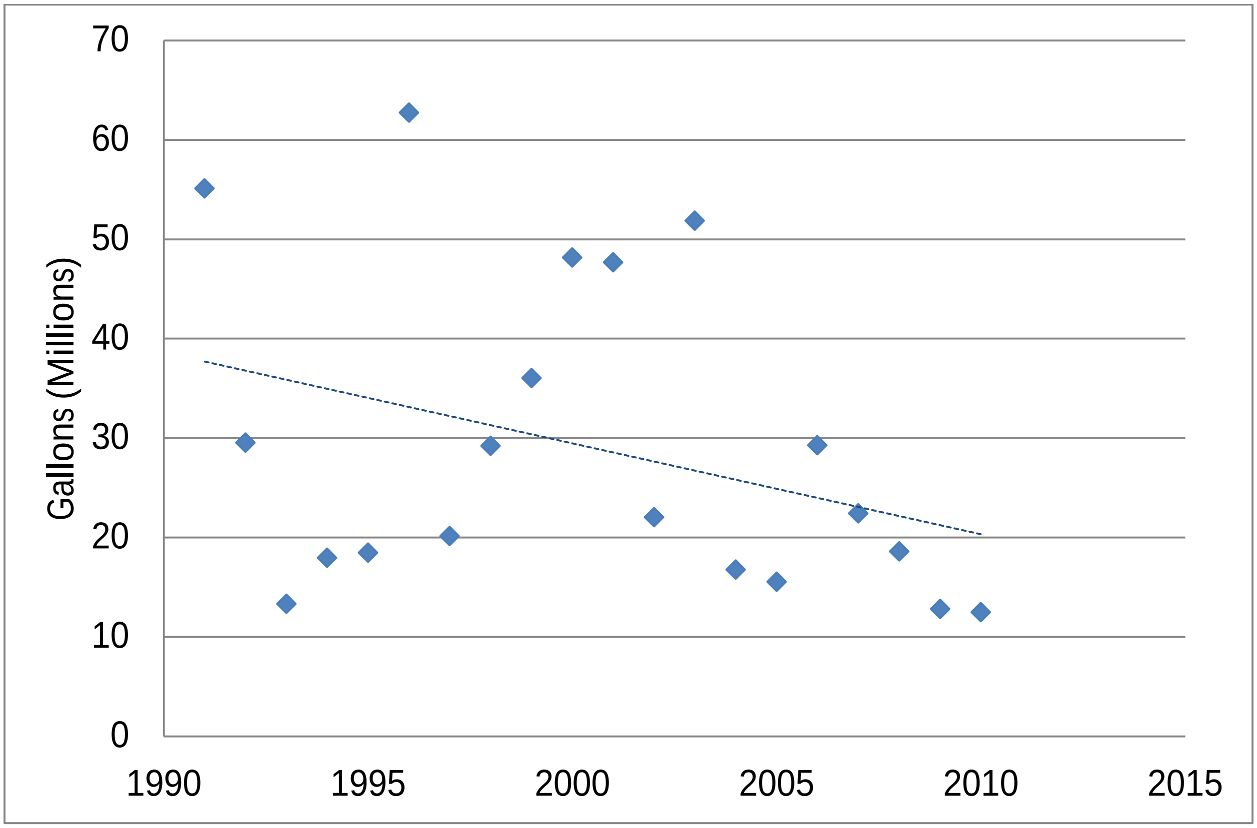


Figure 13. Total annual groundwater and surface water withdrawals in the Bois de Sioux River Watershed (1990-2010)

IV. Watershed-wide data collection methodology

Watershed pollutant load monitoring

Water quality samples are collected year-round at all WPLMN sites. Approximately 30-35 mid-stream grab samples are collected per site each year. Sample collection intensity is greatest during periods of moderate and high flow due to the importance these samples carry in pollutant load calculations. Sampling also occurs during low flow periods but at a lower frequency. Water quality and discharge data are combined in the "Flux32 Pollutant Load Model" to create concentration/flow regression equations. These equations are used to estimate pollutant concentrations and loads on days when samples are not collected. Primary outputs from the Flux32 model include pollutant loads and flow weighted mean concentrations (FWMC). A pollutant load is defined as the amount (mass) of a pollutant passing a stream location over a given period of time. The FWMC is an estimate of the overall water quality and is computed by dividing the pollutant load by the total flow volume. Estimated annual pollutant loads are calculated for total suspended solids (TSS), TP, dissolved orthophosphate (DOP), total Kjeldahl nitrogen (TKN) and nitrate plus nitrite-nitrogen (NO3_2). The primary Flux32 outputs include pollutant loads (Table 1) and FWMC (Figures 14).

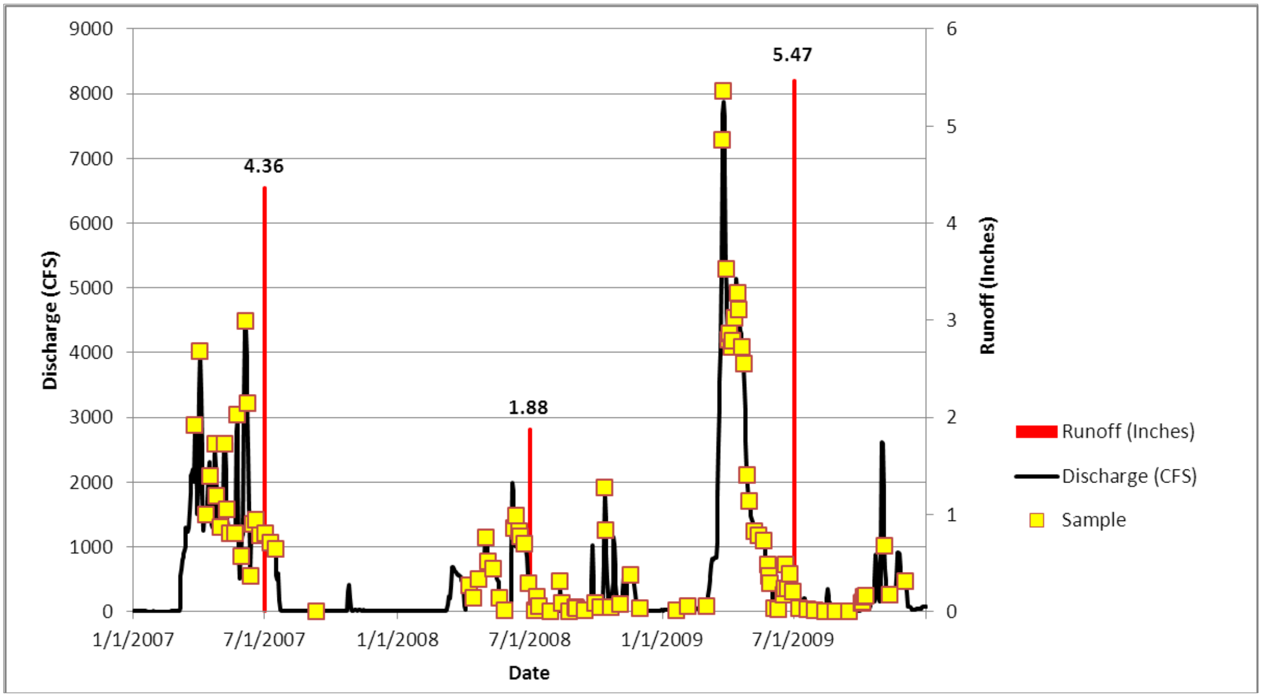


Figure 14. Hydrograph and annual runoff for the Bois de Sioux River near Doran (2007-2009)

The continuous monitoring performed by this program is designed to measure and compare regional differences and long-term trends in water quality. Given that 'intensive' watershed monitoring will occur only once every 10 years, comparing these regional differences and long-term trends will be particularly helpful when the IWM data is represented contextually over time. The load monitoring network will also provide critical information for identifying baseline or acceptable loads for maintaining and protecting water resources. In the case of impaired waters, the data collected through these efforts will be used to aid in the development of TMDL studies, implementation of plans, assist watershed modeling efforts, and provide information to watershed research projects.

Stream water sampling

Three water chemistry stations (two on the Bois de Sioux River and one on the Rabbit River) were sampled from May thru September in 2010, and again June thru August of 2011, to provide sufficient water chemistry data to assess aquatic life and recreation uses. Following the IWM design, water chemistry stations were placed at the outlet of each 11 HUC sub-watershed that was >40 square miles in area (purple circles and green circles/triangles in (Figure 3). All of these stations were sampled by MPCA staff. (See Appendix 2 for locations of stream water chemistry monitoring sites. See Appendix 1 for definitions of stream chemistry analytes monitored in this study). Steer Creek, County Ditch 52, Lake Traverse, Mud Lake, and Judicial Ditch 11 11-HUC watersheds did not have an intensive chemistry collection station placed at their outlets due to the small drainage area (<40 mi2) of the watersheds.

Stream biological sampling

The biological monitoring component of the IWM in the Bois de Sioux River Watershed was completed during the summer of 2010. A total of 8 sites were established throughout the watershed and sampled. These sites were located near the outlets of most minor HUC-14 watersheds. In addition, 3 existing biological monitoring stations within the watershed were revisited in 2010. These monitoring stations were initially established by the MDNR in 1984, or as part of a 1994 survey. While data from the preceding 10 years contributed to the watershed assessments, the majority of data utilized for the 2012 assessment was collected in 2010. A total of 10 stream segments (AUIDs) were sampled for biology in the Bois de Sioux River Watershed. Water body assessments to determine aquatic life use support were conducted for 7 stream segments. Water body assessments were not conducted for 3 stream segments because criteria for channelized reaches had not been developed prior to the assessments. Nonetheless, the biological information that was not used in the assessment process will be crucial to the stressor identification process and will also be used as a basis for long term trend results in subsequent reporting cycles. Qualitative ratings for non-assessed reaches area included in each 11 digit summary where applicable and in Appendix 5.1.

To measure the health of aquatic life at each biological monitoring station, IBIs, specifically fish and MIBIs, were calculated based on monitoring data collected for each of these communities. A fish and macroinvertebrate classification framework was developed to account for natural variation in community structure which is attributed to geographic region, watershed drainage area, water temperature and stream gradient. As a result, Minnesota's streams and rivers were divided into seven distinct warm water classes and two cold water classes, with each class having its own unique fish IBI and MIBI. Each IBI class uses a unique suite of metrics, scoring functions, impairment thresholds, and confidence intervals (CIs) (For IBI classes, thresholds and CIs, see Appendix 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 and Appendix 5.

Fish contaminants

Mercury and PCBs were analyzed in fish tissue samples collected from the Bois de Sioux River, Mud Lake, and Traverse Lake. MPCA biomonitoring staff collected the fish from the Bois de Sioux River. The MDNR fisheries staff collected fish from the lakes. One bluegill sunfish from Traverse Lake was tested for perfluorochemicals (PFCs). The PFC that bioaccumulates in fish and is a known health concern for human consumption is perfluorooctane sulfonate (PFOS), and therefore, is the only PFC reported here. PFCs became a contaminant of emerging concern in 2004 when high concentrations were measured in fish from the Mississippi River, Pool 2. Extensive statewide monitoring of lakes and rivers for PFCs in fish was continued through 2010. More focused monitoring for PFCs will continue in known contaminated waters, such as the Mississippi River.

Captured fish were wrapped in aluminum foil and frozen until they were thawed, scaled, filleted, and ground. The homogenized fillets were placed in 125 mL glass jars with Teflon™ lids and frozen until thawed for mercury or PCBs analyses. The Minnesota Department of Agriculture Laboratory performed all mercury and PCBs analyses of fish tissue. For the single PFC sample, homogenate from a bluegill sunfish was shipped to EPA Research Triangle Park Laboratory.

The MPCA has included waters impaired for contaminants in fish on the 303d Impaired Waters List since 1998. Impairment assessment for PCBs and PFCs in fish tissue is based on the fish consumption advisories prepared by the Minnesota Department of Health (MDH). If the consumption advice is to restrict consumption of a particular fish species to less than a meal per week because of PCBs or PFCs, the MPCA considers the lake or river impaired. The threshold concentration for impairment (consumption advice of one meal per month) is 0.22 mg/kg for PCBs and 0.200 mg/kg (200 ppb) for PFOS.

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

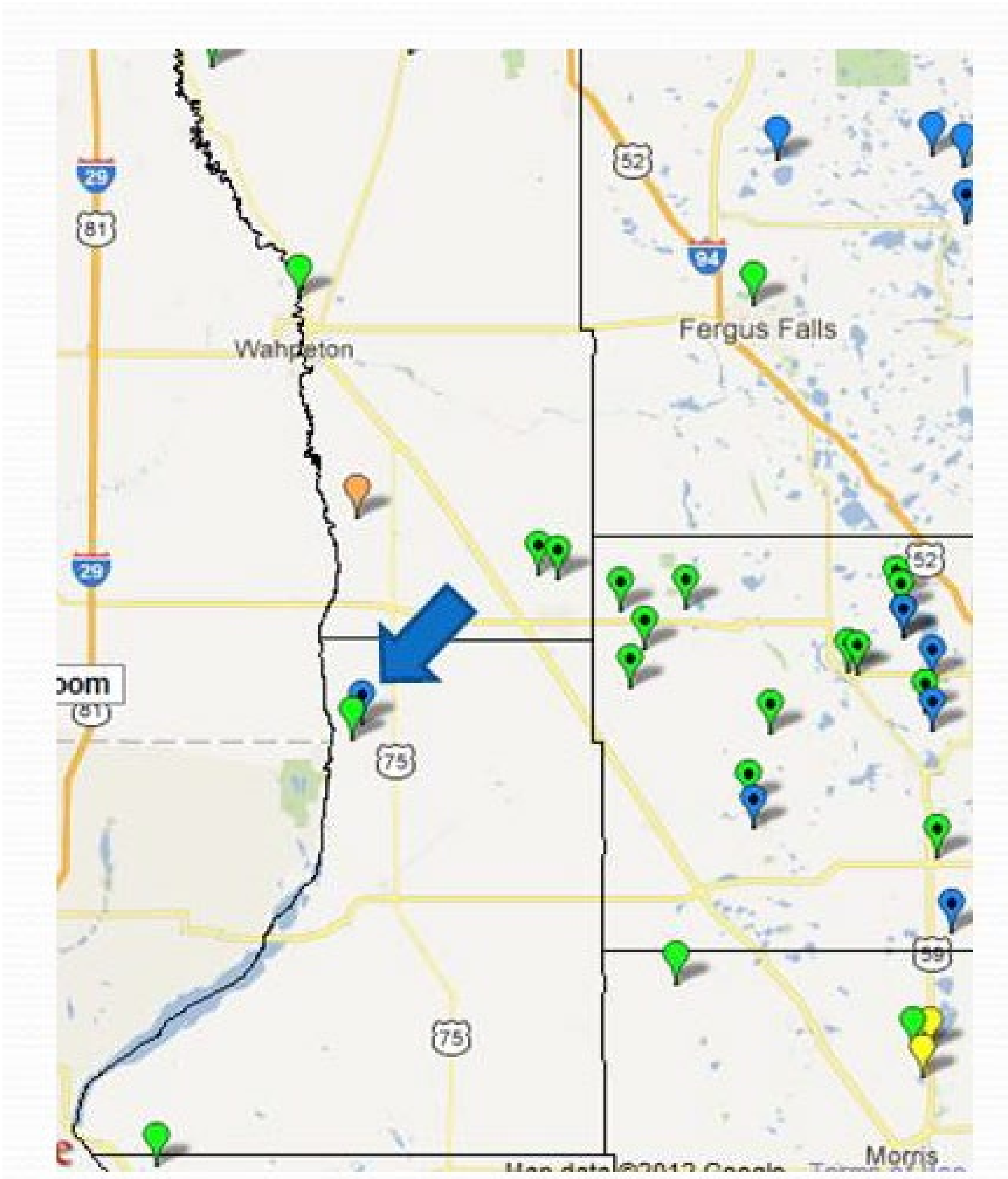
PCBs in fish have not been monitored as intensively as mercury in the last three decades because of monitoring completed in the 1970s and 1980s. These studies identified that high concentrations of PCBs were only a concern downstream of large urban areas in large rivers, such as the Mississippi River and in Lake Superior. Therefore, continued widespread frequent monitoring of smaller river systems was not necessary. However, limited PCB monitoring of forage fish was included in the watershed sampling design to confirm PCBs are not appearing in the smaller streams.

Lake water sampling

MPCA sampled lakes Traverse, Mud, Upper Lightning, and Ash between 2008 and 2010, as part of the Clean Water Legacy funded condition monitoring program for the purpose of enhancing the dataset for lake assessment of aquatic recreation. Ducks Unlimited also collected data on Ash Lake in 2009 and 2010 which supplemented the agency dataset and allowed for a complete assessment of the lake. Volunteer data from MPCA's CLMP has been collected sporadically in the past on Lake Traverse; currently, the most recent Secchi transparency data is from 2011. Sampling methods are similar among monitoring groups and are described in the document entitled "*MPCA Standard Operating Procedure for Lake Water Quality*" found at http://www.pca.state.mn.us/publications/wq-s1-16.pdf. The lake water quality assessment standard requires eight observations/samples within a 10 year period for phosphorus, chlorophyll-a and Secchi depth.

Groundwater monitoring

Groundwater quantity is monitored by the MDNR through a network of observation wells. Figure 15 shows the locations of wells in the watershed and neighboring counties.



= water table aquifer
= bedrock aquifer
= buried artesian aquifer
= other aquifer
indicates measurements are no longer made

Figure 15. Locations of area MDNR observation wells

Figure 16 is the hydrograph generated by elevation readings from the only water table well with a 20 year record in the watershed. Well 78000 was sealed in 2011, and during the 20 years it was monitored it did not show a trend to the water table surface. It is located in Traverse County. A new observation well was constructed in the vicinity of 78000 in 2011, and is completed in a buried drift aquifer.

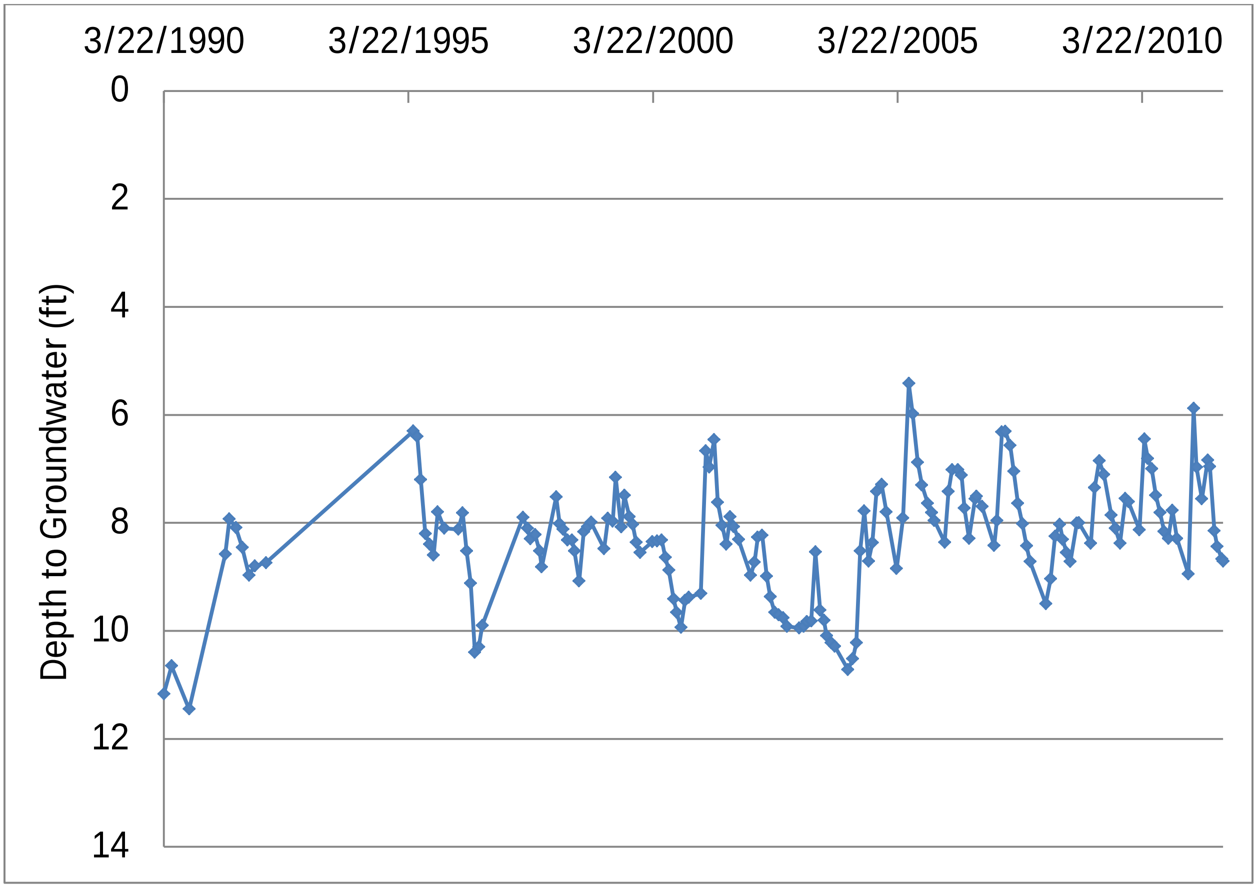


Figure 16. Hydrograph from Observation Well 78000, in Traverse County

Groundwater quality is monitored by the MPCA through a smaller network of observation wells. Figure 17 shows the locations of the Ambient Groundwater Monitoring Program wells that surround the Bois de Sioux Watershed. Though there are no Ambient network wells within the watershed, information from wells in the neighboring watersheds can be used to evaluate groundwater within the Bois de Sioux River Watershed.

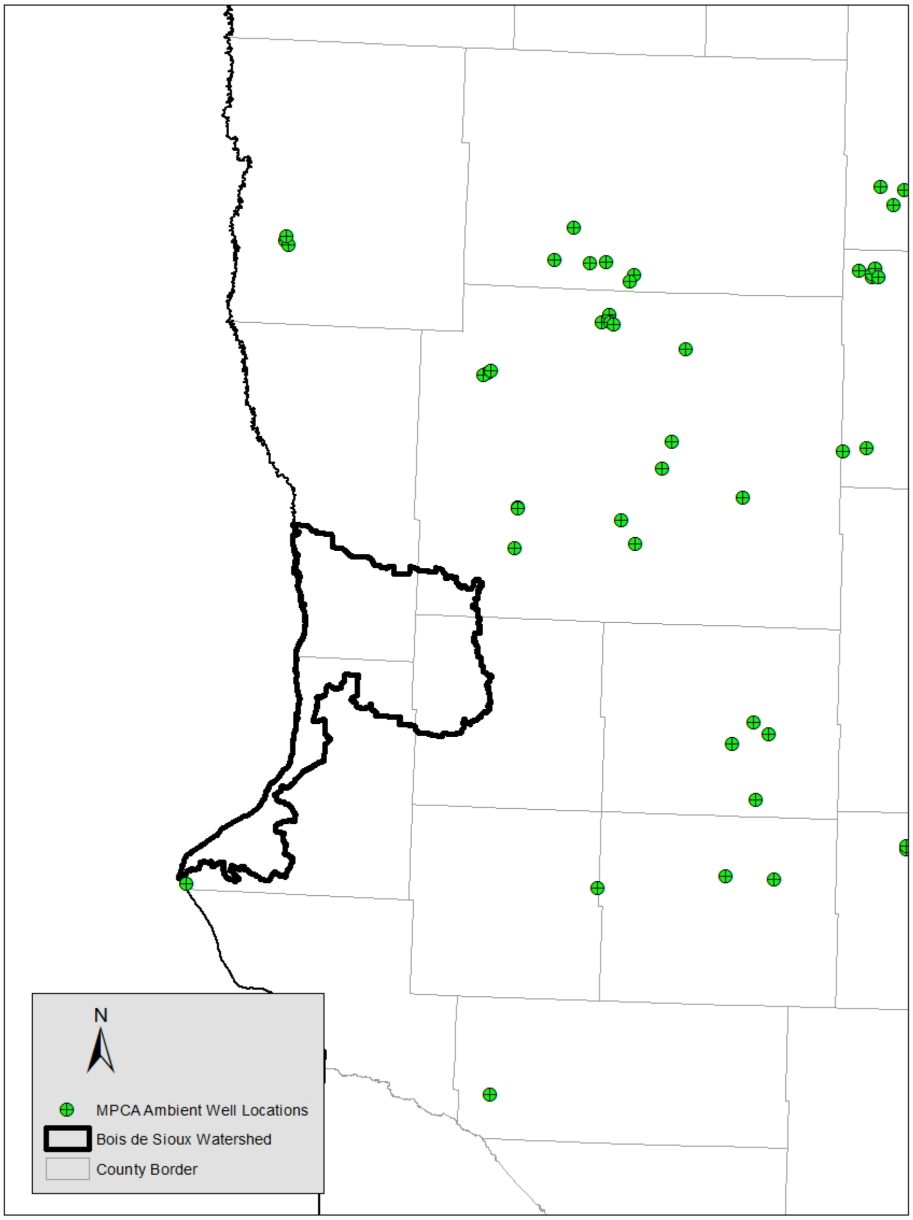


Figure 17. Locations of wells in the MPCA Ambient Groundwater Monitoring Program

The MPCA Ambient network monitors trends in statewide groundwater quality by sampling for a comprehensive suite of chemicals including nutrients, metals, and volatile organic compounds.

Data collected from these wells indicates the presence of naturally-occurring constituents like iron, sulfate and manganese. Some of these may impact water aesthetically, creating need for treatment prior to household use. Chloride is also commonly detected and its source can either be from natural conditions or be an indicator of human impacts to groundwater.

Arsenic concentrations in groundwater

Another source of information on groundwater quality comes from the MDNR Traverse-Grant Regional Hydrogeologic Assessment, which investigated the concentration of naturally occurring arsenic in regional aquifers (Figure 18).

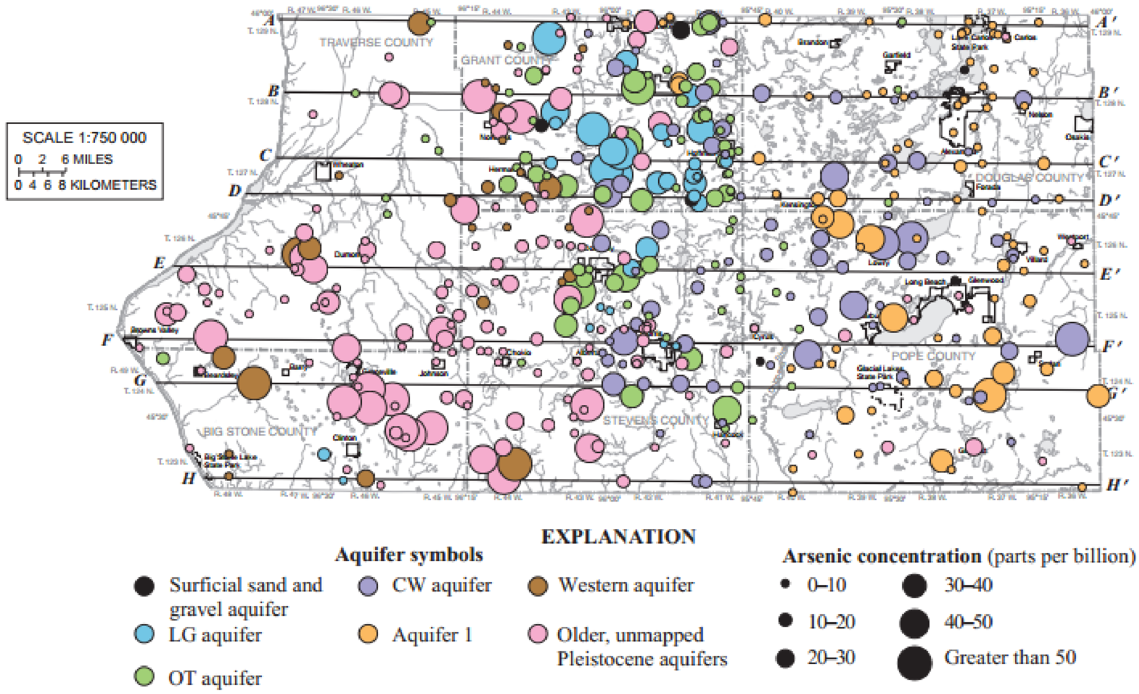


Figure 18. Summary of naturally occurring arsenic values from groundwater samples (Traverse-Grant Regional Hydrogeologic Assessment, MDNR)

Lake levels

There are few major lakes in the watershed. Only Lake Traverse has an active record of elevation readings from 2002 to 2012 (Figure 19). There is a small, statistically insignificant rising trend in water level.

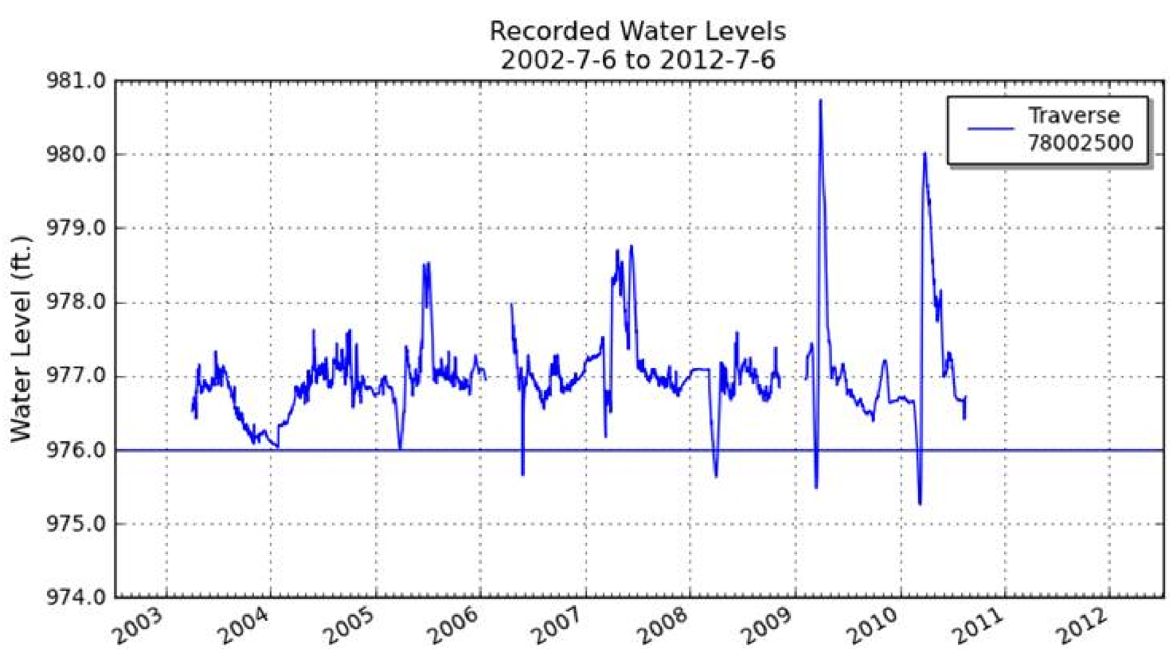


Figure 19. Water elevation for Lake Traverse 2002 - 2013

V. Individual watershed results

HUC-11 watershed units

Assessment results for aquatic life and recreation use are presented for each HUC-11 watershed within the Bois de Sioux River HUC-8 watershed. The primary objective is to portray all the full support and impairment listings within an 11-HUC watershed unit resulting from the complex and multi-step assessment and listing process. (A summary table of assessment results for the entire 8-HUC watershed including aquatic consumption, and drinking water assessments (where applicable) is included in Appendix 3). This scale provides a robust assessment of water quality condition at a practical size for the development, management, and implementation of effective TMDLs and protection strategies. The graphics presented for each of the HUC-11 watershed units contain the assessment results from the 2012 Assessment Cycle as well as any impairment listings from previous assessment cycles. Discussion of assessment results focuses primarily on the 2010 IWM effort, but also considers available data from the last ten years.

The following pages provide an account of each HUC-11 watershed. Each account includes a brief description of the subwatershed, and summary tables of the results for each of the following: a) stream aquatic life and aquatic recreation assessments, b) biological condition of channelized streams and ditches, c) stream habitat quality d) channel stability, and where applicable e) water chemistry for the HUC-11 outlet, and f) lake aquatic recreation assessments. Following the tables is a narrative summary of the assessment results and pertinent water quality projects completed or planned for the subwatershed. A brief description of each of the summary tables is provided below.

Stream assessments

A table is provided in each section summarizing aquatic life and aquatic recreation assessments of all assessable stream reaches within the watershed (i.e., where sufficient information was available to make an assessment). Primarily, these tables reflect the results of the 2012 assessment process, 2014 EPA reporting cycle; however, impairments from previous assessment cycles are also included and are distinguished from new impairments via cell shading (see footnote section of each table). These tables also denote the results of comparing each individual aquatic life and aquatic recreation indicator to their respective criteria (i.e., standards); determinations made during the desktop phase of the assessment process (see Figure 5). Assessment of aquatic life is derived from the analysis of biological (fish and invert IBIs), dissolved oxygen, turbidity, chloride, pH and un-ionized ammonia (NH_3) data, while the assessment of aquatic recreation in streams is based solely on bacteria (Escherichia coli or fecal coliform) data. Included in each table is the specific aquatic life use classification for each stream reach: cold water community (2A); cool or warm water community (2B); or indigenous aquatic community (2C). Stream reaches that do not have sufficient information for either an aquatic life or aquatic recreation assessment (from current or previous assessment cycles) are not included in these tables, but are included in Appendix 5.2 and Appendix 5.3. 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 as well as in the Watershed-Wide Results and Discussion section.

Channelized stream evaluations

Biological criteria have not been developed yet for channelized streams and ditches; therefore, assessment of fish and macroinvertebrate community data for aquatic life use support was not possible at some monitoring stations. A separate table provides a narrative rating of the condition of fish and macroinvertebrate communities at such stations based on IBI results. Evaluation criteria are based on aquatic life use assessment thresholds for each individual IBI class (see Appendix 5.1). IBI scores above this threshold are given a “good” rating, scores falling below this threshold by less than ~15 points (i.e., value varies slightly by IBI class) are given a "fair" rating, and scores falling below the threshold by more than ~15 points are given a "poor" rating. For more information regarding channelized stream evaluation criteria refer to Appendix 5.1.

Stream habitat results

Habitat information documented during each fish sampling visit is provided in each HUC-11 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 watershed.

Watershed outlet water chemistry results

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

Lake assessments

A summary of lake water quality is provided in the HUC-11 sections where available data exists. For lakes with sufficient data, basic modeling was completed. Assessment results for all lakes in the watershed are available in Appendix 3.2. Lake models and corresponding morphometric inputs can be found in Appendix 6.2.

Rabbit River Watershed Unit HUC 09020101110

The Rabbit River subwatershed is the largest 11 digit watershed in the Bois de Sioux River Watershed, encompassing 327 square miles of land within the counties of Wilkin, Traverse, Ottertail, and Grant. The Rabbit River originates from a series of small ditches in the east central portion of the subwatershed. The river flows westward before joining the South Fork of the Rabbit River near the community of Campbell. The South Fork of the Rabbit River is connected to an extensive network of ditches that drain the southern portion of the subwatershed. The Rabbit River continues flowing westward until flowing into the Bois de Sioux River. Land use within the watershed unit is primarily cropland (89%). Remaining small percentages of land use include developed (5.1%), forest (0.4%), rangeland (1.5%), wetland (2.7%), and open water (1.2%). The communities of Nashua, Campbell, and Tintah are found within the subwatershed. In 2010, the MPCA monitored ten AUID's within this subwatershed. Seven biological monitoring sites are also within the subwatershed.

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

					Aquatic Life Indicators:										
AUID ***Reach Name*,** *Reach Description*	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	**Aquatic Life**	**Aquatic Rec.**
09020101-502 Rabbit River Wilkin County Line to Boise de Sioiux River	22.6	2C	94RD002 05RD013 10RD005	TR bridge, 2.25 mi. W of River Center ; Upstream of CR 158, 10 mi. SE of Breckenridge; Upstream of HWY 75, 5 mi. NW of Campbell	EXS	EXS	EXP	EXS	MTS	MTS	MTS	--	EX	NS	NS
09020101-512 Rabbit River South Fork, Wilkin County Line to Rabbit River	7.54	2C	10RD012	Upstream of County Road 152, 2 mi. SE of Campbell	EXS	--	EXS	EXS	--	MTS	--	--	--	NS	NA
09020101-513 County Ditch 9 Unnamed Ditch to Unnamed Cr	4.26	2B, 3C	--	--	--	--	MTS	EXP	--	MTS	--	--	--	IF	NA
09020101-515 Unnamed Creek Unnamed Creek to Rabbit River	2.35	2B, 3C	--	--	--	--	EXS	EXP	--	MTS	--	--	--	NS	NA
09020101-517 Judicial Ditch 12 Unnamed Ditch to JD 7	1.96	2B, 3C	--	--	--	--	EXP	EXP	--	MTS	--	--	--	IF*	NA

09020101-520 Unnamed Ditch Unnamed Ditch to Unnamed Ditch	3.45	2B, 3C	--	--	--	--	IF	MTS	--	MTS	--	--	--	IF	NA
09020101-527 Unnamed Ditch Headwaters to Unnamed Ditch	4.06	2B, 3C	--	--	--	--	EXP	MTS	--	MTS	--	--	--	IF*	NA

Abbreviations for Indicator Evaluations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **MTS** = Meets criteria; **EXP** = Exceeds criteria, potential impairment;
EXS = Exceeds criteria, potential severe impairment; **EX** = Exceeds criteria (Bacteria).
Abbreviations for Use Support Determinations: **NA** = Not Assessed, **IF** = Insufficient Information, **NS** = Non-Support, **FS** = Full Support
Key for Cell Shading: = existing impairment, listed prior to 2012 reporting cycle; = new impairment; = full support of designated use.
*Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.

Table 2. Non-assessed biological stations on channelized AUIDs: Rabbit River 11-HUC.

AUID ***Reach Name,*** *Reach Description*	**Reach length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Fish IBI**	**Invert IBI**
09020101-504 Unnamed Ditch Unnamed Ditch to Rabbit River	3.86	2B, 3C	10RD009	Upstream of Township Rd 95, 6 mi. NE of Tintah	Poor	Fair
09020101-547 Unnamed Ditch Unnamed Ditch to Unnamed Ditch	1	2B, 3C	10RD016	Upstream of 240th St, 6.5 mi. E of Charlesville	Poor	Not Sampled
09020101-548 Judicial Ditch 2 Unnamed Ditch to Unnamed Ditch	0.96	2B, 3C	10RD010	Upstream of Hwy 55, 3.5 mi. NE of Tintah	Poor	Poor

See Appendix 5.1 for clarification on the good/fair/poor thresholds and Appendix 5.2 and Appendix 5.3 for IBI results.

Table 3. Minnesota Stream Habitat Assessment (MSHA): Rabbit River 11-HUC.

# 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	94RD002	Rabbit River	0	6	8	6	2	22	poor
1	05RD013	Rabbit River	0	7	13	6	18	44	poor
1	10RD005	Rabbit River	0	9	3	1	6	19	poor
1	10RD009	Trib. to Judicial Ditch 2	0	3.5	11.3	14	14	42.8	poor
1	10RD012	Rabbit River, South Fork	0	8	3	7	18	36	poor
1	10RD016	Trib. to Judicial Ditch 2	1.25	10	7	0	10	28.25	poor
1	10RD010	Judicial Ditch 2	0	6	3	12	7	28	poor
		Average Habitat Results: *Rabbit River 11 HUC*	**0.2**	**7.1**	**6.9**	**6.6**	**10.7**	**31.4**	**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 4. Outlet water chemistry results: Rabbit River 11-HUC 09020101110.

Station location:	**Rabbit River, Upstream of HWY 75, 5 mi. NW of Campbell**							
STORET/EQuIS ID:	**S001-029**							
Station #:	**09020101-502**							
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**Median**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	mg/L	10	< 0.04	0.24	0.1	0.02		
Chloride	mg/L						230	
Chlorophyll-a, Corrected	ug/L	1	82	82				
Dissolved Oxygen (DO)	mg/L	20	4.2	10.4	7.3	7.31	5	2
Escherichia coli	MPN/100ml	16	24	460	106	113	1260	0
Inorganic nitrogen (nitrate and nitrite)	mg/L	10	< 0.03	1.7	0.4	0.14		

Kjeldahl nitrogen	mg/L	10	1.4	2.6	1.9	1.96		
Orthophosphate	ug/L							
pH		20	7.5	8.9	8.2	8.22	6.5-9	0
Pheophytin-a	ug/L	1	< 1	< 1				
Phosphorus	ug/L	10	110	622	355	328		
Specific Conductance	uS/cm	20	159	2649	1272	1318		
Temperature, water	deg °C	20	8.4	28.1	22.0	22.8		
Total suspended solids	mg/L	10	22	138	70.5	68.0		
Total volatile solids	mg/L	10	6	31	16.4	16.5		
Transparency tube	100 cm	20	5	103	15.8	9.0	>20	0
Transparency tube	60 cm						>20	
Turbidity	FNU	4	79.5	113	92.3	91.0	25 NTU	4
Sulfate	mg/L							
Hardness	mg/L							

1Geometric mean of all samples is provided for E. coli or fecal coliform.
2# WQ exceedances represents exceedances of individual maximum standard for E. coli (1260/100ml).

Table 5. Lake water aquatic recreation assessments: Rabbit River 11-HUC.

Name	DOW#	Area (ha)	Trophic Status	percent Littoral	Max. Depth (F)	Avg. Depth (F)	CLMP Trend	Mean TP (µg/L)	Mean chl-a (µg/L)	Secchi Mean (F)	Support Status
Ash	26-0294-00	88	H	100	1.5	1	IF	146	55.1	0.4	NS
Stony	26-0305-00	41	H	100				162			IF
Mud	26-0307-00	28	H	100				327		0.5	IF
Upper Lightning	56-0957-00	218	H	100	1.8	1	IF	101	44.8	0.9	NS

1. Mean depths estimated.
2. NS = not supporting, FS = supporting, IF = insufficient information to determine support, NA = not assessed (too small or wetland-like)
3. H = Hypereutrophic
4. IF = Insufficient information

Summary

Water quality data were available on portions of Judicial Ditch 2, Judicial Ditch 12, the Rabbit River, and two small tributaries. While much of the main stem Rabbit River is a natural channel, the majority of the tributaries (judicial ditches and unnamed creeks) are highly altered straight channels. The MPCA is deferring assessing reaches that are greater than 50% channelized until the TALU standards are promulgated. All of the tributaries were identified as either exceeding turbidity or dissolved oxygen standards or both; however, due to channelization, actual impairments were assigned only to the unchannelized tributary that drains into the Rabbit River near Campbell, Minnesota. The main stem Rabbit River was previously listed as not supporting aquatic life based on dissolved oxygen and turbidity. In addition, excess bacteria levels are also found along the main stem and aquatic recreation use is considered to be impaired.

Seven biological monitoring stations were located in the Rabbit River subwatershed. Biological data was assessable at four of the stations due to their placement on non-channelized stream segments of the Rabbit River or South Fork of the Rabbit River. Fish IBI scores were poor at all biological monitoring stations. The highest FIBI score occurred at station 94RD002 located on the Rabbit River; however, the site still scored well below the threshold value. Low numbers of lithophilic spawning species, such as walleye and silver redhorse, were sampled at both stations on the main stem of the Rabbit River. The majority of every fish sample was comprised of tolerant species such as fathead minnows, black bullheads, and orange spotted sunfish. Most of these species can tolerate low dissolved oxygen and turbidity. Detritivorous species and trophic generalists were also present in most fish samples. Both detritivorous and generalist species can survive in streams degraded by nutrient and sediment inputs. Macroinvertebrate IBI scores were poor at all stations. Invertebrate samples consisted of tolerant taxa and exhibited poor taxa richness at most sites. In addition to widespread turbidity and dissolved oxygen impairments, stream habitat conditions are likely limiting fish and invertebrate community development within the Rabbit River subwatershed. Streams within the LAP are low gradient and lack the coarse substrate necessary to support certain fish species and invertebrate taxa. Stream habitat was poor at stations located on both natural and modified channels. Coarse substrate was absent or embedded when present. Very little cover for fish and invertebrates was present at most stations, especially those located on the Rabbit River. The development of aquatic vegetation is prevented by the turbid conditions present in most streams. Channel development was poor at most stations. The riparian zone was narrow and surrounding land use was rated at zero in the stream habitat assessment for most stations.

Only two lakes had sufficient data for review against the aquatic recreation use standard. Ash Lake, adjacent to the Shuck Wildlife Management Area, is a designated wildlife lake by the MDNR. As such, it is managed via drawdowns (one scheduled for 2012) for wetland vegetation and clear water. Currently very low Secchi and high algal concentrations are limiting rooted vegetation in the basin. Upper Lightning Lake is currently being considered by MDNR for designation as a wildlife lake. The lake is adjacent to the U.S. Fish and Wildlife Services' Dahler Slough Waterfowl Production Area. Again, this basin experiences algal limitation of rooted vegetation. Both lakes exceed the eutrophication standard and are considered to be not supporting aquatic recreation use.

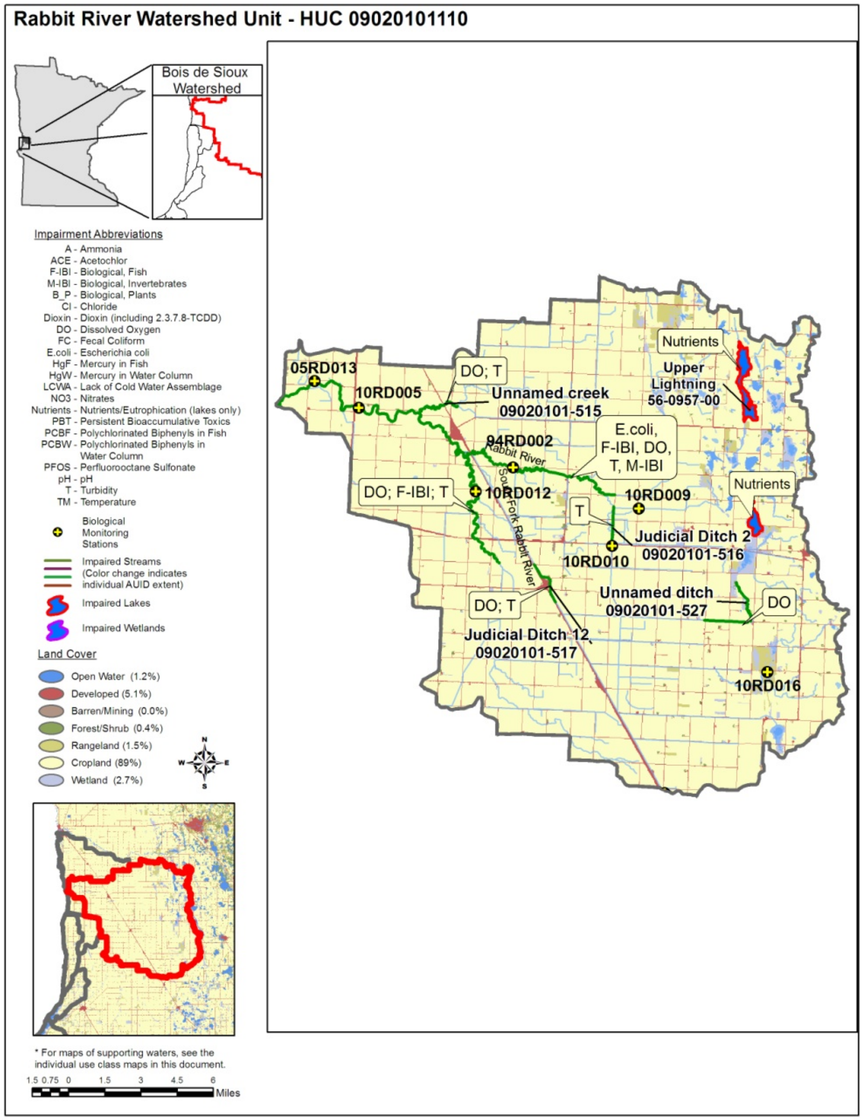


Figure 20. Currently listed impaired waters by parameter and land use characteristics in the Rabbit River subwatershed

Doran Coulee Watershed Unit HUC 09020101120

The Doran Coulee subwatershed drains 67 square miles of Wilkin County. Doran Slough originates in the far eastern portion of the subwatershed and flows westward before turning toward the north, eventually entering into the Bois de Sioux River near the community of Breckenridge. Land use within the watershed unit is primarily row crop (90.7%). Remaining small percentages of land use include developed (6.6%) forest (0.4%), rangeland (0.5%), wetland (1.3%), and open water (0.5%). In 2010, the MPCA monitored and assessed two AUIDs within the subwatershed. One biological monitoring site was sampled within the subwatershed.

Table 6. Aquatic life and recreation assessments on stream reaches: Doran Coulee Watershed unit. 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:								Bacteria	Aquatic Life	Aquatic Rec.
					Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides			
09020101-501 Bois de Sioux River Rabbit River to Otter Tail River	15.27	2C	84RD005	1 mi. upstream of CR 12, 1 mi. S of Breckenridge	EXS	MTS	IF	EXS	MTS	MTS	MTS	--	EX	NS	NS
09020101-510 Unnamed Creek (Doran Slough) Headwaters to Bois de Sioux River	26.72	2C	--	--	--	--	EXS	MTS	MTS	MTS	MTS	--	EX	NS	NS

Abbreviations for Indicator Evaluations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **MTS** = Meets criteria; **EXP** = Exceeds criteria, potential impairment;
EXS = Exceeds criteria, potential severe impairment; **EX** = Exceeds criteria (Bacteria).
Abbreviations for Use Support Determinations: **NA** = Not Assessed, **IF** = Insufficient Information, **NS** = Non-Support, **FS** = Full Support
Key for Cell Shading: = existing impairment, listed prior to 2012 reporting cycle; = new impairment; = full support of designated use.
*Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.

Table 7. Minnesota Stream Habitat Assessment (MSHA): Doran Coulee 11-HUC.

# 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	84RD005	Bois de Sioux River	0	11	7	6	14	38	poor
Average Habitat Results: *Doran Coulee 11 HUC*			0	11	7	6	14	38	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: Doran Coulee 11-HUC

Station location:	**Doran Coulee, At CR 9, 2.5 mi. S of Breckenridge**							
STORET/EQuIS ID:	**S005-144**							
Station #:	**09020101120**							
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**Median**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	mg/L	8	< 0.03	0.061	0.03	0.02		
Chloride	mg/L	5	8.22	34.7	16.5	13.3	230	0
Chlorophyll-a, Corrected	ug/L							
Dissolved Oxygen (DO)	mg/L	23	0.39	5.93	2.7	2.26	5	19
Escherichia coli	MPN/100ml	18	10	> 2420	80	71.3	1260	2
Inorganic nitrogen (nitrate and nitrite)	mg/L	8	<0.02	0.03	0.035	< 0.02		
Kjeldahl nitrogen	mg/L							
Orthophosphate	ug/L							
pH		23	7.21	7.94	7.5	7.51	6.5 - 9	0
Pheophytin-a	ug/L							
Phosphorus	ug/L	8	369	805	556	533		
Specific Conductance	uS/cm	23	402	1972	949	658		
Temperature, water	deg °C	23	9.11	26.67	18.1	17.62		

Total suspended solids	mg/L	16	< 1	8	1.7	1		
Total volatile solids	mg/L							
Transparency tube	100 cm	18	34	> 100	89.4	100	>20	0
Transparency tube	60 cm						>20	
Turbidity	FNU	11	< 0.1	13.3	3.7	2.1	25 NTU	0
Sulfate	mg/L							
Hardness	mg/L							

1Geometric mean of all samples is provided for E. coli or fecal coliform.
2# WQ exceedances represents exceedances of individual maximum standard for E. coli (1260/100ml).

Table 9. Outlet water chemistry results: Doran Coulee 11-HUC.

Station location:	**Bois de Sioux River, 1 mi. upstream of CR 12, 1 mi. S of Breckenridge**							
STORET/EQuIS ID:	**S000-089**							
Station #:	**09020101120**							
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**Median**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	mg/L	10	< 0.04	0.298	0.1	0.09		
Chloride	mg/L						230	
Chlorophyll-a, Corrected	ug/L	7	11	101	54.7	67.0		
Dissolved Oxygen (DO)	mg/L	18	4.1	8.9	6.6	6.60	5	2
Escherichia coli	MPN/100ml	14	11	> 2420	54	43	1260	1
Inorganic nitrogen (nitrate and nitrite)	mg/L	10	< 0.03	0.56	0.2	0.16		
Kjeldahl nitrogen	mg/L	10	0.87	2.1	1.5	1.62		
Orthophosphate	ug/L							
pH		18	7.5	8.5	8.1	8.28	6.5-9	0
Pheophytin-a	ug/L	4	2	20	7.5	4.0		
Phosphorus	ug/L	10	149	471	334	368		
Specific Conductance	uS/cm	18	505	1404	1038	1018		
Temperature, water	deg °C	18	9.1	27.6	22.4	23.0		
Total suspended solids	mg/L	9	12	146	63.0	57.0		

Total volatile solids	mg/L	10	3	23	13.2	11.0		
Transparency tube	100 cm	18	6	93	22.0	14.0	>20	
Transparency tube	60 cm						>20	
Turbidity	FNU	2	44	52	48.6	48.6	25 NTU	2
Sulfate	mg/L							
Hardness	mg/L							

1Geometric mean of all samples is provided for E. coli or fecal coliform.
2# WQ exceedances represents exceedances of individual maximum standard for E. coli (1260/100ml).

Summary

Water quality data were available on Unnamed Creek (Doran Slough) and the Bois de Sioux River between the Rabbit and Otter Tail Rivers. Doran Slough drains through 27 miles of agricultural land before it joins the Bois de Sioux just downstream of Breckenridge, Minnesota. The reach was impaired for aquatic life use due to low oxygen levels and aquatic recreation use due to excessive levels of bacteria. The Bois de Sioux River was previously impaired for aquatic life use based on degraded fish communities, high turbidity, and low dissolved oxygen. New impairments for aquatic recreation based on excess bacteria and aquatic consumption for mercury in fish tissue were identified.

One biological monitoring station, 84RD005, was located in the Doran Coulee subwatershed. The station was located on a natural segment of the Bois de Sioux River just before it joins with the Otter Tail River. The most abundant fish species sampled was the common carp, a tolerant species. Low numbers of lithophilic spawning species, such as walleye and silver red horse, were sampled at the station. The fish IBI score was below the threshold but within the lower confidence interval. Fish sampling conducted in 1983 by the MDNR produced a very similar sample also dominated by common carp. In addition to turbidity and dissolved oxygen impairments, stream habitat conditions are likely limiting the quality of the fish community. No coarse substrate was present at station 84RD005, a characteristic common to streams found within the LAP. Sparse amounts of woody debris were available for cover. Despite limited habitat, the macro invertebrate samples exhibited good taxa richness and the MIBI score was above the threshold.

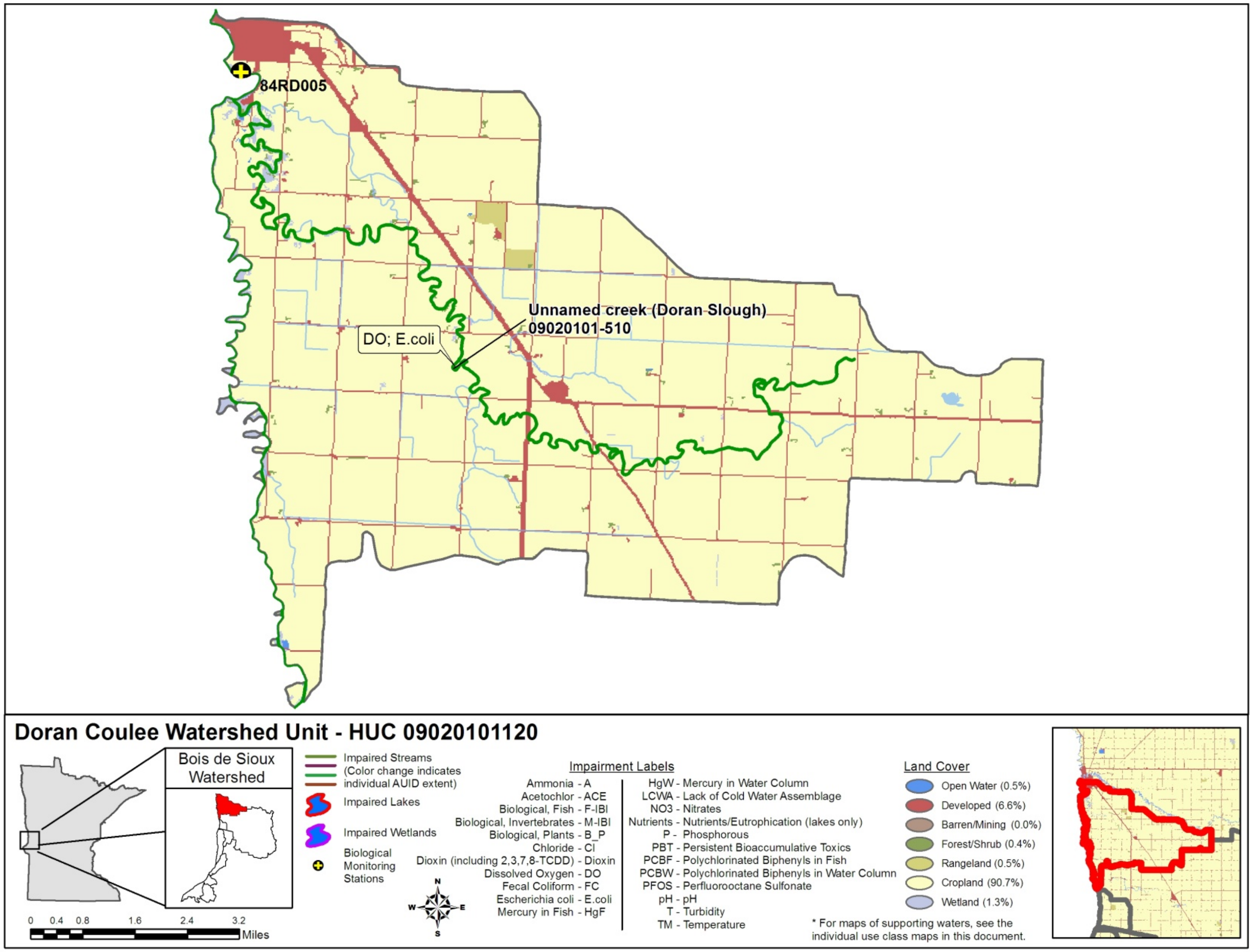


Figure 21. Currently listed impaired waters by parameter and land use characteristics in the Doran Coulee subwatershed

Steer Creek Watershed Unit HUC 09020101025

The Steer Creek subwatershed drains 35 square miles of land within Traverse County. Several small streams flow across the subwatershed into Lake Traverse. Land use is primarily row crop (57.7%) and open water (20.5%). Other land uses include forest (3.9%), developed (4.1%), range land (8.5%) and wetland (5.3%). In 2010, the MPCA monitored one AUID and sampled one biological monitoring site within the subwatershed.

Table 10. Aquatic life and recreation assessments on stream reaches: Steer Creek watershed unit. Reaches are organized upstream to downstream in the table.

AUID ***Reach Name,*** *Reach Description*	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	**Aquatic Life**	**Aquatic Rec.**
09020101-535 Unnamed Creek Unnamed Creek to Lake Traverse	0.45	2B, 3C	10RD022	Upstream of Hwy 27, 4 mi. SW of Dakomin	EXS	MTS	--	--	--	--	--	--	--	NS	NA

Abbreviations for Indicator Evaluations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **MTS** = Meets criteria; **EXP** = Exceeds criteria, potential impairment;
EXS = Exceeds criteria, potential severe impairment; **EX** = Exceeds criteria (Bacteria).
Abbreviations for Use Support Determinations: **NA** = Not Assessed, **IF** = Insufficient Information, **NS** = Non-Support, **FS** = Full Support
Key for Cell Shading: ☐ = existing impairment, listed prior to 2012 reporting cycle; ☐ = new impairment; ☐ = full support of designated use.
*Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.

Table 11. Minnesota Stream Habitat Assessment (MSHA): Steer Creek 11-HUC.

# 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**
	10RD022	Trib. to Lake Traverse	2.5	11	18.4	12	17	60.9	fair
		Average Habitat Results: *Steer Creek 11 HUC*	2.5	11	18.4	12	17	60.9	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)

Summary

One biological monitoring station, 10RD022, was located within the Steer Creek subwatershed on a tributary to Lake Traverse. The fish sample contained only three species of fish; all of the species were tolerant. Two of the three species, creek chubs and blacknose dace, are generalist feeders. Generalist feeders can persist in degraded and frequently disturbed habitats because they can utilize multiple food sources. The FIBI score was low. The macroinvertebrate sample scored just below the threshold value. Station 10RD022 had the highest ranked stream habitat of all stations within the Bois de Sioux watershed. Moderately embedded coarse substrate and various forms of cover were present. The station also had the highest stream gradient value (8.78 ft/mi) of any station in the Bois de Sioux watershed.

The Steer Creek subwatershed lies within the Northern Glaciated Plains ecoregion. Unlike streams within the Lake Agassiz Plain, streams within the Steer Creek subwatershed contained erodible sand and silt bank materials instead of more cohesive clay-silt mixtures. Severe bank erosion and evidence of channel instability was present throughout the station (*see Figure 22 below*). Excessive scouring, severe bank failures at outside bends, and excess deposition of sediment on inside bends all indicate frequent high flow events occur within the station. Such instability and dramatic flow fluctuations may be limiting fish community development. Certain invertebrate taxa are better adapted to accommodate high flow velocity and can persist in such an environment. Due to its small drainage area and high gradient, the stream likely becomes intermittent during extended dry periods. All of the conditions present within the station favor the existence of tolerant, trophic generalist fish species. Though no water quality data is available for this stream, the excessive bank erosion rates suggest that event-based turbidity exceedances may also be problematic. Consequently, the stream likely contributes considerable sediment to Lake Traverse.

Figure 22. Images of severe bank erosion at biological monitoring station 10RD022 located on Steer Creek

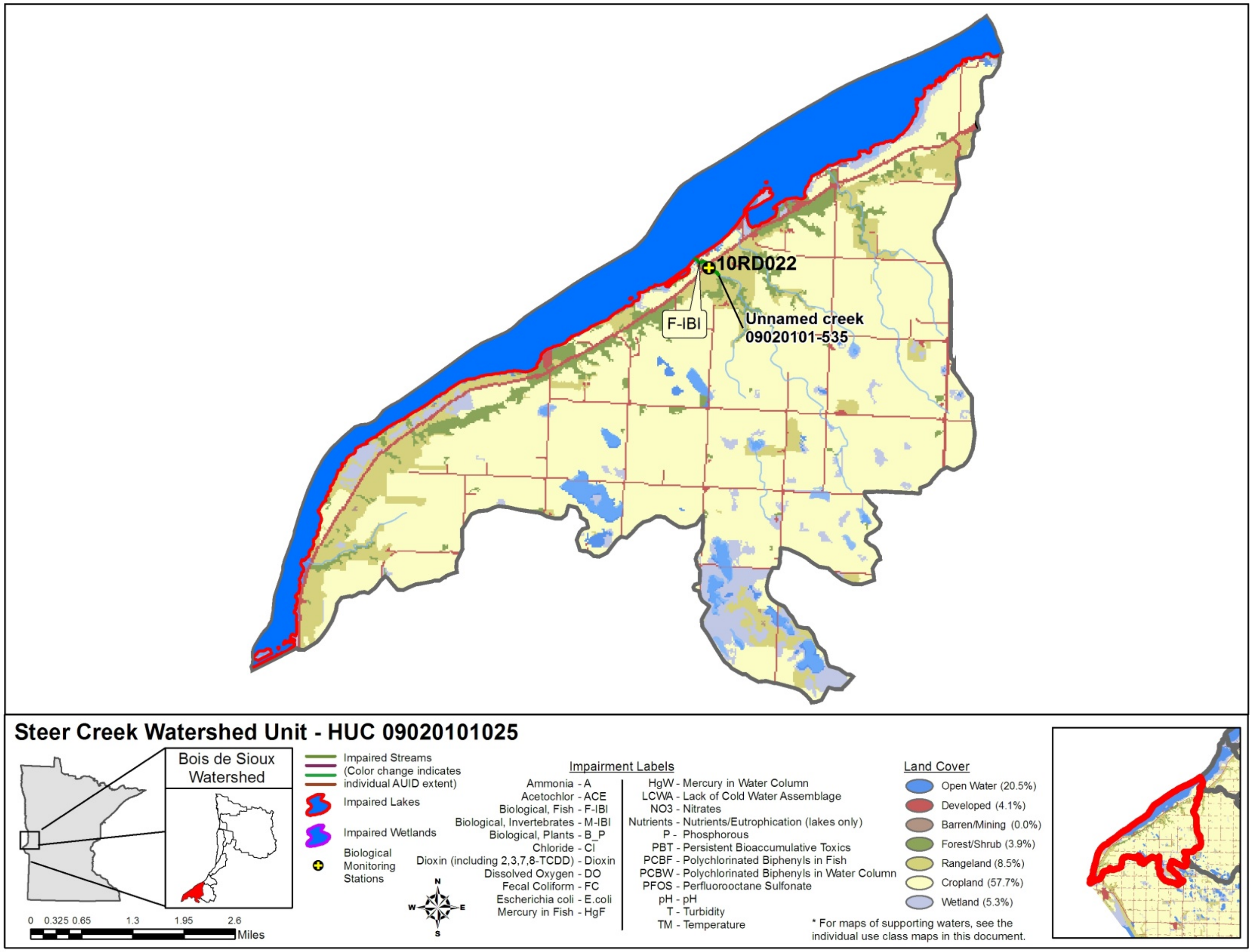


Figure 23. Currently listed impaired waters by parameter and land use characteristics in the Steer Creek subwatershed

C.D. # 52 Watershed Unit HUC 09020101030

The County Ditch # 52 watershed unit drains 32 square miles of land within Traverse County. Several small streams flow across the subwatershed and join together with C.D. #52 just before it flows into Lake Traverse. Land use within the subwatershed is primarily cropland (88.8%). Remaining small percentages of land use include open water (2.3%), wetland (1.4%), rangeland (2%), and developed (4.6%). In 2010, the MPCA monitored two stream segments and sampled two biological monitoring sites within the subwatershed.

Table 12. Aquatic life and recreation assessments on stream reaches: C.D. # 52 Watershed unit. 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:**								**Bacteria**	**Aquatic Life**	**Aquatic Rec.**
					Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides			
09020101-540 County Ditch 52 Unnamed Creek to Unnamed Creek	1.65	2B, 3C	10RD019	Downstream of Twp Rd 18, 1 mi. SE of Dakomin	EXS	MTS	--	--	--	--	--	--	--	NS	NA

Abbreviations for Indicator Evaluations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **MTS** = Meets criteria; **EXP** = Exceeds criteria, potential impairment;
EXS = Exceeds criteria, potential severe impairment; **EX** = Exceeds criteria (Bacteria).
Abbreviations for Use Support Determinations: **NA** = Not Assessed, **IF** = Insufficient Information, **NS** = Non-Support, **FS** = Full Support
Key for Cell Shading: = existing impairment, listed prior to 2012 reporting cycle; = new impairment; = full support of designated use.
Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.

Table 13. Non-assessed biological stations on channelized AUIDs: C.D. # 52 11-HUC .

AUID ***Reach Name,*** *Reach Description*	**Reach length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Fish IBI**	**Invert IBI**
09020101-539 Unnamed Creek Unnamed Creek to County Ditch 52	0.45	2B, 3C	10RD020	Upstream of HWY 27, 0.5 mi. SE of Dakomin	Poor	Fair

See Appendix 5.1 for clarification on the good/fair/poor thresholds and Appendix 5.2 and Appendix 5.3 for IBI results.

Table 14. Minnesota Stream Habitat Assessment (MSHA): C.D. # 52 11-HUC.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrat e	Fish Cover (0-17)	Channel Morph.	MSHA Score (0-100)	MSHA Rating
1	10RD019	County Ditch 52	0	8.5	17.4	13	13	51.9	fair
1	10RD020	Trib. to County Ditch 52	0	9	14	13	16	52	fair
		Average Habitat Results: *C.D. # 52 11 HUC*	**0**	8.75	15.7	13	14.5	51.95	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)

Summary

Two biological monitoring stations were located within the County Ditch 52 subwatershed. The County Ditch 52 stream segment was found to be impaired for aquatic life use based on a low FIBI score at station 10RD019. Only two tolerant species of fish, fathead minnows and brook stickleback, were sampled at station 10RD019. The sample contained high numbers of fathead minnows. The MIBI scored above the threshold value.

The station features a high stream gradient of 7.51 ft/mile. Various forms of cover and coarse substrate were present in the downstream portion of the station. Stream bank materials within the County Ditch 52 subwatershed consisted of friable sand and silt mixtures rather than cohesive clay-silt found in LAP streams. Excessive sediment was present in the upstream portion of the station due to catastrophic bank failure near the road crossing. The erosion and resulting bank failure was so severe that the stream channel was almost completely blocked in places (*see Figure 24 below*). High flow events well beyond the capacity of the stream channel, together with high gradient, are resulting in high stream velocities that destroy banks, create an unstable channel, and carry high loads of sediment. The unstable environment and increased turbidity also appear to be limiting fish community development. Some invertebrate taxa sampled at the station are better adapted to accommodate high flow velocity and can persist in such an environment. A perched culvert was found just upstream of the station.

Station 10RD020 was located on a channelized tributary to County Ditch 52. Similar to County Ditch 52 the fish sample contained high numbers of tolerant species and generalist feeders. Also, the FIBI was low but the MIBI scored above the threshold. Again, due to adaptations, some invertebrates can tolerate high flow velocities that fish cannot. Severely embedded coarse substrate, poor channel stability, and severe bank erosion within the station indicate frequent dramatic fluctuations in flow. The environmental instability caused by fluctuations in flow is likely limiting fish community development. The culvert immediately downstream of the station was perched, and may limit fish movement during moderate/low flow. Though no water quality data is available for this stream segment the excessive bank erosion rates suggest that turbidity may be problematic. Consequently, both streams within the County Ditch 52 watershed are likely contributing considerable amounts of sediment to Lake Traverse.

Figure 24. Images of severe bank failure present within station 10RD019 located on County Ditch # 52

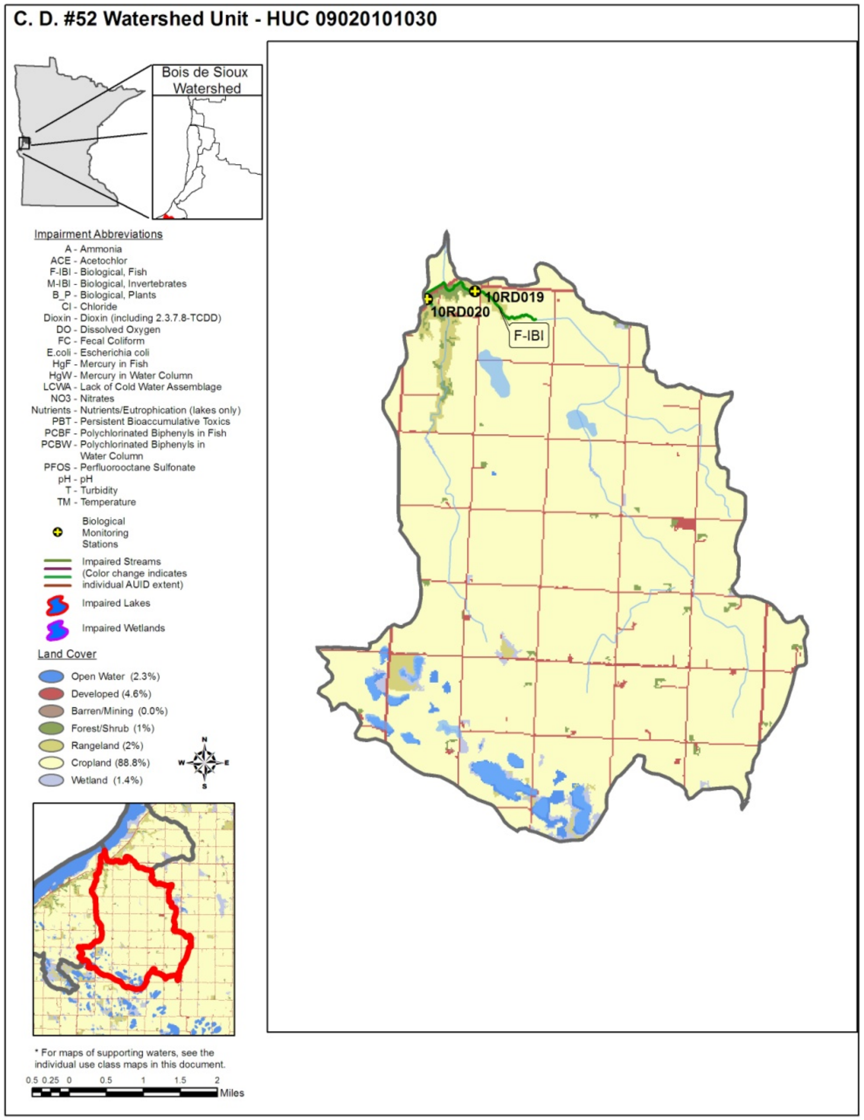


Figure 25. Currently listed impaired waters by parameter and land use characteristics in the C.D. #52 subwatershed

Lake Traverse Watershed Unit HUC 09020101040

The Lake Traverse subwatershed drains 14 square miles of Traverse County, and is the smallest watershed unit in the Bois de Sioux River Watershed. Several small streams flow across the subwatershed into Lake Traverse. Land use is primarily crop land (60.6%) and open water (17.7%). Other land use percentages include wetland (9.9%), rangeland (6.7%), barren (0.3%), forest (0.7%), and developed (4%). No stream segments were assessed and no biological monitoring sites were sampled within the Lake Traverse watershed unit.

Summary

Due to the very small and ephemeral nature of the streams in the Lake Traverse subwatershed, no biological monitoring stations were sampled, and no chemistry data for streams were collected either. Lake Traverse is a large reservoir controlled via Reservation Dam by the U.S. Army Corps of Engineers. The impoundment is 16 miles long, shallow, and creates the border between South Dakota and Minnesota. The lake has very high concentrations of phosphorus; however, based on the data record, the expected response of decreased clarity and increased algal production has not been captured. As a result, the lake is considered to have insufficient information to determine impairment – the available data do not indicate support or non-support. However, nutrient concentrations are well above the level necessary to produce nuisance algal blooms.

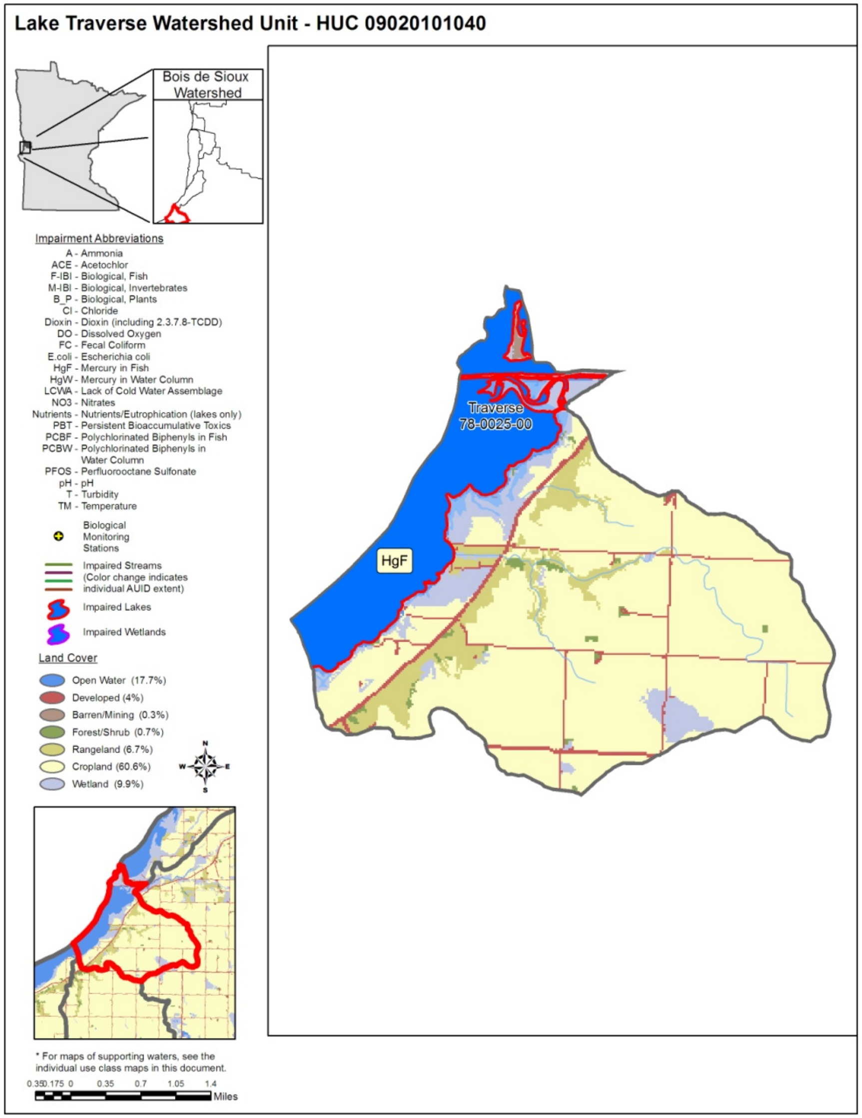


Figure 26. Currently listed impaired waters by parameter and land use characteristics in the Lake Traverse subwatershed

Mud Lake Watershed Unit HUC 09020101060

The Mud Lake subwatershed drains 25 square miles of Traverse County. Several small streams flow across the subwatershed into Lake Traverse. Land use is primarily crop land (65.8%). Remaining land use percentages include wetland (13.8%), rangeland (5.1%), forest (0.5%), barren (0.2%), open water (9.3%), and developed (5.4%). No stream segments were assessed and no biological monitoring stations were sampled within the subwatershed.

Table 15. Lake water aquatic recreation assessments: Mud Lake 11-HUC.

Name	DOW#	Area (ha)	Trophic Status	Percent Littoral	Max. Depth (F)	Avg. Depth (F)	CLMP Trend	Mean TP (µg/L)	Mean Chl-a (µg/L)	Secchi Mean (F)	Support Status
Mud	78-0024-00	664	H	100	2.6	1.0	IF	442	28.9	0.3	NS

1. Mean depths estimated.
2. NS = not supporting, FS = supporting, IF = insufficient information to determine support, NA = not assessed (too small or wetland-like)
3. H = Hypereutrophic
4. IF = Insufficient Information

Summary

No biological monitoring stations were located within the subwatershed and no stream water chemistry data were collected either. Mud Lake is a large, shallow reservoir managed by the U.S Army Corps of Engineers for flood control and water conservation during periods of drought. Periodic drawdowns occur to improve the lake conditions for migratory waterfowl, and winterkills do occur. Based on two years of sampling, the lake is highly variable; suspended sediment concentrations are very high and can limit algal production. Phosphorus concentrations are very high, not unexpectedly, considering the high concentrations coming from upstream Lake Traverse. The lake has a 2 meter deep channel with most of the lake between 0.3 and 0.6 meters deep; however, during high water, the depth can increase over 3 meters above normal pool elevation. Modeling was conducted to determine if the basin had sufficient residence time to be considered a lake. The results indicate that even though the mean depth is only 0.3 meters, the lake still had an estimated residence time of greater than 14 days at low flow; consequently Mud Lake is considered a shallow lake and assessed as not supporting aquatic recreation.

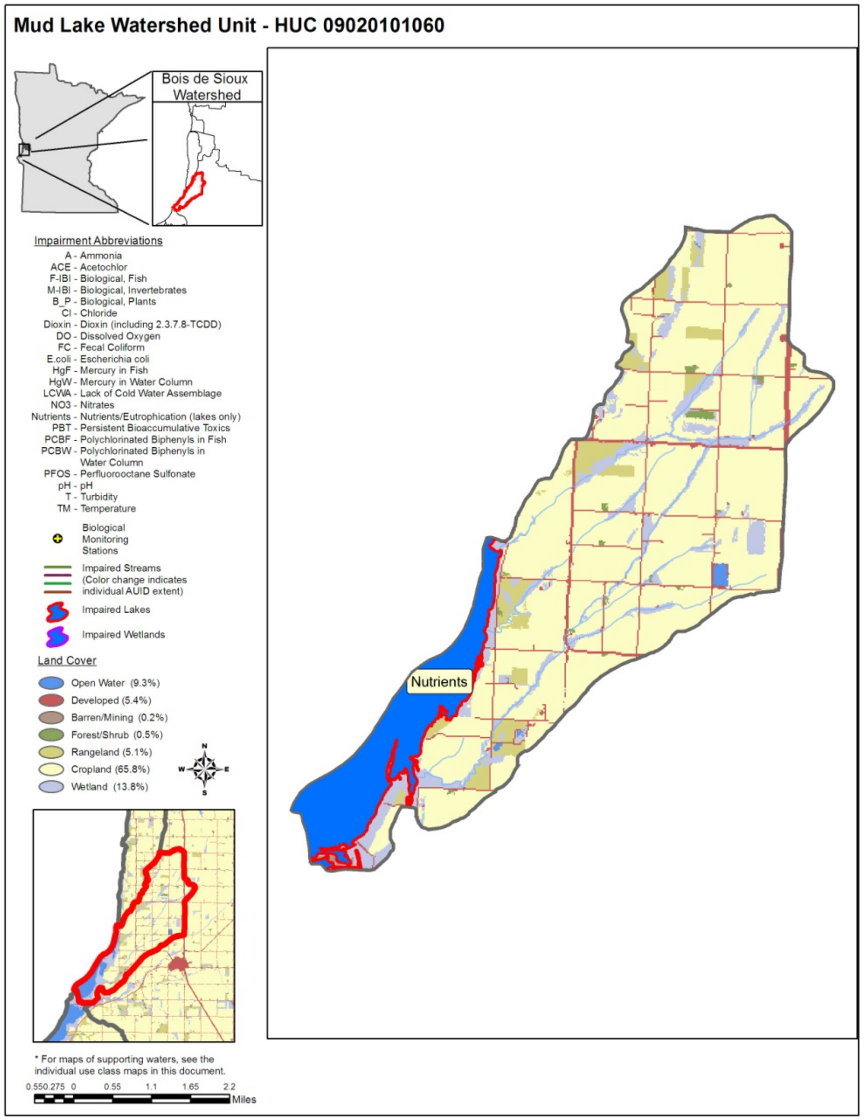


Figure 27. Currently listed impaired waters by parameter and land use characteristics in the Mud Lake subwatershed

J.D. #11 Watershed Unit HUC 09020101070

The Judicial Ditch # 11 subwatershed drains 20 square miles of land within Traverse and Wilkin County. A network of channelized ditches crosses the subwatershed. Land use is primarily crop land (92.3%). Remaining land use percentages include wetland (0.4%), rangeland (0.1%), forest (0.4%), and developed (6.9%). There is no open water in the subwatershed. No stream segments were assessed and no biological monitoring stations were sampled in the subwatershed.

Summary

No biological monitoring stations were located within the Judicial Ditch 11 subwatershed. No lake or stream data were collected for the subwatershed.

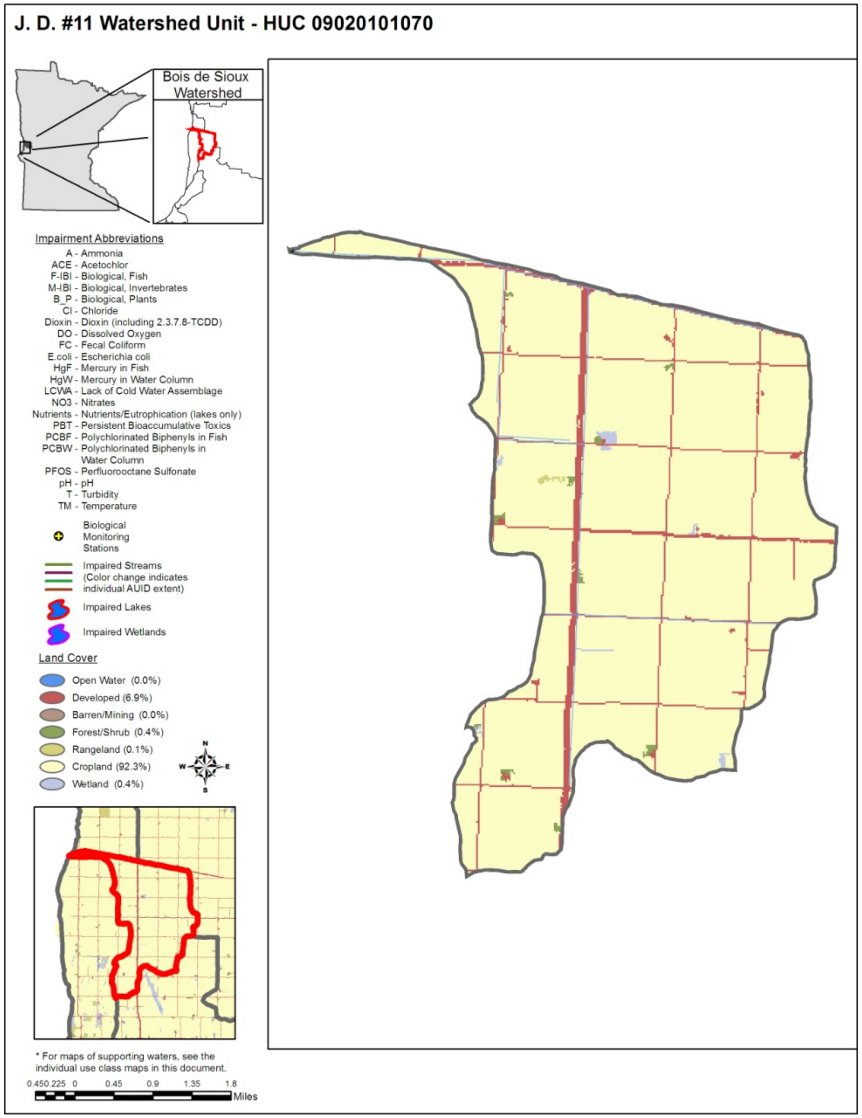


Figure 28. Currently listed impaired waters by parameter and land use characteristics in the J.D. #11 subwatershed

Bois de Sioux River Watershed Unit HUC 09020101090

The Bios de Sioux River subwatershed drains 41 square miles of land within Traverse and Wilkin County. Numerous small streams flow westward into the Bois de Sioux River and several small channelized ditches flow across the upper subwatershed. Land use is primarily crop land (86.7%). Remaining percentages of land use include wetland (4.8%), rangeland (3%), forest (0.7%), open water (0.5%), and developed (4.3%). One stream segment was monitored and one biological monitoring site was sampled within the subwatershed.

Table 16. Non-assessed biological stations on channelized AUIDs: Bois de Sioux 11-HUC.

AUID ***Reach Name***, *Reach Description*	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	**Aquatic Life**	**Aquatic Rec.**
09020101-503 Bois de Sioux River Mud Lake to Rabbit River	19.85	2C	84RD001	At Hwy 55, 5.5 mi. W of Tenney	--	--	EXP	EXS	MTS	MTS	MTS	--	MTS	IF*	FS

Abbreviations for Indicator Evaluations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **MTS** = Meets criteria; **EXP** = Exceeds criteria, potential impairment;
EXS = Exceeds criteria, potential severe impairment; **EX** = Exceeds criteria (Bacteria).
Abbreviations for Use Support Determinations: **NA** = Not Assessed, **IF** = Insufficient Information, **NS** = Non-Support, **FS** = Full Support
Key for Cell Shading: = existing impairment, listed prior to 2012 reporting cycle; = new impairment; = full support of designated use.
Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.

Table 17. Minnesota Stream Habitat Assessment (MSHA): Bois de Sioux 11-HUC.

# 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	84RD001	Bois de Sioux River	0	9	13	5	4	31	poor
		Average Habitat Results: *Bois de Sioux 11 HUC*	0	9	13	5	4	31	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 18. Outlet water chemistry results: Bois de Sioux 11-HUC.

Station location:	Bois de Sioux River, At Hwy 55, 5.5 mi. W of Tenney							
STORET/EQuIS ID:	S003-119							
Station #:	09020101090							
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**Median**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	mg/L	11	< 0.04	0.152	0.1	0.072		
Chloride	mg/L	4	12.5	20.5	16.6	16.65	230	0
Chlorophyll-a, Corrected	ug/L							
Dissolved Oxygen (DO)	mg/L	25	4.6	11.7	7.5	7.25	5	3
Escherichia coli	MPN/100ml	18	11	1299.7	80.4	69.65	1260	1
Inorganic nitrogen (nitrate and nitrite)	mg/L	10	< 0.03	0.6	0.2	0.125		
Kjeldahl nitrogen	mg/L	10	1.06	2.06	1.6	1.565		
Orthophosphate	ug/L							
pH		25	7.4	8.95	8.3	8.4	6.5-9	0
Pheophytin-a	ug/L	1	5	5				
Phosphorus	ug/L	10	256	499	362	305		
Specific Conductance	uS/cm	25	154	1733	1068	1085		
Temperature, water	deg °C	25	9	29.5	21.9	23.17		
Total suspended solids	mg/L	16	11	164	59.3	46		
Total volatile solids	mg/L	10	3	30	13.5	13		
Transparency tube	100 cm	25	6.5	95	24.5	15	>20	
Transparency tube	60 cm						>20	
Turbidity	FNU	11	5.9	98.5	47.8	42.3	25 NTU	7
Sulfate	mg/L							
Hardness	mg/L							

1 Geometric mean of all samples is provided for E. coli or fecal coliform.

2# WQ exceedances represents exceedances of individual maximum standard for E. coli (1260/100ml).

Summary

Water quality data were available from the downstream end of this 20 mile reach of the Bois de Sioux River from the outlet of Mud Lake to the confluence with the Rabbit River. Over this span, turbidity often exceeded the standard and total suspended solids exceeded the proposed criteria of 65 mg/L. An impairment due to turbidity was recommended, but due to the highly altered nature of this portion of the river, the impairment is deferred until the promulgation of the Tiered Aquatic Life Use standards. Low dissolved oxygen was considered a possible stressor to aquatic life, with some exceedances of the standard, but not a strong enough dataset to determine impairment. Bacteria measurements met the standard and this portion of the river supports aquatic recreation. Aquatic consumption was impaired based on excess mercury in fish tissue.

One biological monitoring station, 84RD001, was located within the Bois de Sioux subwatershed on a channelized section of the Bois de Sioux River. Station 84RD001 had the highest FIBI score of any station (FIBI = 53) in the entire Bois de Sioux River Watershed. The station also featured the lowest percentage of tolerant fish species. The fish sample contained good numbers of piscivorous species such as walleye and white bass. Lithophilic insectivorous fish species were also present. Conditions at station 84RD001 were very similar to those at station 84RD005, which was on the Bios de Sioux River in the Doran Coulee watershed. Compared to 84RD005, station 84RD001 featured sand substrate and possibly less severe/frequent dissolved oxygen standard exceedances. Similar to most streams within the Bois de Sioux River Watershed, stream habitat was poor at station 84RD001.The stream bed lacked coarse substrate, a characteristic common to most streams within the LAP. Fish cover was sparse and the channel was poorly developed. Macroinvertebrates were not sampled at station 84RD001.

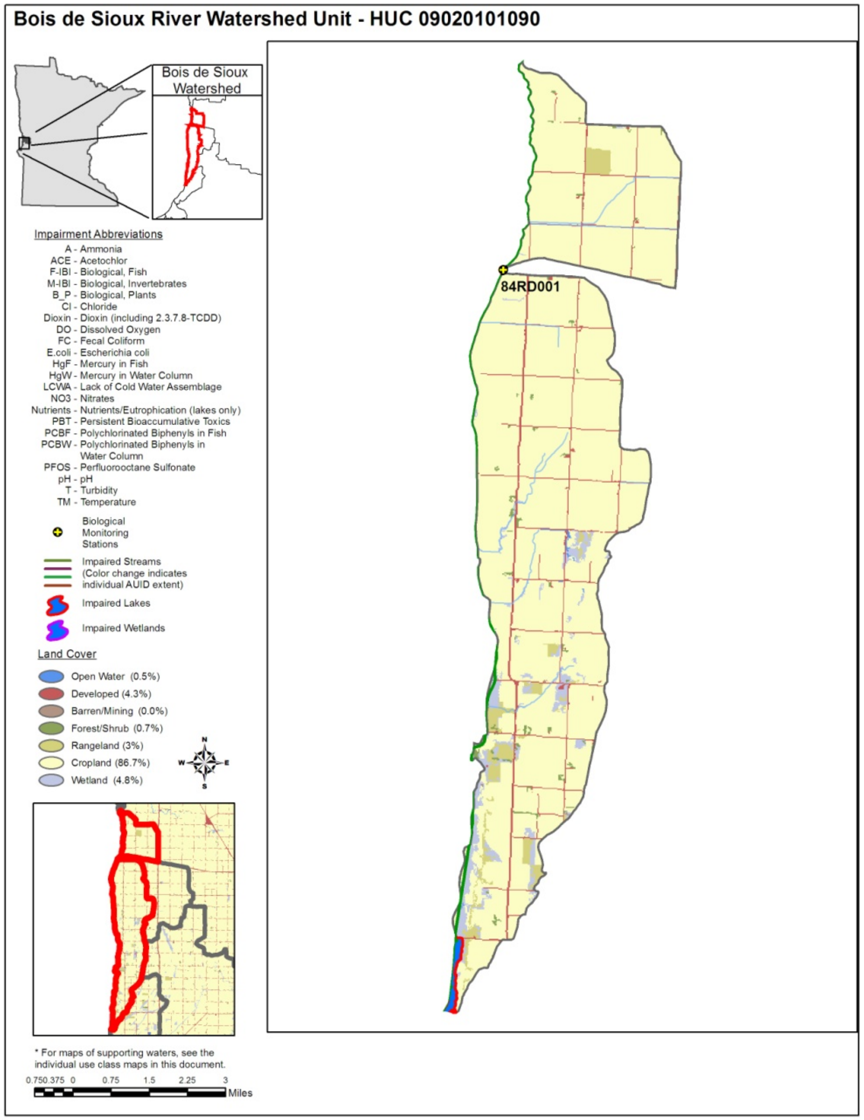


Figure 29. Currently listed impaired waters by parameter and land use characteristics in the Bois de Sioux subwatershed

VI. Watershed-wide results and discussion

Assessment results and data summaries are included below for the entire Bois de Sioux River Watershed, grouped by sample type. Summaries are provided for load monitoring 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 within the watershed. Additionally, groundwater monitoring results and long-term monitoring trends are included where applicable.

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

Pollutant load monitoring

The Bois de Sioux River is monitored at CSAH 6 near Doran. Many years of water quality data from throughout Minnesota, combined with previous analysis of Minnesota's ecoregion patterns, resulted in the development of three "River Nutrient Regions" (RNR) (MPCA 2010a), each with unique nutrient level expectations. Of the state's three RNRs (North, Central, South), the Bois de Sioux River's load monitoring station is located within the South RNR. Annual FWMCs were calculated and compared for years 2007-2009 (Figure 29, Figure 30 and Figure 31) and compared to the RNR draft standards (only TP and TSS draft standards are available for the South RNR). It should be noted that while a FWMC exceeding a given water quality standard is generally a good indicator the waterbody is out of compliance with the River Nutrient Region standard, the rule does not always hold true. Waters of the state are listed as impaired based on the percentage of individual samples exceeding the numeric standard, generally 10% and greater (MPCA 2010a), over the most recent 10 year period and not based on comparisons with FWMCs. A river with a FWMC above a water quality standard, for example, would not be listed as impaired if less than 10% of the individual samples collected over the assessment period were above the standard.

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

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

Total suspended solids

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

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

Currently, the state of Minnesota's TSS standards is considered to be draft until complete approval. Within the South RNR, the TSS draft standard is 65 mg/L (MPCA 2010c); when greater than 10% of the individual samples exceed the draft standard, the river is out of compliance. Calculations from 2007 through 2009 show 61, 81, and 48% of the individual TSS samples exceeded the 65 mg/L draft standard, respectively. In addition, the computed FWMCs for the three sampling years all exceeded the 65 mg/L draft standard (Figure 29). In 2007, the sample with the highest measured TSS concentration (270 mg/L) was collected at the peak of a high intensity rainfall event on July 2nd. In 2008, the sample with the highest measured TSS concentration (352 mg/L) was collected at the peak of a high intensity rainfall event on July 11th. Although the data may not reflect long-term trends for TSS, FWMCs showed a decline in 2007 thru 2009 (Figure 29 and Table 19). However, because of the strong correlation that often exists between pollutant loads and annual runoff volume, the annual load for 2008 (low flow year) is nearly half that of 2007 and 2009. One possible explanation for the increase in annual TSS load for 2009 is that most of the runoff volume occurred during the spring snow melt period (March/April). Heavy snow pack, rain and frozen ground allows for a major increase in runoff volume. Even though most of the sample concentrations during this period were less than 150 mg/L TSS, flows were in excess of 5000 cfs.

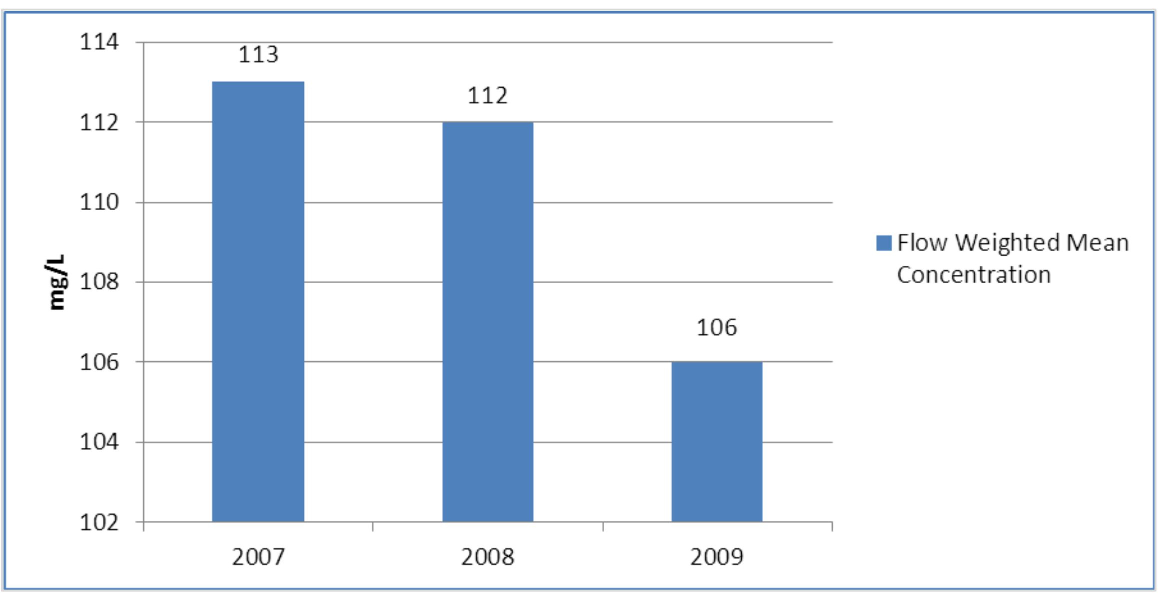


Figure 30. Total Suspended Solids (TSS) flow weighted mean concentrations in the Bois de Sioux River

Table 19. Annual pollutant loads by parameter calculated for the Bois de Sioux River.

	2007	2008	2009
Parameter	Mass (kg)	Mass (kg)	Mass (kg)
Total Suspended Solids	60858202	25900965	71688191
Total Phosphorus	230226	82635	235222
Dissolved Orthophosphate	116849	40196	118518
Nitrate + Nitrite Nitrogen	786012	345111	558754

Total phosphorus

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

Total phosporus standards for Minnesota’s rivers must be considered draft standards until approved. Within the South RNR, the TP draft standard is 150 ug/L as a summer average. Summer average violations of one or more “response” variables (pH, biological oxygen demand (BOD), dissolved oxygen flux, chlorophyll-a) must also occur along with the numeric TP violation for the water to be listed. Concentrations from 2007, 2008 and 2009 show that 92, 97, and 100% of the individual TP samples exceeded the 150 ug/L draft standard, respectively. Observation of Figure 30 shows that all of the FWMCs from 2007 to 2009 are more than double the draft standard.

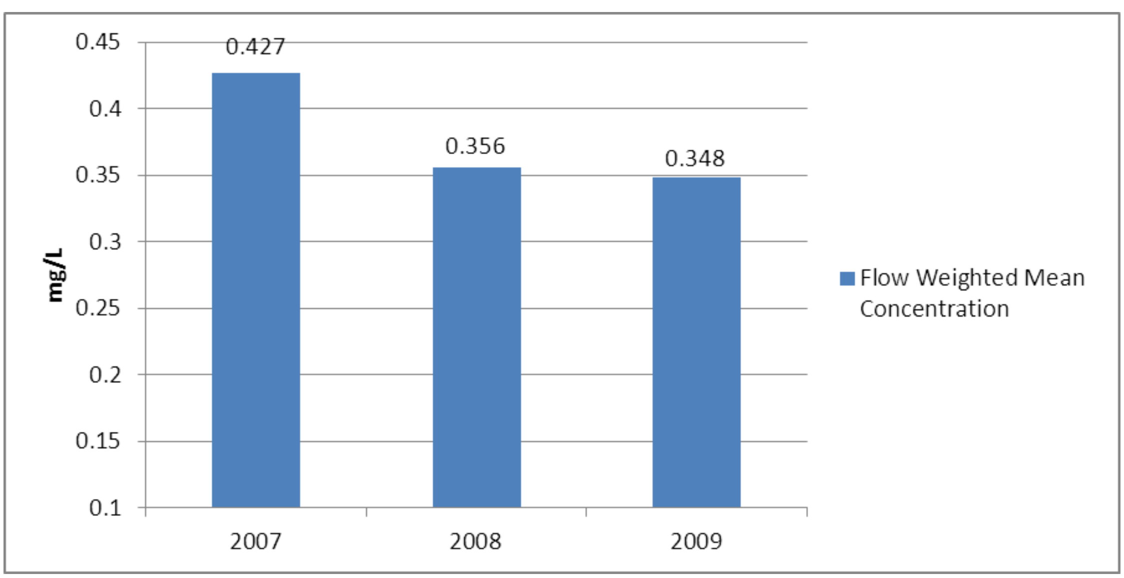


Figure 31. Total phosphorus flow weighted mean concentrations for the Bois de Sioux River

Dissolved orthophosphate

Dissolved orthophosphate is a water soluble form of phosphorus that is readily available to algae (bioavailable) (MPCA and MSUM 2009). While orthophosphates occur naturally in the environment, river and stream concentrations may become elevated with additional inputs from waste water treatment plants, noncompliant septic systems, and fertilizers in urban and agricultural runoff. The 2007 through 2009 FWMC ratio of DOP to TP shows that 49 to 51% of TP is in the orthophosphate form.

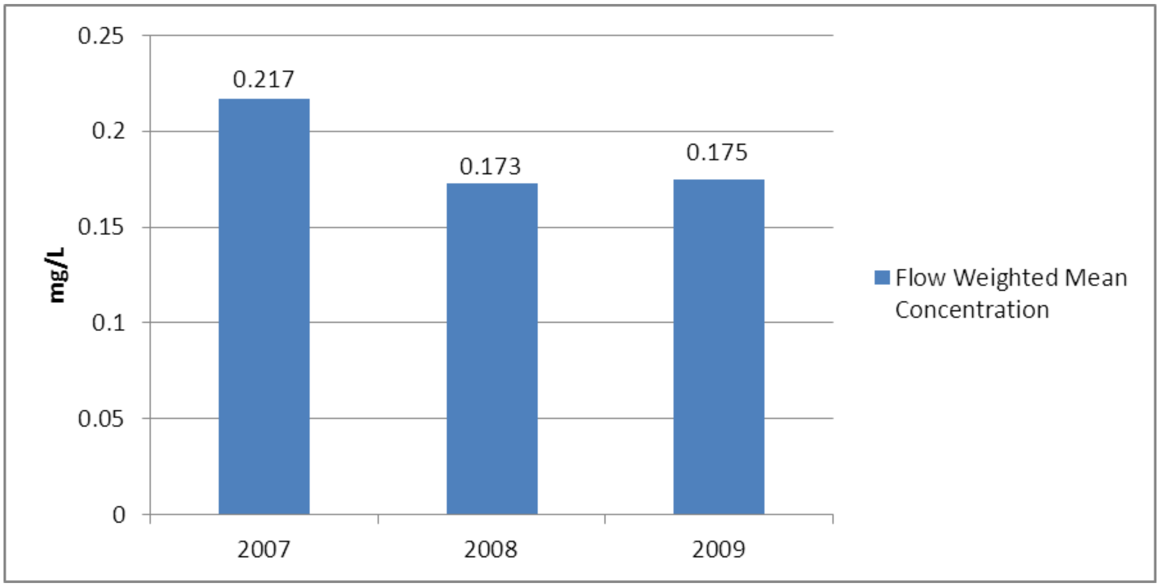


Figure 32. Dissolved Orthophosphate (DOP) flow weighted mean concentrations for the Bois de Sioux River

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 2010b). Because nitrate and nitrite-nitrogen are water soluble, transport to surface waters is enhanced through agricultural drainage. The ability of nitrite-N to be readily converted to nitrate-nitrogen is the basis for the combined laboratory analysis of nitrate plus nitrite-nitrogen, with nitrite-nitrogen typically making up a small proportion of the combined total concentration. These and other forms of nitrogen exist naturally in aquatic environments; however concentrations can vary drastically depending on season, biological activity, and anthropogenic inputs.

Nitrate- N can also be a common toxicant to aquatic organisms in Minnesota's surface waters, with invertebrates appearing to be the most sensitive to nitrate toxicity. Draft nitrate-N standards have been proposed (2012) for the protection of aquatic life in lakes and streams. The draft acute value (maximum standard) for all Class 2 surface waters is 41 mg/L nitrate-N for a 1-day duration, and the draft chronic value for Class 2B (warm water) surface waters is 4.9 mg/L nitrate-N for a 4-day duration. In addition, a draft chronic value of 3.1 mg/L nitrate-N (4-day duration) was determined for protection of Class 2A (cold water) surface waters (MPCA, Aquatic Life Water Quality Standards Technical Support Document for Nitrate, Nov 2010).

Nitrate-N FWMCs from 2007 through 2009 for the Bois de Sioux River were 1.46, 1.49 and 0.826 mg/L, respectively (Figure 32). Calculation of the Bois de Sioux River's annual nitrate-N loads does not show a FWMC vs. annual runoff volume relationship over the three year sampling period (Figure 26). However, nitrate-N concentrations during the high flow spring melt period in 2009 were 1.2 mg/L or less. Lower concentrations occurring during high flow periods tend to decrease FWMCs.

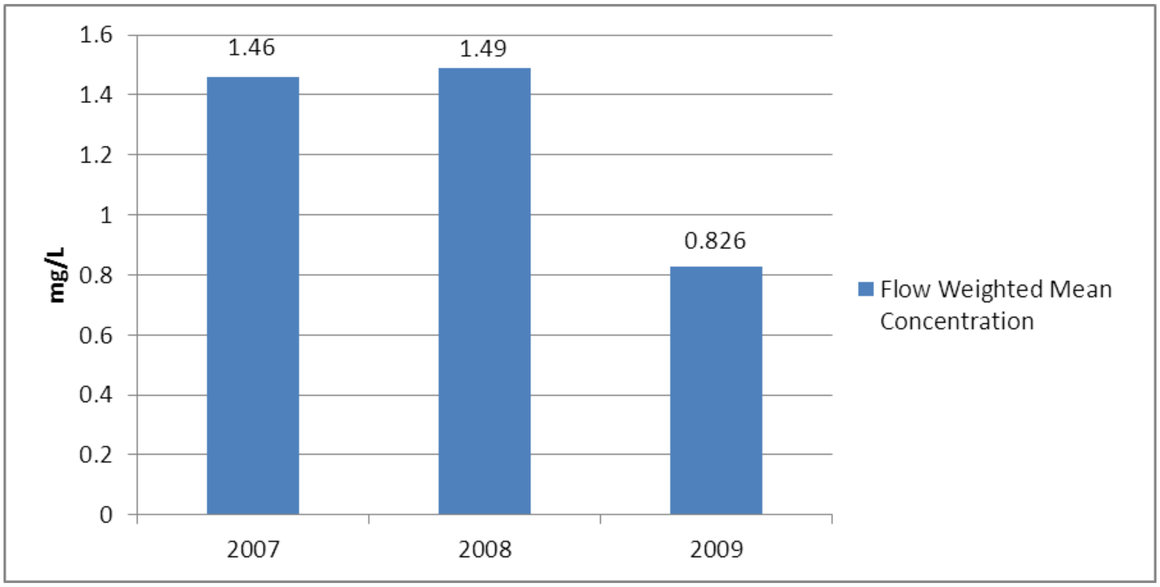


Figure 33. Nitrate + Nitrite Nitrogen (Nitrate-N) flow weighted mean concentrations for the Bois de Sioux River

Stream water quality

Seven of the 52 stream segments (AUIDs) within the Bois de Sioux River Watershed were assessed (Table 20). Of the assessed streams, no streams fully supported aquatic life and only one supported aquatic recreation. Six stream segments were not assessed for biology because greater than 50% of the AUID is channelized or the biological station fell on a channelized stream reach on the AUID. Throughout the watershed, 7 stream segments do not support aquatic life and 3 streams do not support aquatic recreation.

Chemistry and bacteria data were only available in three of the HUC-11 subwatersheds; Bois de Sioux, Rabbit River, and Doran Slough. The remaining watersheds are direct conduits to either Lake Traverse or Mud Lake and did not have large enough conveyances to place a monitoring station on them. The monitored watersheds are highly altered both in land use and in hydrologic modifications (ditching). Upstream of the Rabbit River confluence, the Bois de Sioux River meets aquatic recreation standards, but the downstream end of the Bois de Sioux River, Rabbit River, and Doran Slough Creek all exceed bacteria levels considered safe for recreational opportunities. Sediment and depressed oxygen levels appeared in all three subwatersheds negatively impacting aquatic life communities. Consumption of fish was impaired on the main stem Bois de Sioux River due to elevated levels of mercury in fish tissue; this impairment is common throughout lakes and streams in Minnesota. Overall, water quality in the watershed is poor with limited opportunities for aquatic recreation or fish consumption, and with compromised aquatic communities.

Table 20. Assessment summary for stream water quality in the Bois de Sioux River Watershed.

				Supporting		Non-supporting		
Watershed	Area (acres)	# Total AUIDs	# Assessed AUIDs	# Aquatic Life	# Aquatic Recreation	# Aquatic Life	# Aquatic Recreation	Insufficient Data
09020101 **HUC 8**	**355934**	**52**	**7**	**0**	**1**	**7**	**3**	**7 AL**
09020101110	209,446	30	3	0	0	3	1	5 AL
09020101120	43,244	5	2	0	0	2	2	0
09020101025	22,905	7	1	0	0	1	0	0
09020101030	20,511	3	1	0	0	1	0	1AL
09020101040	8,993	1	0	0	0	0	0	0
09020101060	16,140	1	0	0	0	0	0	0
09020101070	13,115	0	0	0	0	0	0	0
09020101090	26,785	1	0	0	1	0	0	0

Lake water quality

There are only seven named lakes of the 35 lakes greater than 4 ha. in the Bois de Sioux River Watershed. Of those, 4 had sufficient data to assess for aquatic recreation. In this part of Minnesota, lake depth tends to be shallow and the background phosphorus concentrations are higher than found in the central and northern part of the state. The presence of rooted aquatic vegetation and the suppression of rough fish are critical to maintaining a clear lake. Mud, Ash, and Lightning lakes are all very shallow (mean depth 1 meter); this reduces the ability of the basin to assimilate nutrients without adverse effects. All three basins are turbid, carry moderately high chlorophyll-a concentrations, and consequently, do not support recreational opportunities. Lake Traverse, with considerable more depth (2.3 meters mean depth), is still considered shallow. Although the lake has elevated phosphorus concentrations it has not had as significant a response in declined transparency and increased algae as the other basins. However, Lake Traverse is considered to have insufficient information to determine if it supports aquatic recreation. Overall, lake water quality in this watershed is poor due to high phosphorus loads combined with the shallow nature of the basins.

Table 21. Assessment summary for lake water chemistry in the Bois de Sioux River Watershed.

Watershed	Area (acres)	Total Lakes or Reservoirs	Full Support	Non-support	Insufficient Data	Not Assessed
09020101 **HUC 8**	**355934**	**35**	**0**	**3**	**3**	**29**
09020101-025	22905.53	6				6
09020101-030	20511.54	2				2
09020101-040	8993.16	1	0	0	1	
09020101-060	16140.75	1	0	1	0	
09020101-070	13115.52	0				
09020101-090	26785.49	0				
09020101-110	209446.97	25	0	2	2	21
09020101-120	43244.61	0				

Fish contaminant results

Fish species are identified by codes that are defined by their common and scientific names in Table 22. Within this watershed, mercury was measured in the 13 fish species listed. PCBs were measured in eight species. Table 23 summarizes the contaminant concentrations by waterway, fish species, and year. The table shows which contaminants, species, and years were sampled within a given lake. “Total Fish” and “Samples” are shown because many of the panfish, such as black crappie (BKS), bluegill sunfish (BGS) and yellow perch (YP) were composite samples—multiple fish homogenized into a single sample. Sample years ranged from 1979 to 2010. Most of the samples were skin-on fillets (FILSK) or skin-off fillets (FILET) for fish without scales (catfish and bullheads). In 1979, whole fish (WHORG) were sampled.

Mercury was measured in 283 fish (103 samples) from the river and two lakes. The Bois de Sioux River and Traverse Lake are listed as impaired waters because of mercury in fish tissue. The impairment designation in the Bois de Sioux River was caused by the common carp, which met the minimum sample size of five fish and had a 90th percentile mercury concentration exceeding the 0.2 mg/kg impairment threshold. The single channel catfish tested from the Bois de Sioux River exceeded the threshold, too, but because it was only single fish it was not used for the impairment assessment. Multiple species in Traverse Lake are impaired because of mercury. The highest mercury concentration was 1.4 mg/kg in a walleye (WE) collected from Traverse Lake in 1979. Subsequent resampling of Traverse Lake in 1992 and 2005 showed a drop in the maximum mercury concentrations to 0.320 and 0.313 mg/kg, respectively. Northern pike (NP) collected from Traverse Lake in 2009 had a maximum concentration of 0.346 mg/kg. These results indicate that Traverse Lake has clearly remained impaired due to elevated levels of mercury in fish tissue throughout the period of record.

PCBs were measured in 12 fish samples from the Bois de Sioux River and Traverse Lake. All PCB concentrations were at or below the detection limit, with the exception of one walleye caught in 1992 from Traverse Lake. It was only slightly above the detection limit. Perfluorooctane sulfonate (PFOS) was measured in a single bluegill sunfish collected from Traverse Lake in 2007. The PFOS concentration was below the detection limit. Therefore, there are no plans to resample the lake’s fish for PFOS. Overall, these results indicate very low concentrations of PCBs and PFOS in the fish. Mercury concentrations in common carp from the Bois de Sioux River were sufficient to cause impairment and will, therefore, need to be tested again at some point. Traverse Lake continues to be impaired due to elevated levels of mercury in fish tissue and will need continued monitoring.

Table 22. Fish species codes, common names, and scientific names.

Code	Common Name	*Scientific Name*
BGS	Bluegill sunfish	*Lepomis Macrochirus*
BKB	Black bullhead	*Ictalurus Melus*
BKS	Black crappie	*Pomoxis Nigromaculatis*
C	Common Carp	*Cyprinus carpio*
CHC	Channel catfish	*Ictalurus punctatus*
FWD	Freshwater Drum (Sheepshead)	*Aplodinotus grunniens*
NP	Northern pike	*Esox Lucius*
SBU	Smallmouth buffalo	*Ictiobus bubalus*
WE	Walleye	*Sander vitreus*
WHB	White bass	*Morone Chrysops*
WHS	White crappie	*Pomoxis Annularis*
WSU	White sucker	*Catostomus Commersoni*
YP	Yellow perch	*Perca Flavescens*

Table 23. Fish contaminants table

					Total		Length (in)			Mercury (mg/kg)				PCBs (mg/kg)				PFOS (µg/kg)		
Waterway	AUID	SPEC[1]	Year	Anat[2]	Fish	Samples	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Max
Bois de Sioux R. *	09020101 -501, -503	C	2010	FILSK	5	5	21	15.3	25.6	5	0.173	0.135	0.221	2	< 0.025	< 0.025	< 0.025			
		CHC	2010	FILET	1	1	17.6			1	0.388			1	< 0.025					
Mud	78002400	BKS	2010	FILSK	8	2	10.2	9.5	10.9	2	0.089	0.089	0.089							
		C	2010	FILSK	2	1	26.3			1	0.091									
		NP	2010	FILSK	5	5	23.9	21.1	28.9	5	0.119	0.106	0.145							
		WE	2010	FILSK	3	3	14.9	11.2	18.5	3	0.083	0.063	0.095							
		YP	2010	FILSK	4	1	8.9			1	0.094									
Traverse*	78002500	BGS	2005	FILSK	4	1	7.5			1	0.079									
			2007	FILSK	10	1	7.6			1	0.053							1	< 0.92	
		BKB	1985	FILET	10	1	10			1	0.11			1	< 0.05					
		BKS	2005	FILSK	12	1	9.9			1	0.106									
			2007	FILSK	10	1	8.3			1	0.039									
		C	1979	WHORG	10	2	17.9	17.2	18.6	2	0.055	0.03	0.08							
			1985	FILSK	5	1	19			1	0.1			1	< 0.05					
			1992	FILSK	34	5	22.1	14.1	31.1	5	0.055	0.018	0.12	2	0.01	< 0.01	0.011			
			2005	FILSK	4	1	28.5			1	0.137									
		FWD	1985	FILSK	5	1	12			1	0.03			1	< 0.05					
		NP	1979	FILSK	20	7	26.1	19.9	32.3	7	0.367	0.2	0.54							
			2000	FILSK	8	8	23.6	16.4	31.2	8	0.138	0.08	0.24							
			2009	FILSK	12	12	24.5	18.7	34.2	12	0.133	0.037	0.346							
		SBU	1985	FILSK	5	1	19			1	0.14			1	< 0.05					
		WE	1971	PLUG	16	16	14.8	6	20.7	16	0.46	0.26	0.7							
			1979	FILSK	21	6	16.6	12.6	20.1	6	0.683	0.44	1.4							
				WHORG	4	1	14.6			1	0.07									
			1992	FILSK	25	4	19.8	13.5	25.4	4	0.199	0.037	0.32	1	0.016					
			2005	FILSK	8	8	16.3	11.9	22	8	0.168	0.106	0.313							
		WHB	2000	FILSK	6	1	14.1			1	0.11			1	< 0.01					
			2005	FILSK	3	3	14.2	12.5	16.5	3	0.208	0.157	0.288							
		WHS	2007	FILSK	10	1	8.3			1	0.028									
		WSU	1985	FILSK	5	1	17.6			1	0.08			1	< 0.05					
		YP	1992	FILSK	8	1	12			1	0.092									

* Impaired for aquatic consumption – mercury in fish tissue

1 Species codes are defined in Table F1

2 Anatomy codes: FILSK – fillet skin-on; FILET – fillet skin-off; WHORG – whole organism; PLUG – dorsal muscle without skin

Pollutant trends for the Bois de Sioux River

Water quality trends at long-term monitoring stations

No trend data is currently available for the Bios de Sioux Watershed.

Water clarity trends at citizen monitoring sites

The MPCA calculates trends on transparency data collected on lakes and streams annually. A minimum of eight years of data is required to provide a statistically significant trend; for this analysis a seasonal Kendal test is run using the statistical package "R." Of the 17 sites with transparency tube data in the watershed, one had no trend (S001-029) and one had a possible declining trend (S000-553); the rest did not have sufficient data for trend analysis (Figure 35). Only Lake Traverse had sufficient data for trend analysis among lakes and no trend was detected (Figure 35).

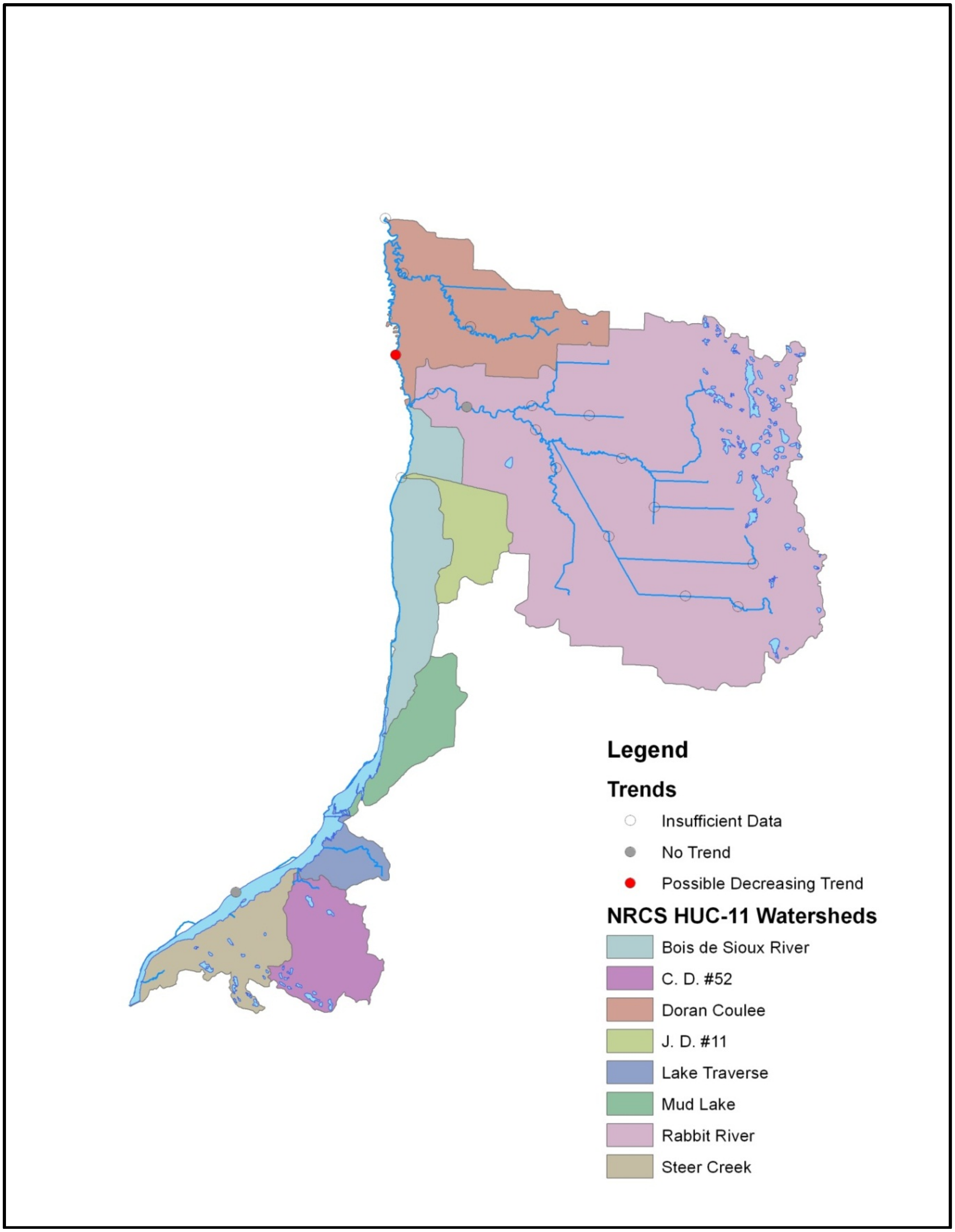


Figure 34. Bois de Sioux River Watershed transparency data trends

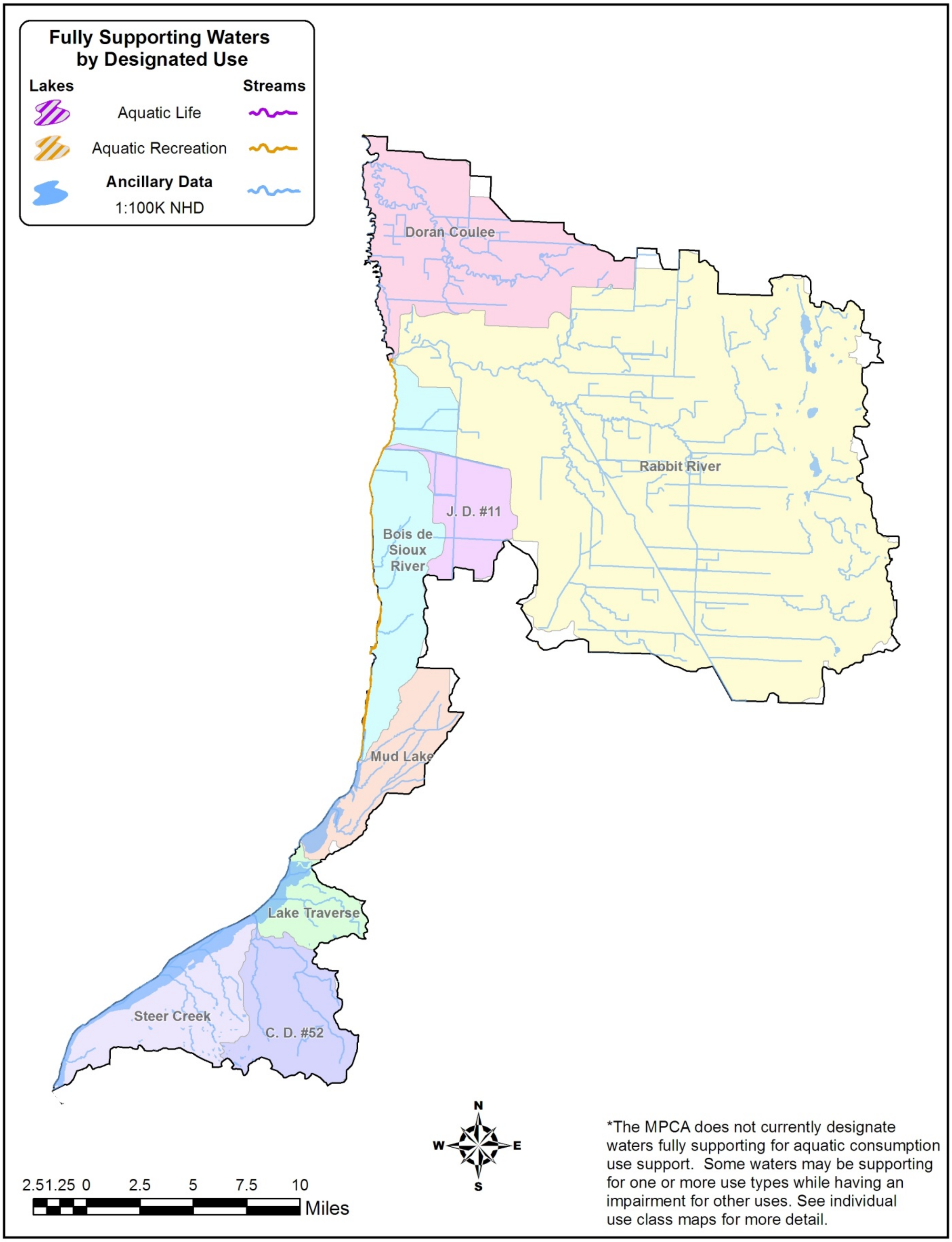


Figure 35. Fully supporting waters by designated use in the Bois de Sioux River Watershed

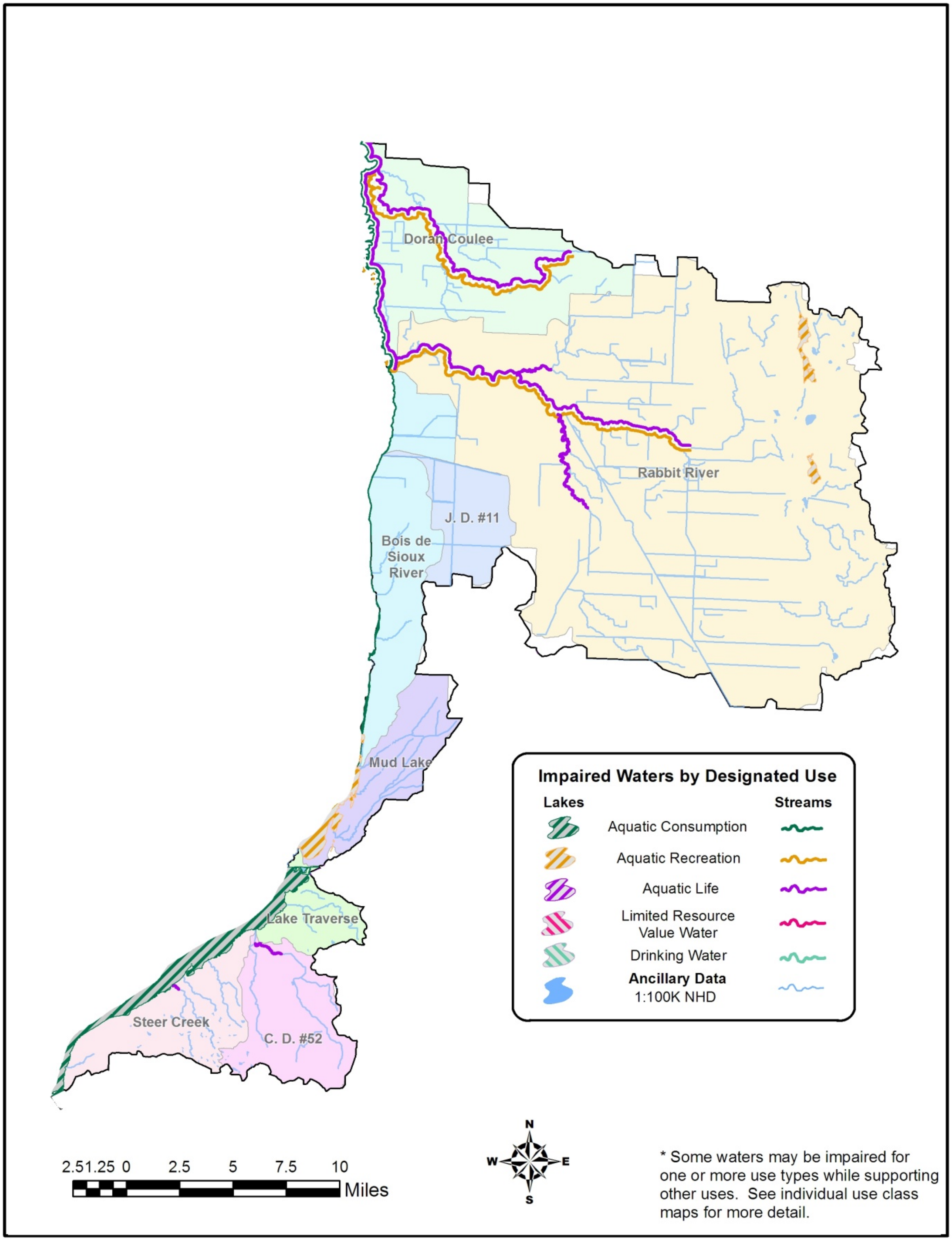


Figure 36. Impaired waters by designated use in the Bois de Sioux River Watershed

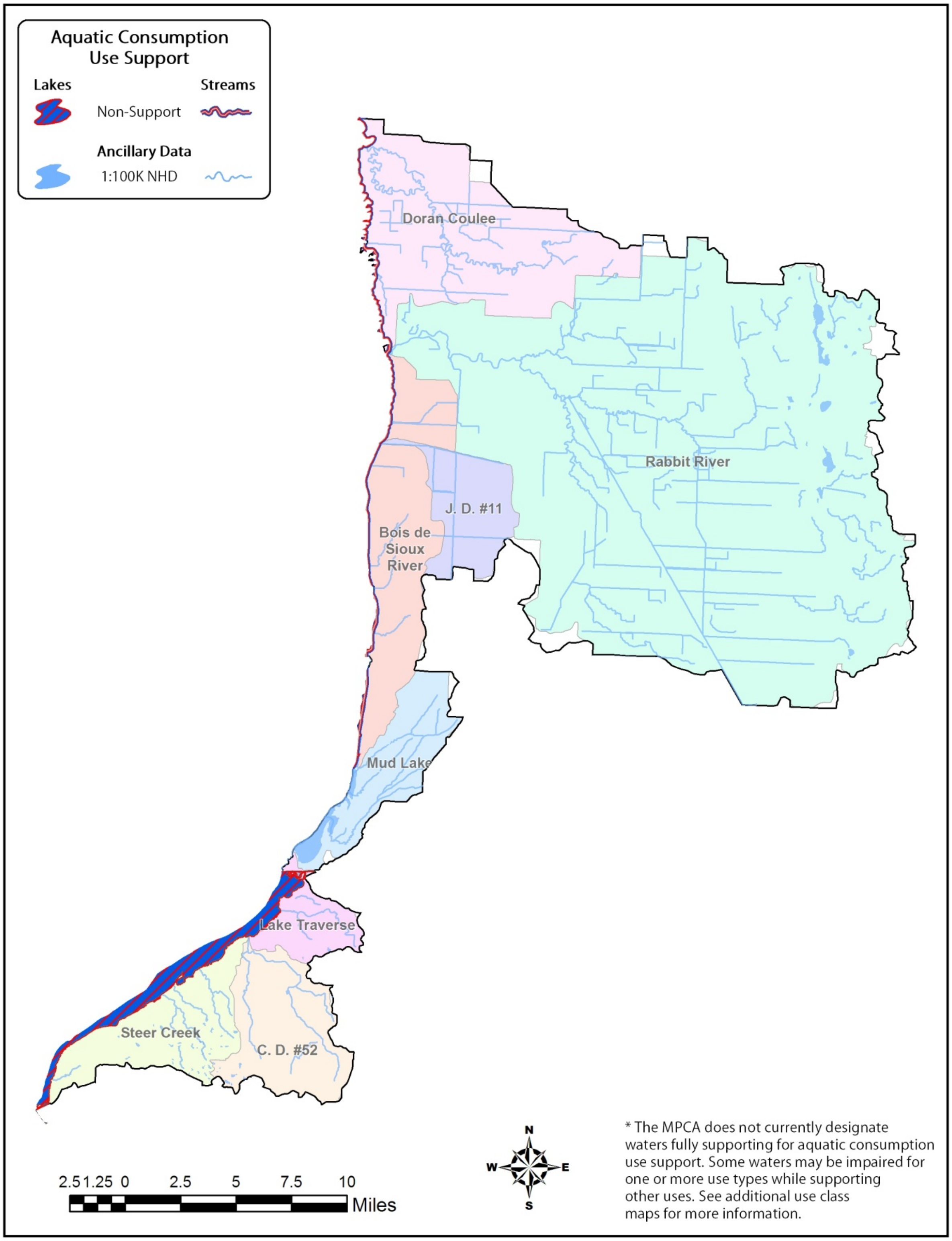


Figure 37. Aquatic consumption use support in the Bois de Sioux River Watershed

VII. Summaries and recommendations

There have been 86 species of fish documented in the Red River Basin. MPCA biological monitoring crews found 31 species of fish during the IWM effort in the Bois de Sioux River Watershed. No species of special concern were found. The most diverse fish communities were sampled at stations on the main stem of the Bois de Sioux River. The preferable habitat of large river species such as white bass and smallmouth buffalo was exclusive to main stem stations; consequently, those were some of the least common species sampled within the Bois de Sioux River Watershed. The low gradient character of the streams in the Lake Agassiz Plain (LAP) combined with the limited amount of coarse substrates limit the abundance and distribution of lithophilic spawning fish. That said, lithophilic spawning species such as walleye and silver redhorse were present in low numbers at stations located on the Bois de Sioux River and Rabbit River. The most abundant and commonly sampled species within the watershed was the fathead minnow, which was present at eight stations. Fathead minnows are tolerant of low dissolved oxygen and are often able to survive in pools during dry periods. Such conditions are found in the intermittent streams that are prevalent in western Minnesota and the Red River Basin (EOR, 2009). Fathead minnows are also one of the first species to move into the disturbed habitat that results from ditching and dredging activities. In general, lower percentages of tolerant individuals were sampled from the larger and marginally more stable sites on the Bois de Sioux River. Other commonly sampled species in the watershed included black bullhead, creek chub, common carp, white sucker, and orange spotted sunfish. Most of these species are also tolerant of low dissolved oxygen levels and increased turbidity as well.

The Bois de Sioux Watershed contains several aquatic macroinvertebrate species. During the 2010 IWM effort a total of 109 unique macroinvertebrate taxa were collected from 10 different locations throughout the watershed. Macroinvertebrates were sampled from myriad habitats, including undercut banks/overhanging vegetation, aquatic macrophytes, riffle/rock and woody debris. The most frequently observed macroinvertebrate taxa within this watershed are: Physa (Gastropoda), Polypedilum (Diptera), Paratanyarsus (Diptera), Cricotopus (Diptera), Dicrotendipes (Diptera), Glyptotendipes (Diptera) and Caenis (Ephemeroptera). The most abundant taxa (total number of organisms) are: Paratanytarsus (288), Glyptotendipies (246), Caenagrionidae (158), Endochironomus (169), Polypedilum (145), Physa (133), Dicrotendipes (93) and Caenis youngi (93). All of the above mentioned taxa are very tolerant of environmental stress (i.e. lack of habitat, elevated nutrients, low dissolved oxygen). Very few sensitive aquatic macroinvertebrate taxa were encountered within this watershed, and they were often encountered in single digit numbers. Some of these sensitive taxa include: Dicranota (Diptera), Oecetis nocturna (Trichoptera), Optioservus (Coleoptera), Pycnopsyche (Trichoptera) and Oecetis (Trichoptera). The low gradient and fine substrates typical of streams within the LAP limit the abundance and distribution of sensitive riffle dwelling Ephemeroptera and Plecoptera species.

Excessive turbidity and low dissolved oxygen were the two most prevalent types of aquatic life impairments within the Bois de Sioux River Watershed. Both impairments may be influenced by a multitude of factors including the surrounding land use, stream morphology, and nutrient inputs. Excessive nutrients such as nitrogen and phosphorus can increase algae and macrophyte production in streams, resulting in low levels of dissolved oxygen, larger diel dissolved oxygen fluctuations, and increased turbidity. Streams within the Bois de Sioux River Watershed are particularly susceptible to excessive nutrients because they are low gradient, often have a limited riparian zone, and many are channelized. In healthy streams, excess nutrients can be utilized by macrophytes, invertebrate and vertebrate biomass, and deposited in the riparian zone during flood events (Rankin et al. 1999). The low gradient, channelized streams in the Bois de Sioux retain nutrients during floods resulting in more time for algal biomass and bacteria to utilize the nutrients and increase production (Rankin et al. 1999). In addition to the high nutrient levels, high levels of bacteria found in some streams in the Bois de Sioux River Watershed can increase biological oxygen demand and also reduce dissolved oxygen.

Nutrient sources within the Bois de Sioux River Watershed include fertilizer, waste water treatment plants, septic systems, feedlot runoff, and nutrient recycling from stream bed sediment (Red River Basin Board 2001). Counties adjacent to the Red River have been identified as having high fertilizer applications (Tornes and Brigham 1994). In the Red River Basin, approximately 2.81 (lb/acre)/yr nitrogen and 0.58 (lb/acre)/yr TP are exported to surface water from agricultural land (Bourne and others, 2002). A USGS study of 23 sites within the Red River Basin determined that the Bois de Sioux River had one of the highest dissolved phosphorus concentrations in the basin (Christensen, 2007). Phosphorus and organic compounds containing nitrogen are transported to surface water on substrate surfaces found in field sediment run off. Soluble nutrients, such as nitrate, are transported in both surface and subsurface run off. Drainage practices such as tiling can increase the amount of nitrate delivered to streams because the tiles rapidly convey drainage water and bypass the riparian zone that would otherwise serve as a buffer. Current MPCA draft standards consider phosphorus levels below 55 ug/L good and phosphorus levels above 150 ug/L poor (MPCA 2013). Total phosphorus concentrations exceeded 350 ug/L at all biological stations on the Rabbit River and at station 84RD005 on the Bois de Sioux River. In spite of the intensive agriculture throughout the watershed nitrogen levels at most stations were fairly low.

Turbidity can be caused by suspended sediment, organic matter, soluble organic compounds, and algae. Simon et al. found that streams within the Red River Basin have the highest median suspended sediment concentration of any given region in Minnesota except the Western Cornbelt Plains ecoregion (EOR 2009). Streams within the LAP ecoregion, which constitutes a substantial portion of the Bois de Sioux River Watershed, often have high sediment levels despite the fact that sediment delivery is reduced by the flat topography (EOR 2009). Unfortunately, the combination of a very flat topography and fertile soils has resulted in cultivation of most of the floodplain which in turn has resulted in stream sedimentation problems, mainly during the frequent spring flood events. The highest sediment loads within Red River tributaries occur during intense spring rain falls when agricultural fields have little cover (EOR 2009). The lack of riparian buffers, development of farm field gullies, and stream bank erosion exacerbate the problem and contribute to excessive turbidity in the streams of the LAP ecoregion (EOR 2009).

In summary, streams in the Bois de Sioux River Watershed are in overall poor condition. Because of their geographic and geologic setting on the landscape they are highly susceptible to the disturbances that are prevalent throughout the watershed. As a consequence, stream habitat, water chemistry and the biology have all been compromised. Assessments for aquatic life, recreation, and fish consumption indicate non-support of these uses in most cases where sufficient data has been collected. Widespread changes in land use practices will need to occur before we are likely to see a significant improvement in most indicators. Since the vast majority of land in the watershed is privately owned, and the improvements needed will involve a change in agricultural practices that are largely voluntary, increased public understanding and interest regarding the condition and value of stream resources in this region will be necessary.

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Appendix 1 - Water chemistry definitions

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

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

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

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

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

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

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

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

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

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

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

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

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

Appendix 2 - Intensive watershed monitoring water chemistry stations in the Bois de Sioux Watershed

Biological Station ID	STORET/ EQuIS ID	Waterbody Name	Location	11-digit HUC
84RD001	S003-119	Bois de Sioux	At Hwy 55, 5.5 mi. W of Tenney	09020101090
84RD005	S000-089	Bois de Sioux	1 mi. Upstream of CR12, 1 mi. S of Breckenridge	09020101120
10RD005	S001-029	Rabbit River	At Hwy 75, 5 mi. NW of Campbell	09020101110

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

AUID DESCRIPTIONS				USES					BIOLOGICAL CRITERIA		WATER QUALITY STANDARDS										ECOREGION EXPECTATIONS			
National Hydrography Dataset (NHD) Assessment Segment AUID	Stream Segment Name	Segment Description	NHD Length (Miles)	Use Class	Aquatic Life	Aquatic Recreation	Aquatic Consumption	Class 7	Fish	Macroinvertebrates	Acetochlor	Alachlor	Atrazine	Chloride	Bacteria (Aquatic Recreation)	Metolachlor	Dissolved Oxygen	pH	Turbidity	Un-ionized ammonia	Oxygen Demand (BOD)	Nitrite/Nitrate	Total Phosphorous	Suspended Solids
HUC 11: 09020101110 (Rabbit River)																								
09020101-502	Rabbit River	Wilkin County Line to Boise de Sioux River	22.6	2C	NS	NS			EXS	EXS				MTS	EX		EXP	MTS	EXS	MTS				
09020101-504	Unnamed Ditch	Unnamed Ditch to Rabbit River	3.86	2B, 3C	NA*	NA			--	--				--	--		--	--	--	--				
09020101-512	Rabbit River	South Fork, Wilkin County Line to Rabbit River	7.54	2C	NS	NA			EXS	--				--	--		EXS	MTS	EXS	--				
09020101-513	County Ditch 9	Unnamed Ditch to Unnamed Cr	4.26	2B, 3C	IF	NA			--	--				--	--		MTS	MTS	EXP	--				
09020101-515	Unnamed Creek	Unnamed Creek to Rabbit River	2.35	2B, 3C	NS	NA			--	--				--	--		EXS	MTS	EXP	--				
09020101-517	Judicial Ditch 12	Unnamed Ditch to JD 7	1.96	2B, 3C	IF*	NA			--	--				--	--		EXP	MTS	EXP	--				
09020101-520	Unnamed Ditch	Unnamed Ditch to Unnamed Ditch	3.45	2B, 3C	IF	NA			--	--				--	--		IF	MTS	MTS	MTS				
09020101-527	Unnamed Ditch	Headwaters to Unnamed Ditch	4.06	2B, 3C	IF*	NA			--	--				--	--		EXP	MTS	MTS	--				
09020101-547	Unnamed Ditch	Unnamed Ditch to Unnamed Ditch	1	2B, 3C	NA*	NA			--	--				--	--		--	--	--	--				
09020101-548	Judicial Ditch 2	Unnamed Ditch to Unnamed Ditch	0.96	2B, 3C	NA*	NA			--	--				--	--		--	--	--	--				

Full Support (FS); Not Supporting (NS); Insufficient Data (IF); Not Assessed (NA); Meets standards or ecoregion expectations (MT/MTS), Potential Exceedence (EXP), Exceeds standards or ecoregion expectations (EX/EXS).

Key for Cell Shading: = existing impairment, listed prior to 2012 reporting cycle; = new impairment; = full support of designated use. *Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.

AUID DESCRIPTIONS				USES					BIOLOGICAL CRITERIA		WATER QUALITY STANDARDS										ECOREGION EXPECTATIONS		
National Hydrography Dataset (NHD) Assessment Segment AUID	Stream Segment Name	Segment Description	NHD Length (Miles)	Use Class	Aquatic Life	Aquatic Recreation	Aquatic Consumption	Class 7	Fish	Macroinvertebrates	Acetochlor	Alachlor	Atrazine	Chloride	Bacteria (Aquatic Recreation)	Metolachlor	Dissolved Oxygen	pH	Turbidity	Un-ionized ammonia	Nitrite/Nitrate	Total Phosphorous	Suspended Solids
HUC 11: 09020101120 (Doran Coulee)																							
09020101-501	Bois de Sioux River	Rabbit River to Otter Tail River	15.27	2C	NS	NS				MTS	MTS	NA	MTS	MTS	EX		IF	MTS	EXS	MTS			
09020101-510	Unnamed Creek (Doran Slough)	Headwaters to Bois de Sioux River	26.72	2C	NS	NS			--	--				MTS	EX		EXS	MTS	MTS	MTS			

Full Support (FS); Not Supporting (NS); Insufficient Data (IF); Not Assessed (NA); Meets standards or ecoregion expectations (MT/MTS), Potential Exceedence (EXP), Exceeds standards or ecoregion expectations (EX/EXS).

Key for Cell Shading: ▭ = existing impairment, listed prior to 2012 reporting cycle; ▭ = new impairment; ▭ = full support of designated use. *Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.

AUID DESCRIPTIONS				USES					BIOLOGICAL CRITERIA		WATER QUALITY STANDARDS										ECOREGION EXPECTATIONS		
National Hydrography Dataset (NHD) Assessment Segment AUID	Stream Segment Name	Segment Description	NHD Length (Miles)	Use Class	Aquatic Life	Aquatic Recreation	Aquatic Consumption	Class 7	Fish	Macroinvertebrates	Acetochlor	Alachlor	Atrazine	Chloride	Bacteria (Aquatic Recreation)	Metolachlor	Dissolved Oxygen	pH	Turbidity	Un-ionized ammonia	Nitrite/Nitrate	Total Phosphorous	Suspended Solids
HUC 11: 09020101025 (Steer Creek)																							
09020101-535	Unnamed Creek	Unnamed Creek to Lake Traverse	0.45	2B, 3C	NS	NA			EXS	MTS				--	--		--	--	--	--			

HUC 11: 09020101030 (C.D. #52)

09020101-539	Unnamed Creek	Unnamed Creek to County Ditch 52	0.45	2B, 3C	IF*	NA				EXS	MTS				--	--		--	--	--	--				
09020101-540	County Ditch 52	Unnamed Creek to Unnamed Creek	1.65	2B, 3C	NS	NA				EXS	MTS				--	--		--	--	--	--				

HUC 11: 09020101090 (Bois de Sioux)

09020101-503	Bois de Sioux River	Mud Lake to Rabbit River	19.85	2C	IF	FS				--	--				MTS	MTS		EXP	MTS	EXS	MTS				

Full Support (FS); Not Supporting (NS); Insufficient Data (IF); Not Assessed (NA); Meets standards or ecoregion expectations (MT/MTS), Potential Exceedence (EXP), Exceeds standards or ecoregion expectations (EX/EXS).

Key for Cell Shading: = existing impairment, listed prior to 2012 reporting cycle; = new impairment; = full support of designated use. *Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.

Appendix 3.2 - Assessment results for lakes in the Bois de Sioux Watershed

Lake ID	Lake Name	County	HUC – 11	Ecoregion	Lake Area (ha)	Max depth (m)	Mean Depth (m)	Watershed Area (ha)	% Littoral	Aquatic Recreation Use Support²
26-0223-00	Bailey Slough	Grant	09020101-110	RRV	76	0.4		1222	100	
26-0267-00	Unnamed	Grant	09020101-110	RRV	13				100	
26-0268-00	Unnamed	Grant	09020101-110	RRV	10				100	
26-0272-00	Unnamed	Grant	09020101-110	RRV	25				100	
[1]26-0294-00	Ash	Grant	09020101-110	RRV/NGP	88	1.5	1	2686	100	NS
26-0303-00	Unnamed	Grant	09020101-110	RRV	37				100	
26-0304-00	Unnamed	Grant	09020101-110	RRV	13				100	
26-0305-00	Stony	Grant	09020101-110	RRV/NGP	41			334	100	IF
26-0306-00	Unnamed	Grant	09020101-110	RRV	8				100	
26-0307-00	Mud	Grant	09020101-110	RRV/NGP	28			5444	100	IF
26-0349-00	Unnamed	Grant	09020101-110	RRV	4				100	
26-0358-00	Unnamed	Grant	09020101-110	RRV	6				100	
26-0361-00	Unnamed	Grant	09020101-110	RRV	30				100	
26-0362-00	Unnamed	Grant	09020101-110	RRV	4				100	
26-0395-00	Unnamed	Grant	09020101-110	RRV	6				100	
56-0802-00	Unnamed	Otter Tail	09020101-110	RRV	10				100	
56-0803-00	Unnamed	Otter Tail	09020101-110	RRV	9				100	
56-0809-00	Unnamed	Otter Tail	09020101-110	RRV	6				100	

Lake ID	Lake Name	County	HUC – 11	Ecoregion	Lake Area (ha)	Max depth (m)	Mean Depth (m)	Watershed Area (ha)	% Littoral	Aquatic Recreation Use Support²
56-0810-00	Unnamed	Otter Tail	09020101-110	RRV	8				100	
[1]56-0957-00	Upper Lightning	Otter Tail	09020101-110	RRV/NGP	218	1.8	1	3886	100	NS
56-0960-00	Unnamed	Otter Tail	09020101-110	RRV	23				100	
56-0961-00	Unnamed	Otter Tail	09020101-110	RRV	9				100	
56-0962-00	Unnamed	Otter Tail	09020101-110	RRV	89				100	
56-1393-00	Unnamed	Otter Tail	09020101-110	RRV	4				100	
56-1394-00	Unnamed	Otter Tail	09020101-110	RRV	6				100	
78-0008-00	Unnamed	Traverse	09020101-030	NGP	24				100	
78-0022-00	Unnamed	Traverse	09020101-030	NGP	40				100	
[1]78-0024-00	Mud	Traverse	09020101-060	NGP	664	2.6	1	307790	100	NS
78-0025-00	Traverse	Traverse	09020101-040	NGP	2339	3.7	2.3	288542	100	IF
78-0039-00	Unnamed	Traverse	09020101-025	NGP	18				100	
78-0040-00	Unnamed	Traverse	09020101-025	NGP	11				100	
78-0041-00	Unnamed	Traverse	09020101-025	NGP	11				100	
78-0044-00	Unnamed	Traverse	09020101-025	NGP	14				100	
78-0057-00	Unnamed	Traverse	09020101-025	NGP	4				100	
78-0073-00	Unnamed	Traverse	09020101-025	NGP	4				100	

Appendix 4.1 - Minnesota statewide IBI thresholds and confidence limits

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

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

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Fish Class	Threshold	FIBI	Visit Date
HUC 11: 09020101110 (Rabbit River)							
09020101-502	05RD013	Rabbit River	319.12	1	39	21	7/19/2005
09020101-502	94RD002	Rabbit River	116.26	2	45	26	6/16/2010
09020101-502	10RD005	Rabbit River	303.41	1	39	18	6/15/2010
09020101-512	10RD012	Rabbit River, South Fork	53.91	2	45	19	6/15/2010
HUC 11: 09020101120 (Doran Coulee)							
09020101-501	84RD005	Bois de Sioux River	1971.01	1	39	41	8/16/2010
HUC 11: 09020101025 (Steer Creek)							
09020101-540	10RD022	Unnamed creek	6.69	3	51	31	6/8/2010
HUC 11: 09020101030 (C.D. #52)							
09020101-540	10RD019	County Ditch 52	17.43	3	51	0	6/8/2010

HUC 11: 09020101090 (Bois de Sioux River)

See Appendix 5.2

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

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Invert Class	Threshold	MIBI	Visit Date
HUC 11: 09020101110 (Rabbit River)							
09020101-502	05RD013	Rabbit River	319.12	7	38.3	26.56	9/20/2005
09020101-502	94RD002	Rabbit River	116.26	7	38.3	32.05	8/5/2010
09020101-502	10RD005	Rabbit River	303.41	7	38.3	22.22	8/4/2010
HUC 11: 09020101120 (Doran Coulee)							
09020101-501	84RD005	Bois de Sioux River	1971.01	2	30.7	36.90	9/12/2011
HUC 11: 09020101025 (Steer Creek)							
09020101-540	10RD022	Unnamed creek	6.69	5	35.9	33.85	8/4/2010
HUC 11: 09020101030 (C.D. #52)							
09020101-540	10RD019	County Ditch 52	17.43	5	35.9	42.46	8/4/2010

Appendix 5.1 - Good/fair/poor thresholds for biological stations on non-assessed channelized AUIDs

Ratings of **Good** for channelized streams are based on Minnesota's general use threshold for aquatic life (Appendix 4.1). Stations with IBIs that score above this general use threshold would be given a rating of **Good**. The **Fair** rating is calculated as a 15 point drop from the general use threshold. Stations with IBI scores below the general use threshold, but above the **Fair** threshold would be given a rating of **Fair**. Stations scoring below the Fair threshold would be considered **Poor**.

Class #	Class Name	Good	Fair	Poor
Fish				
1	Southern Rivers	>38	38-24	<24
2	Southern Streams	>44	44-30	<30
3	Southern Headwaters	>50	50-36	<36
4	Northern Rivers	>34	34-20	<20
5	Northern Streams	>49	49-35	<35
6	Northern Headwaters	>39	39-25	<25
7	Low Gradient Streams	>39	39-25	<25
Invertebrates				
1	Northern Forest Rivers	>51	52-36	<36
2	Prairie Forest Rivers	>31	31-16	<16
3	Northern Forest Streams RR	>50	50-35	<35
4	Northern Forest Streams GP	>52	52-37	<37
5	Southern Streams RR	>36	36-21	<21
6	Southern Forest Streams GP	>47	47-32	<32
7	Prairie Streams GP	>38	38-23	<23

Appendix 5.2 - Channelized stream reach and AUID IBI scores-FISH (non-assessed)

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Fish Class	Good	Fair	Poor	FIBI	Visit Date
HUC 11: 09020101110 (Rabbit River)									
09020101-504	10RD009	Trib. to Judicial Ditch 2	25.10	3			x	16	6/8/2010
09020101-547	10RD016	Trib. to Judicial Ditch 2	5.67	3			x	0	6/8/2010
09020101-548	10RD010	Judicial Ditch 2	53.24	2			x	18	6/14/2010
HUC 11: 09020101130 (Doran Coulee)									
09020101-539	10RD020	Unnamed Creek	11.61	3			x	33	6/8/2010
HUC 11: 09020101090 (Bois de Sioux River)									
09020101-503	84RD001	Bois de Sioux River	1494.71	1	x			53	7/28/2010

Appendix 5.3 - Channelized stream reach and AUID IBI scores-macroinverbrates (non-assessed)

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Invert Class	Good	Fair	Poor	MIBI	Visit Date
HUC 11: 09020101110 (Rabbit River)									
09020101-504	10RD009	Trib. to Judicial Ditch 2	25.10	7		x		24.17	8/5/2010
09020101-547	10RD016	Trib. to Judicial Ditch 2	5.67	7					Not Sampled
09020101-548	10RD010	Judicial Ditch 2	53.24	7			x	1.47	8/9/2010
HUC 11: 09020101130 (Doran Coulee)									
09020101-539	10RD020	Unnamed Creek	11.61	5			x	36.84	8/4/2010
HUC 11: 09020101090 (Bois de Sioux River)									
09020101-503	84RD001	Bois de Sioux River	1494.71	2					Not Sampled

Appendix 6.1 - Minnesota's ecoregion-based lake eutrophication standards

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

Appendix 6.2 - MINLEAP model estimates of phosphorus loads for lakes in the Boise de Sioux River Watershed

Lake ID	Lake Name	Obs TP (µg/L)	MINLEAP TP (µg/L)	Obs Chl-a (µg/L)	MINLEAP Chl-a (µg/L)	Obs Secchi (m)	MINLEAP Secchi (m)	Avg. TP Inflow (µg/L)	TP Load (kg/yr)	Background TP (µg/L)	%P Retention	Outflow (hm3/yr)	Residence Time (yrs)	Areal Load (m/yr)	Trophic Status
26-0294-00	Ash	146	141	55.1	91	0.4	0.5	455	564	39	69	1.24	0.7	1.41	
56-0957-00	Upper Lightning	101	119	44.8	71	0.9	0.6	501	843	44	76	1.68	1.3	0.77	
78-0024-00	Mud	442	276	28.9	242	0.3	0.3	403	61,757	45	32	153	16 days	23	
78-0025-00	Traverse	211	164	19.6	113	1.0	0.5	413	58,410	33	60	142	0.4	6	

Model was run under NGP scenario with the stream phosphorus concentration calibrated to 400 ug/L in order to better match locally sampled conditions for all lakes.