Vermillion River Watershed Monitoring and Assessment Report

Minnesota Pollution Control Agency

October 2012

Authors

MPCA Vermillion River Watershed Report Team:
John Genet, Pam Anderson, Brooke Asleson Dave Christopherson, David Duffey, Gerald Flom, Dan Helwig, Bruce Monson, Andrew Streitz, Steve Thompson

Contributors / acknowledgements *(if any)*

Citizen Lake Monitoring Program Volunteers
Dakota County Soil and Water Conservation District
Minnesota Department of Natural Resources
Minnesota Department of Health
Minnesota Department of Agriculture
Metropolitan Council Environmental Services
Vermillion River Watershed Joint Powers Organization

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

Minnesota Pollution Control Agency

520 Lafayette Road North | Saint Paul, MN 55155-4194 | www.pca.state.mn.us | 651-296-6300
Toll free 800-657-3864 | TTY 651-282-5332

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

Document number: wq-ws3-07040001c

Contents

Table of Figures

Table of Tables

Executive Summary

This assessment report is the first in a series of reports for watershed work being conducted in the Vermillion River Watershed. The results of surface water monitoring and assessment activities in the Vermillion River Watershed are reported here. Subsequent reports will explain stressor identification, Total Maximum Daily Loads (TMDLs), and restoration and protection plans for the watershed.

The Vermillion River Watershed is located in southeastern Minnesota and is part of the Mississippi River - Lake Pepin (07040001) major watershed. Skirting the southern edge of the Twin Cities Metropolitan Area, the Vermillion River flows through a mixed urban and agricultural landscape. Agriculture is currently the predominant land use, accounting for 65 percent of the watershed. However, that percentage has been steadily declining as agricultural land is being converted to residential, commercial, and industrial development. Upper portions of the Vermillion River as well as some of its tributaries have significant groundwater influx and are Minnesota Department of Natural Resources Designated Trout Streams.

In 2008, the Minnesota Pollution Control Agency (MPCA) undertook an intensive watershed monitoring effort of the Vermillion River Watershed's surface waters. Biological monitoring was conducted at fifteen locations along the Vermillion River and several of its tributaries. At two locations along the Vermillion River, water chemistry samples were collected during summer 2008 and 2009. In addition, surface water monitoring data collected between 2001 and 2010 by the MPCA and partners within the watershed were compiled. Monitoring data were evaluated during the spring of 2011, to assess the aquatic life, aquatic recreation, and aquatic consumption designated uses of rivers and streams in the watershed. Lakes were not targeted during the intensive watershed monitoring effort that took place in 2008 and 2009. However, lake monitoring data collected in previous years was used to assess the aquatic recreation use of several lakes within the watershed.

Aquatic life was assessed on 22 streams segments in the watershed using a combination of biological indicators and water chemistry parameters. Three segments were supporting the aquatic life use, six were not supporting this designated use, and thirteen either had an insufficient amount of data to adequately assess or were considered channelized. Channelized reaches are currently not being assessed by the MPCA until a tiered aquatic life use (TALU) system is adopted into rule. In this report, the biological quality of channelized streams was rated on a good/fair/poor scale based on biological indicator results.

A total of ten stream segments and four lakes were found to have impaired aquatic recreation, meaning that conditions in these waters are not suitable for swimming and other forms of recreation. The majority of these impairment determinations were made during previous assessment cycles, prior to the 2011, assessment of the Vermillion River Watershed. Four lakes in the watershed were supporting aquatic recreation. Aquatic consumption was assessed at two locations along the Vermillion River, one above the falls at Hastings and one below the falls. Analysis of the concentration of contaminants such as mercury and polychlorinated biphenyls in the tissue of fish collected at these locations resulted in the entire Vermillion River being listed as impaired for aquatic consumption.

I. 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) requiring 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 take appropriate actions to restore these waters, including the development of TMDLs. A TMDL is a comprehensive study identifying the assimilative capacity of a water body, all pollution sources causing or contributing to its impairment, and the reductions needed to restore a water body so that it can 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 CWLA of 2006, provided a policy framework and the initial resources to state and local governments to accelerate efforts to monitor, assess, restore and protect surface waters. Funding from the Clean Water Fund created by the passage of the Clean Water, Land, and Legacy Amendment to the state constitution allows this effort to persist. In response, the MPCA has developed a watershed monitoring strategy which uses an effective and efficient integration of water monitoring programs to provide a more comprehensive assessment of water quality and expedite the restoration and protection process. This has permitted the MPCA to establish a goal to assess the condition of Minnesota's surface waters via a 10-year cycle, and provides an opportunity to more fully integrate MPCA water resource management efforts with local government and stakeholders to allow for coordinated development and implementation of water quality restoration and improvement projects.

The rationale behind the watershed monitoring approach is to intensively monitor the 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 efforts. The monitoring strategy was implemented in the Vermillion River Watershed beginning in the summer of 2008. This report provides a summary of all water quality assessment results in the Vermillion River Watershed and incorporates all data available for the assessment process, including watershed monitoring, volunteer monitoring, and monitoring conducted by local government units. Consequently, there is an 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, restoring, and preserving the quality of Minnesota's water resources.

II. 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/index.php/view-document.html?gid=10230).

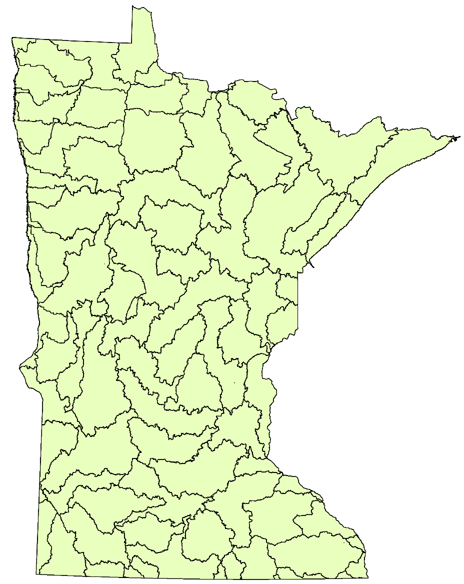


Figure 1. Major watersheds within Minnesota (8-Digit HUC)

Load monitoring network

The first component of this effort is the Major Watershed Load Monitoring Program (MWLMP), which involves permanent flow and water chemistry monitoring stations on Minnesota's major rivers, including the Red, Minnesota, Mississippi, and Rainy rivers, and the outlets of major tributaries (also referred to as major watersheds). MWLMP staff and program cooperators monitor water quality at many of these outlets and at various locations along Minnesota's major rivers. Initiated in 2007 and funded with appropriations from Minnesota's Clean Water Fund, the MWLMP's multi-agency monitoring approach combines site-specific stream flow data from United States Geological Survey (USGS) and Minnesota Department of Natural Resources (DNR) flow gauging stations. This partnership effort, along with water quality data collected by the Metropolitan Council Environmental Services (MCES), and local monitoring organizations, is a cornerstone of the watershed approach.

Water quality samples are collected year round at all MWLMP monitoring sites. Approximately 30-35 mid-stream grab samples are collected per site per 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 to estimate pollutant concentrations and loads on days when samples are not collected. Primary outputs from Flux32 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 unit of time. The flow weighted mean concentration is used to estimate the overall quality of water passing this point, computed by dividing the pollutant load by the total flow volume that passed the stream location over the same given unit of time. Annual pollutant loads are calculated for total suspended solids (TSS), total phosphorus (TP), dissolved orthophosphate (DOP), and nitrate plus nitrite-nitrogen (nitrate-N). When fully implemented, the MWLMP will monitor and compute pollutant loads at 79 stream sites across the State.

The on-going monitoring performed by the program is designed to measure and compare regional differences and long-term trends in water quality. This will be particularly helpful in putting the intensive watershed monitoring data for a given watershed (see below) into a longer-term context, given that the intensive monitoring will occur only once every 10 years. 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.

Intensive watershed monitoring

Stream monitoring

The intensive watershed monitoring strategy utilizes a nested watershed design allowing the aggregation of watersheds from a coarse to a fine scale (Figure 2). The foundation of this comprehensive approach is the 81 major watersheds within Minnesota. Streams are broken into segments by hydrologic unit codes (HUC) to define separate waterbodies within a watershed. Sampling occurs in each major watershed once every 10 years. In this approach, intermediate-sized (approximately 11-digit HUC) and "minor" (14-digit HUC) watersheds are sampled along with the major watershed outlet to provide a complete assessment of water quality (Figure 2). River/stream sites are selected near the outlet at all watershed scales. This approach provides holistic assessment coverage of rivers and streams without monitoring every single stream reach (See Figure 3 for an illustration of the monitoring site coverage within the Vermillion River Watershed).

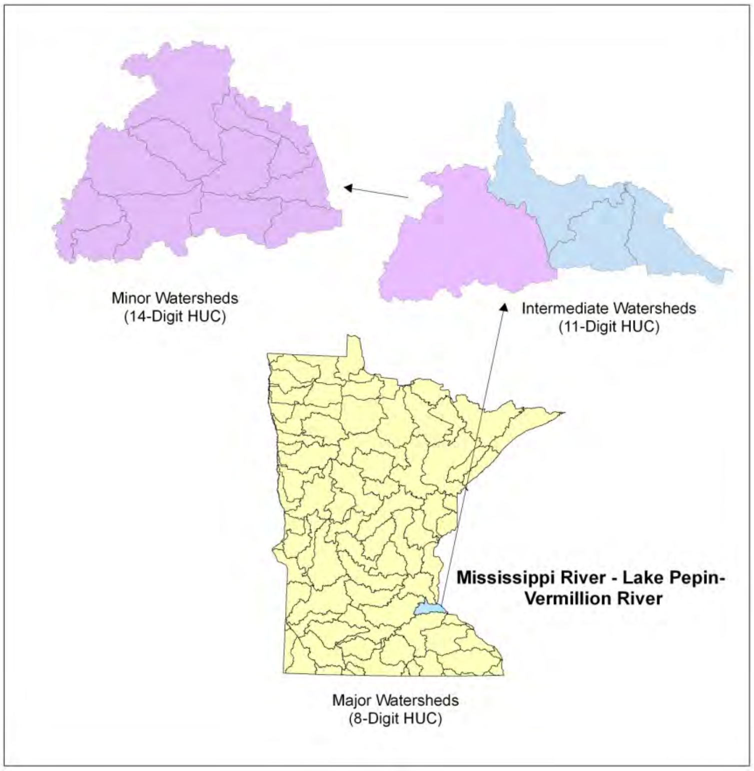


Figure 2. The intensive watershed monitoring design.

The outlet of the major watershed (purple dot in Figure 3) is sampled for biology, water chemistry, and fish contaminants to allow for the assessment of aquatic life, aquatic recreation, and aquatic consumption use support. Each 11-HUC outlet (green dots in Figure 3) is sampled for biology and water chemistry for the assessment of aquatic life and aquatic recreation use support. Watersheds at this scale generally consist of major tributary streams with drainage areas ranging from 75 to 150 mi^2. Lastly, most minor watersheds (typically 10-20 mi^2) are sampled for biology (fish and macroinvertebrates) to assess aquatic life use support (red dots in Figure 3). Specific locations for sites sampled as part of the intensive monitoring effort in the Vermillion River Watershed can be found in Appendix 2.

The second step of the intensive watershed monitoring effort consists of follow-up monitoring at areas determined to have impaired waters. This follow-up monitoring is designed to collect the information needed to initiate the stressor identification process, in order to identify the source(s) and cause(s) of impairment to be addressed in TMDL development and implementation.

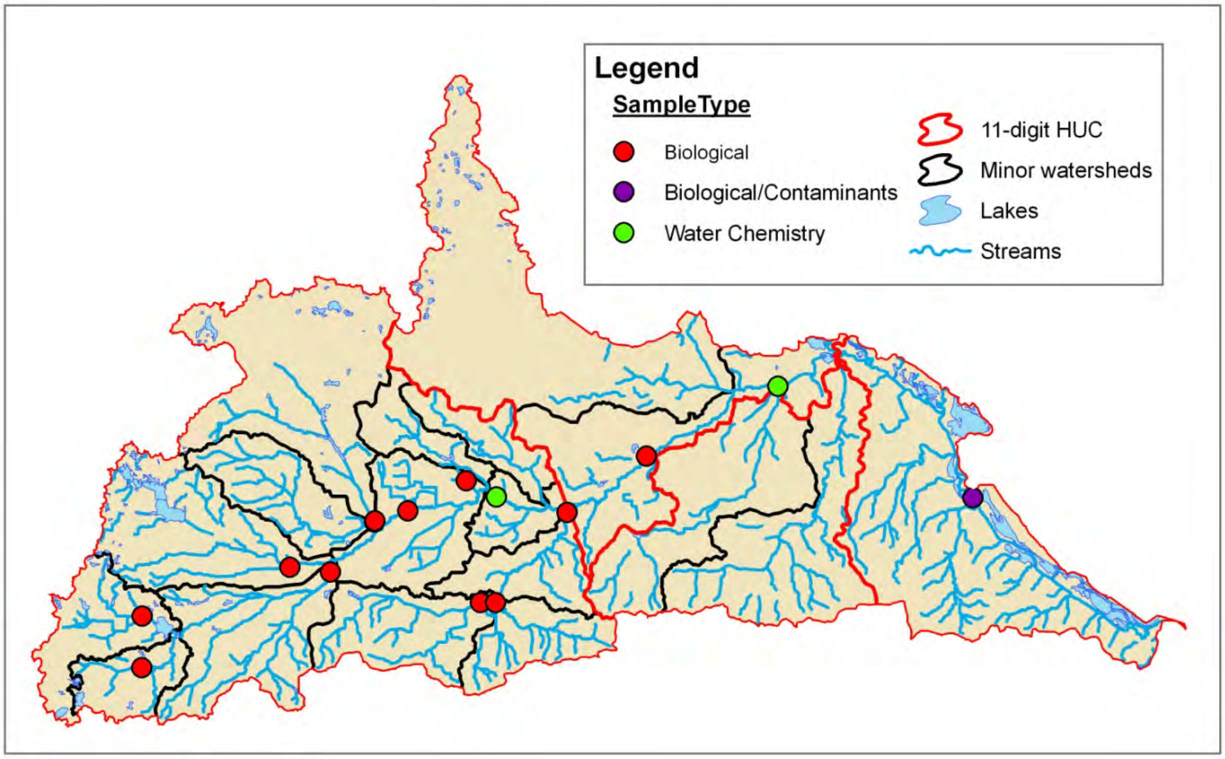


Figure 3. Intensive watershed monitoring stream stations in the Vermillion River Watershed.

Lake monitoring

The MPCA conducts and supports lake monitoring for a variety of objectives. Lake condition monitoring activities are focused on assessing the recreational use support of lakes and identifying trends over time. The MPCA also assesses lakes for aquatic consumption use support, based on fish-tissue and water-column concentrations of toxic pollutants. Lake monitoring was added to the watershed monitoring framework in 2009 after monitoring in this watershed was near completion, so while there is some data available, not all of the lakes in the Vermillion River Watershed currently have enough information for assessment.

Even when pooling MPCA and local resources, the MPCA is not able to monitor all lakes in Minnesota. The primary focus of MPCA monitoring is lakes $\geq$500 acres in size (“large lakes”). These resources typically have public access points, they generally provide the greatest aquatic recreational opportunity to Minnesota’s citizens, and these lakes collectively represent 72 percent of the total lake area (greater than 10 acres) within Minnesota. Though the primary focus is on monitoring and assessing larger lakes, the MPCA is also committed to directly monitoring, or supporting the monitoring of, the majority of lakes between 100-499 acres (“small lakes”) for assessment purposes.

Citizen and local monitoring

Citizen monitoring is an important component of the watershed monitoring approach. The MPCA coordinates two programs aimed at encouraging citizen surface water monitoring: the Citizen Lake Monitoring Program (CLMP) and the Citizen Stream Monitoring Program (CSMP). Like the permanent load monitoring network, sustained citizen monitoring can provide the long-term picture needed to help evaluate current status and trends. The advance identification of lake and stream sites that will be sampled by agency staff provides an opportunity to actively recruit volunteers to monitor those sites, so that water quality data collected by volunteers are available for the years before and after the intensive monitoring efforts by MPCA staff. This citizen-collected data helps agency staff interpret the results from the intensive monitoring effort, which only occurs two out of every ten years. It also allows interested parties to track any water quality changes that occur in the years between the intensive monitoring events. Coordinating with volunteers to focus monitoring efforts where it will be most effective for planning and tracking purposes will help local citizens/governments see how their efforts are being used to inform water quality management decisions and affect change.

The MPCA also passes through funding via Surface Water Assessment Grants (SWAGs) to local groups such as counties, soil and water conservation districts (SWCDs), watershed districts, nonprofits, and educational institutions to monitor lake and stream water quality. These local partners greatly expand our overall capacity to conduct sampling. Many SWAG grantees invite citizen participation in their monitoring projects.

The annual SWAG Request for Proposal (RFP) identifies the major watersheds that are scheduled for upcoming intensive monitoring activities. HUC-11 stream outlet chemistry sites and lakes less than 500 acres that need monitoring are identified in the RFP and local entities are invited to request funds to complete the sampling. SWAG grantees conduct detailed sampling efforts following the same established monitoring protocols and quality assurance procedures used by the MPCA. All of the lake and stream monitoring data from SWAG projects are combined with MPCA and citizen monitoring data to assess the condition of lakes and streams in the Vermillion River Watershed (Figure 4).

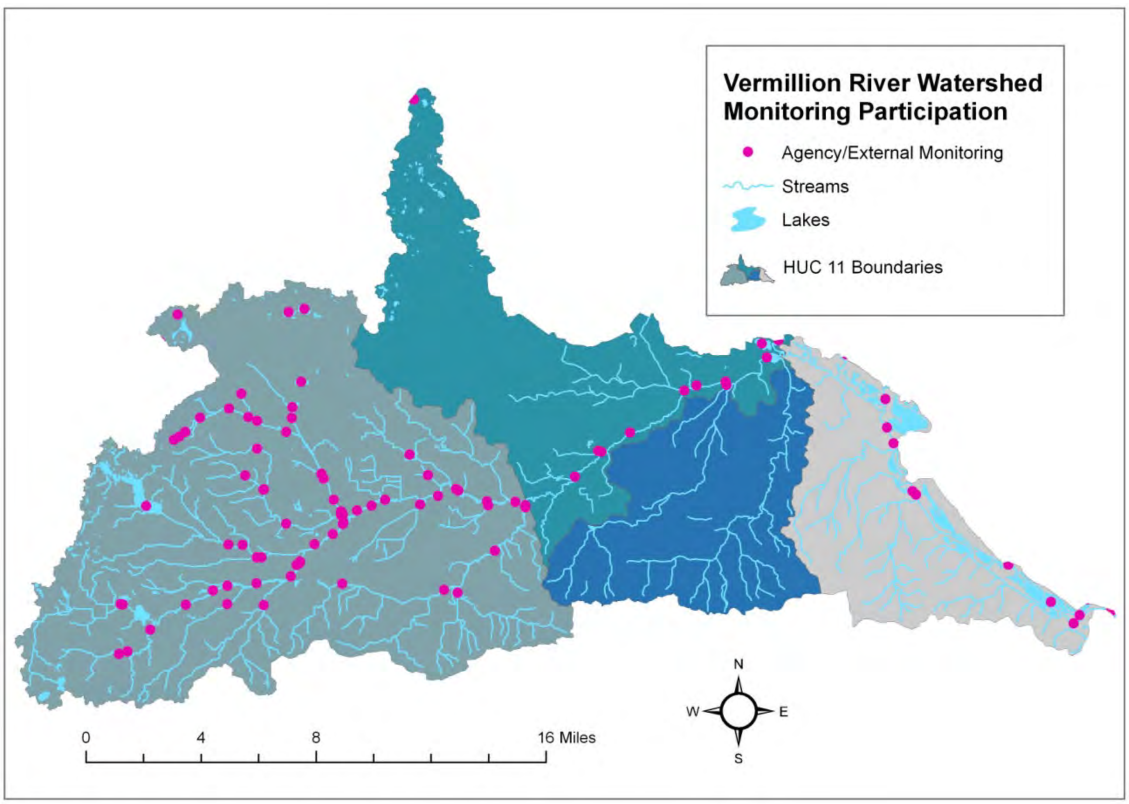


Figure 4. Monitoring locations of local groups, citizens, and the MPCA in the Vermillion River Watershed.

III. Assessment Methodology

The Clean Water Act requires states to report on the condition of the waters of the state every two years. This biennial report to Congress contains an updated list of surface waters that are determined to be supporting or non-supporting of their designated uses. 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 methodology 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. Use attainment status describes whether or not a waterbody is supporting its designated use as evaluated by the comparison of monitoring data to criteria specified by Minnesota Water Quality Standards (Minn. R. 7050 2008; https://www.revisor.leg.state.mn.us/rules/?id=7050). 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. Protection of aquatic life means the maintenance of healthy, diverse and successfully reproducing populations of aquatic organisms, including fish and invertebrates. Protection of recreation means the maintenance of conditions suitable for swimming and other forms of water recreation. Protection of consumption means protecting citizens who eat fish inhabiting Minnesota waters or receive their drinking water from waterbodies protected for this use.

Numeric water quality standards represent concentrations of specific pollutants in water that protect a specific designated use. Ideally, if the standard is not exceeded, the use will be protected. However, nature is very complex and variable, therefore, the MPCA uses a variety of tools to fully assess designated uses. Assessment methodologies often differ by parameter and designated use. Furthermore, pollutant concentrations may be expressed in different ways such as chronic value, maximum value, final acute value, magnitude, duration and frequency.

Narrative standards are statements of conditions in and on the water, such as biological condition, that protect their designated uses. Interpretations of narrative criteria for aquatic life support in streams are based on multi-metric biological indices including the Fish Index of Biological Integrity (Fish IBI or F-IBI), which evaluates the health of the fish community, and the Macroinvertebrate Index of Biological Integrity (Invert IBI or M-IBI), which evaluates the health of the aquatic invertebrate community. Biological monitoring is a direct means to assess aquatic life use support, as the aquatic community tends to integrate the effects of pollutants and stressors over time.

Assessment units

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

Conceptually, the process for determining use attainment status of a waterbody is similar for each designated use: comparison of monitoring data to established water quality standards. However, the complexity of that process and the amount of information required to make accurate assessments varies between uses. In part, the level of complexity in the assessment process depends on the strength of the dose-response relationship; i.e., if chemical B exceeds water quality criterion X, how often is beneficial use Y truly not being attained. For beneficial uses related to human health, such as drinking water, the relationship is well understood and thus, the assessment process is a relatively simple interpretation of 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, habitat).

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 to consider when making such determinations.

Any new impairment determination (i.e., waterbody not attaining its beneficial use) is reviewed using Geographic Information System (GIS) to determine if greater than 50 percent 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 framework. For additional information see: Tiered Aquatic Life Use (TALU) Framework (http://www.pca.state.mn.us/index.php/water/water-permits-and-rules/water-rulemaking/tiered-aquatic-life-use-talu-framework.html). Since large portions of a watershed may be channelized, reaches with biological data are evaluated on a "good-fair-poor" system to help evaluate their condition (see Section VI).

Figure 5. Flowchart of aquatic life use assessment process.

The last step in the assessment process is the Professional Judgement Group (PJG) 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 have a vested interest in the outcomes of the assessment process. Information obtained during this meeting may be used to revise previous use attainment decisions. The result of this meeting is a compilation of the assessed waters which will be included in the watershed assessment report. 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.

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 paid for by MPCA is entered into Environmental Quality Information System (EQuIS), MPCA's water quality data system. MPCA uploads the data from EQuIS to United States Environmental Protectin Agency's (EPA) STORET data warehouse. Water quality monitoring projects required to store data in EQuIS are those with federal or state funding under CWA Section 319, Clean Water Partnership (CWP), CWLA Surface Water Assessment Grants, and the TMDL program. Many local projects not funded by MPCA choose to submit their data to the MPCA in EQuIS-ready format, so that it may be utilized in the assessment process. Prior to each assessment cycle, the MPCA requests data from local entities and partner organizations using the most effective methods, including direct contacts and GovDelivery distribution lists.

Period of record

The MPCA uses data collected over the most recent 10 year period for all water quality assessments. Generally, the most recent data from the 10 year assessment period is reviewed first when assessing toxic pollutants, eutrophication and fish contaminants. Also, the more recent data for all pollutant categories may be given more weight during the comprehensive watershed assessment or professional judgment group meetings. The goal is to use data from the 10 year period that best represents the current water quality conditions. Using data over a 10 year period 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.

IV. Watershed Overview

Originating in southeastern Scott County, the Vermillion River flows northeast about 60 miles before joining the Mississippi River near the city of Red Wing. The watershed of the Vermillion River has been grouped together with several other tributaries of the Mississippi River (including those on the Wisconsin side) in USGS's hydrologic unit classification system. This hydrologic unit is known as the Vermillion-Rush which has a hydrologic unit code of 07040001. The Minnesota portion of this unit is called the Mississippi River – Lake Pepin watershed. This report is limited to the Minnesota portion of this hydrologic unit, north of the Cannon River watershed (i.e., the Vermillion River Watershed). Monitoring and assessment results for the Minnesota portion of this watershed occurring south of the Cannon River (e.g., Wells Cr., Hay Cr., Bullard Cr.) is presented in a separate report (http://www.pca.state.mn.us/index.php/view-document.html?gid=18230).

The Vermillion River Watershed is approximately 348 mi^2 and includes portions of Scott, Dakota, and Goodhue Counties (Figure 6). The headwaters of the Vermillion River occur within the North Central Hardwood Forest (NCHF) ecoregion, but the majority of the watershed is in the Western Cornbelt Plains (WCBP) ecoregion (White and Omernik 2007). The western portion of the watershed was formed by the edges of the Superior Lobe and Des Moines Lobe during the Wisconsin glaciation. This moraine area is characterized by rolling to steep hills and numerous closed basins where lakes and wetlands exist. Much of the watershed is covered by outwash plains and valleys composed largely of sands and gravels that become finer in texture farther eastward away from the moraine (for a more thorough description of the Surficial Geology of the watershed see VRWJPO 2005). Well-drained, silty or loamy soils are prevalent throughout much of the watershed, resulting in high rates of infiltration in its undeveloped areas. Annual recharge of surficial aquifers in the Vermillion River watershed has been estimated to be 6-8 inches per year or roughly 19-25 percent of the annual precipitation (Chapman et al. 2008).

Land use summary

Despite its proximity to the Twin Cities Metropolitan Area, the Vermillion River Watershed is predominantly an agricultural watershed. Rangeland (pastures, hay fields) and cropland together account for approximately 65 percent of the watershed area. However, land use estimates presented in Figure 7 are somewhat dated for such a rapidly developing watershed (*Source:* 2001 National Land Cover Data Set) and likely underestimate the current extent of developed areas (e.g., residential, commercial, industrial, etc.) in this watershed. An abrupt change in land use occurs after the Vermillion River flows over the falls at Hastings in the eastern portion of the watershed. This region of the watershed is within the Mississippi River floodplain and is largely comprised of bottomland hardwood forest, wetlands, and lakes.

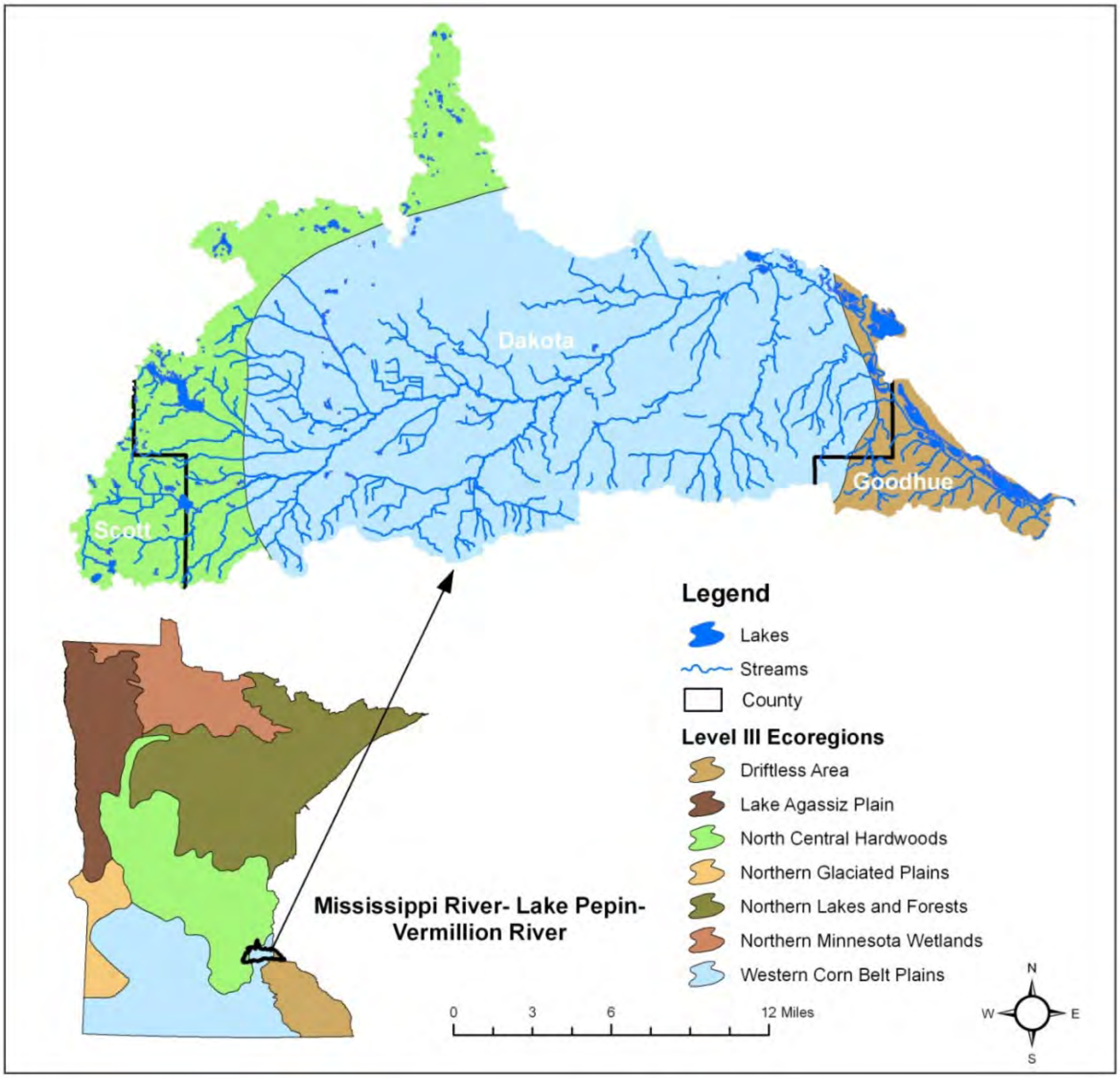


Figure 6. Ecoregions within the Vermillion River Watershed.

Surface water hydrology

The headwaters of the Vermillion River lie in the southeastern corner of Scott County in an area that was historically hardwood forest. From this location the river meanders northeast a total of 40 miles, skirting the southern edge of the Twin Cities Metropolitan Area, before reaching the falls at Hastings. As it enters Dakota County, the Vermillion River transitions into a prairie river where groundwater influx is significant enough to support a coldwater fish assemblage. Downstream of Empire, and for the remainder of its length, the Vermillion River is considered a cool water/warm water river. Below the Hastings Falls, the river splits into the Vermillion Slough which periodically flows north a short distance to the Mississippi River and the Vermillion River which continues south for another 20 miles before draining into the Mississippi near the City of Red Wing. From the headwaters to the mouth of the Vermillion River there is a 420 foot elevation change with an abrupt 90 foot drop at the falls in Hastings (VRWJPO 2005).

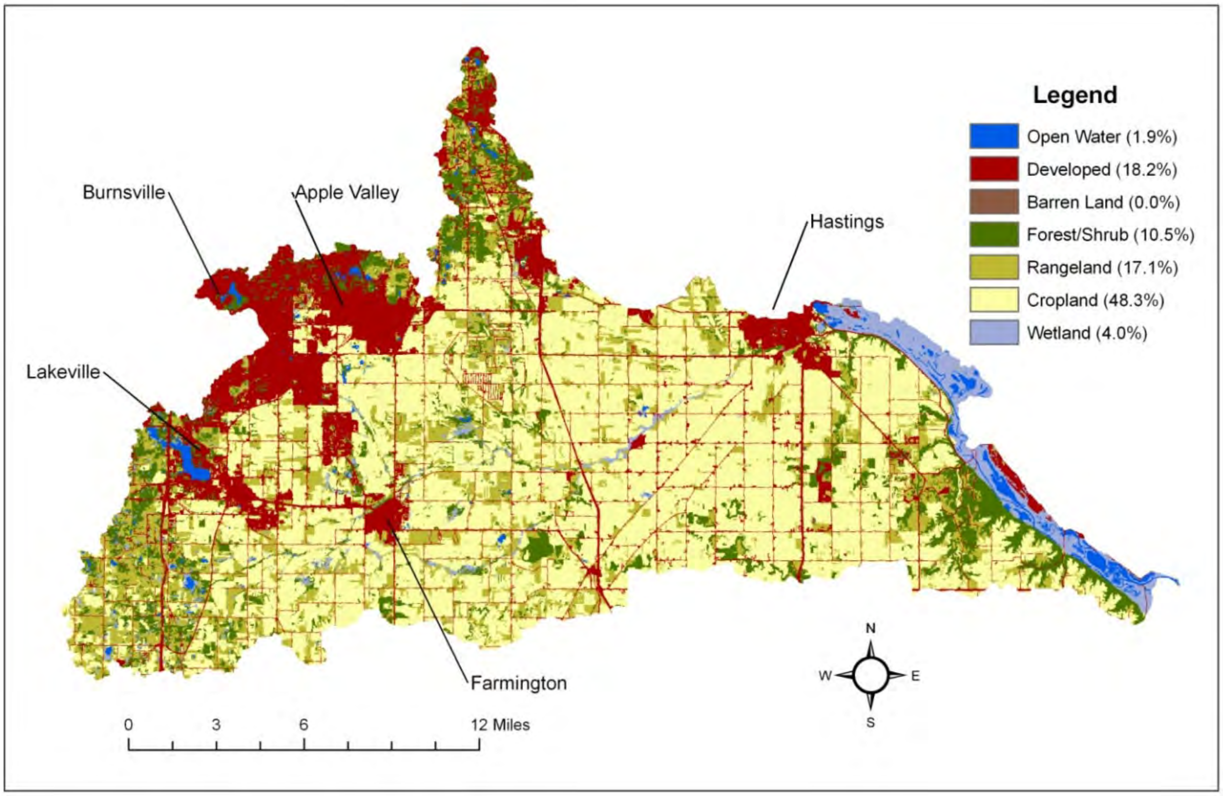


Figure 7. Land use within the Vermillion River Watershed.

Average annual flow data from USGS gaging station 05345000, located on the Vermillion River near Empire, suggests a pattern of increasing stream flow over the past 35 years (Figure 8), however, this pattern does not represent a statistically significant trend ($p > 0.05$). Examining data from the last 20 years (1991-2010) reveals a statistically significant ($p < 0.05$) decreasing trend in stream discharge. The relatively flat precipitation pattern observed over this same period (Figure 10) suggests that water withdrawals (surface and groundwater) in the watershed may be contributing to the observed declines in Vermillion River discharge.

The only major tributary to the Vermillion River is the South Branch Vermillion River; the two come together just downstream of the town of Empire. The lower section of the South Branch is also designated a coldwater stream. North Creek, Middle Creek, and South Creek are smaller tributaries that join the Vermillion River near the city of Farmington. The majority of other tributaries in this watershed are unnamed, intermittent streams that have not been monitored and thus, were not assessed by the MPCA at this time.

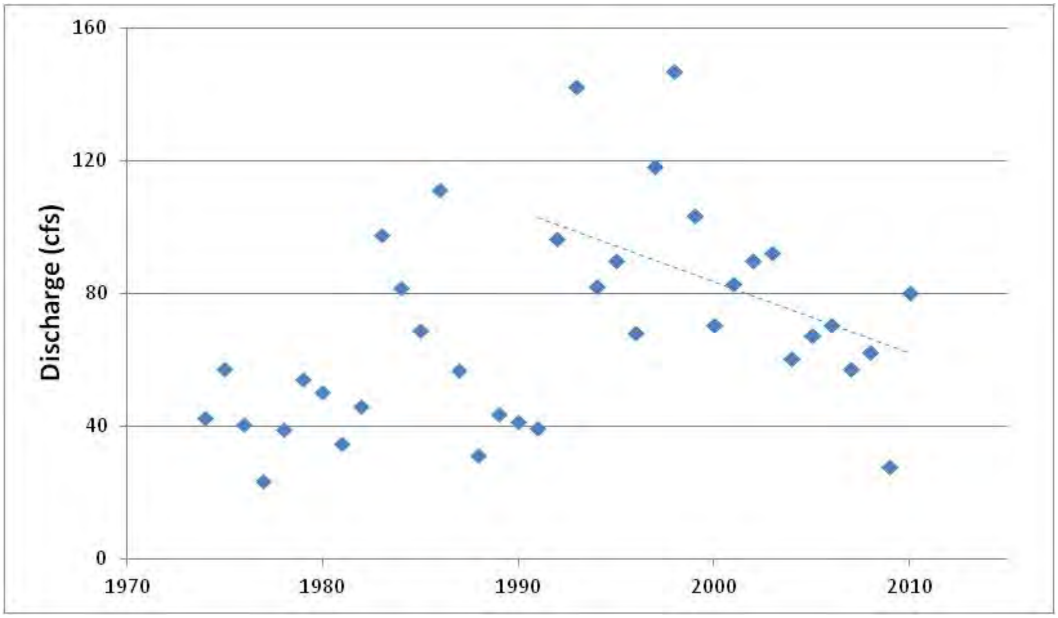


Figure 8. Annual mean discharge of the Vermillion River at USGS gaging station 05345000 located near Empire, MN.

Lakes are not a prominent feature of the Vermillion River watershed. Most of the large (> 100 acres) lakes in the watershed occur along the Mississippi River corridor and maintain surface water connections to the Mississippi and/or Vermillion Rivers. Only three lakes in the watershed exceed 500 acres in size (North, Sturgeon, and Marion) and several exceed 100 acres (e.g., Clear, Goose, Isabelle, Alimagnet, and Wildcat).

Like other parts of southern Minnesota, the Vermillion River watershed has less than 50 percent of its original wetlands remaining (BWSR 2004). The majority of wetlands that exist in the watershed today are confined to the Mississippi River floodplain as well as the riparian corridor of the Vermillion River and its tributaries. Meanwhile, the number of stormwater ponds in the watershed has dramatically increased in recent decades in association with urban development.

Climate and precipitation

Average annual precipitation in the Vermillion River Watershed ranged from 31 to 35 inches, depending on location, for the 1981 to 2010 period (NCDC 2011). During the 2008 water year (October 2007 through September 2008), when most of the monitoring was conducted in the watershed, precipitation was slightly drier than normal (Figure 9). The Vermillion River Watershed is in the east-central region of Minnesota. The areal average precipitation (i.e., average of all rainfall gauges in a certain area) for this region exhibits a statistically significant ($p = 0.001$) rising trend over the past 100 years (Figure 10). This is a strong trend and matches similar trends observed in other regions of the state. Over the past 20 years, rainfall in east-central Minnesota shows no statistically significant trend ($p > 0.05$).

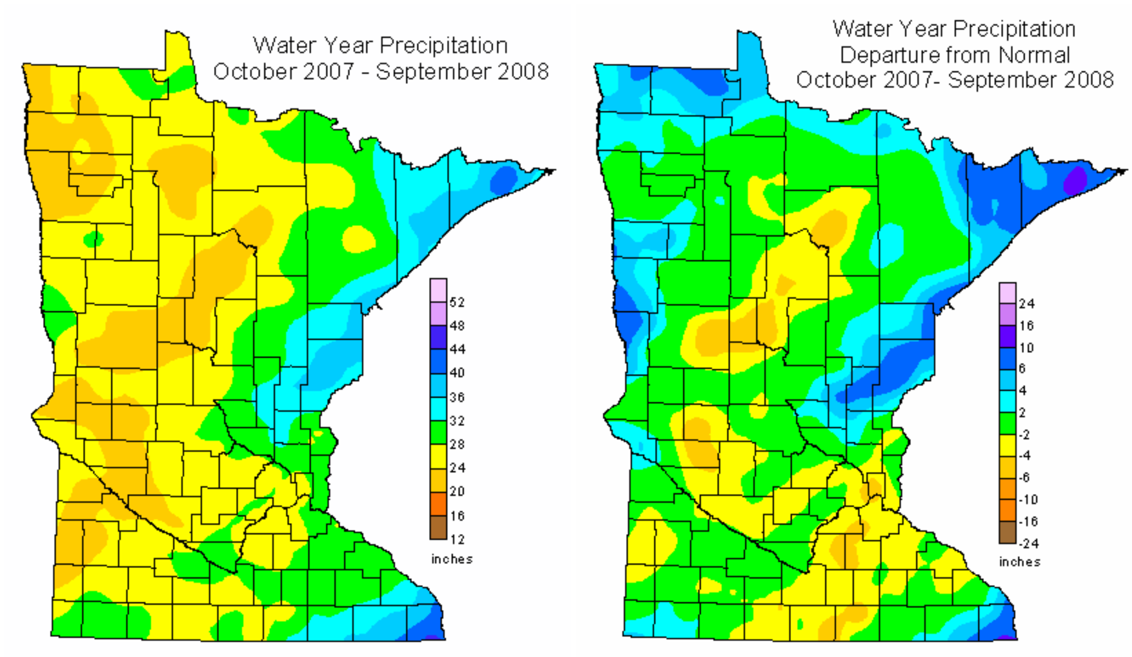


Figure 9. State wide precipitation levels during the 2008 water year.

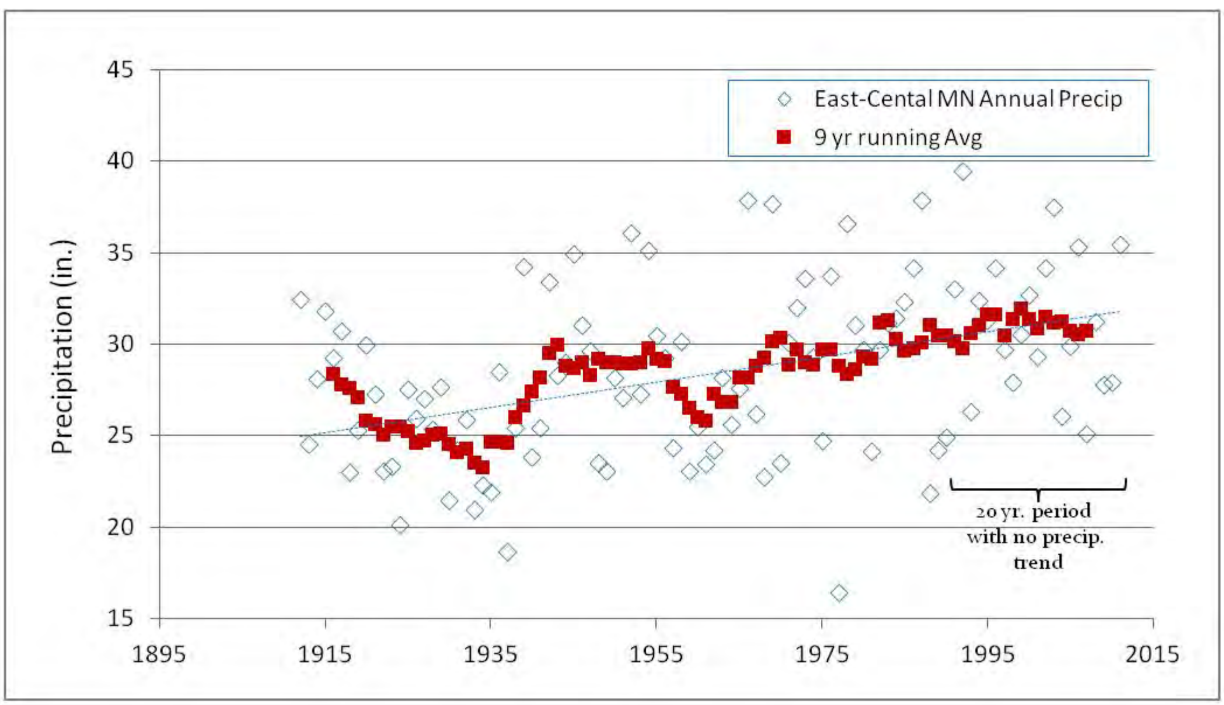


Figure 10. Annual precipitation for the east-central region of Minnesota. *Data Source:* Western Regional Climate Center, available on web at [http://www.wrcc.dri.edu/spi/divplot1map.html.](http://www.wrcc.dri.edu/spi/divplot1map.html)

Surficial and groundwater withdrawals

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

Figure 11 shows the distribution of permitted water withdrawals in the Vermillion River Watershed. The largest permitted consumers of water in Minnesota are (in order) municipalities, industry, and irrigation. Withdrawals in the Vermillion are mostly for irrigation and municipal use. Over the last 20 years groundwater and surface water withdrawals in the Vermillion River Watershed have increased (Figure 12). Statistically significant increasing usage trends exist for both groundwater and surface water withdrawals during this time frame, p = 0.001 and 0.01, respectively. The large jump in both groundwater and surface water withdrawals starting around 1995 is a trend that is found throughout the state.

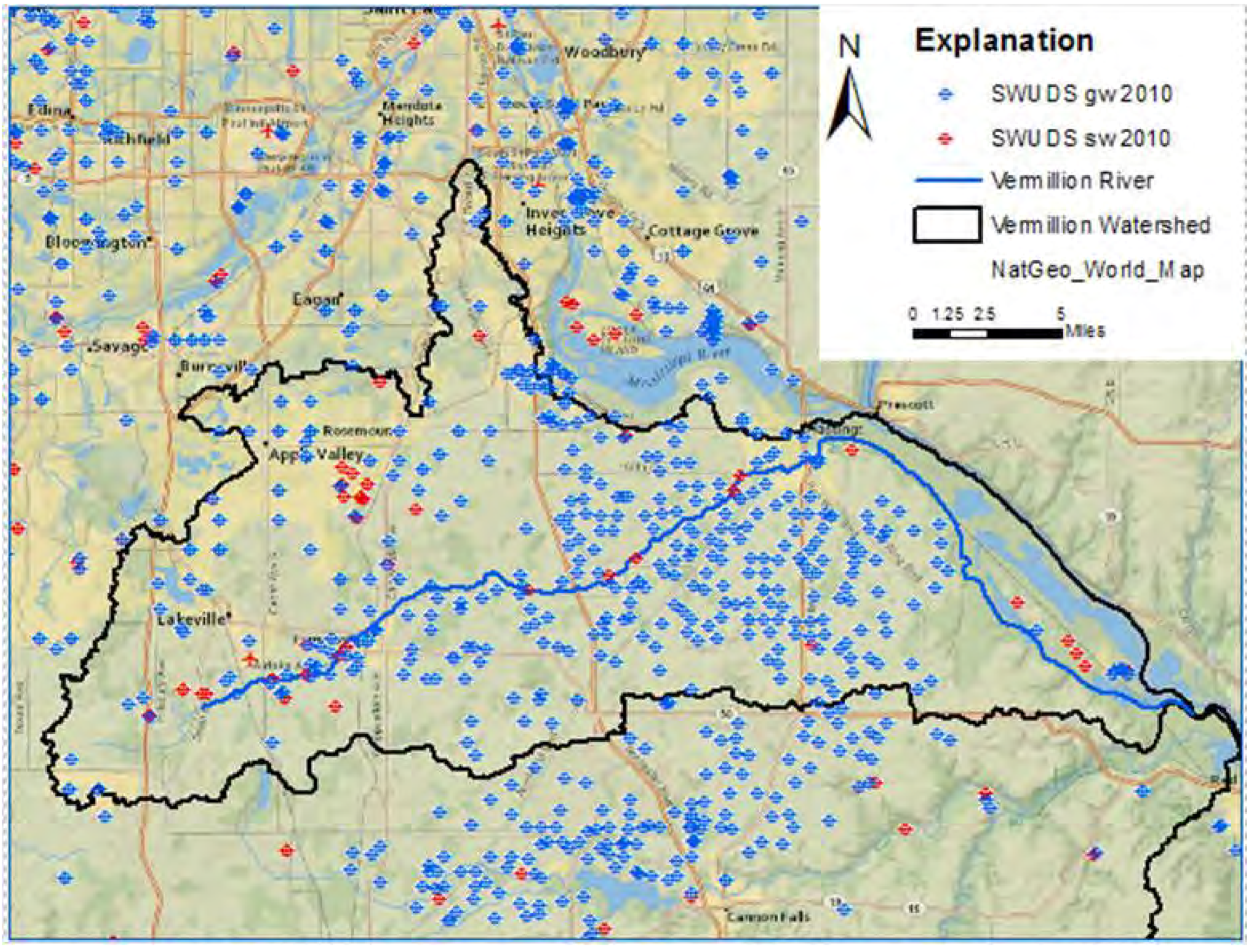


Figure 11. Locations of permitted water withdrawals in the Vermillion River Watershed (blue = groundwater withdrawals, red = surface water withdrawals).

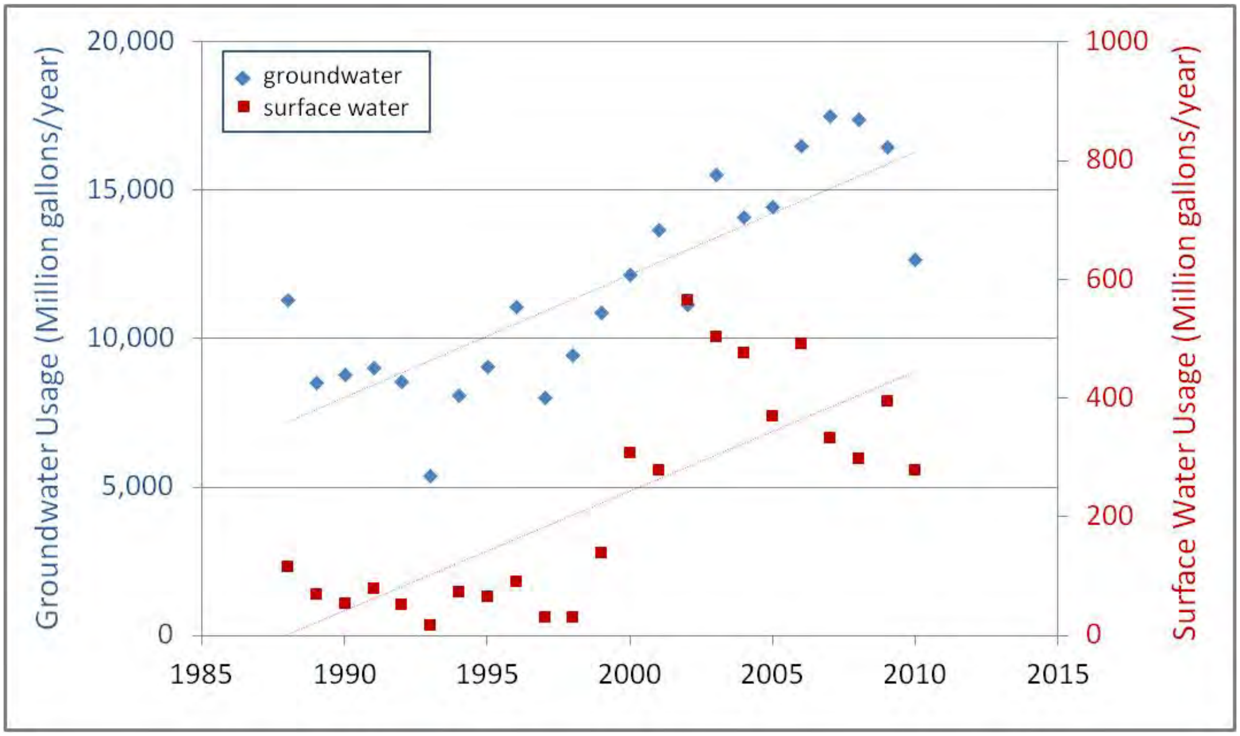


Figure 12. Annual water withdrawal totals in the Vermillion River Watershed.

The observed combination of declining stream flow (Figure 8) and increased water usage (Figure 12) over the past 20 years in the Vermillion River Watershed is similar to patterns observed in other watersheds (e.g., North Fork of the Crow River, Little Rock Creek) throughout the state where such investigations have occurred. Based on the priority system created for groundwater investigations of watersheds, the Vermillion River Watershed is given a moderate to high probability of exhibiting groundwater-surface water interactions that would necessitate further groundwater review. This conclusion is based upon statistically significant rising trends in groundwater and surface water withdrawals, and short-term statistically significant declines in Vermillion River stream flow.

V. Watershed-Wide Data Collection Methodology

Load monitoring

The Vermillion watershed is not currently monitored by the MPCA Watershed Pollutant Load Monitoring Network, but is monitored by the Metropolitan Council Environmental Services (MCES). Pollutant loads were calculated by MCES using flow and water quality data collected at the falls in Hastings, Minnesota (approximately two miles upstream of the point where the river splits into two channels).

Water chemistry and discharge data are coupled in Flux32, a pollutant load model originally developed by Dr. Bill Walker and recently upgraded by the U.S. Army Corp of Engineers and MPCA, to create concentration/flow regression equations for estimating pollutant concentrations and loads on days when samples are not collected. Primary outputs include: annual pollutant loads, defined as the amount (mass) of a pollutant passing a stream location over a defined period of time; and flow weighted mean concentrations (FWMCs), which are computed by dividing the pollutant load by the total seasonal flow volume. Annual pollutant loads and flow weighted means are calculated for total suspended solids (TSS), total phosphorus (TP), and nitrate + nitrite nitrogen (Nitrate-N).

Stream water sampling

Two stations were sampled from May through September in 2008, and again June through August of 2009, to provide sufficient water chemistry data for assessing aquatic life and aquatic recreation designated uses in the 11-HUC subwatersheds (green dots in Figure 3). Following the IWM design, sampling locations were established near the outlets of these subwatersheds. A water chemistry monitoring station was not placed within the Hardwood 11-HUC because this subwatershed lacked perennial streams. Similarly, the IWM design did not include stream monitoring stations within the Mississippi (Direct) River (HUC 07040001080) subwatershed due to it being more representative of the Mississippi River and its watershed. The Mississippi River is not the subject of this report and will be addressed in a separate future report. See Appendix 2 for locations of stream water chemistry monitoring sites. See Appendix 1 for definitions of stream chemistry analytes monitored in this study.

Stream biological sampling

The biological monitoring component of intensive watershed monitoring in the Vermillion River Watershed was completed during the summer of 2008. A total of fifteen biological monitoring sites were established across the watershed and sampled. These sites were located near the outlets of most minor HUC-14 watersheds, selected following the sampling design. In addition, biological data from four existing monitoring stations within the watershed were included in the assessment process. These monitoring stations were established as part of a random Lower Mississippi River Basin survey in 2004, or as part of a 2007, investigation into the quality of channelized streams with intact riparian zones. While data from the last ten years contributed to the watershed assessments, the majority of data utilized for the 2011 assessment, was collected in 2008. A total of thirteen stream assessment units were sampled for biology in the Vermillion River Watershed and aquatic life assessments were conducted for nine of these. In anticipation of transitioning to a TALU framework, biological monitoring data was not assessed on channelized stream segments due to their potential to qualify for a 'modified' aquatic life use classification and its associated water quality criteria. 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 to investigate trends in water quality condition in subsequent reporting cycles.

To measure the health of aquatic life at each biological monitoring station, indices of biological integrity (IBIs), specifically fish and macroinvertebrate IBIs, were calculated based on monitoring data collected for each of these communities. A fish and macroinvertebrate classification framework was developed to account for natural variation in community structure. Minnesota's streams and rivers were divided into nine distinct classes (seven warm water and two cold water), with each class having its own unique fish IBI and macroinvertebrate IBI. The classification factors used to produce the seven classes were drainage area, gradient, water temperature and geographic region of the state. Fish and macroinvertebrate communities occurring at sites within each class are more similar to each other than those occurring in other classes. These classification factors are unaffected by human disturbance to ensure that the framework reflects natural variability and that the resulting IBIs reflect human-induced impacts to the waterbody. IBI development was stratified by class, with a unique suite of metrics, scoring functions, impairment thresholds, and confidence intervals identified for each. IBI scores higher than the impairment threshold indicate that the stream reach supports aquatic life. Contrarily, scores below this threshold indicate that the stream reach does not support aquatic life. Confidence limits around the impairment threshold help to ascertain where additional information may be considered to help inform the impairment decision. When IBI scores fall within the confidence interval, interpretation and assessment of waterbody condition involves consideration of potential stressors, and draws upon additional information regarding water chemistry, physical habitat, land use activities, etc. For individual biological monitoring station IBI scores, thresholds and confidence intervals for all biological monitoring sites within the watershed refer to Appendices 5, 6, 8, and 9.

Fish contaminants

Mercury and polychlorinated biphenyls (PCBs) were analyzed in fish tissue samples collected from the Vermillion River in 1995 and 2008. Two lakes, Alimagnet and Marion, had fish collected in 1990 and 1995, respectively, for mercury and PCBs analysis. Fish were usually collected by the DNR, although in 2008, the fish from the Vermillion River were collected by MPCA's biomonitoring unit. 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. In 2008, fish were collected from Alimagnet Lake and analyzed for perfluorochemicals (PFCs). The whole fish were shipped frozen and on dry ice to AXYS Analytical Laboratory for processing and analysis of the fish for PFCs.

Prior to 2006, mercury fish tissue concentrations were assessed for water quality impairment based on the Minnesota Department of Health's fish consumption advisory. An advisory more restrictive than a meal per week was classified as impaired for mercury in fish tissue based on average concentrations. Since 2006, a waterbody has been classified as impaired for mercury in fish tissue if 10 percent of the fish samples (measured as the 90^{th} percentile) exceed 0.2 mg/kg of mercury, which is one of Minnesota's water quality standards for mercury. At least five fish samples 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 recently.

PCBs in fish have not been monitored as intensively as mercury in the last three decades due to monitoring completed in the 1970s and 1980s. These 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. This implied that it was not necessary to continue widespread frequent monitoring of smaller river systems as is done with mercury. However, limited PCB monitoring was included in the watershed sampling design to ensure that this conclusion is still accurate. Impairment assessment for PCBs in fish tissue is based on the fish consumption advisories prepared by the Minnesota Department of Health. If the consumption advice is to restrict consumption of a particular fish species to less than a meal per week because of PCBs, the MPCA considers the lake or river impaired. The threshold concentration for impairment is 0.22 mg/kg PCBs and more restrictive advice is recommended for consumption (one meal per month).

Lake water sampling

Lakes were not targeted during the Intensive Watershed Monitoring efforts that took place in 2008 and 2009. However, extensive monitoring of lakes has occurred in the metropolitan area in the past. Lake water chemistry and Secchi data used in this report was taken from the MPCA's EQuIS database. This data was collected by local partners including CLMP volunteers. Sampling methods are similar among lake 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/index.php/view-document.html?gid=6492. The lake water quality assessment standard requires eight observations/samples within a 10 year period for phosphorus, chlorophyll-a, and Secchi depth.

VI. Individual Watershed Results

HUC-11 watershed units

Assessment results are presented for each of the HUC-11 watershed units within the Vermillion River Watershed. This is intended to enable the assessment of all surface waters at one time and the ability to develop comprehensive TMDL studies on a watershed basis, rather than the reach-by-reach and parameter-by-parameter approach often historically employed. This scale provides a robust assessment of water quality condition in the 11-digit watershed unit and is a practical size for the development, management, and implementation of effective TMDLs and protection strategies. The primary objective is to portray all the impairments within a watershed resulting from the complex and multi-step assessment and listing process. 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 2008 intensive watershed monitoring effort but, also considers available data from the last 10 years.

Given all the potential sources of data and differing assessment methodologies for indicators and designated uses, it is not currently feasible to provide results or summary tables for every monitoring station by parameter. However, in the proceeding pages an individual account of each HUC-11 watershed is provided. Each account includes a brief description of the subwatershed, a table summarizing stream aquatic life and aquatic recreation assessments, a table summarizing the biological condition of channelized streams and ditches, a stream habitat results table, a summary of water chemistry results for the HUC-11 outlet, a summary of lake aquatic recreation assessments, and a narrative summary of the assessment results for the subwatershed. A brief description of each of these components 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 2011 assessment process (2012 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); these determinations were made during the desktop phase of the assessment process (see Figure 5). Assessments of aquatic life are derived from the analysis of biological (fish and macroinvertebrate IBIs), dissolved oxygen, turbidity, chloride, pH and un-ionized ammonia (NH_3) data, while the assessment of aquatic recreation in streams is based solely on bacteria (*Escherichia coli*) 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 3. Where applicable and sufficient data exists, assessments of other designated uses (e.g., drinking water and aquatic consumption) are presented in the Watershed-Wide Results and Discussion section and in Appendix 3.

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 7). IBI scores above this threshold are given a "good" rating, scores falling below this threshold by less than 15 points are given a "fair" rating, and scores falling below the threshold by more than 15 points are given a "poor" rating.

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 Vermillion 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; these results are available in Appendix 10.

Vermillion River Watershed Unit HUC 07040001055

The Vermillion River Watershed Unit is the largest watershed in the Vermillion River drainage, encompassing 173 square miles in Scott and Dakota Counties. This watershed unit contains the headwaters of the Vermillion River which begins in eastern Scott County, an area of mixed residential and agricultural land use. Located on the southern edge of the Twin Cities Metropolitan Area, this watershed unit includes the cities of Lakeville and Farmington as well as portions of Burnsville and Apple Valley. Land use in this rapidly developing portion of the watershed is a mixture of agriculture (61 percent) and urban development (25 percent). As such, there are numerous point (e.g., wastewater treatment facilities) and non-point (e.g., row crops, housing developments) pollution sources, presenting some unique challenges for maintaining water quality in this subwatershed. The majority of the Vermillion River mainstem occurring within this watershed unit is designated coldwater as well as sections of the South Branch Vermillion River and an Unnamed Creek (07040001-527, a.k.a. South Creek) that flows through the city of Lakeville. Biological monitoring station 08LM114 represents the outlet of this subwatershed which was collocated with existing Metropolitan Council (VR 15.6) and Dakota County SWCD (A9) stations.

Stream assessment results and summary

Three stream segments within the Vermillion River HUC 11 watershed unit are supporting aquatic life and all three represent warm water (Class 2B) reaches (Table 1). In two of these reaches the biological indicators are indicating potential impairment (EXP), meaning that IBI scores are close to their respective thresholds. However, examining multiple lines of evidence (e.g., other indicators, upstream/downstream conditions, habitat) lead to a determination of full support (FS) for the overall aquatic life use assessment.

Fish and macroinvertebrate community monitoring data indicate that cold water sections of the Vermillion River, the South Branch Vermillion River, and some of their tributaries are not supporting (NS) aquatic life (Table 1). Dissolved oxygen and turbidity have been identified as impairments for some of these sections, while in other sections they have been identified as possible stressors to aquatic life. While data collected at the outlet of this subwatershed shows elevated turbidity (Table 2), examination of all the data collected along this stretch of the Vermillion (07040001-507) indicates that turbidity is below the 10 NTU water quality standard most of the time and was the basis for evaluating turbidity as meeting criteria (MTS). Even though dissolved oxygen and turbidity provide some insights on what may be affecting aquatic life in these cold water streams, a thorough stressor identification process will be required in order to identify and prioritize the causes of these observed biological impairments. Impairments on two cold water streams (South Cr. -527 and North Cr. -671) have been deferred pending the adoption of TALU because the majority of these stream segments are channelized.

Water samples to test for the presence of pesticides were collected and analyzed by the Minnesota Department of Agriculture from the outlet of this subwatershed on the Vermillion River (07040001-507). Pesticides and their degradates such as acetochlor, alachlor, atrazine, desethyl atrazine, and metolachlor were occasionally detected in the samples but were not exceeding their associated water quality standards (Table 1).

Table 1. Aquatic Life and Recreation Assessments on Stream Reaches in the Vermillion River 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.**
07040001-516 ***Vermillion River****,* *Headwaters to T113 R20W S8, east line*	7	2B	08LM125	Upstream of Dupont Ave., 4.5 mi. SW of Lakeville	EXP	EXP	IF	MTS	MTS	MTS	MTS	--	EX	FS	NS
07040001-517 ***Vermillion River,*** *T113 R20W S9, west line to T114 R19W S31, north line*	10	2A	04LM052 08LM123	Upstream of Ash St., ~ 1 mi. SW of Farmington Upstream of Ash St W, 1 mi. W of Farmington	EXS	EXS	EXP	EXP	MTS	MTS	MTS	--	EX	NS	NS
07040001-507 ***Vermillion River,*** *T114 R19W S30, south line to S. Br. Vermillion River*	12	2A	04LM133 98LM004 08LM114	Downstream of Hwy 3, just N of Farmington Downstream of Biscayne Ave. Upstream of Blaine Ave.	EXS	EXS	MTS	MTS	MTS	MTS	MTS	MTS	EX	NS	NS
07040001-527 ***Unnamed creek (South Cr.),*** *Unnamed cr to Vermillion R*	3	2A	09LM003 08LM124	At Cedar Ave., 1 mi. E of Lakeville Downstream of Flagstaff Ave.	EXS	EXS	--	NA	--	--	--	--	--	IF*	NA
07040001-546 ***Unnamed creek (Middle Cr.),*** *Headwaters to Unnamed cr*	5	2B	--	--	--	--	--	--	--	--	--	--	EX	NA	NS
07040001-548 ***Unnamed creek,*** *Unnamed cr to Unnamed cr*	1	2B	--	--	--	--	--	--	--	--	--	--	EX	NA	NS
07040001-668 ***Unnamed creek (Middle Cr.),*** *Unnamed cr to T114 R20W S25, east line*	2	2B	--	--	--	--	--	--	--	--	--	--	--	NA	NA

AUID *Reach Name, Reach Description*	Reach Length (miles)	Use Class	Biological Station ID	Location of Biological Station	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	Aquatic Life	Aquatic Rec.
07040001-669 ***Unnamed creek (Middle Cr.),*** *T114 R19W S30, west line to Unnamed cr*	1	2B†	09LM008 08LM122	Downstream of Akin Rd., 1 mi. NW of Farmington Upstream of Chippendale Ave. W, 1.5 mi. N of Farmington	MTS	MTS	--	--	--	--	--	--	--	FS	NA
07040001-542 ***Unnamed creek (North Cr.),*** *Headwaters to Unnamed cr*	6	2B	--	--	--	--	--	MTS	--	--	--	--	EX	IF	NS
07040001-670 ***Unnamed creek (North Cr.),*** *Unnamed cr to T114 R19W S19, south line*	1	2B	07LM019	0.5 mi W of CR 3, 2 mi. N of Farmington	--	--	--	--	--	--	--	--	EX	NA	NS
07040001-671 ***Unnamed creek (North Cr.),*** *T114 R19W S30, north line to Unnamed cr*	0.4	2A	08LM121	Upstream of Chippendale Ave. W, 1.5 mi. N of Farmington	NA	NA	EXP	EXP	MTS	MTS	IF	--	EX	NA*	NS
07040001-545 ***Unnamed creek (Vermillion River Tributary),*** *Unnamed cr to Vermillion R*	0.4	2A	--	--	--	--	EXS	IF	MTS	MTS	IF	--	EX	NS	NS
07040001-706 ***Vermillion River, South Branch,*** *Headwaters to T113 R19W S2, east line*	9	2B	08LM118	Downstream of 230th St E, 3.5 mi. SE of Farmington	MTS	EXP	--	--	--	--	--	--	--	FS	NA
07040001-707 ***Vermillion River, South Branch,*** *T113 R19W S1, west line to T114 R18W S29, north line*	6	2A†	04LM029 09LM007 08LM116	Upstream of CR 81, 1 mi. S of Empire At CR 81, 1 mi. S of Empire Upstream of CSAH 66, 6.5 mi. E of Farmington	EXP	EXP	IF	EXP	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: = previous impairment or deferred impairment prior to 2012 reporting cycle; = new impairment; = full support of designated use.
*Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.
†Reach was assessed based on use class included in table and existing use class as defined in Minn. Rule 7050 is different. MPCA is currently in the process of changing the existing use class for this AUID in rule based on an analysis of the biological community and temperature data.

Three channelized, warm water streams in this 11-HUC were not assessed for aquatic life, instead their biological condition was characterized based on IBI scores (Table 3). One of these streams exhibited an unhealthy or poor fish community, while two out of three exhibited poor macroinvertebrate communities. A poor rating indicates that the biological communities are likely being impacted by more than just the modified habitat conditions associated with stream channelization.

According to Minnesota Stream Habitat Assessments (MSHA) conducted at biological monitoring stations, the Vermillion River has good to fair habitat ratings (Table 4). In comparison to stations with good habitat ratings, locations with fair ratings tended to have intensive land use in close proximity to the stream and a relatively narrow riparian buffer. In general, MSHA scores indicate that substrate conditions and the amount of fish cover are similar among the Vermillion River stations. MSHA scores for the South Branch Vermillion stations ranged from 60 to 67 and individual category scores were very similar to those observed along the Vermillion River. Overall, these habitat assessments indicate a lack of shading at certain locations (e.g., 04LM052, 04LM133, 04LM029), which may be affecting the thermal regime of these cold water streams and the aquatic communities found therein.

Table 2. Outlet water chemistry results for the Vermillion River 11-HUC

Station Location:	**Vermillion River at Blaine Avenue, Farmington, MN**
STORET ID:	**S000-896**
Station #:	**08LM114**

Parameter	Units	# Samples	Minimum	Maximum	Mean[1]	Median	WQ standard	# WQ exceedances[2]	WCBP 75th percentile[3]
Ammonia-nitrogen	mg/l	12	< 0.02	< 0.02	< 0.02	< 0.02			
Biological Oxygen Demand 5 day (BOD5)	mg/l	22	< 1.0	1.6	1.1	1			
Chloride	mg/l	11	34	51	22	39	230		
Dissolved oxygen (DO)	mg/l	41	7.8	11.2	9.3	9.1	7		
Escherichia coli	MPN/100ml	41	13	1203	223	146	126		
Hardness, Ca, Mg	mg/l CaCO3	12	292	352	319	320			
Inorganic nitrogen (nitrate and nitrite)	mg/l	23	0.88	2.74	1.61	1.51			
pH	--	41	7.9	8.2	8.1	8.1	6.5-8.5		
Phosphorus	µg/l	10	53	174	89	79			350
Temperature, water	deg C	41	10.1	20.4	15.5	16.2	30		24
Total suspended solids	mg/l	21	3	33	10.7	8			76
Turbidity	NTRU	41	2	15	5.8	5	10	4	

[1]Geometric mean of all samples is provided for *E. coli*.
[2]Represents exceedances of individual maximum standard for *E. coli* (1260/100ml) or fecal coliform.
[3]Based on 1970-1992 summer data; see Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions (McCollor and Heiskary 1993).

Based on an analysis of biological monitoring and water temperature data, as well as, discussions with the DNR, two stream segments are being proposed to change aquatic life use classifications. The lower section of the South Branch Vermillion R. (-707) is being proposed to change from warm water (2B) to cold water (2A) in Minn. R. ch. 7050. Further monitoring was conducted in 2011 to evaluate whether an unnamed tributary to the South Branch (-552) should also be re-classified to 2A. The results of this evaluation are not yet available. In addition, Middle Creek (-669) is being proposed for re-classification to a warm water aquatic life use class. Both of these streams were assessed based on their proposed use classification, not their existing use. Impairments on these streams will not be included on the 303d Impaired Waters List until their proposed use class changes have been adopted into Minn. R. ch. 7050.

Table 3. Non-assessed biological stations on channelized AUIDs in the Vermillion River 11-HUC.

AUID ***Reach Name***, *Reach Description*	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Fish IBI**	**Invert IBI**
07040001-697 ***Unnamed creek,*** *Unnamed cr to Rice Lk*	1	2B	08LM126	Downstream of Pillsbury Ave, 3.5 mi. SW of Lakeville	Poor	Poor
07040001-680 ***Unnamed creek (Vermillion River Tributary),*** *Headwaters to T114 R19W S14, south line*	1	2B	08LM120	Upstream of Annette Ave, 4 mi. NE of Farmington	Good	Poor
07040001-552 ***Unnamed creek*****,** *Unnamed cr to S Br Vermillion R*	2	2B	08LM117	Upstream of 230th St E, 4 mi. SE of Farmington	Good	Fair

Elevated bacteria levels have been found on all sampled streams within this watershed, resulting in aquatic recreation impairments being reported in either in the current reporting cycle or during previous cycles (Table 1). The majority of these impairments were identified on previous Impaired Waters Lists (2002, 2008, & 2010) with only one new aquatic recreation impairment being added to the 2012 List. Some of the previously listed aquatic recreation impairments appear as not assessed (NA) in Table 1 because there was no new data within the current ten-year assessment window to either confirm or refute the previous findings. Two of the impaired segments of the Vermillion River (507 and-692) were included in the Lower Mississippi River Basin-Fecal Coliform TMDL and Implementation Plan completed in 2006 and 2007, respectively. Based on bacteria data collected over the past ten years, it appears that these two segments are still impaired for aquatic recreation (Table 1 and Table 6).

The Empire wastewater treatment plant (WWTP) is located within the Vermillion River HUC-11 watershed. In March 2008, this facility moved its discharge location from the Vermillion River to the Mississippi River. Based on data collected from stations located upstream (98LM004, VR 20.6) and downstream (08LM114, VR 15.6) of the WWTP outfall on the Vermillion River, immediate improvements in water quality were observed on this section of the Vermillion after the outfall was moved (Figure 13). Another benefit to the aquatic life inhabiting this river was the removal of the thermal impact created by the WWTP. Before the outfall was relocated to the Mississippi River, the mean water temperature at the downstream monitoring station was significantly (~ 1 ^{o}C, $p < 0.05$) higher than the upstream station over an eight year period (2000-2008).

Table 4. Minnesota Stream Habitat Assessment (MSHA) results for the Vermillion River Watershed Unit.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
2	08LM125	Vermillion River	5	14	18	8.5	23	68.5	Good
1	04LM052	Vermillion River	0	9	16	8	23	56	Fair
1	08LM123	Vermillion River	0	8	18	12	25	63	Fair
2	04LM133	Vermillion River	2.5	9	16	7.5	25	60	Fair
1	98LM004	Vermillion River	5	12	17.9	13	33	80.9	Good
1	08LM114	Vermillion River	5	11	19.1	8	30	73.1	Good
1	08LM126	Trib. to Rice Lake	3	7	2	7	5	24	Poor
1	08LM124	Unnamed creek (South Creek)	0	8.5	8	10	13	39.5	Poor
1	08LM122	Unnamed creek (Middle Creek)	1	9.5	16.8	8	23	58.3	Fair
1	07LM019	Trib. to Vermillion River (North Cr.)	1	11.5	7.3	12	24	55.8	Fair
1	08LM121	Unnamed creek (North Cr.)	0	8	12.8	13	26	59.8	Fair
1	08LM120	Trib. to Vermillion River	3.8	10	8.3	7	15	44.1	Poor
2	08LM118	Vermillion River, South Branch	0	13	18.3	9	20	60.3	Fair
1	04LM029	Vermillion River, South Branch	0	9	20.4	13	22	64.4	Fair
1	08LM116	Vermillion River, South Branch	2.5	12	13.5	12	27	67	Good
1	08LM117	Unnamed creek	0	13.5	15.8	11	21	61.3	Fair
Average Habitat Results: *Vermillion River 11-HUC*			**1.8**	**10.3**	**14.3**	**9.9**	**22.2**	**58.5**	**Fair**

Qualitative habitat ratings

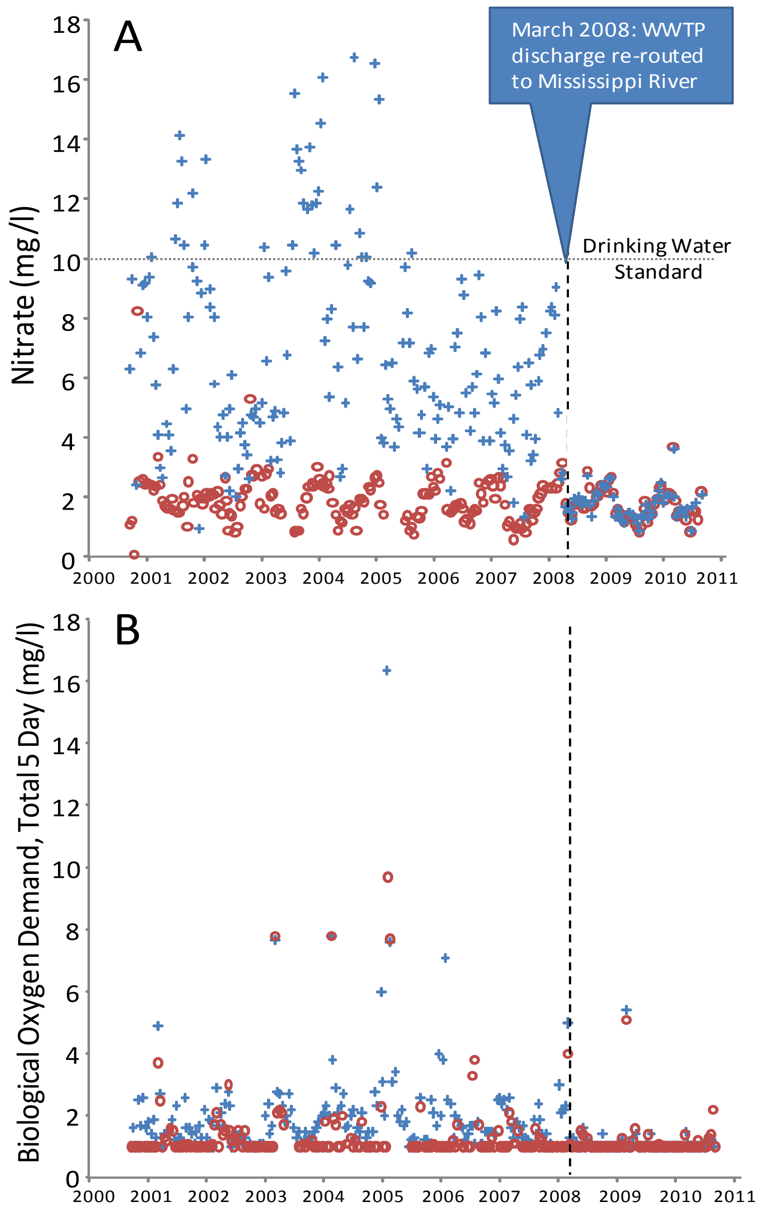
Good: MSHA score above the median of the least-disturbed sites (MSHA>66)

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

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

After the relocation, from 2008 to 2010, the difference in water temperature between the two stations was no longer statistically significant ($p > 0.05$).

Following removal of the effluent discharge to the Vermillion River, the response of the aquatic community downstream of the WWTP has been variable. In three out of four years following the re-routing of wastewater effluent, fish IBI scores remain lower at the downstream station (Figure 14). Invertebrate monitoring data are only available from these two stations in 2008; these data also indicate that the downstream station is in worse biological condition than the upstream station. However, fish IBIs at the downstream station showed general improvement from 2008 to2010, before returning to 2008 levels in 2011. Without biological data from these two stations before the plant began discharging to the Vermillion River, as well as, before the discharge location was moved to the Mississippi River, it is difficult to interpret whether the observed patterns in the biological data are due to habitat differences between the two stations, a legacy of the WWTP's impacts on the downstream station, or both. Habitat condition at both stations was rated as 'good' in 2008 according to the MSHA (Table 4).



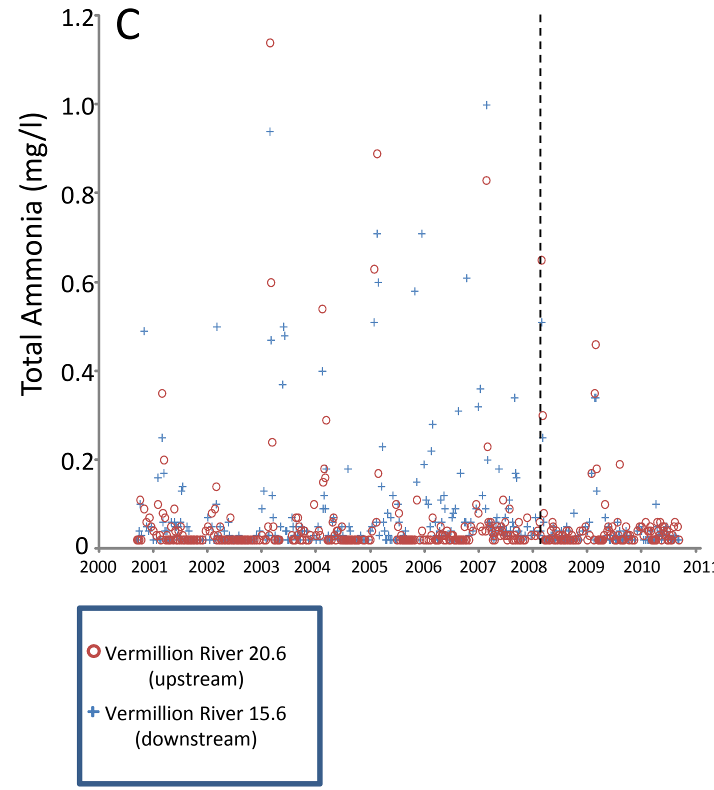


Figure 13. Comparison of (A) nitrate, (B) biological oxygen demand, and (C) total ammonia between stations located upstream and downstream of the Empire WWTP on the Vermillion River. Vertical dashed line on each graph indicates the date WWTP effluent was re-routed to the Mississippi River.

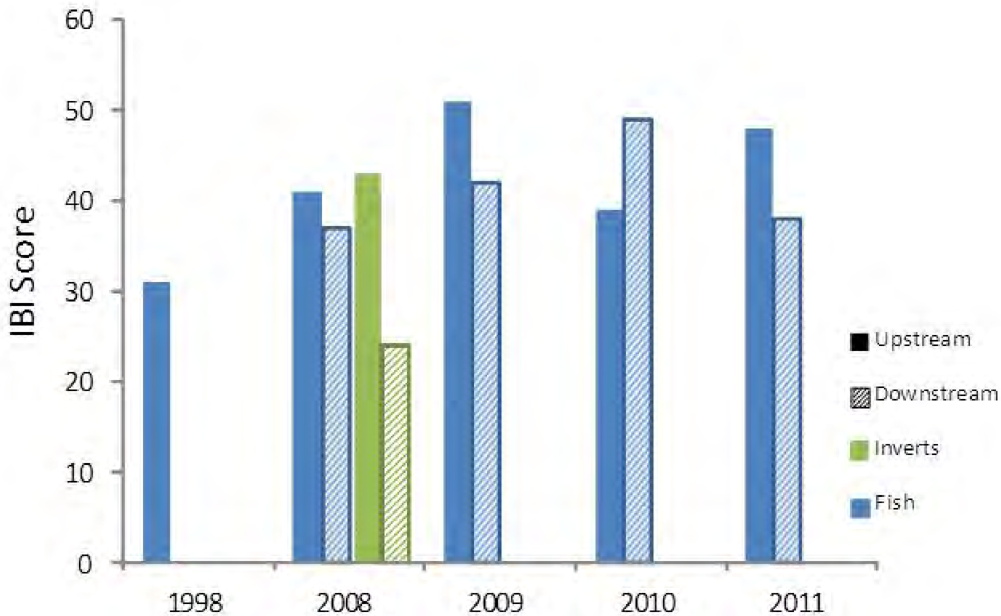


Figure 14. Index of biological integrity (IBI) scores from Vermillion River monitoring stations located upstream and downstream of the Empire WWTP. Biological monitoring in 2008 occurred after the March relocation of the WWTP outfall to the Mississippi River. Solid bars are upstream and hatched bars are downstream.

Lake assessment results and summary

Eight lakes were reviewed for aquatic recreation use in the Vermillion River HUC-11 watershed (Table 5). The lakes are limited to the headwaters portion of the watershed; four in Apple Valley, three in Lakeville, and one in Empire Township. Of those, four are considered impaired for aquatic recreation: Alimagnet, Long, Farquar, and a small unnamed lake in Lakeville. Lakes in this watershed are all shallow (less than 4.1 meters) and face heavy development pressure. Shallow lakes have limited ability to assimilate nutrients; those meeting standards will require protection efforts to keep phosphorus out of the lakes to reduce the chance of increased algal blooms and limited transparency. MINLEAP modeling results for these lakes are included in Appendix 10.

Marion Lake has been listed for mercury in fish tissue since 1998, because of high mercury levels measured in northern pike. Perfluorochemicals (PFCs) were tested in black crappie and bluegill sunfish from Alimagnet Lake in 2008 (seven fish of each species). The mean concentration of perfluorooctane sulfonate (PFOS) was below the one meal per week threshold of 40 mg/kg (ppb); therefore, restricted fish consumption because of PFOS was not recommended by Minnesota Department of Health (MDH).

Table 5. Morphometric data and assessment results for lakes in the Vermillion River HUC-11.

Lake ID	Lake Name	County	HUC-11	Ecoregion	Lake Area (ha)	Max Depth (m)	Mean Depth (m)	Watershed Area (ha)	% Littoral	Aquatic Recreation Use Support[5]
19-0021-00[1]	Alimagnet	Dakota	07040001055	NCHF	42	3.4	1.5	400	100	NS
19-0022-00[1]	Long	Dakota	07040001035	WCBP	15.8	1.5	0.8	390	100	NS
19-0023-00[1]	Farquar	Dakota	07040001035	WCBP	27	3	1.3	823	100	NS
19-0026-01[2]	Marion (East Bay)	Dakota	07040001055	NCHF	104	5.2	2.1	2018	41[4]	FS
19-0342-00[3]	Unnamed	Dakota	07040001055	WCBP	5.7	2.4	1.5	1273	100	IF
19-0348-00[2]	Unnamed	Dakota	07040001055	NCHF	2.8	3.4	1.8	47	100	NA
19-0349-00[2]	Unnamed	Dakota	07040001055	NCHF	12	3	1.4	3237	100	NS
19-0456-00[1]	Cobblestone	Dakota	07040001055	NCHF	15	5.5	2.8	1331	100	FS

1. Watershed area from City of Apple Valley
2. Watershed area from City of Lakeville
3. Watershed area estimated from DNR lake catchment file
4. Percent littoral limited to the east basin; whole lake littoral area is approximately 80%.
5. NS = not supporting, FS = supporting, IF = insufficient information to determine support, NA = not assessed (too small or wetland-like)

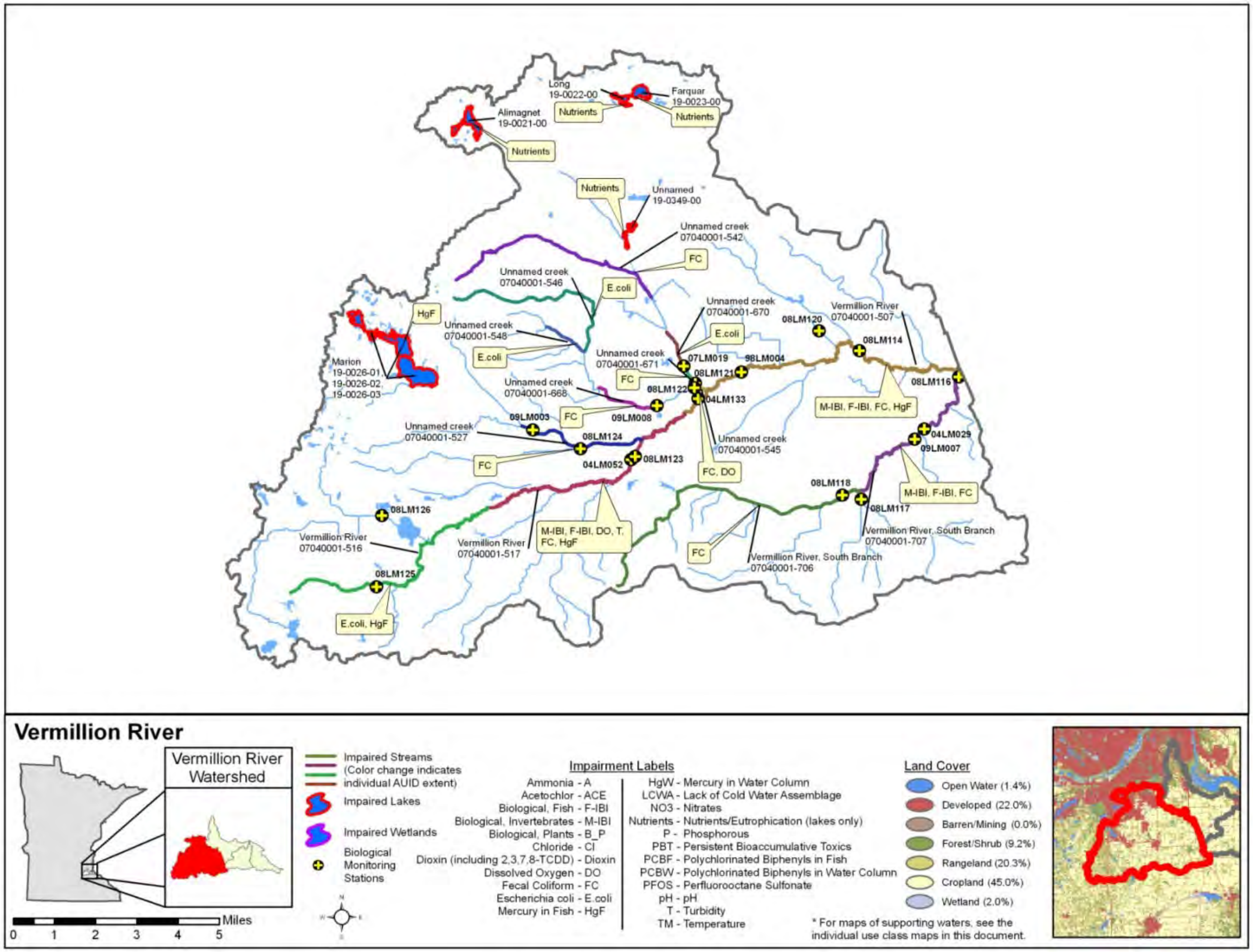


Figure 15. Currently listed impaired waters by parameter in the Vermillion River HUC 11 watershed.

North Vermillion River Watershed unit HUC 07040001035

This watershed unit is a flow-through system with an area of approximately 75 square miles and includes the section of the Vermillion River stretching from the confluence with the South Branch Vermillion River to Vermillion Slough. This section flows through the city of Hastings where the River drops 90 feet over a waterfall as it descends onto the Mississippi River floodplain. Including the city of Rosemount and portions of Apple Valley and Inver Grove Heights, this watershed unit is also under increasing development pressure as it transitions from a predominantly agricultural landscape to an urban setting. The majority of the Vermillion River within this subwatershed is designated warmwater. Other streams within this watershed unit are intermittent and thus, were not able to be assessed using current MPCA protocols. The outlet of this watershed unit is represented by site 08LM113 on the Vermillion River which was collocated with Metropolitan Council's VR 2.7 station.

Stream assessment results and summary

The Vermillion River was the only watercourse assessed in this subwatershed (Table 6). Biological assessment of fish community data indicates that aquatic life is impaired in this section of the river. Fish were sampled at two stations (08LM113 & 08LM115) between 2008 and 2010; all resulting IBI scores were below the impairment threshold. Invertebrate data collected from these same sites (2008-2010) were generally above the impairment threshold; however, the invert community along this stretch of river was deemed potentially impaired (EXP) due to a 2010, sample scoring below the threshold. Water quality parameters measured to assess aquatic life were all meeting standards (MTS). In particular, turbidity and dissolved oxygen were meeting standards for this reach, despite upstream impairments for the same parameters. This is likely due to the transition in designated use class (and associated standards) from cold water to warm water that takes place on the Vermillion River about a mile downstream of its confluence with the South Branch Vermillion River. For instance, the dissolved oxygen standard for a cold water stream is 7 mg/l compared to 5 mg/l on a warm water stream.

Table 6. Aquatic Life and Recreation Assessments on Stream Reaches in the North Vermillion River Watershed Unit.

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.
07040001-692 ***Vermillion River***, *T114 R18W S21, west line to Hastings Dam*	11	2B	08LM115 08LM113	Downstream of CSAH 85 Upstream of CSAH 47	EXS	EXP	MTS	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: = previous impairment or deferred impairment prior to 2012 reporting cycle; = new impairment; = full support of designated use.

Table 7. Outlet water chemistry results for the North Vermillion River 11-HUC

Station Location:	Vermillion River at CSAH-47								
STORET ID:	S002-429								
Station #:	08LM113								
Parameter	**Units**	**# Samples**	**Minimum**	**Maximum**	**Mean[1]**	**Median**	**WQ standard**	**# WQ exceedances[2]**	**WCBP 75th percentile[3]**
Ammonia-nitrogen	mg/l	15	< 0.02	< 0.02	< 0.02	< 0.02			
Chloride	mg/l	15	28	49	34.5	34	230		
Dissolved oxygen (DO)	mg/l	41	7.5	11.8	9.1	8.8	5		
Escherichia coli	MPN/100ml	41	41	> 2420	301	186	126	2	
Hardness, Ca, Mg	mg/l CaCO3	12	152	398	304	312			
Inorganic nitrogen (nitrate and nitrite)	mg/l	13	2.5	4.9	6.9	4.16			
pH	--	41	7.8	8.3	8.1	8.1	6.5-9		
Phosphorus	mg/l	5	89	174	112	100			350
Temperature, water	deg C	41	10.8	22.6	17.4	18.0	30		24
Total suspended solids	mg/l	13	3	54	16.2	14			76
Turbidity	NTRU	41	2	22	7.2	6	25		

[1]Geometric mean of all samples is provided for *E. coli*.
[2]Represents exceedances of individual maximum standard for *E. coli* (1260/100ml) or fecal coliform.
[3]Based on 1970-1992 summer data; see *Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions* (McCollor and Heiskary 1993).

Overall habitat scores at the two biological stations on this section of river suggest that habitat quality is not contributing to the observed aquatic life (fish) impairment (Table 8). The individual MSHA ratings however, indicate that lack of fish cover and substrate quality may be potential stressors to the fish community. Moreover, these habitat scores only represent the conditions at two stations, and thus do not account for habitat disturbances (i.e., lack of riparian buffer, channelization) that may be occurring elsewhere in this assessment unit.

Table 8. Minnesota Stream Habitat Assessment (MSHA) results for the North Vermillion River Watershed Unit.

# 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	08LM115	Vermillion River	5	10	19.7	8	25	67.7	Good
1	08LM113	Vermillion River	2.5	10.5	19.9	7	31	70.9	Good
Average Habitat Results: *North Vermillion River 11 HUC*			**3.8**	**10.3**	**19.8**	**7.5**	**28**	**69.3**	**Good**

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

Excessive bacteria was found in samples collected as recent as 2010, from this section of the Vermillion River, indicating that despite efforts to address bacterial contamination in this watershed (i.e., Lower Mississippi River Basin-Fecal Coliform TMDL and Implementation Plan) this river remains impaired for aquatic recreation (Table 6). As mentioned in the previous HUC-11 section, contributing streams from the upstream watershed are all impaired for bacteria as well. A study conducted in 2004, (Vermillion River Watershed Fecal Coliform Bacteria Study) identified individual sewage treatment systems (ISTS) as the greatest contributor to the bacteria problem in the Vermillion River, followed by manure application to fields, urban runoff, and feedlot runoff.

Lake assessment results and summary

Three lakes were reviewed for aquatic recreation use in the North Vermillion River watershed (Table 9). The lakes are limited to the upper portions of the watershed, with the exception of Lake Isabelle in Hastings, which is influenced by the Mississippi and Vermillion Rivers. Both Marcott and Horseshoe are supporting the aquatic recreation designated use. The majority of the lakes in this watershed are small, shallow, and under heavy development pressure. Measures to reduce phosphorus run off from reaching the lakes would help prevent algal blooms and reduced transparency. MINLEAP modeling results for these lakes are included in Appendix 10.

Table 9. Morphometric data and assessment results for lakes in the North Vermillion River HUC-11.

Lake ID	Lake Name	County	HUC-11	Ecoregion	Lake Area (ha)	Max Depth (m)	Mean Depth (m)	Watershed Area (ha)	% Littoral	Aquatic Recreation Use Support[2]
19-0004-00[1]	Isabelle	Dakota	07040001035	WCBP	42	1.8	0.6	1.6	100	IF
19-0041-00[1]	Marcott	Dakota	07040001035	WCBP	9	7.9	2.1	1267	93	FS
19-0051-00[1]	Horseshoe	Dakota	07040001035	WCBP	6	3.2	1.5	430	100	FS

1. Watershed area estimated from Metropolitan Council approximate sewer-shed layer (1997).
2. NS = not supporting, FS = supporting, IF = insufficient information to determine support, NA = not assessed (too small or wetland-like)

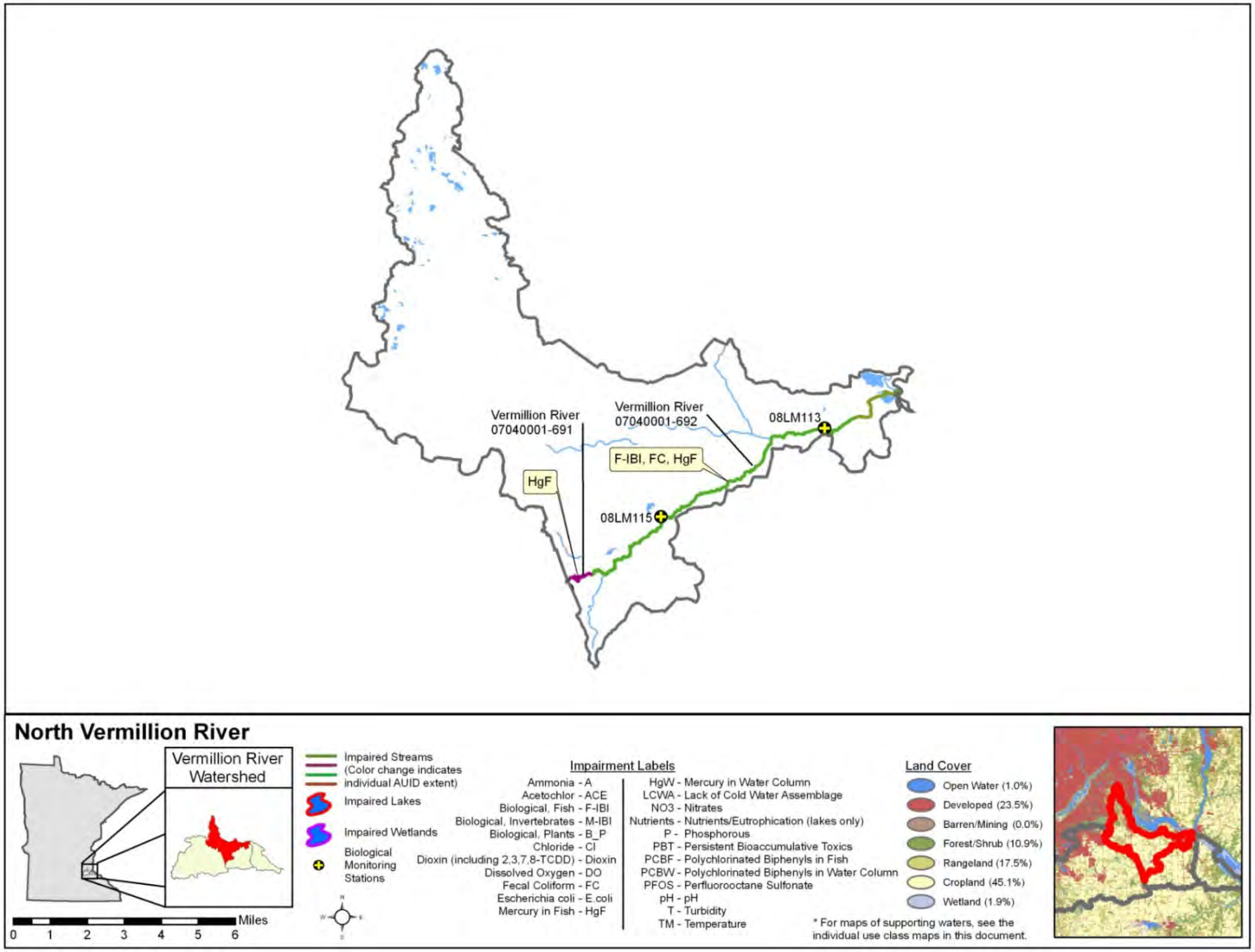


Figure 16. Currently listed impaired waters by parameter in the North Vermillion River HUC 11 watershed.

Mississippi (Direct) River Watershed Unit HUC 07040001075

Encompassing an area of 50 square miles, this watershed unit includes a 22 mile stretch of the Vermillion River that flows through bottomland forest before entering the Mississippi River as well as several small tributaries coming off the bluff to the west. This subwatershed straddles Dakota and Goodhue Counties and consists of a mixture of residential development, row crops, hardwood forests, and wetlands. A significant portion of this watershed unit occurs within the Richard J. Dorer Memorial Hardwood State Forest, and the Gores Wildlife Management Area occupies a large area of bottomland forest in the northern part of this unit. A fish contaminant monitoring station is located within this watershed unit, approximately 10 miles upstream of the River's southern outlet to the Mississippi River. Water quality assessments for this watershed unit are limited to the Vermillion River mainstem.

Stream assessment results and summary

The biological indicators provide mixed results along this stretch of the Vermillion River, which may be the result of its connectivity to the Mississippi River via numerous sloughs located along its 22 mile length. These connections allow fish species that inhabit large rivers access to this lower section of the Vermillion, bolstering the species richness of the fish community sample and the overall IBI score. While the macroinvertebrate community may also be bolstered by an influx of large river species, the stronger impact on the invertebrate assessment may be the fact that sampling was restricted to wadeable areas along this stretch of the Vermillion and the limited number of habitat types within these areas. The end result being that this section of the Vermillion was sampled similar to how non-wadeable, large rivers are sampled, but the invertebrate community was assessed as if it were a wadeable stream. Thus, it was decided at the comprehensive watershed assessment meeting that it was not appropriate to deem this section of the Vermillion River as impaired for aquatic life based on the macroinvertebrate IBI despite it indicating a potentially severe impairment (EXS) (Table 10). The Upper Mississippi River Basin Association is currently in the process of developing assessment tools for the Mississippi River, its backwaters, and side channels. Once developed, the MPCA will evaluate whether it is more appropriate to assess the aquatic life designated use of this unique stretch of the Vermillion River using such tools.

This section of the Vermillion River was determined to be impaired for aquatic life in 1994, based on exceedances of the turbidity water quality standard (Table 10). A TMDL study for this impairment was completed in 2009, and during that process it was determined that this lower portion of the Vermillion River receives significantly more inflow from Mississippi River Pool 3 than from the upper Vermillion. This determination supports the argument that the lower Vermillion River is more characteristic of a large river with a contributing watershed area that far exceeds that of the Vermillion River itself and thus, requires assessment tools that account for these unique circumstances. The implementation plan for the lower Vermillion River turbidity TMDL was completed in June 2011. Intensive watershed monitoring of the Vermillion River is scheduled to occur again in 2018 and 2019. Assessment of data collected during this time, and in the 10 years preceding, will provide a measure of the implementation plan's progress towards improving the turbid conditions along the lower Vermillion River.

Table 10. Aquatic Life and Recreation Assessments on Stream Reaches in the Mississippi (Direct) River Watershed Unit.

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.
07040001-504 ***Vermillion River***, *Hastings Dam to Mississippi R*	22	2B	08LM112	Downstream of CSAH 68, 6 mi. SE of Hastings	MTS	EXS	IF	EXS	MTS	MTS	MTS	--	IF	NS	IF

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: = previous impairment or deferred impairment prior to 2012 reporting cycle; = new impairment; = full support of designated use.

Table 11. Minnesota Stream Habitat Assessment (MSHA) results for the Mississippi (Direct) River Watershed Unit.

# 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	08LM112	Vermillion River	5	11.5	9	7	14	46.5	Fair
Average Habitat Results: *Mississippi (Direct) River 11 HUC*			**5**	**11.5**	**9**	**7**	**14**	**46.5**	**Fair**

Qualitative habitat ratings

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

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

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

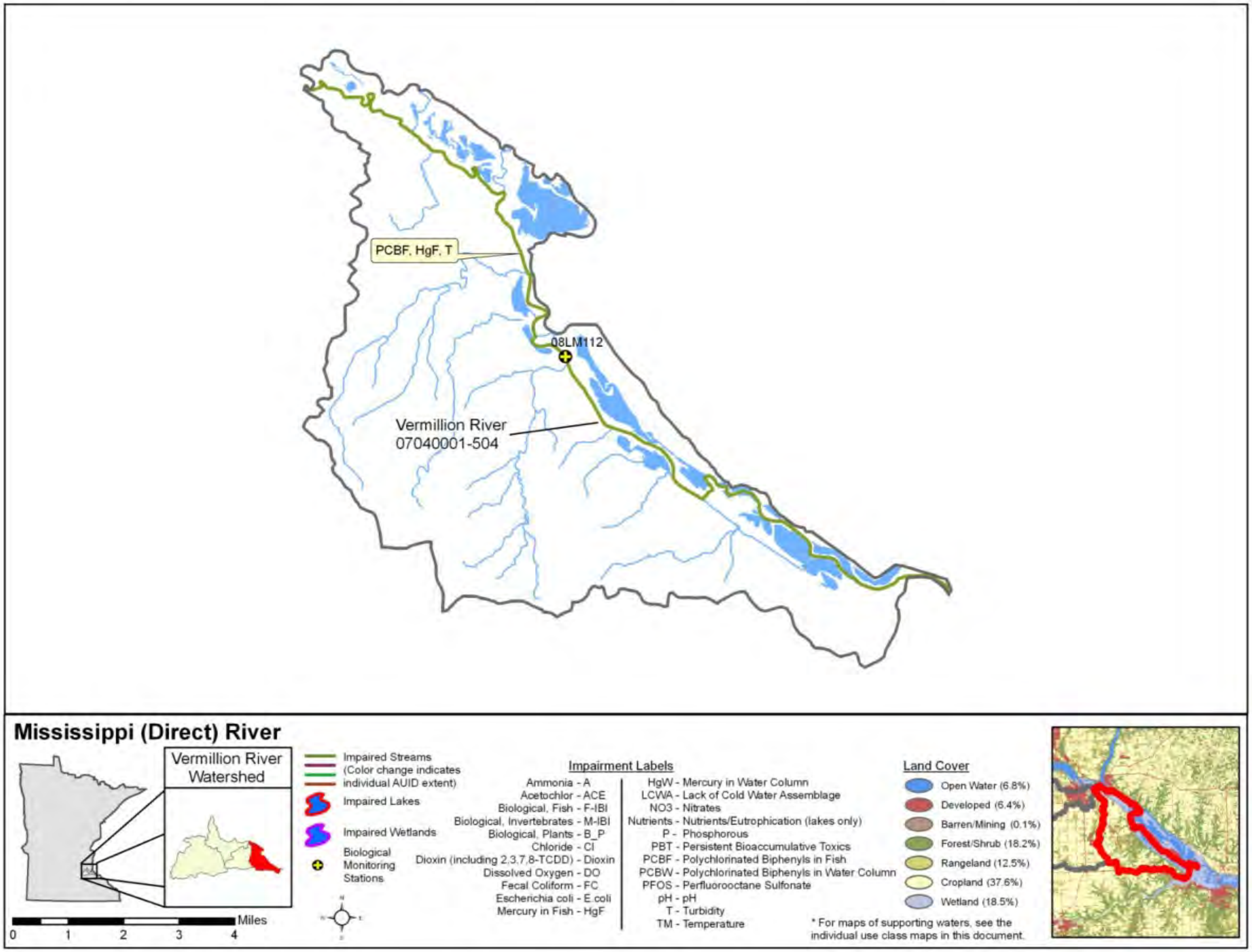


Figure 17. Currently listed impaired waters by parameter in the Mississippi (Direct) River HUC 11 watershed.

Hardwood Watershed Unit HUC 07040001045

The Hardwood Watershed Unit represents an area of approximately 51 square miles and is comprised entirely of ephemeral/intermittent streams. This subwatershed also does not contain any natural lakes or ponds of significant size. The lack of permanent waterbodies is due to the excessively drained nature of soils within this watershed unit. As a result, a significant amount of land in this subwatershed is classified as having 'severe' or 'very severe limitations' for crop production (NRCS 2007). Thus, irrigation of row crops and plant nurseries is a significant feature of this predominantly agricultural landscape. Given the lack of permanent waterbodies, the MPCA does not have any water quality assessment data for this watershed unit.

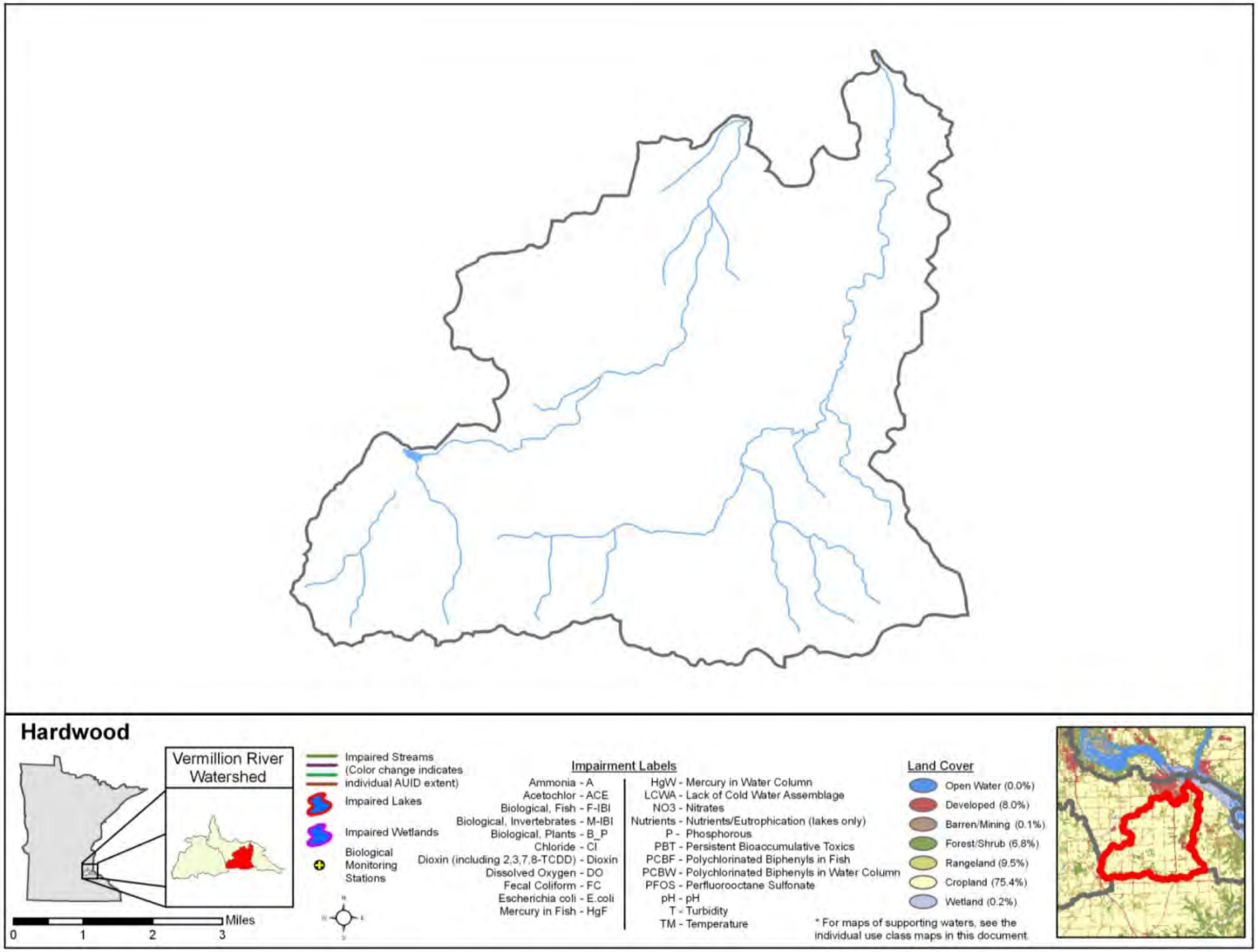


Figure 18. Currently listed impaired waters by parameter in the Hardwood HUC 11 watershed. The MPCA currently does not have any assessment data for this watershed.

VII. Watershed-Wide Results and Discussion

Fish contaminants

Mercury and PCBs in fish have been tested in the Vermillion River and in Alimagnet and Marion Lakes (Table 12). The Vermillion River, from the Hastings dam to the Mississippi River, has been listed as impaired due to elevated levels of mercury and PCBs in fish tissue since 1998. Marion Lake was also listed due to mercury in fish tissue in 1998.

Fish were again collected from the Vermillion River for analysis of contaminants in 2008. The reach downstream of the Hastings dam (07040001-504) was sampled again and an upstream reach (07040001-517) at Farmington was tested for the first time. Mercury concentrations in carp and walleye at the downstream site were below the threshold concentration for impairment. PCB concentrations in the carp were below the impairment threshold; however, one of the walleye exceeded the 0.22 mg/kg threshold. In the upper reach of the Vermillion River, at Farmington, the 90th percentile for mercury in northern pike exceeded the 0.2 mg/kg threshold for impairment, while the PCB concentrations were very low. Thus, while results from 2008, indicated that mercury levels have declined in the lower reach, the new data from the upper reach indicates the Vermillion River is still impaired for mercury in fish. The five Vermillion River AUIDs above the Hastings dam were added to the impaired waters inventory in 2012, and categorized as 4A because a Statewide Mercury TMDL has already been approved by EPA and these AUIDs are eligible to be covered by this approved TMDL (Table 12). Category 4A waters remain on the impaired waters inventory until such a time that additional data indicates that they are no longer impaired.

Fish were collected in 2008, from Alimagnet Lake for analysis of perfluorochemicals (PFCs). The PFC that accumulates in fish to levels of concern is perfluorooctane sulfonate (PFOS). Based on 12 bluegill sunfish and 11 black crappies, the PFOS concentrations ranged from 16 µg/kg (ppb) to 47 mg/kg. The mean PFOS concentration was 24 mg/kg in the bluegill sunfish and 32 µg/kg in the black crappie. Therefore, the PFOS levels were well below the impairment threshold of 200 µg/kg.

Table 12 Summary of mercury and PCBs in fish by waterway and AUID.

						Length (in)			Mercury (mg/kg)				PCBs (mg/kg)			
Waterway	AUID	EPA Category	Year	Species	N	Mean	Min	Max	Mean	Min	Max	90th Pctl	N	Mean	Min	Max
Alimagnet	19-0021-00		1990	Bluegill sunfish	1*	5.4			0.170			NA	1*	<0.03		
				Black bullhead	1*	5.8			0.110			NA	1*	<0.03		
Marion	19-0026-01, 19-0026-02, 19-0026-03	4A	1995	Bluegill sunfish	1*	6.5			0.055			NA				
				Common Carp	2*	22.9	21.3	24.4	0.037	0.034	0.040	0.040	1*	0.035		
				Northern pike	5*	23.3	17.8	29.8	0.210	0.110	0.360	0.360	1*	0.030		
				Walleye	4*	16.0	11.9	22.5	0.172	0.069	0.360	0.360				
Vermillion River																
08LM112, DOWNSTREAM OF CTY RD 68, 6 MI SE OF HASTINGS	07040001-504	4A-mercury; 5B-PCBs	2008	Common Carp	2	18.2	16.2	20.2	0.063	0.037	0.088	0.088	2	0.063	<0.025	0.100
				Walleye	6	17.3	14.5	22.0	0.116	0.088	0.157	0.154	3	0.180	0.060	0.280
5 MI SE OF HASTINGS, ABOVE CLEAR LAKE			1995	Black crappie	1*	10.8			0.120			NA	1*	0.077		
				Common Carp	5*	20.8	12.0	28.6	0.190	0.041	0.290	0.290	5*	0.424	0.010	0.851
				Northern pike	4*	24.9	19.1	31.0	0.116	0.049	0.240	0.240	4*	0.124	0.011	0.360
RAMBLING RIVER PARK IN FARMINGTON	07040001-507, -516, -517, -691, -692	4A-mercury	2008	Northern pike	9	20.4	15.9	26.9	0.137	0.082	0.255	0.243	1	<0.025		
				White sucker	9	13.0	10.1	15.4	0.036	0.010	0.104	0.088	1	<0.025		

* composite samples (more than one fish per sample)

NA - not available

Pollutant load monitoring

Discharge data was collected on the Vermillion River upstream of the falls in the city of Hastings. Annual daily average flows measured at this station are shown in Figure 19. This data set in conjunction with MCES water quality data was used to estimate loads and FWMCs for total suspended solids (TSS), total phosphorus (TP), and nitrate + nitrite-nitrogen (Nitrate-N) for the portion of the Vermillion River Watershed upstream of Hastings .

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. Elevated levels of TSS and 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 can be attributed to "non-point" as well as "point" or end of pipe sources such as industrial or waste water treatment facilities. Major "non-point" sources of phosphorus include dissolved phosphorus from fertilizers and phosphorus adsorbed to and transported with sediment during runoff.

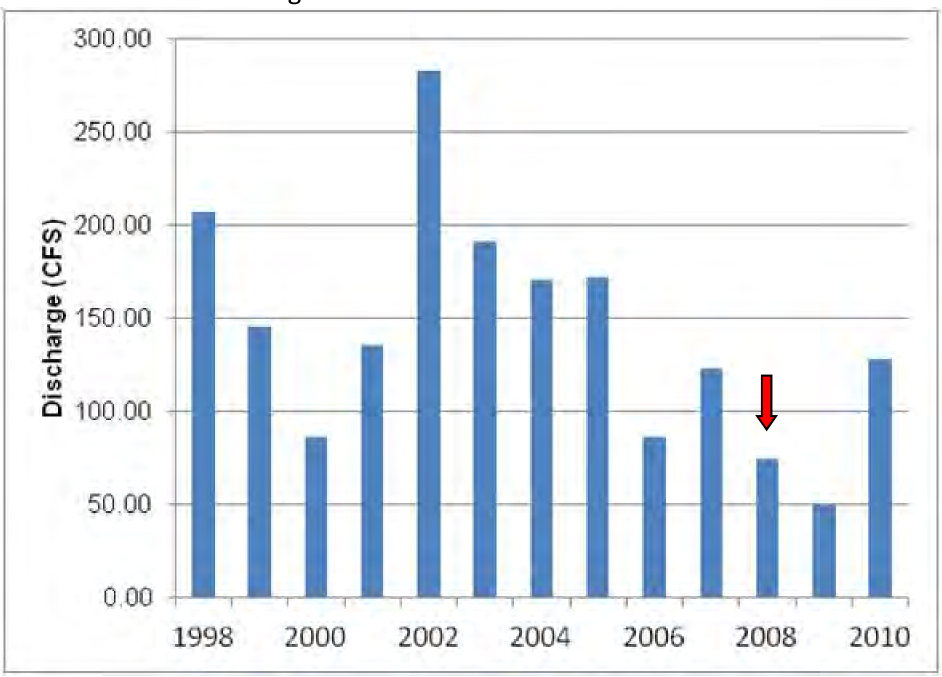


Figure 19. Vermillion River annual daily average flow at MCES station VR 2.0 located in Hastings, MN. Red arrow on chart indicates the year that the Empire WWTP re-routed discharge to the Mississippi River directly.

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 drain tile flow. Runoff pathways along with other factors determine the type and levels of pollutants transported in runoff to receiving waters. 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 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 and Nitrate-N levels tend to be elevated.

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 2010), each with unique nutrient standards. Of the state's three RNR's (North, Central, South), the Vermillion River watershed is located within the South RNR.

Total suspended solids

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

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

Currently, the State of Minnesota's TSS standards are moving from the "development phase" into the "approval phase" and must be considered to be draft standards until the process is complete. Within the South RNR, the TSS draft standard is 65 mg/L (MPCA 2011). The computed annual FWMC for the Vermillion River exceeded the draft standard in 1998 but remained below the draft standard for all subsequent years (Figure 20). The annual load of TSS shows dramatic increases in 1998 and 2002 (Figure 21), years with the highest recorded discharge within the observed period (1998-2010).

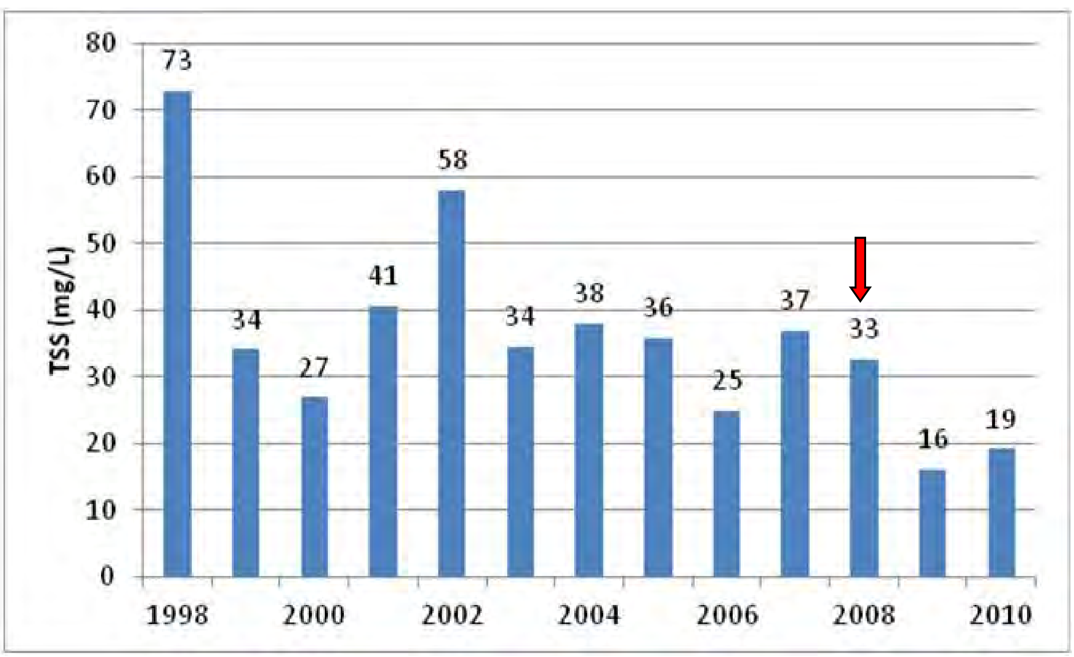


Figure 20. Annual flow weighted mean concentration of total suspended solids for the Vermillion River Watershed, 1998-2010 (MCES). Red arrow on chart indicates the year that the Empire WWTP re-routed discharge to the Mississippi River directly.

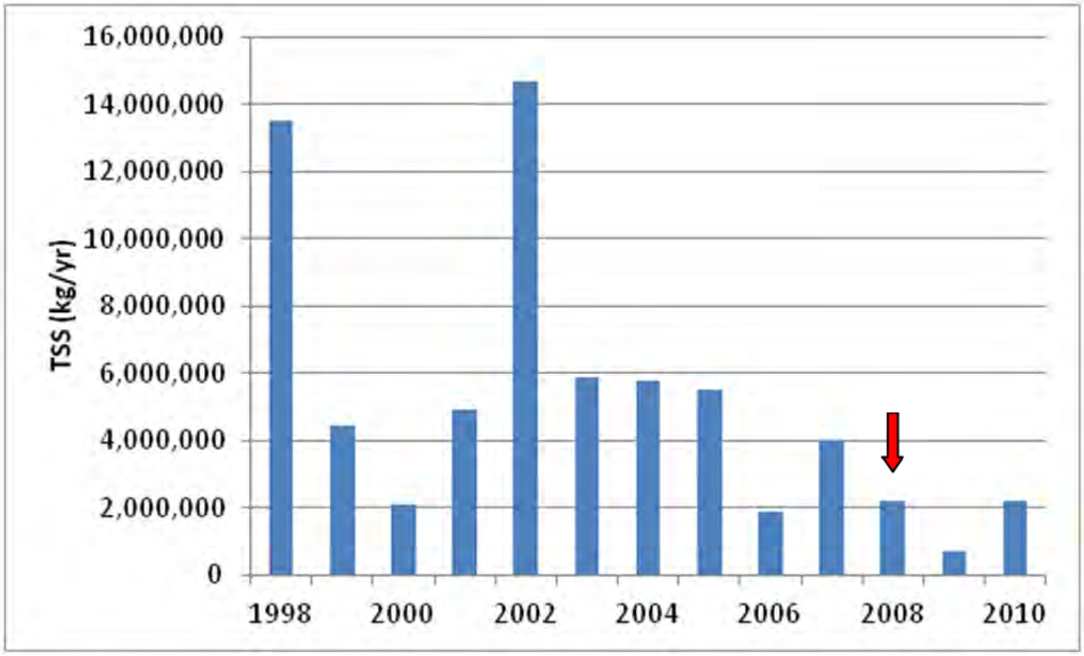


Figure 21. Annual pollutant load of total suspended solids calculated for the Vermillion River Watershed, 1998-2010 (MCES 2010). Red arrow on chart indicates the year that the Empire WWTP re-routed discharge to the Mississippi River directly.

Total phosphorus

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

Total phosphorus standards for Minnesota's rivers are in the approval phase and must be considered draft standards until final approval. The South RNR proposed draft standard is 150 ug/L as a summer average. Summer average violations of one or more "response" variables (pH, biological oxygen demand, dissolved oxygen flux, chlorophyll-a) must also occur along with the TP numeric violation for the water to be listed as impaired. From 1998 to 2006 the annual TP FWMC averaged over 550 ug/l then dropped to an average of 130 ug/l over the period of 2008-2010 (Figure 22). The diversion of the Empire Wastewater Treatment Facility discharge in March of 2008 directly to the Mississippi River is responsible for the reduction in TP concentrations in the Vermillion River. Phosphorus pollutant loads in the Vermillion River watershed were not as tightly coupled to precipitation and discharge as TSS was, indicative of a watershed that has a mix of point and non-point phosphorus sources (Figure 23).

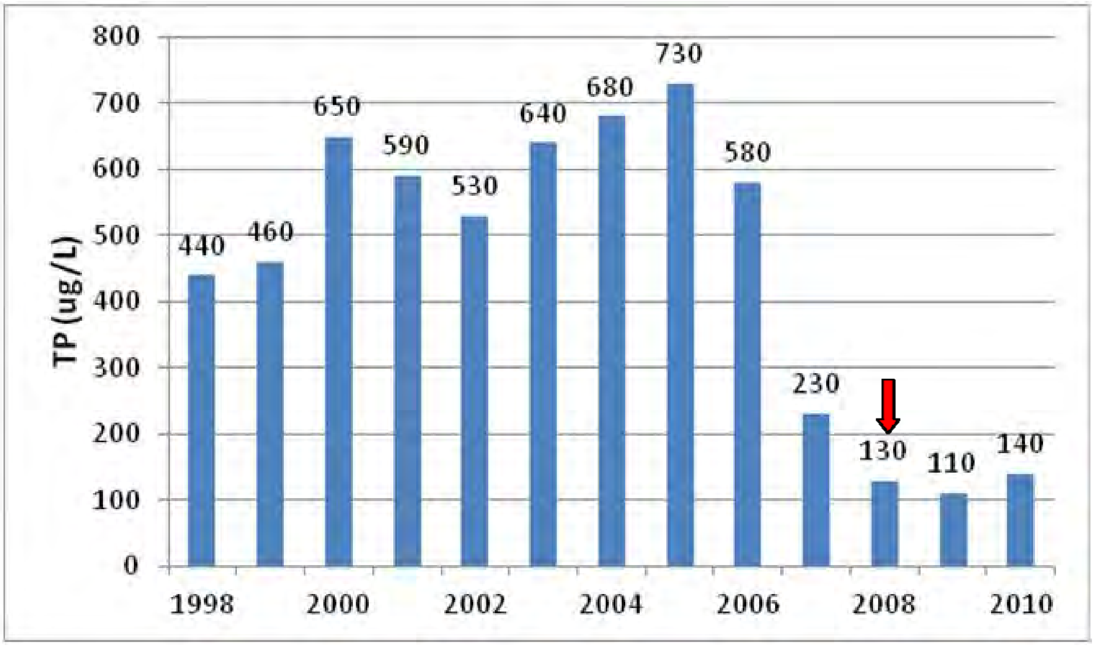


Figure 22. Annual flow weighted mean concentration of total phosphorus for the Vermillion River Watershed, 1998-2010 (MCES). Red arrow on chart indicates the year that the Empire WWTP re-routed discharge to the Mississippi River directly.

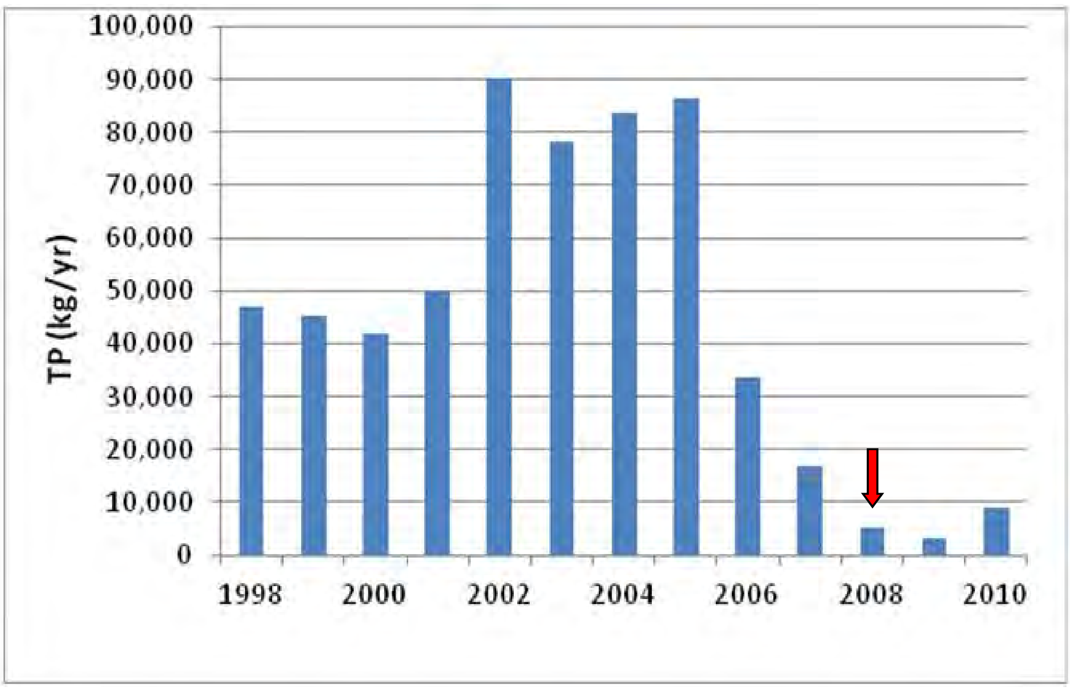


Figure 23. Annual pollutant load of total phosphorus calculated for the Vermillion River Watershed, 1998-2010 (MCES 2010). Red arrow on chart indicates the year that the Empire WWTP re-routed discharge to the Mississippi River directly.

Nitrogen

Nitrate (NO_3) and nitrite (NO_2) nitrogen are inorganic forms of nitrogen 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. Because nitrate and nitrite-nitrogen are water soluble, transport to surface waters is enhanced through agricultural drainage. The ability of nitrite to be readily converted to nitrate 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. Studies have shown that the elevated nitrate-nitrogen levels in the Minnesota River and Mississippi River basins contribute to hypoxia (low levels of dissolved oxygen) in the Gulf of Mexico. This occurs by nitrate-nitrogen stimulating the growth of algae which, through death and biological decomposition, consumes large amounts of dissolved oxygen and thereby threaten aquatic life (MPCA and MSUM 2009).

Currently Nitrate-N standards are absent for Minnesota rivers, but are in the development. The draft acute Nitrate-N value (maximum standard) is 41 mg/L for a one-day duration, and the draft chronic value 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. FWMCs of Nitrate-N within the Vermillion River are near the draft chronic Nitrate-N warm water standard and typically exceeding the cold water standard (Figure 24), though, sections of the river that are designated as cold water are further up in the watershed. As with TP, diversion of the Empire WWTP also likely contributed to the lower Nitrate-N concentrations and loads observed from 2008 to 2010 in the watershed (Figures 24 and 25).

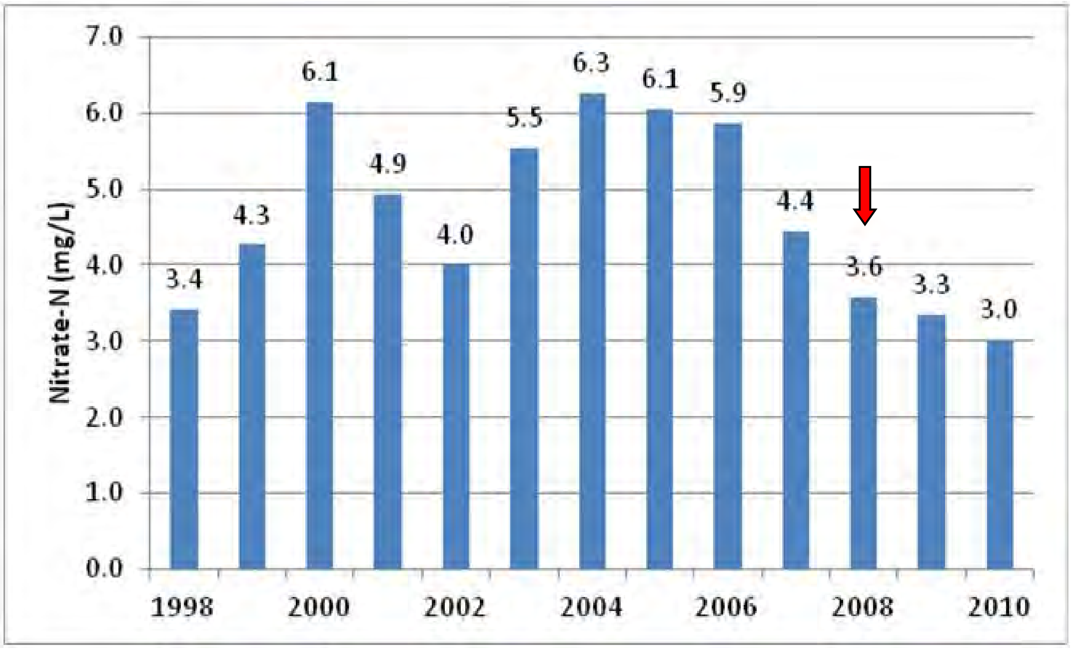


Figure 24. Annual flow weighted mean concentration of nitrate + nitrite-nitrogen for the Vermillion River Watershed, 1998-2010 (MCES). Red arrow on chart indicates the year that the Empire WWTP re-routed discharge to the Mississippi River directly.

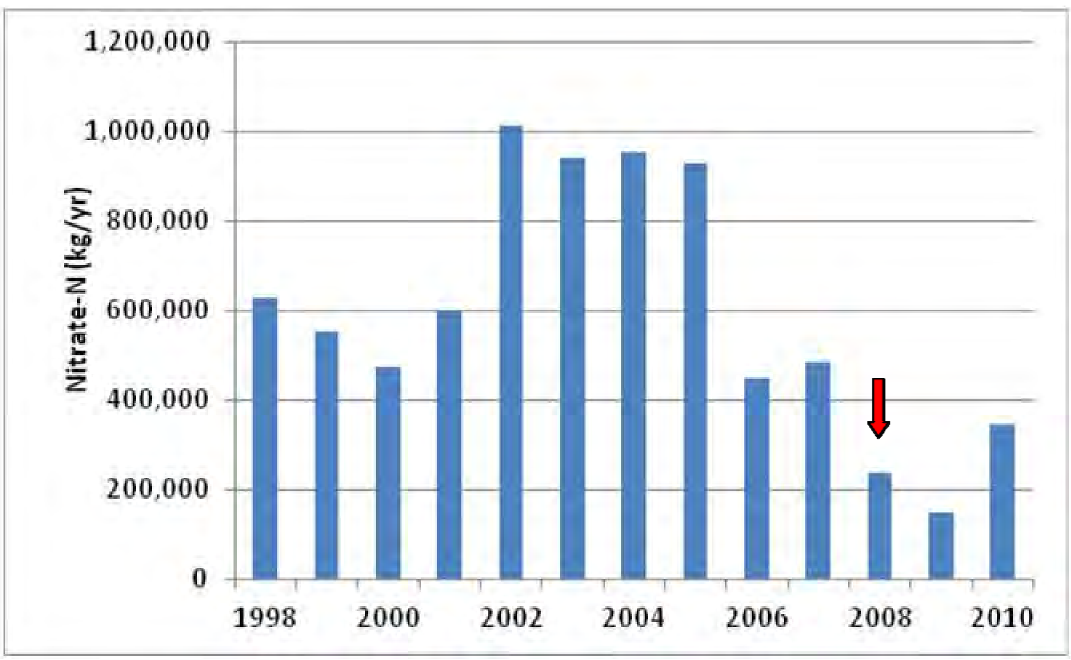


Figure 25. Annual pollutant load of nitrate + nitrite-nitrogen calculated for the Vermillion River Watershed, 1998-2010 (MCES 2010). Red arrow on chart indicates the year that the Empire WWTP re-routed discharge to the Mississippi River directly.

Stream water quality assessments

Currently, the MPCA has designated 64 stream assessment units (i.e., AUIDs) in the Vermillion River Watershed. Thirty of these assessment units have a cold water aquatic life use designation, while 33 have a warm water aquatic life use designation. There is also one section of stream that is designated as a Class 7 limited resource value water that is not protected for aquatic life. Of the 63 stream assessment units in this watershed protected for aquatic life (cold or warm water), data from 22 of these were analyzed during the 2011 assessment process. Of the assessed streams, only three were considered to be fully supporting of aquatic life and none were supporting aquatic recreation (Figure 26). The three streams supporting aquatic life were either warm water or being proposed to be re-classified to a warm water aquatic life use designation.

In this watershed six stream assessment units were determined to be impaired or not-supporting (NS) their aquatic life designated use (Table 13, Figure 27). This list includes four stretches of the Vermillion River, comprising the majority of its length. Aquatic life impairments are not exclusive to either warm or cold water streams in this watershed; there are three impairments in each stream class. However, one of the warm water segments (S. Br. Vermillion R., 07040001-707) is being proposed for re-classification to a cold water aquatic life use class and was assessed as such. Of the six assessment units impaired for aquatic life, only three represent newly impaired streams (i.e., 2012 will represent their initial inclusion on the Impaired Waters List). The other impaired assessment units have been listed in previous cycles and may or may not have additional impairments being added on the 2012 Impaired Waters List. All new aquatic life impairments in the Vermillion River watershed are based on either fish or macroinvertebrate bioassessment results.

A total of eleven stream assessment units were determined to have impaired aquatic recreation (Table 13, Figure 27). This list includes cold water and warm water streams as well as the majority of the Vermillion River upstream of the waterfalls in Hastings. Of these impairments, only one (Vermillion R., 07040001-516) represents a new aquatic recreation impairment listing for the 2012 reporting cycle.

Two stream assessment units did not have a sufficient amount of data to assess aquatic life, while one stream did not have enough data to assess aquatic recreation. Such streams are given an 'insufficient information' (IF) designation in Appendix 3. Additionally, an assessment of IF was given to 07040001-527 due to the deferment of the aquatic life impairments (fish and macroinvertebrate) because greater than 50 percent of this assessment unit was determined to be channelized. There were five streams that were not assessed (NA) for aquatic life because biological monitoring stations were located on channelized portions of the stream. Ten assessment units had no bacteria data and thus, were not assessed for aquatic recreation in the current assessment cycle.

Table 13. Summary of aquatic life, aquatic recreation, and aquatic consumption stream assessments in the Vermillion River Watershed. The MPCA does not currently designate waters fully supporting for aquatic consumption.

			Supporting Use		Non-support		
HUC-11 watershed	Area (mi^2)	# AUIDs Reviewed*	# Aquatic Life	# Aquatic Recreation	# Aquatic Life	# Aquatic Recreation	# Aquatic Consumption
Vermillion River	173	18	3	0	4	10	3
North Vermillion R.	75	2	0	0	1	1	2
Mississippi (Direct) R. (07040001075)	50	2	0	0	1	0	1
Hardwood	51	0	0	0	0	0	0
Vermillion River Watershed	**348**	**22**	**3**	**0**	**6**	**11**	**6**

*Not all AUIDs have sufficient data to assess for aquatic life or aquatic recreation.

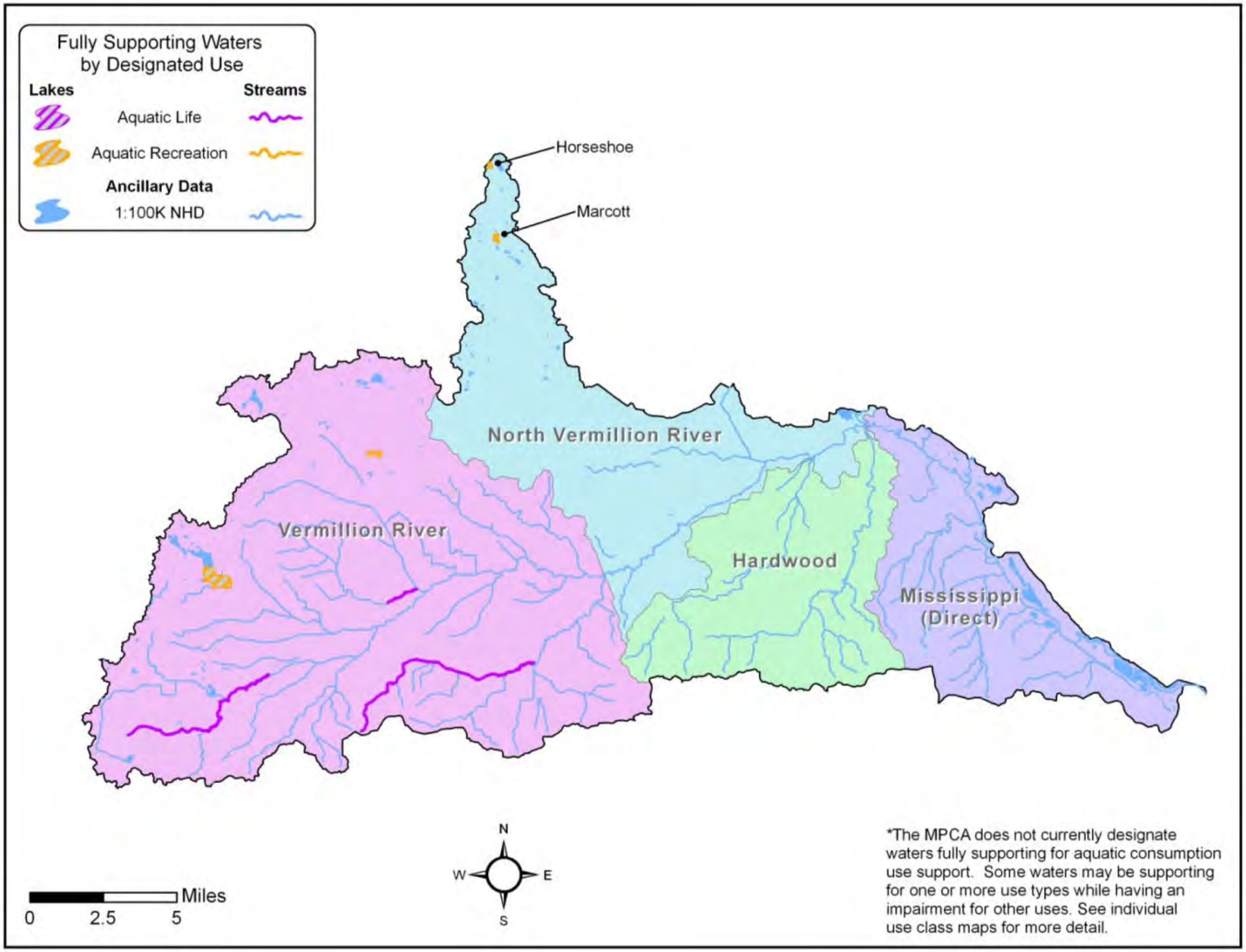


Figure 26. Supporting waters by designated use in the Vermillion River Watershed.

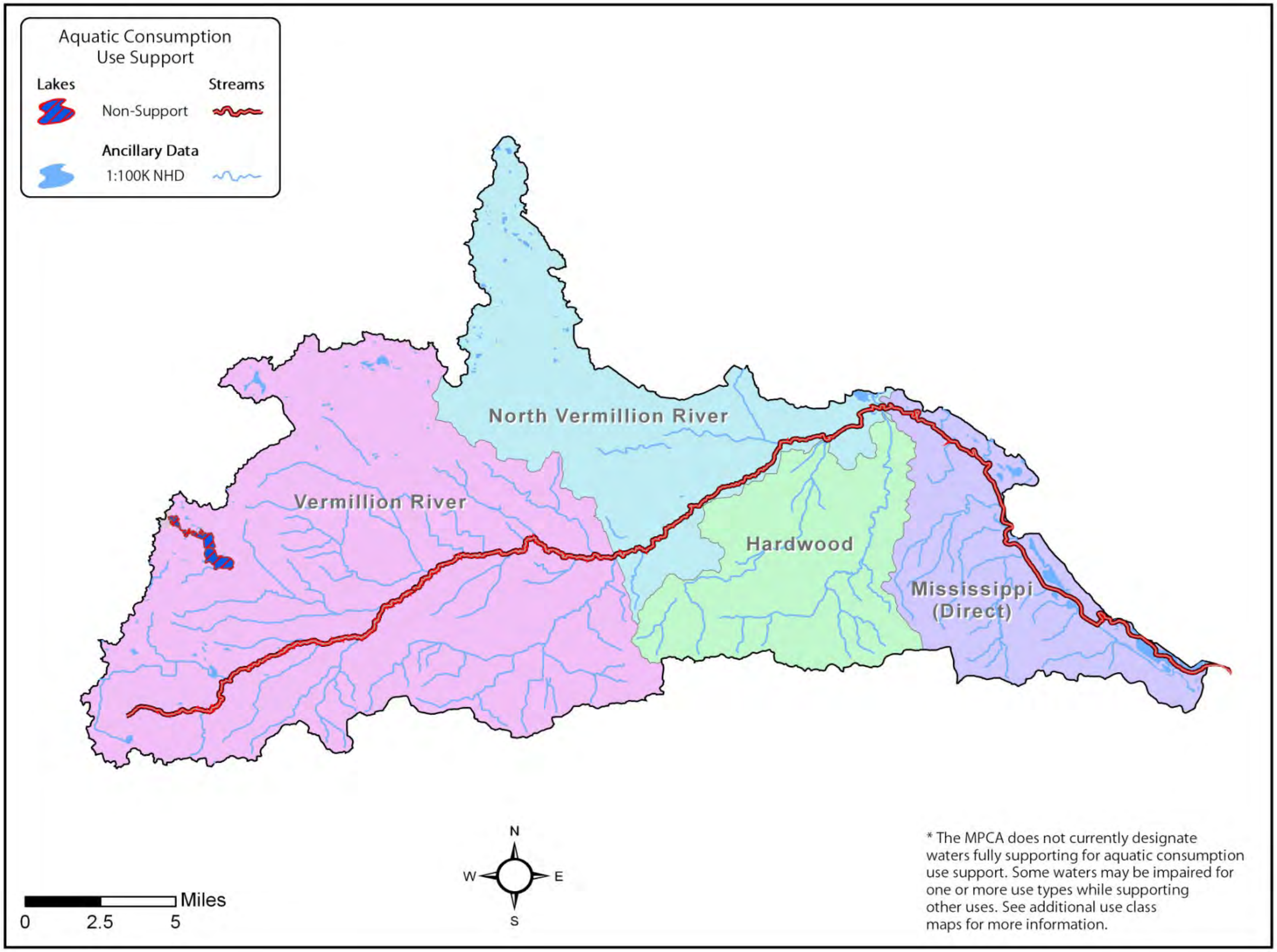


Figure 27. Impaired waters by designated use in the Vermillion River Watershed

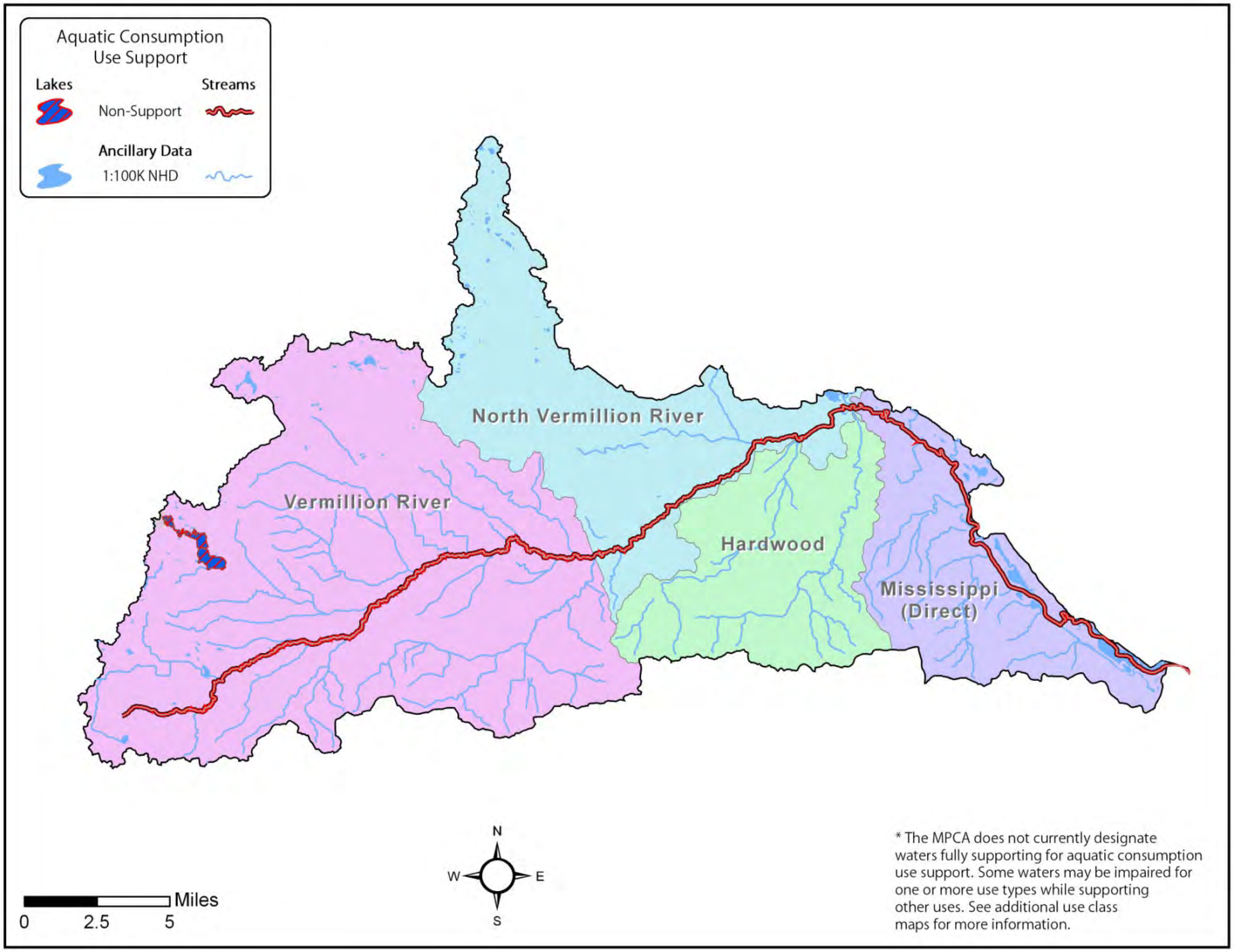


Figure 28. Aquatic consumption use support in the Vermillion River Watershed.

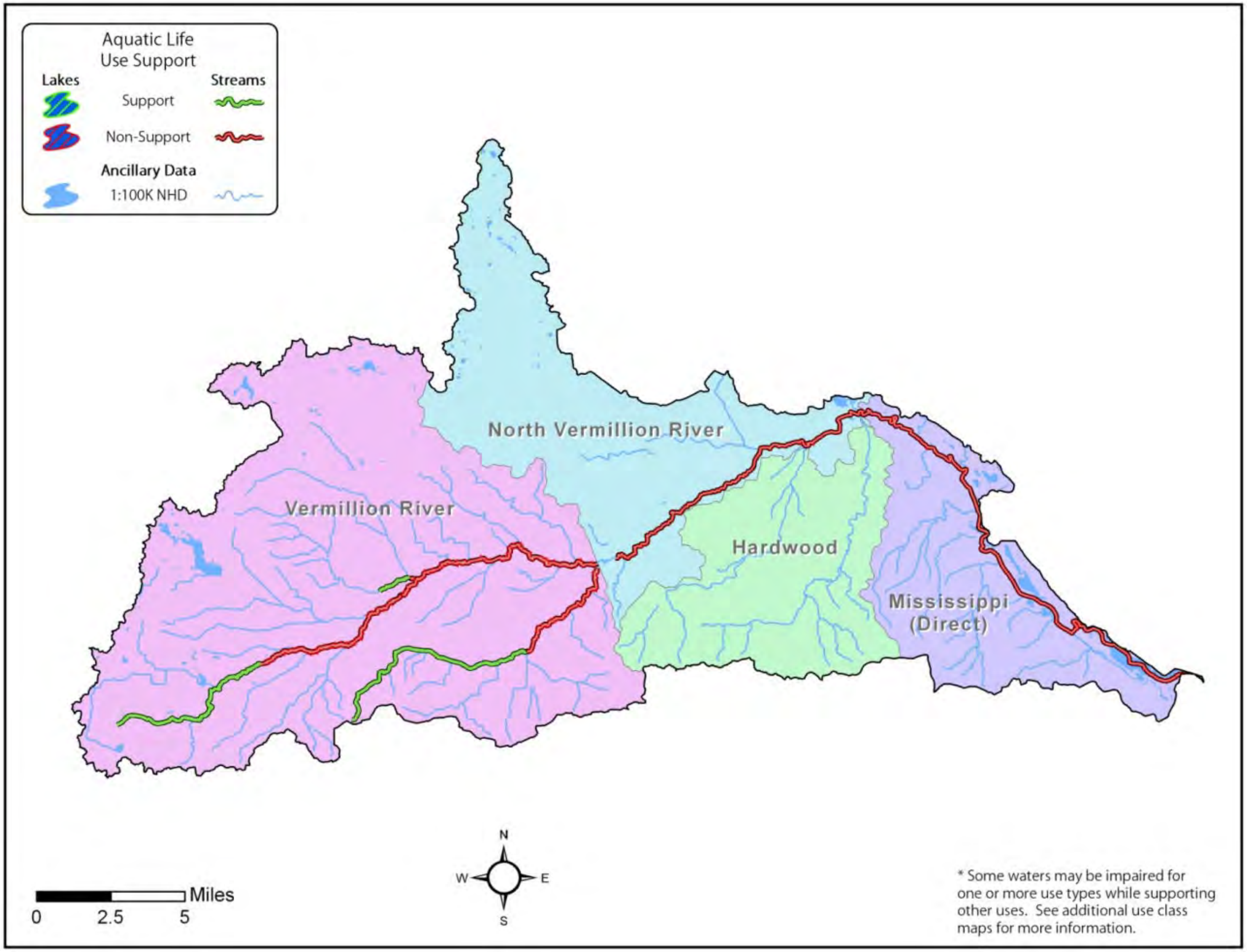


Figure 29. Aquatic life use support in the Vermillion River Watershed.

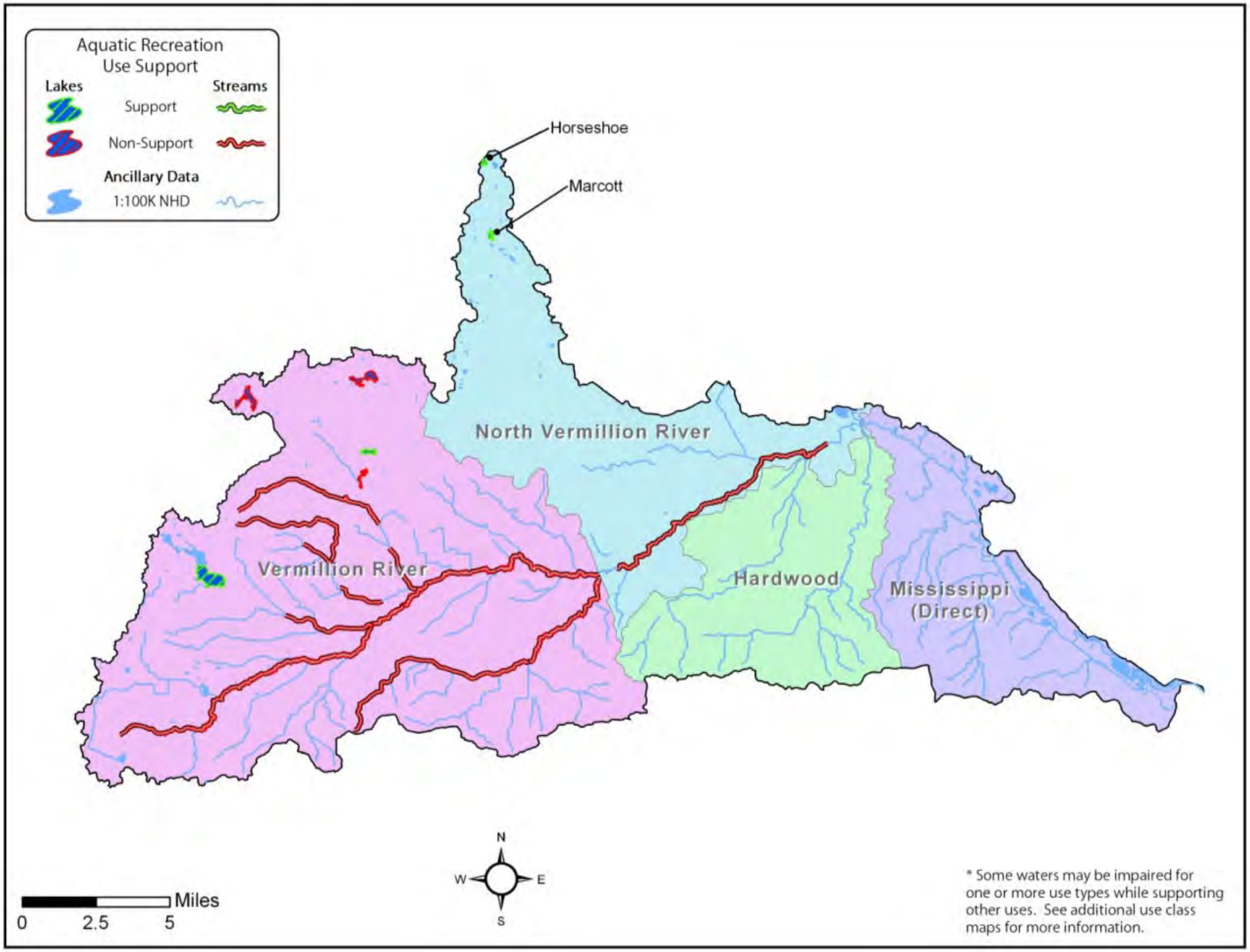


Figure 30. Aquatic recreation use support in the Vermillion River Watershed.

VIII. Water Quality Trends

Water chemistry data collected by MCES from the Vermillion River at Blaine Avenue (the outlet of the Vermillion River HUC-11 watershed) were analyzed for trends over the entire period of record (1982 to 2008) and over the second half of this period (1995-2008). Analyses were performed using the Seasonal Kendall Test for Trends. Trends shown in Table 14 are significant at the 90 percent confidence level and percentage changes are statistical estimates based on the available data (actual changes could be higher or lower). A designation of "no trend" means that a statistically significant trend has not been found; this may simply be the result of insufficient data.

Table 14. Pollutant trends for the Vermillion River at Blaine Avenue (VR 15.6/S000-896).

	Total Suspended Solids[1]	Total Phosphorus[1]	Nitrite/ Nitrate[1]	Ammonia[1]	Biochemical Oxygen Demand[1]	Chloride[2]
overall trend	**decrease**	**decrease**	**no trend**	**decrease**	**increase**	little data
average annual change	-1.7%	-1.9%		-3.0%	1.6%	
total change	-37%	-40%		-56%	54%	
1995 - 2008 trend	**decrease**	**decrease**	**decrease**	**no trend**	**no trend**	little data
average annual change	-4.0%	-9.6%	-4.3%			
total change	-41%	-73%	-43%			
median concentrations first 10 years	19	0.8	4	0.08	1.2	no data
median concentrations most recent 10 years	12	0.5	5	<.05	1.4	52

[1] Concentrations are median summer (Jun-Aug) values in mg/l.
[2] Concentrations are median year-round values in mg/l.

Concentrations of most measured pollutants in the upper Vermillion River Watershed appear to be declining (Table 14). Total suspended solids, total phosphorus, and nitrate/nitrite all exhibited decreasing trends in the most recent time period analyzed, 1995 to 2008. While biochemical oxygen demand did not show a decreasing trend during this time period, "no trend" detected during this period at least indicates that the overall increasing trend could be slowing in its rate of increase or ending altogether. It is anticipated that further decreases in pollutant concentrations will be observed at this monitoring station following cessation of the Empire WWTP discharging effluent to the Vermillion River a few miles upstream (see Figure 13).

The MPCA also looks for trends in the transparency data collected annually on lakes and streams. A minimum of eight years of data is required to provide a statistically significant trend; for this analysis a Seasonal Kendall Test is run using the statistical package "R." None of the stream sites in the Vermillion River watershed had sufficient data for analysis. Six lakes met the minimum data requirements; of those Farquar Lake has a declining trend in transparency while Lake Marion and Unnamed (Valley) Lake have improving trends in transparency.

IX. Summary and Recommendations

Throughout the majority of its length the Vermillion River is not supporting aquatic life, aquatic recreation, and aquatic consumption. While the diversion of the Empire WWTP to the Mississippi River in 2008, decreased pollutant levels in the lower half of the Vermillion River, development in the upper portion of the watershed (i.e., Vermillion River HUC 11) and the associated water quality impacts (e.g., point and nonpoint sources, altered watershed hydrology, habitat alteration, etc.) continue to exert stress on aquatic communities upstream of Hastings. All assessed cold water segments of the Vermillion River and the South Branch Vermillion River were determined to be impaired for aquatic life. Cold water streams may be particularly sensitive to development pressure in the watershed given their proximity to Lakeville, Farmington, and Apple Valley. Urban development typically increases the amount of impervious surface (e.g., roads, parking lots, roofs), unvegetated ponds (e.g., stormwater ponds, golf course water hazards), and water usage in a watershed, cumulatively acting to increase surface water temperatures.


The Vermillion River supports a brown trout fishery in a rapidly developing area of the Twin Cities.

The Vermillion River Watershed is unique because it provides trout fishing opportunities in close proximity to a major metropolitan area. However, development pressure from expanding suburbs presents unique challenges for the restoration and protection of cold water streams in this watershed. In 2006, the Vermillion River Watershed Joint Powers Organization (VRWJPO) received a Targeted Watersheds Grant from the U.S. Environmental Protection Agency to explore a market trading method for reducing water temperature in the Vermillion River. While the study concluded that thermal trading was not the best strategy for reducing the temperature of the Vermillion River, it identified alternative approaches that could be implemented in the watershed (VRWJPO 2009). For example, incorporating infiltration practices such as soil amendment, permeable pavement, and bioretention ponds into development plans reduces stormwater volume and thermal impacts on streams. Also, increasing the amount of shading along riparian corridors is an effective method for cooling streams, but does not prevent the spike in water temperature that occurs at the onset of storm events. Increasing the amount of vegetation in ponds is another tactic to increase shading and keep surface water temperatures down. In 2009, the MPCA and VRWJPO initiated a U.S. EPA Section 319 project to demonstrate and evaluate some of the cooling best management practices (BMPs) recommended by the Targeted Watersheds study. Implementation of such practices will not only benefit cold water assemblages in the watershed, but warm water assemblages as well.

The BMPs for reducing thermal impacts on aquatic communities also work to control the rate and volume of stormwater entering lakes, streams, and wetlands in the watershed. Reducing the associated amount of erosion and sediment transport in streams benefits both warm water and cold water assemblages by increasing the quantity and quality of in-stream habitat, improving water clarity for visual predators (e.g., brown trout, northern pike, largemouth bass), and increasing the feeding efficiency of filter-feeding organisms (e.g., mussels, net-spinning caddisflies, blackfly larvae). Improving the management of stormwater runoff in the upper portions of the watershed will likely play a large role in addressing the fish, macroinvertebrate, and turbidity impairments that are currently listed in the watershed. However, additional monitoring as part of the stressor identification process will be required to confirm whether stormwater impacts are the principle cause of these impairments.

The headwaters of both the Vermillion River and the South Branch Vermillion River are supporting aquatic life. Both of these are designated warm water reaches originating in relatively less developed areas of the watershed. The MPCA and U.S. EPA recognize that protecting relatively healthy streams such as these from degradation is a more cost-effective approach than the alternative, restoring a stream after it has become impaired (U.S. EPA 2012). Protection of existing natural areas, "Smart Growth" land use planning, Low Impact Development, and riparian corridor easements are examples of approaches that could be utilized to protect these two headwater systems.

Bacterial contamination is a ubiquitous problem for rivers and streams in the Vermillion River Watershed preventing attainment of the aquatic recreation designated use. Fecal coliform (prior to 2010 Impaired Waters List) and E. coli impairments occur in virtually all streams that have been assessed in this watershed. These are primarily listings that have occurred in previous assessment cycles and in some cases remediation efforts have already been initiated. Data collected as part of the 2008-2009 intensive watershed monitoring effort likely did not detect any significant improvements resulting from such activities, as the implementation plan for some of these impairments had only recently been completed in 2007. Monitoring conducted during the next IWM effort in the Vermillion River Watershed, and in the years preceding it, will provide a better indication as to the success of efforts to restore the aquatic recreation use of rivers and streams in this watershed.

In 2008, lakes had not yet become formally integrated into the IWM approach. However, using data collected in previous years aquatic recreation was able to be assessed in the majority of lakes in the watershed occurring outside of the Vermillion River/Mississippi River floodplain.

X. Literature Cited

Chapman, K., B. Olsen, H. Kieweg, and B. Nerbonne. 2008. Groundwater environment and temperature in the Vermillion River watershed. Report prepared for Vermillion River Watershed Joint Powers Organization, Apple Valley, MN.

McCollor, S. and S. Heiskary. 1993. Selected water quality characteristics of minimally impacted streams from Minnesota's seven ecoregions. Addendum to: Descriptive characteristics of the seven ecoregions of Minnesota. MPCA St. Paul, MN.

Metropolitan Council Environmental Services (MCES). 2010. Standard Operating Procedure: Estimation of Annual Tributary Stream Pollutant Loads with Flux 32. St. Paul, MN.

Minnesota Pollution Control Agency (MPCA). 2010. Regionalization of Minnesota's Rivers for Application of River Nutrient Criteria. St. Paul, MN. http://www.pca.state.mn.us/index.php/view-document.html?gid=14948.

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

Minnesota Pollution Control Agency (MPCA) and Minnesota State University of Mankato (MSUM). 2009. State of the Minnesota River, Summary of Surface Water Quality Monitoring 2000-2008. http://mrbdc.mnsu.edu/sites/mrbdc.mnsu.edu/files/public/reports/basin/statemr08.html.

National Climatic Data Center (NCDC). 2011. Climatography of the United States No. 20 (1981-2010). U.S. Department of Commerce, National Oceanic & Atmospheric Administration, National Climatic Data Center, Asheville, NC.

National Resource Conservation Service (NRCS). 2007. Rapid Watershed Assessment: Rush - Vermillion (MN/WI) HUC: 07040001. NRCS. USDA. http://www.mn.nrcs.usda.gov/technical/rwa/assessments/reports/rush_vermillion.pdf.

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

U.S. Environmental Protection Agency (U.S. EPA). 2012. Identifying and Protecting Healthy Watersheds: Concepts, Assessments, and Management Approaches. U.S. Environmental Protection Agency, Office of Water, Office of Wetlands, Oceans, and Watersheds, Washington, DC.

Vermillion River Watershed Joint Powers Organization (VRWJPO). 2009. Creating the optimal regulatory and market framework to preserve stream flow and temperature stability in an urbanizing trout stream in the Midwest. U.S. Environmental Protection Agency Targeted Watersheds Grant Final Report. http://vermillionriverwatershed.org/index.php?option=com_content&view=article&id=52&Itemid=61

White, D. and J.M. Omernik. 2007. Minnesota level III and IV ecoregions map (scale 1:2,500,000). U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory, Western Ecology Division, Corvallis, OR. ftp://ftp.epa.gov/wed/ecoregions/mn/mn_map.pdf.

Appendix 1. Water chemistry definitions

Ammonia–Nitrogen/Total Ammonia – The combination of unionized ammonia (NH_3) and the ammonium ion (NH_4^+), the most reduced inorganic forms of nitrogen in water. Excess ammonia contributes to the eutrophication of waterbodies. Ammonia-nitrogen is found in fertilizers, septic systems and animal waste.

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 occurs when organic matter or nutrient inputs are high and light availability is low.

Escherichia coli (E. coli) - A type of fecal coli form bacteria that come 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 to be readily converted to nitrate 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 (OP) - Orthophosphate is a water soluble form of phosphorus that is readily available to algae (bio-available). While orthophosphates occur naturally in the environment, river and stream concentrations may become elevated with additional inputs from waste water treatment plants, non-compliant 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. The water temperature of warm water streams varies by season, corresponding to ambient air temperature, while groundwater-fed, cold water stream temperatures remain relatively constant throughout the year.

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

Total Phosphorus (TP) - Phosphorus is an essential nutrient 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. Elevated levels of phosphorus can lead to 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 (NH_3) - Ammonia is present in aquatic systems mainly as the dissociated ion NH_4^+, 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 NH_4^+ 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 stations in the Vermillion River Watershed.

Site ID	STORET ID	StreamName	Location	SampleType
08LM114	S000-896	Vermillion River	Upstream of Blaine Ave., 3.5 mi. NE of Farmington	Bio/Water Chemistry
08LM123	S003-325	Vermillion River	Upstream of Ash St W, 1 mi. W of Farmington	Biological
08LM124		Unnamed Creek	Downstream of Flagstaff Ave., 2 mi. W of Farmington	Biological
98LM004		Vermillion River	Downstream of Biscayne Ave, 1 mi. NE of Farmington	Biological
08LM112	S001-230	Vermillion River	At CSAH 68, 6 mi. SE of Hastings	Bio/Contaminants
08LM120		Trib to Vermillion River	At Annette Ave, 4 mi. NE of Farmington	Biological
08LM126		Trib to Rice Lake	At Pillsbury Ave, 3.5 mi. SW of Lakeville	Biological
08LM125		Vermillion River	At Dupont Ave., 4.5 mi. SW of Lakeville	Biological
08LM122		Unnamed creek	Upstream of Chippandale Ave. W, 1.5 mi. N of Farmington	Biological
08LM121		Unnamed Creek	Upstream of Chippandale Ave. W, 1.5 mi. N of Farmington	Biological
08LM118		Vermillion River, South Branch	At 230th St E, 3.5 mi. SE of Farmington	Biological
08LM117		Unnamed creek	Upstream of 230th St. W, 4 mi. SE of Farmington	Biological
08LM116	S002-421	Vermillion River, South Branch	Upstream of CSAH 66, 6.5 mi. E of Farmington	Biological
08LM115		Vermillion River	Downstream of CSAH 85, 1 mi. NE of Vermillion	Biological
08LM113	S002-429	Vermillion River	At CSAH 47, .5 mi. SW of Hastings	Bio/Water Chemistry

Appendix 3. Summary of stream assessments in the Vermillion River Watershed.

Assessment Unit ID (AUID)	Stream Reach Name	Reach Description	Reach Length (miles)	Use Class	Use Assessments: Aquatic Life	Aquatic Recreation	Aquatic Consumption	Drinking Water	303d listed impairments (2012)[1]	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria (Aq. Recreation)
HUC 11: 07040001055 (Vermillion River)																		
07040001-507	Vermillion River	T114 R19W S30, south line to S Br Vermillion R	12	1B, 2A	NS	NS	NS	IF	FC, B_F, B_I, HGF	EXS	EXS	MTS	MTS	MTS	MTS	MTS	MTS	EX
07040001-516	Vermillion River	Headwaters to T113 R20W S8, east line	7	2B	FS	NS	NS	NA	E.coli, HGF	EXP	EXP	IF	MTS	MTS	MTS	MTS		EX
07040001-517	Vermillion River	T113 R20W S9, west line to T114 R19W S31, north line	10	1B, 2A	NS	NS	NS	IF	DO, T, FC, B_F, B_I, HGF	EXS	EXS	EXP	EXP	MTS	MTS	MTS		EX
07040001-527	Unnamed creek	Unnamed cr to Vermillion R	3	1B, 2A	IF	NA	NA	NA	FC				NA					
07040001-542	Unnamed creek	Headwaters to Unnamed cr	6	2B	IF	NS	NA	NA	FC				MTS					EX
07040001-545	Unnamed creek (Vermillion River Tributary)	Unnamed cr to Vermillion R	0.4	1B, 2A	NS	NS	NA	NA	DO, FC			EXS	IF	MTS	MTS	IF		EX
07040001-546	Unnamed creek	Headwaters to Unnamed cr	5	2B	NA	NS	NA	NA	E.coli									EX
07040001-548	Unnamed creek	Unnamed cr to Unnamed cr	1	2B	NA	NS	NA	NA	E.coli									EX
07040001-552	Unnamed creek	Unnamed cr to S Br Vermillion R	2	2B	NA	NA	NA	NA										
07040001-664	Unnamed creek	T113 R20W S4, west line to Unnamed cr	2	1B, 2A	NA	NA	NA	NA					NA					
07040001-666	Unnamed creek	Unnamed cr to T113 R20W S11, north line	1	2B	IF	NA	NA	NA										
07040001-669	Unnamed creek (Vermillion River Tributary)	T114 R19W S30, west line to Unnamed cr	1	1B, 2A[2]	FS	NA	NA	NA		MTS								

					Use Assessments					Aquatic Life Indicators								
Assessment Unit ID (AUID)	Stream Reach Name	Reach Description	Reach Length (miles)	Use Class	Aquatic Life	Aquatic Recreation	Aquatic Consumption	Drinking Water	303d listed impairments (2012) [1]	Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria (Aq. Recreation)
07040001-670	Unnamed creek (Vermillion River Tributary)	Unnamed cr to T114 R19W S19, south line	1	2B	NA	NS	NA	NA	E.coli									EX
07040001-671	Unnamed creek (Vermillion River Tributary)	T114 R19W S30, north line to Unnamed cr	0.4	1B, 2A	NA	NS	NA	NA	FC			EXP	EXP	MTS	MTS	IF		EX
07040001-680	Unnamed creek (Vermillion River Tributary)	Headwaters to T114 R19W S14, south line	1	2B	NA	NA	NA	NA										
07040001-697	Unnamed creek	Unnamed cr to Rice Lk	1	2B	NA	NA	NA	NA										
07040001-706	Vermillion River, South Branch	Headwaters to T113 R19W S2, east line	9	2B	FS	NA	NA	NA		MTS	EXP							
07040001-707	Vermillion River, South Branch	T113 R19W S1, west line to T114 R18W S29, north line	6	2B[2]	NS	NS	NA	NA	B_F, B_I	EXP	EXP	IF	EXP	MTS	MTS	MTS		EX
HUC 11: 07040001035 (North Vermillion River)																		
07040001-520	Vermillion Slough	Vermillion R to Mississippi R	2	2B	NA	NA	NA	NA					MTS			MTS		
07040001-691	Vermillion River	S Br Vermillion R to T114 R18W S20, east line	1	1B, 2A	NA	NA	NS	NA	HGF									
07040001-692	Vermillion River	T114 R18W S21, west line to Hastings Dam	11	2B	NS	NS	NS	NA	FC, B_F, HGF	EXS	EXP	MTS	MTS	MTS	MTS	MTS		EX
HUC 11: 07040001075 (Mississippi (Direct) River)																		
07040001-504	Vermillion River	Vermillion R/Vermillion Slough, Hastings Dam to Mississippi R	22	2B	NS	IF	NS	NA	T, HGF, PCBF	MTS	EXS	IF	EXS	MTS	MTS	MTS		IF
07040001-521	Truedale Slough	Vermillion R to Mississippi R	2	2B	NA	NA	NA	NA								MTS		

[1] Impairment abbreviations: **B_F** – Fish Bioassessment; **B_I** – Aquatic Macroinvertebrate Bioassessment; **DO** – Dissolved Oxygen; **E.coli** – Escherichia coli; **FC** – Fecal coliform bacteria; **HGF** – Mercury in Fish Tissue; **PCBF** – Polychlorinated biphenyls in Fish Tissue; **T** – Turbidity.
[2] The MPCA is currently in the process of changing the existing aquatic life use class for this AUID in rule based on an analysis of the biological community and temperature data.

Appendix 4. Minnesota statewide IBI thresholds and confidence limits

Class #	Class Name	Use Class	Threshold	Confidence Limit	Upper	Lower
Fish						
1	Southern Rivers	2B	39	±11	50	28
2	Southern Streams	2B	45	±9	54	36
3	Southern Headwaters	2B	51	±7	58	44
4	Northern Rivers	2B	35	±9	44	26
5	Northern Streams	2B	50	±9	59	41
6	Northern Headwaters	2B	40	±16	56	24
7	Low Gradient	2B	40	±10	50	30
10	Southern Coldwater	2A	45	±13	58	32
11	Northern Coldwater	2A	37	±10	47	27
Macroinvertebrates						
1	Northern Forest Rivers	2B	51.3	±10.8	62.1	40.5
2	Prairie Forest Rivers	2B	30.7	±10.8	41.5	19.9
3	Northern Forest Streams RR	2B	50.3	±12.6	62.9	37.7
4	Northern Forest Streams GP	2B	52.4	±13.6	66.0	38.8
5	Southern Streams RR	2B	35.9	±12.6	48.5	23.3
6	Southern Forest Streams GP	2B	46.8	±13.6	60.4	33.2
7	Prairie Streams GP	2B	38.3	±13.6	51.9	24.7
8	Northern Coldwater	2A	26.0	±12.4	38.4	13.6
9	Southern Coldwater	2A	46.1	±13.8	59.9	32.3

Appendix 5. Biological monitoring results from stations on natural stream segments- fish IBI.

AUID	Biological Station ID	Stream Reach Name	Drainage Area (mi^2)	Fish Class	Threshold	Fish IBI	Sample Date	Data Source
HUC 11: 07040001055 (Vermillion River)								
07040001-507	04LM133	Vermillion River	62.3	10	45	34	08-Jul-04	MPCA
07040001-507	04LM133	Vermillion River	62.3	10	45	26	05-Aug-04	MPCA
07040001-507	98LM004	Vermillion River	109.0	10	45	41	30-Jun-08	MPCA
07040001-507	98LM004	Vermillion River	109.0	10	45	51	12-Sep-09	VRWJPO[1]
07040001-507	98LM004	Vermillion River	109.0	10	45	39	13-Sep-10	VRWJPO[1]
07040001-507	08LM114	Vermillion River	128.6	10	45	37	30-Jun-08	MPCA
07040001-507	08LM114	Vermillion River	128.6	10	45	42	01-Aug-09	VRWJPO[1]
07040001-507	08LM114	Vermillion River	128.6	10	45	49	21-Sep-10	VRWJPO[1]
07040001-516	08LM125	Vermillion River	3.9	3	51	51	11-Aug-08	MPCA
07040001-517	08LM123	Vermillion River	38.1	10	45	28	18-Jun-08	MPCA
07040001-517	08LM123	Vermillion River	38.1	10	45	45	21-Aug-09	VRWJPO[1]
07040001-517	08LM123	Vermillion River	38.1	10	45	40	08-Sep-10	VRWJPO[1]
07040001-517	09LM005	Vermillion River	61.3	10	45	34	24-Aug-09	VRWJPO[1]
07040001-517	09LM005	Vermillion River	61.3	10	45	36	17-Sep-10	VRWJPO[1]
07040001-517	09LM002	Vermillion River	21.0	10	45	41	02-Sep-09	VRWJPO[1]
07040001-517	09LM002	Vermillion River	21.0	10	45	33	01-Sep-10	VRWJPO[1]
07040001-517	04LM052	Vermillion River	38.0	10	45	22	08-Jul-04	MPCA
07040001-527	09LM003	Unnamed creek	15.3	10	45	36	16-Sep-09	VRWJPO[1]
07040001-527	09LM003	Unnamed creek	15.3	10	45	42	15-Sep-10	VRWJPO[1]
07040001-666	09LM004	Unnamed creek	7.0	3	51	73	02-Sep-09	VRWJPO[1]
07040001-666	09LM004	Unnamed creek	7.0	3	51	75	13-Sep-10	VRWJPO[1]
07040001-669	08LM122	Unnamed creek (Vermillion River Tributary)	12.2	3	51	57	19-Jun-08	MPCA
07040001-706	08LM118	Vermillion River, South Branch	13.4	3	51	75	11-Aug-08	MPCA
07040001-707	08LM116	Vermillion River, South Branch	32.5	10	45	23	18-Jun-08	MPCA
07040001-707	08LM116	Vermillion River, South Branch	32.5	10	45	46	21-Aug-09	VRWJPO[1]
07040001-707	08LM116	Vermillion River, South Branch	32.5	10	45	48	16-Sep-10	VRWJPO[1]
07040001-707	04LM029	Vermillion River, South Branch	27.6	10	45	35	08-Jul-04	MPCA
HUC 11: 07040001035 (North Vermillion River)								
07040001-692	08LM115	Vermillion River	187.4	2	45	36	01-Jul-08	MPCA
07040001-692	08LM115	Vermillion River	187.4	2	45	43	30-Sep-09	VRWJPO[1]
07040001-692	08LM115	Vermillion River	187.4	2	45	38	13-Sep-10	VRWJPO[1]
07040001-692	08LM113	Vermillion River	243.0	2	45	37	01-Jul-08	MPCA
HUC 11: 07040001075 (Mississippi (Direct) River)								
07040001-504	08LM112	Vermillion River	323.5	1	39	73	13-Aug-08	MPCA

[1] Data provided by Vermillion River Watershed Joint Powers Organization was used as supporting information for assessing aquatic life.

Appendix 6. Biological monitoring results from stations on natural stream segments- macroinvertebrate IBI.

AUID	Biological Station ID	Stream Reach Name	Drainage Area (mi^2)	Invert Class	Threshold	Invert IBI	Sample Date	Data Source
HUC 11: 07040001055 (Vermillion River)								
07040001-507	04LM133	Vermillion River	62.3	9	46.1	42.1	16-Aug-04	MPCA
07040001-507	08LM114	Vermillion River	128.6	9	46.1	24.1	27-Aug-08	MPCA
07040001-507	98LM004	Vermillion River	109.0	9	46.1	43.4	09-Sep-08	MPCA
07040001-516	08LM125	Vermillion River	3.9	5	35.9	36.1	09-Sep-08	MPCA
07040001-517	04LM052	Vermillion River	38.0	9	46.1	19.1	16-Aug-04	MPCA
07040001-517	08LM123	Vermillion River	38.1	9	46.1	14.3	28-Aug-08	MPCA
07040001-517	08LM123	Vermillion River	38.1	9	46.1	16.0	01-Sep-09	VRWJPO[1]
07040001-517	08LM123	Vermillion River	38.1	9	46.1	42.1	01-Sep-10	VRWJPO[1]
07040001-517	09LM002	Vermillion River	21.0	9	46.1	58.5	01-Sep-09	VRWJPO[1]
07040001-517	09LM002	Vermillion River	21.0	9	46.1	43.1	10-Sep-10	VRWJPO[1]
07040001-517	09LM005	Vermillion River	61.3	9	46.1	50.1	27-Aug-09	VRWJPO[1]
07040001-517	09LM005	Vermillion River	61.3	9	46.1	44.6	27-Aug-10	VRWJPO[1]
07040001-527	09LM003	Unnamed Creek	15.3	9	46.1	0.3	01-Sep-09	VRWJPO[1]
07040001-527	09LM003	Unnamed Creek	15.3	9	46.1	14.6	01-Sep-10	VRWJPO[1]
07040001-666	09LM004	Unnamed Tributary to Vermillion River	7.0	5	35.9	40.3	01-Sep-09	VRWJPO[1]
07040001-666	09LM004	Unnamed Tributary to Vermillion River	7.0	5	35.9	31.0	27-Aug-10	VRWJPO[1]
07040001-669	08LM122	Unnamed creek	12.2	6	46.8	53.5	28-Aug-08	MPCA
07040001-706	08LM118	Vermillion River, South Branch	13.4	6	46.8	48.6	27-Aug-08	MPCA
07040001-707	04LM029	Vermillion River, South Branch	27.6	9	46.1	54.6	16-Aug-04	MPCA
07040001-707	08LM116	Vermillion River, South Branch	32.5	9	46.1	22.3	27-Aug-08	MPCA
07040001-707	08LM116	Vermillion River, South Branch	32.5	9	46.1	43.2	02-Sep-09	VRWJPO[1]
07040001-707	08LM116	Vermillion River, South Branch	32.5	9	46.1	45.1	01-Sep-10	VRWJPO[1]
HUC 11: 07040001035 (North Vermillion River)								
07040001-692	08LM113	Vermillion River	243.0	5	35.9	47.4	27-Aug-08	MPCA
07040001-692	08LM115	Vermillion River	187.4	6	46.8	50.1	27-Aug-08	MPCA
07040001-692	08LM115	Vermillion River	187.4	6	46.8	60.6	27-Aug-09	VRWJPO[1]
07040001-692	08LM115	Vermillion River	187.4	6	46.8	28.8	01-Sep-10	VRWJPO[1]
HUC 11: 07040001075 (Mississippi (Direct) River)								
07040001-504	08LM112	Vermillion River	323.5	6	46.8	22.7	09-Sep-08	MPCA

[1] Data provided by Vermillion River Watershed Joint Powers Organization was used as supporting information for assessing aquatic life.

Appendix 7. Good/fair/poor thresholds for biological stations on non-assessed, channelized warm water streams.

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
Macroinvertebrates				
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 8. Biological monitoring results from stations on channelized stream segments- fish IBI.

AUID	Biological Station ID	Stream Reach Name	Drainage Area (mi^2)	Fish Class	Fish IBI	IBI Rating[1]	Sample Date	Data Source
HUC 11: 07040001055 (Vermillion River)								
07040001-527	08LM124	Unnamed creek	21.6	10	31	n/a	27-Jun-08	MPCA
07040001-527	08LM124	Unnamed creek	21.6	10	42	n/a	02-Sep-09	VRWJPO[2]
07040001-527	08LM124	Unnamed creek	21.6	10	55	n/a	01-Sep-10	VRWJPO[2]
07040001-552	08LM117	Unnamed creek	8.8	3	68	good	17-Jun-08	MPCA
07040001-552	08LM117	Unnamed creek	8.8	3	80	good	03-Sep-09	VRWJPO[2]
07040001-552	08LM117	Unnamed creek	8.8	3	74	good	01-Sep-10	VRWJPO[2]
07040001-670	07LM019	Unnamed creek (Vermillion River Tributary)	31.5	2	38	fair	16-Aug-07	MPCA
07040001-671	08LM121	Unnamed creek (Vermillion River Tributary)	33.5	10	25	n/a	19-Jun-08	MPCA
07040001-671	08LM121	Unnamed creek (Vermillion River Tributary)	33.5	10	40	n/a	03-Sep-09	VRWJPO[2]
07040001-671	08LM121	Unnamed creek (Vermillion River Tributary)	33.5	10	45	n/a	08-Sep-10	VRWJPO[2]
07040001-680	08LM120	Unnamed creek (Vermillion River Tributary)	0.7	3	70	good	19-Jun-08	MPCA
07040001-697	08LM126	Unnamed creek	10.3	7	11	poor	03-Jul-08	MPCA
07040001-707	09LM007	Vermillion River, South Branch	30.1	10	40	n/a	10-Aug-09	VRWJPO[2]
07040001-707	09LM007	Vermillion River, South Branch	30.1	10	38	n/a	14-Sep-10	VRWJPO[2]

[1] The MPCA has not yet determined appropriate thresholds for channelized cold water streams.

[2] Data was provided by Vermillion River Watershed Joint Powers Organization.

Appendix 9. Biological monitoring results from stations on channelized stream segments- macroinvertebrate IBI.

AUID	Biological Station ID	Stream Reach Name	Drainage Area (mi^2)	Invert Class	Invert IBI	IBI Rating[1]	Sample Date	Data Source
HUC 11: 07040001055 (Vermillion River)								
07040001-527	08LM124	Unnamed Creek	21.6	9	36.2	n/a	09-Sep-08	MPCA
07040001-527	08LM124	Unnamed Creek	21.6	9	16.2	n/a	04-Sep-09	VRWJPO[2]
07040001-527	08LM124	Unnamed Creek	21.6	9	42.0	n/a	27-Aug-10	VRWJPO[2]
07040001-552	08LM117	Unnamed creek	8.8	6	47.5	good	27-Aug-08	MPCA
07040001-552	08LM117	Unnamed creek	8.8	6	31.3	fair	02-Sep-09	VRWJPO[2]
07040001-552	08LM117	Unnamed creek	8.8	6	30.4	fair	10-Sep-10	VRWJPO[2]
07040001-669	09LM008	Unnamed creek	11.0	6	32.5	fair	27-Aug-10	VRWJPO[2]
07040001-671	08LM121	Unnamed Creek	33.5	9	15.9	n/a	28-Aug-08	MPCA
07040001-671	08LM121	Unnamed Creek	33.5	9	24.6	n/a	04-Sep-09	VRWJPO[2]
07040001-671	08LM121	Unnamed Creek	33.5	9	28.8	n/a	04-Sep-09	VRWJPO[2]
07040001-671	08LM121	Unnamed Creek	33.5	9	50.6	n/a	10-Sep-10	VRWJPO[2]
07040001-680	08LM120	Trib. to Vermillion River	0.7	6	20.7	poor	28-Aug-08	MPCA
07040001-697	08LM126	Trib. to Rice Lake	10.3	6	5.7	poor	09-Sep-08	MPCA
07040001-707	09LM007	Vermillion River, South Branch	30.1	9	11.6	n/a	02-Sep-09	VRWJPO[2]
07040001-707	09LM007	Vermillion River, South Branch	30.1	9	8.1	n/a	10-Sep-10	VRWJPO[2]
07040001-707	09LM007	Vermillion River, South Branch	30.1	9	26.0	n/a	10-Sep-10	VRWJPO[2]

[1] The MPCA has not yet determined appropriate thresholds for channelized cold water streams.

[2] Data was provided by Vermillion River Watershed Joint Powers Organization.

Appendix 10. MINLEAP modeling results

Lake ID	Lake Name	Obs TP	MINLEAP TP	Obs Chl-a	MINLEAP Chl-a	Obs Secchi	MINLEAP Secchi	Average TP Inflow	TP Load	Backgroun d TP	P Retention	Outflow	Residence Time	Areal Load
		ug/L	ug/L	ug/L	ug/L	m	m	ug/L	kg/yr	ug/L	%	hm3/yr	years	m/yr
19-0004-00	Isabelle	-	-	-	-	0.2		505	14	-	-	0.03	9.2	0.06
19-0021-00	Alimagnet	119	59	53.8	25	0.7	1.2	167	90	-	65	0.54	1.2	1.28
19-0022-00	Long	309	239	192.7	196	0.3	0.3	569	294	-	58	0.52	0.2	3.27
19-0023-00	Farquar	200	218	141.4	172	0.4	0.4	569	618	-	62	1.09	0.3	4.02
19-0026-01	Marion (East Bay)	44	64	27.4	28	1.9	1.1	157	419	-	60	2.67	0.8	2.56
19-0041-00	Marcott	25	298	3.4	270	2.4	0.3	570	942	-	48	1.65	0.1	18.36
19-0051-00	Horseshoe	33	272	4.4	236	2.0	0.3	570	320	-	52	0.56	0.2	9.38
19-0342-00	Unnamed	48	358	24.3	353	-	-	570	945	-	37	1.66	0.1	29.09
19-0348-00	Unnamed	62	64	26.3	29	1.7	1.1	159	10	-	60	0.06	0.8	2.22
19-0349-00	Unnamed	188	116	143.4	68	0.5	0.6	149	626	-	22	4.21	0.0	35.11
19-0456-00	Cobblestone	57	86	31.0	44	0.8	0.8	150	261	-	43	1.74	0.2	11.58