Two Rivers Watershed Monitoring and Assessment Report

Minnesota Pollution Control Agency

November 2016

Authors

MPCA Two Rivers Watershed Report Team: Anthony J. Dingmann, Michael Bourdaghs, Andrew Butzer, Dave Christopherson, David Duffey, Mark Gernes, Joseph Hadash, Nate Sather, Michael Sharp, Bruce Monson, Scott Niemela, Shawn Nelson, Danielle Kvasager, Kris Parson

International Water Institute
Kittson Country Soil and Water Conservation District
Minnesota Department of Natural Resources
Minnesota Department of Health
Minnesota Department of Agriculture
Two Rivers Watershed District

Contributors/acknowledgements

Citizen Stream Monitoring Program Volunteers

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

The MPCA is reducing printing and mailing costs by using the Internet to distribute reports and information to wider audience. Visit our website for more information.

MPCA reports are printed on 100% post-consumer recycled content paper manufactured without chlorine or chlorine derivatives.

Minnesota Pollution Control Agency

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

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

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

Document number: wq-ws3-09020312b

List of acronyms

AUID Assessment Unit Identification Determination

CCSI Channel Condition and Stability Index

CD County Ditch

Chl-a Chlorophyll-a

CI Confidence Interval

CLMP Citizen Lake Monitoring Program

CR County Road

CSAH County State Aid Highway

CSMP Citizen Stream Monitoring Program

CWA Clean Water Act

CWLA Clean Water Legacy Act

DO Dissolved Oxygen

DOP Dissolved Orthophosphate

E Eutrophic

EPA U.S. Environmental Protection Agency

EQuIS Environmental Quality Information System

E. coli *Escherichia coli*

EXS Exceeds Criteria, Potential Severe Impairment

F-IBI Fish Index of Biotic Integrity

FS Full Support

FQA Floristic Quality Assessment

FWMC Flow Weighted Mean Concentration

H Hypereutrophic

HUC Hydrologic Unit Code

IBI Index of Biotic Integrity

IF Insufficient Information

IWI International Water Institute

IWM Intensive Watershed Monitoring

K Potassium

LAP Lake Agassiz Plain

LRVW Limited Resource Value Water

M Mesotrophic

MCES Metropolitan Council Environmental Services

MDA Minnesota Department of Agriculture

MDH Minnesota Department of Health

M-IBI Macroinvertebrate Index of Biotic Integrity

MINLEAP Minnesota Lake Eutrophication Analysis Procedure

MLRA Major Land Resource Area

MNDNR Minnesota Department of Natural Resources

MPCA Minnesota Pollution Control Agency

MPN Most Probable Number

MSHA Minnesota Stream Habitat Assessment

MTS Meets the Standard

MWP Mixed Wood Plains

MWS Mixed Wood Shield

N Nitrogen

Nitrate-N Nitrate Plus Nitrite Nitrogen

NA Not Assessed

NHD National Hydrologic Dataset

NH_3 Ammonia

NPDES National Pollution Discharge Elimination System

NS Not Supporting

NT No Trend

OP Orthophosphate

P Phosphorous

PCB Polychlorinated Biphenyl

PFC Perfluorochemicals

PFOS Perfluorooctane Sulfonate

PMR Pesticide Monitoring Region

PWI Protected Waters Inventory

RNR River Nutrient Region

SWAG Surface Water Assessment Grant

SWCD Soil and Water Conservation District

TALU Tiered Aquatic Life Uses

TKN Total Kjeldahl Nitrogen

TMDL Total Maximum Daily Load

TP Total Phosphorous

TSS Total Suspended Solids

UAA Use Attainability Analysis

USGS United States Geological Survey

WMA Wildlife Management Area

WPLMN Watershed Pollutant Load Monitoring Network

Contents

Executive summary **1**

Introduction **2**

I. The watershed monitoring approach 3

II. Assessment methodology 9

III. Watershed overview 15

IV. Watershed-wide data collection methodology 27

V. Individual HUC-11 subwatershed results 31

Upper South Fork Two Rivers Subwatershed HUC 09020312010 33

State Ditch #95 Subwatershed HUC 09020312020 43

Lower South Fork Two Rivers Subwatershed HUC 09020312030 49

Middle Branch, Two Rivers Subwatershed HUC 09020312040 58

North Branch, Two Rivers Subwatershed HUC 09020312050 63

VI. Watershed-wide results and discussion 72

VII. Summaries and recommendations 98

Literature cited **101**

Appendix 1-Water chemistry definitions 104

Appendix 2 - Intensive watershed monitoring water chemistry stations in the Two Rivers Watershed 106

Appendix 3 - AUID table of stream assessment results (by parameter and beneficial use). 107

Appendix 4-Assessment results for lakes in the Two Rivers Watershed 110

Appendix 5 - Minnesota statewide IBI thresholds and confidence limits 111

Appendix 6. Two Rivers Watershed F-IBI and M-IBI thresholds and results. 112

Appendix 6.1 - Biological monitoring results – F-IBI (assessable reaches). 112

Appendix 6.2 – Biological monitoring results – M-IBI (assessable reaches). 114

Appendix 7 - Minnesota's ecoregion-based lake eutrophication standards. 116

Appendix 8 – Fish species found during biological monitoring surveys. 117

Appendix 9 – Macroinvertebrate species found during biological monitoring surveys. 119

List of Tables

Table 1. Table of proposed Tiered Aquatic Life Use (TALU) Standards. 10
Table 2. Aquatic life and recreation assessments on stream reaches: Upper South Fork Two Rivers Subwatershed. Reaches are organized upstream to downstream in the table. 34
Table 3. MSHA: Upper South Fork Two Rivers Subwatershed. 35
Table 4. Lake assessments: Upper South Branch Two Rivers Subwatershed. 35
Table 5. Outlet water chemistry results: Upper South Fork Two Rivers Subwatershed. 36
Table 6. Aquatic life and recreation assessments on stream reaches: State Ditch #95 Subwatershed. Reaches are organized upstream to downstream in the table. 44
Table 7. MSHA: State Ditch #95 Subwatershed. 44
Table 8. Outlet water chemistry results: State Ditch #95 Subwatershed. 45
Table 9. Aquatic life and recreation assessments on stream reaches: Lower South Fork Two Rivers Subwatershed. Reaches are organized upstream to downstream in the table. 50
Table 10. MSHA: Lower South Fork Two Rivers Subwatershed. 51
Table 11. Channel Condition and Stability Assessment (CCSI): Lower South Fork Two Rivers Subwatershed. 51
Table 12. Outlet water chemistry results: Lower South Fork Two Rivers Subwatershed. 52
Table 13. Aquatic life and recreation assessments on stream reaches: Middle Branch, Two Rivers Subwatershed. Reaches are organized upstream to downstream in the table. 59
Table 14. MSHA: Middle Branch, Two Rivers Subwatershed. 59
Table 16. Aquatic life and recreation assessments on stream reaches: North Branch, Two Rivers Subwatershed. Reaches are organized upstream to downstream in the table. 64
Table 17. MSHA: North Branch, Two Rivers Subwatershed. 65
Table 18. Outlet water chemistry results: North Branch, Two Rivers Subwatershed. 66
Table 19. WPLMN Stream Monitoring Sites for the Two Rivers Watershed. 72
Table 20. Annual Pollutant Loads (kg) for the Two River near Hallock, Minnesota. 75
Table 21. Mean TP and DOP concentrations during July and the remainder of the year for the Two River near Hallock, Minnesota. 79
Table 22. Assessment summary for stream water quality in the Two Rivers Watershed. 80
Table 23. Assessment summary for lake water chemistry in the Two Rivers Watershed. 81
Table 24. Fish species codes, common names, and scientific names. 83
Table 25. Summary statistics of fish lengths, mercury, and PCBs by waterway species-year. 83
Table 26. Vegetation condition of all wetlands by extent (MPCA 2015). 90
Table 27. Two Rivers on US-75, 1 mile N of Hallock (S000-186)(TMB-19) (period of record 1971 - 2010). 92
Table 28. Water clarity trends at citizen stream monitoring sites. 92

List of Figures

Figure 1. Major watersheds within Minnesota (8 digit HUC scale). 3
Figure 2. WPLMN monitoring sites in the Two Rivers Watershed. 4
Figure 3. The IWM Design. 5
Figure 4. Intensive watershed monitoring sites for streams in the Two Rivers Watershed. 6
Figure 5. Monitoring locations of MPCA, Citizen Volunteers, and Local Partners in the Two Rivers Watershed. 8
Figure 6. Flowchart of aquatic life use assessment process. 13
Figure 7. The Two Rivers Watershed within the Lake Agassiz and Northern Minnesota Wetlands ecoregions of Northwest Minnesota. 18
Figure 8. Major Land Resource Areas (MLRA) in the Two Rivers Watershed 19
Figure 9. Land use in the Two Rivers Watershed. 20
Figure 10. Map of percent modified streams by major watershed (HUC-8). 22
Figure 11. Comparison of natural to altered streams in the Two Rivers Watershed (percentages derived from the State-wide Altered Water Course project). 23
Figure 12. State-wide precipitation levels during the 2013 water year. 24
Figure 13. Precipitation trends in Northwestern Minnesota (1995-2014) with five year running average. 24
Figure 14. Precipitation trends in northwestern Minnesota (1915-2015) with ten year running average. 25
Figure 15. Western province generalized cross section (Source: MNDNR, 2001). 26
Figure 16. 2009-2013 hydrograph, sampling regime and annual runoff for the Two River near Hallock, Minnesota. 27
Figure 17. Lake Bronson dam located at the outlet of Lake Bronson on the South Branch, Two Rivers. 41
Figure 18. Rock grade control structure possibly affecting fish passage on AUID -522. 41
Figure 19. Currently listed impaired waters by parameter and land use characteristics in the Upper South Fork Two Rivers Subwatershed 42
Figure 20. Currently listed impaired waters by parameter and land use characteristics in the State Ditch #95 Subwatershed 48
Figure 21. Dam located on the South Branch, Two Rivers upstream of Hallock, Minnesota. 56
Figure 22. Normal flow (left) versus high flows (right) at 05RD004. 56
Figure 23. Currently listed impaired waters by parameter and land use characteristics in the Lower South Fork Two Rivers Subwatershed. 57
Figure 24. Currently listed impaired waters by parameter and land use characteristics in the Middle Branch, Two Rivers Subwatershed. 62
Figure 25. Horseshoe Lake Dam on AUID -514. 70
Figure 26. Currently listed impaired waters by parameter and land use characteristics in the North Branch, Two Rivers Subwatershed. 71
Figure 27. Percent land disturbance and NLCD 2011 land use for the state of Minnesota. 73
Figure 28. 2007-2013 WPLMN average annual TSS, TP, NO3-NO2-N and DOP FWMCs by major watershed. 74
Figure 29. TSS FWMCs and Loads for the Two River near Hallock, Minnesota. 76
Figure 30. Monthly percentages of the average annual TSS load for the Two River near Hallock, 2009-2013. 76
Figure 31. TSS load duration curve for Two River near Hallock, Minnesota, 2009-2014. 77
Figure 32. TP Flow Weighted Mean Concentrations and Loads for the Two River near Hallock, Minnesota. 78
Figure 33. Monthly percentages of the average annual NO3-NO2-N and TP loads for the Two Rivers near Hallock, 2009-2013. 78
Figure 34. NO3+NO2-N Flow Weighted Mean Concentrations and Loads for the Two River near Hallock, Minnesota. 80
Figure 35. Arsenic Occurrence in New Wells in the Two Rivers Watershed area (2008-2012). 84
Figure 36. Average Annual Recharge Rate to Surficial Materials in Snake River Watershed (1971-2000). 85
Figure 37. Locations of active permitted groundwater and surface water withdrawals in the Two Rivers Watershed. 86
Figure 38. Total annual groundwater and surface water withdrawals in the Two Rivers Watershed. 86
Figure 39. Mean Annual Discharge, South Branch Two Rivers at Lake Bronson, MN (1993-2013). 87

Figure 40. Mean July/August discharge, South Branch Two Rivers at Lake Bronson, MN (1993-2013)............87
Figure 41. Wetlands and surface water in the Two Rivers Watershed. Wetland data are from the National Wetlands Inventory. 88
Figure 42. Historical wetland loss by sub-watershed in the Two Rivers Watershed. 89
Figure 43. Wetland vegetation monitoring results in the Two Rivers Watershed. 91
Figure 44. Fully supporting waters by designated use in the Two Rivers Watershed. 93
Figure 45. Impaired waters by designated use in the Two Rivers Watershed. 94
Figure 46. Aquatic consumption use support in the Two Rivers Watershed. 95
Figure 47. Aquatic life use support in the Two Rivers Watershed..96
Figure 48. Aquatic recreation use support in the Two Rivers Watershed. 97

Executive summary

The Two Rivers Watershed (09020312) encompasses portions of Roseau, Kittson, and Marshall Counties covering 932 mi^2 and draining approximately 596,350 acres (NRCS, 2008). The watershed consists of three branches of the Two Rivers – the South, Middle, and North. The South Branch arises southeast of Badger and flows southwest to the town of Pelan where it turns and flows northwest while the Middle Branch begins northeast of Lake Bronson and flows westerly. The South Branch flows into the Middle Branch on the eastern edge of the town of Hallock. The North Branch begins northeast of Lancaster and flows west to its confluence with the Middle Branch west of Hallock, forming the main stem Two River roughly five river miles before outletting into the Red River of the North. The Two Rivers Watershed has 54 basins (waterbodies with a MNDNR lake ID) greater than 10 acres and 52 named stream assessment units (AUIDs).

The Two River and its tributaries provide habitat for aquatic life, riparian corridors for wildlife, and recreational opportunities such as fishing, swimming, and canoeing. Today, roughly 64% of the watersheds landscape is utilized for cropland, 16% is wetlands, 10% is forested, 5% is rangeland, 4% is residential housing, business and industrial complexes, and less than 1% is open water (Figure 7).

In 2013, the Minnesota Pollution Control Agency (MPCA) initiated an intensive watershed monitoring (IWM) effort of the Two Rivers Watershed's surface waters. Thirty-two stream sites were sampled for biology at the outlets of variable sized subwatersheds within the Two Rivers Watershed. These locations included the mainstem Two River, major tributaries, and the headwaters of smaller streams. As part of this effort, MPCA staff joined with the International Water Institute, Kittson County Soil and Water Conservation District, and The Friends of Lake Bronson State Park to complete stream and lake water chemistry sampling. In 2015, a holistic approach was taken to assess all of the watershed's surface waterbodies for aquatic life, recreation, and fish consumption, where sufficient data were available. Twenty-three stream segments (i.e., AUIDs) and one lake (Lake Bronson 35-0003-00) were assessed in this effort. Not all lake and stream AUIDs were able to be assessed due to insufficient data. Most of the basins in the watershed were small, shallow basins that have wetland characteristics, making them not assessable as lakes.

Throughout the watershed, six streams fully support aquatic life and six fully support aquatic recreation. Fifteen streams do not support aquatic life and five do not support aquatic recreation (Appendix 3 - AUID table of stream assessment results (by parameter and beneficial use)). The aquatic recreation impairments are due to high bacteria levels. One AUID that was previously determined to be impaired for aquatic life due to high total suspended solids (TSS) levels will be proposed for delisting: North Branch, Two Rivers (AUID 09020312-508).

It was not possible to determine the impairment status for aquatic life and aquatic recreation in Lake Bronson because the data were inconclusive. Total phosphorus levels exceeded the recreation standards, but chlorophyll-a (chl-a), chloride, and Secchi tube depth met standards. There was no biological data available to calculate a F-IBI or Plant-IBIs.

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

Introduction

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

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

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

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

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

I. The watershed monitoring approach

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

Watershed Pollutant Load Monitoring Network

The Watershed Pollutant Load Monitoring Network (WPLMN) is a long-term program designed to measure and compare regional differences and long-term trends in water quality among Minnesota's major rivers including the Red, Rainy, St. Croix, Mississippi, and Minnesota, and the outlets of the major tributaries (8-digit hydrologic unit code (HUC) scale) draining to these rivers. Since the program's inception in 2007, the WPLMN has adopted a multi-agency monitoring design that combines site specific stream flow data from United States Geological Survey (USGS) and the Minnesota Department of Natural Resources (MNDNR) flow gaging stations with water quality data collected by the Metropolitan Council Environmental Services (MCES), local monitoring organizations, and MPCA to compute pollutant loads for 199 stream and river monitoring sites across Minnesota. Monitoring sites span three ranges of scale with annual loads calculated for Basin and Major Watershed sites and seasonal loads for subwatershed sites:

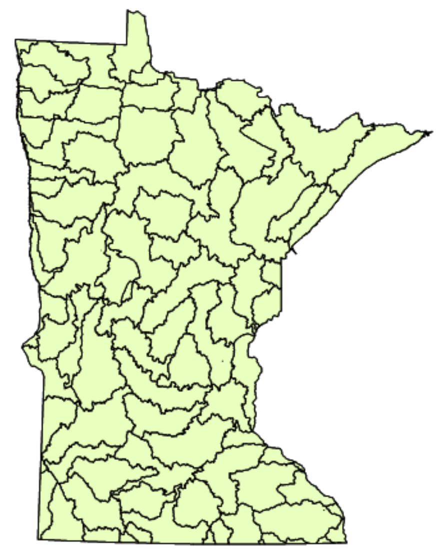

Figure 1. Major watersheds within Minnesota (8 digit HUC scale).

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

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

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

Data will also be used to assist with: TMDL studies and implementation plans; watershed modeling efforts; watershed research projects; and watershed restoration and protection strategies. More information can be found at the WPLMN website including a map of the sites.

The Two River near Hallock site on County State Aid Highway (CSAH) 16 (DNR/MPCA ID 70012001, EQuIS ID S000-569) is the furthest downstream WPLMN monitoring site in the Two Rivers Watershed and drains an area of approximately 932 mi^2 (Figure 2). The gage is operated by the MNDNR and is located approximately five river miles above the confluence of the Two River with the Red River near Hallock, Minnesota. An average of 29 mid-stream grab samples per year were collected from this site between 2009 and 2013. Three subwatershed sites were also established in the watershed during 2013; the South Branch, Two Rivers at Lake Bronson, at US Highway 59 (MNDNR/MPCA ID 70033001, USGS ID 05094000, EQuIS ID S002-365); the South Branch, Two Rivers at Hallock at MN Highway 175 (MNDNR/MPCA ID 70018001, EQuIS ID S005-387); and the North Branch, Two Rivers near Northcote, County Road 65 (MNDNR/MPCA ID 7002002, EQuIS ID S008-208).

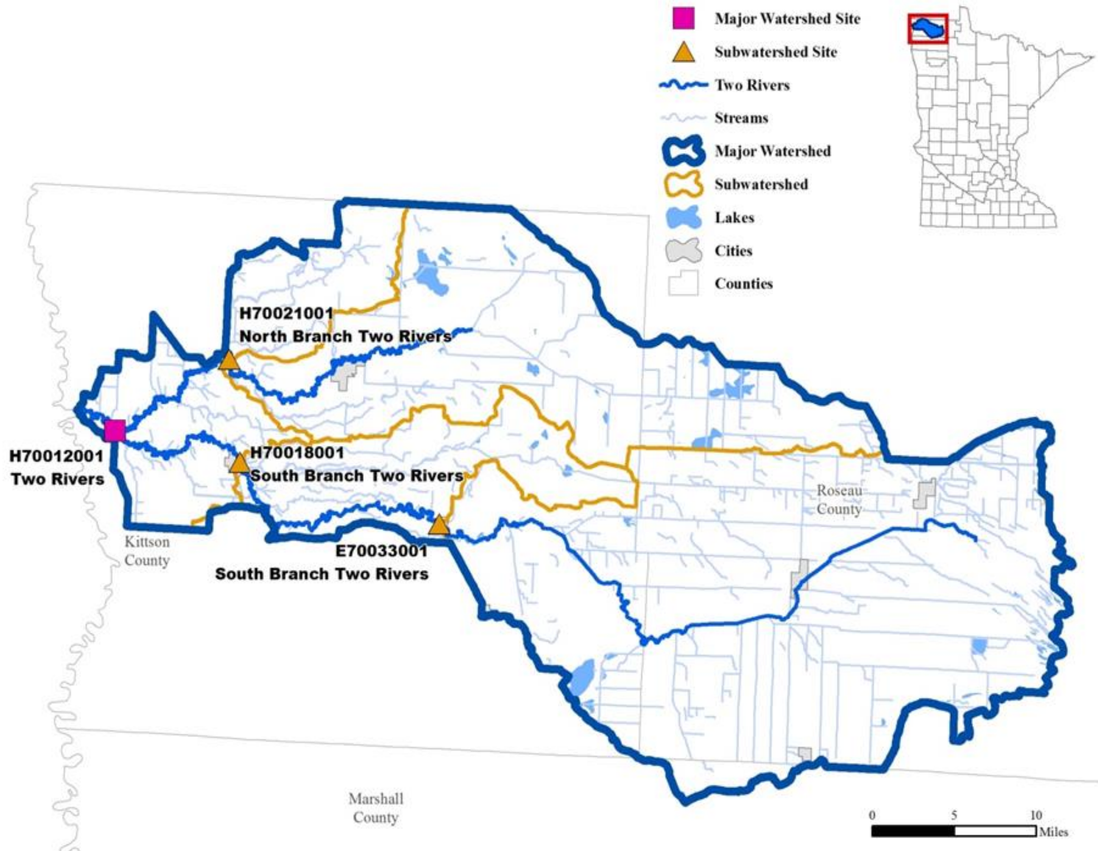

Figure 2. WPLMN monitoring sites in the Two Rivers Watershed.

Intensive watershed monitoring

The IWM strategy utilizes a nested watershed design allowing the sampling of streams within watersheds from a coarse to a fine scale (Figure 3). Each watershed scale is defined by a hydrologic unit code (HUC). These HUCs define watershed boundaries for water bodies within a similar geographic and hydrologic extent. The foundation of this approach is the 80 major watersheds (HUC-8) within Minnesota. Using this approach, many of the smaller headwaters and tributaries to the main stem river are sampled in a systematic way so that a more holistic assessment of the watershed can be conducted and problem areas identified without monitoring every stream reach. Each major watershed is the focus of attention for at least one year within the 10-year cycle.

River/stream sites are selected near the outlet of each of three watershed scales, HUC-8, HUC-11, and HUC-14 (Figure 3). Within each scale, different water uses are assessed based on the opportunity for that use (i.e., fishing, swimming, and supporting aquatic life such as fish and insects). The major river watershed is represented by the HUC-8 scale. The outlet of the major HUC-8 watershed (purple dot in Figure 4) is sampled for biology (fish and macroinvertebrates), water chemistry, and fish contaminants to allow for the assessment of aquatic life, aquatic recreation, and aquatic consumption use support. The HUC-11 is the next smaller subwatershed scale which generally consists of major tributary streams with drainage areas ranging from 75 to 150 mi^2. Each HUC-11 outlet (green dots in Figure 4 is sampled for biology and water chemistry for the assessment of aquatic life and aquatic recreation use support.

Within each HUC-11, smaller watersheds (HUC-14s, typically 10-20 mi^2), are sampled at each outlet that flows into the major HUC-11 tributaries. Each of these minor subwatershed outlets is sampled for biology to assess aquatic life use support (red dots in Figure 4).

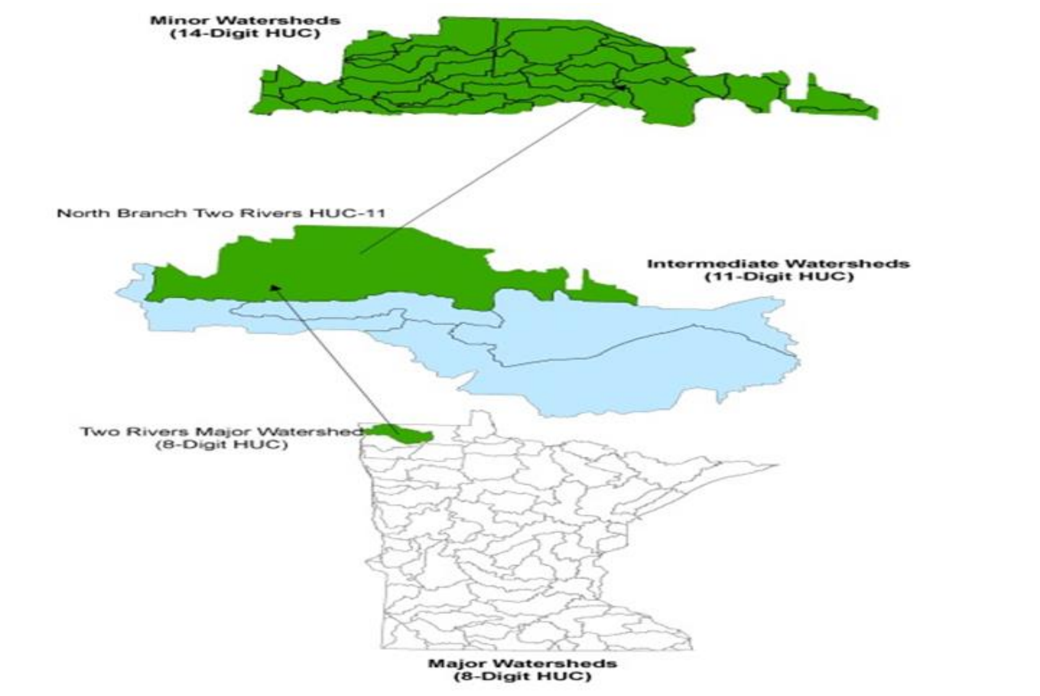

Figure 3. The IWM Design.

Within the IWM strategy, lakes are selected to represent the range of conditions and lake type (size and depth) found within the watershed. Lakes most heavily used for recreation (all those greater than 500 acres and at least 25% of lakes 100-499 acres) are monitored for water chemistry to determine if recreational uses, such as swimming and wading, are being supported. Lakes are sampled monthly from May-September for a two-year period. The lone lake to be monitored within this watershed was Lake Bronson.

Specific locations for sites sampled as part of the intensive monitoring effort in the Two Rivers Watershed are shown in Figure 4 and are listed in Appendix 2, Appendix 6.1, and Appendix 6.2.

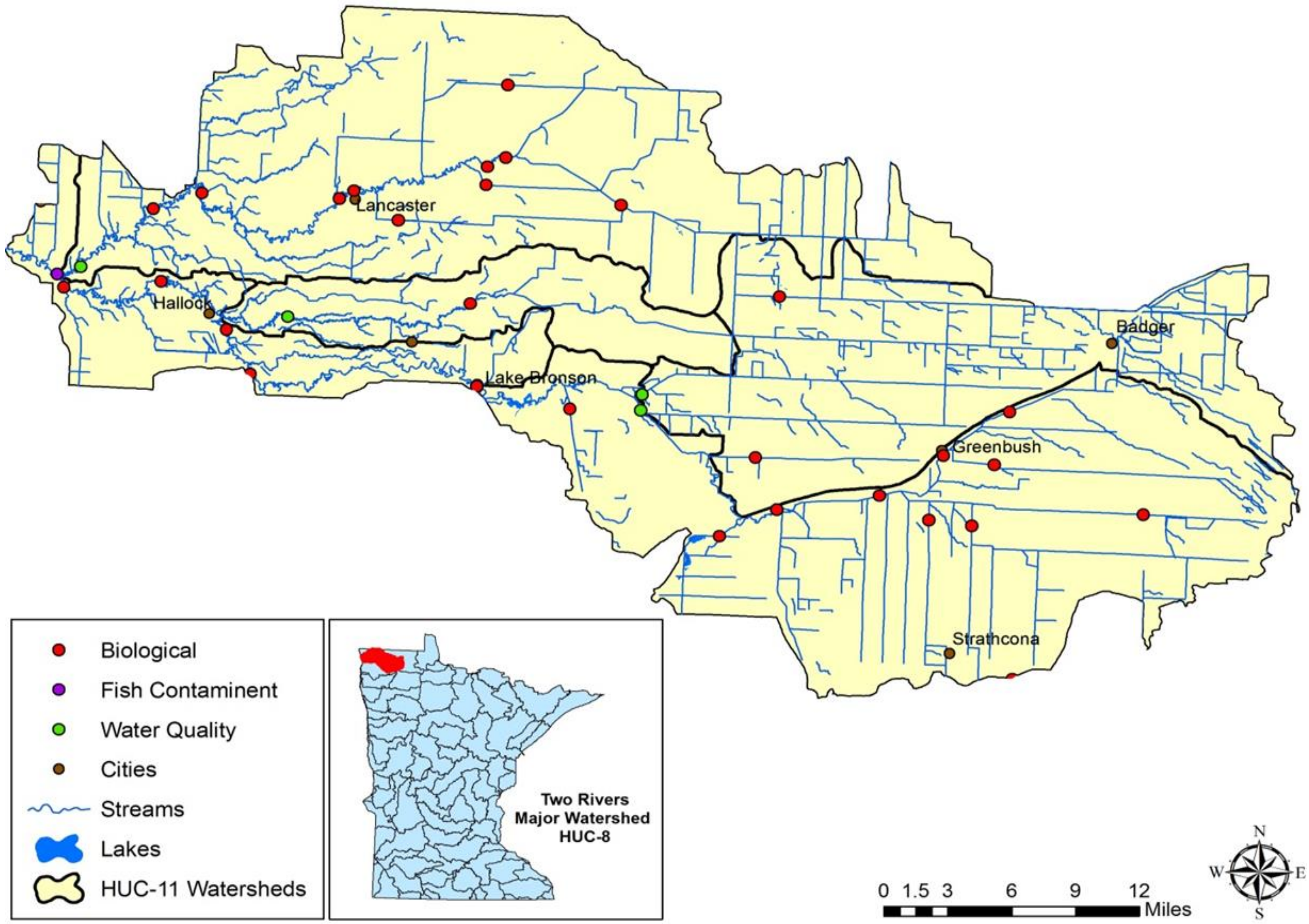

Figure 4. Intensive watershed monitoring sites for streams in the Two Rivers Watershed.

Citizen and local monitoring

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

The MPCA also coordinates two programs aimed at encouraging long term citizen surface water monitoring: Citizen Lake Monitoring Program (CLMP) and the Citizen Stream Monitoring Program (CSMP). Like the permanent load monitoring network, having citizen volunteers monitor a given lake or stream site monthly and from year to year can provide the long-term picture needed to help evaluate current status and trends. Citizen monitoring is especially effective at helping to track water quality changes that occur in the years between intensive monitoring years. Figure 5 provides an illustration of the locations where citizen monitoring data were used for assessment in the Two Rivers Watershed.

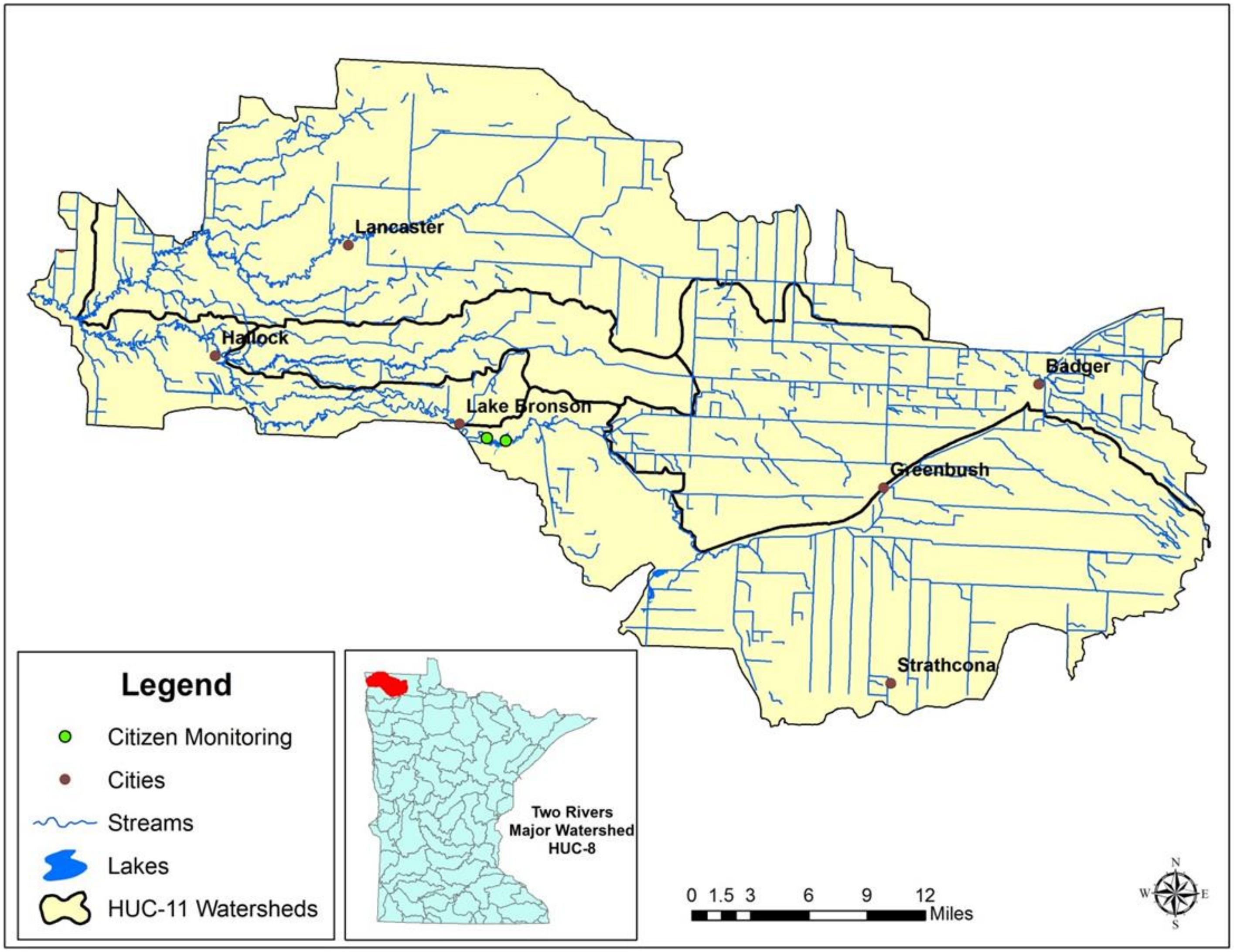

Figure 5. Monitoring locations of MPCA, Citizen Volunteers, and Local Partners in the Two Rivers Watershed.

II. Assessment methodology

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

Water quality standards

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

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

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

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

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

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

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

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

Assessment units

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

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

Determining use attainment

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

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

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

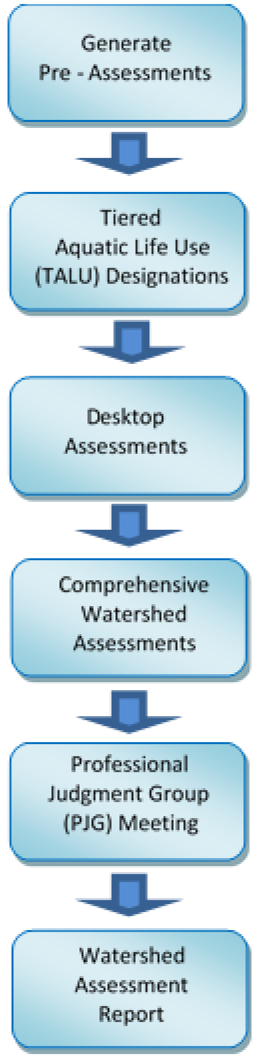

Figure 6. Flowchart of aquatic life use assessment process.

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

The last step in the assessment process is the Professional Judgment Group (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 be responsible for local watershed reports and project planning. Information obtained during this meeting may be used to revise previous use attainment decisions (e.g., sampling events that may have been uncharacteristic due to annual climate, flow variation, and/or local factors such as impoundments that do not represent the majority of conditions on the AUID).

Waterbodies that do not meet standards and therefore do not attain one or more of their designated uses are considered impaired waters and are placed on the draft 303(d) Impaired Waters List. Assessment results are also included in watershed monitoring and assessment reports.

Data management

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

Period of record

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

III. Watershed overview

Physical setting

The Two Rivers Watershed encompasses portions of Roseau, Kittson, and Marshall Counties covering 932 mi^2 and drains approximately 596,350 acres (NRCS, 2008). The watershed actually consists of three different branches of the Two Rivers – the South, Middle, and North. The South Branch arises southeast of Badger and flows in a westerly direction. The Middle Branch drainage area begins east of the Kittson and Roseau County line and travels through the central portion of Kittson County, outletting into the South Branch just east of the city of Hallock. The North Branch drainage area begins in northwestern Roseau County, and joins the South Branch to form the main stem Two Rivers three miles east of where it outlets into the Red River of the North (MPCA, Two Rivers Webpage).

The Two Rivers is located within the Lake Agassiz Plain which covers approximately 15,690 mi^2 and was created approximately 10,000 years ago when great continental glaciers of North America started to recede to the north (USGS, Webpage). The melting ice formed many large glacial lakes, the last of which was Glacial Lake Agassiz which filled the Red River Valley. Today, what remains is an extremely flat lake plain, with an average gradient of about six inches per mile, a lake washed till plain, and gently rolling uplands along the eastern and western edges of the Red River Valley (USGS, Webpage).

These flat plain areas combined with their rich and loamy soils, make the Red River Valley one of the most productive agricultural regions in the Great Plains (USGS, Webpage). The intensively farmed region of the Two Rivers watershed coincides with two major ecoregions Figure 7 and Figure 9, as the ecoregions change, so does the land use types. The very flat and poorly defined floodplains however, lead to the region experiencing numerous major floods over the years. These floods have led to the creation of extensive man-made drainage networks (channelization) designed to remove surface water quickly from agricultural lands. Today, rapid surface water removal from agricultural fields continues to be a focus with underground tile piping becoming widely used within the region.

History

Through archaeological expeditions performed in the 1930s and the 1970s, evidence of occupation dating back 1,800 years has been confirmed around the burial mounds that are located on the sand ridges in the eastern part of the Kittson County. Early civilizations date back to the "Woodland Period" where evidence shows that Laurel, Arvilla, St. Croix, and Blackduck people were the early occupants of the area. However, approximately 400 years ago, the Cree, Assiniboin, Sioux, and Ojibway inhabited the area (Visit Northwest Minnesota, Webpage).

The first non-Native American explorers to visit the region were fur traders. Pembina, North Dakota's oldest settlement, which is located just across the Red River of the North from St. Vincent, dates its beginning to 1797, when the first trading post was established by Charles Baptiste Chaboillez of the Northwest Fur Company. The fur traders and voyageurs traveled on the eastern side of the Red River, which eventually would be Kittson County. Alexander Henry, who erected a fort for the Northwest Fur Company in Pembina, is considered to be the first white man to test agriculture in the valley. In the early 1800's Red River Ox Cart trails were developed and homesteads around the region began to increase. The need for the ox carts diminished in the mid-1800s as the steamboats became the new mode for transporting furs and supplies.

The first non-Native American settlement was established in 1857, at St. Vincent, Minnesota. With rumors of a railroad coming through, settlers moved across the river from Pembina to stake their claims. Twenty years later, in 1878, the St. Paul and Pacific Railroad line finally reached St. Vincent and opened up the area to settlement. It wasn't until the early 1900s that the eastern portion of the county was settled. The Soo Line railroad was completed in 1904, and more settlements soon followed (Visit NW Minnesota, webpage). With the increase in settlements, the land use gradually changed from woods and vast prairies to agricultural lands as settlers took advantage of the Red River Valley's rich soils.

Land use summary

Land use within the Two Rivers Watershed is dominated by agriculture with wetlands and forests making up a large remainder of the land use. This is especially true in the central portion of the watershed where a large wetland/forest complex is located running north to south. Smaller forest/wetland areas do exist in other areas throughout the watershed but to a lesser extent. Very little open water occurs within the watershed, with only one lake being present.

The Two Rivers Watershed lies within two of Minnesota's ecoregions (Figure 7). The north-central portion of the watershed lies within the Northern Minnesota Wetlands (NMW) ecoregion while the remainder of the watershed lies in the Lake Agassiz Plain (LAP) ecoregion. The United State Department of Agriculture (USDA) Major Land Resource Areas (MLRA) for the Two Rivers Watershed includes two classifications: the majority of the watershed is classified as Red River Valley of the North, while the extreme southeast portion of the watershed is classified as Northern Minnesota Glacial Lake Basins (Figure 8).

Land cover in the watershed is distributed as follows: 64% cropland, 16% wetlands, 10% forest/shrub, 5% rangeland, 4% developed, and 1% open water (Figure 9). Farmland occurs throughout the watershed, with most farms being smaller family farms, however some operations do exceed 1,000 acres in size. Thirty-seven percent of the operations are less than 180 acres, 44% are from 180 to 1,000 acres and the remaining farms are greater than 1,000 acres (NRCS, 2008). The most common crops grown in the watershed are small grains, sugar beets, corn, and soybeans (NRCS, 2008).

The 2007, population estimates showed approximately 5,015 people reside within the Two Rivers Watershed (NRCS, 2008); equating to roughly five people per square mile. The largest population centers are located in the towns of Hallock, Lancaster, Greenbush, and Badger.

Terrain: The LAP ecoregion is extremely flat with soils that are thick and composed mostly of silt and clay textures. These soils have a high water table and are very productive (NRCS, 2008). The NMW ecoregion is also comprised of mostly flat terrain however this region has areas of gently sloping land where forests, marshes, and wetlands occur. The soils here are much the same as the LAP ecoregion, consisting mostly of silt, clay and loamy soils. The growing season is slightly shorter in these regions compared to southern portions of the state, averaging roughly 120 days (MNDNR, website).

Vegetation: The LAP ecoregion consists primarily of agricultural lands but where natural areas are present, combinations of aspen savannas, tallgrass prairie, wet prairie, and dry gravel prairie exist. In areas where hardwoods are present (mostly along streams and floodplains) species such as silver maple, elm, cottonwood, and ash are most common (MNDNR, website). Similar to the LAP ecoregion, the NMW ecoregion does consist of agricultural lands but to a lesser extent with forests, marshes, and wetlands being more common. In addition to the hardwood species mentioned above, a variety of wetland plant species occur, consisting mostly of rushes, cattails, and sedges.

Wildlife: Whitetail deer, rabbits, squirrels, coyote, multiple hawk species, eagles, and a variety of waterfowl species are common wildlife in both of the ecoregions. Moose and wolves are occasionally seen as well. Common fish species include northern pike, walleye, sauger, channel catfish, and many minnow species.

Land use/human activities: Approximately 82% of the watershed's acreage is privately owned with agricultural farming being the most common private land use (NRCS, 2008). State, county, or federally owned lands make up the remaining land ownerships. Hunting for big and small game, upland birds, and waterfowl commonly take place within the watershed.

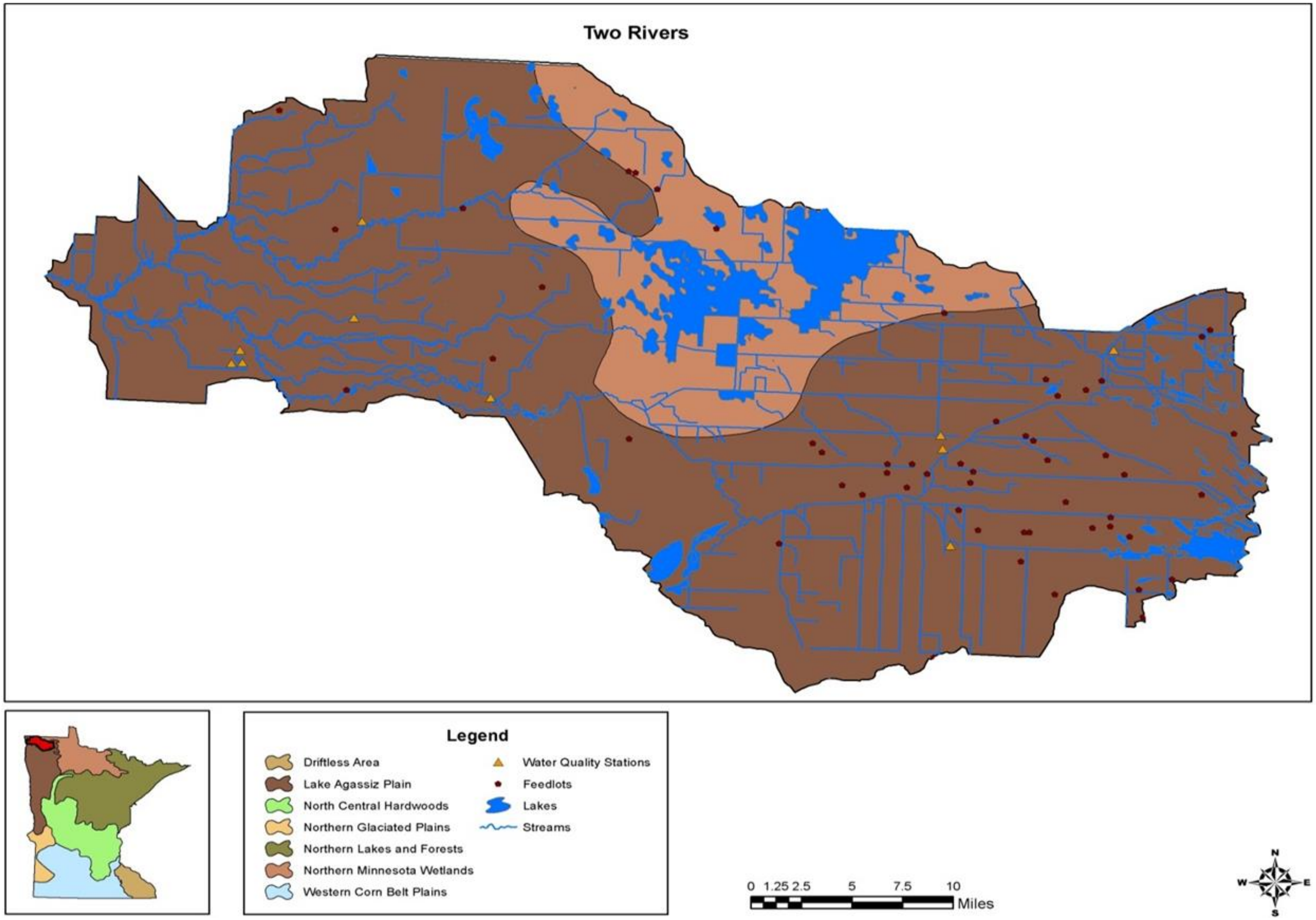

Figure 7. The Two Rivers Watershed within the Lake Agassiz and Northern Minnesota Wetlands ecoregions of Northwest Minnesota.

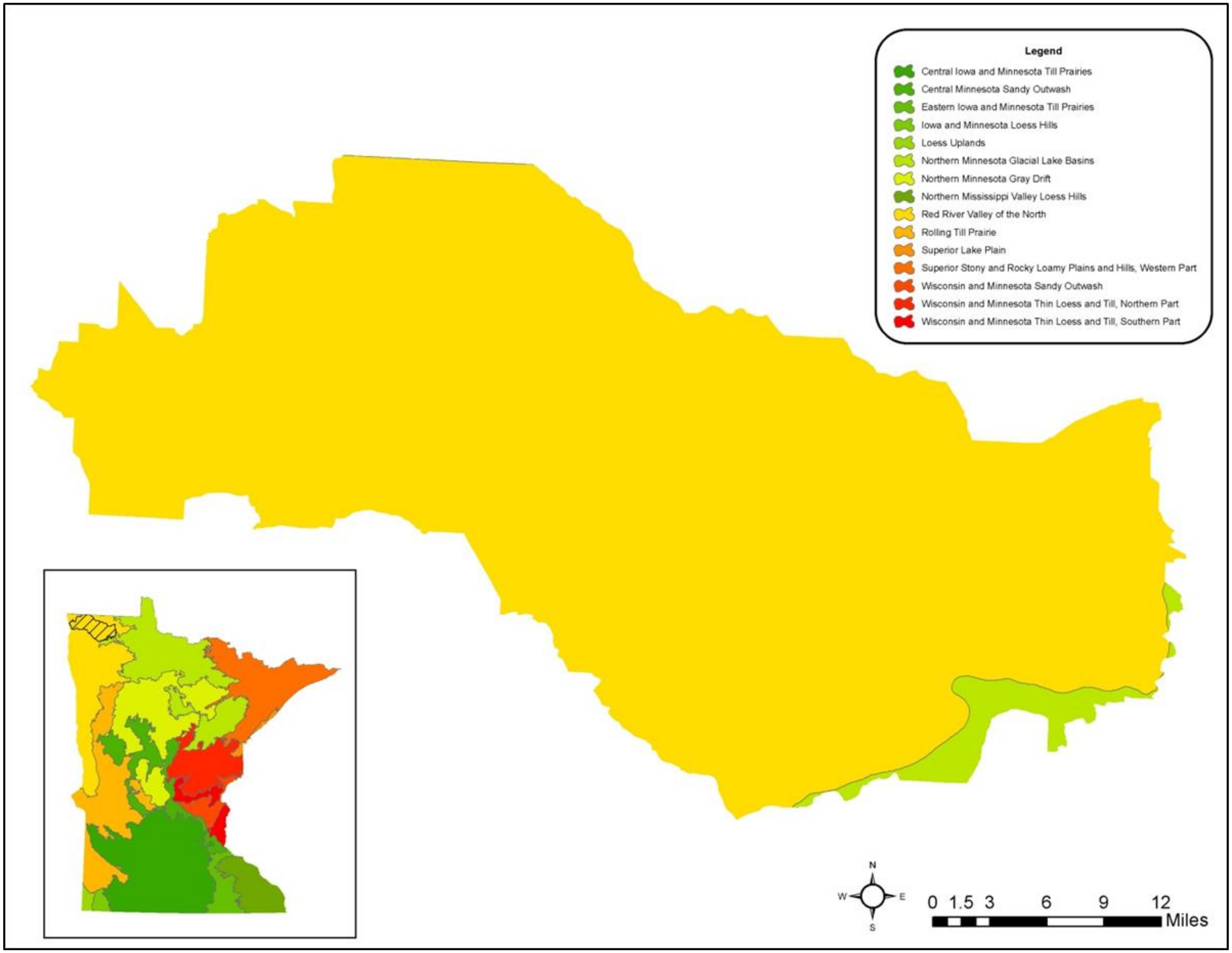

Figure 8. Major Land Resource Areas (MLRA) in the Two Rivers Watershed

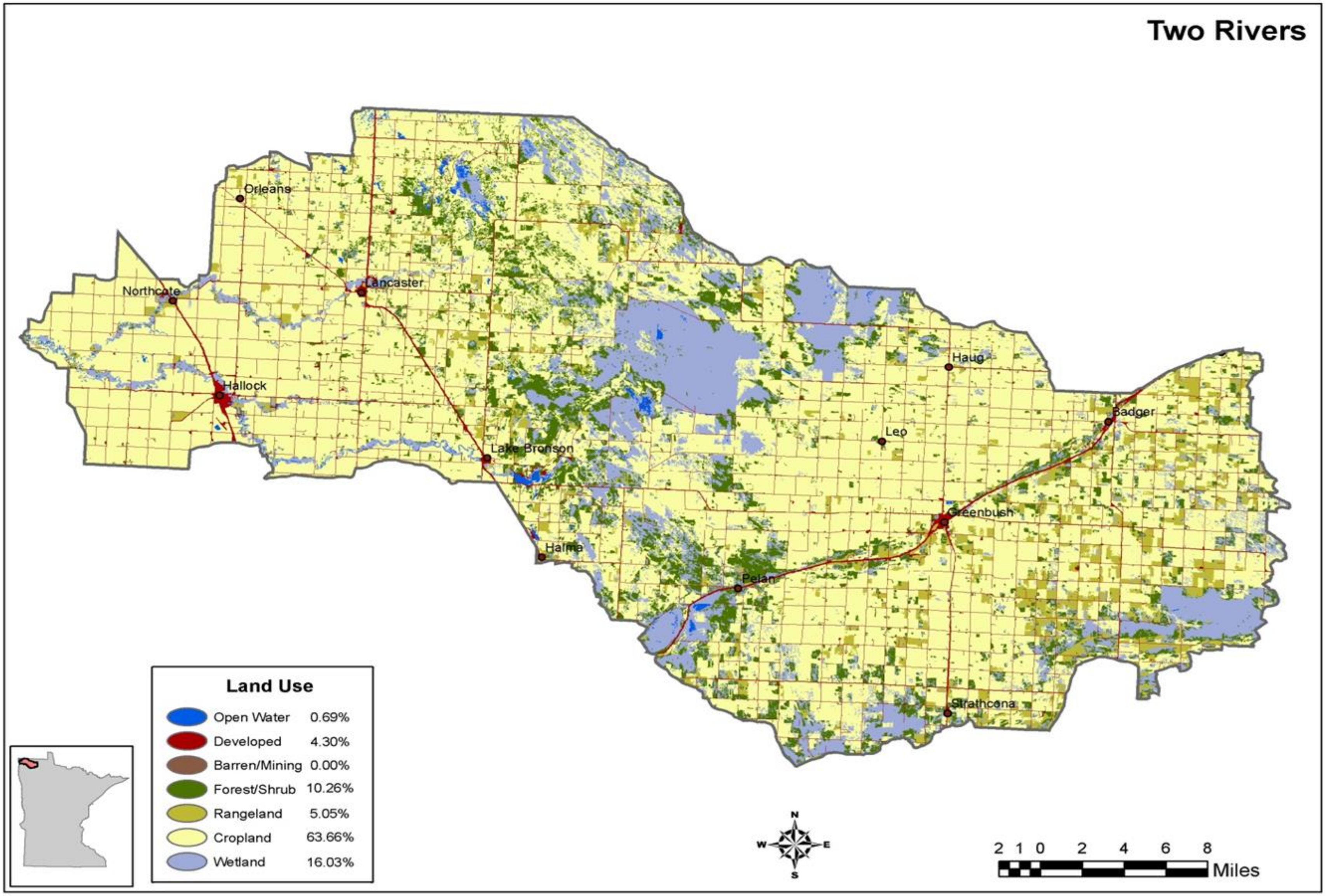

Figure 9. Land use in the Two Rivers Watershed.

Surface water hydrology

The streams within the Two Rivers Watershed are highly impacted by human development similar to other watersheds in surrounding areas (Figure 10). Overall, over 79% of the streams within the watershed have been altered (Figure 11) by channelization and ditching. In addition to stream channel alteration, the creation of dams within the watershed also affects the hydrology and biological communities within the watershed.

The highest elevation of the Two Rivers Watershed is roughly 1,197 feet above sea level and is found in the northeastern portion of the watershed. The elevation decreases as the watershed progresses westerly, to an elevation of 794 feet. The watershed is virtually devoid of lakes, with Lake Bronson being the largest and most utilized. Within the Two Rivers Watershed there are a total of three MNDNR documented dams, all of which are owned and operated by the MNDNR. One is located on State Ditch 90, near Twin Lakes Wildlife Management Area (WMA) which is used to control water levels for vegetation and wildlife management. The remaining two dams are located on the South Branch, Two Rivers. The most upstream of these is located at the outlet of Lake Bronson and was built in 1937, as a way to help conserve water during the drought of 1930s. The dam in turn created an artificial lake which now supports recreational opportunities such as fishing and boating as well as flood control. The most downstream dam is located just upstream of the town of Hallock and is primarily used for flood control.

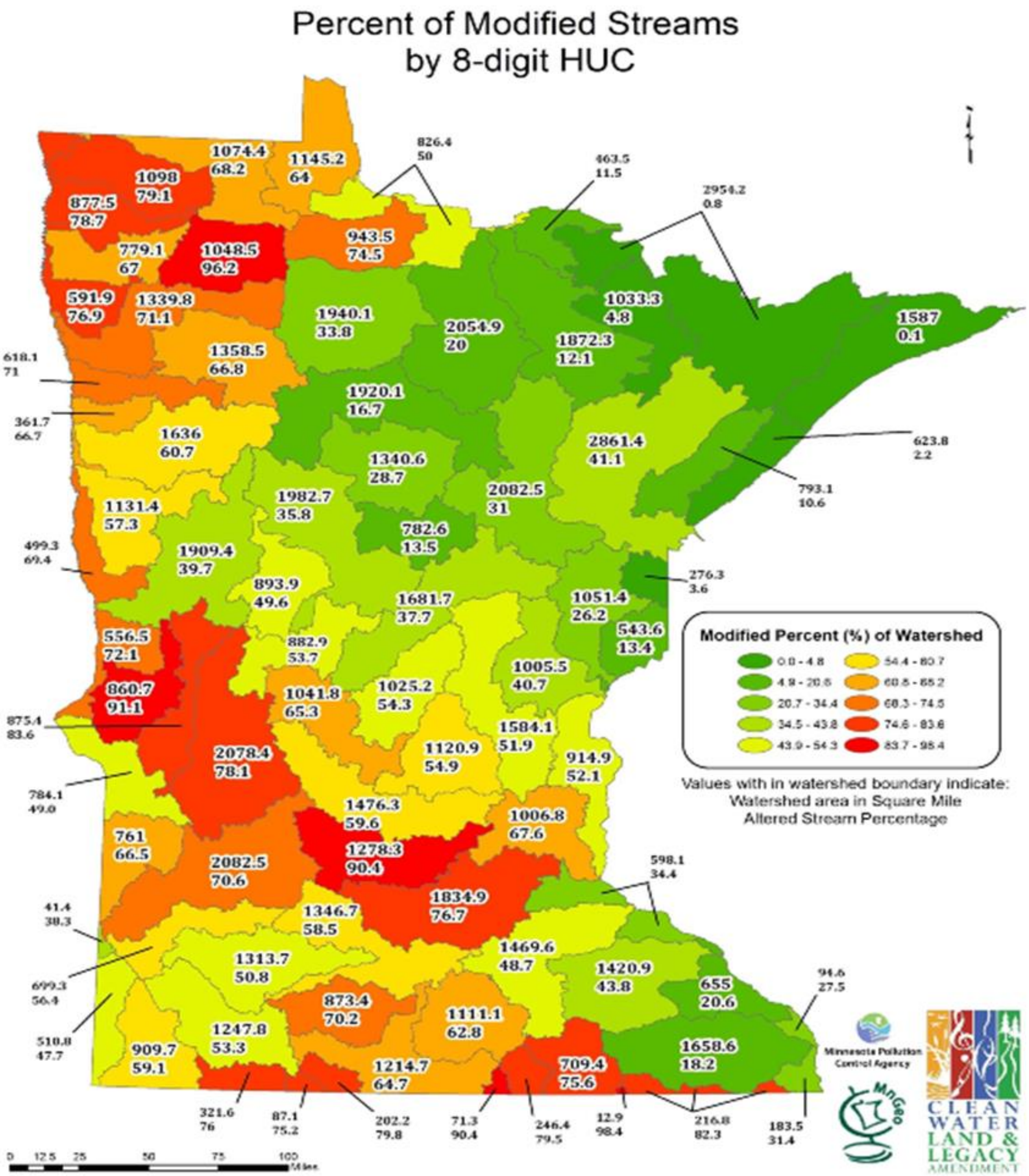

Figure 10. Map of percent modified streams by major watershed (HUC-8).

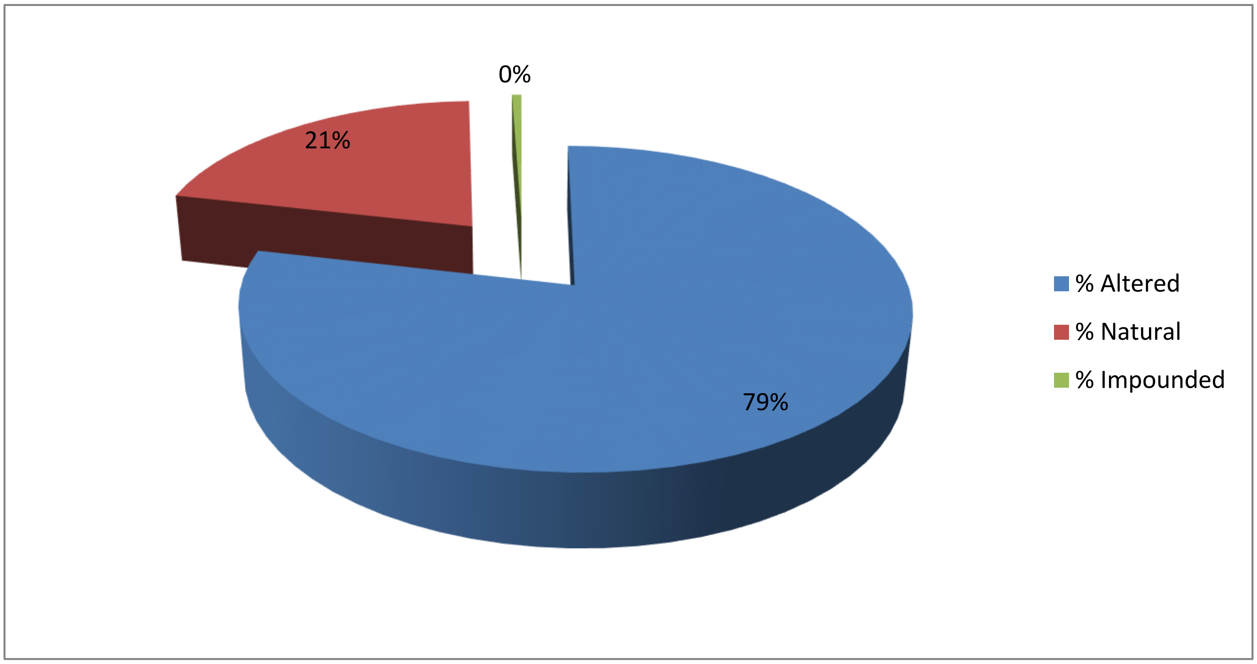

Figure 11. Comparison of natural to altered streams in the Two Rivers Watershed (percentages derived from the State-wide Altered Water Course project).

Climate and precipitation

The ecoregion has a continental climate, marked by warm summers and cold winters. The mean annual temperature for Minnesota is 3˚C; the mean summer temperature for the Two Rivers Watershed is 18.8˚C; and the mean winter temperature is -15˚C (High Plains Regional Climate Center webpage, 2013).

Precipitation is the source of almost all water inputs to a watershed. The Two Rivers Watershed receives 19-21" of precipitation per year. In the water year 2013, the southern and western portions of the watershed received roughly 20" while northern and eastern portions of the watershed received up to 28" of precipitation (Figure 12). The water year 2013, rainfall ranged from normal to seven inches above normal (Figure 12) (MNDNR, 2015).

Figure 13 displays the areal average representation of precipitation in Northwestern Minnesota. An aerial average is a spatial average of all the precipitation data collected within a certain area presented as a single dataset. These data are taken from the Western Regional Climate Center, available as a link off of the University of Minnesota Climate website: http://www.wrcc.dri.edu/spi/divplot1map.html. Though rainfall can vary in intensity and time of year, rainfall totals in the west-central region display no significant trend over the last 20 years. However, precipitation in west central Minnesota exhibits a statistically significant rising trend over the past 100 years (p=0.001) (Figure 14). This is a strong trend and matches similar trends throughout Minnesota.

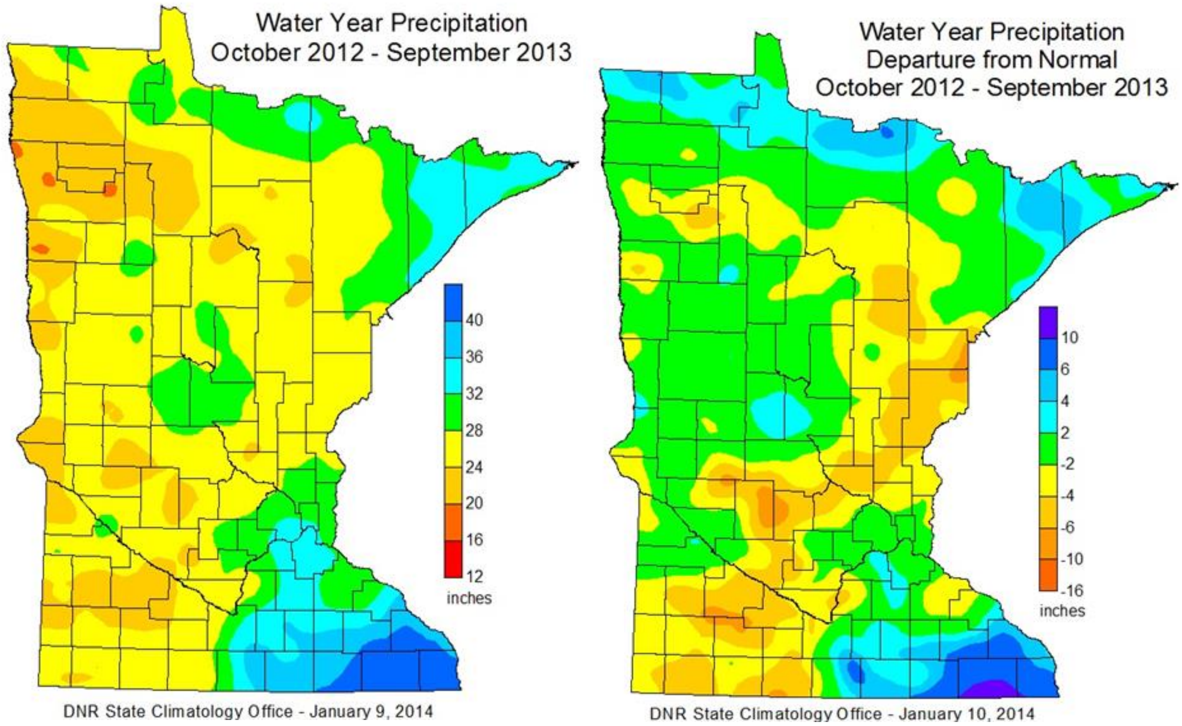

Figure 12. State-wide precipitation levels during the 2013 water year.

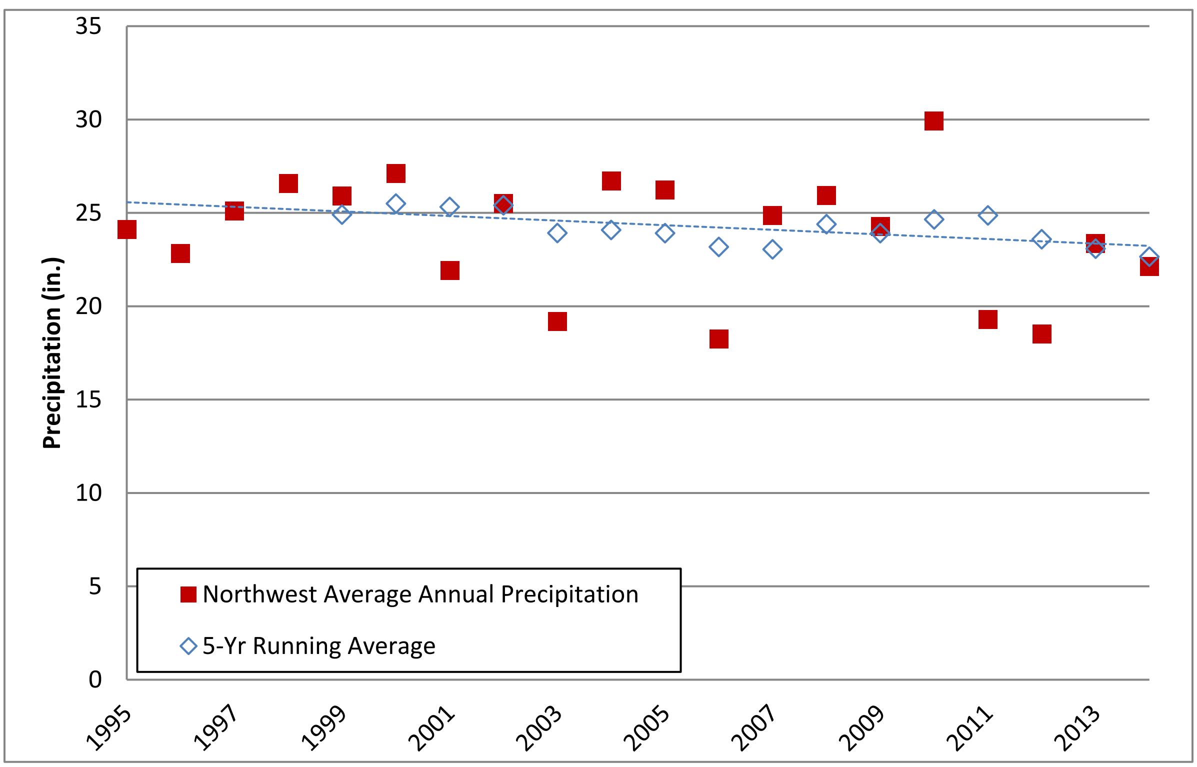

Figure 13. Precipitation trends in Northwestern Minnesota (1995-2014) with five year running average.

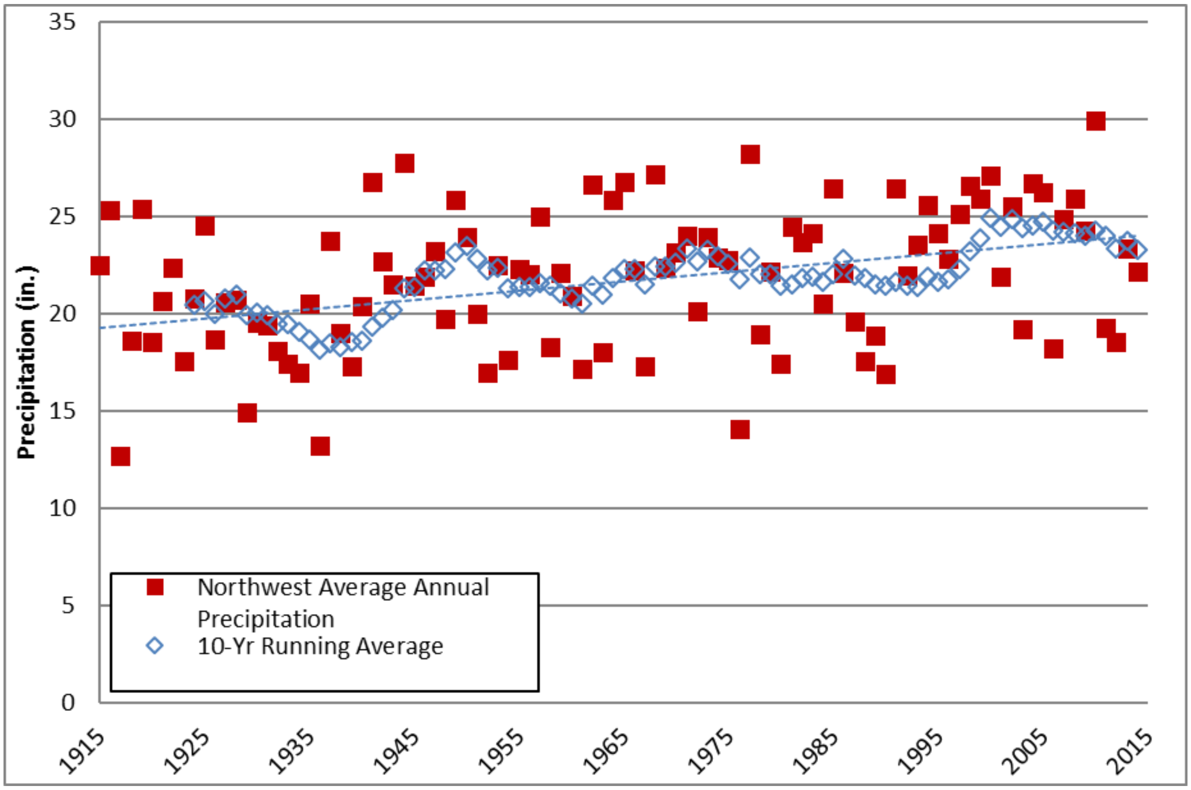

Figure 14. Precipitation trends in northwestern Minnesota (1915-2015) with 10 year running average.

Hydrogeology

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

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

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

Figure 15. Western province generalized cross section (Source: MNDNR, 2001).

Wetlands

The Two Rivers Watershed is situated at the eastern edge of the historical prairie pothole region of western and south western Minnesota. The watershed's surface geology primarily consists of ground moraine and outwash plains resulting from Wadena Lobe glacial processes as part of the Alexandria Moraine complex. This hill, valley, and flat outwash till geology created ideal conditions for a diverse wetland resource to develop in several hydrogeomorphic settings including depressional, slope and floodplain flats.

IV. Watershed-wide data collection methodology

Watershed Pollutant Load Monitoring Network

Intensive water quality sampling occurs at all WPLMN sites. Thirty-five samples/year are allocated for basin and major watershed sites and 25 samples/season (ice out through Oct. 31) for subwatershed sites. Because correlations between concentration and flow exist for many of the monitored analytes, sampling frequency is typically greatest during periods of moderate to high flow (Figure 16). Because these relationships can also shift between storms or with season, computation of accurate load estimates requires frequent sampling of all major runoff events. Low flow periods are also sampled and are well represented, but sampling frequency tends to be less as concentrations are generally more stable when compared to periods of elevated flow. Despite discharge related differences in sample collection frequency, this staggered approach to sampling generally results in samples being well distributed over the entire range of flows

Annual water quality and daily average flow data are coupled in the “Flux32,” pollutant load model, originally developed by Dr. Bill Walker and recently upgraded by the U.S. Army Corp of Engineers and the MPCA to compute pollutant loads for all WPLMN monitoring sites. Flux32 allows the user to create seasonal or discharge constrained concentration/flow regression equations to estimate pollutant concentrations and loads on days when samples were not collected. Primary output includes annual and daily pollutant loads and flow weighted mean concentrations (FWMCs) (pollutant load/total flow volume). Loads and FWMCs are calculated for TSS, TP, dissolved orthophosphate (DOP), nitrate plus nitrite nitrogen (NO2+NO3-N), and total Kjeldahl nitrogen (TKN).

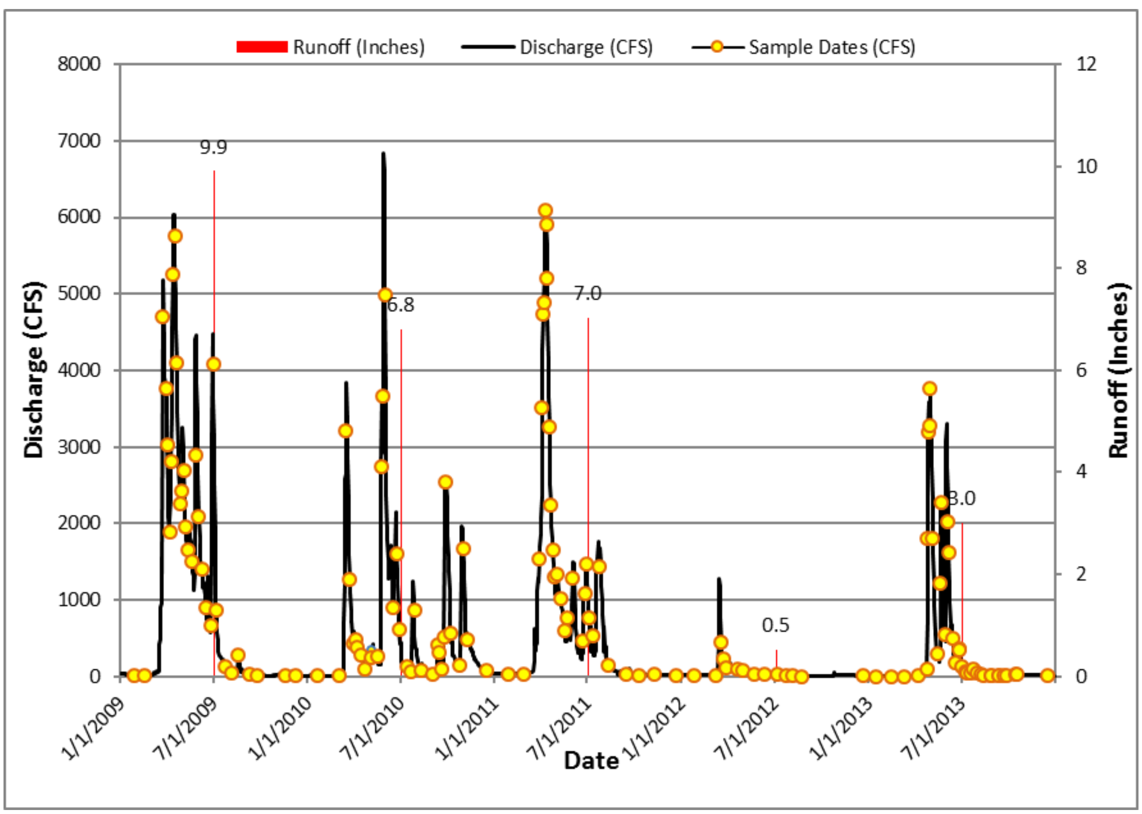

Figure 16. 2009-2013 hydrograph, sampling regime and annual runoff for the Two River near Hallock, Minnesota.

Stream water sampling

Five water chemistry stations were sampled from May thru September in 2013, and again June thru August of 2014, to provide sufficient water chemistry data to assess all components of the Aquatic Life and Recreation Use Standards. Following the IWM design, water chemistry stations were placed at the outlet of each HUC-11 subwatershed that was 75-150 mi^2 in area. A SWAG was awarded to the International Water Institute (IWI) in partnership with the Two Rivers Watershed District for condition monitoring of streams in the Red River Basin. (See Appendix 2 - Intensive watershed monitoring water chemistry stations in the Two Rivers Watershed for locations of stream water chemistry monitoring sites. See Appendix 1 for definitions of stream chemistry analytes monitored in this study).

Stream flow methodology

MPCA and the MNDNR joint stream water quantity and quality monitoring data for dozens of sites across the state on major rivers, at the mouths of most of the state's major watersheds, and at the mouths of some HUC-11 subwatersheds are available at the MNDNR/MPCA Cooperative Stream Gaging webpage at: http://www.dnr.state.mn.us/waters/csg/index.html. In addition, USGS gaging stations can be found at http://waterdata.usgs.gov/nwis/rt.

Stream biological sampling

The biological monitoring component of the IWM in the Two Rivers Watershed was completed during the summer of 2013. A total of 32 sites were established across the watershed and sampled. Of these sites, 22 were newly established and 10 were existing stations from previous monitoring. These sites were located near the outlets of most minor HUC-14 watersheds. While data from the last 10 years contributed to the watershed assessments, the majority of data utilized for the 2015 assessment were collected in 2013. A total of 21 AUIDs were sampled and assessed for biology in the Two Rivers Watershed.

To measure the health of aquatic life at each biological monitoring station, indices of biological integrity (IBIs), specifically fish index of biotic integrity (F-IBI) and macroinvertebrate index of biotic integrity (M-IBI), were calculated based on monitoring data collected for each of these communities. A fish and macroinvertebrate classification framework was developed to account for natural variation in community structure which is attributed to geographic region, watershed drainage area, water temperature, and stream gradient. As a result, Minnesota's streams and rivers were divided into seven distinct warm water classes and two cold water classes, with each class having its own unique F-IBI and M-IBI. Each IBI class uses a unique suite of metrics, scoring functions, impairment thresholds, and confidence intervals (CIs) (For IBI classes, thresholds, and CIs, see Appendix 5). IBI scores higher than the impairment threshold and upper CI indicate that the stream reach supports aquatic life. Contrarily, scores below the impairment threshold and lower CI indicate that the stream reach does not support aquatic life. When an IBI score falls within the upper and lower confidence limits additional information may be considered when making the impairment decision such as the consideration of potential local and watershed stressors and additional monitoring information (e.g., water chemistry, physical habitat, and observations of local land use activities). For IBI results for each individual biological monitoring station, see Appendix 6. Two Rivers Watershed F-IBI and M-IBI thresholds and results Appendix 6.1 - Biological monitoring results – F-IBI (assessable reaches) and Appendix 6.2.

Fish contaminants

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

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

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

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

Lake water sampling

Lake Bronson was sampled in 2013 and 2014, to enhance the dataset to assess aquatic recreation. The Friends of Lake Bronson State Park is enrolled in the MPCA's Advanced Citizen Lake Monitoring Program (CLMP+) and conducted the lake monitoring. CLMP+ was developed to expand the basic Citizen Lake Monitoring Program (CLMP), which is typically water transparency with a Secchi disk, to include additional monitoring where none currently exists. The advanced program includes temperature and DO profiles, alkalinity, chloride, chl-a, color, nitrogen, phosphorus, and solids. These sampling methods are similar among monitoring groups and are described in the document entitled "MPCA Standard Operating Procedure for Lake Water Quality" found at http://www.pca.state.mn.us/publications/wq-s1-16.pdf. The lake water quality assessment standard requires eight observations/samples within a 10-year period for phosphorus, chl-a, and Secchi depth.

Groundwater monitoring

Groundwater quality

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

Groundwater quantity

Monitoring wells from the MNDNR Observation Well Network track the elevation of groundwater across the state. The elevation of groundwater is measured as depth to water in feet and reflects the fluctuation of the water table as it rises and falls with seasonal variations and anthropogenic influences. Data from these wells and others are available at (MNDNR, 2014a): http://www.dnr.state.mn.us/waters/groundwater_section/obwell/waterleveldata.html.

Groundwater / surface water withdrawals

The MNDNR permits all high capacity water withdrawals where the pumped volume exceeds 10,000 gallons/day or 1 million gallons/year. Permit holders are required to track water use and report back to the MNDNR yearly. Information on the program and the program database are found at (MNDNR, 2014b): http://www.dnr.state.mn.us/waters/watermgmt_section/appropriations/wateruse.html.

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

Wetland monitoring

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

V. Individual HUC-11 subwatershed results

Assessment results for aquatic life and recreation use are presented for each HUC-11 subwatershed within the Two Rivers Watershed. The primary objective is to portray all the full support and impairment listings within an HUC-11 subwatershed resulting from the complex and multi-step assessment and listing process. (A summary table of assessment results for the entire HUC-8 watershed including aquatic consumption, and drinking water assessments (where applicable) is included in Appendix 4. This scale provides a robust assessment of water quality condition at a practical size for the development, management, and implementation of effective TMDLs and protection strategies. The graphics presented for each of the HUC-11 subwatersheds show the assessment results from the 2015 assessment cycle as well as any impairment listings from previous assessment cycles. Discussion of assessment results focuses primarily on the 2013 IWM effort, but also considers available data from the last 10-years.

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

Stream assessments

A table is provided in each section summarizing aquatic life and aquatic recreation assessments of all assessable stream reaches within the HUC-11 subwatershed (i.e., where sufficient information was available to make an assessment). Primarily, these tables reflect the results of the 2015 assessment process/2016 EPA reporting cycle); however, impairments from previous assessment cycles are also included and are distinguished from new impairments via cell shading (see footnote section of each table). These tables also denote the results of comparing each individual aquatic life and aquatic recreation indicator to their respective criteria (i.e., standards); determinations made during the desktop phase of the assessment process (see Figure 3. The IWM Design.). Assessment of aquatic life is derived from the analysis of biological (F-IBI and M-IBIs), DO, TSS, chloride, pH, and un-ionized ammonia (NH_3) data, while the assessment of aquatic recreation in streams is based solely on bacteria (*E. coli* or fecal coliform) data. Included in each table is the specific aquatic life use classification for each stream reach: cold water community (2A); cool or warm water community (2B); or indigenous aquatic community (2C). Where applicable and sufficient data exists, assessments of other designated uses (e.g., Class 7, drinking water, or aquatic consumption) are discussed in the summary section of each HUC-11 subwatershed as well as in the watershed-wide results and discussion section.

Stream habitat results

Habitat information documented during each fish sampling visit is provided in each HUC-11 subwatershed section. These tables convey the results of the Minnesota Stream Habitat Assessment (MSHA) survey, which evaluates the section of stream sampled for biology and can provide an indication of potential stressors (e.g., siltation, eutrophication, etc.) impacting fish and macroinvertebrate communities. The MSHA score is comprised of five scoring categories including adjacent land use, riparian zone, substrate, fish cover and channel morphology, which are summed for a total possible score of 100 points. Scores for each category, a summation of the total MSHA score, and a narrative habitat condition rating are provided in the tables for each biological monitoring station. Where multiple visits occur at the same station, the scores from each visit have been averaged. The final row in each table displays average MSHA scores and a rating for the HUC-11 subwatershed.

Stream stability results

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

HUC-11 subwatershed outlet water chemistry results

Summary tables display the water chemistry results for the monitoring station representing the outlet of the HUC-11 subwatershed. This data along with other data collected within the 10-year assessment window can provide valuable insight on water quality characteristics and potential parameters of concern within the watershed. Parameters included in these tables are those most closely related to the standards or expectations used for assessing aquatic life and recreation.

Lake assessments

A summary of lake water quality is provided in the HUC-11 subwatershed sections where available data exists. For lakes with sufficient data, basic modeling was completed. Assessment results for all lakes in the watershed are available in Appendix 4.

Upper South Fork Two Rivers Subwatershed HUC 09020312010

The Upper South Fork Two Rivers Subwatershed begins in southwestern Roseau County with a very small portion in northern Marshall County and flows westerly into southeastern Kittson County, draining an area of 332.9 mi2. This subwatershed contains the headwaters of the South Branch, Two Rivers which originates from a small line of wetlands meandering through a vast area of agricultural lands approximately ten miles northeast of Greenbush. With the exception of a few segments of the South Branch, Two Rivers, most of the watercourses in this subwatershed have been altered or straightened. The river flows southwest until it crosses into Kittson County where it turns and flows northwest, receiving water from many small tributaries such as state and county ditches along the way and ending at Lake Bronson. The subwatershed has water chemistry data available from one lake, ten stream AUIDs, and ten biological monitoring stations. The subwatershed consists mostly of cropland and wetlands comprising 57% and 17% each, respectively. Forest, rangeland, and development comprise the remainder of the land use at 12%, 10%, and 4% each, respectively (Figure 19). The water chemistry monitoring station for this subwatershed is on the South Branch, Two Rivers, 7.8 miles east of Pelan.

Table 2. Aquatic life and recreation assessments on stream reaches: Upper South Fork Two Rivers Subwatershed. Reaches are organized upstream to downstream in the table.

AUID *reach name,* *reach description*	Reach length (miles)	Use class	Biological station ID	Location of biological station	Aquatic Life Indicators:								Aquatic recreation indicators:		Aquatic life	Aquatic recreation
					F-IBI	M-IBI	DO	TSS	Chloride	pH	NH_3	Pesticides	Bacteria	Nutrients		
09020312-507 ***South Branch, Two Rivers*** *Headwaters to State Ditch 91 Lateral Ditch 2*	10.64	WWg	13RD096	Off 230 Ave, 3 mi. NE of Greenbush	MTS	-	IF	IF	-	IF	IF	-	-	-	SUP	NA
09020312-506 ***South Branch, Two Rivers*** *Unnamed Ditch to Lateral Ditch 2 State Ditch 95*	25.06	WWg	05RD181 13RD045	Downstream of CR 29, 3 mi. SW of Greenbush Upstream of CR 105, 8 mi. SW of Greenbush	EXS	EXS	IF	MTS	MTS	MTS	MTS	-	EXS	-	IMP	IMP
09020312-505 ***South Branch, Two Rivers*** *Lateral Ditch 2 to Lake Bronson*	7.67	WWg	13RD042	Upstream of CSAH 10, 7.5 mi. E of Lake Bronson	EXS	EXS	MTS	MTS	MTS	MTS	MTS	-	EXS	-	IMP	IMP
09020312-515 ***Lateral Ditch 4 of State Ditch 91*** *Headwaters to Lateral Ditch 12 State Ditch 91*	13.70	WWm	13RD058	8.5 mi. SE of Greenbush at 190th and 290th Ave Inter. DS of 290th	MTS	MTS	IF	IF	-	IF	IF	-	-	-	SUP	NA
09020312-550 ***Unnamed Ditch*** *110th St to Lateral Ditch 12 State Ditch 91*	7.16	WWm	13RD054	Upstream of 210th Ave, 4 mi. SE of Greenbush	MTS	MTS	IF	IF	-	IF	IF	-	-	-	SUP	NA
09020312-551 ***Unnamed Ditch*** *110th St to Lateral Ditch 4 State Ditch 91*	7.03	WWm	13RD052	Downstream of 190th Ave, 2.5 mi. S of Greenbush	MTS	IF	IF	IF	-	IF	IF	-	-	-	SUP	NA
09020312-522 ***County Ditch 4*** *Unnamed Ditch to Unnamed Ditch*	2.02	WWg	05RD002	3/4 miles upstream of CR106, off of CR105, 2.5 miles E of Twin Lakes WMA	EXS	MTS	IF	IF	-	IF	IF	-	-	-	IMP	NA
09020312-546 ***State Ditch 90*** *Upper Twin Lake (35-0001-00) to South Branch, Two Rivers*	2.30	WWg	13RD064	Just US of dam at end of minimum maintenance road.	MTS	-	IF	IF	-	IF	IF	-	-	-	SUP	NA
09020312-544 ***State Ditch 49*** *Headwaters to S. Br. Two Rivers*	5.34	WWg	13RD044	Downstream of CSAH 10, 4.5 mi. E of Lake Bronson	EXS	-	IF	IF	-	IF	IF	-	-	-	IMP	NA

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

Table 3. MSHA: Upper South Fork Two Rivers Subwatershed.

# Visits	Biological station ID	Reach name	Land use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish cover (0-17)	Channel morph. (0-36)	MSHA score (0-100)	MSHA rating
1	13RD096	South Branch, Two Rivers	3	9	11	14	7	44	Poor
2	05RD181	South Branch, Two Rivers	3.75	9.75	18.5	12.5	16	60.5	Fair
1	13RD045	South Branch, Two Rivers	3.75	10	18.4	13	22	67.15	Good
1	13RD042	South Branch, Two Rivers	0	7.5	20.85	14	23	65.35	Fair
2	13RD058	Lateral Ditch 4 of State Ditch 91	0	6	15.5	12	8.5	42	Poor
1	13RD054	Unnamed Ditch	0	6.5	12.8	9	20	48.3	Fair
2	13RD052	Unnamed Ditch	2.125	8.25	20.5	5	5.5	41.37	Poor
1	05RD002	County Ditch 4	4	10	20	13	8	55	Fair
1	13RD064	State Ditch 90	5	11.5	3	14	11	44.5	Poor
2	13RD044	State Ditch 49	5	10.5	13.75	12.5	17	58.75	Fair
Average habitat results: *Upper South Fork Two Rivers Subwatershed*			**2.66**	**8.9**	**15.43**	**11.9**	**13.8**	**52.69**	**Fair**

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

Table 4. Lake assessments: Upper South Branch Two Rivers Subwatershed.

Name	DNR Lake ID	Area (acres)	Trophic Status	Percent littoral	Max. depth (m)	Mean depth (m)	CLMP trend	Mean TP (µg/L)	Mean chl-a (µg/L)	Mean Secchi (m)	AQR support status	AQL support status
Lake Bronson	35-0003-00	320	E	76.2	8.84	3.57	NT	94.1	13.2	1.6	IF	IF

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

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

Table 5. Outlet water chemistry results: Upper South Fork Two Rivers Subwatershed.

Station location:	South Branch, Two Rivers at CSAH10, 7.8 mi NW of Pelan						
STORET/EQuIS ID:	S002-996						
Station #:	13RD042						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances**
Ammonia-nitrogen	ug/L	16	<40	81	46	40	5
Chloride	mg/L	16	4.5	17.0	9.1	230	
DO	mg/L	29	5.60	12.01	8.14	5	
pH		41	5.73	8.44	7.92	6.5 - 9	1
Secchi tube	100 cm	18	20.0	>100.0	83.7	25	1
TSS	mg/L	30	<1.0	45.0	6.0	30	1
Phosphorus	ug/L	20	26	200	69	150	1
Chl-a, corrected	ug/L	8	<1.0	13.0	3.3	35	
***E. coli* (geometric mean)**	MPN/ 100ml	3	51	168	-	126	1
E. coli	MPN/ 100ml	30	9	>2419	-	1260	1
Inorganic nitrogen (nitrate and nitrite)	mg/L	20	<0.02	2.46	0.27		
Kjeldahl nitrogen	mg/L	18	0.83	5.56	1.43		
Orthophosphate	ug/L	-	-	-	-		
Pheophytin-a	ug/L	-	-	-	-		
Specific Conductance	uS/cm	41	265	781	476		
Temperature, water	deg °C	41	10.50	25.55	18.86		
Sulfate	mg/L	10	21.5	62.4	46.5		
Hardness	mg/L	10	187	264	227		

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

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Upper South Branch, Two Rivers Subwatershed, conducted from 2009 to 2014 (IWM work was conducted between May and September from 2013 to 2014). This specific data does not necessarily reflect all data that was used to assess the AUID.**

Summary

South Branch, Two Rivers (AUID 09020312-507), is a 10.64-mile-long reach that begins at its headwaters about four miles southeast of Badger. The river flows west and then southwest, following MN Highway 11 for much of its course and ends at its confluence with Lateral Ditch #2 of State Ditch #91 about 1.5 miles northeast of Greenbush. The surrounding land use is a mixture of cropland and pasture with sporadic wetlands and forest. One biological monitoring station is located on the reach, 13RD096. The F-IBI score was well above the impairment threshold with eight species and nearly 400 individuals being sampled, of which nearly 90% were sensitive headwater species (primarily northern redbelly dace). The fish population showed a negative relationship with habitat however, as this station scored poor with excess amounts of sediment, limited amounts of gravel (mostly embedded), and slow flow. Although the F-IBI score was high, the population is likely dependent on flow. The fish sample was taken in early June while water was flowing well, however the stream does go dry most years in late summer. The collection of macroinvertebrates during the late summer of 2013 was unsuccessful because the stream had no water at the time. Water chemistry data on this AUID was limited to the biological visits, so there is insufficient information to assess for aquatic life and recreation.

South Branch, Two Rivers (AUID 09020312-506), is a 25-mile-long reach that begins at the confluence with Lateral Ditch #2 of State Ditch #91. It flows southwest until the Roseau-Kittson County line where it turns northwest and ends at Lateral Ditch #2 of State Ditch #95. The surrounding land use is a mixture of cropland, pasture, and forest along the upper end of the reach, then just west of the county line, transitions to large tracts of wetlands and forested land with interspersed cropland. This reach has an existing aquatic life impairment (F-IBI) from 2002. Two biological monitoring stations are located on the reach, 05RD181 and 13RD045 from upstream to downstream. Two fish samples were taken at 05RD181 (2006 and 2014) both resulting in identical F-IBI scores (38) well below the impairment threshold. The latter sample confirms the existing F-IBI impairment. The habitat scores at this station were fair but declined 17 points from 2006 to 2014. The most noticeable reason for the decline in habitat scores was that coarse substrates and riffles were present in 2006, but absent in 2014. Consequently, riffle spawning individuals (e.g., white sucker, blacknose dace, and blackside darter), although present in both samples, declined drastically in the same time period. On the other hand, northern redbelly dace, a more wetland oriented species tolerant of finer substrates was absent in 2006, but found in high abundance in 2014, again suggesting habitat changes within the stream. The fish community at 13RD045 scored slightly above the impairment threshold. The sample consisted of two sensitive species and many lithophilic spawning species. The presence of coarse substrates and/or riffles appears to affect fish populations within this reach based on the decline in coarse substrates and riffle dwelling species at 05RD181 and the high abundance of both coarse substrates and riffle dwelling species at 13RD045. Both of the macroinvertebrate samples at 05RD181 were poor and dominated by tolerant taxa. Macroinvertebrates also scored poorly at 13RD045 despite the presence of more diverse habitat perhaps suggesting the presence of water quality or hydrologic impacts on the community.

Un-ionized ammonia, chloride, and pH were all meeting aquatic life standards (40 ug/L, 230 mg/L, and 6.5-9, respectively). No measurements exceeded the standard for any of these parameters. TSS levels supported aquatic life with only 7.6% of samples exceeding the 30 mg/L standard and 6.3% of Secchi tube samples exceeding the standard. DO was below the 5 mg/L standard in 10% of samples. However, the DO exceedances were minor, the lowest concentration being 3.40 mg/L. The reach appears to experience highly variable flow regimes with periods of zero to no flow (likely negatively effecting DO concentrations and thus the biological communities). Continuous DO monitoring should be considered on this reach to confirm DO is not limiting aquatic life. TP exceeds the South Nutrient Region standard with a mean of 161.3 ug/L (standard being 150 ug/L), but there is not sufficient data to determine if there is a response (i.e., there is no chl-a, DO flux, or BOD5 data). Therefore, it cannot be determined if eutrophication is impacting aquatic life on this reach. *E. coli* samples yielded one individual and one geometric monthly mean exceedance (standards of 1260 Most Probable Number (MPN)/100 mL and 126 MPN/100 mL, respectively) during the assessment period. Since there is at least one month exceeding the geometric monthly mean (in this instance 140/100mL for July), the reach does not support aquatic recreation.

South Branch, Two Rivers (AUID 09020312-505), is a 7.67-mile reach that begins at Lateral Ditch #2 of State Ditch #95 and flows northwest, ending at Lake Bronson (35-0003-00) near the outlet of the subwatershed. The land use along this reach is mostly wetlands and forest interspersed with cropland and pasture. There was one biological station (13RD042) on this reach. Both biological communities scored poorly. Although the fish community did consist of 11 species, it was dominated by tolerant species (mostly white sucker and northern pike). The macroinvertebrate sample was numerically dominated by filtering taxa. Habitat in the reach was nearly in the good range consisting of abundant coarse substrates and high amounts of cover. Although substrate and cover conditions were good, the stream channel is completely straightened which may be reducing flow and depth variability. A dam is located on the west edge of Lake Bronson which is impassable to fish and likely having an effect on the species within both Lake Bronson as well as upstream portions of the subwatershed. The dam (and Lake Bronson) was created in 1937 to provide a backup source of municipal water for the cities of Lake Bronson and Hallock, however the lake is now only used for recreation. The dam has three concrete spillways which are each 20-feet wide and have a four-foot operable gate on top to control outflow from the lake (Figure 17).

This reach does support aquatic life based on the water chemistry parameters. Un-ionized ammonia, chloride, and pH were all meeting aquatic life standards, of these parameters only one pH exceedance was observed during the 10-year assessment window. DO did not exceed the 5 mg/L standard in five years of sampling, however there were no early morning samples so judgement cannot be made on aquatic life use based on DO on this reach. TSS and surrogate Secchi tube had only single exceedances each in 31 and 43 samples, respectively, indicating that TSS is meeting aquatic life standards. Total phosphorus was meeting the South Nutrient Region standard with a mean of 66.9 ug/L. Limited chl-a data was available, but with a mean concentration of 3.3 ug/L it is meeting the standard (35 ug/L). *E. coli* samples yielded one individual and one geometric monthly mean exceedance during the assessment period. Since there is at least one month exceeding the geometric monthly mean (in this instance 168/100 mL for July), the reach does not support aquatic recreation.

Lateral Ditch #4 of State Ditch #91 (AUID 09020312-515), is a 13.70-mile-long modified reach that flows from east to west and ends with its confluence with Lateral Ditch #12 of State Ditch #91 about 2.5 miles southeast of Greenbush. This reach drains a large wetland complex (which also serves as an impoundment) near its headwaters, transitions downstream to pasture, then cropland. One biological monitoring station is on the reach, 13RD058 where both biological communities scored well above their respective modified thresholds. The fish community included nine species of which three were sensitive and in moderate abundance, including Iowa darter which was only sampled on this reach and AUID -546. The macroinvertebrate sample was dominated by Valvata (a snail) in addition to many taxa which are tolerant of low DO. Habitat at this station is poor, characterized by no depth variability, slow flow, and no sinuosity. The biological communities are likely influenced by low flow conditions during certain times of year depending on precipitation patterns and discharge from the upstream wetland/impoundment. Chemistry data on this AUID was limited to the biological visits, so there is insufficient information to assess for aquatic life and recreation.

Unnamed Ditch (AUID 09020312-550), is a 7.16 mile modified reach that flows from south to north along 210th Ave and ends with its confluence with Lateral Ditch #12 of State Ditch #91 about 2.5 miles southeast Greenbush. The surrounding land use is wetlands near the upper end of the reach, transitioning downstream to a mixture of pasture, cropland, and sporadic wetlands. One biological monitoring station is on the reach, 13RD054, where both fish and macroinvertebrates scored above their respective modified thresholds. Although two of the ten fish species sampled were sensitive, the number of individuals was low in comparison to the overall number of fish. The macroinvertebrate community consisted of several tolerant taxa, many tolerant of low concentrations of DO, high levels of suspended solids, and unstable substrates. However, some intolerant taxa were present and good taxa richness was observed. Several grade control structures exist on this reach, including both upstream, within, and downstream of the biological station. Although these structures may not block fish passage during moderate to high flows, they are likely prohibiting fish from swimming upstream during low to moderate flow periods. It is conceivable, that with habitat improvement and management, this reach could achieve a general use designation. Water chemistry data on this AUID was limited to the biological visits, so there is insufficient information to assess for aquatic life and recreation.

Unnamed Ditch (AUID 09020312-551), is a seven mile modified reach that flows from south to north along 190th Ave and ends with its confluence with Lateral Ditch #4 of State Ditch #91 about two miles south-southwest Greenbush. The surrounding land use is a wetland complex near the upper end of the reach and then transitions downstream to a mixture of pasture and cropland. One biological monitoring station is on the reach, 13RD052, where the F-IBI score was slightly above the modified threshold, consisting of only four species and low numbers of individuals. Habitat on this reach was poor due to a lack of cover and poor channel morphology. In addition to the poor habitat, it is likely that flow conditions dictate the biological communities. Conversations with county employees at the time of fish sampling indicate that it is common for the reach to go dry during late summer months. This was confirmed during the attempted macroinvertebrate sample when the stream was dry. Chemistry data on this AUID was limited to the biological visits, so there is insufficient information to assess for aquatic life and recreation.

Roseau County Ditch #4 (AUID 09020312-522), is a two mile reach that flows from south to north along 120th Ave and ends with its confluence with an Unnamed Ditch about two miles east of Pelan (County Ditch #4 continues to flow northward 1.43 miles as AUID -523 to its confluence with the South Branch, Two Rivers). A wetland complex drains into the upper end of the reach; however, land use quickly transitions to mostly cropland. The reach experiences variable flow conditions and during periods of little/no precipitation is subject to having dry sections. One biological monitoring station is on the reach, 05RD002, which was sampled for fish and macroinvertebrates in 2005. The fish community scored well below the impairment threshold with only five species and low number of individuals. The lack of fish on this reach can likely be attributed to the frequency of low flows, however two rock grade control structures (Figure 18) (similar to those on AUID -550) as well as a perched culvert exist between the station and the South Branch, Two Rivers. These grade control structures consist of cobble and boulder with a steep incline and are likely prohibiting fish passage during most of the year with the exception of high flows. Macroinvertebrates scored well, likely due to good habitat complexity and persistent flow at the time of sampling. Habitat on this reach was fair with physical habitat likely not limiting the biological communities. Coarse substrates, woody debris, and abundant vegetation were all present. However, similar to the AUID’s mentioned above this reach is completely channelized and lacks sinuosity and depth variability. Water chemistry data on this AUID was limited to the biological visits, so there is insufficient information to assess for aquatic life and recreation.

State Ditch #90 (AUID 09020312-546), is a 2.30 mile reach that flows from Upper Twin Lake (35-0001-00) northeast through the Twin Lakes Wildlife Management Area (WMA) to its confluence with the South Branch, Two Rivers in Pelan. The surrounding land use is dominated by a complex of wetlands and deciduous forest. Biological monitoring station 13RD064 existed, located just downstream of the Twin

Lakes WMA. The fish community at this station scored above the impairment threshold, consisting of nine species of which three were sensitive including Iowa darter which was only sampled here and AUID -515. Contrary to the high F-IBI score, the habitat at this station was poor, specifically the substrate and channel morphology. Similar to other reaches, the biological communities here are likely dependent on flow which is variable throughout the year. The dam located just upstream of the station is the limiting factor as it holds water within the Twin Lakes WMA and is only released based on precipitation and/or water levels. This was evident later in the summer when a macroinvertebrate sample was attempted but the reach was dry. Water chemistry data on this AUID was limited to the biological visits, so there is insufficient information to assess for aquatic life and recreation.

State Ditch #49 (AUID 09020312-544), is a 5.34 mile reach that flows northeasterly from its headwaters to its confluence with the South Branch, Two Rivers about one-mile northeast of Lake Bronson. The land use surrounding the reach is dominated by wetlands, deciduous forest, and cropland. One biological monitoring station is on the reach, 13RD044 which is located near the southeast corner of Lake Bronson State Park. Fish were sampled twice (2013 and 2014) with both samples resulting in very poor F-IBI scores. These samples produced a low numbers of species (three each sample) and individuals (18 and 13, respectfully). Habitat within this reach was fair, however similar to other reaches in this subwatershed the substrates and channel morphology was poor. Flow again appears to be the limiting factor on this reach as the stream was dry during the attempted macroinvertebrate sample in late summer 2013. Given the availability of cover during the fish sample, it is possible that biological communities could benefit and survive here if continuous flow existed. Water chemistry data on this AUID was limited to the biological visits, so there is insufficient information to assess for aquatic life and recreation.

Lake Bronson (35-0003-00) is a 320-acre eutrophic lake with a catchment watershed area of 347,732 acres (543.33 mi^2) and a catchment to lake surface area ratio of 1087:1. The lake is wholly within the Lake Agassiz Plain Ecoregion; since this ecoregion does not have a specific eutrophication standard assigned, a land use analysis was completed to determine the appropriate ecoregion standard to compare it to (Appendix 7). The catchment was 15.77% wetland/open water, 4.48% developed, 7.64% pasture/grasslands, 10.89% forest, and 61.23% cultivated crops: this land use composition is most indicative of the Northern Glaciated Plains (NGP)/Western Corn Belt Plains (WCBP) ecoregion. The maximum depth of Lake Bronson is 29 feet with 76.2% littoral area, so it was compared to the deep lake nutrient standard. Since Lake Bronson is a flow-through lake, a Minnesota Lake Eutrophication Analysis Procedure (MINLEAP) model was computed to determine if the residence time under median and low flow conditions would be of sufficient duration to qualify it as a lake (definition of a reservoir in statue requires a 14-day residence time under 1 in 10-year low flow conditions). The residence times were estimated to be 14-days (median flow) and 72 days (low flow), so the deep lake eutrophication standards are appropriate for Lake Bronson as the lake morphometry and setting meet the definition in rule. TP exceeds the WCBP ecoregion standard (65 ug/L). Chl-a and Secchi had mean values of 13.2 ug/L and 1.6 meters, respectively, and are both meeting the standard. Therefore, there is insufficient information to determine aquatic recreation use support as the response variables meet the standard but TP does not. Chloride concentrations were less than 7.30 mg/L, far below the 230 mg/L chronic standard for chloride toxicity. No biological data is available to determine if the lake is supporting aquatic life use; Lake Bronson was not a suitable sample for fish because of the morphometry of the lake –the shoreline drops off quickly in many places which makes it difficult to efficiently electrofish and set trap nets.

On the very west edge of this subwatershed (at the outlet of Lake Bronson) AUID 09020312-502 begins, however no water chemistry or biological monitoring stations were located in this subwatershed. The AUID continues into the Lower South Fork, Two Rivers Subwatershed.

Overall, this subwatershed is severely altered with hydrological modifications likely playing a significant role in the subwatershed's poor biological condition. Although most streams are surrounded by a natural landscape, nearly all have been channelized. Not only do the straightened streams lack sinuosity, they also lack depth variability, channel development, and riparian cover/shade due to trees and/or shrubs being removed during the straightening process. More importantly, the straightening of these streams quickly drains water from the landscape, discharging it downstream as fast as possible. Many of the smaller tributaries are dry by mid to late summer, which was evident by multiple failed attempts at macroinvertebrate sampling. Habitat conditions did not appear to be as important as hydrology in influencing the composition of biological communities within this subwatershed. In some instances, moderate to good biological communities existed where there was poor habitat, but flow was continuous. Still in other instances, poor biological communities occurred where the habitat was good but the stream was likely to go dry. These examples further show the importance for continuous flow.

Lastly, dams and grade control structures on several reaches are likely prohibiting fish passage. Not only are fish prohibited from migrating upstream (i.e., spawning) but during low flows they also cannot migrate downstream to deeper water, essentially being trapped in the low water/flow areas. Between the loss of natural channels, reduced flow/water availability, and the blockage of fish migration, the biological communities within this subwatershed have been drastically affected by human disturbance.

Figure 17. Lake Bronson dam located at the outlet of Lake Bronson on the South Branch, Two Rivers.

Figure 18. Rock grade control structure possibly affecting fish passage on AUID -522.

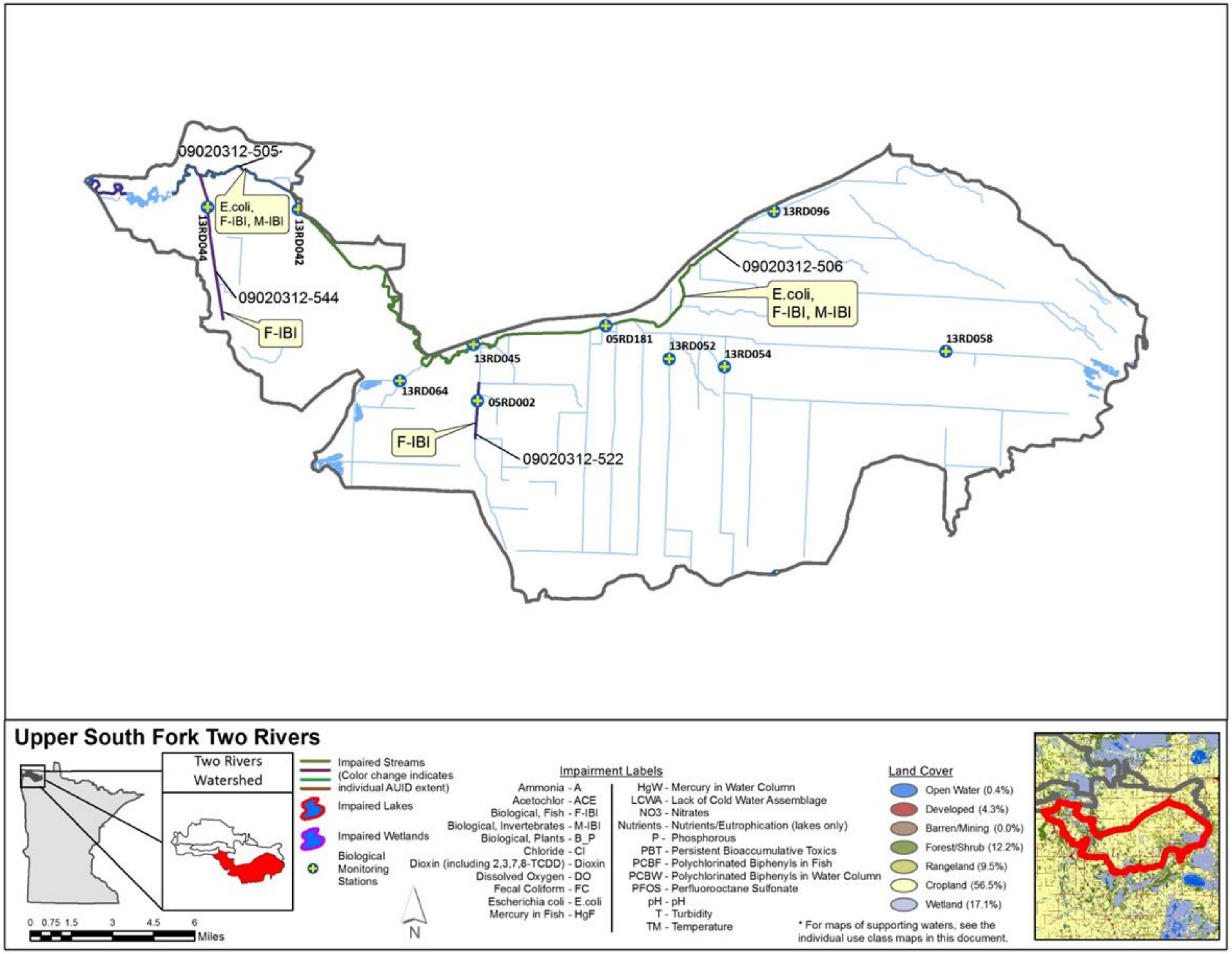

Figure 19. Currently listed impaired waters by parameter and land use characteristics in the Upper South Fork Two Rivers Subwatershed

State Ditch #95 Subwatershed HUC 09020312020

The State Ditch #95 Subwatershed begins near the town of Badger in west-central Roseau County, flowing west into extreme eastern Kittson County and draining an area of 213.8 mi^2. Like the previous subwatershed, most of the watercourses in State Ditch #95 Subwatershed have been altered or straightened. The waterways are primarily made up of human made ditch complexes and few natural channels. The land use consists mostly of cropland, 73%, while wetlands and forests comprise 9% and 8%, respectfully, followed closely by range and developed lands at 5% each (Figure 20). The subwatershed has water chemistry data available from four stream AUIDs and biological monitoring data from two stations. The water chemistry monitoring station for this subwatershed is on Lateral Ditch 1 off of an unnamed road just north of CSAH 10, 7.5 miles East of Lake Bronson.

Table 6. Aquatic life and recreation assessments on stream reaches: State Ditch #95 Subwatershed. Reaches are organized upstream to downstream in the table.

AUID *reach name, reach description*	Reach length (miles)	Use class	Biological station ID	Location of biological station	Aquatic Life Indicators:								Aquatic recreation indicators:		Aquatic life	Aquatic recreation
					F-IBI	M-IBI	DO	TSS	Chloride	pH	NH_3	Pesticides	Bacteria	Nutrients		
09020312-535 ***County Ditch 13*** *Unnamed Ditch to Badger Creek (disconnected portion)*	5.43	WWg	-	-	-	-	IF	MTS	IF	MTS	MTS	-	EXS	-	IF	IMP
09020312-539 ***Lateral Ditch 1 of State Ditch 95*** *Unnamed Ditch to State Ditch 50*	12.07	WWm	13RD048	Downstream of 270th St, 8 mi. NW of Greenbush	EXS	EXS	IF	IF	IF	IF	IF	-	-	-	IMP	NA
09020312-521 ***Lateral Ditch 1 of State Ditch 95*** *Unnamed Ditch to State Ditch 95*	0.86	WWm	13RD043	Downstream of Unnamed Road off of CSAH 10, 7.5 mi. E of Lake Bronson	EXS	EXS	IF	MTS	MTS	MTS	MTS	-	MTS	-	IMP	SUP

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

Table 7. MSHA: State Ditch #95 Subwatershed.

# Visits	Biological station ID	Reach Name	Land use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish cover (0-17)	Channel morph. (0-36)	MSHA score (0-100)	MSHA rating
1	13RD048	Lateral Ditch 1 of State Ditch 95	1.25	7.5	20	12	10	50.75	Fair
2	13RD043	Lateral Ditch 1 of State Ditch 95	0.75	8.75	19.9	13.5	9	51.9	Fair
		Average Habitat Results: *State Ditch #95 Subwatershed*	**1**	**8.13**	**19.95**	**12.75**	**9.5**	**51.33**	**Fair**

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

Table 8. Outlet water chemistry results: State Ditch #95 Subwatershed.

Station location:	Lateral Ditch #1 of State Ditch #95, 8.5 mi NW of Pelan						
STORET/EQuIS ID:	S002-997						
Station #:	13RD043						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances**
Ammonia-nitrogen	ug/L	16	<40	140	47	40	3
Chloride	mg/L	16	2.8	15.2	6.6	230	
DO	mg/L	29	4.10	11.76	7.28	5	6
pH		41	7.25	8.40	7.76	6.5 - 9	
Secchi yube	100 cm	18	45.0	>100.0	89.8	25	
TSS	mg/L	31	<1.0	17.0	4.0	30	
Phosphorus	ug/L	20	23	179	77	150	2
Chl-a, corrected	ug/L	-	-	-	-	35	
***E. coli* (geometric mean)**	MPN/ 100ml	3	37	102	-	126	
E. coli	MPN/ 100ml	30	3	>2419	-	1260	2
Inorganic nitrogen (nitrate and nitrite)	mg/L	19	<0.02	0.76	0.12		
Kjeldahl nitrogen	mg/L	10	0.73	2.59	1.61		
Orthophosphate	ug/L	-	-	-	-		
Pheophytin-a	ug/L	-	-	-	-		
Specific conductance	uS/cm	41	262	896	556		
Temperature, water	deg °C	41	9.91	27.22	18.77		
Sulfate	mg/L	10	54.7	238.0	123.0		
Hardness	mg/L	10	183	408	287		

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

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the State Ditch #95 Subwatershed, conducted from 2009 to 2014 (IWM work was conducted between May and September from 2013 to 2014). This specific data does not necessarily reflect all data that was used to assess the AUID.**

Summary

Roseau County Ditch #13 (AUID 09020312-535), is a 5.43-mile reach that begins about one-mile northeast of Badger and flows from east to west. Land use surrounding this reach is a mixture of wetland, forest, cropland, and pasture. There is an impoundment/retention pond just upstream of the reach. While no biological monitoring stations were on this reach, water chemistry was assessed. Un-ionized ammonia and pH were both meeting aquatic life standards, no exceedances were observed during the 10-year assessment window. DO exceeded the standard only once (3.70 mg/L) in 33 samples over six years. There were 37 TSS samples taken over seven years with all values being well below the 30 mg/L standard, the highest being only 14 mg/L. Also, none of the surrogate Secchi tube values exceeded the 25 cm threshold in 38 samples, so TSS is meeting aquatic life standards. TP meets the South Nutrient Region standard (150 ug/L) with a mean of 100.9 ug/L. Since TP meets and there is no response variable, the reach meets the river eutrophication standard. *E. coli* samples yielded one individual and one geometric monthly mean exceedance during the assessment period. Since there is at least one month exceeding the geometric monthly mean (243/100 mL for July), the reach does not support aquatic recreation.

Lateral Ditch #1 of State Ditch #95 (AUID 09020312-539), is a 12 mile modified reach that begins about eight miles west-northwest of Badger. It flows from east to west for about ten miles then turns south for the remainder of its course. Land use along the upper end of the reach is dominated by cropland, but transitions to large wetland complexes near the downstream end of the reach. There was one biological monitoring station on the reach (13RD048). Both biological communities scored well below the modified use threshold. The fish community consisted of five species and 34 individuals, all of which were tolerant (e.g., white sucker, fathead minnow, central mudminnow). The macroinvertebrates were dominated by snails and other low DO tolerant taxa. Although the habitat was fair, the lack of multiple cover types and periods of low/no flow likely influence the poor biological communities. Cover was extensive, however only consisted of thick vegetation with large amounts of filamentous algae. In addition, the reach had no depth variability, channel development, or sinuosity. During certain times of the year (mostly high water conditions) this reach may receive water from the Roseau River Watershed via multiple channelized ditches. An area known as “Big Swamp” holds water during high water conditions and when it has reached capacity, water often flows from the Roseau River Watershed into the Two Rivers Watershed, affecting this stretch of stream. Water chemistry data on this AUID was limited to the biological visits, so there is insufficient information to assess for aquatic life and recreation.

Lateral Ditch #1 of State Ditch #95 (AUID 09020312-521), is a 0.86 mile long reach that begins about 7.5 miles northwest of Pelan where it flows southwesterly to its confluence with the South Branch, Two Rivers. Much of the surrounding land use is cropland, however the water from the upstream AUID (unassessed -543) is bordered by cropland and large wetland complexes. One biological monitoring station was located at the outlet of this subwatershed, 13RD043. Two fish samples were taken here, one early and one late in July of 2013. The earlier sample had a F-IBI score well below the impairment threshold consisting of only five species (all tolerant) and 23 individuals. Although the later sample did have a F-IBI above the threshold, the number of species and individuals were still low. The better F-IBI score was due to a moderate abundance of sensitive and riffle dwelling species. The macroinvertebrate IBI score was just above the general use threshold but more than half of the sample was blackfly larva and other moderately tolerant taxa. Habitat in this reach was similar to AUID -539 in that only thick vegetation with extensive filamentous algae as well as scattered boulders were present. The stream also lacked sinuosity, channel development, and depth variability.

Un-ionized ammonia, chloride, and pH met aquatic life standards, no exceedances were found during the assessment window. DO exceeded the standard in 20% of measurements over five years of sampling. The exceedances were not severe – the lowest concentration measured was 4.10 mg/L. The DO data was deemed inconclusive due to the fact that all of the exceedances were minor. Additional DO measurements or continuous monitoring should be conducted to confirm if DO is truly an issue on this reach. TSS and surrogate S-tube yielded no exceedances in 32 and 43 samples, respectively, so TSS is meeting aquatic life standards. TP data meets the South Nutrient Region standard with a mean concentration of 74.5 ug/L. The reach meets the river eutrophication standard since TP meets and there is no response variable. *E. coli* concentrations met the aquatic recreation standards. Only two of 30 samples exceeded the individual standard of 1260/100 mL, and there were no geometric monthly mean exceedances.

Overall, this subwatershed is very similar to the Upper South Fork Two Rivers Subwatershed in that nearly all of the streams are channelized. The sampled reaches possess similar characteristics; a lack of sinuosity, cover types, and probably most importantly, highly variable flow regimes. Drastic fluctuations in water levels exacerbated by extensive drainage throughout the subwatershed likely contribute to the poor biological results. Lastly, although nutrient levels were below the standard, there were significant amounts of filamentous algae in most reaches suggesting that at certain times of the year nutrients may also be an issue.

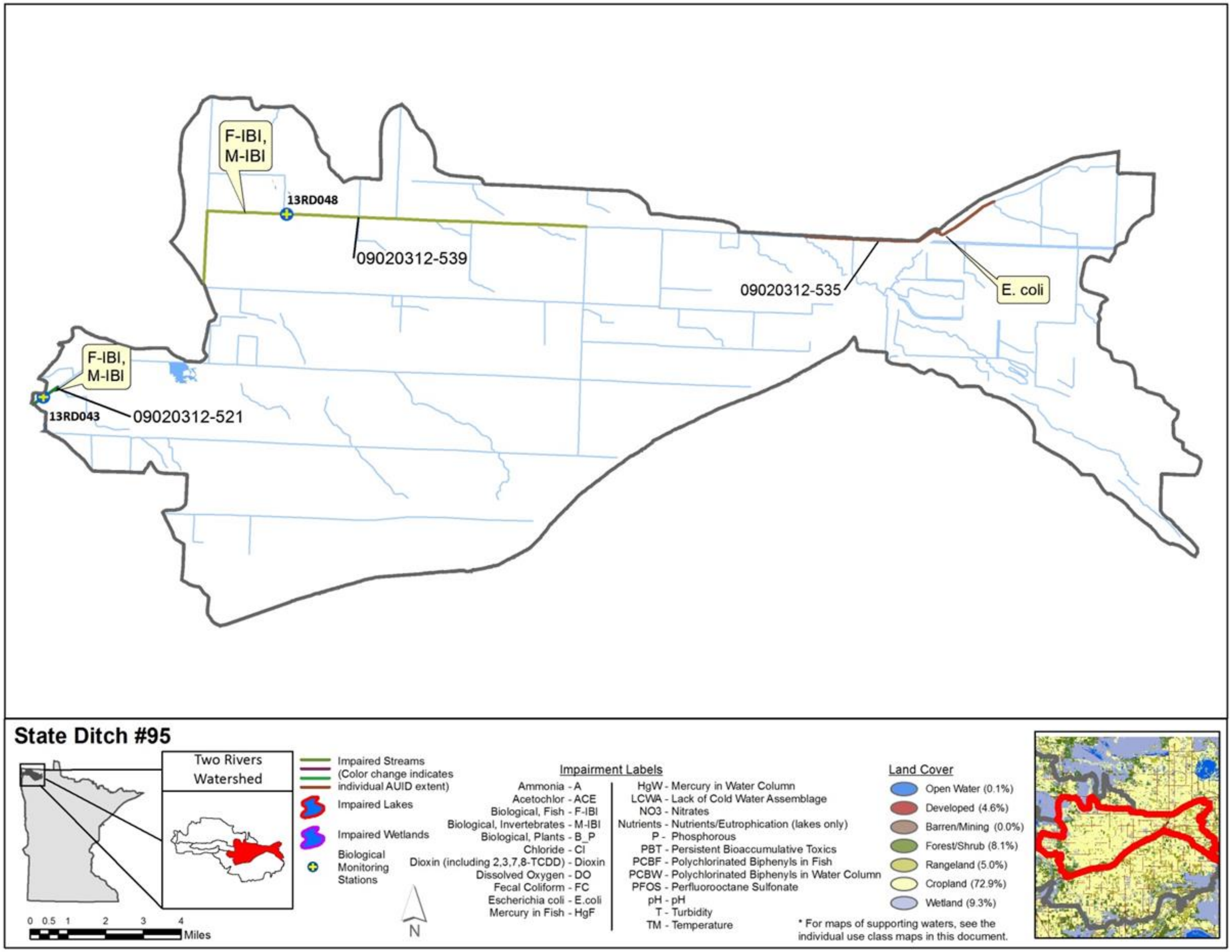

Figure 20. Currently listed impaired waters by parameter and land use characteristics in the State Ditch #95 Subwatershed

Lower South Fork Two Rivers Subwatershed HUC 09020312030

The Lower South Fork Two Rivers Subwatershed is located in central and western Kittson County and drains an area of 93.9 mi^2. This subwatershed contains the South Branch, Two Rivers which begins at the outlet of Lake Bronson and flows northwest to its confluence with the Middle Branch, Two Rivers near Hallock. At this point, they combine to make the Two River mainstem which flows northwesterly until its confluence with the Red River of the North. Unlike the subwatersheds to the east, most of the assessed reaches in this subwatershed have unaltered, sinuous stream channels. The subwatershed consists mostly of cropland at roughly 79% while wetland and forests combine to make up 12%. Developed land occupies only 6% while range and open water make up 2% and 1 %, respectively (Figure 23). The subwatershed has water chemistry data available from three stream AUIDs and biological monitoring data from seven stations. The water chemistry monitoring station for this subwatershed is on the Two River at County Road 16, seven miles west of Hallock.

Table 9. Aquatic life and recreation assessments on stream reaches: Lower South Fork Two Rivers Subwatershed. Reaches are organized upstream to downstream in the table.

AUID ***reach name,*** *reach description*	Reach length (miles)	Use class	Biological station ID	Location of biological station	Aquatic Life Indicators:							Aquatic recreation indicators:			Aquatic life	Aquatic recreation
					F-IBI	M-IBI	DO	TSS	Chloride	pH	NH_3	Pesticides	Bacteria	Nutrients		
09020312-502 ***Two River, South Branch*** *Lake Bronson to M. Br. Two Rivers*	33.04	WWg	13RD082 10EM192 93RD401 13RD085	On Cty Hwy 15, SW corner of Lake Bronson Downstream of CR 175, 0.5 mi. W of Lake Bronson At Albin bridge, 3 mi SE Hallock On Unnamed Road, 0.6 mi E of US Hwy 75, 1.5 mi SE of Hallock	EXS	EXS	IF	MTS	MTS	MTS	MTS	-	MTS	-	IMP	SUP
09020312-501 ***Two Rivers*** *Middle Br Two Rivers to N. Br. Two Rivers*	21.03	WWg	13RD056 13RD084	Upstream of Unnamed Rd, 2 mi. NW of Hallock 6 mi W of Hallock on Unknown Rd, 0.5 mi E of Hwy 16	MTS	IF	IF	EXS	MTS	MTS	MTS	-	EXS	-	IMP	IMP
09020312-509 ***Two Rivers*** *N. Br. Two Rivers to Red River of the North*	6.95	WWg	05RD004	Upstream of County Route 16, 8 miles NW of Hallock	MTS	IF	IF	EXS	MTS	MTS	MTS	-	EXS	-	IMP	SUP

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

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

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

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

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

Table 10. MSHA: Lower South Fork Two Rivers Subwatershed.

# Visits	Biological station ID	Reach name	Land use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish cover (0-17)	Channel morph. (0-36)	MSHA score (0-100)	MSHA rating
1	13RD082	South Branch, Two Rivers	1	10	21.3	13	27	72.3	Good
1	10EM192	South Branch, Two Rivers	2.75	9.5	23.35	13	27	75.6	Good
1	93RD401	South Branch, Two Rivers	0	6	18	13	18	55	Fair
1	13RD085	South Branch, Two Rivers	2.5	3	10	12	8	35.5	Poor
1	13RD056	Two Rivers	2.5	5.5	11.75	12	20	51.75	Fair
1	13RD084	Two Rivers	2.5	7	7	8	23	47.5	Fair
2	05RD004	Two Rivers	4.5	8.5	6.65	5.5	17	42.15	Poor
Average Habitat Results: *Lower South Fork Two Rivers Subwatershed*			**2.25**	**7.07**	**14.01**	**10.93**	**20**	**54.26**	**Fair**

Qualitative habitat ratings

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

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

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

Table 11. Channel Condition and Stability Assessment (CCSI): Lower South Fork Two Rivers Subwatershed.

# Visits	Biological station ID	Stream name	Upper banks (43-4)	Lower banks (46-5)	Substrate (37-3)	Channel evolution (11-1)	CCSI Score (137-13)	CCSI rating
1	05RD004	Two Rivers	16	21	22	3	62	Moderately Unstable
Average Stream Stability Results: *Lower South Fork Two Rivers Subwatershed*			**16**	**21**	**22**	**3**	**62**	Moderately Unstable

Qualitative channel stability ratings

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

Table 12. Outlet water chemistry results: Lower South Fork Two Rivers Subwatershed.

Station location:	Two Rivers at CSAH 16, 7.1 mi W of Hallock						
STORET/EQuIS ID:	S000-569						
Station #:	05RD004						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances**
Ammonia-nitrogen	ug/L	54	<3	178	52	40	19
Chloride	mg/L	52	5.1	88.6	26.6	230	
DO	mg/L	234	0.86	14.41	8.73	5	10
pH		247	7.31	8.80	8.01	6.5 - 9	
Secchi tube	100 cm	80	2.0	>100.0	15.4	10	44
TSS	mg/L	228	<1.0	952.0	81.2	65	91
Phosphorus	ug/L	225	30	683	189	150	125
Chl-a, corrected	ug/L	22	3.0	30.0	8.0	35	
***E. coli* (geometric mean)**	MPN/ 100ml	3	80	117	-	126	
E. coli	MPN/ 100ml	34	15	1553	-	1260	1
Inorganic nitrogen (nitrate and nitrite)	mg/L	230	<0.02	7.12	0.51		
Kjeldahl nitrogen	mg/L	191	0.64	3.50	1.32		
Orthophosphate	ug/L	10	17	377	127		
Pheophytin-a	ug/L	21	<1.0	5.0	2.6		
Specific conductance	uS/cm	248	153	1799	551		
Temperature, water	deg °C	248	-0.08	32.71	14.48		
Sulfate	mg/L	50	1.2	102.0	43.1		
Hardness	mg/L	27	152	499	271.6		
Total volatile solids	mg/L	110	<1.0	95.0	10.5		
Color		11	35	350	144		

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

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

Summary

South Branch, Two Rivers (AUID 09020312-502) is a 33-mile reach that begins at the outlet of Lake Bronson and flows west to the confluence with the Middle Branch, Two Rivers in Hallock. The land use within the corridor of the floodplain is wetland/forest but most of the land in the watershed is being utilized for row crops. This reach has four biological monitoring stations, 13RD082, 10EM192, 93RD401, and 13RD085 from upstream to downstream. The upstream portion is shallower with abundant cover, coarse substrate, and little erosion but transitions downstream to deeper water with less coarse substrate, and increased erosion. The condition of the biological community decreases from upstream to downstream as habitat conditions deteriorate and the reach becomes impaired for fish and macroinvertebrates.

Fish and macroinvertebrate communities were very good at the two upstream sites. There were numerous sensitive species in high abundance as well as many riffle dwelling species which correlated with good habitat attributes. The stream channel begins to degrade downstream of 10EM192 with increased erosion rates and less coarse substrate. The declining habitat conditions were associated with fish communities that consisted of mostly tolerant species (i.e., common and sand shiners) as well as fewer riffle dwelling species. Furthest downstream at 13RD085, the stream channel is significantly deeper than the upstream stations, consisting of no coarse substrates and severe bank erosion. Although the F-IBI score is at the impairment threshold at this station, only one sensitive species was found (rock bass and only one individual) while tolerant species dominated the community. Larger and longer lived species were also found here (e.g., shorthead and golden redhorse) that were not found at the three upstream stations. Although the number of species was between 11 and 16 at all stations, abundant coarse substrate and lower erosion rates correlated with increased F-IBI scores. Connectivity is likely an issue on this system as well, as a concrete dam is located just upstream of Hallock about one mile downstream of 13RD085 (

Figure **21**). The dam was originally constructed for the purpose of supplying Hallock with drinking water. Currently, the drinking water is supplied by rural water meaning the dam is no longer needed for drinking water supply. The two stations that scored poorly for F-IBI are directly upstream of the dam where flow and habitat are reduced. Given the dam is no longer needed for drinking water, if it were removed or modified it is possible fish communities could improve upstream and in connecting waters. The macroinvertebrate community was similar with high scores and increased number of sensitive taxa at the two upstream stations but declined drastically at 93RD401 which was dominated by taxa tolerant of unstable substrates. Macroinvertebrate communities also appear to be affected by the poor habitat conditions in parts of this reach.

Although biological communities are being negatively affected by poor habitat, water quality appears to be good. Chloride, un-ionized ammonia, and pH are meeting their standards. No exceedances were found during the assessment period. None of the 56 DO measurements exceeded the 5 mg/L standard. There was not enough early morning DO readings to make a decision for aquatic life use, but DO does not appear to be limiting aquatic life. There were no exceedances of the TSS standard over five years of sampling, as concentrations were well below the 65 mg/L standard with the highest value being 26 mg/L. Likewise, no exceedances were observed for the Secchi tube surrogate over eight years, the lowest value being 18 cm. The mean TP value was 150 ug/L, which is right at South Nutrient Region standard (the standard being 150 ug/L). However, the river eutrophication status could not be determined due to no data for any of the response variables. No individual or geometric monthly mean exceedances were found when comparing *E. coli* concentrations to aquatic recreation standards. The highest individual *E. coli* concentration was 228/100 mL, and the highest geometric monthly mean was 55/100 mL for September. This reach is therefore meeting aquatic recreation use standards.

Two Rivers (AUID 09020312-501) is a 21-mile reach that originates with the confluence with the Middle Branch, Two Rivers in Hallock and winds its way northwest to the confluence with the North Branch, Two Rivers. The land use within the immediate floodplain is wetland/forest, but most of the land in the watershed is dominated by cropland. There are existing impairments for *E. coli* (2010) and turbidity (2006) on this reach. Two biological monitoring stations existed, 13RD056 and 13RD084 from upstream to downstream.

The fish communities at these two stations were both very good. Although the number of species sampled was significantly lower at 13RD056 (14) versus at 13RD084 (24), both consisted of sensitive species as well as an abundance of larger, longer lived species (i.e., redhorse, walleye, channel catfish). In addition, although coarse substrates were limited at these sites, many of the species sampled were lithophilic spawners (i.e., sauger, redhorse, common shiner). These stations were also the only two in the subwatershed where mooneye (sensitive species) were sampled. Habitat at both sites was fair however both sites contained many positive habitat attributes such as good depth variability, sinuosity, and various flow types. Similar to the upstream AUID, erosion and sediment appears to be a problem on this reach which is evident by high TSS values. Macroinvertebrate communities sampled in 2013 yielded mixed results. 13RD056 scored well, had good species richness and numerous EPT (Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)) taxa. The downstream station however scored poorly with only 167 individuals collected which was likely due to a lack of habitat. The sites were visited again in 2015, and deemed non-sampleable because there was a lack of invertebrate habitat. It is likely that the highly variable flow in this stream reach is reducing habitat complexity which is crucial to the development of healthy macroinvertebrate communities.

Un-ionized ammonia, chloride, and pH were all meeting aquatic life standards. No exceedances were observed in the entire DO dataset – 62 samples over a ten-year data window. There was not enough early morning DO measurements to assess the reach, but the available data suggests that DO does not appear to be stressing aquatic life. There was enough data on total phosphorus concentrations and chl-a to conduct a river eutrophication assessment. The average TP concentration was 171.1 ug/L, which exceeds the eutrophication standard for the South Nutrient Region. The mean Chl-a concentration was 6.5 ug/L, so it is meeting the standard (35 ug/L). Since there was no response between the high levels of TP and chl-a, there is insufficient information that eutrophication is impacting aquatic life. Secchi tube readings only exceeded the surrogate threshold in 8.3% of samples, but TSS exceeded the standard in 32.8% of samples. The samples appeared to be biased towards storm events and the spring freshet, particularly an event in spring 2014. However, even when the event-based samples are excluded, TSS still exceeds the standard in 20% of cases. The TSS data suggests non-support for aquatic life use and the existing turbidity impairment is confirmed. There were no individual exceedances of the *E. coli* standard but there were two geometric mean exceedances. The geometric mean exceedances were 233/100 mL for July and 208/100 mL for September. This confirms the existing *E. coli* impairment from 2010.

Two Rivers (AUID 09020312-509) is a seven-mile reach that begins at the confluence with the North Branch, Two Rivers and ends with the confluence with the Red River of the North about three miles east of Joliette, ND. The land use near the stream channel is wetland/forest, but land in the subwatershed is primarily cropland. There is an existing impairment for turbidity (2008) on this reach. The reach consisted of one biological monitoring station, 05RD004, which is located roughly one mile upstream of the confluence with the Red River of the North.

The fish community was sampled twice, once in 2006 and again in 2013. Both samples resulted in identical F-IBI scores (63), well above the impairment threshold with 20 species being captured during each visit. Most of the species captured were highly tolerant of disturbance but sensitive species were also present. However, the number of individuals at each site was somewhat low with less than

150 individuals in each sample. Similar to the upstream AUID, there were many lithophilic spawners and large bodied, long lived species in each sample in spite of the poor habitat and lack of coarse substrate. Habitat scores declined from 2006 to 2013, with the most notable difference between the two time periods being an increase in bank erosion and the amount of overhanging and instream vegetation. Macroinvertebrate communities at 05RD004 appear to be severely impacted by variable flow and lack of habitat. Three samples have been attempted, the first attempt was made in 2005, during drought conditions and was deemed non-assessable. The second sample was collected in 2013, (a year of high flows) and contained only 169 individuals, all of which were tolerant. In 2015, the site was visited but not sampled because there was no invertebrate habitat present. The lack of macroinvertebrate habitat is characteristic of many of the streams in the Two Rivers Watershed near the pour points as extremely high flow volumes dislodge most habitat (e.g., logs and vegetation) in these areas. Flow fluctuations during the year vary with season, precipitation patterns, and the water level of the Red River of the North. During spring snowmelt runoff or high precipitation events, the water level within this reach can fluctuate up to tens of feet (Figure 22). The stream at times may also flow in the opposite direction (west to east) when the Red River of the North is higher than the Two Rivers and pushes water up into the lower reaches of the Two Rivers.

Un-ionized ammonia, chloride, and pH met aquatic life standards. A robust DO data set was available, with 158 samples taken over 10 years. Only 5.1% of DO samples exceeded the standard, but some of the exceedances were extreme – the lowest recorded value was 0.80 mg/L. However, there were an insufficient number of early morning samples, so an aquatic life use determination was not made on this reach based on DO. There was sufficient total phosphorus and chl-a data to conduct a river eutrophication assessment. The average TP concentration of 194.3 ug/L exceeded the South Nutrient Region eutrophication standard of 150 ug/L while the Chl-a concentration of 8.5 ug/L met the standard (35 ug/L). Since there was no response between TP and chl-a, there is insufficient information to indicate that eutrophication is impacting aquatic life. There were high exceedances for TSS and surrogate S-tube, 46.7% and 48.5% respectively, over the assessment period. The sediment parameters were not biased by storm events. This assessment indicates non-support for aquatic life and confirms the existing turbidity impairment. *E. coli* is meeting aquatic recreation standards with only one individual exceedance (1553/100 mL) being found out of 34 samples and no geometric monthly means exceeding the standard.

Overall, this subwatershed has a robust fish community ranging from 11 to 24 species at each station with abundant minnow and larger bodied species. Fish communities further up in the South Branch, Two Rivers watershed appeared to be dependent on good habitat and coarse substrates. On the mainstem Two Rivers however, fish communities did not appear to be as dependent on local habitat conditions as F-IBI scores were good at the outlet station but the habitat was poor in all categories. The close proximity to the Red River of the North may help support the fish communities in the lower reaches of the Two Rivers system. Several of these fish species likely migrate to/from the Red River of the North into the Two Rivers depending on time of year and/or water levels. Macroinvertebrate species are responding to the poor habitat in the lower reaches of the watershed because they are very dependent on available substrates to colonize. It is likely that the highly variable flow regimes within this subwatershed have the most impact on biological communities. Habitat utilized by these communities such as woody debris and vegetation are often flushed downstream, leaving reaches with highly eroded banks and void of habitat.

Figure 21. Dam located on the South Branch, Two Rivers upstream of Hallock, Minnesota.

Figure 22. Normal flow (left) versus high flows (right) at 05RD004.

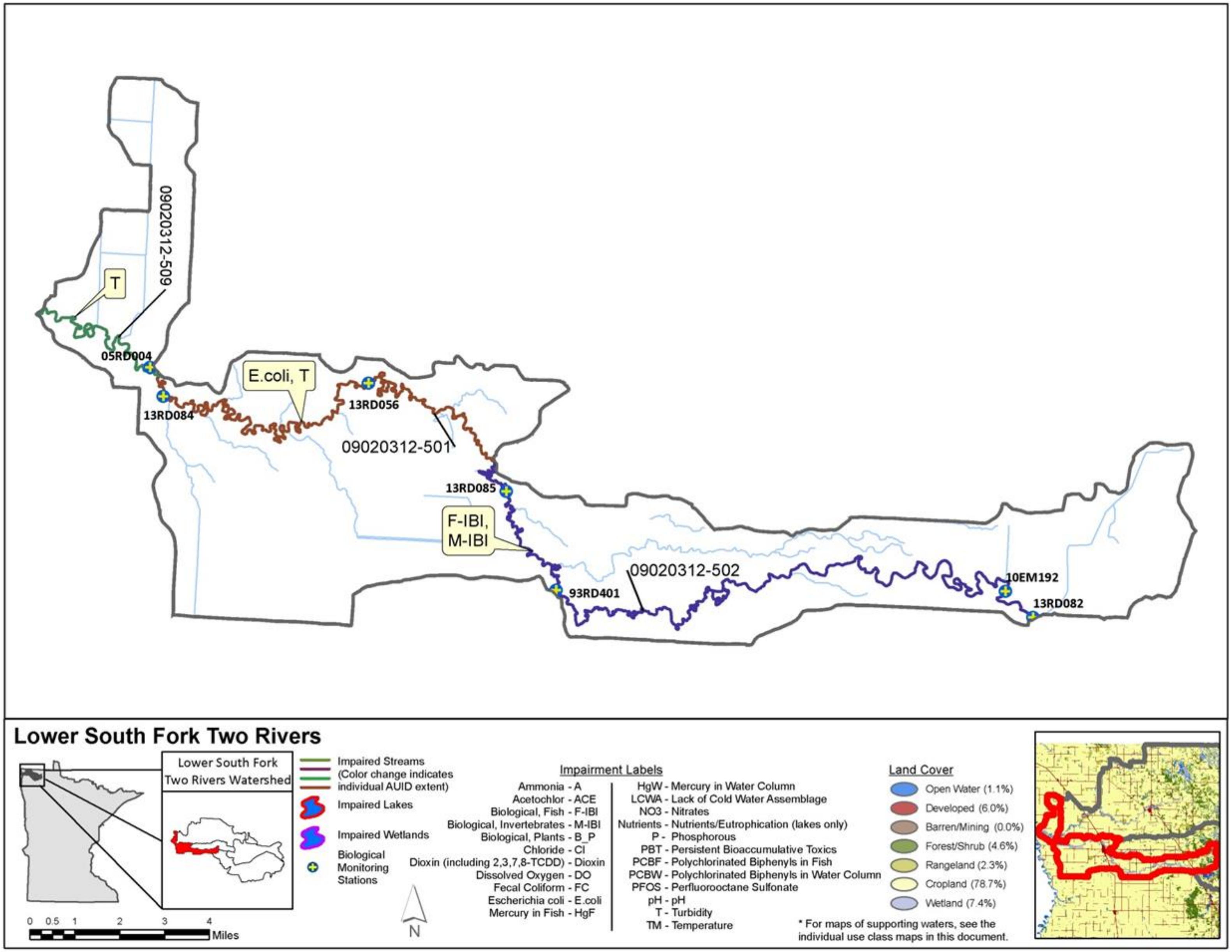

Figure 23. Currently listed impaired waters by parameter and land use characteristics in the Lower South Fork Two Rivers Subwatershed.

Middle Branch, Two Rivers Subwatershed HUC 09020312040

The Middle Branch, Two Rivers Subwatershed is located in eastern and central Kittson County and is the smallest of the subwatersheds, draining an area of 78.2 mi^2. This subwatershed contains the headwaters of the Middle Branch, Two Rivers which originates on the far eastern end of the subwatershed in the Beaches Wildlife Management Area (WMA) at Beaches Lake (35-0008-00). Stream segments in the upper end of the subwatershed, are channelized to enhance drainage through the wetlands, but the downstream assessed reach follows through a natural channel. Approximately half way through the subwatershed (near US Highway 59) the landscape transitions from a mix of wetland, forest, and cropland to nearly all cropland. Although the subwatershed consists mostly of cropland, 57%, wetlands and forests are more abundant in this subwatershed than any other at 22% and 14%, respectively. The remainder of the land use is made up of development, rangeland, and open water at 4%, 2%, and 1%, respectively (Figure 24). Water chemistry data is available from one stream AUID and biological monitoring data from two stations. The water chemistry monitoring station for this subwatershed is on the Middle Branch, Two Rivers at Highway 175, five miles east of Hallock.

Table 13. Aquatic life and recreation assessments on stream reaches: Middle Branch, Two Rivers Subwatershed. Reaches are organized upstream to downstream in the table.

AUID *reach name*, *reach description*	Reach length (miles)	Use class	Biological station ID	Location of biological station	Aquatic Life Indicators: F-IBI	M-IBI	DO	TSS	Chloride	pH	NH_3	Pesticides	Aquatic recreation indicators: Bacteria	Nutrients	Aquatic life	Aquatic rec.
09020312-503 ***Middle Branch, Two Rivers*** *Cty Ditch 23 to S. Br. Two Rivers*	29.65	WWg	93RD405 05RD093	Between Township Roads 59 & 15, 3 mi N of Lake Bronson 3 miles E of Hallock, upstream of State Route 175.	EXS	EXS	IF	MTS	MTS	MTS	MTS	-	EXS	-	IMP	IMP

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

Table 14. MSHA: Middle Branch, Two Rivers Subwatershed.

# Visits	Biological station ID	Reach name	Land use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish cover (0-17)	Channel morph. (0-36)	MSHA score (0-100)	MSHA rating
1	93RD405	Middle Branch, Two Rivers	5	12	22	17	28	84	Good
3	05RD093	Middle Branch, Two Rivers	4.16	8.83	17.85	12.66	23.0	66.51	Good
Average Habitat Results: *Middle Branch, Two Rivers Subwatershed*			**4.58**	**10.42**	**19.93**	**14.83**	**25.5**	**75.26**	**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)

Table 15. Outlet water chemistry results: Middle Branch, Two Rivers Subwatershed.

Station location:	Middle Branch, Two Rivers, 3 mi SE of Hallock						
STORET/EQuIS ID:	S003-100						
Station #:	05RD093						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances**
Ammonia-nitrogen	ug/L	6	<40	49	40	40	1
Chloride	mg/L	6	3.4	8.0	5.4	230	
DO	mg/L	44	6.21	12.51	8.74	5	
pH		43	7.69	8.43	8.12	6.5 - 9	
Secchi tube	100 cm	8	14.0	75.5	45.3	10	
TSS	mg/L	20	<1.0	35.0	7.7	65	
Phosphorus	ug/L	15	22	198	59	150	1
Chl-a, Corrected	ug/L	8	1.0	10.0	3.5	35	
***E. coli* (geometric mean)**	MPN/ 100ml	3	57	150	-	126	2
E. coli	MPN/ 100ml	27	8	770	-	1260	
Inorganic nitrogen (nitrate and nitrite)	mg/L	15	<0.02	0.03	0.022		
Kjeldahl nitrogen	mg/L	7	0.97	1.38	1.20		
Orthophosphate	ug/L	-	-	-	-		
Pheophytin-a	ug/L	-	-	-	-		
Specific conductance	uS/cm	42	258	827	454		
Temperature, water	deg °C	44	4.89	23.40	16.52		
Sulfate	mg/L	-	-	-	-		
Hardness	mg/L	-	-	-	-		

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

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

Summary

Middle Branch, Two Rivers (09020312-503) is a 29.65 mile reach that flows from east to west. It begins in a large wetland complex, converges with Kittson County Ditch #23 and ends with the confluence with the South Branch, Two Rivers. There is an existing fish bioassessment impairment (2002). The reach contains biological monitoring stations 93RD405 and 05RD093 from upstream to downstream.

Fish communities within this reach were variable, ranging from very poor to exceptional. The F-IBI score at 93RD405 was near the impairment threshold. The sample was dominated by white suckers and had six species, one being sensitive. Fish samples from 05RD093 taken at three different times over the last 10-years indicate that F-IBI scores have decreased dramatically. In 2006, the F-IBI was well over the exceptional use threshold (79) but the score dropped to 12 in 2013 and 0 in 2014. The changes in F-IBI corresponded with a decrease in the number of fish species as well as the number of individuals. For example, in 2006 there were 11 species sampled but only five species in the following two samples. Similarly, 150 individuals were sampled in 2006 and only 40 and 11 in the following samples. The results from these two stations confirm the existing F-IBI impairment for this reach. An analysis of habitat scores, site and aerial pictures, sample notes, and water chemistry samples failed to discern any significant changes between 2006 and 2013. Interestingly, the macroinvertebrate community's results coincide with the trend observed in the fish community. Macroinvertebrate community scores decreased from 2005 to 2013, at 05RD093, while scores at 93RD405 were good. Both stations had a great deal of periphyton growth. The macroinvertebrate community at 05RF093 appeared to respond to the increase in periphyton with a corresponding increase in filtering taxa. In general, though, habitat does not appear to be a limiting factor within this reach. Station 93RD405 scored very well, having the highest overall MSHA score in the entire subwatershed (84) and all three samples at 05RD093 resulted in good MSHA scores. By analyzing aerial photos, two "private stream fords" appear to cross the stream between 05RD093 and the confluence with the South Branch, Two Rivers. The crossings appear to let water through although they may block and hold back some water as pools are seen upstream of each "ford". It is possible that during low flow periods or if the crossing was blocked with debris that they might prohibit fish from swimming upstream. In addition, a dam is located at the outlet of the wetland complex upstream of 93RD405. Although this dam is not prohibiting fish from getting to either of the biological stations, it is possible that it is holding back water and reducing flow during certain times of the year, which may be affecting biological communities downstream of the dam.

There were no exceedances of standards for Chloride, un-ionized ammonia, and pH samples. DO measurements resulted in no exceedances in 45 samples over seven years. Early morning DO data was lacking, so an aquatic life use recommendation was not made with respect to DO. TSS and Secchi tube are both meeting aquatic life use standards with no values exceeding the 65 mg/L standard or 10 cm surrogate standards. TP concentrations average 68.1 ug/L, which meets the South Nutrient Region standard. Limited chl-a data was available, but with a mean concentration of 3.5 ug/L it is meeting the standard. *E. coli* samples resulted in no individual exceedances however there were two geometric monthly mean exceedances. The geometric monthly means that exceeded were 150/100 mL for July and 126/100 mL for August. As a result, aquatic recreation use is not supported on this reach.

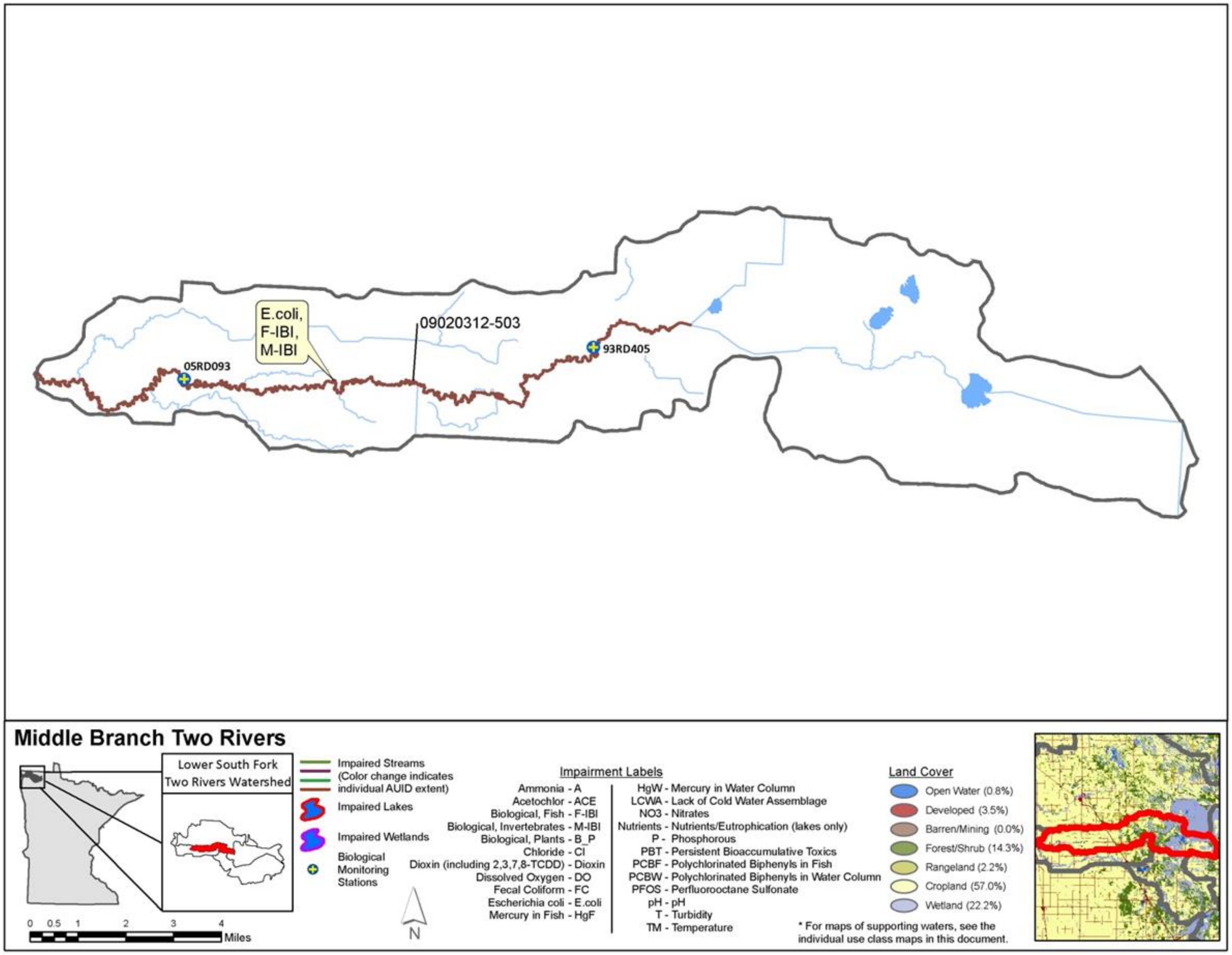

Figure 24. Currently listed impaired waters by parameter and land use characteristics in the Middle Branch, Two Rivers Subwatershed.

North Branch, Two Rivers Subwatershed HUC 09020312050

The North Branch, Two Rivers Subwatershed begins in western Roseau County, flows into northeastern Kittson County eventually ending in western Kittson County. It is the largest of the subwatersheds, draining an area of 356.9mi^2. This subwatershed contains the headwaters of the North Branch, Two Rivers, which originates in ditched systems and small streams that flow through a mixed landscape of large wetland complexes, forest, and pasture. The subwatershed covers portions of the Roseau River, Beaches, Caribou, and Skull Lake WMAs. Land use transitions from a mix of forest, wetlands, and cropland in the east to primarily cropland with interspersed pastures in the west – the transition line again appears to be US Highway 59. The river continues to gather water from small ditches and tributaries along its path until its confluence with the Two Rivers mainstem approximately seven miles northwest of Hallock. The majority of the tributary streams in this subwatershed are channelized, either to enhance drainage through wetlands or cropland, however the North Branch, Two Rivers does follow a natural course. Like most other subwatersheds, the land use consists largely of cropland, 65%, while wetland and forest comprise 17% and 10%, respectively. The remainder of the subwatershed is comprised of development, rangeland, and open water at 4%, 3%, and 1%, respectively (Figure 26). Water chemistry data is available from seven stream AUIDs and 11 biological monitoring stations. The water chemistry monitoring station is on the North Branch, Two Rivers at County Road 58, six miles northwest of Hallock.

Table 15. Aquatic life and recreation assessments on stream reaches: North Branch, Two Rivers Subwatershed. Reaches are organized upstream to downstream in the table.

					Aquatic Life Indicators:								Aquatic recreation indicators:			
AUID ***reach name,*** *reach description*	**Reach length (miles)**	**Use class**	**Biological station ID**	**Location of biological station**	F-IBI	M-IBI	DO	TSS	Chloride	pH	NH_3	Pesticides	Bacteria	Nutrients	**Aquatic life**	**Aquatic rec.**
09020312-504 ***North Branch, Two Rivers*** *Headwaters to Cty Ditch 22*	38.40	WWg	05RD094 13RD089 93RD403 13RD070	16 miles NE of Hallock, 1 mi upstream of CR 15 0.5 mi N of Lancaster DS of Hwy 59 State Hwy 6 bridge, in Lancaster Upstream of CSAH 4, 5.5 mi. N of Hallock	EXS	MTS	IF	MTS	-	MTS	MTS	-	MTS	-	IMP	SUP
09020312-508 ***North Branch, Two Rivers*** *Cty Ditch 22 to Two River*	22.18	WWg	05RD053 13RD041 13RD053	Downstream of CR 58, 6 mi. WNW of Hallock. Downstream of CR 58, 6 mi. NW of Hallock Downstream of Hwy 75, 5 mi. NW of Hallock	EXS	MTS	IF	MTS	MTS	MTS	MTS	-	MTS	-	IMP	SUP
09020312-531 ***State Ditch 72*** *Judicial Ditch 31 to State Ditch 85*	1.30	WWg	13RD055	Adjacent to 310th St, 10.5 mi. NE of Lake Bronson	EXS	EXS	IF	IF	-	IF	IF	-	-	-	IMP	NA
09020312-547 ***State Ditch 85*** *Headwaters to N. Br. Two Rivers*	7.04	WWg	13RD091	6.5 mi NE of Lancaster, at intersection of Cty Hwy 4 & Unnamed St.	MTS	MTS	IF	IF	-	IF	IF	-	-	-	SUP	NA
09020312-514 ***State Ditch 84*** *Headwaters to N. Br. Two Rivers*	16.68	WWg	13RD067	Downstream of CR 51, 9 mi. NE of Lancaster	EXS	-	IF	IF	-	IF	IF	-	-	-	IMP	NA
09020312-549 ***Judicial Ditch 31*** *Unnamed Creek to N. Br. Two Rivers*	2.45	WWg	13RD057	Upstream Unnamed Rd, 2 mi. E of Lancaster	EXS	-	IF	IF	-	IF	IF	-	-	-	IMP	NA
09020312-528 ***State Ditch 72*** *Unnamed Ditch to Unnamed Ditch*	2.0	WWg	-	-	-	-	EXS	MTS	IF	MTS	MTS	-	MTS	-	NA	SUP

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

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

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

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

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

Table 16. MSHA: North Branch, Two Rivers Subwatershed.

# Visits	Biological station ID	Reach name	Land use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish cover (0-17)	Channel morph. (0-36)	MSHA score (0-100)	MSHA rating
2	05RD094	North Branch, Two Rivers	5	11	22.35	15.5	25	78.85	Good
1	13RD089	North Branch, Two Rivers	5	9.5	18.4	16	26	74.9	Good
1	93RD403	North Branch, Two Rivers	5	12	20.4	17	32	86.4	Good
1	13RD070	North Branch, Two Rivers	0	8	13	14	13	48	Fair
1	13RD053	North Branch, Two Rivers	0	7	10	9	11	37	Poor
1	13RD041	North Branch, Two Rivers	3.75	9	11	12	15	50.75	Fair
1	05RD053	North Branch, Two Rivers	5	10	10	6	20	51	Fair
1	13RD055	State Ditch 72	5	9.5	20	15	16	65.5	Fair
1	13RD091	State Ditch 85	3	6	21.9	13	17	60.9	Fair
2	13RD067	State Ditch 84	4.75	8.5	15.65	13	14	55.9	Fair
2	13RD057	Judicial Ditch 31	2.5	8	16.1	12.5	15.5	54.6	Fair
Average Habitat Results: *North Branch, Two Rivers Subwatershed*			**3.55**	**8.95**	**16.25**	**13**	**18.59**	**60.35**	**Fair**

Qualitative habitat ratings

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

Table 17. Outlet water chemistry results: North Branch, Two Rivers Subwatershed.

Station location:	North Branch, Two Rivers at CR 58, 6 mi NW of Hallock						
STORET/EQuIS ID:	S007-442						
Station #:	05RD053						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances**
Ammonia-nitrogen	ug/L	9	<40	69	43	40	1
Chloride	mg/L	9	9.02	39.00	20.94	230	
Dissolved Oxygen (DO)	mg/L	9	5.13	9.54	7.31	5	
pH		18	6.54	8.30	7.81	6.5 - 9	
Secchi Tube	100 cm	18	4	60	22.61	10	3
Total suspended solids	mg/L	9	10	176	33.7	65	1
Phosphorus	ug/L	9	68	338	131	150	3
Chl-a, Corrected	ug/L	-	-	-	-	35	
Escherichia coli (geometric mean)	MPN/ 100ml	3	38.8	120.2	-	126	
Escherichia coli	MPN/ 100ml	15	22	770	-	1260	
Inorganic nitrogen (nitrate and nitrite)	mg/L	9	<0.03	0.52	0.09		
Kjeldahl nitrogen	mg/L	9	0.98	1.8	1.33		
Orthophosphate	ug/L	-	-	-	-		
Pheophytin-a	ug/L	-	-	-	-		
Specific Conductance	uS/cm	18	360	626	510		
Temperature, water	deg °C	18	11.65	26.83	20.63		
Sulfate	mg/L	9	14.4	41.4	31.5		
Hardness	mg/L	9	178	269	238		
Total Volatile Solids	mg/L	2	2.0	4.0	3.0		

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

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

Summary

State Ditch #72 (AUID 09020312-528) is a two-mile reach, beginning about 9.5 miles north-northwest of Greenbush. This AUID is on the far southern end of the Roseau River WMA and is surrounded by cropland and wetland complexes. No biological monitoring stations exist on this reach. Un-ionized ammonia, pH, and TSS all were meeting aquatic life standards. No values from these parameters exceeded water chemistry standards. The average concentration of total phosphorus was 90.5 ug/L, which meets the South Nutrient Region standard. Limited chl-a data was available, but with a mean concentration of 2.8 ug/L it is meeting the standard, thus the river eutrophication standard is met on this reach. DO exceeded the standard in 52.4% of samples, with many measurements between 2.0 to 4.0 mg/L. However, after further investigation, it was determined that the water being sampled on this reach originates from the nearby wetland complexes and is not representative of stream conditions. Therefore, this reach was not assessed for DO. There were no individual or geometric monthly mean exceedances of *E. coli* standards. All values were well below the standards designed to protect aquatic recreation. The greatest individual reading was 365/100 mL and the largest geometric mean was only 45/100 mL. Therefore, the reach fully supports aquatic recreation.

State Ditch #72 (AUID 09020312-531) is a 1.30 mile reach that flows in a northwesterly direction bordering the north end of Beaches WMA. Land use is a mixture of wetlands and cropland. One biological monitoring station was located on this reach, 13RD055. Both biological communities were poor, scoring below their respective impairment thresholds. The fish community was comprised of six species, all of which were tolerant (i.e., black bullhead, northern pike, central mudminnow). The macroinvertebrate community was dominated by low gradient, low DO tolerant taxa. Although this reach is entirely channelized, the habitat was fair to good and does not appear to be limiting the biological communities. Notes and pictures taken during the sampling events show very slow flow and large amounts of matted filamentous algae throughout the reach. It appears that this reach is subject to frequent slow and/or no flow which may be affecting biological communities. Similar to AUID -539 mentioned in the State Ditch #95 Subwatershed summary, this reach may at times receive a significant amount of its flow from water originating in the “Big Swamp” area within the Roseau River Watershed. Chemistry data on this AUID was limited to the biological visits, so there not sufficient information to assess for aquatic life and recreation based on the chemistry information.

State Ditch #85 (AUID 09020312-547) is a seven-mile-long reach that flows from the end of AUID -531, west to its confluence with the North Branch, Two Rivers about five miles northeast of Lancaster. Land along this reach is primarily wetlands and cropland. The reach flows through the north end of Beaches WMA. One biological monitoring station was located on this reach, 13RD091. Both biological communities scored above their respective impairment thresholds. The fish community consisted of nine species, one of which was sensitive (northern redbelly dace) as well as multiple riffle dwelling species. The macroinvertebrate community is healthy, likely a reflection of the good habitat complexity and riffles. Although the habitat is very similar to AUID -531, this reach does consist of increased flow and coarse substrates in addition to less filamentous algae. It is likely that the sustained flows through this reach are benefitting the biological communities. Chemistry data on this AUID was limited to the biological visits, so there is not sufficient information to assess for aquatic life and recreation based on the chemistry information

State Ditch #84 (AUID 09020312-514) is a 16.68-mile reach which originates along the south border of Caribou WMA and flows west through the Skull Lake WMA before winding south, then west, then south again, ending at its confluence with the North Branch, Two Rivers in Lancaster. The land use along this AUID is comprised of large wetland complexes, forest, and cropland. One biological monitoring station was located on this reach, 13RD067. The site was sampled twice for fish, once in 2013 and again in 2014 with both samples scoring poorly. The 2013, sample consisted of four species and nine individuals while the 2014, sample only consisted of three species and six fish. Although the reach is entirely channelized, the habitat is fair with good cover and substrate. Hydrological issues appear to be limiting the biological communities as the water level was low and flow was slow at the time of fish sampling and the reach was dry at the time of macroinvertebrate sampling. There is a grade control structure at the downstream end of the reach, near its confluence with the North Branch, Two Rivers in addition to the Horseshoe Lake Dam (Figure 25) which is a 15 foot high structure situated along the reach, within the Skull Lake WMA. The dam is owned by the MNDNR and was completed in 1968 to create a reservoir for flood control, recreation, and wildlife habitat purposes. The dam is a complete barrier to connectivity at all flow conditions. Additionally, the Northcote Dam is located downstream of the reach along the North Branch, Two Rivers (AUID -508) and is also a barrier to fish migration. Given the adequate habitat within this reach, flow and stream connectivity are the likely drivers of the poor biological communities. Chemistry data on this AUID was limited to the biological visits, so there is not sufficient information to assess for aquatic life and recreation based on the chemistry information.

Judicial Ditch #31 (AUID 09020312-549) is a 2.45 mile reach that flows west, then north, through a mixed landscape of forest, wetlands, and cropland to its confluence with the North Branch, Two Rivers about one mile east of Lancaster. Similar to AUID -514, this reach consisted of one biological monitoring station, 13RD057 sampled for fish in 2013 and 2014. Both fish samples resulted in poor F-IBI scores consisting of three species per sample with five and seven individuals, respectively. Although habitat was fair, hydrological issues again appear to be the limiting factor on this reach as the stream was dry at the time of macroinvertebrate sampling. If continuous flow existed, biological communities could possibly improve within this stream. Chemistry data on this AUID was limited to the biological visits, so there is not sufficient information to assess for aquatic life and recreation.

North Branch, Two Rivers (AUID 09020312-504) is a 38.40-mile reach which begins at its headwaters just west of Beaches WMA and flows southwesterly, through Lancaster and ends at its confluence with Kittson County Ditch #22, two miles northeast of Northcote. Land use along this AUID is a mixture of forest, wetland, and cropland then transitions (around US Highway 59) to primarily cropland with interspersed pastures and wetlands. There are existing impairments for DO (2010) and F-IBI (2002) on this reach. The reach consisted of five biological monitoring stations, 05RD094, 13RD090, 13RD089, 93RD403, and 13RD070 from upstream to downstream.

Fish communities within this reach scored from well below the impairment threshold at the upstream station, and at or slightly above the threshold at the three downstream stations, confirming the existing F-IBI impairment. Species composition ranged from 7 to 12 species at each station and although each consisted of at least one sensitive species, the majority of each sample consisted of tolerant species. Variable water levels and connectivity issues are likely limiting the fish communities in the upstream portions of this reach. Although flow at 05RD094 was very good at the time of sampling, conversations with landowners indicate that this portion is frequently stagnant and that beaver dams are common throughout. Station 05RF090, roughly two miles downstream of 05RD094, was in fact impounded by beaver dams in 2013 and consequently the station was not sampled for fish or invertebrates. Habitat within this reach was exceptional at the three upstream (sampleable) sites scoring high in nearly each category and consisting of abundant coarse substrates with many different cover types. The high quality habitat attributes are evident as riffle dwelling species are much more abundant than at the downstream site. This is especially true at 93RD403 as it was the lone site to have longnose dace which is a sensitive riffle dwelling species. A transition occurs between stations 93RD403 and 13RD070 at which point the stream channel deepens, erosion and sedimentation rates increase, and water clarity and habitat dramatically decrease. At the most downstream station 13RD070 the fish community consisted of only seven species and 20 individuals, of which most were black bullheads and common shiners (both tolerant). In addition, the habitat declined nearly 40 points from 93RD403 to 13RD070 with increased bank erosion and substrates comprised of nearly all sand and silt. Secchi tube readings also declined from >100 at the three upstream (sampleable) stations to only 19.5 at 13RD070. Land use is a likely contributing factor to the decline in stream habitat and water clarity within the downstream portion of this AUID. Upstream of the transition mentioned above, the stream meanders through woods and wetlands with small amounts of cropland whereas downstream of the transition the land use is nearly all cropland. The runoff from fields is a likely source of sediment but the channelized tributaries may also contribute to the increased bank erosion rates by altering the flow regime. Macroinvertebrate IBI scores were correlated with habitat quality. The lowest site in the reach, 13RD070, scored poorly for both macroinvertebrate and habitat. Stream banks at 13RD070 were sloughing, water clarity was turbid, and deep silt was a hindrance for macroinvertebrate sampling staff.

There were no un-ionized ammonia or pH values that exceeded standards. There were only two TSS exceedances observed from 40 samples over six years of sampling. The Secchi tube surrogate exceeded the 10 cm threshold in 6.8% of measurements. The exceedances for TSS and Secchi tube appear to have been biased towards event-based sampling (particularly an event in April 2014). When the samples that were taken during the high flow events were excluded from consideration, TSS met aquatic life standards. One DO exceedance was observed in 50 samples. The single exceedance was minor, just 4.30 mg/L, but there were not enough early morning DO samples taken during the assessment period to determine if the existing DO impairment could be removed. With a mean concentration of 77.4 ug/L, TP data meets the South Nutrient Region standard (150 ug/L). There were no exceedances of the individual or geometric monthly mean *E. coli* standards. The highest individual *E. coli* concentration was 248/100 mL, and the highest geometric monthly mean was 104/100 mL for July. This reach meets the aquatic recreation standards.

North Branch, Two Rivers (AUID 09020312-508) is a 22.18-mile reach that begins just east of Northcote at the confluence with Kittson County Ditch #22, and flows southwesterly to its confluence with the Two Rivers. With the exception of a few pastures, land use is primarily cropland along this AUID. There are existing impairments for DO (2010) and turbidity (2008) on this reach. Three biological monitoring stations are on the reach, 13RD053, 13RD041, and 05RD053 from upstream to downstream.

Fish communities on this reach were poor at the two upstream stations but improved to very good at the downstream station. Connectivity and reduced flow/water levels appear to be the main factors limiting fish communities along this reach. A concrete dam (Northcote Dam) is located roughly one-half mile downstream of 13RD053. The dam reduces flow and pools water upstream. In addition, the dam is likely prohibiting fish from migrating upstream which is evident by the reduced number of species sampled (10) above the dam station versus the downstream of the dam (16 and 17, respectively). The species composition is also being effected as the number of larger bodied species (channel catfish, shorthead redhorse, bigmouth buffalo, walleye) were all absent upstream of the dam but present downstream. In addition, a large beaver dam was located at the upstream end of 13RD041 with more dams likely upstream based on aerial photos. Not only are these dams prohibiting fish passage but they are also slowing the flow and allowing fine sediments to settle out. Although coarse substrates were present at the two upstream stations, they were severely imbedded and not accessible to aquatic communities. Conversely, coarse substrates and riffles were present and able to be utilized by fish at 05RD053 which coincided with a high F-IBI score. Here, the fish population consisted of three sensitive species, abundant larger bodied species, and an increased number of lithophilic spawning species. Two macroinvertebrate samples were collected at 13RD041 in 2013 and 2014. The 2013, sample was poor, with only 223 individuals captured, while the 2014, sample was good perhaps due to aquatic vegetation being sampled where it was absent in 2013. 13RD053 was too deep to get a macroinvertebrate sample, and a sample at 05RD053 was attempted however negatively affected by drought conditions. Removal of the dams (both natural and manmade) may improve IBI scores by reducing barriers to fish migration, increasing stream flow and freeing up coarse substrates for all biological communities.

There were no un-ionized ammonia, chloride, and pH values that exceeded the aquatic life standards. DO exceeded the 5 mg/L standard just once in 49 samples over seven years. However, the minimum number of early morning DO samples was not attained, so the existing DO impairment will not be removed from the impaired waters list. There was only one TSS exceedance observed from 42 samples over seven years of sampling and Secchi tube readings exceeded the surrogate standard only three times in 73 samples over eight years. These sediment data suggest that the existing turbidity impairment can be removed from the impaired waters list. The average TP concentration was 90.5 ug/L, which meets the South Nutrient Region standard. There was a limited amount of chl-a data available, but the mean concentration of 2.8 ug/L did meet the standard. There was one exceedance of the *E. coli* standard (just over the standard at 1299/100 mL) out of 36 samples and no geometric monthly mean exceedances. Therefore, aquatic recreation use is supported on this reach.

Overall, this subwatershed is characterized by biological communities that are in poor to good condition. The quality of the communities appears to be related to stream connectivity and hydrology. In the headwater tributaries, the biological communities appear to be most frequently subjected to and negatively affected by variable flow. Many of the headwater systems that were sampled for fish during the summer had very slow flow and went dry before macroinvertebrates could be sampled. Habitat was usually fair to good but the lack of flow appeared to hampered survival. In reaches where continuous flow was present all year (AUID -547), the biological communities were in good condition. Flow permanence is likely influenced by drainage practices that are designed to remove water off of the landscape quickly but result in highly variable stream flows and impacts to the biological communities.

In the mainstem North Branch, Two Rivers biological communities had a similar relationship with flow. Although none of the sites went dry during the 2013, sampling, IBI scores were lower where slow flow was noted or where landowners indicated that the stream may go dry (05RD094). Beaver dams appear to be causing the slow flow on the upper reaches of this stream in addition to likely creating a barrier to fish passage. Similarly, the concrete dam downstream of 13RD053 is impeding fish migration and slowing flow directly upstream. The removal of these barriers (specifically the concrete dam) may enhance flow and improve habitat condition for the biological communities in the mainstem and tributaries.

Figure 25. Horseshoe Lake Dam on AUID -514.

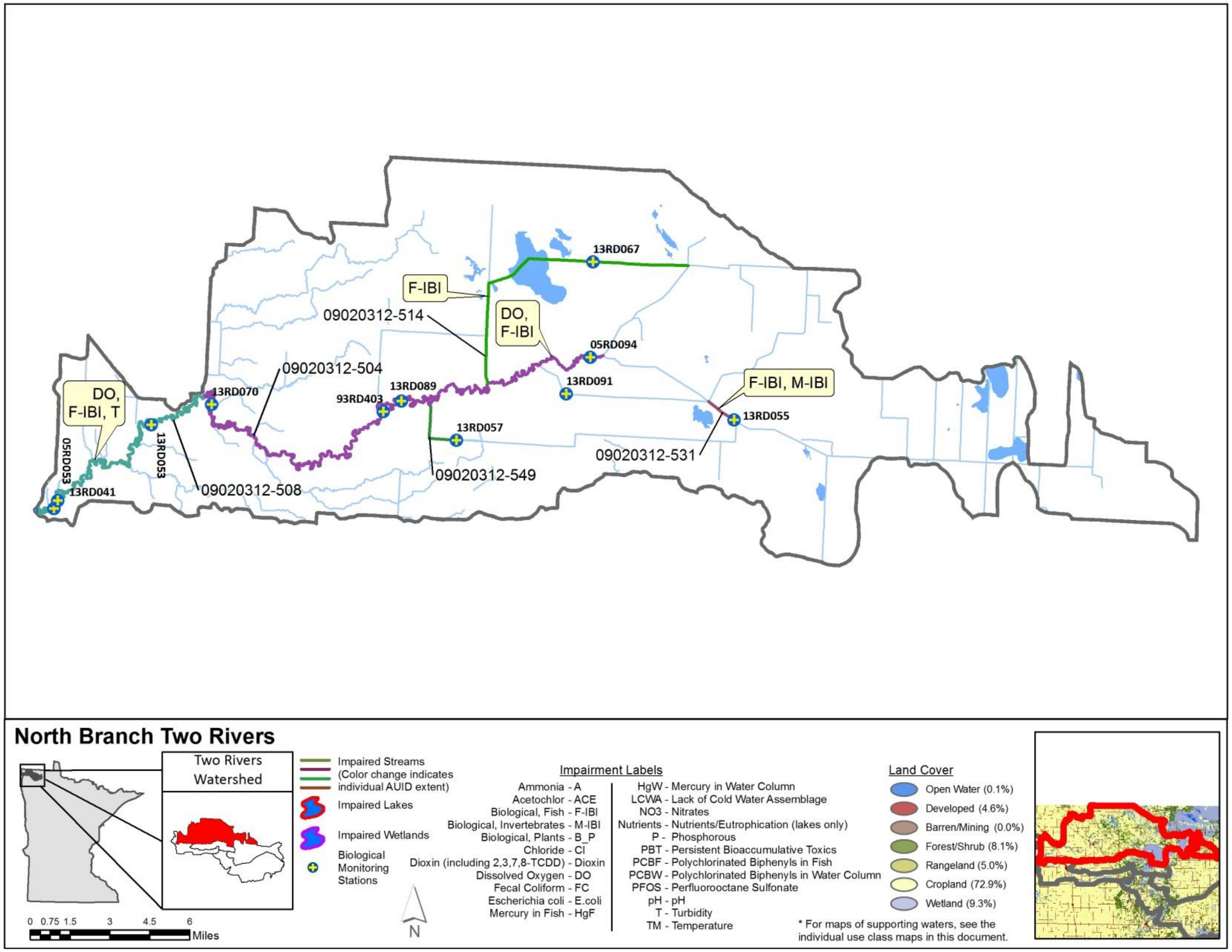

Figure 26. Currently listed impaired waters by parameter and land use characteristics in the North Branch, Two Rivers Subwatershed.

VI. Watershed-wide results and discussion

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

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

Watershed Pollutant Load Monitoring Network

Samples have been collected and loads calculated for the Two River near Hallock, CSAH 16 beginning in 2009. Three subwatershed sites were established in 2013 (Table 18); however due to their recent establishment, data was not available at the time of this report. Analysis and results within this report are limited to the data collected at the Two River outlet near Hallock.

Table 18. WPLMN Stream Monitoring Sites for the Two Rivers Watershed.

Site type	Stream name/location	USGS	MNDNR/MPCA	EQuIS
Major Watershed	Two River near Hallock, CSAH16	NA	H70012001	S000-569
Subwatershed	South Branch, Two Rivers at Lake Bronson, US Hwy 59	05094000	E70033001	S002-365
Subwatershed	South Branch, Two Rivers at Hallock, MN Hwy 175	NA	H70018001	S005-387
Subwatershed	North Branch, Two Rivers near Northcote, CR 65	NA	H7002002	S008-208

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

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

Annual FWMCs for the Two River near Hallock were calculated for 2009 to 2013, and compared with South RNR standards (only TP and TSS river standards exist for Minnesota at this time) to give an indication of the overall water quality of the watershed and contrast year to year variability. See below for specific parameter results and discussion. It should be noted that while a FWMC exceeding water quality standards is generally a good indicator that the water body is out of compliance with the RNR standard, the rule may not always hold true. Waters of the state are listed as impaired based on the percentage of individual samples exceeding the numeric standard, generally 10% and greater, over the most recent 10-year period (MPCA, 2014) and not based on comparisons with FWMCs. A river with a FWMC above a water quality standard, for example, would not be listed as impaired if less than 10% of the individual samples collected over the assessment period exceeded the standard.

Pollutant sources and source contributions affecting rivers can be diverse from one watershed to the next depending on land use, climate, soils, slopes, and other watershed factors. Regional correlations between land use, percent land disturbance, and water quality can be observed in Figure 27 and Figure 28. Elevated nutrient and sediment levels in streams and rivers can occur naturally in landscapes composed of young glacial soils, steep slopes, or other natural factors; however, land use, percent disturbance and other anthropogenic influences also strongly influence measured water quality. As a general rule, elevated levels of TSS and nitrate plus nitrite-nitrogen (NO_3+NO_2-N) are regarded as “non-point” source derived pollutants originating from many small diffuse sources such as urban or agricultural runoff. Excess TP and DOP can be attributed to both non-point as well as point sources such as industrial or waste water treatment plants. Major “non-point” sources of phosphorus include dissolved phosphorus from fertilizers and phosphorus adsorbed to and transported with sediment during runoff.

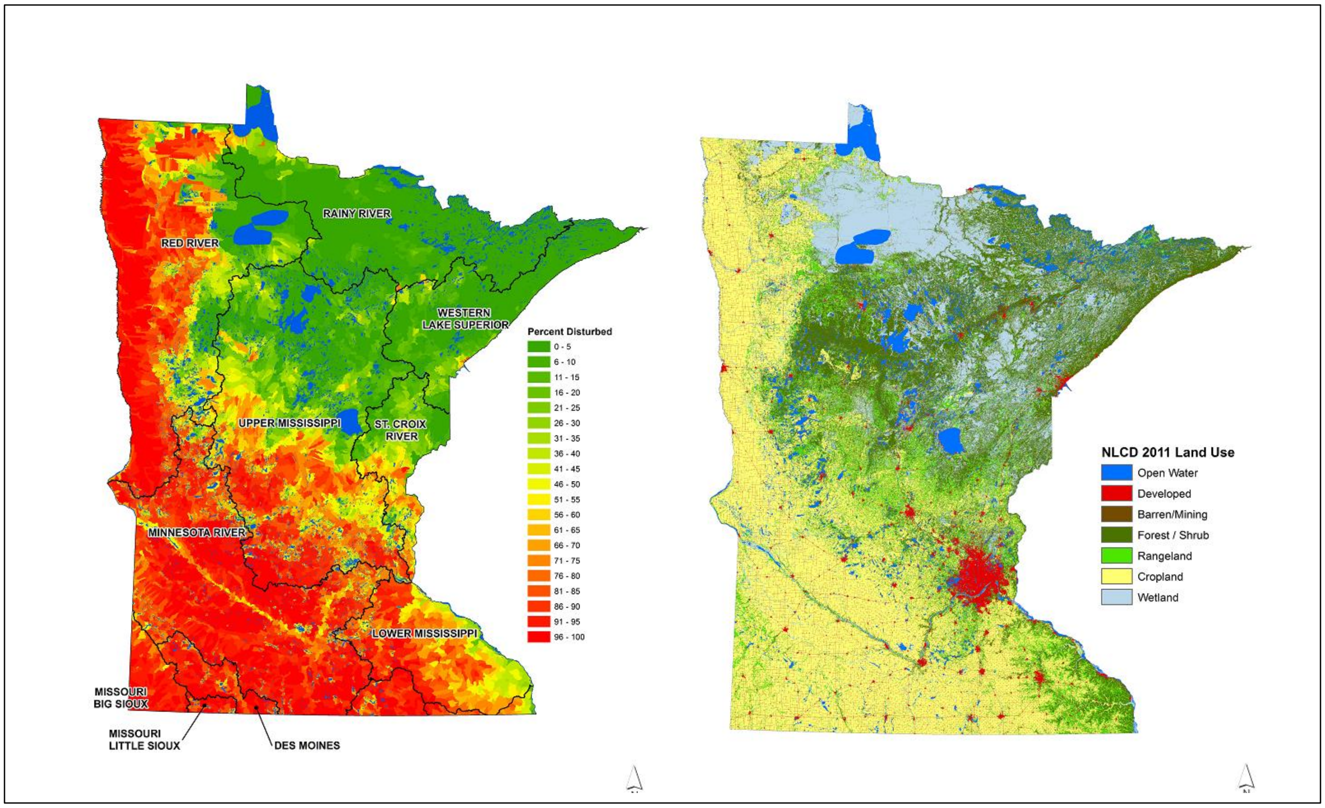

Figure 27. Percent land disturbance and NLCD 2011 land use for the state of Minnesota.

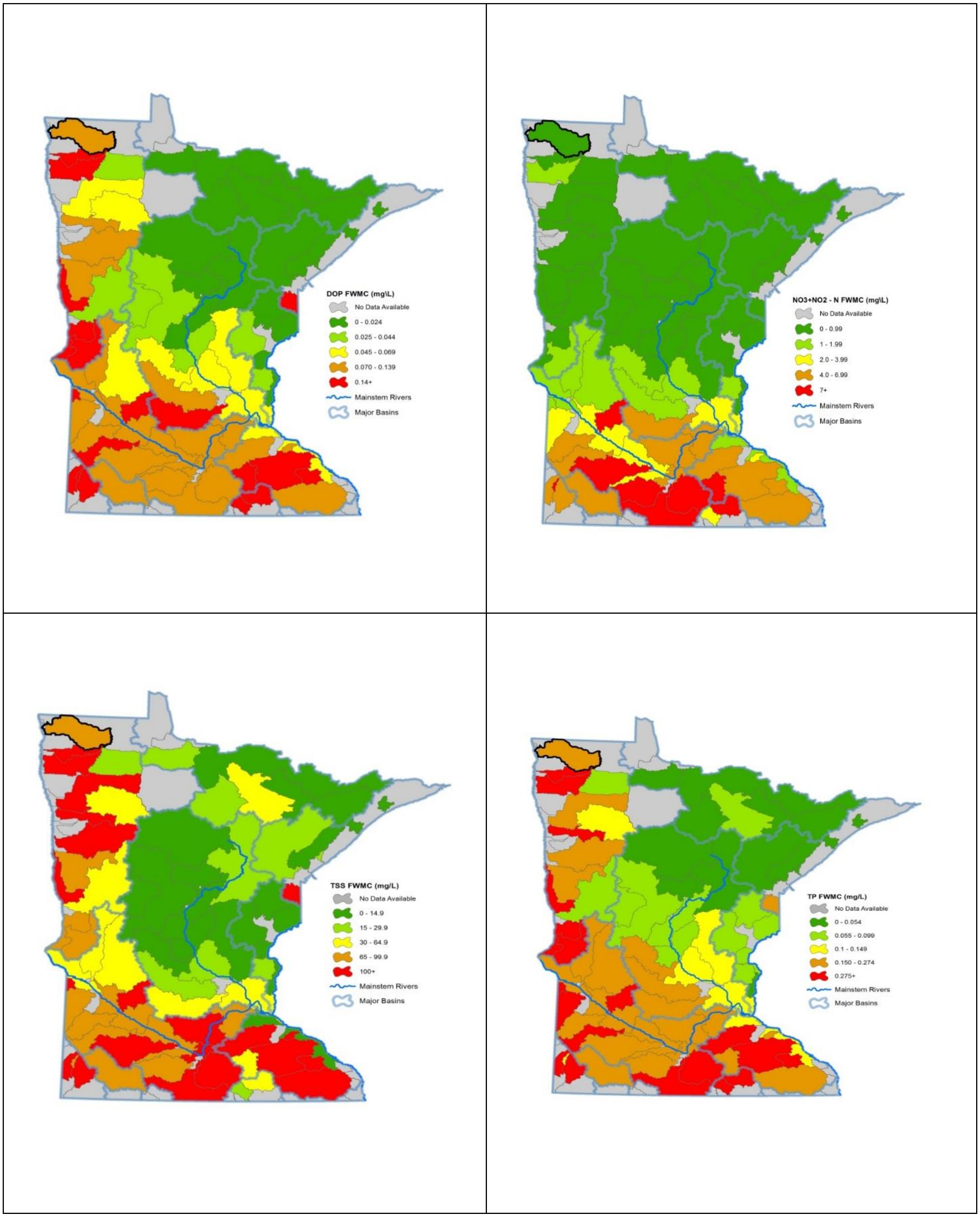

Figure 28. 2007-2013 WPLMN average annual TSS, TP, NO3-NO2-N and DOP FWMCs by major watershed.

Within a given watershed, pollutant sources and source contributions can also be quite variable from one runoff event to the next depending on factors such as: vegetative canopy development, soil conditions (frozen/unfrozen saturation level, etc.), and precipitation type, intensity, and amount. Surface erosion and in-stream sediment concentrations, for example, will typically be much higher following high intensity rain events prior to canopy development when compared to post-canopy events where soils are more protected and less surface runoff and more infiltration occur. Precipitation type and intensity can influence the major course of storm runoff, routing water through several potential pathways including overland, shallow, and deep groundwater, or through artificial agricultural and urban drainage networks. Runoff pathways along with other factors determine the type and levels of pollutants transported in runoff to receiving waters and help explain between-storm and temporal differences in in-stream pollutant concentrations. Pollutant loads, the product of concentration and flow, are influenced not only by in-stream pollutant concentrations but also the volume of runoff delivered to the stream. During years when high intensity rain events provide the greatest proportion of total annual runoff, FWMCs of TSS tend to be higher and DOP and NO_3+NO_2-N concentrations tend to be lower. In contrast, during years with high snow melt runoff and less intense rainfall events, TSS FWMCs tend to be lower while DOP, and NO3+NO2-N levels tend to be elevated. TP concentrations can be high from both runoff sources although storm generated runoff will typically have a greater proportion of sediment bound phosphorus resulting in lower DOP/TP ratios when compared to snowmelt runoff. Years with larger runoff volumes will typically have larger loads when compared to years with lesser runoff volumes. Table 19 for example, shows the 2011, TSS load to be approximately five times higher than the following year's load, largely because of differences in runoff volume.

Table 19. Annual Pollutant Loads (kg) for the Two River near Hallock, Minnesota.

Parameter	2009	2010	2011	2012	2013
TSS	44,510,410	51,768,260	24,056,680	4,924,345	11,688,850
TP	117,230	105,880	69,746	6,631	45,193
DOP	54,790	57,545	37,715	4,777	23,862
NO_3+NO_2-N	112,554	369,778	620,499	39,271	91,438

Total suspended solids

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

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

Minnesota's water quality standards for river eutrophication and TSS were adopted into Minn. R. ch. 7050 in 2014 and approved by the EPA in January 2015. Within the south RNR, a river is considered impaired when greater than 10% of the individual samples exceed the TSS standard of 65 mg/L. (MPCA, 2011). From 2009 through 2013, 34% of the 142 water quality samples collected at the Two River near Hallock monitoring site exceeded this standard. Total suspended solids FWMCs for this site also exceeded the 65 mg/L standard two out of five years as shown in Figure 29.

When compared with other HUC-8 watersheds throughout the state, Figure 28 shows the average annual TSS FWMC to be several times higher for the Two Rivers Watershed versus watersheds in north central and northeast Minnesota, but in line with the agriculturally rich watersheds found in northwest, north central, and southern regions of the state.

Seasonality and climate influence the timing and size of TSS loads. Figure 30 illustrates the majority of the average annual flow volume (82%) and average annual TSS load (85%) pass through the watershed beginning in March and running through the end of June, the period when vegetative canopy is lacking or minimal.

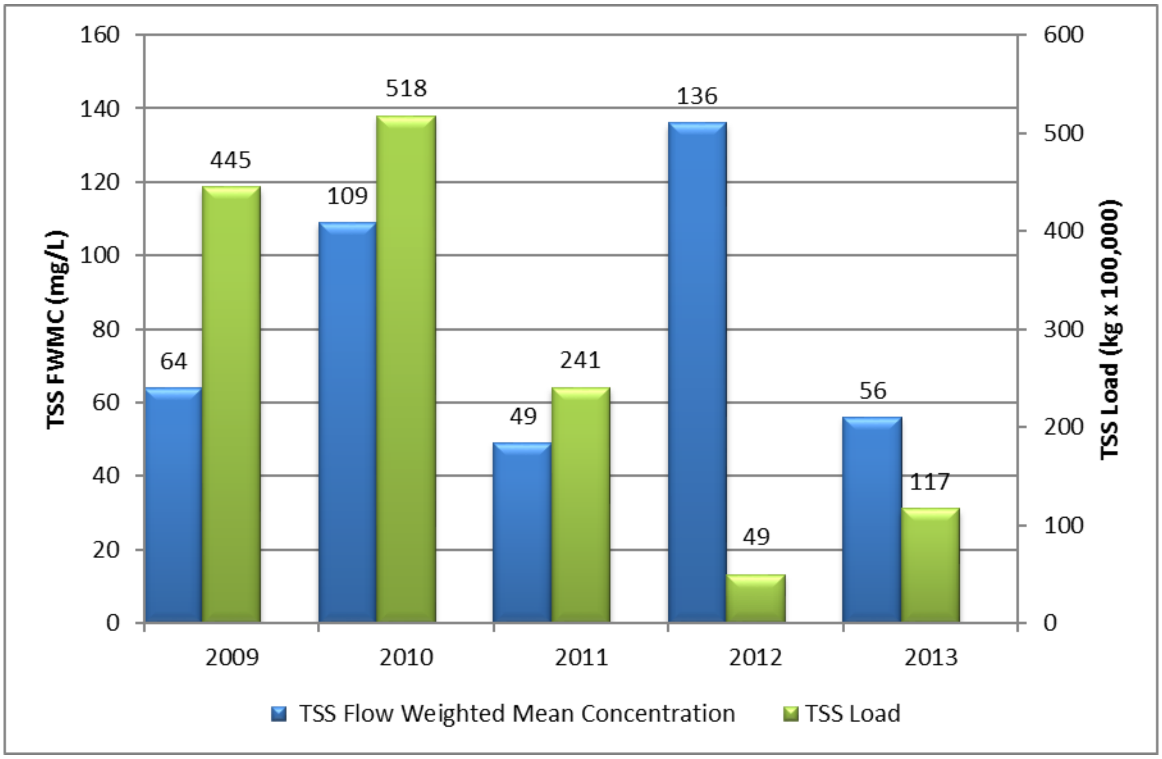

Figure 29. TSS FWMCs and Loads for the Two River near Hallock, Minnesota.

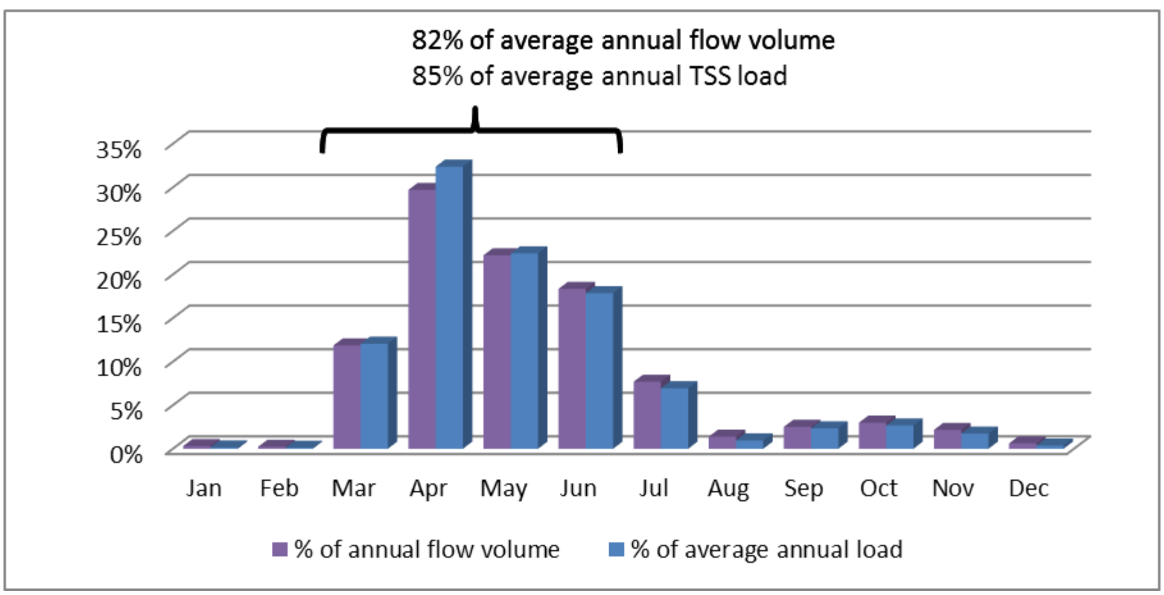

Figure 30. Monthly percentages of the average annual TSS load for the Two River near Hallock, 2009-2013.

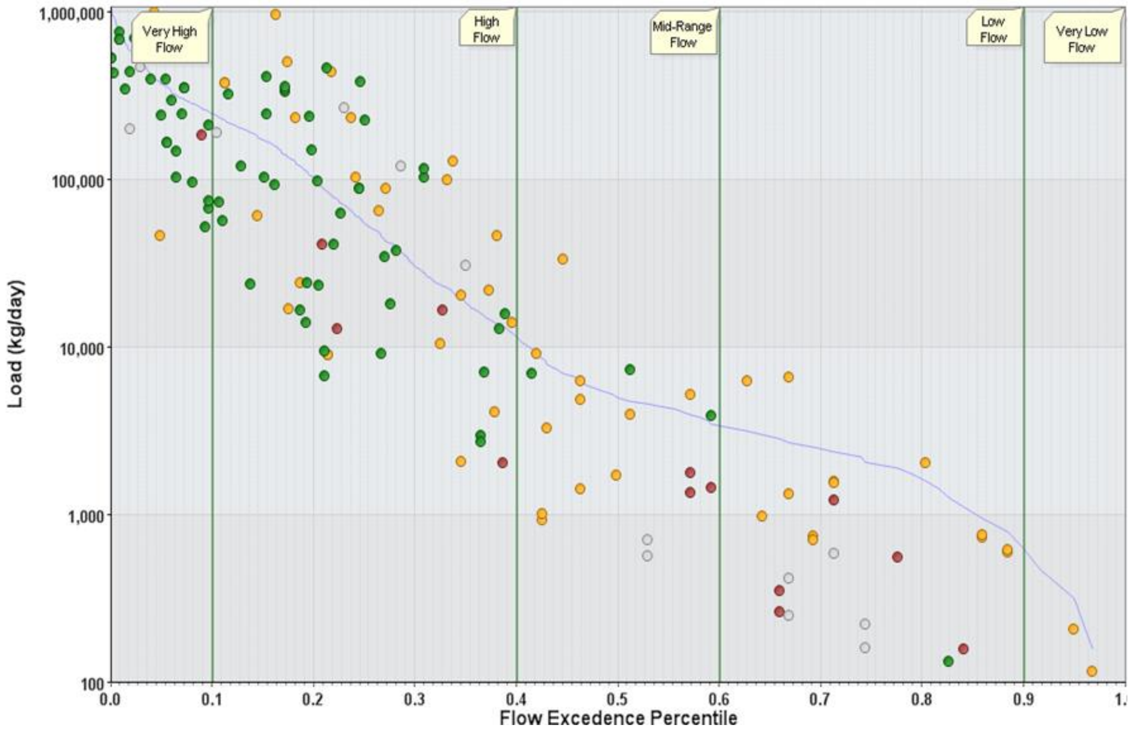

Figure 31. TSS load duration curve for Two River near Hallock, Minnesota, 2009-2014.

Flow conditions under which violations in Minnesota's TSS standard are most likely to occur for the Two River is best illustrated with the TSS load duration curve for the Two River near Hallock (Figure 31). A load duration curve is a plot of daily loads computed from TSS sample concentrations plotted against the exceedance curve, above which daily loads are considered non-compliant with TSS water quality standards for the South RNR. Figure 31 shows most exceedances of the TSS standard occur under "moist" to "high flow" conditions and during the spring and summer seasons.

Total phosphorus

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

Within the south RNR, a violation of Minnesota's water quality standard for river eutrophication occurs when the TP summer mean concentration (June through September) is at or above 0.150 mg/L along with a summer average violation of one or more "response" variables (pH, biological oxygen demand, DO flux, chl-a). A comparison of all 2009 through 2013 total TP data collected for the Two River near Hallock show TP concentrations at or above the 0.150 mg/L south RNR TP standard 48% of the time. The summer TP averages were above the standard for three of the five years. TP FWMCs were also greater than the standard in four of the five years (Figure 32).

Similar to TSS, NO_3+ NO_2-N, and flow, Figure 33 illustrates the majority of the average annual TP load (84%) passes through the system beginning in March and running through the end of June. Interestingly, 44% of the average annual load is carried through the system during the months of March and April alone, a period largely dominated by snowmelt runoff and spring showers.

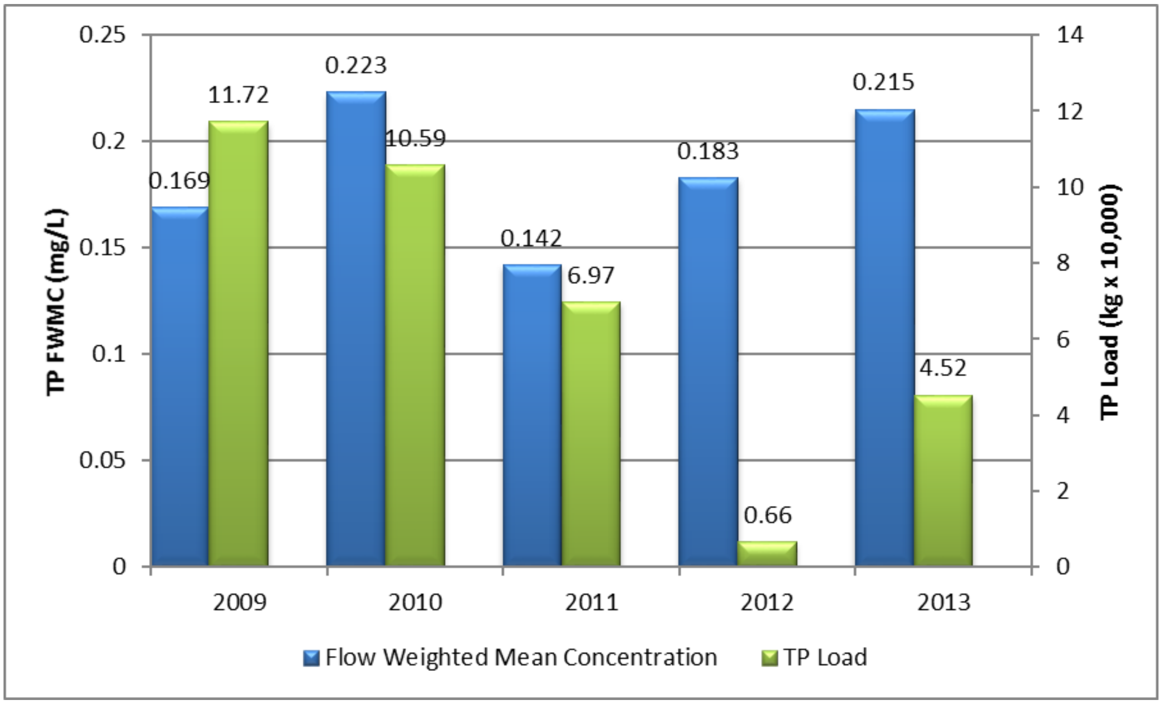

Figure 32. TP Flow Weighted Mean Concentrations and Loads for the Two River near Hallock, Minnesota.

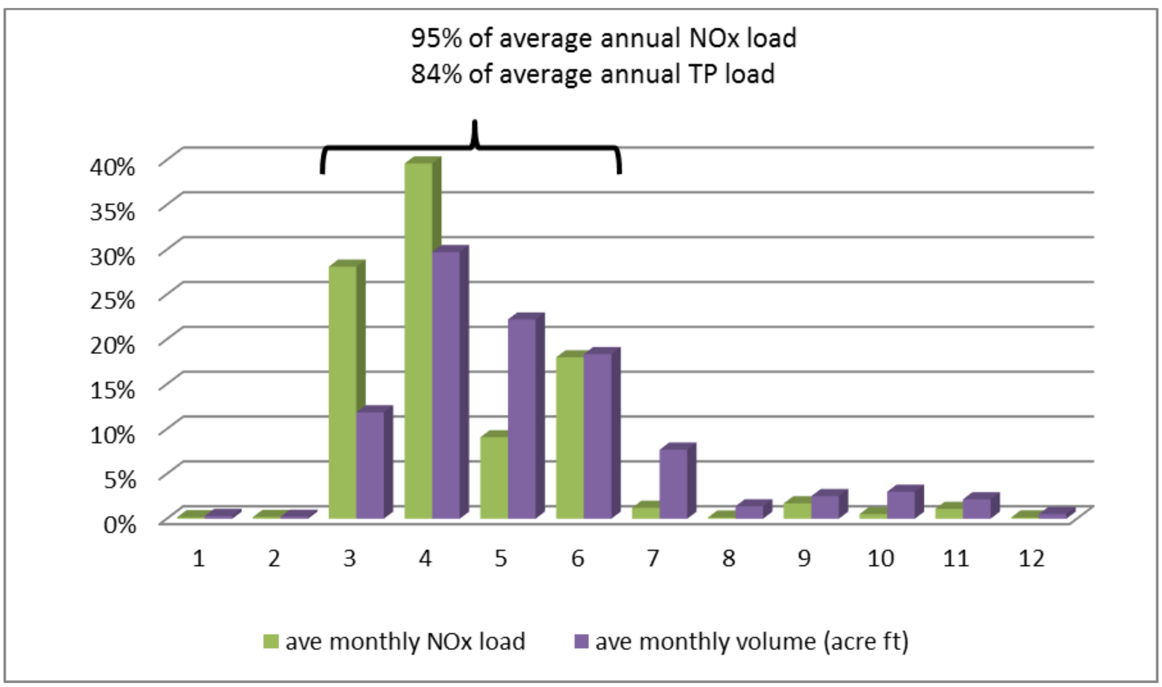

Figure 33. Monthly percentages of the average annual NO3-NO2-N and TP loads for the Two Rivers near Hallock, 2009-2013.

Due to soil frost and snow packed ditches, melt water can be trapped on the landscape for days or weeks at a time allowing for desorption of phosphorus from agricultural soils and plant residue resulting in elevated dissolved orthophosphate concentrations. During years with sudden spring thaws, surface soils can also be eroded when surface frost lets go, allowing the transport of sediment bound phosphorus to receiving streams. Further analysis of 141 water quality samples show the month of July had the highest mean TP concentration at 0.210 mg/L (Table 20), 44% in the form of DOP. The average TP concentration for the other eleven months of the year is about half the July average at 0.118 mg/L, 79% in the form of DOP. DOP is a form of phosphorus directly available for biological uptake.

Table 20. Mean TP and DOP concentrations during July and the remainder of the year for the Two River near Hallock, Minnesota.

	Mean TP (mg/L)	Mean DOP (mg/L)	DOP/TP ratio
July	0.210	0.093	44%
August-June	0.118	0.093	79%

Nitrate plus nitrite - nitrogen

Nitrate and nitrite-nitrogen are inorganic forms of nitrogen present within the environment that are formed through the oxidation of ammonia-nitrogen by nitrifying bacteria (nitrification). Ammonia-nitrogen is found in fertilizers, septic systems, and animal waste. Once converted from ammonia-nitrogen to nitrate and nitrite-nitrogen, they too, like phosphorus, can stimulate excessive levels of some algae species in streams (MPCA, 2013). Because nitrate and nitrite-nitrogen are water soluble, transport to surface waters is enhanced through agricultural drainage. The ability of nitrite-N to be readily converted to nitrate-nitrogen is the basis for the combined laboratory analysis of nitrate plus nitrite-nitrogen, with nitrite-nitrogen typically making up a small proportion of the combined total concentration. These and other forms of nitrogen exist naturally in aquatic environments; however, concentrations can vary drastically depending on season, biological activity, and anthropogenic inputs. Environmentally, studies have shown that the elevated nitrate-nitrogen levels in the Minnesota River basin contribute to hypoxia (low levels of DO) in the Gulf of Mexico. This occurs by nitrate-nitrogen stimulating the growth of algae which, through death and biological decomposition, consume large amounts of DO and thereby threaten aquatic life (MPCA and MSUM, 2009).

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

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

From a statewide perspective, Figure 28 shows the average annual NO_3+NO_2-N FWMCs to be highest in the southern part of the state. These FWMCs are several times higher than watersheds north of the twin cities metropolitan area. Watersheds characterized as having low or medium levels of nitrate generally have more land in forest or grasses, more in wetlands, more in small grains, and less land in row crops and tile drainage (MPCA, 2013).

Seasonal NO_3+ NO_2-N load dynamics for the Two River are similar to TSS, TP, and runoff with 95% of the load (Figure 33) passing through the system beginning in March and running through the end of June when vegetative canopy is lacking or in the early stages of development and transpiration rates are low.

Figure 34 shows the NO_3+ NO_2-N FWMCs over the five year period for the Two River near Hallock. Flow weighted mean concentrations for the site ranged from 0.16 to 1.3 mg/L over the monitoring period with a five-year average of 0.76 mg/L. Of the 140 individual samples collected between 2009 and 2013, none exceeded the nitrate drinking water standard of 10 mg/L. Furthermore, Figure 34 shows the influence annual runoff volume has on annual NO_3+ NO_2-N loads. For example, the load associated with the year of the highest runoff volumes (2011), makes up 50% of the entire load over the five-year period.

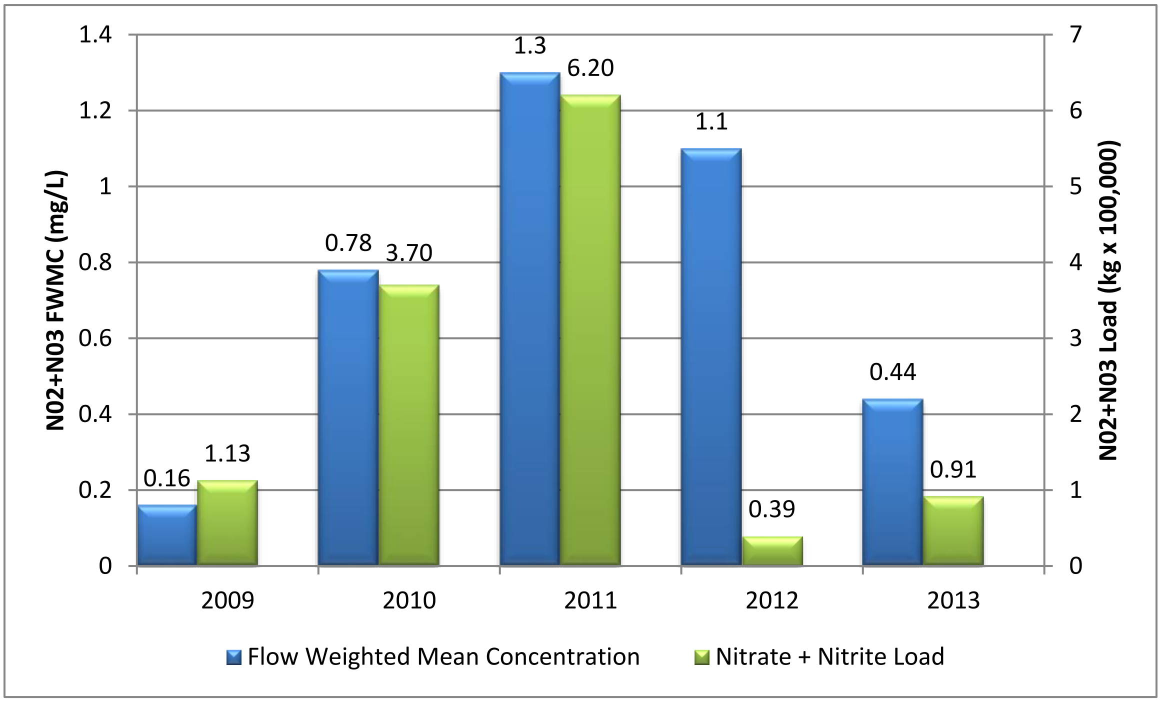

Figure 34. NO3+NO2-N Flow Weighted Mean Concentrations and Loads for the Two River near Hallock, Minnesota.

Stream water quality

Twenty-three of the 52 stream reaches were assessed (Appendix 4). Of the 23 assessed stream reaches,

11 streams had bacteria data available for aquatic recreation assessment while 12 AUIDs were not assessed due to insufficient information. Of the 11 stream reaches assessed for aquatic recreation, five do not support aquatic recreation and six support aquatic recreation. Twenty-one reaches had biological data available for aquatic life assessment while two were not assessed due to insufficient information. Of the 21 stream segments assessed for aquatic life, 15 AUIDs did not support aquatic life and six support aquatic life.

Table 21. Assessment summary for stream water quality in the Two Rivers Watershed.

				Supporting		Non-supporting			
Watershed	Area (acres)	# Total AUIDs	# Assessed AUIDs	# Aquatic Life	# Aquatic Recreation	# Aquatic Life	# Aquatic Recreation	Insufficient Data	# Delistings
09020312 HUC 8	**688,448**	**52**	**23**	**6**	**6**	**15**	**5**	**2 AL, 12 AR**	**1**
09020312010	213,056	14	9	5	0	4	2	0 AL, 8 AR	0
09020312020	136,832	15	3	0	1	2	1	1 AL, 2 AR	0
09020312030	60,096	5	3	0	2	3	1	0 AL, 0 AR	0
09020312040	50,048	3	1	0	0	1	1	0 AL, 0 AR	0
09020312050	228,416	15	7	1	3	5	0	1 AL, 4 AR	1

Lake water quality

As seen in Table 23, Lake Bronson (35-0003-00) did not have sufficient data to assess for aquatic life or aquatic recreation.

Table 22. Assessment summary for lake water chemistry in the Two Rivers Watershed.

			Supporting		Non-supporting			
Watershed	Area (acres)	Lakes >10 Acres	# Aquatic Life	# Aquatic Recreation	# Aquatic Life	# Aquatic Recreation	Insufficient Data	# Delistings
09020312 HUC 8	**688,448**	**1**	**0**	**0**	**0**	**0**	**0**	**0**
030203120 10	213,056	1	0	0	0	0	1	0
090203120 20	136,832	0	0	0	0	0	0	0
090203120 30	60,096	0	0	0	0	0	0	0
090203120 40	50,048	0	0	0	0	0	0	0
090203120 50	228,416	0	0	0	0	0	0	0

Stream biological monitoring

Fish

Historically, throughout the Red River Basin, there have been 86 different species of fish sampled. Although the Two Rivers Watershed only encompasses a small portion of the Red River Basin, 46 fish species were sampled during this survey. This basin does not have any fish species identified by the MNDNR as endangered; however, it does have one threatened species (pugnose shiner) and two species of special concern (least darter and lake sturgeon), none of which were sampled in the Two Rivers Watershed during this survey. The MNDNR has also identified one aquatic invasive species within this basin, Eurasian watermilfoil.

Some species of fish were found at many sites with high densities, while other species were found at limited sites in low numbers. The most commonly found fish species within the watershed were the common shiner and white sucker, which were sampled at 25 and 26 of the 32 sites, respectively.

These two species also occurred in the highest numbers, totaling 1,567 and 1,891 individuals, respectively. Other species that were commonly found throughout the watershed included northern pike, creek chub, and central mudminnow, all of which were sampled at over 60% of the sites. A number of species were only sampled at one site and in low numbers such as bigmouth shiner, brown bullhead, largemouth bass, longnose dace, quillback, and white bass. A list of the species sampled, how many sites each species were sampled at, and the total number of individuals can be found in Appendix 8.

Macroinvertebrates

During macroinvertebrate sampling in the Two Rivers watershed, 241 unique macroinvertebrate taxa were collected and no endangered macroinvertebrate taxa were present. The Two Rivers Watershed's macroinvertebrate community is subject to a great deal of anthropogenic stress as a result of land use practices. Localized stressors such as low DO, high nutrient levels, excess sediment, stream instability, and lack of permanent flow were common through much of the watershed. The most abundant taxa in the watershed were all tolerant to disturbance including; a midge, *Polypedilum*; black flies, *Simulium*; a snail, *Physa*; an amphipod, *Hyalella;* and a mayfly *Caenis diminata*. Though the majority of the watershed is dominated by tolerant taxa, there are portions of the watershed that have pockets of more sensitive taxa. These areas were generally associated with less disturbed stream channels and substantial buffers. Some of the notable less tolerant taxa observed included *Gomphus* a dragonfly, *Chimarra* and *Ceraclea,* both Caddisflies. The populations of sensitive organisms found in less disturbed areas have the potential to serve as source populations as improvements in water quality within the Two Rivers watershed. A list of species sampled, how many occurrences were observed, and the total number of individuals collected can be found in Appendix 6.

Fish contaminant results

Mercury was analyzed in fish tissue samples collected from Lake Bronson in 2013. No other fish contaminant data is available for the Two Rivers Watershed. Five fish species were tested for contaminants. Fish species are identified by codes that are defined by their common and scientific names (Table 23). A total of 30 fish were collected for contaminant analysis.

Contaminant concentrations are summarized by waterway, fish species, and year (Table 24). "Total Fish" indicates the total number of fish analyzed and "N" indicates the number of samples. The number of fish exceeds the number of samples when fish are combined into a composite sample. This was typically done for panfish, such as bluegill sunfish (BGS) and yellow perch (YP). "Anat." refers to the sample anatomy. Since 1989, most of the samples have been skin-on fillets (FILSK) or for fish without scales (catfish and bullheads), skin-off fillets (FILET). Occasionally whole fish (WHORG) are analyzed.

Lake Bronson is not listed as impaired for mercury in fish tissue in MPCA's 2014, draft Impaired Waters List; however the data collected in 2013 clearly shows the fish have high mercury concentrations and the lake will be included in the 2016 Impaired Waters Inventory. The Fish Contaminant Monitoring Program will continue to retest the fish from Lake Bronson to assess mercury levels.

Table 23. Fish species codes, common names, and scientific names.

Species	Common Name	*Scientific Name*
BKS	Black crappie	*Pomoxis nigromaculatis*
NP	Northern pike	*Esox lucius*
WE	Walleye	*Sander vitreus*
WSU	White sucker	Catostomus commersoni
YP	Yellow perch	*Perca flavescens*

Table 24. Summary statistics of fish lengths, mercury, and PCBs by waterway species-year.

Major Watershed	HUC-8	AUID	Waterway	Species[1]	Year	Anat.[2]	Total Fish	N	Length (in)			Mercury (mg/kg)		
									Mean	Min	Max	Mean	Min	Max
Two Rivers	09020312	35000300	BRONSON	BKS	2013	FILSK	4	1	9.3	9.3	9.3	0.427	0.427	0.427
				NP	2013	FILSK	8	8	20.7	16.0	29.8	0.623	0.422	0.920
				WE	2013	FILSK	8	8	17.2	11.3	21.6	0.974	0.537	1.256
				WSU	2013	FILSK	5	1	16.6	16.6	16.6	0.415	0.415	0.415
				YP	2013	FILSK	5	1	7.8	7.8	7.8	0.268	0.268	0.268

1. Species codes are defined in Table FC1.
2. Anatomy codes: FILSK – edible fillet.

Groundwater quality

The Two Rivers Watershed is located in Northwest Minnesota with three types of aquifers: Cretaceous, buried sand and gravel, and surficial sand and gravel aquifers. A baseline study conducted by the MPCA found that the median concentrations of most chemicals in the sand and gravel aquifers in this region were slightly higher, while iron and sulfate were much higher, than concentrations in similar aquifers statewide (MPCA, 1999).

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

The MDA monitors pesticides and nitrate on an annual basis in groundwater across agricultural areas in the state. The Two Rivers Watershed lies within MDA's Pesticide Monitoring Region 1 (PMR 1), also referred to as the Northwest Red River region. According to the MDA's Water Quality Monitoring Report, there were no pesticides detected in 2013 (MDA, 2014). However, nitrates were detected in 57% of the samples collected from PMR 1 with a median concentration of 0.08 mg/L. Of those samples, 36% were at or below background level of 3.0 mg/L, 7% were within 3.01 to 10.00 mg/L, and 14% were above the drinking water standard of 10.00 mg/L (MDA, 2014).

Another source of information on groundwater quality comes from the MDH, who requires testing for arsenic in all newly constructed wells. This effort has found that 10.4% of all wells installed in the state from 2008 to 2013 have arsenic levels above the MCL for drinking water of 10 micrograms per liter. In northwest Minnesota, the majority of new wells are within the water quality standards for arsenic levels, but there are some exceedances (Figure 35).

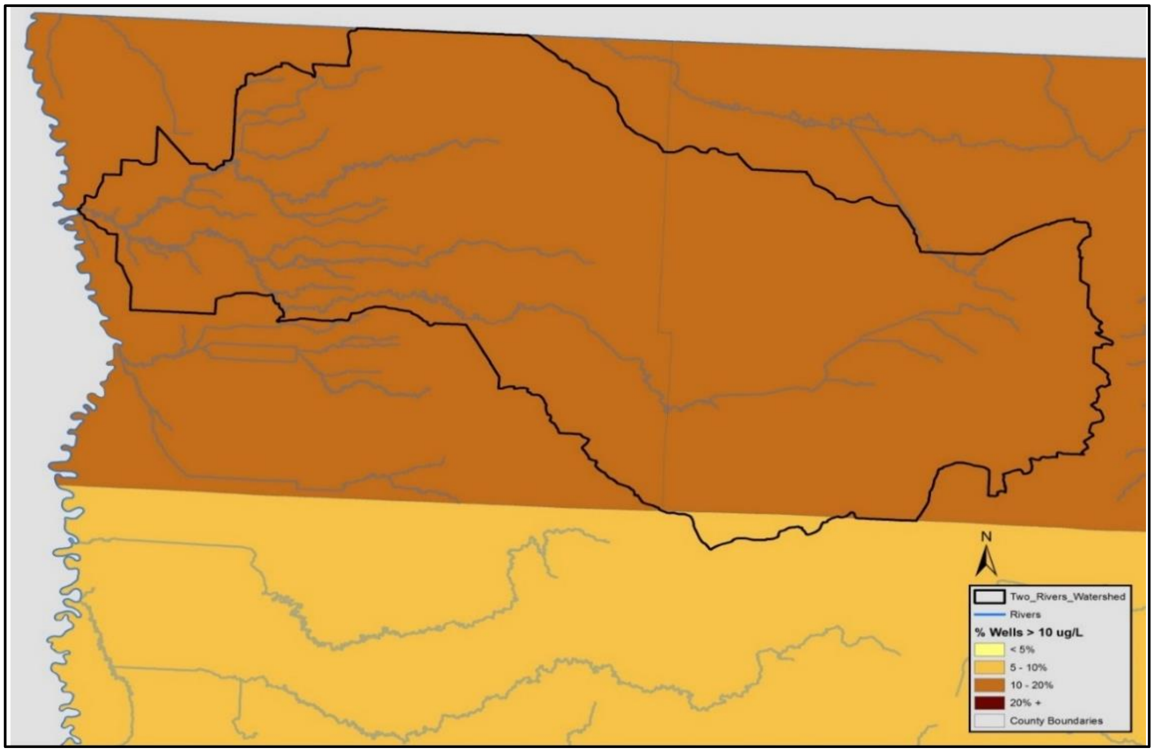

Figure 35. Arsenic Occurrence in New Wells in the Two Rivers Watershed area (2008-2012) (Source: MDH, 2012).

Groundwater quantity

Monitoring wells from the MNDNR Observation Well Network track the elevation of groundwater across the state. The elevation of groundwater is measured as depth to water in feet and reflects the fluctuation of the water table as it rises and falls with seasonal variations and anthropogenic influences. There are no currently-monitored observation wells in the Two Rivers Watershed.

Groundwater in the Two Rivers Watershed is available primarily through surficial sand and gravel aquifers, buried sand and gravel aquifers and deeper cretaceous aquifers. Recharge of these aquifers is limited to areas located at topographic highs, areas with surficial sand and gravel deposits, and those along the bedrock/surficial deposit interface. Typically, recharge rates in unconfined aquifers are estimated at 20% to 25% of precipitation received, but can be less than 10% of precipitation where glacial clays or till are present (USGS, 2007). For the Two Rivers Watershed, the average annual recharge rate to surficial materials is quite low, at zero to four inches per year for the majority of the watershed (Figure 36).

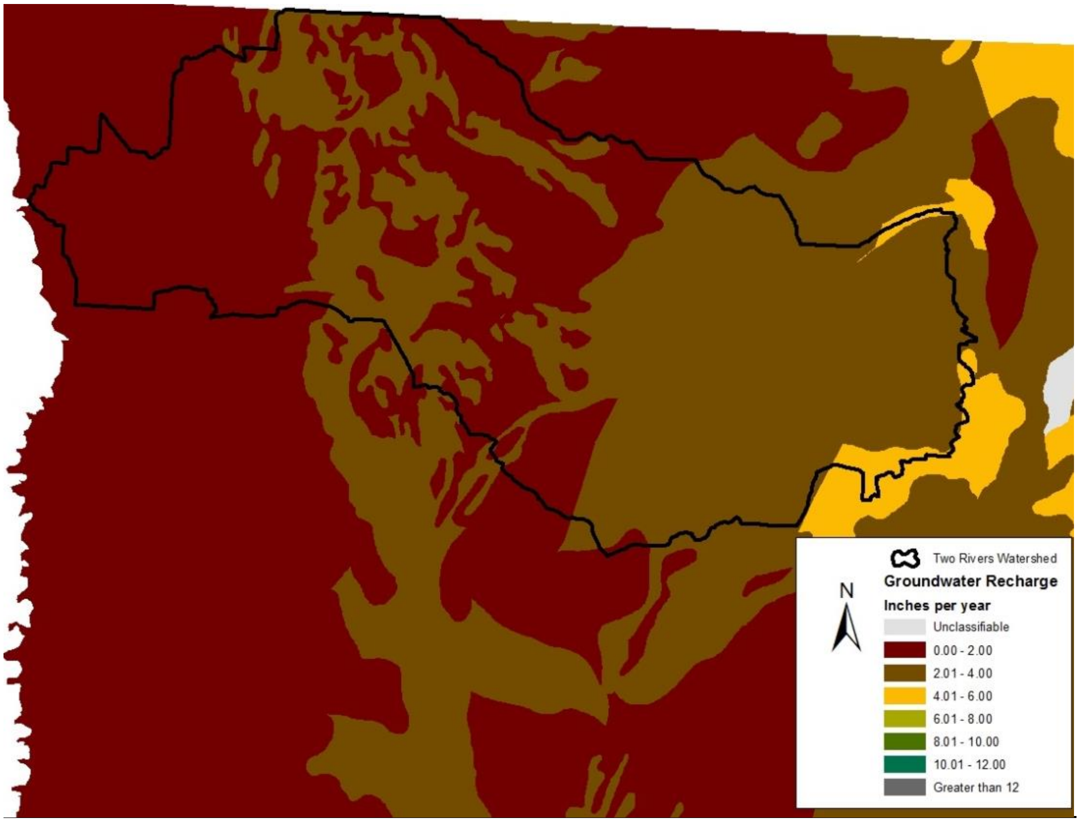

Figure 36. Average Annual Recharge Rate to Surficial Materials in Snake River Watershed (1971-2000).

High-capacity withdrawals

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

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

The three largest permitted consumers of water in the state (in order) are municipalities, industry, and irrigation. The withdrawals within the Two Rivers Watershed are mostly for municipal use and irrigation which are displayed in Figure 37.

Figure 38 displays total groundwater and surface water withdrawals from the watershed from 1993-2013. For this time period, groundwater withdrawals exhibit a statistically-significant rising trend ($p=0.1$) while surface water withdrawals exhibit an even stronger trend ($p = 0.001$).

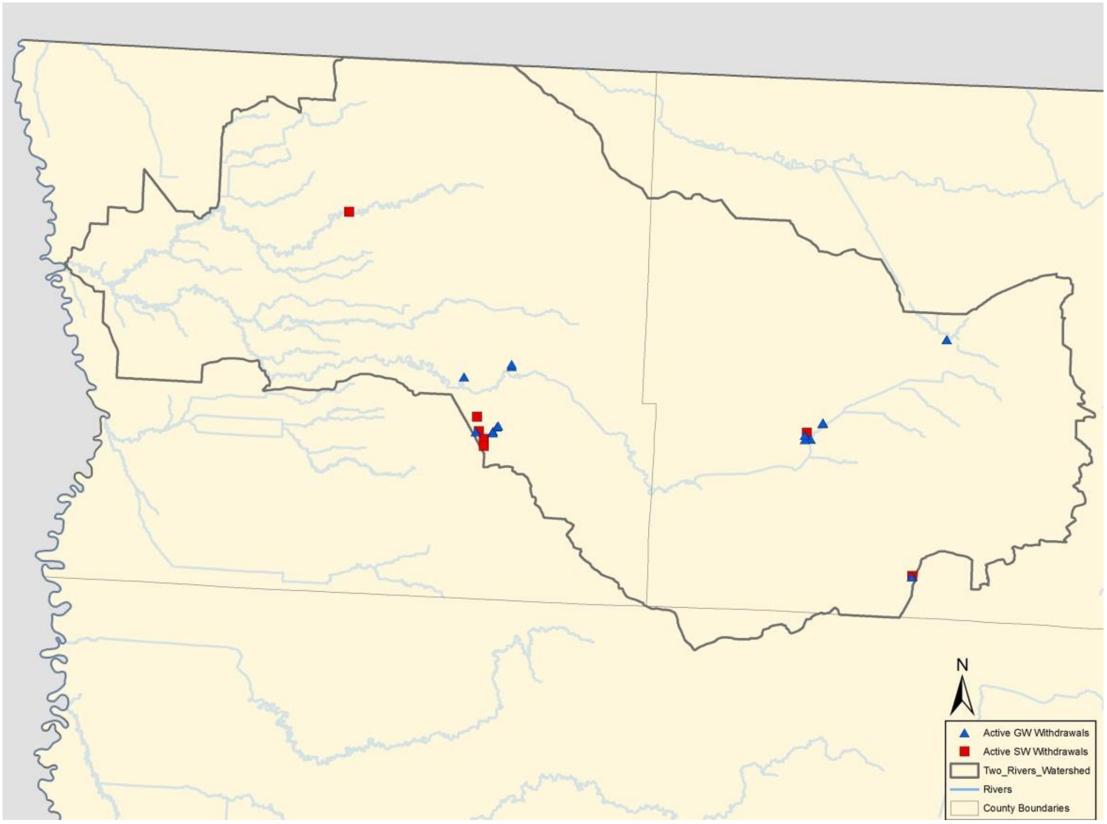

Figure 37. Locations of active permitted groundwater and surface water withdrawals in the Two Rivers Watershed.

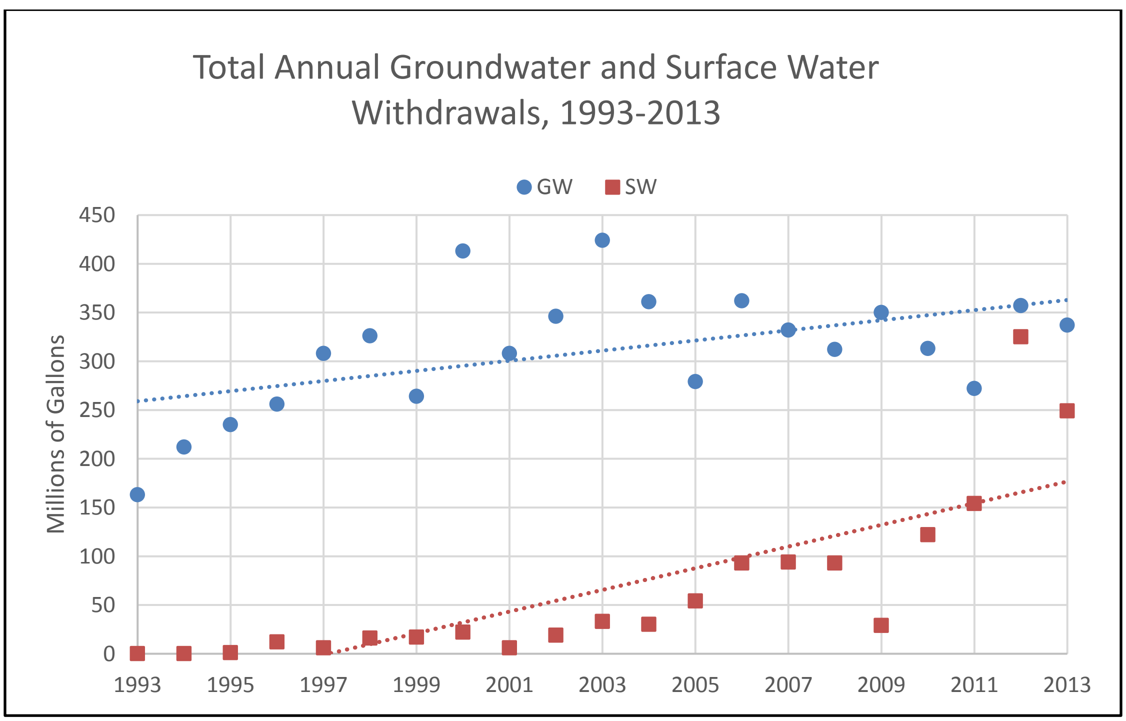

Figure 38. Total annual groundwater and surface water withdrawals in the Two Rivers Watershed (1993-2013).

Stream flow

Figure 39 and Figure 40 display mean annual discharge for the South Branch, Two Rivers from 1993-2013, and mean monthly discharge for the months of July and August over the same time period. Analysis of both datasets indicates there is no significant positive or negative trend in discharge.

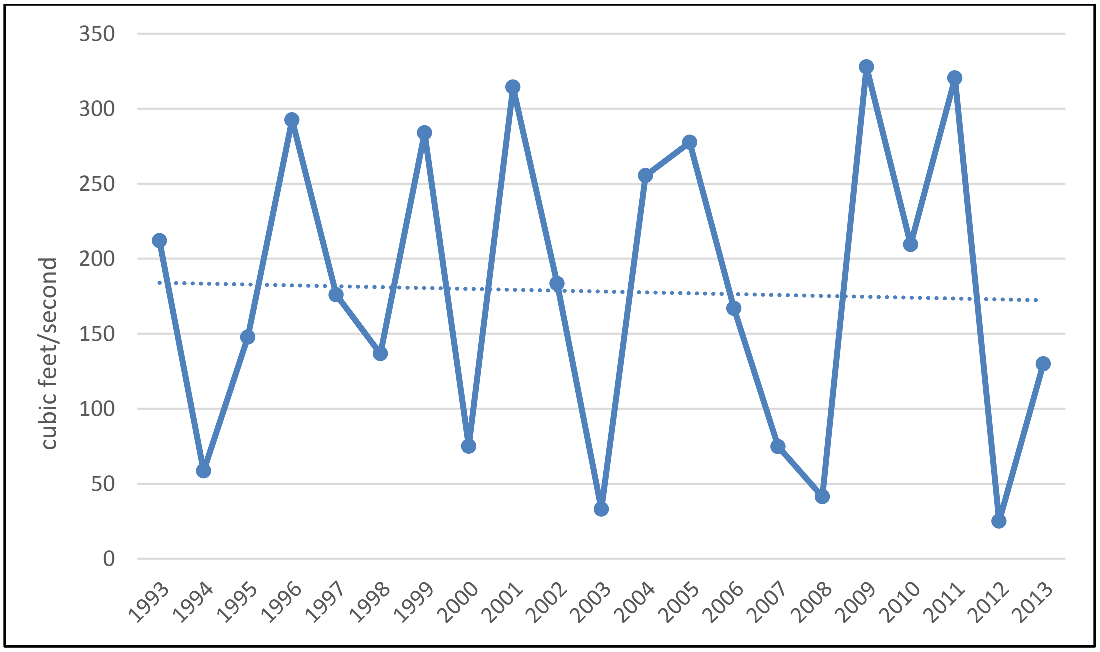

Figure 39. Mean Annual Discharge, South Branch Two Rivers at Lake Bronson, MN (1993-2013).

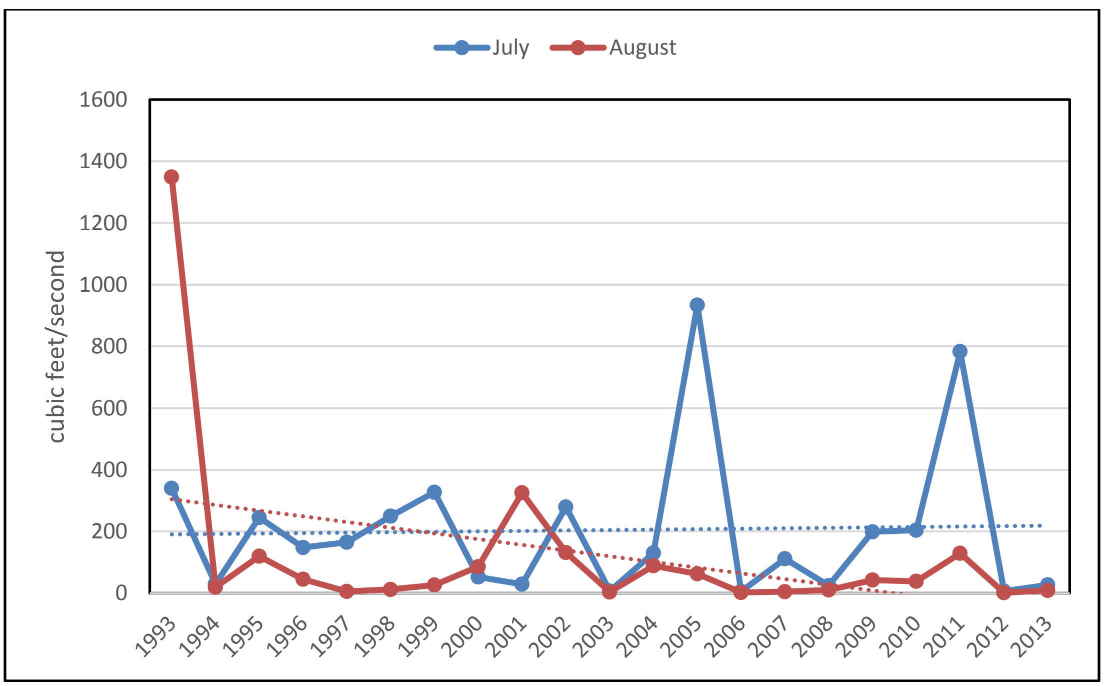

Figure 40. Mean July/August discharge, South Branch Two Rivers at Lake Bronson, MN (1993-2013).

Wetland condition

Wetlands are common in the Two Rivers Watershed. National Wetlands Inventory (NWI) data estimate 103,271 acres of wetland-which is approximately 15% of the watershed area (Figure 41). This wetland extent, however, is below the current statewide wetland coverage rate of 19% (Kloiber and Norris 2013). The predominant wetland type is the Emergent wetland class (i.e., dominated by grasses, sedges, bulrushes, and/or cattails) which comprises roughly 61% of the wetlands in the Two Rivers Watershed.

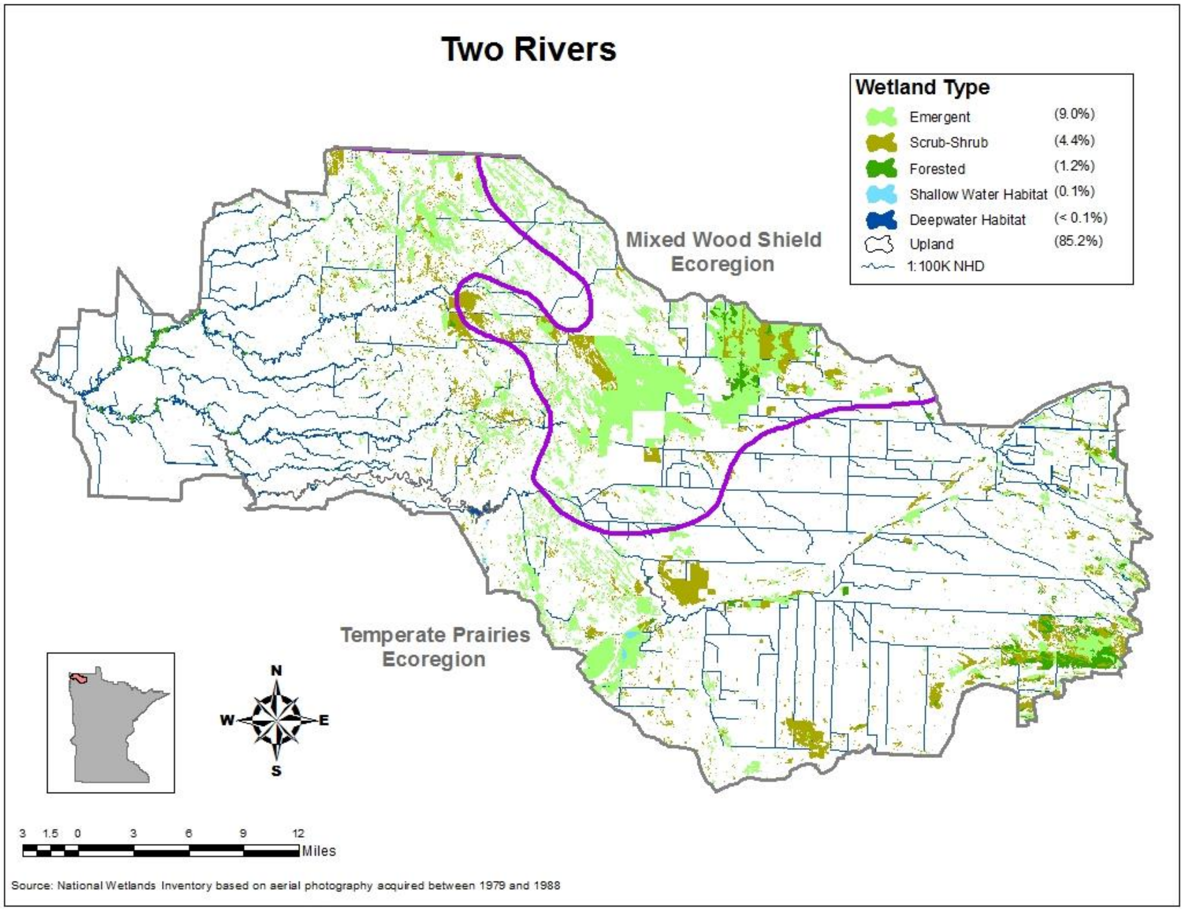

Figure 41. Wetlands and surface water in the Two Rivers Watershed. Wetland data are from the National Wetlands Inventory. Included is the level II ecoregion boundary (purple).

While the watershed has greater current wetland coverage compared to other Red River Valley watersheds, drainage has dramatically decreased the historical wetland extent. Soil survey data can be used to estimate historical wetland extent, as wetland soil features persist after artificial drainage. Mapped Poorly and Very Poorly drained soil drainage classes (which would typically support wetlands if not artificially drained) equal 546,868 acres-or approximately 83% of the watershed. Comparing that total to the current NWI estimate reveals that approximately 81% of the historical wetland extent has been lost.

Wetland drainage impacts are not distributed evenly throughout the watershed (Figure 42). The majority of the sub-watersheds have historical wetland loss rates between 75% - 90%. The lowest plain of the Two Rivers Watershed (near the Red River of the North) has lost approximately 98% of historical wetlands. The subwatersheds primarily occurring in the Mixed Wood Shield ecoregion are where the majority of the current wetlands in the watershed remain (Figure 41), having loss rates of 50 - 75%

(Figure 42). Attempts were made to drain the large wetland complexes still located here, but largely resulted in only partial drainage.

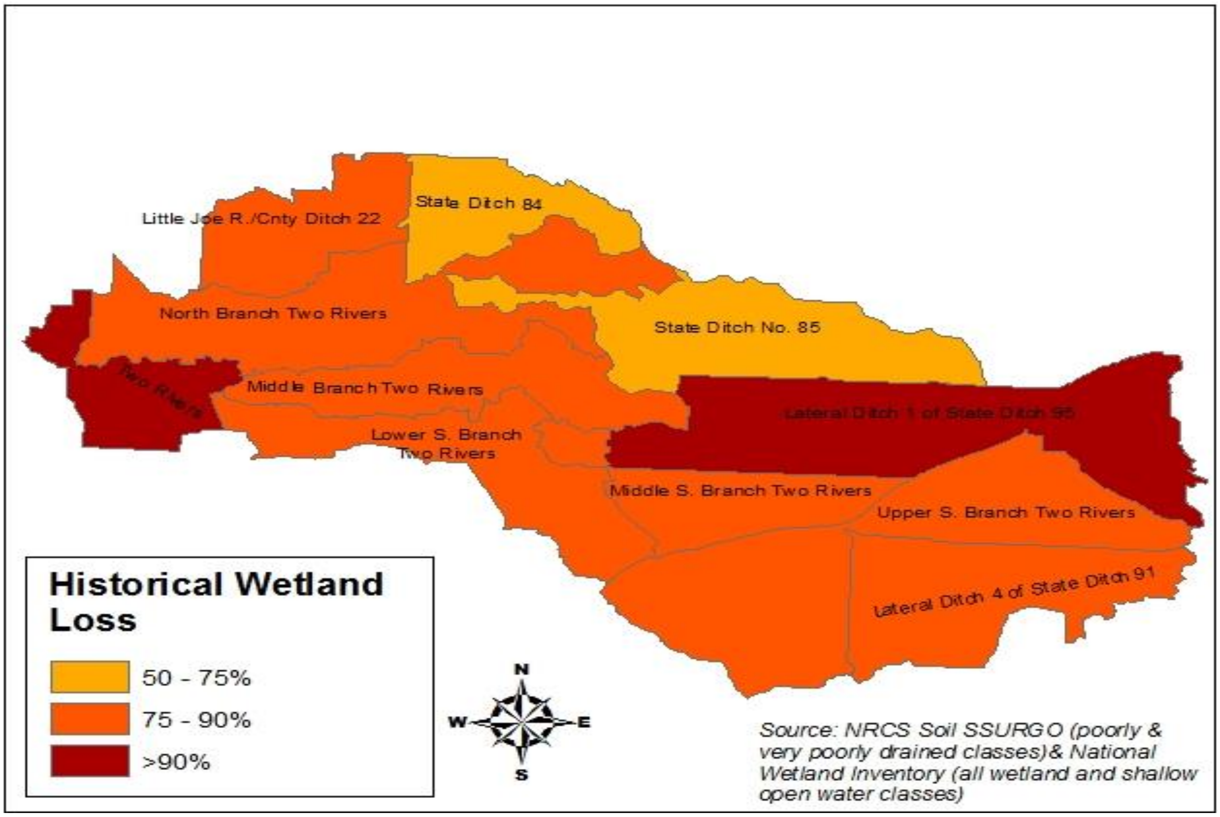

Figure 42. Historical wetland loss by sub-watershed in the Two Rivers Watershed.

Two glacial landforms are present in the Two Rivers Watershed (MNGS, 1997) that have largely dictated the current wetland extent patterns; as well as, the kinds of hydrogeomorphically (HGM) (Smith et al., 1995) functioning wetland types that are currently (or were once) present. Glacial lake Agassiz once covered the entire watershed, creating glacial lake plains in the eastern half and westernmost quarter of the watershed. The extremely flat landscape that remained following the drainage of Glacial Lake Agassiz had little capacity to drain surface water-promoting saturated soil conditions over expansive areas. The mineral flat HGM type wetlands that formed due to these factors have in large part been effectively drained via surface ditching (and more recently subsurface tile drainage) to increase agriculture production. Extensive organic flat HGM wetlands also formed where local conditions promoted near constant surface saturation, allowing for the buildup of organic soils. The majority of the large wetland complexes remaining are organic flats (Figure 41). A relatively narrow band (approximately 15 miles in width) of sand and gravel lake modified beach ridges and glacial till run north-south through the watershed, bisecting the lake plains. Agricultural pressure is somewhat less in this area due to decreased soil quality and many smaller depressional and mineral/organic HGM wetlands remain in the topographic depressions and swales (Figure 42).

The predominant water source for hydrogeomorphically flat type wetlands (both with mineral or organic soils) is precipitation and the primary loss is by evapotranspiration and saturation-overland flow (Smith et al., 1995). Wetland saturation-overland water—particularly from organic flat wetlands—can influence stream water quality by delivering high dissolved organic material/low DO water as it very slowly drains from the surface of the wetland to the stream (Acreman and Holden, 2013). In the Two Rivers Watershed, saturation-overland flow likely accounted for a significant portion of the source waters for natural stream channels. The North, Middle, and South Branches of the Two Rivers continue to receive saturation-overland flow water via surface ditches from partially drained wetland complexes.

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

The MPCA currently does not monitor wetlands systematically by watershed. Alternatively, the overall status and trends of wetland quality in the state and by major ecoregion is being tracked through probabilistic monitoring. Probabilistic monitoring refers to the process of randomly selecting sites to monitor; from which, an unbiased estimate of the resource can be made. Probabilistic survey results may provide a reasonable approximation of the current wetland quality in the Two Rivers Watershed. As few open water depressional wetlands exist in the watershed due to the lake plain geomorphology and drainage history, the focus will be on vegetation quality results of all wetland types.

Overall vegetation quality is generally high in Minnesota's wetlands (Table 25). Wetlands in exceptional or good condition have had few (if any) changes in the expected native composition or the abundance distribution. However, wetland quality varies widely in different parts of the state. The vegetation quality of > 80% of the wetland acreage in the Mixed Wood Shield is in exceptional-good condition. The exact opposite is true in both the Mixed Wood Plains and Temperate Prairies ecoregions—where > 80% of the wetland extent is in fair or poor condition (i.e., moderate changes in native composition and structure to complete replacement by non-native invasive species). As approximately 75% of Minnesota's wetlands occur in the Mixed Wood Shield ecoregion, the high levels of good to exceptional condition found there largely masks the widespread degraded vegetation condition found in remainder of the state.

Table 25. Vegetation condition of all wetlands by extent (MPCA 2015).

Condition Category	Statewide	Mixed Wood Shield	Mixed Wood Plains	Temperate Prairies
Exceptional	49%	64%	6%	7%
Good	18%	20%	12%	11%
Fair	23%	16%	42%	40%
Poor	10%		40%	42%

The Two Rivers Watershed primarily occurs in the Temperate Prairies ecoregion, with a modest portion in the Mixed Wood Shield (Figure 41). As such, wetland quality may be expected to be better in the Mixed Wood Shield portion compared to the Temperate Prairies portion of the watershed (Figure 41). However, the far northwest region of Minnesota may be better described as transitional, as the contrasting natural features and land use patterns typical of the Temperate Prairies and Mixed Wood Shield ecoregions broadly intergrade. The MNDNR has described this area as the Tallgrass Aspen Parklands, and treats it as a unique ecoregion. Given that, wetland quality may be more appropriately expected to have greater variation in the watershed, than either ecoregion alone, depending on local conditions.

Five probabilistic survey wetland monitoring sites are located in the watershed ranging in wetland vegetation quality from exceptional, to fair, to poor (Figure 43). While this is a small sample size, it may be illustrating the expected wide variability of wetland vegetation quality in the Tallgrass Aspen Parklands. Intact wetland vegetation communities remain in the Two Rivers Watershed. Conversely, degraded (fair-poor condition) communities are also likely to be common to prevalent. Plant communities assessed as fair-poor have had moderate to extreme changes in expected species composition and abundance distributions. These changes are associated with a broad spectrum of human impacts-such as physical and hydrological alterations-that often promote increases in the abundance of non-native plant species such as Reed canary grass and/or Narrow leaved cattail. Wetlands with Poor vegetation condition often have had significant to complete replacement of native species by either of these non-native invasives (MPCA, 2015).

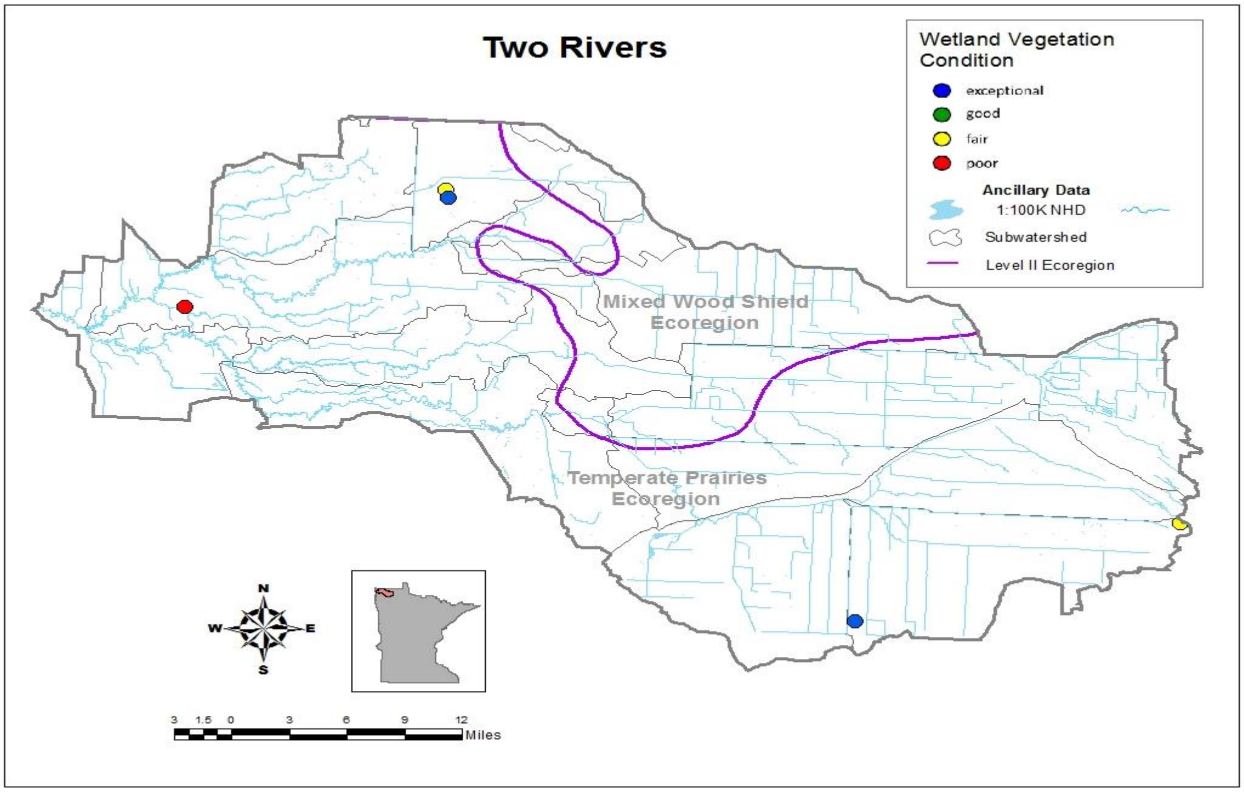

Figure 43. Wetland vegetation monitoring results in the Two Rivers Watershed.

Pollutant trends for the Two Rivers Watershed

Table 26. Two Rivers on US-75, 1 mile N of Hallock (S000-186)(TMB-19) (period of record 1971 - 2010).

	Total Suspended Solids	Total Phosphorus	Nitrate	Nitrite/ Ammonia	Biochemical Oxygen Demand	Chloride
Overall Trend	No Trend	Decrease	No Trend	No Trend	Decrease	No Trend
Estimated Average Annual Change		-2.10%			-3.50%	
Estimated Total Change		-57%			-75%	
1995 - 2010 trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend
Estimated Average Annual Change						
Estimated Total Change						
Median Concentrations First 10-years	24	0.3	<0.01	0.1	3	22
Median Concentrations Most Recent 10-years	30	0.2	0.08	<0.05	2	17

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

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

Water clarity trends at citizen monitoring sites

MPCA's CLMP has volunteer data available from only one lake, Lake Bronson, in the watershed. Water clarity has shown no trend at both Lake Bronson monitoring sites 35-0003-00-201 and 35-0003-00-204 (Table 28). There are no CSMP volunteers in the watershed. It is important to note, the River Watch Citizen Monitoring Program (in partnership with IWI) is conducted throughout the Red River Basin. This citizen program has water chemistry data available from streams, ditches, lakes, and impoundments within the Two Rivers Watershed. Information on these sites can be found at http://riverwatch.wq.io/.

Table 27. Water clarity trends at citizen stream monitoring sites.

Two Rivers HUC 09020312	Citizen Lake Monitoring Program
Number of sites w/ increasing trend	0
Number of sites w/ decreasing trend	0
Number of sites w/ no trend	2

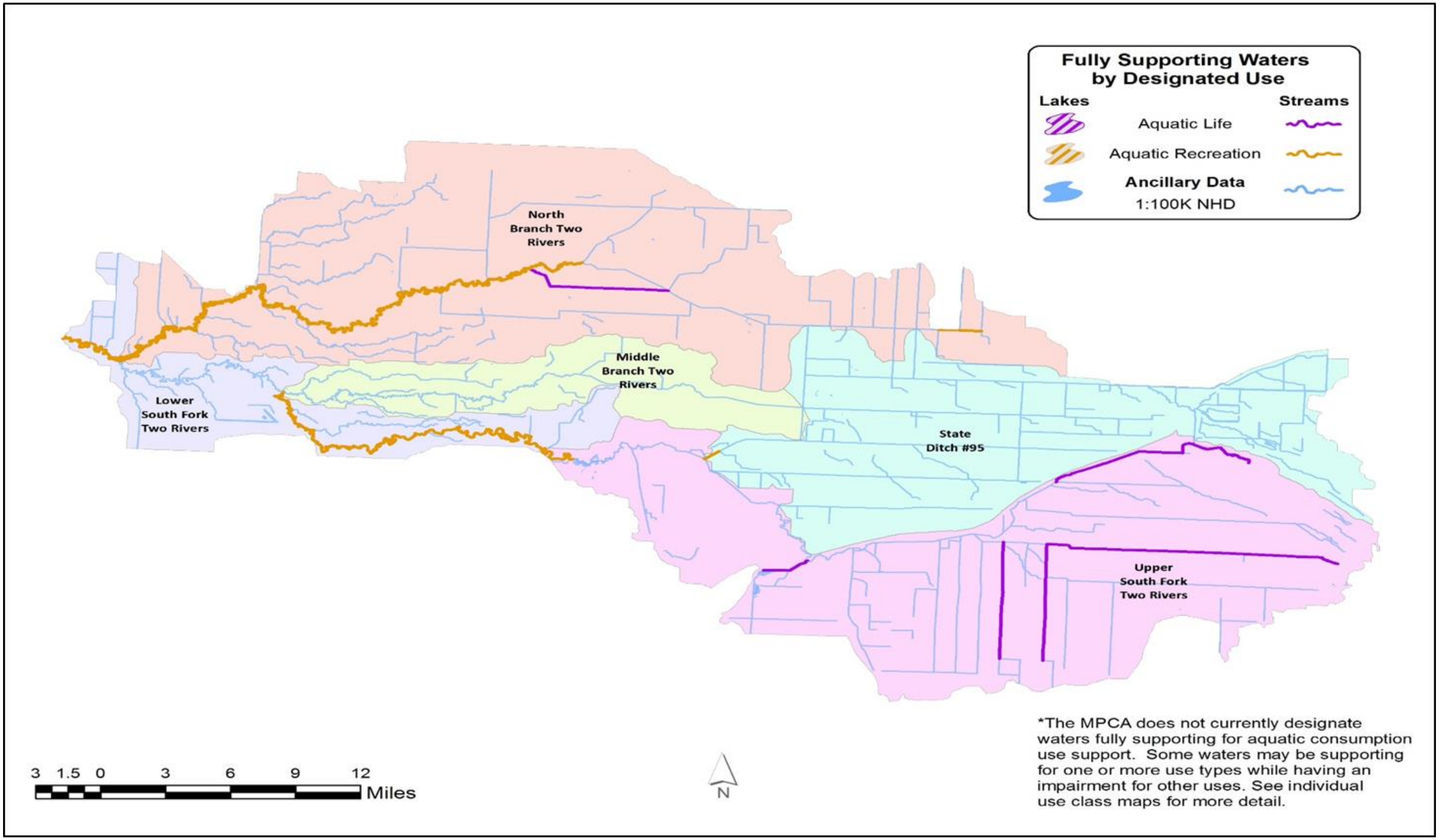

Figure 44. Fully supporting waters by designated use in the Two Rivers Watershed.

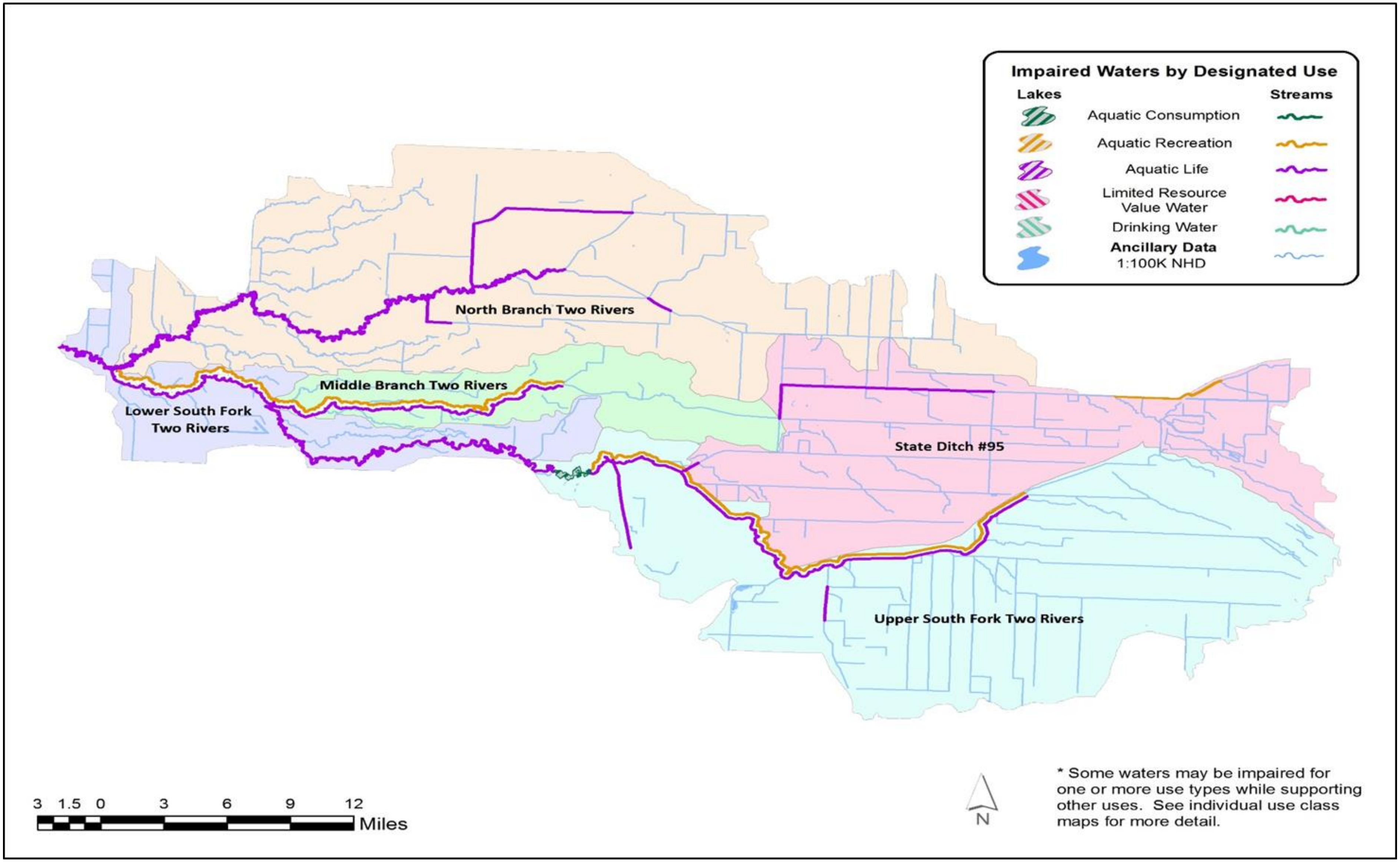

Figure 45. Impaired waters by designated use in the Two Rivers Watershed.

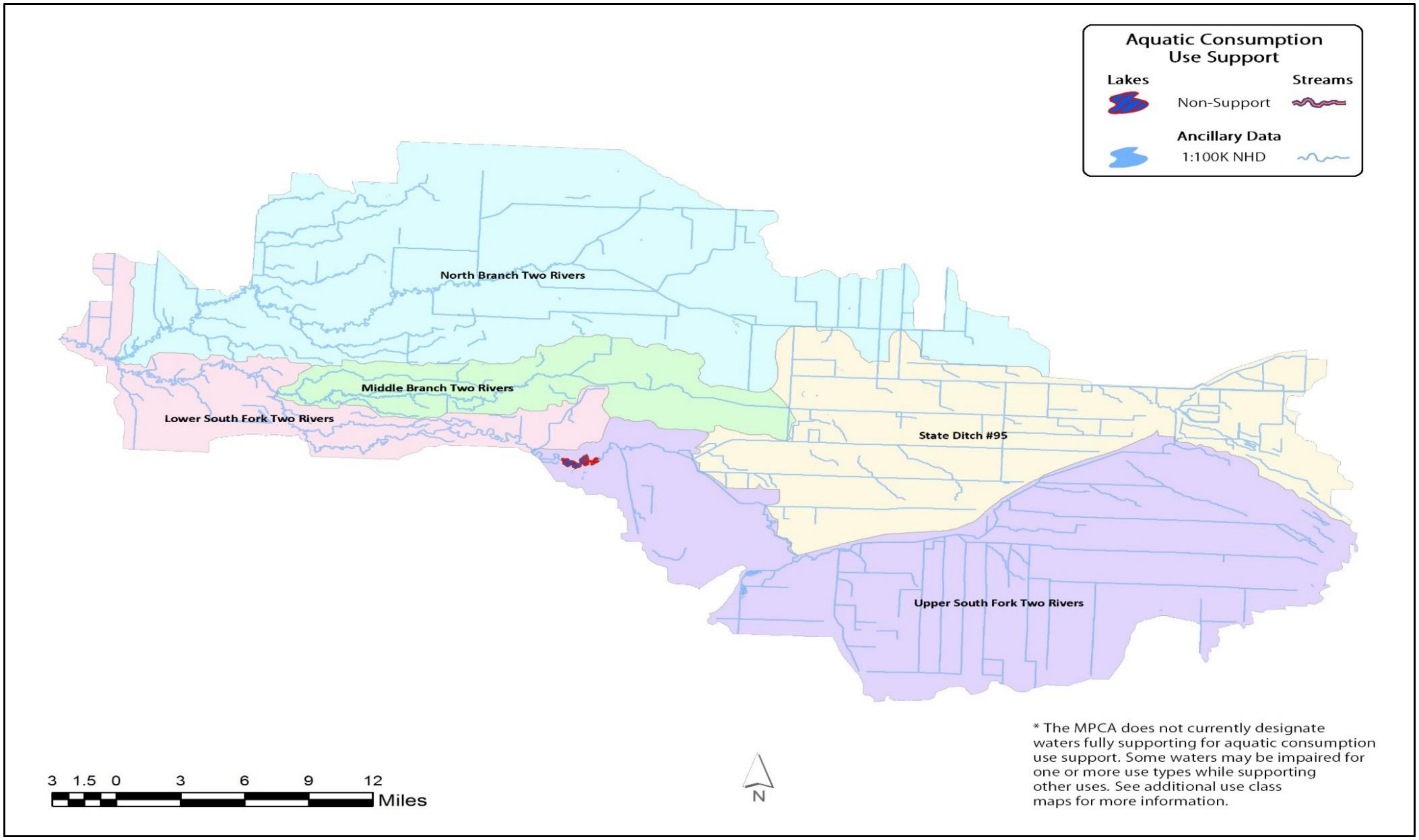

Figure 46. Aquatic consumption use support in the Two Rivers Watershed.

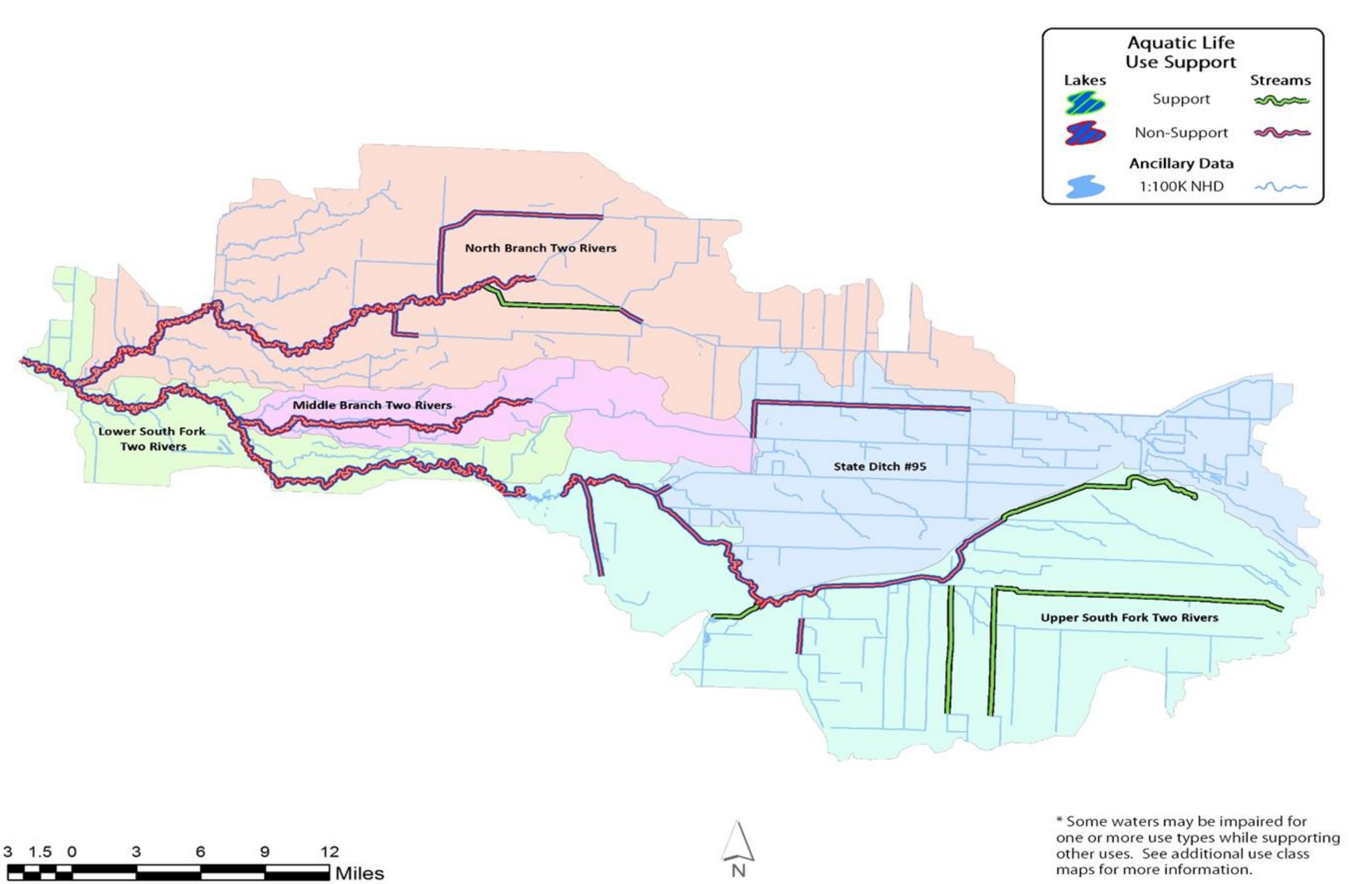

Figure 47. Aquatic life use support in the Two Rivers Watershed.

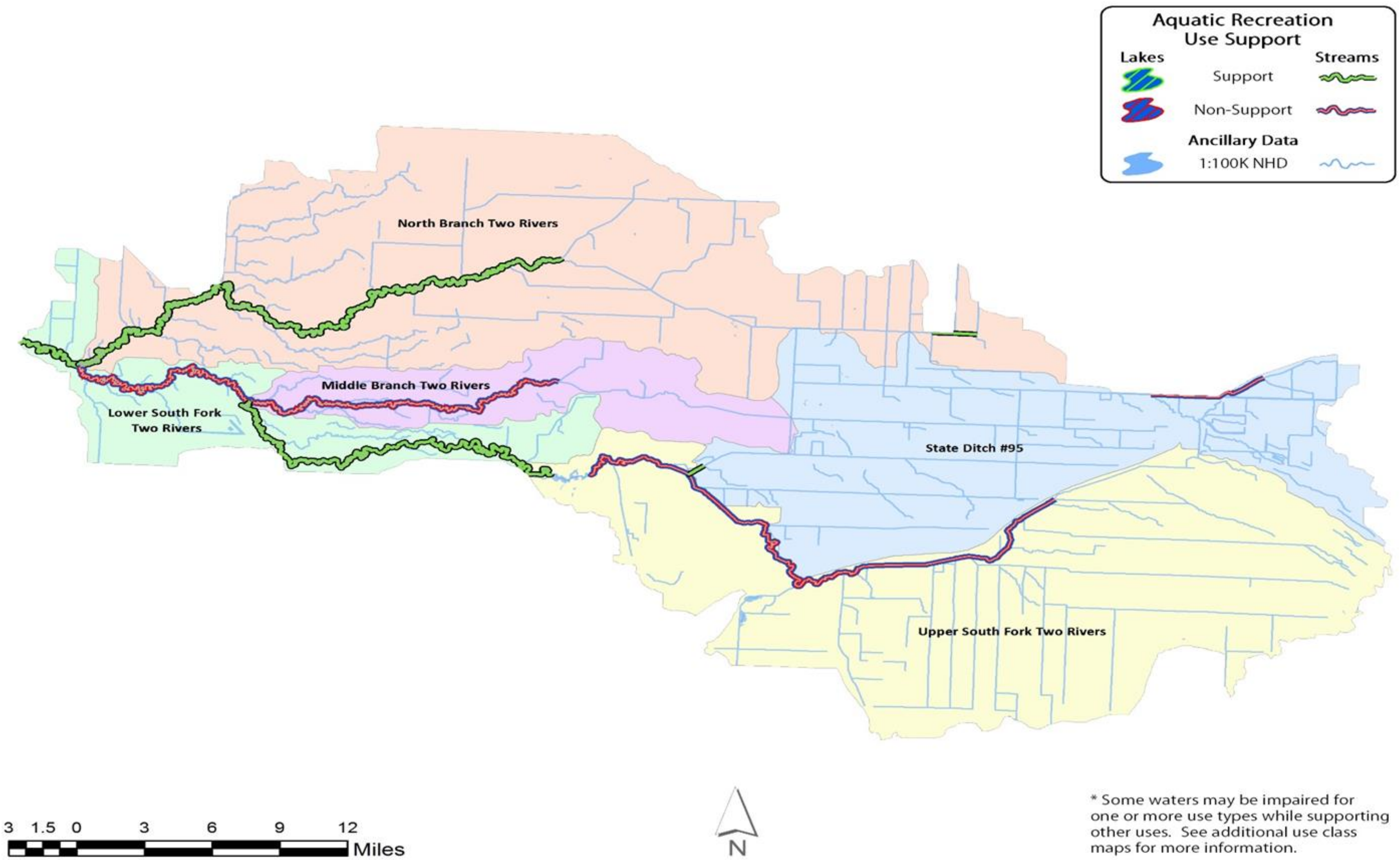

Figure 48. Aquatic recreation use support in the Two Rivers Watershed.

VII. Summaries and recommendations

Although the Two Rivers Watershed is largely comprised of agricultural lands (63% cropland and 5% rangeland), the watershed does consist of a moderate amount of wetland (16%) and forest (10%). Also, a high percentage (79%) of the streams in the watershed have been channelized. The land use changes combined with direct alteration of stream channels likely contributed to two common themes. First, the smaller headwater streams which were nearly all channelized, often went dry by the end of July. Secondly, the major waterways (South Branch, Two Rivers; Middle Branch, Two Rivers; North Branch, Two Rivers; and Two River) within the watershed, while not as commonly channelized, had high rates of bank erosion, loss of coarse substrate, and highly turbid waters.

As a result of the channel manipulation, variable flow regimes, and intensive land use within the watershed, three AUIDs within the watershed are not meeting the state's turbidity standard and are considered impaired for TSS, most notably the two AUIDs on the Two River mainstem. Although present in lower concentrations in the upstream portions of the watershed, TSS drastically increases in the downstream one-third of the watershed. The TSS concentrations correspond with habitat, most notably substrates. Within the upper one-third of the watershed, substrates consisting of sand, gravel, cobble, and scattered boulders are common. However, in the lower one third of the watershed dominant substrate shift to fine material or severely embedded coarse material and stream bank erosion is often severe. These physical and chemical characteristics of the streams often coincided with the key fish and invertebrate community attributes. For example, in areas where coarse substrates and less turbid waters were present, a higher abundance of riffle dwelling and lithophilic spawning species (e.g., blackside darter and blacknose dace) were generally found. In downstream sections of these streams where coarse substrate was absent and turbidity concentrations increased, the concentration of tolerant species increased (e.g., common carp and bigmouth buffalo).

Bacteria (*E. coli*) concentrations are also an area of concern as six stream reaches exceeded the state standard. Bacteria concentrations were extremely variable (ranging between 3 MPN/100 ml and >2419 MPN/100 ml) with problems persisting throughout the watershed. Although the exceedances that caused the impairments were not numerous (often one to two geometric monthly mean and/or individual exceedances) the presence of high bacteria concentrations at certain times of the year is evident. Because of the high concentrations, these six stream reaches do not support aquatic recreation. A possible contributor to the bacteria impairments is the presence of livestock access to the streams. Cattle were often observed to have unrestricted access to the stream in many locations throughout the watershed.

Habitat within the watershed varied depending on the stream as well as the station location on those streams. The ditches and tributaries feeding into the major waterways had fair habitat (average MSHA score of 52.5), often scoring poorly for channel morphology (due to channelization) and fish cover. Habitat scores on the three different branches of the Two Rivers were much higher, averaging 65 (nearly good), struggling most in the land use and riparian categories. Within each stream, from upstream to downstream, erosion rates increased, cover declined, and substrates transitioned from coarse to fine. Habitat on the Two Rivers main stem was generally poor, with high erosion rates, sediment concentrations, and very little fish cover. Here, flows increase to such high levels that much of the available cover within the system (i.e., wood and vegetation) are apparently flushed downstream.

Flow instability rather than habitat seemed to be the primary factor influencing the fish and macroinvertebrate communities, particularly in headwater streams. Locations existed where fair to good habitat was present during early summer fish samples but the stream was dry during the late summer macroinvertebrate sampling period. Although fish can migrate downstream to avoid areas with depleting water levels, the areas they migrate to may not be ideal living conditions. These areas may not provide spawning habitat and/or areas to escape from high flows or predation. Macroinvertebrates however, cannot as easily escape the receding water levels. Many macroinvertebrate species do not have the ability to migrate and thus are forced to live in very little water or if the stream goes completely dry, these organisms often end up perishing from the conditions. Unfortunately, the lack of consistent flow in many systems within the watershed negates the positive habitat attributes some streams may have. In general, where streams went dry or had very little water, species composition for fish, and macroinvertebrates were often comprised of mostly tolerant species.

Dams can create recreational opportunities such as areas for fishing and camping and can also aid in water storage and flood control; however, the impact of dams on a streams physical, chemical and biological composition can be profound. Dams restrict water flow to downstream areas, create impoundments upstream, alter stream flow, and prevent fish passage, among other impacts. Dams create barriers which restrict fish from reaching suitable spawning areas. Four dams are located within the Two Rivers Watershed, two on the South Branch, Two Rivers, one on the North Branch, Two Rivers, and one on State Ditch #90. The dams are designed for flood control but they likely prohibit fish passage. In addition to dams, aerial photos also show several areas on the Middle Branch, Two Rivers where fish passage may be prohibited by rock grade control structures and private “crossings”. These areas should be investigated to determine their effect on flow and fish passage. Lastly, natural dams (e.g., beaver dams) can also have negative impacts on waterways similar to man-made dams. Several waterways within this watershed have beaver impoundments that are clearly affecting the flow regime of the streams and likely playing a negative roll in fish migration.

The high percentage of channelization and bacteria concentrations found within the Two Rivers Watershed pose negative impacts to not only the watersheds aesthetic and recreational aspects, but also to downstream waters and the biological communities that reside there. In order to reduce turbidity and bacteria concentrations and possibly bring them back into compliance with the state standard, considerable measures must be taken on a watershed wide scale to improve the habitat within the streams as well as the buffer and land use that surround them.

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

- Establish or repair riparian zones using native vegetation and/or trees
- Protect any current riparian buffer zones and quality stream habitat
- Establish best management practices to improve current sedimentation and erosion issues and to prevent additional sedimentation
- Reduce and/or limit the amount of channelization, drainage, and tiling occurring within the watershed
- Reduce the amount of agricultural runoff and livestock access to streams
- Improve fish and macroinvertebrate habitat within the waterways
- Remove dams, rock grade controls, and private rock “fords” that impede fish migration
- Continued monitoring to evaluate and document declining or improving conditions
- Continuous DO monitoring on several AUIDs to determine if low DO concentrations are affecting biological communities

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

Progress is currently being made to complete a watershed-wide TMDL study and Water Restoration and Protection Strategy, with an anticipated completion date of early 2017. The study will primarily focus on the ongoing turbidity and DO impairments within the watershed. The study should also incorporate additional monitoring along the three branches of the Two Rivers as well as the Two Rivers Mainstem, to monitor potential downstream effects of mitigations efforts that will be installed on the landscape in the future as a result of TMDL implementation activities.

Literature cited

Acreman, M. & Holden, J. Wetlands. 2013. 33: 773. doi:10.1007/s13157-013-0473-2

Genet, J. A. 2012. Status and Trends of wetland s in Minnesota: Depressional Wetland Quality Baseline. Minnesota Pollution Control Agency, Biological Monitoring Program, St. Paul, Minnesota. 80 pp. http://www.pca.state.mn.us/index.php/view-document.html?gid=17741

High Plains Regional Climate Center. Climate Summaries. Historical Climate Data. Precipitation Summary. Station: 210355 Austin 3 S, MN. 1971-2000 NCDC Normals. http://mrcc.isws.illinois.edu/climate_midwest/historical/precip/mn/210075_psum.html

Kloiber, S.M. and D.J. Norris. 2013. Status and trends of wetlands in Minnesota: wetland quantity trends from 2006 to 2011. Minnesota Department of Natural Resources. St. Paul, MN. http://files.dnr.state.mn.us/eco/wetlands/wstmp_trend_report_2006-2011.pdf

Lorenz, D.L. and Stoner, J.D; U.S. Geological Survey, Department of the Interior. 1996. Sampling Design for Assessing Water Quality of the Red River of the North Basin, Minnesota, North Dakota, and South Dakota, 1993-1995. Water-Resources Investigations Report 96-4129.

McCollor, S., and S. Heiskary. 1993. Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions. Addendum to Fandrei, G., S. Heiskary, and S. McCollor. 1988. Descriptive Characteristics of the Seven Ecoregions in Minnesota. Division of Water Quality, Program Development Section, Minnesota Pollution Control Agency, St. Paul, Minnesota. 140 p.

Minnesota Department of Agriculture (MDA): Pesticide and Fertilizer Management. 2014. 2013 Water quality Monitoring Report. MAU-14-101.

Minnesota Department of Health (MDH). 2012. Arsenic Occurrence in New Wells, August 2008-January 2012. Retrieved from http://www.health.state.mn.us/divs/eh/wells/waterquality/arsenicmap.pdf

Minnesota Department of Natural Resources (MNDNR) webpage. Reconnecting Rivers. http://files.dnr.state.mn.us/eco/streamhab/reconnecting_rivers_appendix.pdf

Minnesota Department of Natural Resources (MNDNR) webpage. Red River Valley Section. http://www.dnr.state.mn.us/ecs/251A/index.html

Minnesota Department of Natural Resources (MNDNR): Waters. 2001. Figure 1: Minnesota Ground Water Provinces. Retrieved from http://files.dnr.state.mn.us/natural_resources/water/groundwater/provinces/gwprov.pdf

Minnesota Department of Natural Resources (MNDNR): State Climatology Office. 2015. Water Year Precipitation Maps. Retrieved from http://www.dnr.state.mn.us/climate/historical/water_year_maps.html

Minnesota Department of Natural Resources (MNDNR). 2014a. Water use-Water Appropriations Permit Program. Retrieved from http://www.dnr.state.mn.us/waters/watermgmt_section/appropriations/wateruse.html

Minnesota Department of Natural Resources (MNDNR). 2014b. Ground Water Level Data. Retrieved from http://www.dnr.state.mn.us/waters/groundwater_section/obwell/waterleveldata.html

Minnesota Geological Survey (MNGS). 1997. Minnesota at a Glance—Quaternary Glacial Geology. Minnesota Geological Survey, University of Minnesota, St. Paul, MN. http://conservancy.umn.edu/handle/59427

Minnesota Pollution Control Agency (MPCA). Two Rivers Watershed webpage. https://www.pca.state.mn.us/water/watersheds/snake-river-red-river-basin

Minnesota Pollution Control Agency (MPCA). 1999. Baseline Water Quality of Minnesota's Principal Aquifers: Region 3, Northwest Minnesota.

Minnesota Pollution Control Agency (MPCA). 2007. Minnesota Statewide Mercury Total Maximum Daily Load. Minnesota Pollution Control Agency, St. Paul, Minnesota.

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

Minnesota Pollution Control Agency (MPCA) and Minnesota State University 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/state_08/2008_fullreport1109.pdf?field_pubtitle_value=State+of+the+Minnesota+River&field_pubauthor_value=&body_value=&taxonomy_vocabulary_1_tid%255B%255D=1258&=Apply

Minnesota Pollution Control Agency (MPCA). 2010. Aquatic Life Water Quality Standards Draft Technical Support Document for Total Suspended Solids (Turbidity). http://www.pca.state.mn.us/index.php/view-document.html?gid=14922.

Minnesota Pollution Control Agency (MPCA). 2010. Aquatic Life Water Quality Standards Technical Support Document for Nitrate. http://www.pca.state.mn.us/index.php/view-document.html?gid=14949

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

Minnesota Pollution Control Agency. 2015. Status and Trends of Wetlands Minnesota: Vegetation Quality Baseline. Wq-bwm-1-09. Minnesota Pollution Control Agency, St. Paul, MN. https://www.pca.state.mn.us/sites/default/files/wq-bwm1-09.pdf

Minnesota Pollution Control Agency (MPCA). 2013. Regionalization of Minnesota's Rivers for Application of River Nutrient Criteria. http://www.pca.state.mn.us/index.php/view-document.html?gid=14948

Minnesota Pollution Control Agency (MPCA). 2013. Nitrogen in Minnesota's Waters. Conditions, trends, sources, and reductions. https://www.pca.state.mn.us/sites/default/files/wq-s6-26a.pdf

Minnesota Pollution Control Agency (MPCA). 2014. Guidance Manual for Assessing the Quality of Minnesota Surface Water for the Determination of Impairment: 305(b) Report and 303(d) List. http://www.pca.state.mn.us/index.php/view-document.html?gid=16988

Minnesota Rules Chapter 7050. 2008. Standards for the Protection of the Quality and Purity of the Waters of the State. Reviser of Statutes and Minnesota Pollution Control Agency, St. Paul, Minnesota.

National Resource Conservation Service (NRCS). 2008. Rapid Watershed Assessment: Two Rivers Watershed (MN) HUC: 09020309. NRCS. USDA. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_022747.pdf.

Omernik, J.M. and A.L. Gallant. 1988. Ecoregions of the Upper Midwest States. EPA/600/3-88/037. Corvallis, OR: United States Environmental Protection Agency. 56 p.

Smith, D.R., A. Ammann, C. Bartoldus, and M.M. Brinson. 1995. An approach for assessing wetland functions using hydrogeomorphic classification, reference wetlands, and functional indices. Wetlands

Research Technical Report WRP-DE-9. US Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

State Climatology Office- MNDNR Division of Ecological and Water Resources. 2010. http://www.climate.umn.edu/doc/hydro_yr_pre_maps.htm.

United States Geological Survey (USGS) webpage. Lake Agassiz Plain Ecoregion Summary. http://landcovertrends.usgs.gov/gp/eco48Report.html

United States Geological Survey (USGS). 2007. Ground Water Recharge in Minnesota. Retrieved from http://pubs.usgs.gov/fs/2007/3002/pdf/FS2007-3002_web.pdf

United States Geological Survey (USGS). 2013. Ecoregions of North Dakota and South Dakota 48. Lake Agassiz Plain. Retrieved from http://www.npwrc.usgs.gov/resource/habitat/ndsdeco/48a.htm

United States Geological Survey (USGS). 2014. USGS Current Water Data for Minnesota. Retrieved from http://waterdata.usgs.gov/mn/nwis/rt

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

Visit Northwest Minnesota. Kittson county History. http://www.visitnwminnesota.com/Kittsonhistory.htm

Western Regional Climate Center (N.D.), USA Divisional Climate Data. Retrieved from http://www.wrcc.dri.edu/spi/divplot1map.html

Appendix 1 - Water chemistry definitions

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

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

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

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

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

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

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

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

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

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

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

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

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

Appendix 2 - Intensive watershed monitoring water chemistry stations in the Two Rivers Watershed

Biological Station ID	STORET/ EQuIS ID	Waterbody Name	Location	HUC-11
13RD042	S002-996	South Branch, Two Rivers	South Branch, Two Rivers at CSAH10, 7.8 mi NW of Pelan	09020312010
13RD043	S002-997	Lateral Ditch #1 of State Ditch #95	Lateral Ditch #1 of State Ditch #95, 8.5 mi NW of Pelan	09020312020
05RD004	S000-569	Two Rivers	Two Rivers at CSAH16, 7.1 mi W of Hallock	09020312030
05RD093	S003-100	Middle Branch, Two Rivers	Middle Branch, Two Rivers, 3 mi SE of Hallock	09020312040
05RD053	S007-442	North Branch, Two Rivers	North Branch, Two Rivers at CR58, 6 mi NW of Hallock	09020312050

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

AUID DESCRIPTIONS				USES				WATER QUALITY STANDARDS								
								Aquatic Life Indicators:							Aquatic Rec. Indicators:	
Assessment Unit ID (AUID)	Stream Reach Name	Reach Description	Reach Length (Miles)	Use Class	Aquatic Life	Aquatic Recreation	303d listed impairments YEAR	Fish	Macroinvertebrates	Dissolved Oxygen	TSS	Chloride	pH	NH3	Bacteria	Nutrients
HUC 11: 09020312010 (Upper South Fork two Rivers Subwatershed)																
09020312-507	***South Branch, Two Rivers***	*Headwaters to State Ditch 91 Lateral Ditch 2*	10.64	WWg	SUP	NA		MTS	-	IF	IF	-	IF	IF	-	-
09020312-506	***South Branch, Two Rivers***	*Unnamed Ditch to Lateral Ditch 2 State Ditch 95*	25.06	WWg	IMP	IMP	2002	EXS	EXS	IF	MTS	MTS	MTS	MTS	EXS	-
09020312-505	***South Branch, Two Rivers***	*Lateral Ditch 2 to Lake Bronson*	7.67	WWg	IMP	IMP		EXS	EXS	MTS	MTS	MTS	MTS	MTS	EXS	-
09020312-515	***Lateral Ditch 4 of State Ditch 91***	*Headwaters to Lateral Ditch 12 State Ditch 91*	13.7	WWm	SUP	NA		MTS	MTS	IF	IF	-	IF	IF	-	-
09020312-550	***Unnamed Ditch***	*110th St to Lateral Ditch 12 State Ditch 91*	7.16	WWm	SUP	NA		MTS	MTS	IF	IF	-	IF	IF	-	-
09020312-551	***Unnamed Ditch***	*110th St to Lateral Ditch 4 State Ditch 91*	7.03	WWm	SUP	NA		MTS	IF	IF	IF	-	IF	IF	-	-
09020312-522	***County Ditch 4***	*Unnamed Ditch to Unnamed Ditch*	2.02	WWg	IMP	NA		EXS	MTS	IF	IF	-	IF	IF	-	-
09020312-546	***State Ditch 90***	*Upper Twin Lake (35-0001-00) to South Branch, Two Rivers*	2.3	WWg	SUP	NA		MTS	-	IF	IF	-	IF	IF	-	-
09020312-544	***State Ditch 49***	*Headwaters to S. Br. Two Rivers*	5.34	WWg	IMP	NA		EXS	-	IF	IF	-	IF	IF	-	-

HUC 11: 09020312020(State Ditch #95 Subwatershed)																	
09020312-535	***County Ditch 13***	*Unnamed Ditch to Badger Creek(disconnected portion)*	5.43	WWg	IF	IMP			-	-	IF	MTS	IF	MTS	MTS	EXS	-
09020312-539	***Lateral Ditch of State Ditch 95***	*Unnamed Ditch to State Ditch 50*	12.07	WWm	IMP	NA			EXS	EXS	IF	IF	IF	IF	IF	-	-
09020312-521	***Lateral Ditch of State Ditch 95***	*Unnamed Ditch to State Ditch 95*	0.86	WWg	IMP	SUP			EXS	EXS	IF	MTS	MTS	MTS	MTS	MTS	-
HUC 11:09020312030 (Lower South Fork Two Rivers Subwatershed)																	
09020312-502	***Two River, South Branch***	*Lake Bronson to M Branch Two Rivers*	33.04	WWg	IMP	SUP			EXS	EXS	IF	MTS	MTS	MTS	MTS	MTS	-
09020312-501	***Two Rivers***	*Middle Branch Two Rivers to N Br Two R*	21.03	WWg	IMP	IMP	2006 & 2010		MTS	IF	IF	EXS	MTS	MTS	MTS	EXS	-
09020312-509	***Two Rivers***	*N Br Two Rivers to Red River of the North*	6.95	WWg	IMP	SUP	2008		EXS	IF	IF	EXS	MTS	MTS	MTS	EXS	-
HUC 11: 09020312040(Middle Branch, Two Rivers Subwatershed)																	
09020312-503	***Middle Branch, Two Rivers***	*Cty Ditch 23 to South Br Two Rivers*	29.65	WWg	IMP	IMP	2002		EXS	EXS	IF	MTS	MTS	MTS	MTS	EXS	-
HUC 11: 09020312050(North Branch, Two Rivers Subwatershed)																	
09020312-531	***State Ditch 72***	*Judicial Ditch 31 to State Ditch 85*	1.3	WWg	IMP	NA			EXS	EXS	IF	IF	-	IF	IF	-	-
09020312-547	***State Ditch 85***	*Headwaters to N Br Two Rivers*	7.04	WWg	SUP	NA			MTS	MTS	IF	IF	-	IF	IF	-	-
09020312-504	***North Branch, Two Rivers***	*Headwaters to Cty Ditch 22*	38.4	WWg	IMP	SUP	2002 & 2010		EXS	MTS	IF	MTS	-	MTS	MTS	MTS	-

09020312-549	***Judicial Ditch 31***	*Unnamed Creek to N Br Two Rivers*	2.45	WWg	IMP	NA			EXS	-	IF	IF	-	IF	IF	-	-
09020312-514	***State Ditch 84***	*Headwaters to N Branch Two Rivers*	16.68	WWg	IMP	NA			EXS	-	IF	IF	-	IF	IF	-	-
09020312-508	***North Branch, Two Rivers***	*Cty Ditch 22 to Two Rivers*	22.18	WWg	IMP	SUP			EXS	MTS	IF	MTS	MTS	MTS	MTS	MTS	-
09020312-528	***State Ditch 72***	*Unnamed Ditch to Unnamed Ditch*	2	WWg	NA	SUP	2010 & 2008		-	-	EXS	MTS	IF	MTS	MTS	MTS	-

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

Key for Cell Shading: = existing impairment, listed prior to 2016 reporting cycle; = new impairment; = full support of designated use.

Appendix 4 - Assessment results for lakes in the Two Rivers Watershed

Lake ID	Lake Name	County	HUC-11	Ecoregion	Lake Area (acres)	Max Depth (m)	Watershed Area (acres)	% Littoral	Mean depth (m)	Support Status
35-0003-00	Bronson	Kittson	09020312010	WCBP	320	8.84	347,732	76.2	8.84	IF AQR, IF AQL

Abbreviations: **FS** – Full Support **N/A** – Not Assessed

NS – Non-Support

IF – Insufficient Information

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

Appendix 5 - Minnesota statewide IBI thresholds and confidence limits

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

Appendix 6. Two Rivers Watershed F-IBI and M-IBI thresholds and results

Appendix 6.1 - Biological monitoring results – F-IBI (assessable reaches)

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Fish Class	Threshold	FIBI	Visit Date
HUC-11: 09020312010 (Upper South Fork Two Rivers Subwatershed)							
09020312-507	13RD096	***South Branch, Two Rivers***	14.82	6	42	56.16	10-Jun-14
09020312-506	05RD181	***South Branch, Two Rivers***	186.84	5	47	38.13	19-Jun-06
09020312-506	05RD181	***South Branch, Two Rivers***	186.84	5	47	38.49	11-Jun-14
09020312-506	13RD045	***South Branch, Two Rivers***	231.17	5	47	49.44	15-Jul-13
09020312-505	13RD042	***South Branch, Two Rivers***	328.84	5	47	36.13	26-Jun-13
09020312-515*	13RD058	***Lateral Ditch 4 of State Ditch 91***	193.76	6	23	54.96	10-Jul-13
09020312-550*	13RD054	***Unnamed Ditch***	44.42	6	23	41.04	25-Jun-13
09020312-551*	13RD052	***Unnamed Ditch***	8.02	6	23	33.66	31-Jul-13
09020312-551*	13RD052	***Unnamed Ditch***	8.02	6	23	26.23	17-Jun-13
09020312-522	05RD002	***County Ditch 4***	9.92	6	42	15.04	23-Jun-05
09020312-546	13RD064	***State Ditch 90***	34.97	7	42	52.18	01-Jul-13
09020312-544	13RD044	***State Ditch 49***	22.97	6	42	0.29	18-Jun-13
09020312-544	13RD044	***State Ditch 49***	22.97	6	42	0.29	11-Jun-14
HUC-11: 09020312020 (State Ditch #95 Subwatershed)							
09020312-539*	13RD048	***Lateral Ditch 1 of State Ditch 95***	83.98	5	35	8.54	10-Jul-13
09020312-521	13RD043	***Lateral Ditch 1 of State Ditch 95***	167.63	5	47	0.00	03-Jul-13
09020312-521	13RD043	***Lateral Ditch 1 of State Ditch 95***	167.63	5	47	55.73	30-Jul-13
HUC-11: 09020312030 (Lower South Fork Two Rivers Subwatershed)							
09020312-502	13RD082	***Two River, South Branch***	561.63	4	38	59.85	26-Jun-13
09020312-502	10EM192	***Two River, South Branch***	562.33	4	38	51.03	14-Jul-10

09020312-502	93RD401	***Two River, South Branch***	581.3	1	49	37.23	10-Jul-13
09020312-502	13RD085	***Two River, South Branch***	594.89	1	49	50.31	25-Jun-13
09020312-501	13RD056	***Two River***	679.98	1	49	67.95	08-Jul-13
09020312-501	13RD084	***Two River***	713.2	1	49	67.10	30-Jul-13
09020312-509	05RD004	***Two River***	1099.91	1	49	63.24	27-Jun-06
09020312-509	05RD004	***Two River***	1099.91	1	49	62.39	19-Aug-13
HUC-11: 09020312040 (Middle Branch, Two Rivers Subwatershed)							
09020312-503	93RD405	***Two River, Middle Branch***	39.53	6	42	42.34	02-Jul-13
09020312-503	05RD093	***Two River, Middle Branch***	54.46	2	50	79.38	24-Jul-06
09020312-503	05RD093	***Two River, Middle Branch***	54.46	2	50	0.00	11-Jun-14
09020312-503	05RD093	***Two River, Middle Branch***	54.46	2	50	12.59	16-Jul-13
HUC-11: 03020312050 (North Branch, Two Rivers Subwatershed)							
09020312-504	05RD094	***Two River, North Branch***	128.21	5	47	39.29	31-Aug-05
09020312-504	05RD094	***Two River, North Branch***	128.21	5	47	36.96	12-Jun-14
09020312-504	13RD089	***Two River, North Branch***	231.42	5	47	53.78	02-Jul-13
09020312-504	93RD403	***Two River, North Branch***	241.15	5	47	48.42	02-Jul-13
09020312-504	13RD070	***Two River, North Branch***	283.72	2	50	57.92	09-Jul-13
09020312-508	13RD053	***Two River, North Branch***	353.47	1	49	39.29	09-Jul-13
09020312-508	13RD041	***Two River, North Branch***	385.28	1	49	39.57	16-Jul-13
09020312-508	05RD053	***Two River, North Branch***	385.45	1	49	66.93	27-Jun-06
09020312-531	13RD055	***State Ditch 72***	97.11	5	47	32.68	10-Jul-13
09020312-547	13RD091	***State Ditch 85***	5.98	6	42	44.59	26-Jun-13
09020312-514	13RD067	***State Ditch 84***	13.57	6	42	0.07	10-Jun-14
09020312-514	13RD067	***State Ditch 84***	13.57	6	42	35.07	18-Jun-13
09020312-549	13RD057	***Judicial Ditch 31***	17.2	6	42	0.15	10-Jun-14
09020312-549	13RD057	***Judicial Ditch 31***	17.2	6	42	0.11	18-Jun-13

Appendix 6.2 – Biological monitoring results – M-IBI (assessable reaches)

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi²	Invert Class	Threshold	MIBI	Visit Date
HUC-11: 09020312010 (Upper South Fork Two Rivers Subwatershed)							
09020312-506	05RD181	***South Branch, Two Rivers***	186.84	7	41	29.97	16-Aug-06
09020312-506	05RD181	***South Branch, Two Rivers***	186.84	7	41	42.06	03-Sep-14
09020312-506	13RD045	***South Branch, Two Rivers***	231.17	5	37	32.18	29-Jul-13
09020312-505	13RD042	***South Branch, Two Rivers***	328.84	5	37	28.97	30-Jul-13
09020312-515*	13RD058	***Lateral Ditch 4 of State Ditch 91***	193.76	7	22	38.08	29-Jul-13
09020312-550*	13RD054	***Unnamed Ditch***	44.42	5	24	30.17	29-Jul-13
09020312-551*	13RD052	***Unnamed Ditch***	8.02	5	24	12.77	29-Jul-13
09020312-522	05RD002	***County Ditch 4***	9.92	5	37	32.68	31-Aug-05
HUC-11: 09020312020 (State Ditch #95 Subwatershed)							
09020312-539*	13RD048	***Lateral Ditch 1 of State Ditch 95***	83.98	7	22	10.06	30-Jul-13
09020312-521	13RD043	***Lateral Ditch 1 of State Ditch 95***	167.63	7	41	43.99	30-Jul-13
HUC-11: 09020312030 (Lower South Fork Two Rivers Subwatershed)							
09020312-502	13RD082	***Two River, South Branch***	562.33	2	31	58.79	30-Jul-13
09020312-502	10EM192	***Two River, South Branch***	561.63	2	31	70.12	01-Sep-10
09020312-502	93RD401	***Two River, South Branch***	581.3	2	31	29.99	31-Jul-13
09020312-501	13RD056	***Two River***	679.98	2	31	36.20	31-Jul-13
09020312-501	13RD084	***Two River***	713.2	2	31	20.73	30-Jul-13
09020312-509	05RD004	***Two River***	1099.91	2	31	11.12	30-Aug-05
09020312-509	05RD004	***Two River***	1099.91	2	31	8.67	20-Aug-13
HUC-11: 09020312040 (Middle Branch, Two Rivers Subwatershed)							
09020312-503	93RD405	***Two River, Middle Branch***	54.46	7	41	53.86	30-Jul-13
09020312-503	05RD093	***Two River, Middle Branch***	54.46	7	41	50.21	30-Aug-05
09020312-503	05RD093	***Two River, Middle Branch***	54.46	7	41	33.20	31-Jul-13
HUC-11: 03020312050 (North Branch, Two Rivers Subwatershed)							
09020312-504	05RD094	***Two River, North Branch***	128.21	7	41	68.98	30-Aug-05

09020312-504	13RD089	***Two River, North Branch***	231.42	5	37	63.16	31-Jul-13
09020312-504	93RD403	***Two River, North Branch***	241.15	7	41	74.62	31-Jul-13
09020312-504	13RD070	***Two River, North Branch***	283.72	7	41	35.94	31-Jul-13
09020312-508	13RD053	***Two River, North Branch***	353.47	7	41	17.46	31-Jul-13
09020312-508	13RD041	***Two River, North Branch***	385.28	7	41	24.72	20-Aug-13
09020312-508	13RD041	***Two River, North Branch***	385.28	7	41	45.61	03-Sep-14
09020312-509	05RD053	***Two River, North Branch***	385.45	7	41	32.88	10-Oct-05
09020312-531	13RD055	***State Ditch 72***	97.11	7	41	34.24	30-Jul-13
09020312-504	13RD091	***Two River, North Branch***	5.98	5	37	40.99	30-Jul-13
09020312-504	13RD091	***Two River, North Branch***	5.98	5	37	44.42	30-Jul-13

Appendix 7 - Minnesota's ecoregion-based lake eutrophication standards

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

Appendix 8 – Fish species found during biological monitoring surveys

Common Name	Quantity of Stations Where Present	Quantity of Individuals Collected
bigmouth buffalo	2	17
bigmouth shiner	1	8
black bullhead	7	238
blacknose dace	9	335
blackside darter	18	572
brook stickleback	13	183
brown bullhead	1	1
burbot	9	26
central mudminnow	20	368
channel catfish	4	15
chestnut lamprey	3	4
common carp	5	53
common shiner	25	1567
creek chub	19	740
emerald shiner	2	47
fathead minnow	20	434
finescale dace	5	12
freshwater drum	2	4
golden redhorse	6	34
goldeye	5	30
Iowa darter	2	9
johnny darter	16	669
lamprey ammocoete	3	7
largemouth bass	1	2
longnose dace	1	13
mooneye	2	11
northern pike	24	258
northern redbelly dace	14	1321
pearl dace	3	3
pumpkinseed	2	5
quillback	1	4
river shiner	2	6
rock bass	14	51
sand shiner	9	350
sauger	4	13
shorthead redhorse	5	19
silver chub	2	21

Common Name	Quantity of Stations Where Present	Quantity of Individuals Collected
silver redhorse	5	34
spotfin shiner	10	702
stonecat	5	7
tadpole madtom	6	6
trout-perch	2	10
walleye	6	17
white bass	1	4
white sucker	26	1891
yellow perch	4	11

Appendix 9 – Macroinvertebrate species found during biological monitoring surveys

Taxonomic Name	Number of Stations Where Present	Quantity of Individuals Collected
Amphipoda		
Hyalella	22	706
Coleoptera		
Acilius	4	6
Anacaena	1	1
Berosus	2	2
Coptotomus	1	2
Crenitis	1	1
Desmopachria convexa	1	1
Dubiraphia	15	135
Dytiscidae	3	3
Dytiscus	1	1
Elmidae	1	2
Enochrus	1	1
Gyrinus	8	14
Haliplus	13	50
Helichus	2	2
Helophorus	3	4
Hydraena	8	20
Hydrochus	2	4
Hydrophilidae	2	2
Hydroporus	1	1
Hygrotus	2	2
Laccophilus	4	5
Liodessus	7	198
Macronychus glabratus	4	14
Neoporus	2	2
Ochthebius	3	3
Optioservus	9	41
Paracymus	2	2
Peltodytes	5	16
Rhantus	1	1
Stenelmis	11	71
Tropisternus	2	2
Decapoda		
Orconectes	18	57
Diptera		
Ablabesmyia	22	114
Acricotopus	1	1

Taxonomic Name	Number of Stations Where Present	Quantity of Individuals Collected
Anopheles	3	5
Atherix	5	14
Atrichopogon	2	7
Bezzia	1	1
Bezzia/Palpomyia	4	17
Brillia	1	1
Ceratopogonidae	3	15
Ceratopogoninae	3	4
Chironomini	11	23
Chironomus	3	5
Chrysops	1	1
Cladotanytarsus	2	2
Clinotanypus	1	1
Conchapelopia	1	1
Corynoneura	12	32
Cricotopus	19	113
Cryptochironomus	6	9
Cryptotendipes	1	1
Dasyhelea	1	1
Dicrotendipes	23	181
Endochironomus	2	9
Ephydridae	10	19
Eukiefferiella	2	4
Glyptotendipes	3	6
Guttipelopia	1	1
Hemerodromia	2	2
Kiefferulus	1	1
Labrundinia	13	28
Limnophyes	2	2
Micropsectra	7	9
Microtendipes	9	10
Nanocladius	4	6
Nilotanypus	2	2
Nilothauma	1	1
Orthocladiinae	11	16
Orthocladius	5	14
Parachironomus	4	8
Parakiefferiella	1	1
Paramerina	4	14
Parametriocnemus	3	11
Paratanytarsus	12	92
Paratendipes	4	5

Taxonomic Name	Number of Stations Where Present	Quantity of Individuals Collected
Phaenopsectra	8	12
Polypedilum	27	848
Procladius	6	10
Psectrocladius	3	11
Pseudochironomus	7	8
Rheocricotopus	4	8
Rheotanytarsus	13	53
Sciomyzidae	1	1
Simulium	21	785
Stempellina	1	2
Stempellinella	7	14
Stenochironomus	11	36
Stictochironomus	1	2
Stratiomyidae	2	2
Tanypodinae	13	29
Tanytarsini	10	33
Tanytarsus	17	135
Thienemanniella	7	14
Thienemannimyia	3	5
Thienemannimyia Gr.	22	92
Tipula	1	1
Tipulidae	1	1
Tribelos	1	2
Tvetenia	2	2
Xenochironomus xenolabis	3	4
Zavreliella	1	2
Zavreliella marmorata	1	1
Ephemeroptera		
Acentrella	4	8
Acentrella parvula	6	21
Acentrella turbida	2	4
Acerpenna	12	51
Acerpenna pygmaea	9	174
Anafroptilum	5	18
Anthopotamus	1	1
Baetidae	13	147
Baetis	4	17
Baetis flavistriga	2	4
Baetis intercalaris	9	112
Baetisca	1	1
Caenis	6	47
Caenis diminuta	20	248

Taxonomic Name	Number of Stations Where Present	Quantity of Individuals Collected
Caenis hilaris	5	10
Callibaetis	3	3
Ephoron	1	2
Heptagenia	5	23
Heptageniidae	7	53
Hexagenia	3	11
Isonychia	4	9
Isonychia rufa	1	1
Iswaeon	12	216
Labiobaetis	4	14
Labiobaetis dardanus	6	48
Labiobaetis frondalis	9	88
Labiobaetis propinquus	16	84
Leptophlebia	3	13
Leptophlebiidae	1	1
Leucrocuta	7	12
Maccaffertium	8	13
Maccaffertium mediopunctatum	2	3
Maccaffertium vicarium	1	8
Nixe	1	1
Paracloeodes minutus	1	1
Plauditus	4	7
Procloeon	20	180
Pseudocloeon	3	32
Stenacron	16	208
Stenonema	3	10
Tricorythodes	9	110
Gastropoda		
Ferrissia	11	126
Fossaria	2	2
Gyraulus	14	196
Helisoma	1	27
Helisoma anceps	1	2
Hydrobiidae	6	27
Lymnaea stagnalis	5	5
Lymnaeidae	4	15
Physa	23	403
Physella	3	95
Planorbella	7	9
Planorbidae	6	88
Stagnicola	6	15
Valvata	4	145

Taxonomic Name	Number of Stations Where Present	Quantity of Individuals Collected
Hemiptera		
Belostoma	6	12
Belostoma flumineum	5	6
Callicorixa	1	16
Corixidae	12	146
Gerridae	1	1
Hesperocorixa	6	10
Lethocerus	2	4
Limnoporus	1	2
Metrobates	1	1
Neoplea	2	2
Neoplea striola	2	2
Notonecta	2	2
Palmacorixa	2	6
Ranatra	3	3
Rhagovelia	1	1
Rheumatobates	3	7
Sigara	12	33
Trichocorixa	4	4
Hirudinea		
Hirudinea	9	32
Hydroida		
Hydra	1	1
Lepidoptera		
Petrophila	1	1
Megaloptera		
Sialis	4	8
Nematoda		
Nemata	2	3
Odonata		
Aeshna	1	1
Aeshna umbrosa	4	5
Aeshnidae	2	2
Anax	1	1
Anax junius	2	2
Anisoptera	2	2
Calopterygidae	3	3
Calopteryx aequabilis	3	7
Coenagrionidae	19	131
Corduliidae	2	3
Enallagma	4	86
Gomphidae	1	1

Taxonomic Name	Number of Stations Where Present	Quantity of Individuals Collected
Libellulidae	2	2
Neurocordulia	1	1
Somatochlora	2	2
Plecoptera		
Acroneuria	1	1
Acroneuria lycorias	5	8
Pteronarcys	4	5
Trichoptera		
Agabus	1	1
Ceraclea	5	6
Ceratopsyche	3	29
Ceratopsyche bronta	1	4
Cheumatopsyche	12	167
Chimarra	2	13
Helicopsyche	2	5
Helicopsyche borealis	6	26
Hydropsyche	3	13
Hydropsyche betteni	2	2
Hydropsyche incommoda	2	8
Hydropsyche simulans	4	20
Hydropsychidae	5	16
Hydroptila	13	220
Hydroptilidae	9	14
Leptoceridae	6	15
Limnephilidae	1	2
Micrasema rusticum	1	19
Mystacides	1	1
Nectopsyche	2	4
Nectopsyche diarina	8	52
Neotrichia	2	2
Neureclipsis	1	1
Nyctiophylax	1	2
Oecetis	2	2
Oecetis avara	7	14
Oecetis furva	2	2
Philopotamidae	1	1
Phryganea	1	1
Phryganeidae	3	4
Polycentropodidae	1	1
Polycentropus	2	5
Potamyia	1	1
Psychomyia flavida	1	2

Taxonomic Name	Number of Stations Where Present	Quantity of Individuals Collected
Ptilostomis	1	2
Pycnopsyche	3	3
Triaenodes	6	45
Unclassified		
Acari	21	82
Oligochaeta	17	129
Turbellaria	5	39
Veneroida		
Pisidiidae	14	63