Lower Red River of the North Watershed Monitoring and Assessment Report

Minnesota Pollution Control Agency

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Executive Summary

The Lower Red River of the North Watershed (HUC-09020311) lies in the far northwestern portion of Minnesota; it is comprised of the Tamarac River and the Joe River along with other smaller tributaries. The Tamarac River begins near the town of Strandquist and flows about 80 miles to the west, where it joins the mainstem Red River of the North. The Joe River headwaters occupy the far northwestern corner of Minnesota, including the small towns of Saint Vincent and Humboldt. The lower portion of the Joe River Watershed, including its confluence with the Red River of the North, lies in Canada. These two rivers are considered one watershed due to their similar hydrology even though they are separated by the Two Rivers major watershed. The Lower Red River of the North Watershed covers 800,391 acres and is comprised of 38 lakes and 48 named stream assessment units (AUIDs). The primary land use is agricultural, accounting for over 80 percent of the landscape within the watershed.

In 2008, the Minnesota Pollution Control Agency (MPCA) conducted an intensive watershed monitoring effort of the Lower Red River of the North Watershed's surface waters. Twenty-one sites (on 15 AUIDs) were sampled for biology at the outlets of variable sized subwatersheds within the watershed. These locations included the mouth of major rivers like the Tamarac and Joe Rivers, as well as the outlets of other smaller tributaries. As part of this effort, MPCA also joined with the Red River Watershed Management Board (RRWMB), who completed stream water chemistry sampling at the outlets of the Lower Red River of the North four major subwatersheds. Due to the limited natural ability for water retention, there are no assessable lakes within the Lower Red River Watershed. Therefore, no lake water chemistry sampling was conducted.

Only two of the original 15 AUIDs were assessed for support of both aquatic life and recreation. A portion of the Tamarac River was found to be fully supportive of both aquatic life and recreation, while another AUID on the Tamarac was supportive of aquatic recreation but not aquatic life. In addition, there is existing aquatic life impairment on the Joe River. Judicial Ditch 19 was found to not support aquatic recreation due to excessive bacteria levels. Aquatic biological impairments were isolated to specific reaches on the mainstem of Tamarac River. Due to the extensive modification and channelization in this watershed, many tributaries were not assessable and will be deferred until a tiered aquatic life use (TALU) framework is developed. However, channelized streams throughout the watershed are generally in fair to poor biological condition, with the exception of six sites with healthy fish communities and two sites with healthy invertebrate communities. Turbidity impairments were fairly common across the watershed's tributaries.

Overall, the results from the intensive watershed monitoring and assessment process reveal that the Lower Red River of the North Watershed is in poor condition. The majority of streams in the watershed have been highly altered to promote farmland drainage. The highly altered landscape and stream channel characteristics have resulted in impaired conditions as measured with a broad suite of aquatic community, water chemistry, and stream habitat indicators. The main resource concerns within the watershed are wetland management, surface water quality, flood damage reduction, wildlife habitat, and soil erosion from wind and water (Natural Resources Conservation Service (NRCS) 2011). Many of the resource concerns relate directly to land use and development in the region (NRCS 2011). Land use modifications such as removal of buffers, tiling, and agricultural development result in increased sediment and pollutant loading to surface waters. In addition, hydrologic alteration, including channelization, ditching, and groundwater withdrawal, may be contributing factors to the observed poor water quality conditions.

I. Introduction

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

The MPCA currently conducts a variety of surface water monitoring activities that support our overall mission of helping Minnesotans protect the environment. To be successful preventing and addressing problems, decision makers need good information about the status of the resources, potential and actual threats, options for addressing the threats, and data on how effective management actions have been. 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) of 2006 provided a policy framework and initial resources to state and local governments to accelerate efforts to monitor, assess, restore, and protect surface waters. Funding from the Clean Water Fund created by the passage of the Clean Water, Land, and Legacy Amendment to the state constitution allows a continuation of this work. In response, the MPCA has developed a watershed monitoring strategy which uses an effective and efficient integration of water monitoring programs to provide a more comprehensive assessment of water quality and expedite the restoration and protection process. This has permitted the MPCA to establish a goal to assess the condition of Minnesota's surface waters via a 10-year cycle and provides an opportunity to more fully integrate MPCA water resource management efforts in cooperation with local government and stakeholders, to allow for coordinated development and implementation of water quality restoration and improvement projects.

The rationale behind the watershed approach is to intensively monitor the streams and lakes within a major watershed to determine the overall health of water resources, identify impaired waters, and to identify waters in need of additional protection efforts. This monitoring strategy was implemented in the Lower Red River of the North Watershed beginning in the summer of 2008. This report provides a summary of all water quality assessment results, and incorporates all data available for the assessment process including watershed monitoring, volunteer monitoring, and monitoring conducted by local government units. Consequently, there is an opportunity to begin to address most, if not all, impairments through a coordinated TMDL process at a watershed scale, rather than the reach-by-reach and parameter by parameter approach often historically employed. A watershed approach will more effectively address multiple impairments resulting from the cumulative effects of point and non-point sources of pollution and further the CWA goal of protecting, restoring, and preserving the quality of Minnesota's water resources.

II. The Watershed Monitoring Approach

The watershed approach is a 10-year rotation for assessing waters of the state on the level of Minnesota's 81 major watersheds (Figure 1). The primary feature of the watershed approach is that it provides a unifying focus on the water resources within a watershed as the starting point for water quality assessment, planning, implementation, and results measures. The major benefit of this approach is the integration of monitoring resources to provide a more complete and systematic assessment of water quality at a geographic scale useful for the development and implementation of effective TMDLs and protection strategies. The following paragraphs provide details on each of the four principal monitoring components of the watershed approach. For additional information see: Watershed Approach to Condition Monitoring and Assessment (MPCA 2008) (http://www.pca.state.mn.us/publications/wq-s1-27.pdf).

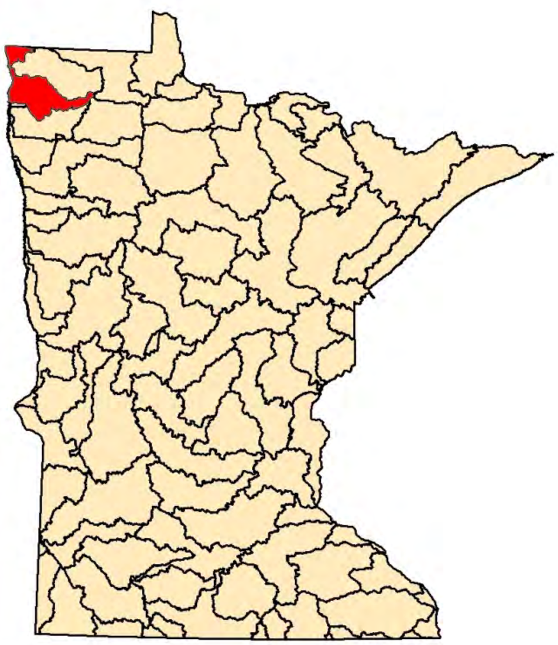

Figure 1. Minnesota's Major Watersheds (8 Digit HUC). Lower Red River of the North Watershed Highlighted

Watershed Pollutant Load Monitoring Network

Funded with appropriations from Minnesota's Clean Water Fund, the Watershed Pollutant Load Monitoring Network (WPLMN) is a long-term program designed to measure and compare regional differences and long-term trends in water quality among Minnesota's major rivers including the Red, Rainy, St. Croix, Mississippi, and Minnesota, and the outlets of the major tributaries (8-digit HUC scale) draining to these rivers. Since the program's inception in 2007, the WPLMN has adopted a multi-agency monitoring design that combines site specific stream flow data from United States Geological Survey (USGS) and Minnesota Department of Natural Resources (MDNR) flow gauging stations with water quality data collected by the Metropolitan Council Environmental Services (MCES), local monitoring organizations, and Minnesota Pollution Control Agency WPLMN staff to compute annual pollutant loads at 79 river monitoring sites across Minnesota. The data from the network will also be used to assist with TMDL studies and implementation plans, watershed modeling efforts, and watershed research projects.

Intensive water quality sampling occurs year round at all WPLMN sites. Thirty-six to 55 mid-stream grab samples were collected at each site per year with a focus on periods of moderate to high flow. Because correlations between concentration and flow exist for many of the monitored analytes, and because these relationships can 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 discharge 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 MPCA. 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 outputs from the model include annual and daily pollutant loads and flow weighted mean concentrations (pollutant load/total flow volume). Loads and flow weighted mean concentrations are calculated for total suspended solids (TSS), total phosphorus (TP), dissolved orthophosphate (DOP), nitrate plus nitrite nitrogen (nitrate-N) and total Kjeldahl nitrogen (TKN).

Intensive watershed monitoring

Stream monitoring

The intensive watershed monitoring strategy utilizes a nested watershed design allowing the aggregation of watersheds from a coarse to a fine scale. The foundation of this comprehensive approach is the 81 major watersheds within Minnesota (Figure 1). Streams are broken in to segments by hydrologic unit codes (HUC) to define separate water-bodies within a watershed. Sampling occurs in each major watershed once every 10 years. In this approach intermediate-sized (approx. HUC-11) and “minor” (14-digit HUC) watersheds are sampled along with the major watershed outlet to provide a complete assessment of water quality (Figure 2). River/stream sites are selected near the outlet at all watershed scales. This approach provides a good coverage of rivers and streams without monitoring every single stream reach (See Figure 3 for an illustration of the monitoring site coverage within the Lower Red River of the North Watershed).

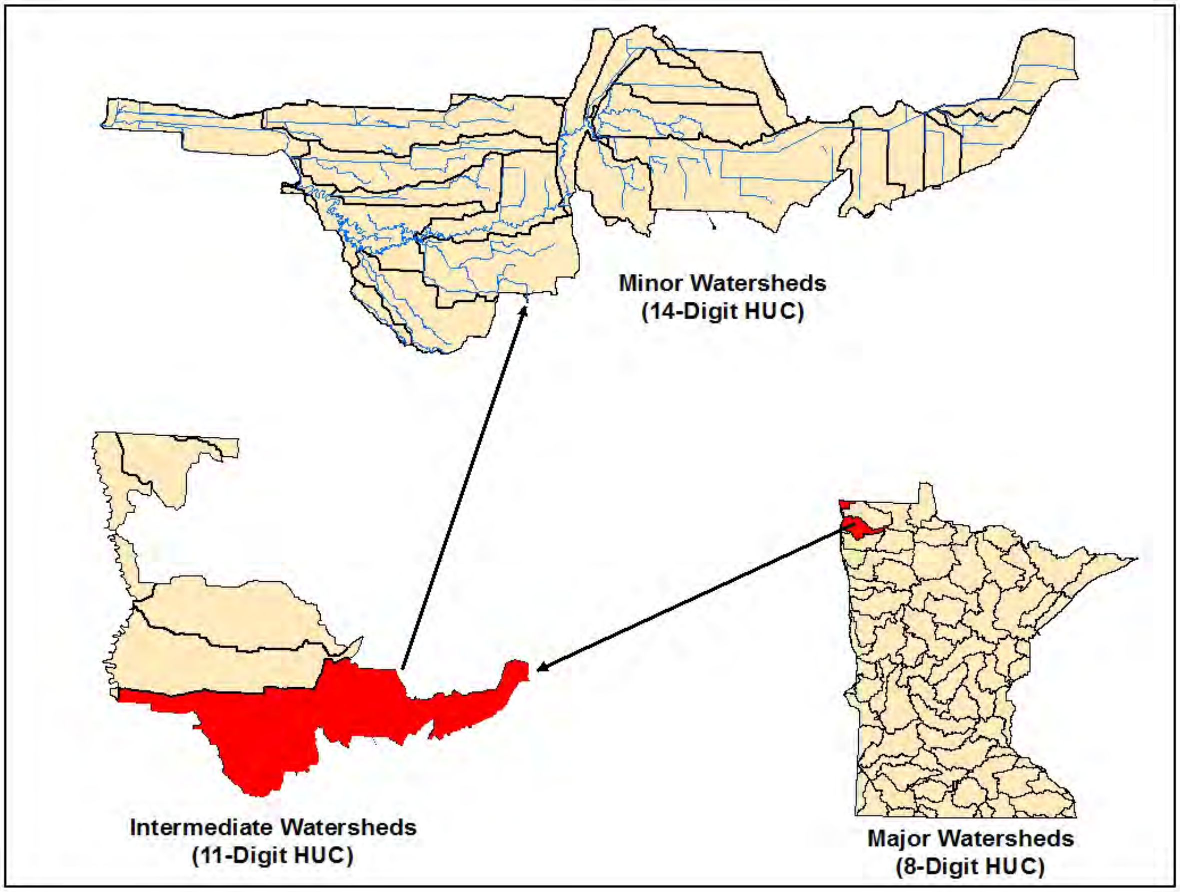

Figure 2. The intensive watershed monitoring design

In most 8-digit HUC watersheds, the major outlet is sampled for biology, water chemistry, and fish contaminants to allow for the assessment of aquatic life, aquatic recreation, and aquatic consumption. However, this watershed includes a segment of the Red River mainstem as well as the smaller tributary streams that enter into it. This report will include only data collected from the tributary streams. The mainstream Red River will be sampled and the results published in a separate report following a longitudinal survey of the Red River of the North. Because the tributary streams entering the Red River in this watershed are relatively small and contain few game fish during the summer index period, there is only one fish contaminant site on the Tamarac River (purple dot in Figure 3) to assess aquatic consumption. Biology (fish and macroinvertebrates) and water chemistry are sampled for the assessment of aquatic life and aquatic recreation use-support at each HUC-11 outlet (green dots in Figure 3). Watersheds at the 11-digit HUC scale typically have drainage areas ranging from 75 to 150 square miles. Lastly, most minor watersheds (typically 10-20 square miles) are sampled for biology only to assess aquatic life use-support (red dots in Figure 3). Specific locations for sites sampled as part of the intensive monitoring effort in the Lower Red River of the North Watershed can be found in Appendix 4.2 and 4.3.

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

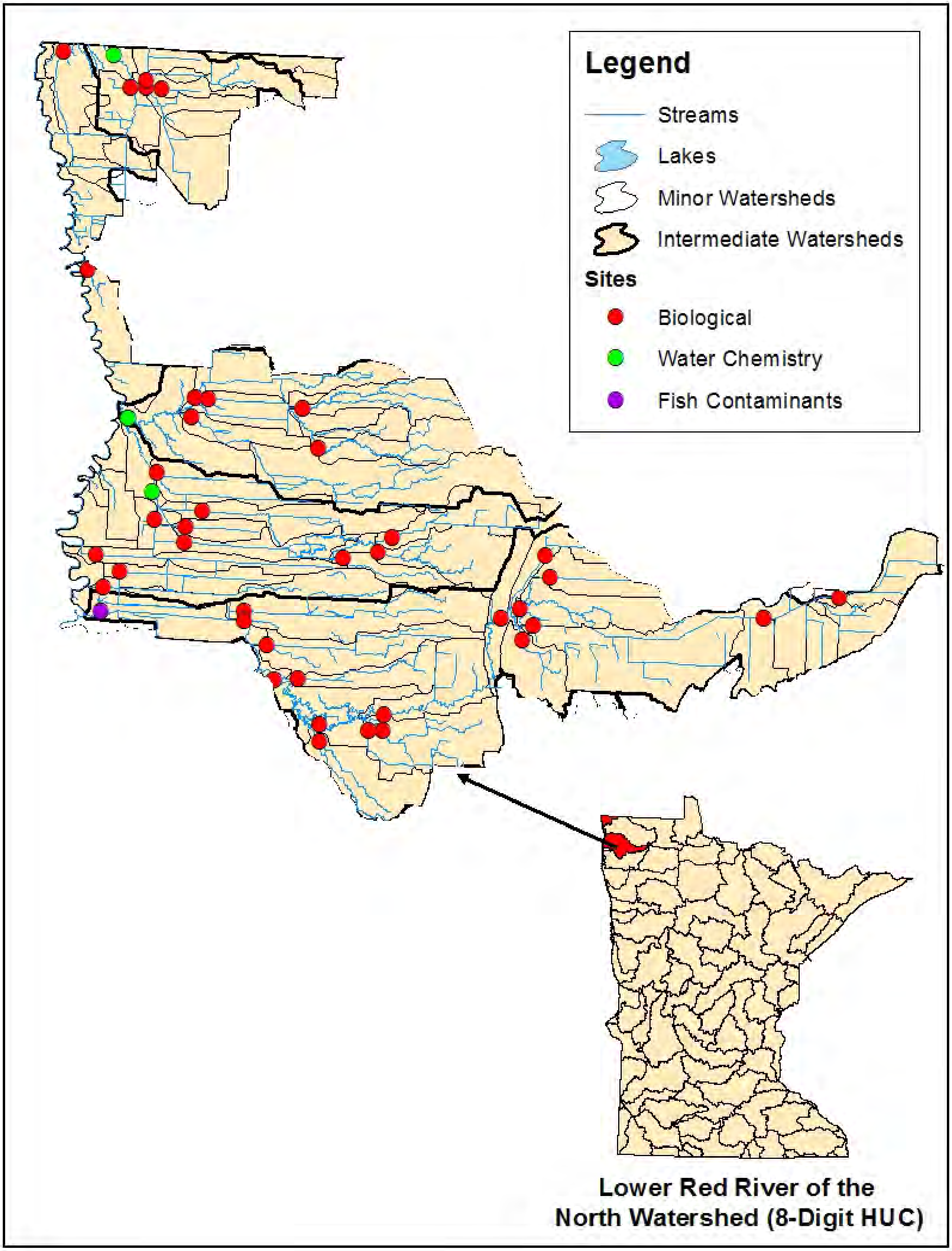

Figure 3. Intensive watershed monitoring stations in the Lower Red River of the North Watershed

Lake monitoring

The Minnesota Pollution Control Agency (MPCA) conducts and supports lake monitoring for a variety of objectives. Lake condition monitoring activities are focused on assessing the recreational use support of lakes and identifying trends over time. The MPCA also assesses lakes for aquatic consumption use support, based on fish-tissue and water-column concentrations of toxic pollutants. Lake monitoring was brought into the watershed monitoring framework in 2009.

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

Citizen and local monitoring

Citizen monitoring is an important component of the watershed monitoring approach. The MPCA coordinates two programs aimed at encouraging citizen surface water monitoring: the Citizen Lake Monitoring Program (CLMP) and the Citizen Stream Monitoring Program (CSMP). Like the permanent load monitoring network, sustained citizen monitoring can provide the long-term picture needed to help evaluate current status and trends. The advanced identification of lake and stream sites that will be sampled by agency staff provides an opportunity to actively recruit volunteers to monitor those sites too, so that water quality data collected by volunteers are available for the years before and after the intensive monitoring effort by MPCA staff. This citizen-collected data helps agency staff interpret the results from the intensive monitoring effort, which only occurs one out of every 10 years. It also allows interested parties to track any water quality changes that occur in the years between the intensive monitoring events. Coordinating with volunteers to focus monitoring efforts where it will be most effective for planning and tracking purposes will help local citizens/governments see how their efforts are being used to inform water quality management decisions and affect change. Figure 4 provides an illustration of citizen monitoring data used for assessment in the Lower Red River of the North Watershed.

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

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

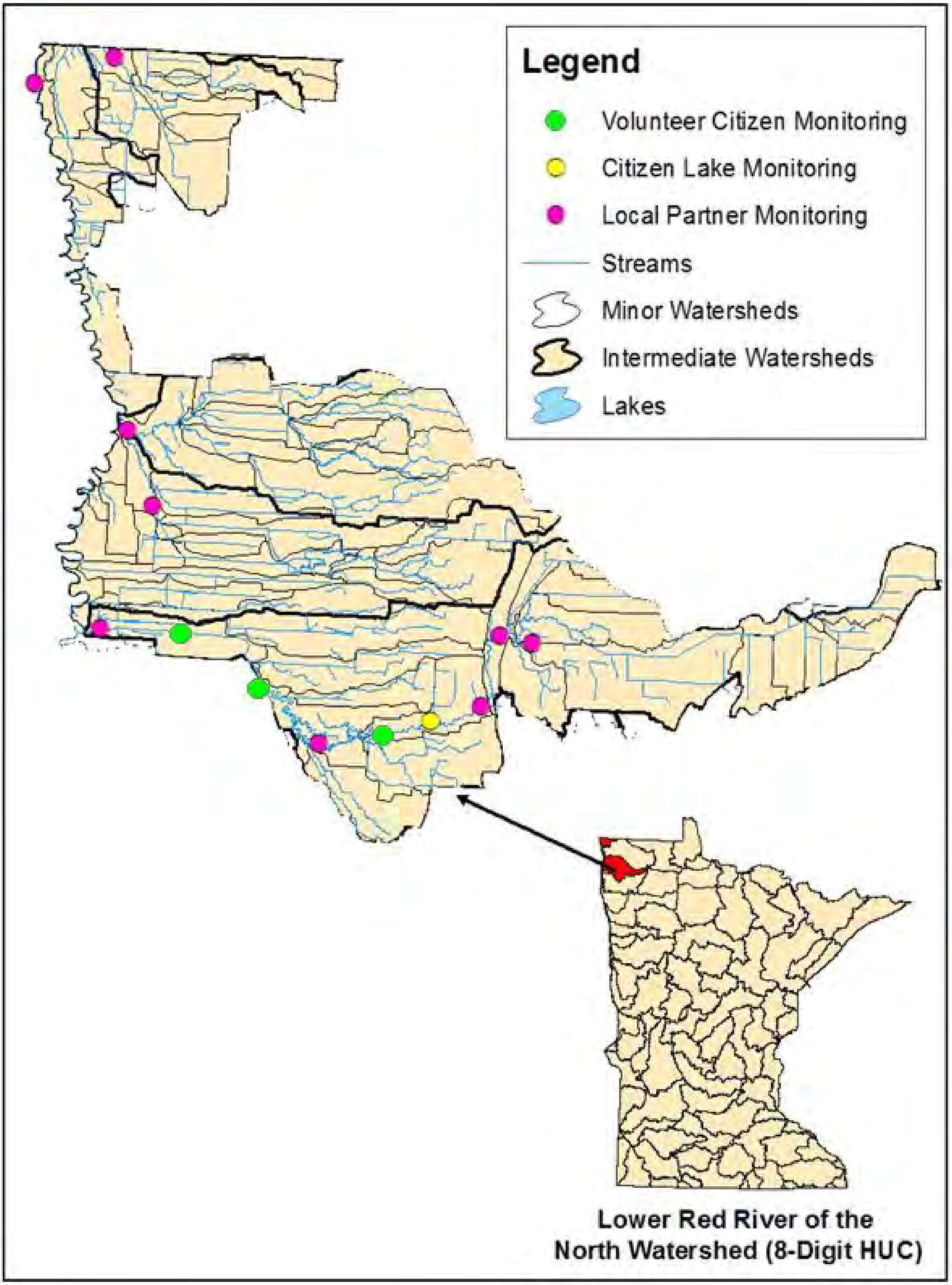

Figure 4. Monitoring locations of local partners and other volunteers in the Lower Red River of the North Watershed

III. Assessment Methodology

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

Water quality standards

Water quality standards are the fundamental benchmarks by which the quality of surface waters are measured and used to determine impairment. Use attainment status is a term describing the degree to which environmental indicators are either above or below criteria specified by Minnesota Water Quality Standards (Minnesota Rules Chapter 7050 2008) (https://www.revisor.leg.state.mn.us/rules/?id=7050). These standards can be numeric or narrative in nature and define the concentrations or conditions of surface waters that allow them to meet their designated beneficial uses, such as for fishing (aquatic life), swimming (aquatic recreation) or human consumption (aquatic consumption). All surface waters in Minnesota, including lakes, rivers, streams and wetlands are protected for aquatic life and recreation where these uses are attainable. Protection of aquatic life means the maintenance of healthy, diverse and successfully reproducing populations of aquatic organisms, including fish and invertebrates. Protection of recreation means the maintenance of conditions suitable for swimming and other forms of water recreation. Protection of consumption means protecting citizens who eat fish inhabiting Minnesota waters or receive their drinking water from waterbodies protected for this use.

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

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

Assessment units

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

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

Determining use attainment status

Conceptually, the process for determining use attainment status of a waterbody is similar for each designated use: comparison of monitoring data to established water quality standards. However, the complexity of that process and the amount of information required to make accurate assessments varies between uses. In part, the level of complexity in the assessment process depends on the strength of the dose-response relationship; i.e., if chemical B exceeds water quality criterion X, how often is beneficial use Y truly not being attained. For beneficial uses related to human health, such as drinking water, the relationship is well understood and thus the assessment process is a relatively simple interpretation of numeric standards. In contrast, assessing whether a waterbody supports a healthy aquatic community is not as straightforward and often requires multiple lines of evidence to make use attainment decisions with a high degree of certainty. Incorporating a multiple lines of evidence approach into MPCA’s assessment process has been evolving over the past few years. The current process used to assess the aquatic life use of rivers and streams is outlined below and in Figure 5.

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

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

Any new impairment determination (i.e., waterbody not attaining its beneficial use) is reviewed using GIS to determine if greater than 50 percent of the assessment unit is channelized. Currently, the MPCA is deferring any new impairments on channelized reaches until new aquatic life use standards have been developed as part of the tiered aquatic life use framework. For additional information see: Tiered Aquatic Life Use (TALU) Framework (http://www.pca.state.mn.us/index.php/water/water-monitoring-and-reporting/water-quality-and-pollutants/the-tiered-aquatic-life-use-talu-framework.html). Since large portions of some watersheds may be channelized, as is the case in this watershed, reaches with biological data are evaluated on a “good-fair-poor” system and reported in tables for each HUC 11 as well as in Appendix 5.2 and 5.3

The last step in the assessment process is the Professional Judgment Group or (PJG) meeting. At this meeting results are shared and discussed with entities outside of the MPCA that may have been involved in data collection or that might have a vested interest in the outcomes of the assessment process. Information obtained during this meeting may be used to revise previous use attainment decisions. The result of this meeting is a compilation of the assessed waters which will be included in the watershed assessment report. Waterbodies that do not meet standards and therefore do not attain one or more of their designated uses are considered impaired waters and are placed on the draft 303(d) Impaired Waters List.

Data management

It is MPCA policy to use all credible and relevant monitoring data to assess surface waters. The MPCA relies on data it collects along with data from other sources, such as sister agencies, local governments, and volunteers. The data must meet rigorous quality-assurance protocols before being used. All monitoring data required or paid for by MPCA is entered into the (Environmental Quality Information System) EQuIS, data system. The MPCA uploads the data from EQuIS to U.S. Environmental Proction Agency’s (EPA) STORET data warehouse. Water quality monitoring projects required to store data in EQuIS are those with federal or state funding under CWA Section 319, Clean Water Partnership (CWP), CWLA Surface Water Assessment Grants, and the Total Maximum Daily Load (TMDL) program. Many local projects not funded by MPCA choose to submit their data to the MPCA in EQuIS-ready format so that it may be utilized in the assessment process. Prior to each assessment cycle, the MPCA requests data from local entities and partner organizations using the most effective methods, including direct contacts and GovDelivery distribution lists.

Period of record

The MPCA uses data collected over the most recent 10-year period for all water quality assessments. Generally, the most recent data from the 10-year assessment period is reviewed first when assessing toxic pollutants, eutrophication and fish contaminants. Also, the more recent data for all pollutant categories may be given more weight during the comprehensive watershed assessment or professional judgment group meetings. The goal is to use data from the 10-year period that best represents the current water quality conditions. Using data over a 10-year period provides a reasonable assurance that data will have been collected over a range of weather and flow conditions and that all seasons will be adequately represented; however, data for the entire period is not required to make an assessment.

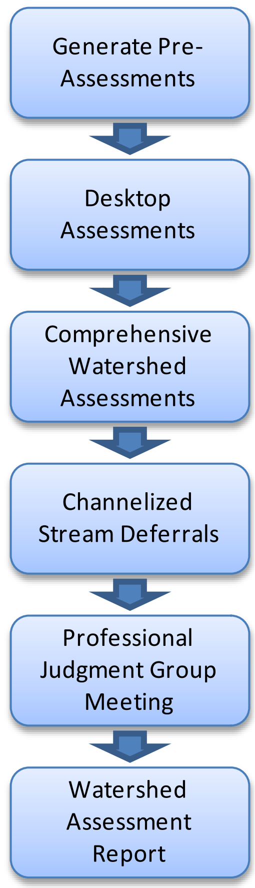

Figure 5. Flowchart of aquatic life use assessment process

IV. Watershed Overview

The Lower Red River of the North Watershed is part of the Red River basin in northwestern Minnesota, northeastern North Dakota, and southern Manitoba, Canada. It drains an area of about 1250 mi^2 between North Dakota and Minnesota. Its hydrologic unit code (HUC) is 09020311 and includes the mainstem of the Red River of the North, which will not be included in this report. The agency has not yet started monitoring the Red River of the North mainstem in a comprehensive manner to collect the necessary biological and chemical data to fully determine aquatic life use support. These AUIDs on the mainstem will be reviewed in the future to determine aquatic life use support once the monitoring strategy for these rivers has been implemented.

The portion of the Lower Red River of the North Watershed within Minnesota is comprised of the Tamarac River and the Joe River, which are similar in hydrology even though they are separated by the Two Rivers Watershed. The Tamarac River begins near the town of Strandquist and flows about 80 miles to the west, where it joins the mainstem Red River of the North, about 11.5 miles northwest of the town of Stephen. The Joe River occupies the far northwestern corner of Minnesota, including the small towns of Saint Vincent and Humboldt. The watershed of the Lower Red River of the North has been grouped together with several other tributaries of the Red River of the North (including those on the North Dakota side) in USGS's hydrologic unit classification system. Unless noted otherwise, statistics reported in the watershed overview section are for the entire watershed, including the portion of the watershed lying within North Dakota but not including any parts of Canada.

The Minnesota portion of the Lower Red River of the North Watershed includes parts of three Minnesota counties: Kittson, Marshall, and Roseau (Figure 6). The drainage area of the Lower Red River of the North in Minnesota is 899 mi^2 or 575,214 acres. The majority of the watershed in Minnesota is in the Lake Agassiz Plain (LAP) ecoregion with only a very small portion of the Northern Minnesota Wetlands (NMW) ecoregion occurring in the southeastern portion of the watershed (Figure 6) (White and Omernik 2007). The LAP is dominated by glacial sediments and glacial landforms deposited from the Des Moines Lobe of Wisconsin Glaciation approximately 12,000 year ago. There are three main landform types formed from Glacial Lake Agassiz: Lake Agassiz plain, Agassiz beach ridge, and Glacial Moraine. The Lake Agassiz Plain consists of glacial lake deposits of clay and silt from the ancient lake bed, the Agassiz Beach Ridge is characterized by glacial lakeshore deposits of delta sand and gravel, and the Glacial Moraine is primarily deposits of clay, silt, sand, gravel, cobble, and boulders (NRCS 2011). Soils in this watershed range from somewhat poorly drained to very poorly drained, to loamy or clayey; which are a mixture of classes such as Mollisols, Vertisols, Alfisols, Entisols, and Histosols (Figure 7).

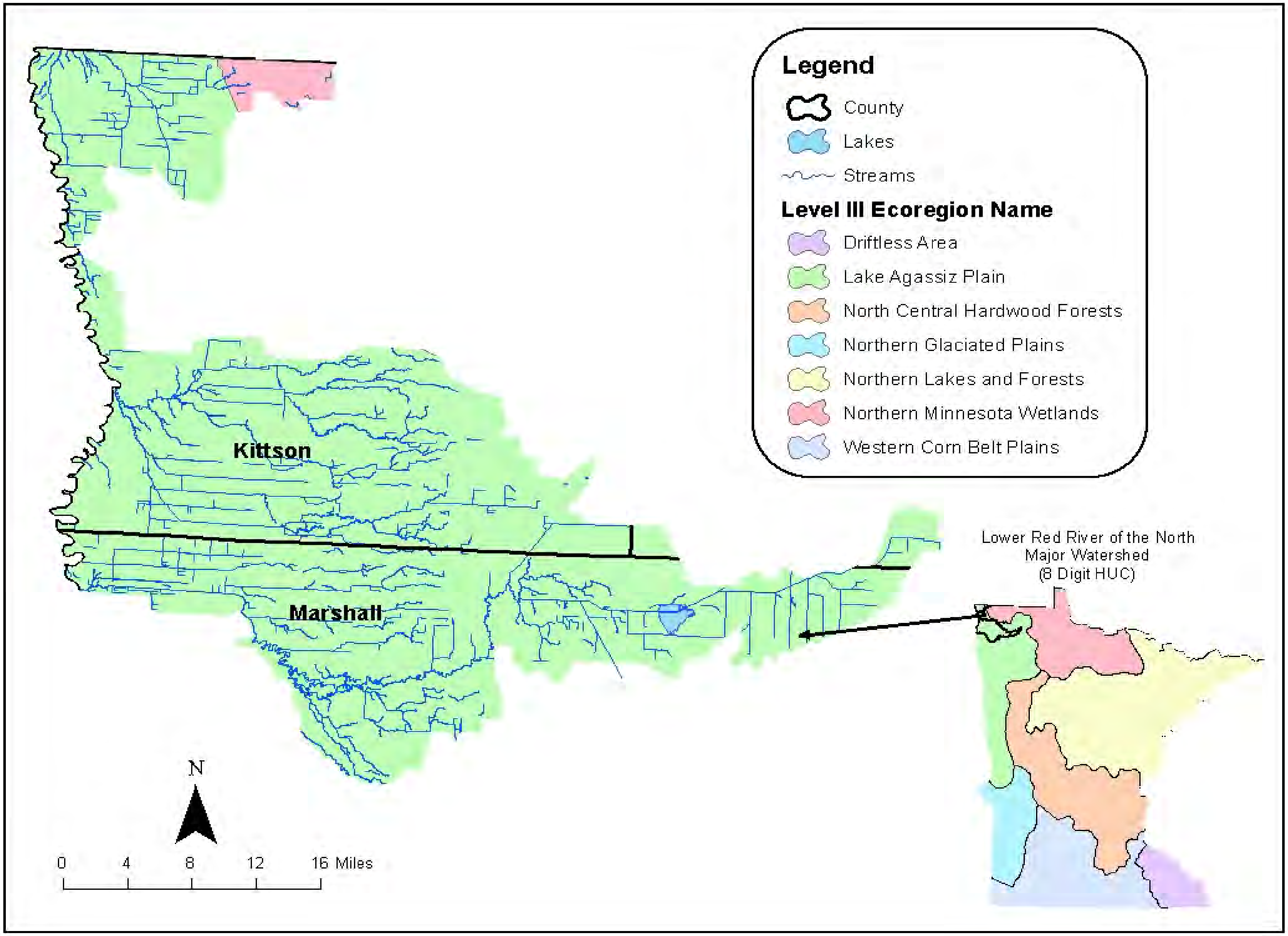

Figure 6. The Lower Red River of the North Watershed in the Lake Agassiz and Northern Minnesota Wetland Ecoregions

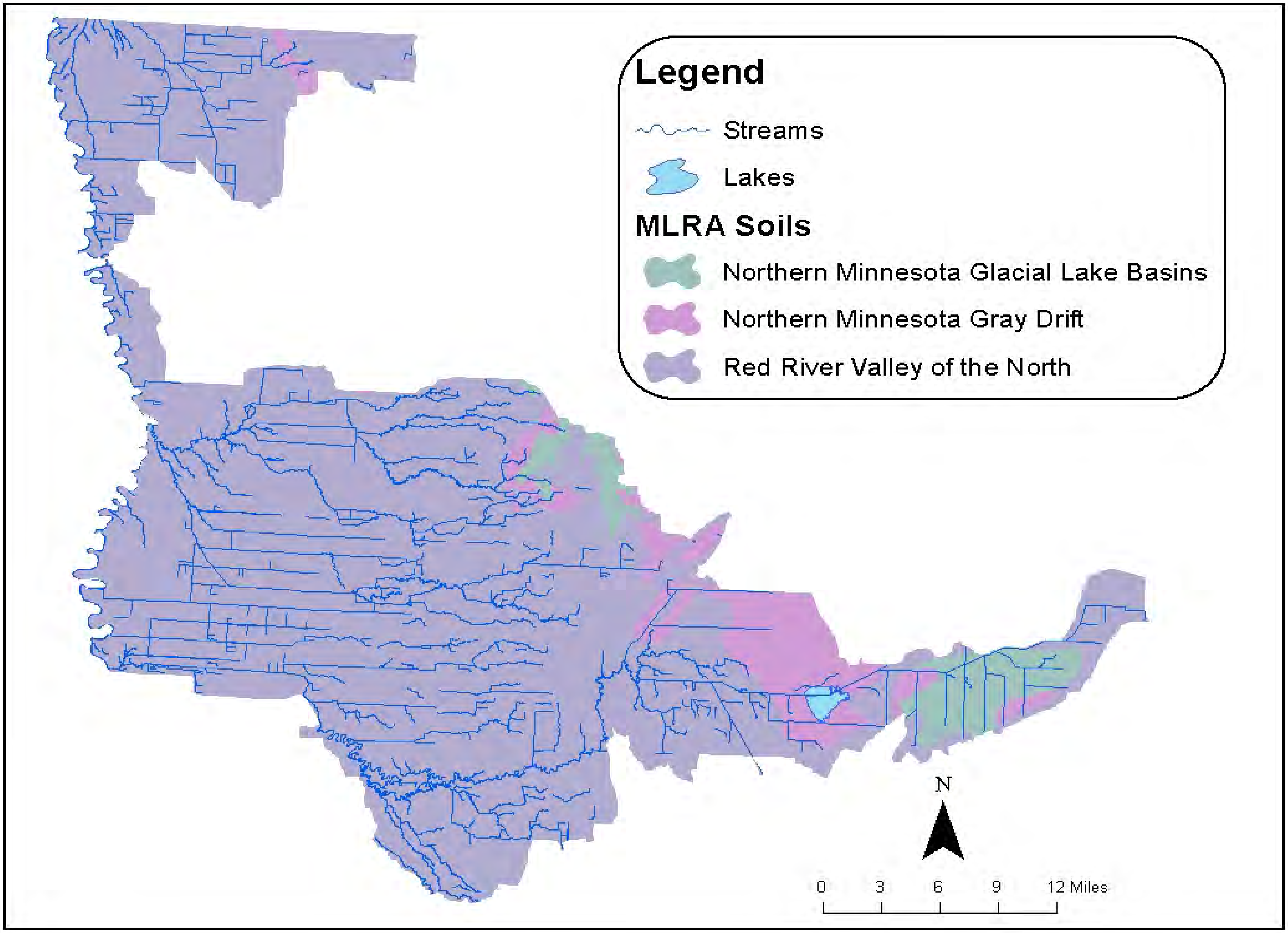

Figure 7. Soils within the Lower Red River of the North Watershed

Land use summary

Historical land cover in the Lower Red River of the North Watershed was a mixture of prairie, brushland, woodlands, and forests in the upland areas and the wetland areas included wet prairies, meadows, fens, or wet forests. (Marschner, 1975). Prairie dominated to the west and wetlands to the east in Minnesota portion of the watershed, prior to western settlement. Much of this pre-settlement vegetation was dependent on the frequency and intensity of fires in this area. The tall grass prairie included species such as Indian grass, big bluestem, asters and goldenrod. The wet prairie was a mixture of grasses, forbs, and shrubs. The grasses of the wet prairie included big bluestem and prairie cord grass. Forbs in this type of prairie were primarily represented by species such as goldenrods, sunflowers, and asters. The brushland and forested areas of the uplands contained a variety of trees like bur oak, american basswood, american elm, eastern cottonwood, green ash, quaking aspen, balsam popular, and willows. The eastern wetland portions were a mixture of deciduous trees, conifers, and sedge meadows (USDA/NRCS, 2006).

The late 1800s brought western settlement and a major land use change in the Red River Valley. The main avenues of transportation during this time were riverboats and railways, which opened much of this area to the settlers (Waters, 1977). The land was beginning to be transformed from river valley into productive farms of substantial acreage. Farming the river valley proved to be a challenge due to the poorly drained soils. Due to the railroad having success with drainage ditches, the farmers soon started to use this method to drain the wet soil on their farms. Minnesota recognized the need for drainage work and passed a comprehensive bill to deal with the issue in 1883. In 1887, the law was expanded and North Dakota enacted a similar law in 1893 (Krenz, 1993). The extensive drainage ditch networks reduced the amount of water on the land to facilitate farming.

Today, in just the Minnesota portion of the this watershed, land cover is distributed as follows: 79.08 percent cropland, 6.67 percent wetlands, 6.50 percent forest/shrub, 4.94 percent developed, 2.08 percent rangeland, and 0.73 percent open water (Figure 7).

Approximately 95.3 percent of the land within the watershed is owned by private landowners (NRCS 2011). Agriculture is the most extensive land use in this area now and very little of the natural vegetation remains. The vast majority of streams have been channelized and an extensive ditch network has been constructed to facilitate drainage for agriculture. About 63 percent of the farmers are full time producers and only 37 percent are part time producers. There are an estimated 778 farms that range from the small family farm to large operations of 1,000 acres or more. The average farm size is 148 acres, with 59 percent of the farms being less than 500 acres in size. There are only 146 permitted feedlots within the watershed, with 16 percent cattle (beef and dairy), five percent chickens, 12 percent swine, 15 percent turkey, and 53 percent being other animals (NRCS, 2011). The main row crops are spring wheat, soybeans, potatoes, sugar beets, corn, oil-producing crops, edible beans, alfalfa, barley, oats, sunflowers, and wheat (USDA, 2006).

The population of this watershed, including North Dakota, is estimated at 7,009, equating to roughly about 5.6 people per square mile (NRCS 2011). The largest population centers are located on the US HWY 75 and US HWY 59 corridors, including the larger towns of Karlstad, Kennedy, and Stephen. There are many smaller towns along these corridors, which include Donaldson, Halma, Humboldt, Saint Vincent, and Strandquist.

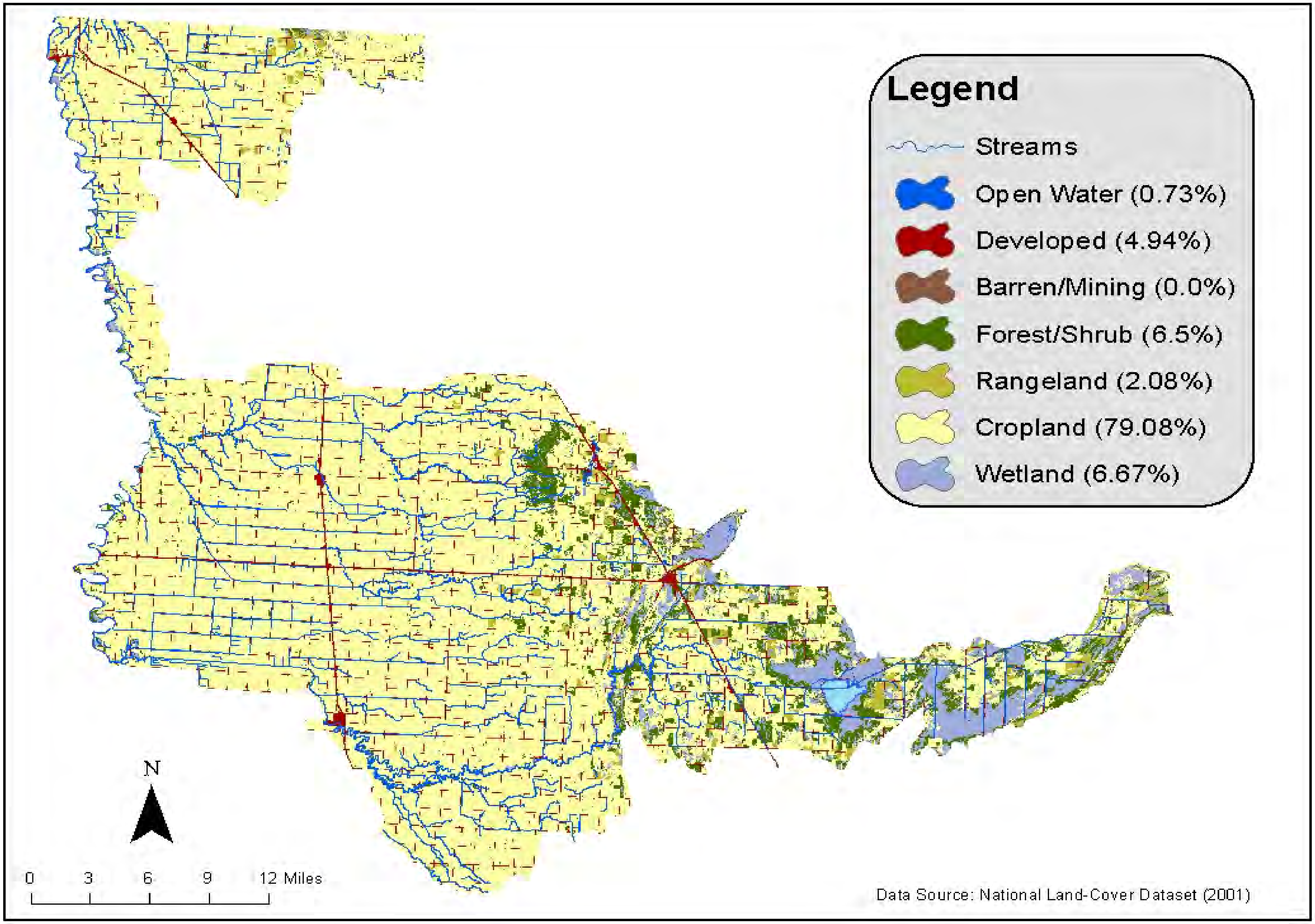

Figure 8. Land use within the Lower Red River of the North Watershed

Surface water hydrology

The Lower Red River of the North Watershed is a sub-watershed of the Red River of the North, a large mainstem river flowing north along the Minnesota and North Dakota border into Manitoba, where it eventually drains into Lake Winnipeg. The mainstem of the Red River spans a course of 400 miles, dropping 210 feet in elevation, and averages a gradient of about a half a foot per river mile (Waters, 1977). The Lower Red River of the North contains both the Tamarac River Watershed and the Joe River Watershed. The Tamarac River starts in the southwestern corner of Roseau County and flows west, where it empties into the mainstem of the Red River in the far northwestern corner of Marshall County, Minnesota. The Tamarac River is 50 miles long and drains 333 mi^2, with low flow and gradient (Waters, 1977). There are many ditches and small intermittent channelized tributaries, which flow directly into the mainstem of the Red River. The Joe River Watershed is a relatively small watershed, which drains 120 mi^2 and is located in Kittson County (Waters, 1977). The Joe River flows northwest about 15 miles from its source near Humboldt, Minnesota to the mainstem Red River in Canada.

The Lower Red River of the North Watershed contains six intermediate watersheds (11-digit HUC) and 56 minor watersheds (14-digit HUC). This watershed has 38 small lakes with a combined surface area of 1,888 acres. There are 5,093 acres of wetlands in this watershed. Within the watershed, there are two dams located on the mainstem of the Tamarac River, one in the city of Stephen and the dam at Florian County Park (Groshens, 2007). The city of Stephen used the dam originally for a source of water for the city and the golf course (Topp, 2001). The city no longer uses the dam as a water source, due to the cities connection to the rural water system (Grosens, 2007). The Florian Park Reservoir is used as a recreational area and forms a lake of 47 acres. The watershed has two primary perennial streams, which are the Tamarac River and the Joe River, along with many drainage ditches that drain into these streams and the mainstem of the Red River. There is one United State Geological Survey (USGS) gage sites located in this watershed, which is located on the Tamarac River.

The Tamarac River and Joe River are very low gradient streams with fine textured stream beds of silt and clay in the far western portion of watershed trending towards more course bottom substrates of sand, gravel, cobble, and boulders further to the east. Both of these tributaries, along with many drainage ditches and other small tributaries draining into the mainstem Red River are subject to seasonal flooding. Consequently, the stability of these streams can be influenced by the backwater flooding of the mainstem Red River (EOR, 2009). The increased periods of saturation, combined with stream flows due to channelization, results in an increased rate of bank erosion in these streams. The bank instability and erosion is extremely evident in most streams and suggest that the stream channels are changing. The hydrology has been affected by climate, but many other human activities like dam and road construction, stream channelization, ditching, converting native landscapes to cropland, draining or filling of wetlands, and water appropriations have significantly altered the natural hydrology (Groshens, 2007).

Climate and precipitation

Annual precipitation levels in this watershed ranged from 21.72 to 31.67 inches in 2008 (Minnesota State Climatologists Office, 2011). The average precipitation normal range is between 17 to 21 inches (USDA/NRCS, 2011). During the October 2007-September 2008, water year, which encompasses the time span in which the majority of the data was collected in the watershed, the precipitation levels were higher than normal (Figure 9).

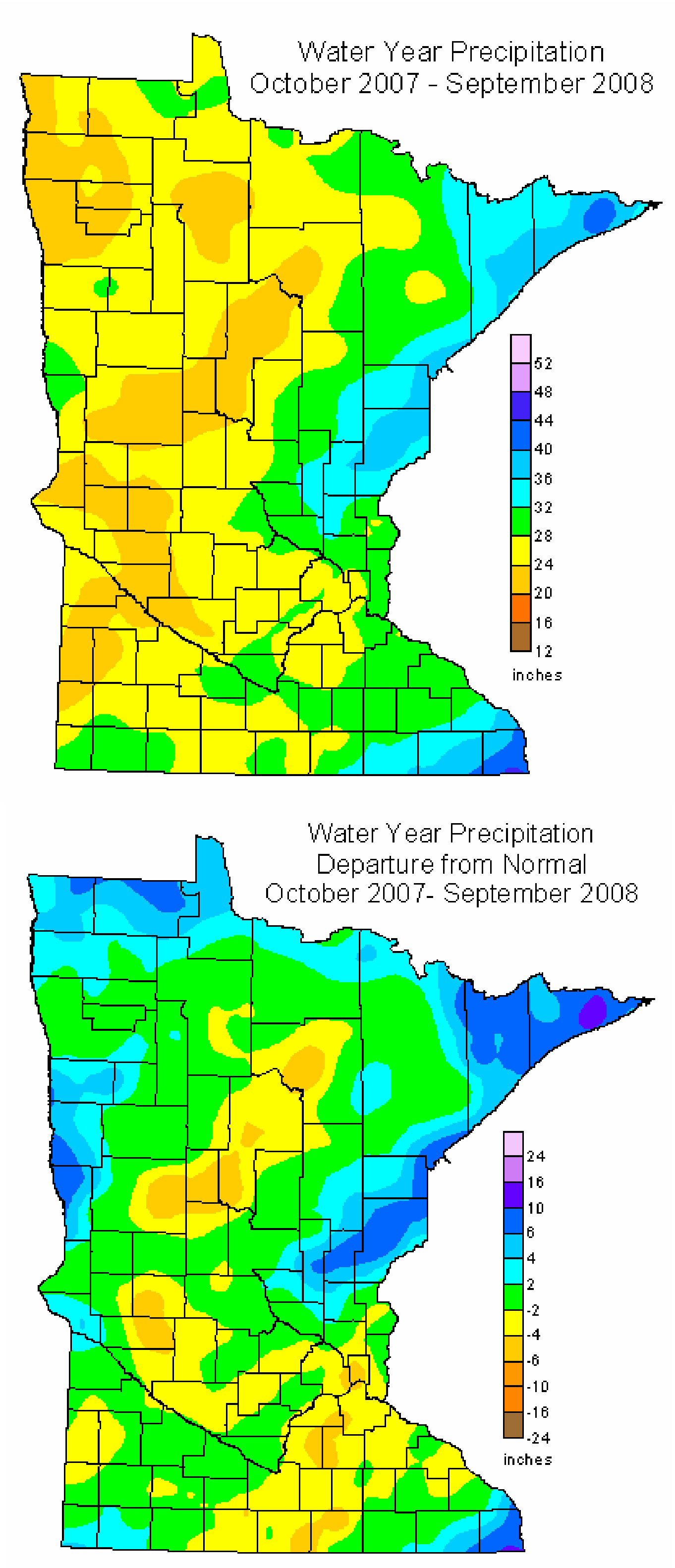

Figure 9. Precipitation in the Lower Red River of the North Watershed

V. Watershed-Wide Data Collection Methodology

Pollutant load monitoring

The Tamarac River is monitored at MDNR gage #69051002 near Robbin, Minnesota, approximately two miles upstream of the confluence with the Red River of the North. Annual flow weighted mean concentrations (FWMCs) and pollutant loads were calculated for 2009 (Figures 18 – 21).

To help put reported numbers into perspective, if a chronic water quality standard, draft standard or surrogate standard exists for a pollutant, the value was inserted as a water quality threshold to provide a general guideline for relative water quality comparisons. It should be noted that while a FWMC exceeding given water quality standard is generally a good indication of non-compliance, this does not always hold true. Waters of the state are listed as impaired based on the percentage of individual samples exceeding a given standard, generally 10 percent and greater, over the most recent 10 year period (although data is not required for all ten years to make an assessment) and not based on comparisons with FWMCs (MPCA 2009 – Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 305(b) Report and 303(d) List). A river with a FWMC above a water quality standard, for example, would not be listed as impaired if less than 10 percent of the individual samples collected over the assessment period were below the standard.

Intensive water quality sampling occurs year round at all MWLMP sites. Thirty to 35 mid-stream grab samples are collected per site per year with sampling frequency greatest during periods of moderate to high flow. Frequent sampling during major runoff events is required to capture the largest pollutant loads and to accurately characterize shifting concentration/flow dynamics. 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 other flow ranges. 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 discharge data are put into the “Flux32” pollutant load model to create concentration/flow regression equations. These derived equations are used to estimate pollutant concentrations and loads on days when samples are not collected. Primary outputs include: annual pollutant loads, defined as the amount (mass) of a pollutant passing a stream location over a defined period of time; and flow weighted mean concentrations (FWMCs), an estimate of the average concentration of a pollutant within the total volume of water that passed the monitoring site during the monitoring period. FWMCs are computed by dividing the pollutant load by the total seasonal flow volume. Annual pollutant loads are calculated for total suspended solids (TSS), total phosphorus (TP), dissolved orthophosphate (DOP), total Kjeldahl nitrogen (TKN) and nitrate plus nitrite nitrogen (NO2+NO3).

Stream water sampling

A total of four water chemistry stations (Figure 10) were sampled in the summer of 2008 and 2009, to provide data for water quality assessments. The monitoring took place cooperatively between staff from the MPCA and the Red River Watershed Management Board (RRWMB). The stations were located near the outlets of the intermediate (HUC-11) watersheds, following the MPCA’s watershed monitoring approach.

The HUC-11 outlet water chemistry data are summarized in Tables 4, 8, 12, and 18 and include those parameters most closely related to the standards or expectations used in the waterbody assessments (i.e. supporting aquatic life and aquatic recreational use). Not all water chemistry parameters of interest have developed water quality standards. McCollor and Heiskary (1993) developed ecoregion expectations for a number of water quality parameters in streams. These guidelines provide a good basis for evaluating water quality data and estimating attainable water quality for an ecoregion. The ecoregion expectations were based on the 75^{th} percentile from a long term dataset of least impacted streams.

Stream biological sampling

A total of 21 biological sites were established throughout the watershed and sampled during the summer months of 2008 (Figure 10). Most of these sites were located near the outlets of the 11-digit HUCs watersheds and minor HUC-14 watersheds. Originally, there were 44 sites selected for biological sampling but 21 sites were non-sampleable due to the site being dry, insufficient flows (<50 percent of the reach has water), impoundments, or no channel or water body present. Two other sites were located on the mainstem on the Red River and were sampled in 2008 but were not used in this report due to the fact the mainstem Red River will be monitored, assessed, and the results summarized using a monitoring strategy specific to large mainstem systems in the near future. While data from the last 10 years was used for assessment, the majority of data used for assessment was collected in 2008. A total of 15 AUIDs were sampled for biology in the Lower Red River of the North Watershed - two AUIDs had two sites each and one AUID had a total of five sites. Of these, two AUIDs were assessed for aquatic life use support and the remaining 13 AUIDs were not assessed due to over 50 percent of the channel being modified. These AUIDs will be deferred until the development of tiered aquatic life use (TALU) standards. In addition, only four of the 15 AUIDs had sufficient information to make a determination on aquatic recreation use support.

To measure the health of the biological communities at each assessable biological monitoring station, Indices of Biological Integrity (IBI) were used, specifically the Fish Index of Biological Integrity (F-IBI) and the Macroinvertebrate Index of Biological Integrity (M-IBI). The F-IBI and M-IBI partitions streams into seven distinct warm water classes and two cold water classes to account for natural, physical, and biological differences associated with different regions of the state, drainage area, gradient, and water temperature (Appendix 4.1). Fish and macroinvertebrate communities within each class are more similar to each other than those occurring in other classes. By partitioning, or accounting for the natural variation in streams, any changes in IBI scores within a class should reflect real change due to human-induced impacts. Each class-specific IBI has a unique suite of metrics, scoring functions, impairment thresholds, and confidence intervals. IBI scores higher than the upper confidence limit reflect good biological condition, while scores below the lower confidence limit reflect poor biological condition. When IBI scores fall within the confidence interval, interpretation and assessment of waterbody condition involves consideration of potential stressors, and draws upon additional information regarding water chemistry, physical habitat, land use activities, etc. For individual biological monitoring station IBI scores, thresholds, and confidence intervals, refer to Appendices 4.2-4.3.

Fish contaminants

Mercury and polychlorinated biphenyls (PCBs) were analyzed in fish tissue samples collected from the Tamarac River in 2008, by the MPCA biological monitoring staff. Captured fish were wrapped in aluminum foil and frozen until they were thawed, scaled, filleted, and ground. The homogenized fillets were placed in 125 mL glass jars with Teflon™ lids and frozen until thawed for mercury or PCBs analyses. The Minnesota Department of Agriculture Laboratory performed all mercury and PCBs analyses of fish tissue.

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

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

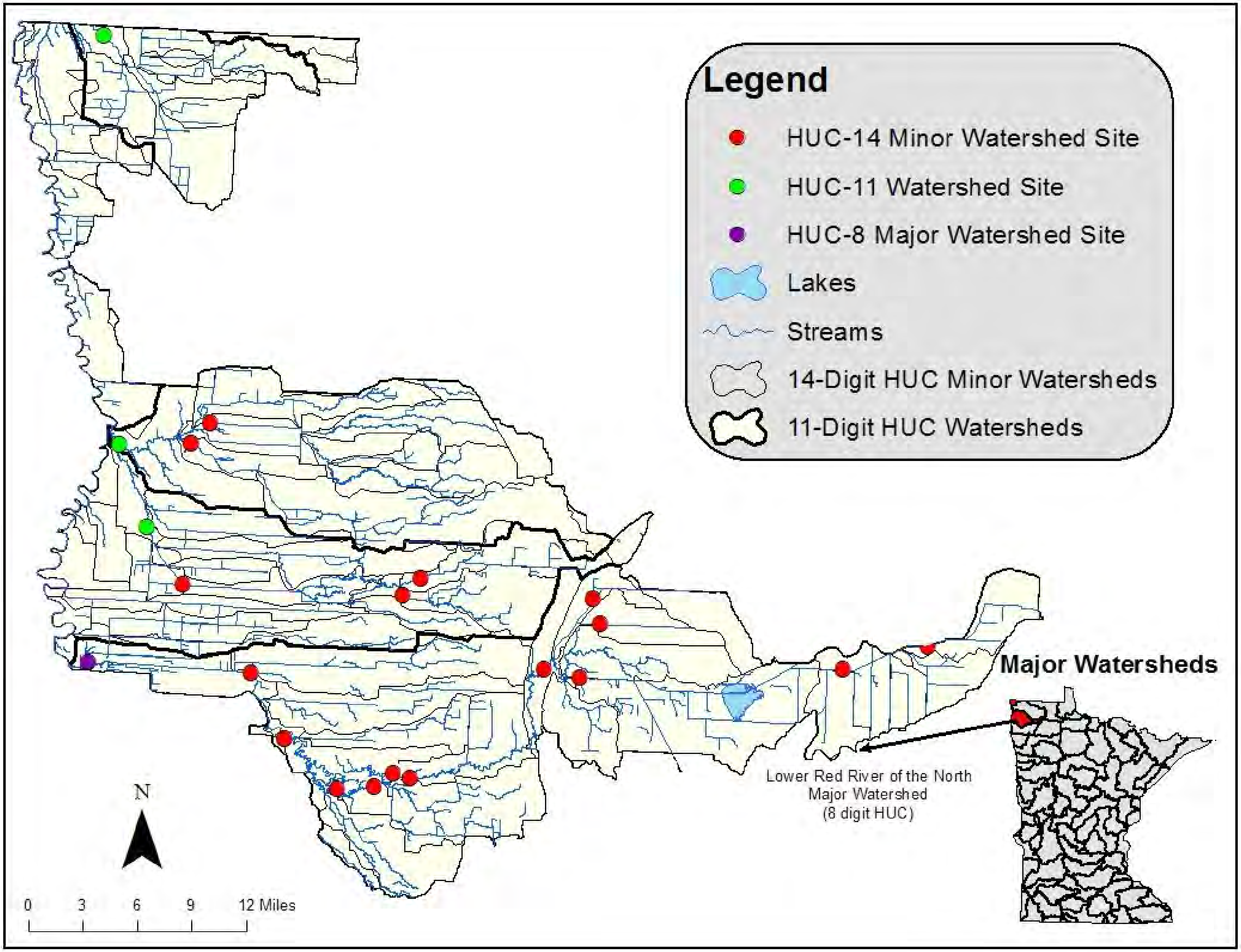

Figure 10. Intensive watershed monitoring stations in the Lower Red River of the North Watershed

Lake water sampling

Due to the limited natural ability for water retention, there are no assessable lakes within the Lower Red River of the North Watershed. A review of the MDNR division of waters list reveals several small and shallow unnamed lakes which are classified as protected. Data was collected on the Florian Park Reservoir however; a model was applied to determine residence time within the basin. Residence time was estimated to be between three and seven days (MNLEAP modeling using MDNR mean depth and acreage inputs). The basin did not meet the 14 day residence time requirement and was not assessed as a lake. Additionally, existing CLMP trend data for the Florian Park Reservoir was determined to be insufficient. No lake water chemistry sampling was conducted in 2008 or 2009, and there will be no further discussion regarding lakes in this report. However, consideration should still be given to these water bodies when determining the dynamics of how water travels and is influenced throughout the watershed.

VI. Individual HUC-11 Watershed Results

Assessment results are presented for each HUC-11 watershed unit within the Lower Red River Watershed, enabling the assessment of all surface waters at one time and the ability to develop comprehensive TMDL studies on a watershed wide basis, rather than the reach by reach and parameter by parameter approach that has been typically employed historically. This scale provides a robust assessment of water quality condition in the 11-digit watershed unit and is a practical size for the development, management and implementation of effective TMDLs and protection strategies. The primary objective of this monitoring strategy is to portray all the impairments within a watershed resulting from the complex and multi-step assessment and listing process. The graphics presented for each of the HUC-11 watershed units contain the assessment results from the 2011 assessment cycle as well as any impairment listings carried forward from previous assessment cycles. Discussion of assessment results will focus primarily on the 2009 intensive watershed monitoring effort, but will also consider all available data from the last 10 years. Monitoring results for the segment of the Red River of the North mainstem will not be included in this report. Instead, a report detailing the results of a longitudinal survey conducted along the entire stretch of the mainstem Red River from its source to the Canadian border will be developed at a later date.

Given all of the potential sources of data and differing assessment methodologies for assessing indicators and designated uses, it is not feasible to provide results or summary tables for every monitoring station by parameter. However, in the proceeding pages an individual account of each 11-digit HUC subwatershed is provided. Within each account, readers are given a brief description of the watershed along with a series of tables including a: 1) stream assessment table, where an overall assessment result is provided for each AUID by each assessable parameter and designated use (i.e. aquatic life and aquatic recreation); 2) non-assessable AUID table where a general indication of condition is provided for channelized streams (where applicable); 3) a stream habitat results table; 4) a watershed outlet water chemistry results table; 5) a table describing lake water chemistry (where applicable) and finally, 6) a narrative that summarizes the unique components of the assessment and highlights noteworthy findings in the results.

Stream assessment

This table provides a summary of all assessable AUIDs by parameter within the watershed (where sufficient information was available to make an assessment). The tables denote the use support status of each individual water chemistry and biological parameter, as well as an overall use support assessment for aquatic life and aquatic recreation for each assessable AUID. The assessment for aquatic life is derived from analyzing biological data, DO, turbidity, chloride, pH and NH3 to determine use status, while the assessment for aquatic recreation in streams is solely based on E. coli concentrations. Immediately following the AUID-specific use support results, the location of any assessed biological monitoring sites are listed. Water chemistry station locations are not provided because information collected as specific locations within each AUID are combined for the purposes of conducting waterbody assessments. Some AUIDs within the subwatershed do not have sufficient information for assessment and are not included in this table. Following the stream assessment table is a narrative table describing the biological condition of stations that could not be assessed due to their occurrence on channelized AUIDs, and is not an assessment for aquatic life for these systems. For more information regarding water chemistry parameters monitored in these studies refer to Appendix 1. A complete listing of all AUIDs within the watershed may be found in Appendix 3.

Channelized stream assessment

Ratings for channelized streams are based on Minnesota's general use threshold for aquatic life. Stations with IBIs that score above the general use threshold would be given a rating of **Good**. The **Fair** rating is calculated as a 15 point drop from the general use threshold. Stations scoring below the Fair threshold would be considered **Poor**. For more information regarding channelized stream parameters refer to Appendix 5.1 – 5.3**.**

Stream habitat results

These tables convey the results of the Minnesota Stream Habitat Assessment (MSHA) surveys that are conducted during each fish sampling visit. The MSHA provides information on available fish habitat, land use and buffers along the immediate site reach, providing clues for impacts such as siltation or eutrophication which may lead to unhealthy fish and macroinvertebrate communities. The MSHA score is comprised of numerous scoring categories including land use, riparian zone, in stream zone (substrate, embeddedness, cover types and amounts) and channel morphology (depth variability, sinuosity, stability, channel development, velocity) which are summed for a total possible score of 100 points. Total scores for each category and a summation of the total MSHA score are included. Where multiple visits occur at the same station, the relative scores from each visit have been averaged. The final row in each table displays average MSHA scores for each scoring category for that particular sub-watershed. A qualitative habitat rating was then assigned to each station: Good ≥ 66, Fair 45-65, or Poor ≤ 44.

Watershed outlet water chemistry results

These summary tables display the water chemistry results for the intensive watershed station representing the outlet of the HUC-11 watershed. This data can provide valuable insight on water quality characteristics and potential parameters of concern within the watershed. While not all of the water chemistry parameters of interest have developed water quality standards, McCollor and Heiskary (1993) have developed ecoregion expectations for a number of water quality parameters in streams. These ecoregion expectations provide a good basis for evaluating water quality data and estimating attainable water quality for an ecoregion. The ecoregion expectations were based on the 75th percentile from a long term dataset of least impacted streams.

HUC-11 and HUC-8 figures

The figures presented for each of the following HUC-11 watershed units contain the assessment results from the most recent assessment cycle as well as any impairment listings carried forward from previous assessment cycles. Following the results by HUC-11 watershed, are a series of figures that provide an overall summary of assessment results by designated use, impaired waters, and fully supporting waters within the entire Lower Red River of the North Watershed (HUC-8).

Tamarac River Watershed Unit HUC 09020311170

The Tamarac River Watershed is the largest subwatershed in the Lower Red River of the North drainage, encompassing 372.69 square miles in Marshall and Roseau Counties. This watershed contains the headwaters of the Tamarac River, which begins in the far south western corner of Roseau County, an area of mostly agricultural land and wetlands, with exception of some small residential areas. The watershed includes the small town of Strandquist, Stephen, and Karlstad. Land use in this portion of the watershed is a mixture of cropland (68.67 percent), developed (4.64 percent), wetlands (13.22 percent), rangeland (3.15 percent), forest/shrub (9.95 percent), and open water (0.37 percent). As such, there are few point sources (e.g., waste water treatment facilities) and many non-point (e.g., row crops, housing developments) pollution sources, which can make it very difficult to maintain water quality in this subwatershed without landowner participation in conservation measures. Biological monitoring station 08RD001 represents the outlet of this subwatershed.

Stream Assessment

Table 1. Aquatic life and recreation assessment on stream reaches in the Tamarac River Watershed. Reaches are organized upstream to downstream in table.

AUID *Reach Name, Reach Description*	Reach Length (miles)	Use Class	Biological Station ID	Location of Biological Station	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	Aquatic Life	Aquatic Rec.
09020311-516 ***Judicial Ditch 19****, Headwaters to Tamarac R*	12.9	2B	--	--	--	--	IF	MTS	MTS	MTS	MTS	--	EX	IF*	NS
09020311-511, ***Tamarac River****, Headwaters to Florian Park Reservoir*	26.19	2Bd	08RD042	Upstream of Unnamed St, 4 mi. S of Karlstad	MTS	MTS	IF	MTS	MTS	MTS	MTS	--	MTS	FS	FS
09020311-503, ***Tamarac River,*** *Florian Park Reservoir to Stephen Dam*	36.41	2Bd	08RD015 05RD042 05RD179 08RD007 08RD031	Upstream of CR 34, 6.5 mi. SE of Stephen 1.5 miles E of County Route 6, ~6 miles SE of Stephen Upstream of CR 30, 5 mi. SE of Stephen Upstream of CR 32, 4 mi. SE of Stephen Upstream of HWY 59, 1 mi. SE Stephen	EXP	EXP	IF	MTS	MTS	MTS	MTS	--	MTS	NS	FS
09020311-505, ***Tamarac River,*** *Stephen Dam to Red R*	15.86	2B	08RD001	Upstream of Hwy 220, 6 mi. SE of Robbin	MTS	EXS	IF	EXS	MTS	MTS	MTS		MTS	IF*	FS

Abbreviations for Indicator Evaluations: -- = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **MTS** = Meets criteria; **EXP** = Exceeds criteria, potential impairment; **EXS** = Exceeds criteria, potential severe impairment; **EX** = Exceeds criteria (Bacteria).

Abbreviations for Use Support Determinations: **NA** = Not Assessed, **IF** = Insufficient Information, **NS** = Non-Support, **FS** = Full Support

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

*Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.

†Reach was assessed based on use class included in table and existing use class as defined in Minn. Rule 7050 is different. The MPCA is currently in the process of changing the existing use class for this AUID in rule based on an analysis of the biological community and temperature data.

Table 2. Non-assess biological stations on channelized AUIDs in the Tamarac River 11 Digit HUC

AUID ***Reach Name***, *Reach Description*	Reach Length (miles)	Use Class	Biological Station ID	Location of Biological Station	Fish IBI	Invert IBI
09020311-541, ***Judicial Ditch 19,*** *Unnamed ditch to Unnamed ditch*	3.8	2B	08RD016	Upstream of 170th Ave NE, 2 mi. SE of Strathcona	Fair	--
09020311-545, ***Judicial Ditch 19,*** *Unnamed ditch to Unnamed ditch*	1.53	2B	08RD004	At East Park Dr NW, 3.5 mi. SW of Strathcona	Good	Good
09020311-516 ***Judicial Ditch 19***, *Headwaters to Tamarac R*	12.9	2B	08RD014	Upstream of 220th Ave NW, 3 mi. NW of Strandquist	Poor	Good
09020311-526, ***State Ditch 90,*** *Unnamed ditch to Lateral Ditch 5*	1.9	2B	08RD010	At unnamed rd, 1 mi. S of Karlstad	Good	Fair
09020311-527, ***Lateral Ditch 5,*** *Headwaters to State Ditch 90*	6.33	2B	08RD011	Upstream of 210th Ave NW, 2 mi. SE of Karlstad	Good	Poor
09020311-505, ***Tamarac River,*** *Stephen Dam to Red R*	15.86	2B	08RD024	Upstream of 400th Ave, 3 mi NW of Stephen	Good	Fair

Table 3. Minnesota Stream Habitat Assessment (MSHA) results in for the Tamarac River 11 Digit HUC

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	08RD016	Judicial Ditch 19	5	8.5	18.85	4	10	46.35	Fair
1	08RD004	Judicial Ditch 19	5	10	18	10	13	56	Fair
2	08RD014	Judicial Ditch 19	0	7.5	17	12	14.5	51	Fair
1	08RD010	State Ditch 90	5	11	16	10	19	61	Fair
2	08RD011	Lateral Ditch 5	5	12	9	13	10	49	Fair
1	08RD042	Tamarac River	2.5	13.5	20	13	30	79	Good
1	08RD015	Tamarac River	0	10.5	16.45	8	24	58.95	Fair
2	05RD042	Tamarac River	2.5	8.5	15.13	11	22	59.13	Fair
1	05RD179	Tamarac River	2.3	9.0	12	6.5	19.5	49.3	Fair
2	08RD007	Tamarac River	0	10.5	7	11	15	43.5	Poor
1	08RD031	Tamarac River	0	10.5	7	14	17	48.5	Fair
1	08RD024	Tamarac River	0	5	8	12	13	38	Poor
1	08RD001	Tamarac River	2.5	8	11.4	10	20	51.9	Fair
Average Habitat Results: *Tamarac River 11 HUC*			**2.3**	**9.6**	**13.5**	**10.3**	**17.5**	**53.2**	**Fair**

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

Table 4. Outlet water chemistry results for the Tamarac River 11 Digit HUC

Station location:	Tamarac River at CSAH-220, 11 mi. W of Stephen											
Equis ID:	S002-100											
Station #:	08RD001											
Parameter	D.O.	E. Coli	NH_3	NO_2 + NO_3	TKN	pH	TP	TSS	TSVS	Spec. cond.	Temp.	T-tube
Units	mg/l		mg/l	mg/l	mg/L		mg/l	mg/l	mg/L	uS/cm	C	cm
# Samples	31	20	19	29	29	32	29	29	16	32	32	32
Minimum	6.83	5.1	0.003	0.02	0.926	7.84	0.075	23	1	350	7.98	2
Maximum	31	461.1	0.069	4.71	7.78	8.65	0.762	696	76	620	28.48	23
Mean[1]	8.64	114.62	0.03	0.22	1.40	8.30	0.16	105.28	12.31	492.09	17.73	8.30
Median	8.65	60.6	0.04	0.02	1.14	8.32	0.137	79	7.5	499	18.455	7.25
WQ standard[2]	5.0	126/1260	0 .04			6.5 - 9.0		100				20
# WQ exceedances[3]	0/31	0/20	2/19	6/29	1/29	0/32	1/29	3/29		0/32	1/32	31/32
RRV 75th Percentile[4]			0.02	0.1	1.09-1.70	8.4	0.33	74		630	25	

[1]Total suspended solids and Transparency tube standards are surrogate standards derived from the turbidity standard of 25

[2]Represents exceedances of individual maximum standard for *E. coli* (1260/100ml) or fecal coliform.

[3]Based on 1970-1992 summer data; see *Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions* (McCollor and Heiskary 1993).

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Tamarac River 11 HUC, a component of the IWM and Load Monitoring work conducted in 2008 and 2009. This specific data does not necessarily reflect all data that was used to assess the AUID.**

Summary

Eight sites sampled for biology (fish and macroinvertebrates) on the mainstem of the Tamarac River provide insight into the streams quality along its length. Fish community results suggest that the poorest quality sections of the Tamarac River are the lower reaches from approximately eight miles southeast of Stephen to the mouth of Tamarac River's confluence with the Red River of the North. An improvement in F-IBI scores at the most downstream site (08RD001) may be a reflection of the sites proximity to the Red River rather than any real improvement in quality. Macroinvertebrate communities followed the same general pattern as the fish with decreasing IBI scores closer to the mouth. However, macroinvertebrate IBI scores were more variable and unlike the F-IBI, M-IBI scores did not improve at the mouth of the Tamarac River. Extensive channelization west of Stephen, along with very intensive land use practices, may contribute to the poor biological quality in the lower reaches of the Tamarac River. The best site on the Tamarac River was located approximately four miles south of Karlstad in the upper most unchannelized reaches. The MSHA score of 79 exceeds that of other sites and corresponds with F-IBI and M-IBI score of 51 and 72 respectively, among the highest IBI scores in this watershed.

Six channelized, warm water streams in this 11-HUC were not assessed for aquatic life; instead their biological conditions were characterized based on IBI scores (Table 2). The majority of the channelized streams were in fair to good biological condition in spite of the extensive channelization. Physical habitat measurements from these sites suggest that they may be recovering from the effects of the channelization as their MSHA scores were generally fair. The better performing streams tended to have a mixture of natural and agricultural land uses and a moderately intact riparian buffer.

Turbidity levels on the Tamarac River increase in a downstream direction to a level that often exceeds state standards near the Tamarac's confluence with the Red River of the North. Similarly, ecoregion norms for TSS, TP, and NO_2/NO_3 are also often exceeded in the lower reaches of the Tamarac River. Bacteria levels, however, are highest in the upper channelized reaches of the watershed; the highest levels occurring at Judicial Ditch 19 (09020311-516) where high bacteria levels did not support aquatic recreation.

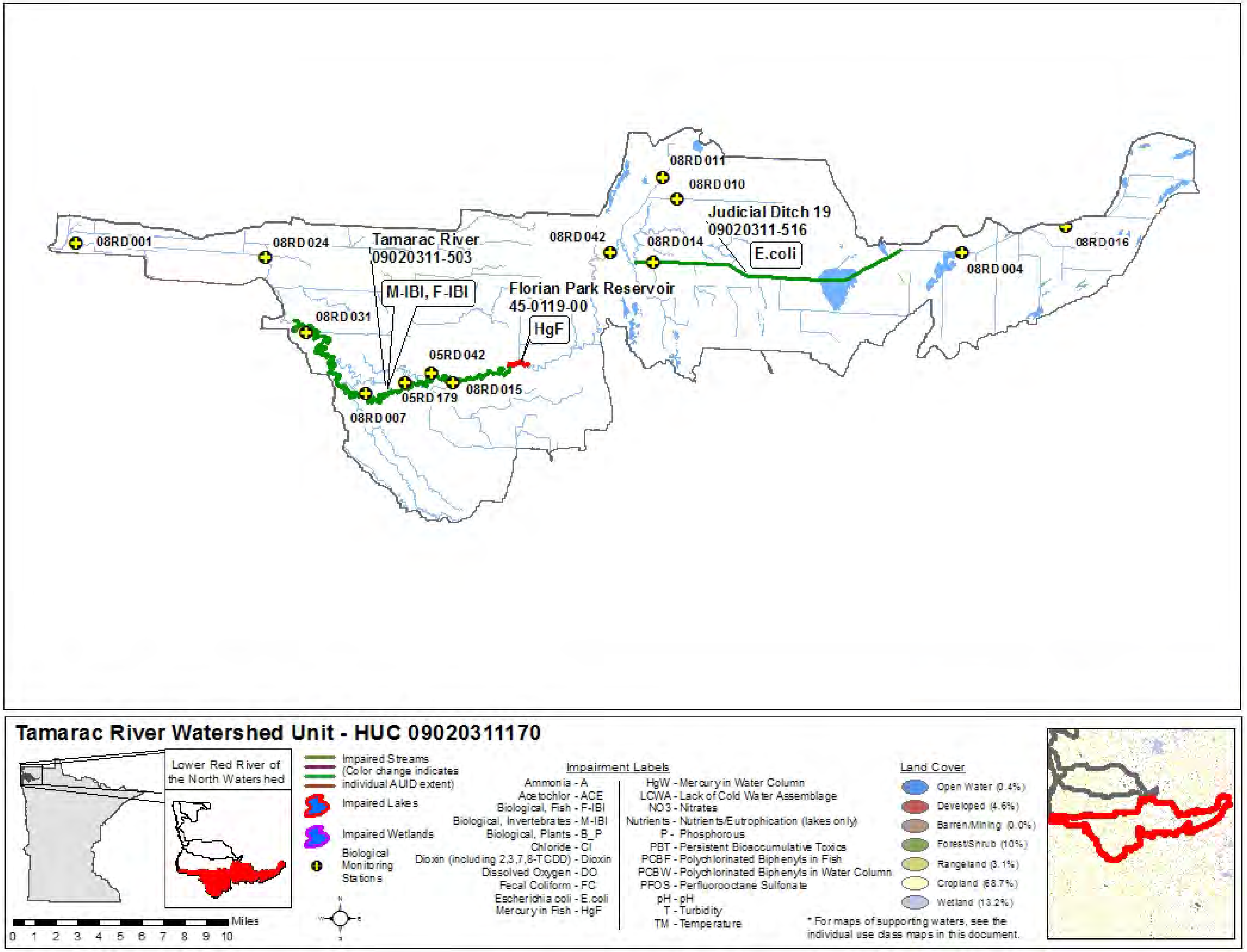

Figure 11. Currently listed impaired waters by parameters and land use characteristics in the Tamarac River Watershed Unit

Donaldson Watershed Unit HUC 09020311180

The Donaldson Watershed is the second largest watershed in the Lower Red River of the North drainage, encompassing 219.35 square miles in Marshall and Kittson Counties. This watershed contains a large network of county ditches and judicial ditches, which begin in the far south eastern corner of Kittson County, an area of mostly agricultural land. The watershed includes the towns of Karlstad and Donaldson. Land use in this subwatershed is a mixture of cropland (86.63 percent), developed (5.33 percent), wetlands (3.0 percent), rangeland (0.91 percent), forest/shrub (3.22 percent), and open water (0.90 percent)). As such, there are few point sources (e.g., waste water treatment facilities) and many non-point (e.g., row crops, housing developments) pollution sources. Biological monitoring station 08RD002 represents the outlet of this subwatershed.

Stream assessment

Table 5. Non-assessed biological stations on channelized AUIDs in the Donaldson 11 Digit HUC

AUID ***Reach Name,*** *Reach Description*	Reach Length (miles)	Use Class	Biological Station ID	Location of Biological Station	Fish IBI	Invert IBI
09020311-518, ***County Ditch 10,*** *Unnamed cr to Unnamed cr*	4.44	2B	08RD036	Downstream of Hwy 11, 8 mi. W of Karlstad	Good	Poor
09020311-540, ***Unnamed creek,*** *Unnamed cr to CD 10*	2.23	2B	08RD037	Upstream of unnamed rd, 8 mi. SE of Donaldson	Good	Fair
09020311-521, ***Judicial Ditch 10,*** *Unnamed cr to CD 16*	7.94	2B	08RD035	At unnamed rd, 5 mi. W of Donaldson	Poor (2)	Poor (2)
09020311-524, ***Judicial Ditch 10,*** *Unnamed ditch to CD 19*	2.43	2B	08RD002	Downstream of unnamed rd, 8 mi. SW of Kennedy	Poor	Poor

Table 6. Minnesota Stream Habitat (MSHA) results for the Donaldson 11 Digit HUC

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	08RD036	County Ditch 10	0	12	11	15	23	61	Fair
1	08RD037	Unnamed Creek	0	12	12.4	14	15	53.4	Fair
2	08RD035	Judicial Ditch 10	0	6	7	3.5	2.5	19	Poor
1	08RD002	Judicial Ditch 10	0	10.5	4	10	9	33.5	Poor
Average Habitat Results: *Donaldson 11 HUC*			**0**	**10.1**	**8.6**	**10.6**	**12.4**	**41.7**	**Poor**

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

Table 7. Outlet water chemistry results for the Donaldson 11 HUC

Station location:	JD #16 at CSAH 23, 6.5 mi. SW of Kennedy											
Equis ID:	S004-875											
Station #:	08RD002											
Parameter	D.O.	E. Coli	NH_3	$NO_2 + NO_3$	TKN	pH	TP	TSS	TSVS	Spec. cond.	Temp.	T-tube
Units	mg/l		mg/l	mg/l	mg/L		mg/l	mg/l	mg/L	uS/cm	C	cm
# Samples	15	13	6	6	6	15	6	6	0	15	15	14
Minimum	0.91	21.6	0.003	0.020	1.050	7.37	0.103	4	0	423	11.92	8
Maximum	10.17	410.6	0.106	2.460	1.640	8.55	0.641	74	0	1067	24.66	>60
Mean	7.64	132.11	0.03	0.43	1.31	8.19	0.35	27.67	0	670.47	19.43	34.86
Median	7.89	77.6	0.003	0.020	1.235	8.23	0.321	20	0	665	20.32	28
WQ standard[1]	5.0	126/1260	0 .04			6.5 - 9.0		100				20
# WQ exceedances[2]	1/15	0/13	2/6	1/6	0/6	0/15	2/6	0/6	0/0	8/15	0/15	4/14
RRV 75th Percentile[3]			0.02	0.1	1.09-1.70	8.4	0.33	74		630	25	

[1]Total suspended solids and Transparency tube standards are surrogate standards derived from the turbidity standard of 25

[2]Represents exceedances of individual maximum standard for *E. coli* (1260/100ml) or fecal coliform.

[3]Based on 1970-1992 summer data; see *Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions* (McCollor and Heiskary 1993).

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Donaldson 11 HUC, a component of the IWM work conducted in 2008 and 2009. This specific data does not necessarily reflect all data that was used to assess the AUID.**

Summary

There were no assessable AUIDs to report from this watershed because tributary streams to the Red River of the North were extensively channelized. The mainstem Red River will be assessed once the monitoring strategy for large rivers has been designed and implemented.

The unnamed tributary streams in this watershed varied both in biological and physical habitat quality. Streams coming off the beach ridge area in the far eastern portion of the watershed had poor to fair M-IBI scores but F-IBI scores were good. These eastern streams also had MSHA scores in the fair range, typified by relatively high habitat component scores for fish cover, riparian quality, and stream morphology. Streams further to the west in the Lake Agassiz Plain scored poorly for both biological indicators as well as MSHA. Streams in this part of the watershed had habitat typified by very poor fish cover, substrate, and channel morphology scores. Water chemistry data collected at the lower reaches of Judicial Ditch 16 were insufficient for assessment; however, most samples met water quality standards and were within ecoregion norms.

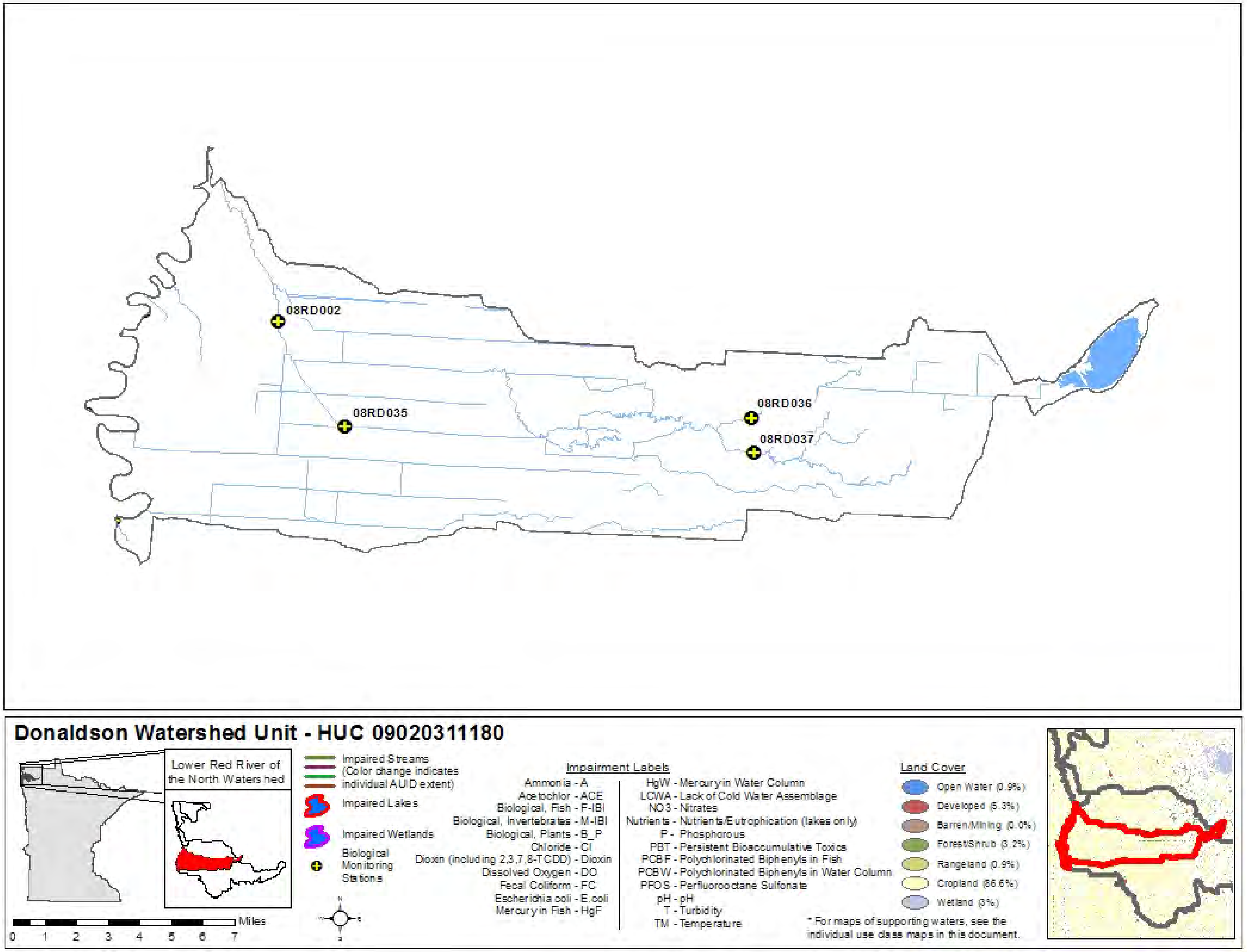

Figure 12. Currently listed impaired waters by parameters and land use characteristics in the Donaldson Watershed Unit

Kennedy Watershed Unit HUC 09020311190

The Kennedy Watershed is the third largest watershed in the Lower Red River of the North drainage, encompassing 179 square miles in Kittson County. This watershed also contains a large network of county, judicial, and state ditches. The watershed begins in the far south eastern corner of Kittson County, an area of mostly agricultural land that includes the small towns of Halma and Kennedy. Land use in this portion of the watershed is a mixture of cropland (83.35 percent), developed (5.36 percent), wetlands (2.13 percent), rangeland (1.28 percent), forest/shrub (7.29 percent), barren/mining (0.01 percent), and open water (0.58 percent). As such, there are few point sources (e.g., waste water treatment facilities) and many non-point (e.g., row crops, housing developments) pollution sources within this subwatershed. Biological monitoring station 08RD003 represents the outlet of this subwatershed.

Stream Assessment

Table 8. Aquatic life and recreation assessment on stream reaches in the Kennedy Watershed. Reaches are organized upstream to downstream in the table.

AUID ***Reach Name,*** *Reach Description*	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	**Aquatic Life**	**Aquatic Rec.**
09020311-509, ***Unnamed creek (County Ditch 27),*** *Headwaters to Red R*	32.26	2B	08RD003	Upstream of unnamed rd, 1.5 mi. SW of Mattson	EXS	--	IF	EXS	--	MTS	MTS	--	IF	IF*	IF

Abbreviations for Indicator Evaluations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **MTS** = Meets criteria; **EXP** = Exceeds criteria, potential impairment; **EXS** = Exceeds criteria, potential severe impairment; **EX** = Exceeds criteria (Bacteria).

Abbreviations for Use Support Determinations: **NA** = Not Assessed, **IF** = Insufficient Information, **NS** = Non-Support, **FS** = Full Support

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

*Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.

†Reach was assessed based on use class included in table and existing use class as defined in Minn. Rule 7050 is different. The MPCA is currently in the process of changing the existing use class for this AUID in rule based on an analysis of the biological community and temperature data.

Table 9. Non-assessed biological stations on channelized AUIDs in the Kennedy 11 digit HUC

AUID ***Reach Name***, *Reach Description*	Reach Length (miles)	Use Class	Biological Station ID	Location of Biological Station	Fish IBI	Invert IBI
09020311-538, ***State Ditch 1,*** *Unnamed cr to Unnamed cr*	6.53	2B	08RD023	Upstream of CR 13, 3.5 mi. SE of Kennedy	Fair	--
09020311-509, ***Unnamed creek (County Ditch 27),*** *Headwaters to Red R*	32.26	2B	08RD027	Downstream of unnamed road, 5 mi. NW of Kennedy	Poor (2)	Poor

Table 10. Minnesota Stream Habitat Assessment (MSHA) results for the Kennedy 11 digit HUC

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	08RD023	State Ditch 1	0	5.5	13	4	19	41.5	Poor
2	08RD027	Unnamed Creek (County Ditch 27)	0	6.3	10	6.5	22.5	45.3	Fair
2	08RD003	Unnamed Creek (County Ditch 27)	0	11.5	7	12.5	15.5	46.5	Fair
Average Habitat Results: *Kennedy 11 HUC*			**0**	**7.8**	**10**	**7.7**	**19**	**44.4**	**Poor**

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

Table 11. Outlet water chemistry results for the Kennedy 11 HUC

Station location:	Unn str (Trib to Red River) at Unn Rd, 1.5 mi SW of Mattson											
Equis ID:	S004-876											
Station #:	08RD003											
Parameter	D.O.	E. Coli	NH_3	NO_2 + NO_3	TKN	pH	TP	TSS	TSVS	Spec. cond.	Temp.	T-tube
Units	mg/l		mg/l	mg/l	mg/L		mg/l	mg/l	mg/L	uS/cm	C	cm
# Samples	15	12	7	7	7	16	7	7		16	16	16
Minimum	5.07	2	0.003	0.02	0.998	7.67	0.069	1		465	11.31	7
Maximum	11.33	209.8	0.08	0.68	1.64	8.52	0.647	99		855	25.82	60
Mean	8.25	64.98	0.01	0.13	1.29	8.14	0.28	24.86		669.25	18.93	26.78
Median	8.38	40.95	0.003	0.02	1.23	8.15	0.273	21		668	20.68	17.25
WQ standard[1]	5.0	126/1260	0 .04			6.5 - 9.0		100				20
# WQ exceedances[2]	0/15	0/12	1/7	2/7	0/7	0/16	1/7	0/7	0/0	10/16	1/16	9/16
RRV 75th Percentile[3]			0.02	0.1	1.09-1.70	8.4	0.33	74		630	25	

[1]Total suspended solids and Transparency tube standards are surrogate standards derived from the turbidity standard of 25

[2]Represents exceedances of individual maximum standard for *E. coli* (1260/100ml) or fecal coliform.

[3]Based on 1970-1992 summer data; see *Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions* (McCollor and Heiskary 1993).

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Kennedy 11 HUC, a component of the IWM work conducted in 2008 and 2009. This specific data does not necessarily reflect all data that was used to assess the AUID.**

Summary

There were no assessable AUIDs in this watershed because nearly all tributary streams to the Red River of the North were extensively channelized. The assessment of aquatic life, near the outlet of County Ditch 27 (08RD003), is being deferred until the development of TALU due to the extensive channelization throughout the AUID (09020311-511). The effect of channelization can be seen in the MSHA habitat scores where overall scores are poor to fair and subcomponent scores for substrate and fish cover habitat values are particularly low. F-IBI scores are also low and reflect a community that lacks abundance and diversity. Low flows prevented the collection of macroinvertebrates from all streams in this watershed including near the outlet (08RD003). Water chemistry data collected near the outlet (08RD003) were not sufficient for assessment, however values for turbidity, TSS, and conductivity often exceeded state standards or ecoregion norms while DO, pH, and ammonia were generally within state guidelines. Overall, the poor physical, chemical, and biological results from this small watershed are typical of the highly altered headwater systems found elsewhere throughout the agricultural regions of Minnesota.

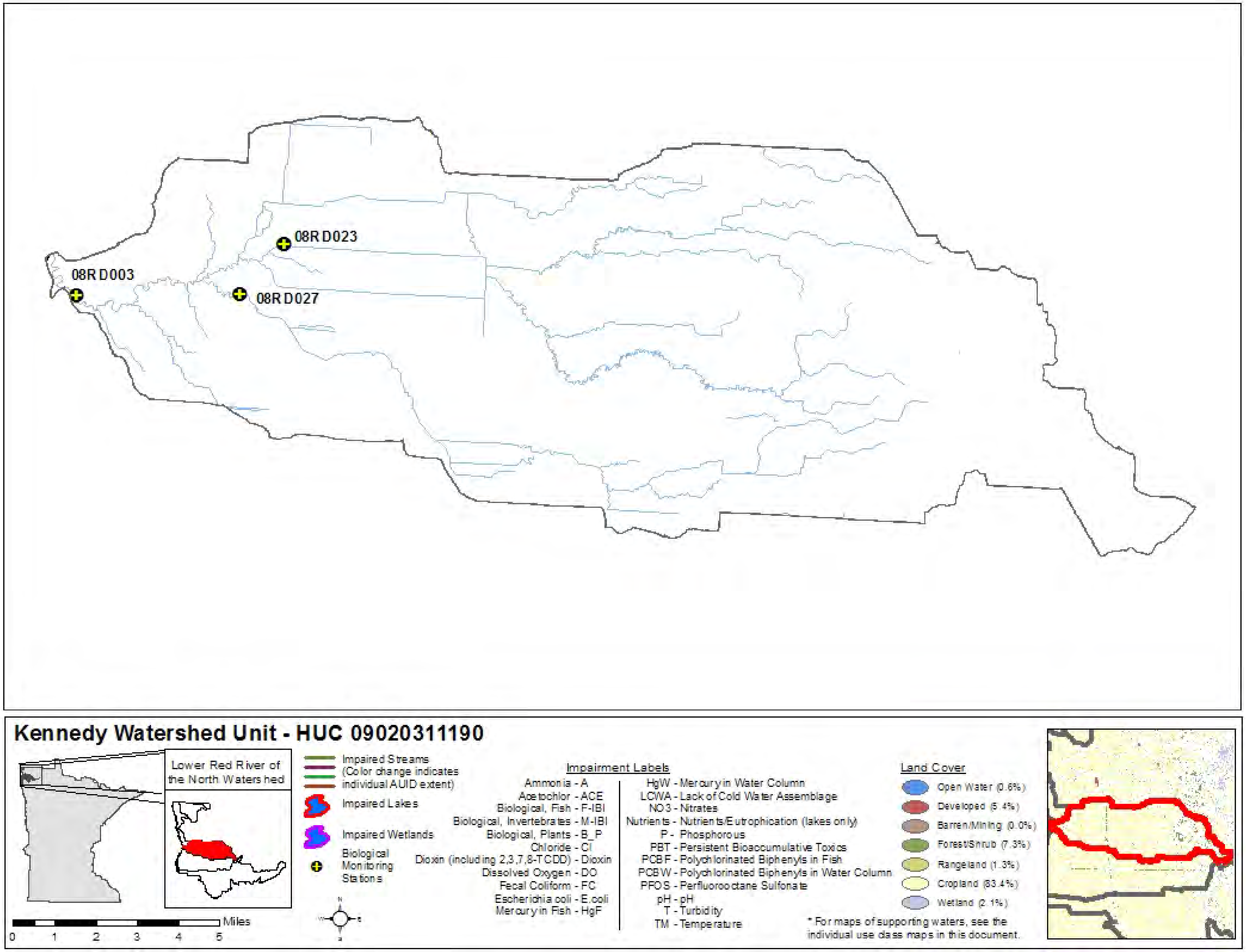

Figure 13. Currently listed impaired waters by parameters and land use characteristics in the Kennedy Watershed Unit

Red River of the North Watershed Unit HUC 09020311200

The Red River of the North Watershed is the second smallest watershed in the Lower Red River of the North drainage, encompassing 36.02 square miles in far western Kittson County. This watershed contains a small section of the mainstem Red River of the North. There are also a few, very small headwater tributary streams in this subwatershed that enter into the Red River, all of which are ephemeral and therefore not sampleable. This watershed unit is located about seven miles west of the city of Hallock. Land use in this portion of the watershed is a mixture of cropland (83.17 percent), developed (4.36 percent), wetlands (5.97 percent), rangeland (0.11 percent), forest/shrub (2.32 percent), and open water (4.06 percent). As such, there are few point sources (e.g., waste water treatment facilities) and many non-point (e.g., row crops, homesteads) pollution sources. There are no biological monitoring stations in this subwatershed. The mainstem Red River will be monitored assessed and the results summarized using a monitoring strategy specific to large mainstem river systems.

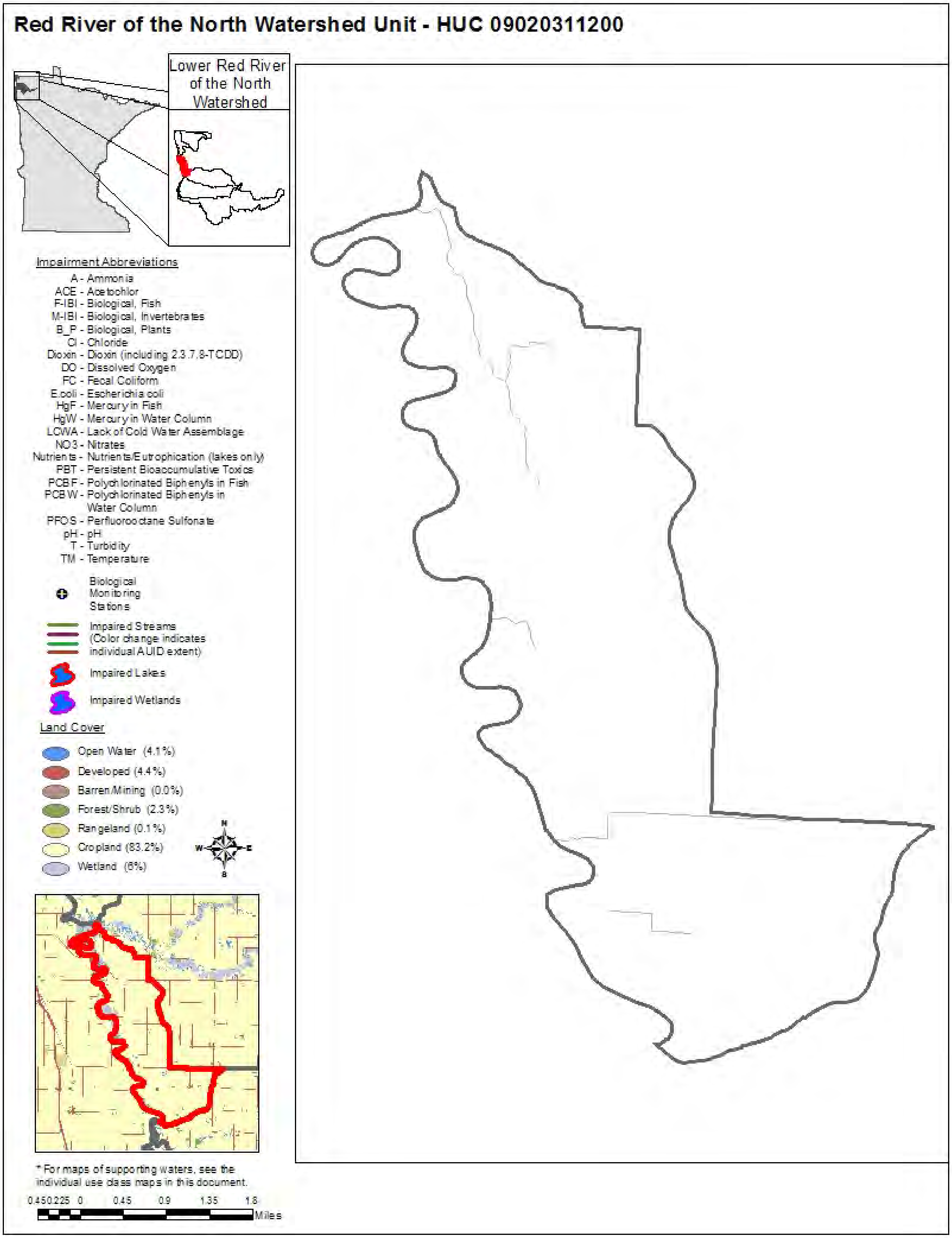

Figure 14. Currently listed impaired waters by parameters and land use characteristics in the Red River of the North Watershed Unit

St. Vincent Watershed Unit HUC 09020311210

The St. Vincent Watershed is the fifth largest watershed in the Lower Red River of the North drainage, encompassing 64.95 square miles in Kittson County. This watershed unit also contains large network of county, judicial, and state ditches, which begin in far north western corner of Kittson County, an area of mostly agricultural land. The small town of St. Vincent is in the northwest corner of the watershed. This watershed contains a small section of the mainstem Red River of the North. There are also a few very small headwater tributary streams in this subwatershed that enter into the Red River, all of which are ephemeral and therefore not sampleable. Land use in this portion of the watershed is a mixture of cropland (86.89 percent), developed (5.61%), wetlands (3.09 percent), rangeland (0.36 percent), forest/shrub (1.67 percent), and open water (2.37 percent). As such, there are few point sources (e.g., waste water treatment facilities) and many non-point (e.g., row crops) pollution sources, which makes participation by local land owners in conservation efforts important. The mainstem Red River will be monitored assessed and the results summarized using a monitoring strategy specific to large mainstem systems.

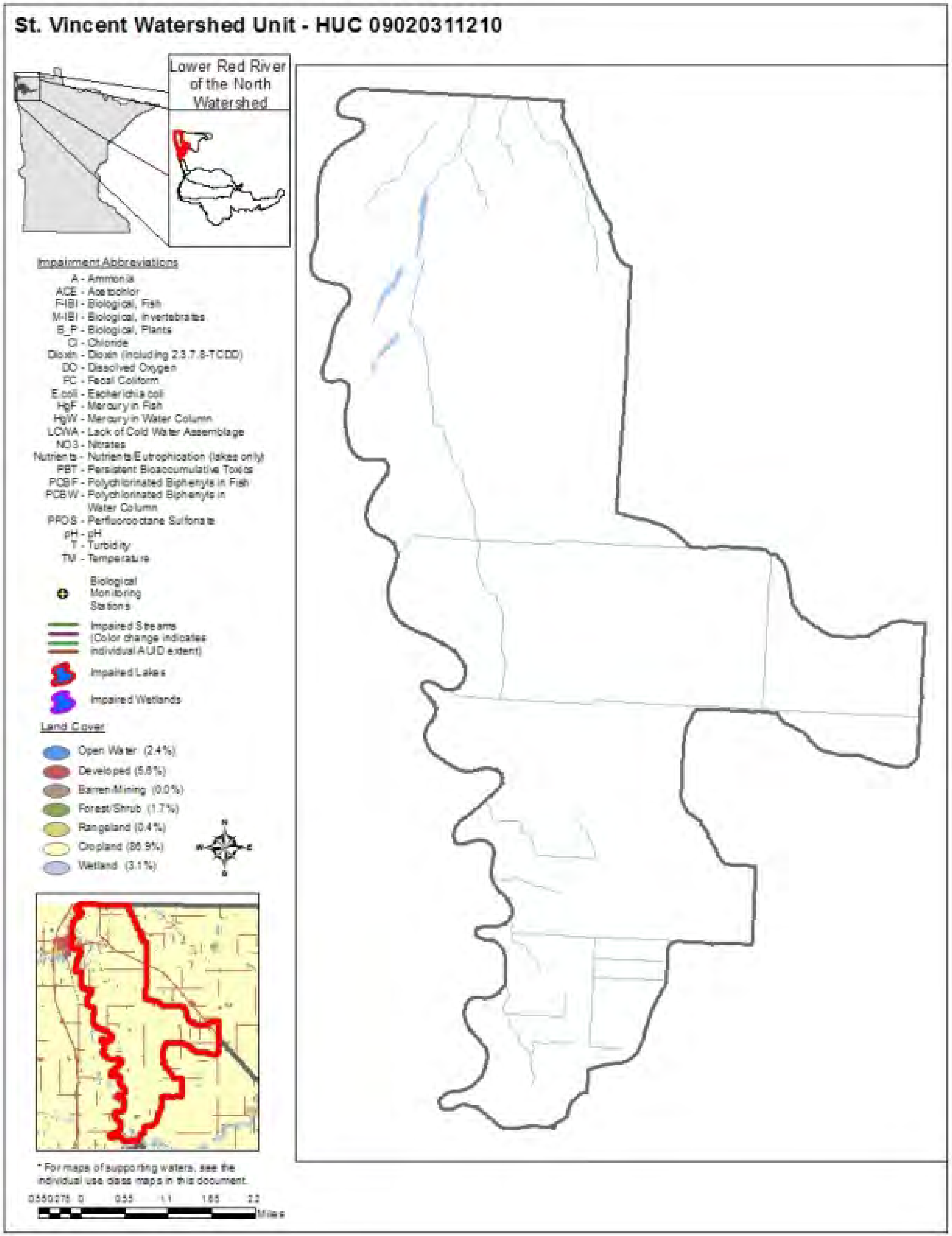

Figure 15. Currently listed impaired waters by parameters and land use characteristics in the St. Vincent Watershed Unit

Joe River Watershed Unit HUC 09020311220

The Joe River Watershed is the fourth largest watershed in the Lower Red River of the North drainage, encompassing 74.21 square miles in Kittson County. The Joe River begins in the northwest corner of Minnesota and crosses the United States/Canada border where it enters the Red River approximately 2.5 miles into Canada. The headwaters of the Joe River along with the other small headwater streams in the watershed have been channelized throughout most of their length. The watershed contains the small town of Humboldt. Land use in this watershed is a mixture of cropland (88.55 percent), developed (4.86 percent), wetlands (1.08 percent), rangeland (3.61 percent), forest/shrub (1.28 percent), and open water (0.62 percent). As such, there are few point sources (e.g., waste water treatment facilities) and many non-point (e.g., row crops, housing developments) pollution sources. Biological monitoring station 93RD400 represents the outlet of this subwatershed.

Stream Assessment

Table 12. Aquatic life and recreation assessment on stream reaches in the Joe River Watershed. Reaches are organized upstream to downstream in the table.

AUID *Reach Name*, Reach Description	Reach Length (miles)	Use Class	Biological Station ID	Location of Biological Station	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	Aquatic Life	Aquatic Rec.
09020311-513, Joe River, Salt Coulee to MN/Canada border	3.31	2C	--	--	--	--	IF	--	EX	MTS	MTS	--	IF	NS*	IF

Abbreviations for Indicator Evaluations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **MTS** = Meets criteria; **EXP** = Exceeds criteria, potential impairment; **EXS** = Exceeds criteria, potential severe impairment; **EX** = Exceeds criteria (Bacteria).

Abbreviations for Use Support Determinations: **NA** = Not Assessed, **IF** = Insufficient Information, **NS** = Non-Support, **FS** = Full Support

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

*Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.

†Reach was assessed based on use class included in table and existing use class as defined in Minn. Rule 7050 is different. The MPCA is currently in the process of changing the existing use class for this AUID in rule based on an analysis of the biological community and temperature data.

Table 13. Non-assessed biological stations on channelized AUIDs in the Joe River 11 Digit HUC

AUID ***Reach Name,*** *Reach Description*	Reach Length (miles)	Use Class	Biological Station ID	Location of Biological Station	Fish IBI	Invert IBI
09020311-513, ***Joe River,*** *Salt Coulee to MN/Canada border*	3.31	2C	93RD400	CR 16/intersection, 4 mi ENE St. Vincent	Poor	Poor

Table 14. Non-assessed biological stations on channelized AUIDs in the Joe River 11 Digit HUC

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	93RD400	Joe River	0	12	4	2	7	25	Poor
Average Habitat Results: *Joe River 11 HUC*			**0**	**12**	**4**	**2**	**7**	**25**	Poor

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

Table 15. Outlet water chemistry results for the Joe River 11 HUC

Station location:	Joe River at CSAH-16, 5 mi NE of St. Vincent										
Equis ID:	S002-359										
Station #:	93RD400										
Parameter	D.O.	E. Coli	NH_3	$NO_2 + NO_3$	TKN	pH	TP	TSS	TSVS	Spec. cond.	Temp.	T-tube
Units	mg/l		mg/l	mg/l	mg/L		mg/l	mg/l	mg/L	uS/cm	C	cm
# Samples	14	15	6	6	6	15	6	6		15	15	15
Minimum	7.24	1	6	6	6	7.74	0.041	1		813	10.02	28
Maximum	12.01	410.6	0.003	0.020	1.24	9.12	0.101	15		2487	24.57	>60
Mean	9.83	66.01	0.087	0.160	1.66	8.35	0.076	3.67		1676.80	18.07	57.87
Median	10.17	20.1	0.028	0.043	1.43	8.49	0.080	1.5		1504	19.32	60
WQ standard[1]	5.0	126/1260	0 .04			6.5 - 9.0		100				20
# WQ exceedances[2]	0/14	0/15	2/6	1/6	0/6	1/15	0/6	0/6	0/0	15/15	0/15	0/15
RRV 75th Percentile[3]			0.02	0.1	1.09-1.70	8.4	0.33	74		630	25	

[1]Total suspended solids and Transparency tube standards are surrogate standards derived from the turbidity standard of 25

[2]Represents exceedances of individual maximum standard for *E. coli* (1260/100ml) or fecal coliform.

[3]Based on 1970-1992 summer data; see *Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions* (McCollor and Heiskary 1993).

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Joe River 11 HUC, a component of the IWM work conducted in 2008 and 2009. This specific data does not necessarily reflect all data that was used to assess the AUID.**

Summary

There was one site (93RD400) sampled for water chemistry, biology, and habitat in the Joe River Watershed. The assessment was deferred until the development of TALU. However, the fish and invertebrate results suggest that aquatic communities are doing quite poorly in this system. Fish sampling yielded a single individual, a small northern pike, and an invertebrate community that was heavily dominated by tolerant worms and snails. The poor biological results are associated with exceptionally poor in-stream habitat. The substrate was composed of fine silts, a lack of pools and riffles, and aquatic vegetation that was characterized as choking (i.e. so pervasive that it has become a problem rather than a benefit to aquatic communities).

The intense plant growth suggests a problem with excessive nutrients; however, nutrient concentrations from six samples collected during the spring and summer indicate that concentrations of phosphorus and nitrogen (NO_2/NO_3) were within ecoregion norms. Conductivity was the only water chemistry parameter consistently above ecoregion norms during the summers of 2008/2009 although past monitoring results have identified chloride levels as excessive as well.

The low gradient nature of the Joe River may be a contributing factor to the poor monitoring results. A lack of flow during the summer months, combined with relatively clear water and fine organic substrate material, provides a rich environment for plants to thrive. The lack of flow also prohibits the formation, or the natural reclamation, of stream habitat heterogeneity (i.e. riffles and pools).

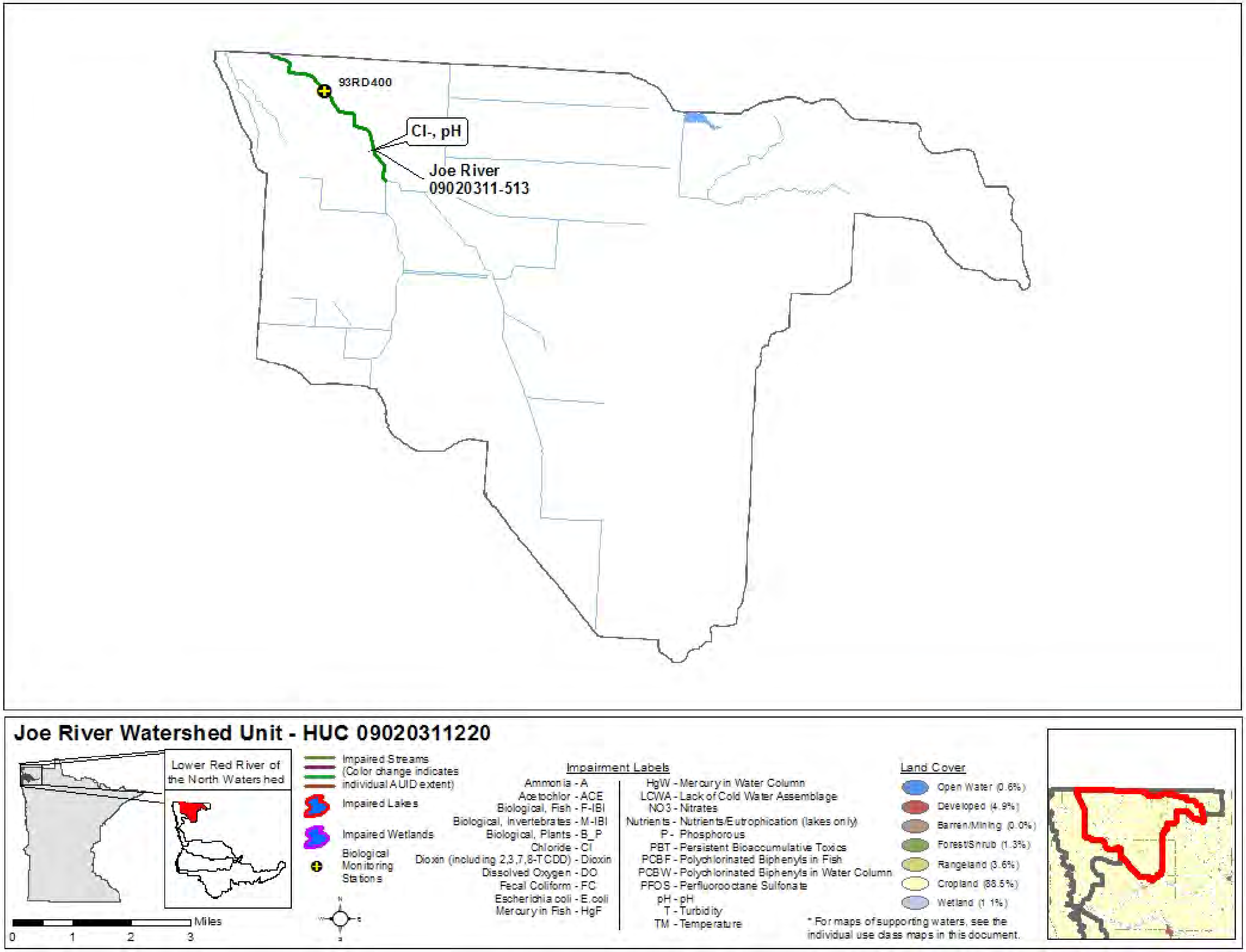

Figure 16. Currently listed impaired waters by parameters and land use characteristics in the Joe River Watershed Unit

Dominion City Ditch Watershed Unit HUC 09020311230

The Dominion City Ditch Watershed Unit is the smallest watershed in the Lower Red River of the North drainage, encompassing 9.93 square miles in far northern Kittson County along the border of Minnesota and Canada. This watershed unit contains a few small sections of ditch and is primarily agricultural land. This watershed is located about nine miles north of the city of Lancaster. Land use in this portion of the watershed is a mixture of cropland (82.33 percent), developed (4.21 percent), wetlands (3.77 percent), rangeland (4.05 percent), forest/shrub (4.58 percent), and open water (1.06 percent). As such, there are very few point sources (e.g., waste water treatment facilities) and many non-point (e.g., row crops, homesteads) pollution sources. There are no sampleable streams or lakes in this watershed.

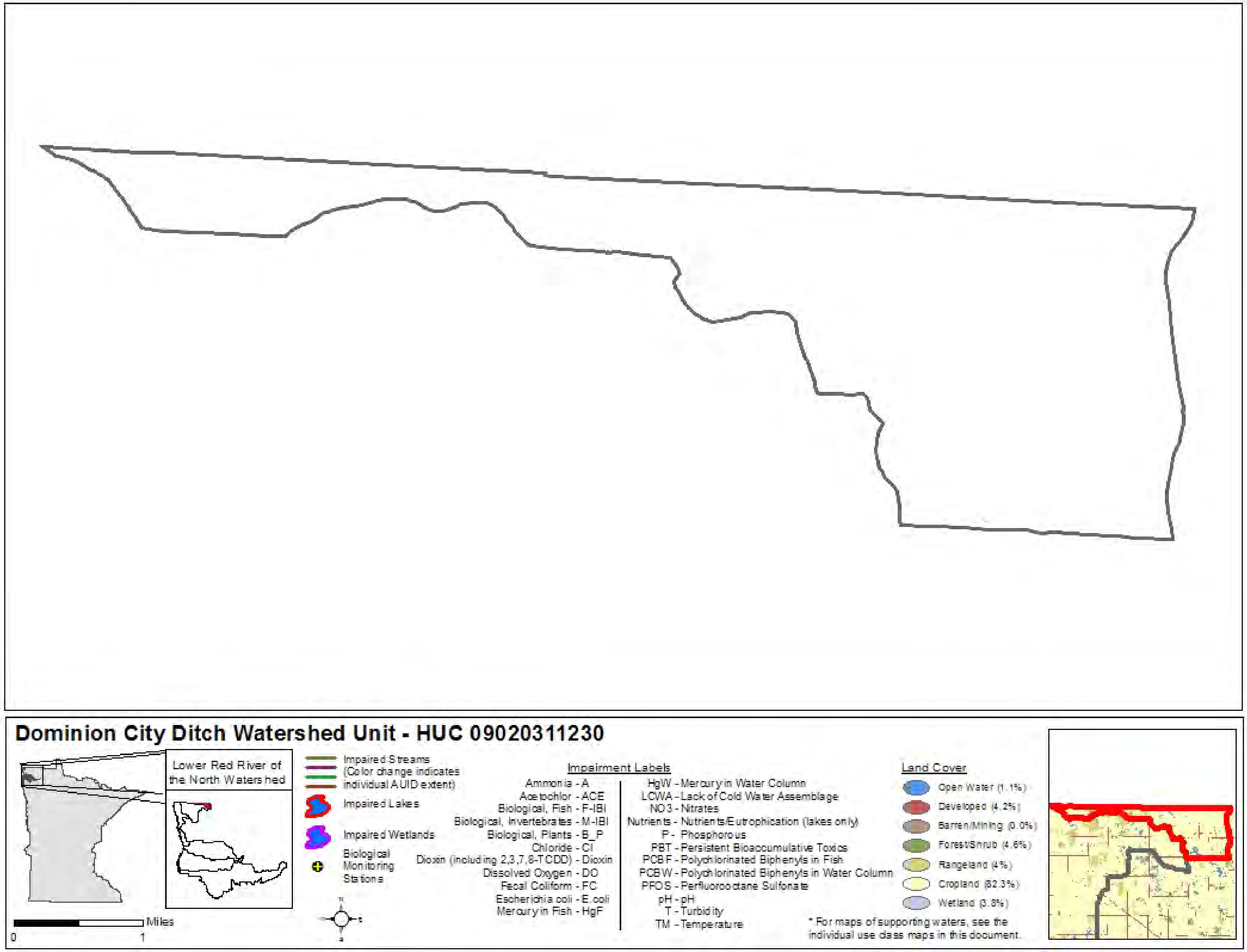

Figure 17. Currently listed impaired waters by parameters and land use characteristics in the Dominion City Ditch Watershed Unit

VII. Watershed wide results and discussion

Assessment results and data summaries for aquatic life and aquatic recreation are included below for the entire eight-digit HUC watershed unit of the Lower Red River of the North, grouped by sampling type. Summaries for aquatic consumption (fish contaminants) and load monitoring (flow weighted mean concentrations) are based on data collected near the mouth of the 11-digit HUC outlet of the Tamarac River. A series of graphics that provide an overall summary of assessment results by designated use, impaired waters, and waters that fully support beneficial uses within the entire Lower Red River of the North Watershed follows the results.

Pollutant load monitoring

Total Suspended Solids

Currently, the State of Minnesota does not have a river standard for Total Suspended Solids (TSS) but does have one for turbidity. Because turbidity is an optical measurement and not a measure of mass, TSS "surrogate" standards for turbidity were developed for ecoregions of the state and are applicable to water quality data collected within each respective ecoregion. TSS concentrations in the Tamarac River Watershed with greater than 10 percent of the samples at or above 60 mg/L are considered out of compliance with the turbidity standard of 25 Nephelometric Turbidity Units (NTUs) for waters within the Lake Agassiz Plain Ecoregion (Aquatic Life Water Quality Standards Draft Technical Support Document for TSS (Turbidity), Revised Draft, Markus, May 2011). In 2009, the percent of TSS samples that exceeded the 60 mg/L surrogate standard was 70 percent while the flow weighted mean concentration was 119 mg/L. In 2010, 91 percent of the samples collected exceeded the standard and the FWMC was 196 mg/L. Figure 18 shows all TSS FWMCs substantially above the standard of 60 mg/L.

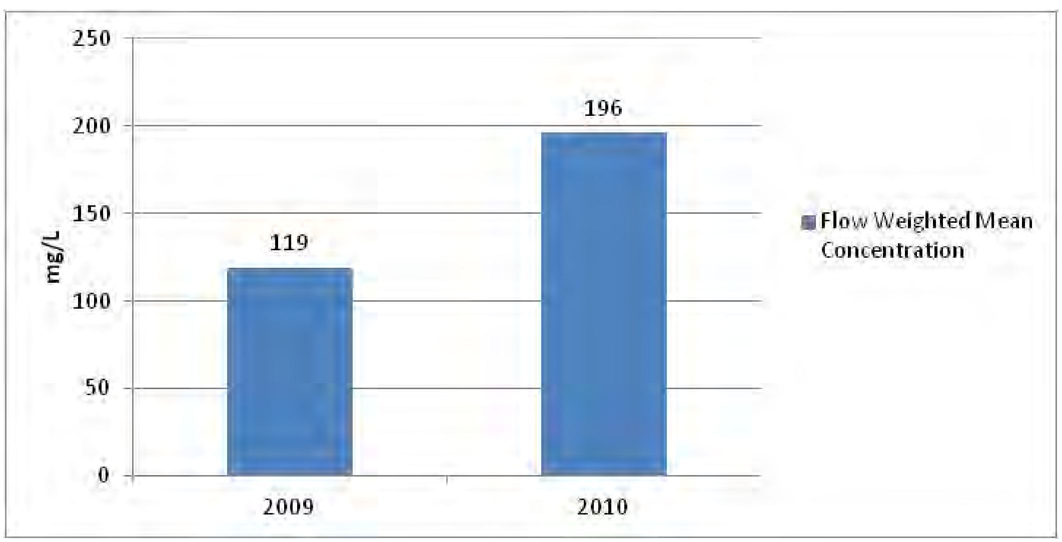

Figure 18. Total Suspended Solids (TSS) flow weighted mean concentrations for the Tamarac River near Robbin, Minnesota, 2009-2010

Total Phosphorus

Total phosphorus standards for Minnesota's rivers are currently moving from the "development phase" into the "approval phase". Many years of water quality data collected throughout Minnesota, combined with previous analysis of Minnesota's ecoregion patterns, resulted in the development of three "River Nutrient Regions" (RNR), each with unique standards. Of the state's three proposed RNR's, the Tamarac River load monitoring station is located within the South RNR which has a TP draft standard of 0.150 mg/L as a summer average. It must be noted that the TP standard is yet to be approved and this threshold must be considered draft until final approval. Summer average violations of one or more "response" variables (pH, biological oxygen demand (BOD), dissolved oxygen flux, chlorophyll-a) must also occur along with the TP numeric violation for the water to be listed. In 2009, the percent of TP samples that exceeded the 0.150 mg/L proposed standard was 27 percent, while the flow weighted mean concentration was 0.219 mg/L. In 2009, 75 percent of the samples collected exceeded the standard and the FWMC was 0.219 mg/L. In 2010, 47 percent of the samples collected exceeded the proposed standard and the FWMC was 0.263 mg/L. Figure 19 shows all TP FWMC's substantially above the draft standard.

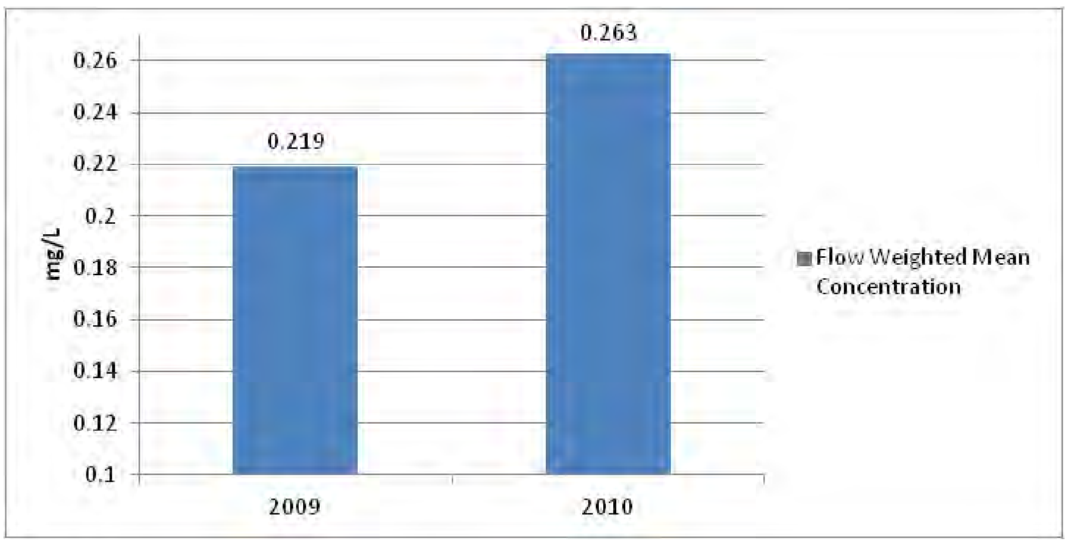

Figure 19. Total Phosphorus flow weighted mean concentrations for the Tamarac River near Robbin, Minnesota, 2009-2010

Dissolved Orthophosphate

Computation of DOP/ TP ratios from 2009 to 2010 show 53 to 54 percent of TP is in the orthophosphate form (see appendix 1).

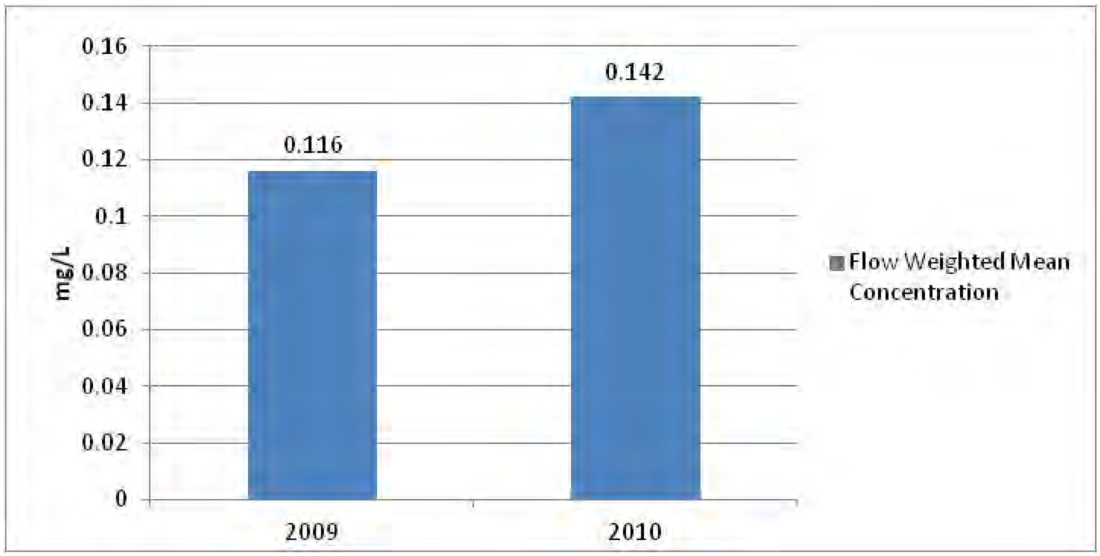

Figure 20. Dissolved Orthophosphate (DOP) flow weighted mean concentrations for the Tamarac River near Robbin, Minnesota 2009-2010

Nitrate plus Nitrite-Nitrogen

Currently nitrate-N standards are absent for Minnesota Rivers, but are in the "development phase". The draft acute nitrate-N value (maximum standard) is 41 mg/L for one-day duration, and the draft chronic value 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 (4-day duration) was determined for protection of class 2A surface waters. Observation of FWMCs of nitrate-nitrogen within the Tamarac River (Figure 21), show concentrations below the proposed acute and chronic nitrate-N standards.

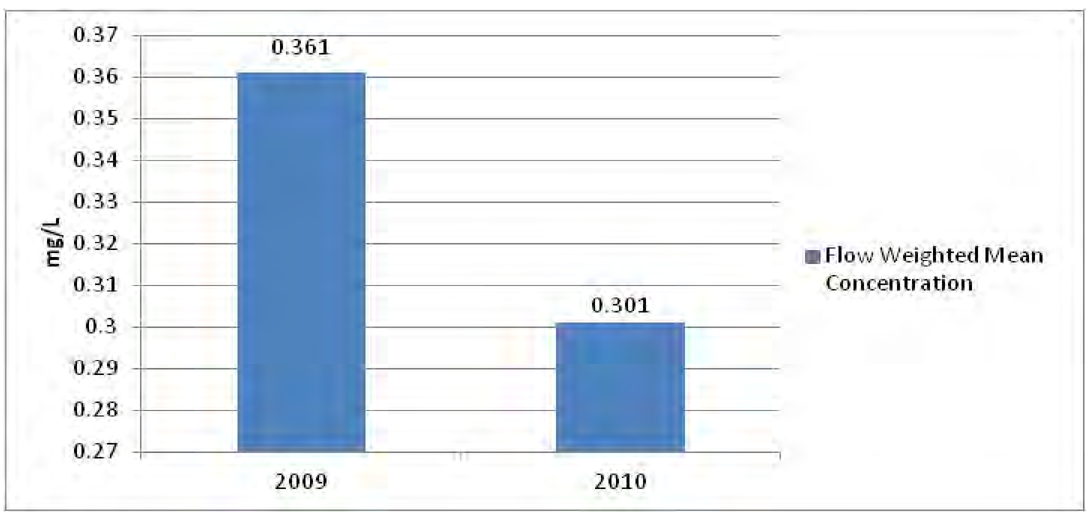

Figure 21. Nitrate-Nitrite Nitrogen (Nitrate-N) flow weighted mean concentrations for the Tamarac River near Robbin, Minnesota 2009-2010

Table 16. Annual pollutant loads by parameter calculated for the Tamarac River near Robbin, Minnesota 2009-2010

	2009		2010	
Parameter	**Mass (kg)**	**FWM (mg/L)**	**Mass (kg)**	**FWM (mg/L)**
Total Suspended Solids	23,158,050	119	29,217,977	196
Total Phosphorus	42,814	0.219	39,119	0.263
Ortho Phosphorus	22,706	0.116	21,206	0.142
Nitrate + Nitrite Nitrogen	70,429	0.361	44,793	0.301

Stream water quality

Overall, the lack of riparian cover found along many of the streams in the watershed, combined with the intensive agricultural land use and altered hydrology; contribute to poor water quality conditions. Throughout the watershed, the prevalence of naturally occurring fine silts and clays exacerbates sediment related problems related to overland runoff and stream bank scouring. As a result, many tributaries in the watershed have elevated TSS and turbidity levels. Insufficient information was collected assessing dissolved oxygen levels (DO). However, water quality criteria were meeting standards for the majority of the assessable AUIDs for chloride, pH, NH_3, pesticides, and bacteria. Judicial Ditch 19 (09020311-516) exceeded standards for bacteria and is considered a new impairment. Chloride was found to exceed the standard at one site on the Joe River (09020311-513).

Biological monitoring

Fish

Historically, it has been shown that 86 different species of fish occur in the Red River of the North basin. Although Minnesota's side of the Lower Red River of the North Watershed encompasses only a small proportion of the Red River of the North basin, 41 of these species were found during the sampling for this report. This watershed does not have any endangered fish species but it does have three species of special concern in Minnesota: *Acipenser fulvescens* (Lake Sturgeon), *Etheostoma microperca* (Least Darter), and *Notropis nubilus* (Pugnose Shiner). No known invasive fish or aquatic plant species are known to exist in this watershed, with the exception of the exotic *Cyprinus carpio* (Common Carp).

Some fish species occurred in high densities while other species had a more limited distribution and low numbers of individuals. The most ubiquitous and abundant fish species within the watershed was the *Pimephales promelas* (Fathead Minnow) which was sampled at every site, totaling 3,228 individuals. Other fish species commonly found throughout the watershed included *Catostomus commersonii* (White Sucker), *Esox lucius* (Northern Pike), *Culaea inconstans* (Brook Stickleback), and *Umbra limi* (Central Mudminnow). *Lepomis gibbosus* (Pumpkinseed), *Notropis percobromus* (Carmine Shiner), *Pomoxis nigromaculatus* (Black Crappie), and *Moxostoma anisurum* (Silver Redhorse) were sampled at only one station and totaled less than three individuals each. A complete list of the species sampled, how many stations each species was sampled at, and the total number of individuals can be found in appendix 6.1.

Macroinvertebrates

The macroinvertebrates sampled ranged from some with very low tolerance levels to high tolerance levels of pollutants or impairments. The most common habitats sampled for invertebrates were aquatic macrophytes and stream banks. Other habitats that were sampled included wood, riffles/rocks, and/or leaf packs.

Much like the fish sampling, the number and types of macroinvertebrates found was very site specific, perhaps due to localized impairments or flow related problems. Overall, 127 different families of macroinvertebrates were found throughout the watershed with the number of individuals in a family ranging from 26 to 7.9 million. The most commonly sampled invertebrates were from the Chironomidae family, commonly known as Chironomids or non-biting midges. In contrast, many macroinvertebrate families were represented by relatively few individuals (<50) such as the Arctiidae (Moths), Isotomidae (Springtails), Tanyderidae (Primitive Crane Flies), and Tetrastemmatidae families (Ribbon Worms). The species with the largest number of individuals found was the Hyalella azteca (amphipod crustacean), with 129,038 individuals. A general trend in this watershed shows that there are larger numbers of tolerant versus intolerant species. This is not surprising given the degraded habitat conditions found throughout the entire watershed. A complete summary of families sampled and the total number counted within that family can be found in appendix 6.2.

Watershed-wide

As suggested by our fish and macroinvertebrate data, biological communities throughout the Lower Red River of the North Watershed are in generally poor condition. Habitat, water chemistry, and flow may all play a role in limiting the biological community. Macroinvertebrate communities in particular tend to perform poorly, perhaps due to their relative lack of mobility.

Fish contaminants

A summary of the mercury and PCB concentrations by species (Table 1) shows mercury concentrations in four of the five fish exceeded the 0.2 mg/Kg threshold for impairment. The Tamarac River is not on the Impaired Waters Inventory for mercury in fish tissue. As noted in the methods, at least five fish of a given species is required to assess for impairment of aquatic consumption. Additional fish should be collected and analyzed for mercury from the Tamarac River, upstream and downstream of the Stephen Dam.

The Minnesota Department of Health has fish consumption advice for the river. Consumption advice can be based on one fish. Advice for sensitive populations (women who are or may become pregnant and children under age 15) is one meal per week for walleye and white sucker and one meal per month for northern pike and sauger.

The two PCB samples were below the detection limit; therefore, additional testing is not needed for PCBs. Composite samples of white sucker (n=5) and northern pike (n=4) were analyzed for PCBs in 1991 and were below the detection limit.

Table 17. Mercury and PCB concentrations in fish collected from Tamarac River in 2008

Waterway	AUID	Species	Length (in)	Mercury (mg/Kg)	PCBs (mg/Kg)
Tamarac River	09020311-503	Northern pike	12.6	0.276	NA
		Sauger	11.5	0.410	NA
		Sauger	13.0	0.558	< 0.025
		Walleye	10.9	0.205	NA
		White sucker	10.8	0.192	< 0.025

NA - not available

Stressor ID

The Lower Red River of the North Watershed is a system heavily influenced by soils, land use, and drainage intensity. With a smaller variety of conditions within the watershed, a narrower spectrum of fish and other aquatic life is to be expected. Several stressors in the Lower Red River of the North play an important role in limiting the health of these biological communities.

A loss of habitat due to channelization is one of the primary biological stressors within the Lower Red River of the North Watershed. A review of the Minnesota Stream Habitat Assessment finds that six of the 21 biological stations assessed had overall poor ratings, 14 had fair ratings and only one had a good rating. Typically, healthier fish communities reside in streams that have not been "maintained" or excavated at all or for a relatively long time. However, this is not often the case in the watershed. Instead, streams are typically cleaned out on a regular basis because they receive heavy sediment loads from in-stream and/or external sources. If a channelized stream is given time to recover and the watershed isn't contributing heavy sediment loads, they can recover biologically and sometimes contain good fish communities with high IBI scores.

Hydrologic modification within the Lower Red River of the North Watershed is also a primary stressor. With extensive ditching and an increase in the rate of tiling to promote drainage throughout the watershed, streams become hydrologically unstable or flashy, resulting in unstable stream channels. In these intensively drained systems, extreme flow events tend to erode the stream banks and beds during periods of heavy precipitation or runoff. Streams in this condition tend to contribute significant sediment loads downstream. Less than ideal conditions for most species are created with the loss of bank and bed habitat through sloughing, erosion, and deposition. Poor riparian land use practices contribute to stream destabilization by decreasing the stability of the banks and increasing sedimentation. Drought conditions in channelized streams are exacerbated because water moves through the system more quickly; resulting in an increased likelihood of very low flow events or in some cases completely dry channels. Sensitive members of an aquatic community can be significantly impacted by the loss of base flow that results from intensive drainage during dry years when stream temperatures and flow rates can vary dramatically.

Overall, runoff from agricultural fields can play an important role in degradation of biological communities within a watershed. Hundreds of tons of sediment are washed off fields and into watercourses during spring runoff and summer storms every year. In the best of conditions erosion is minimal when sufficient vegetation is in place in the form of grassed waterways, riparian buffers and/or other conservation practices. In contrast, where the vegetative buffers are poor or not present, significant erosion can occur and can form blowouts, gullies, and head cuts.

First order streams in particular can be a significant source of nutrients and sediment to an entire watershed. Most of the first order streams are intermittent and may be farmed through or cultivated and planted each season into row crops. During spring melt and summer storm events (of sufficient intensity), these streams collect flow and discharge downstream carrying sediment and nutrients into the receiving ditch and stream system. By restoring these streams with native vegetation buffers, these systems can stabilize and retain the sediment and pollutants that would otherwise be transported downstream each year. The cumulative effect of restoring first order streams could be significant in terms of nutrient and sediment reduction.

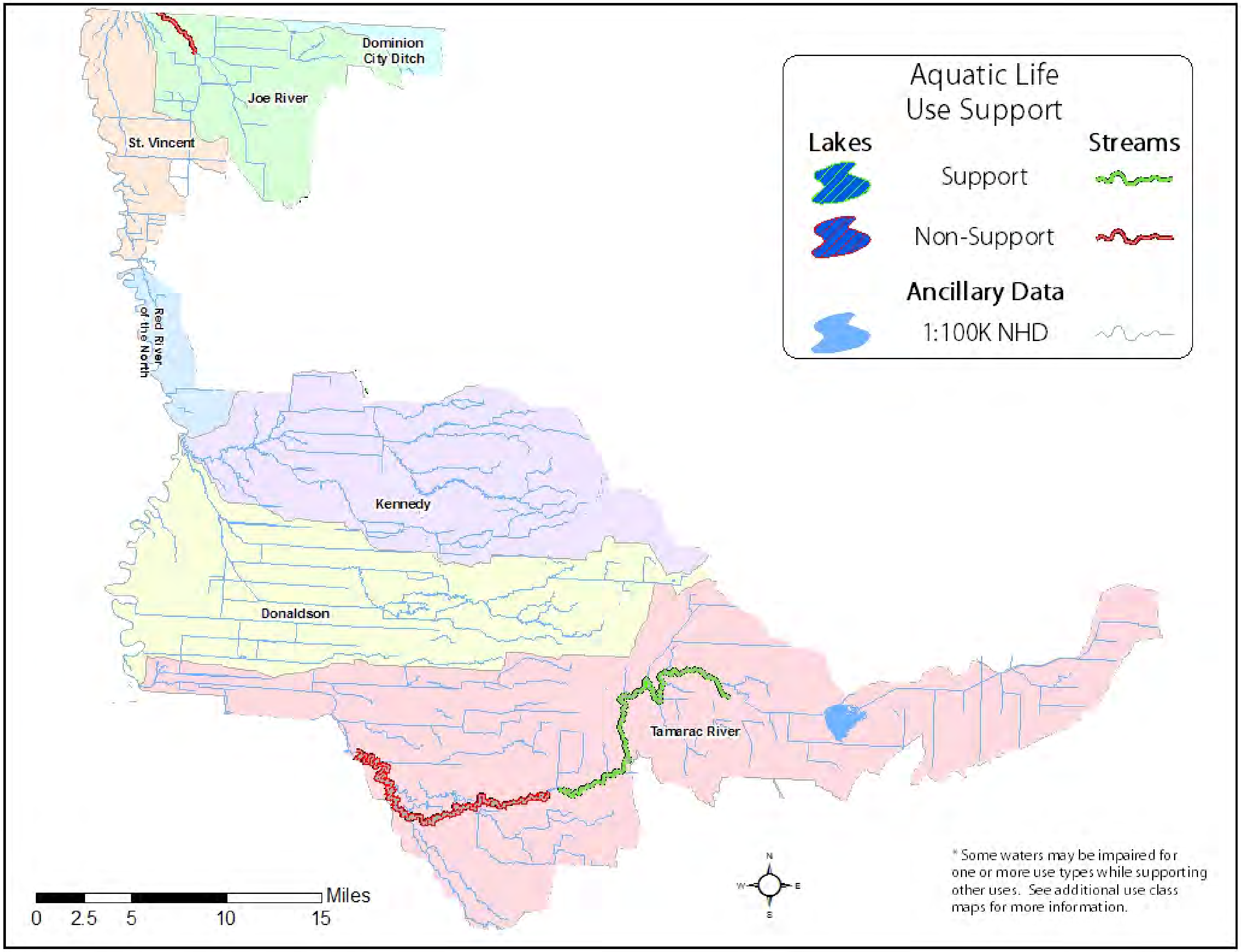

Figure 22. Aquatic life use support in the Lower Red River of the North Watershed

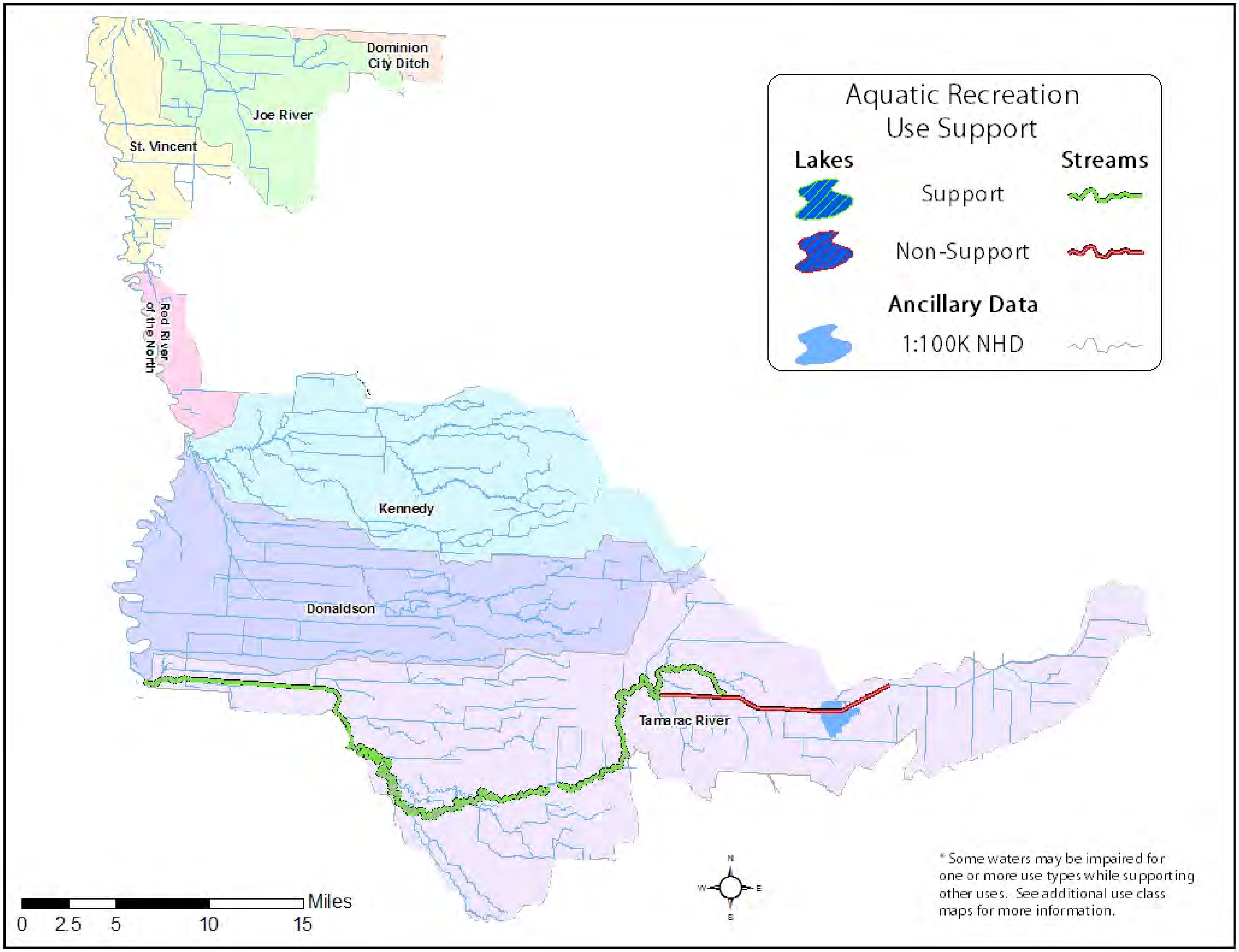

Figure 23. Aquatic recreation use support in the Lower Red River of the North Watershed

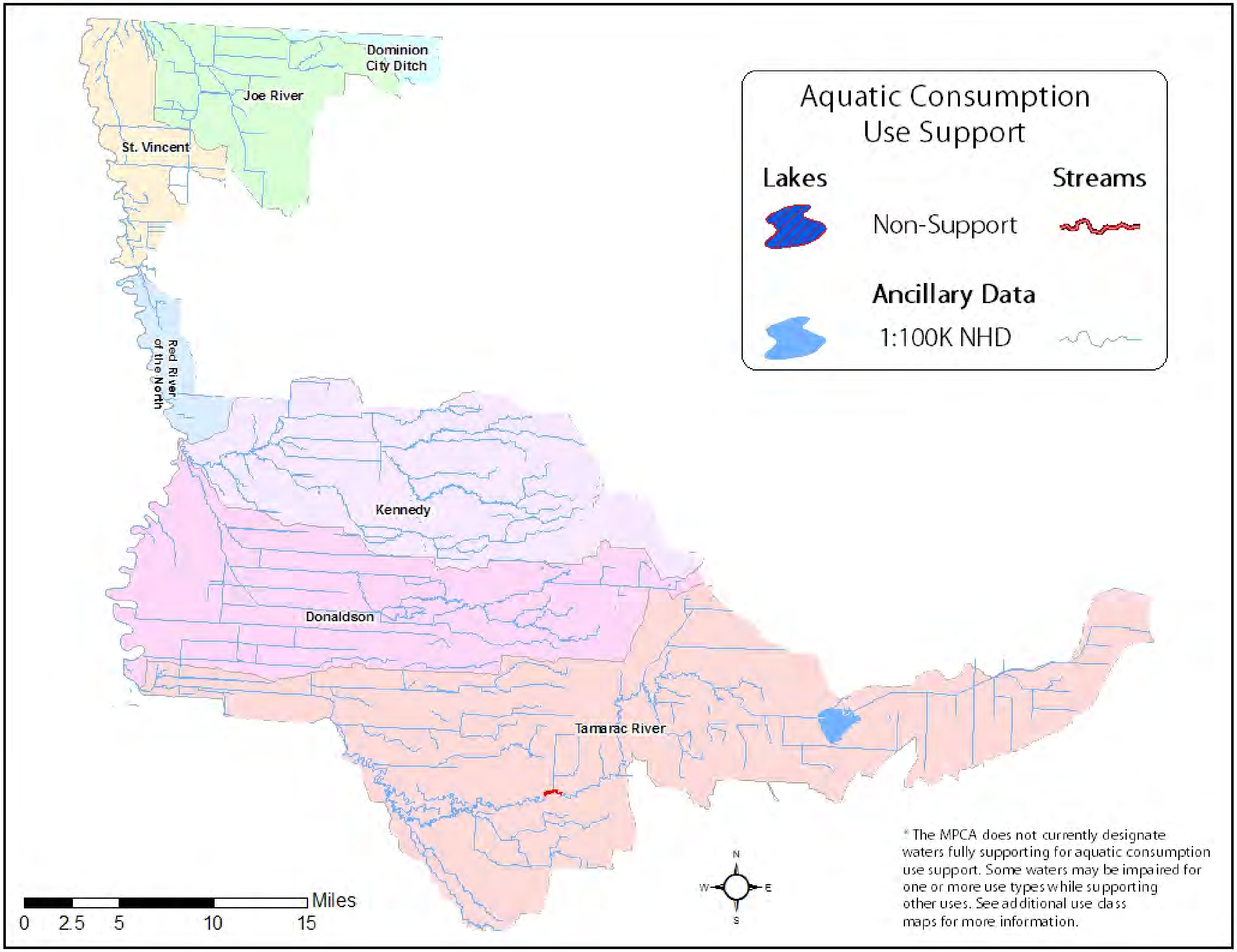

Figure 24. Aquatic consumption use support in the Lower Red River of the North Watershed

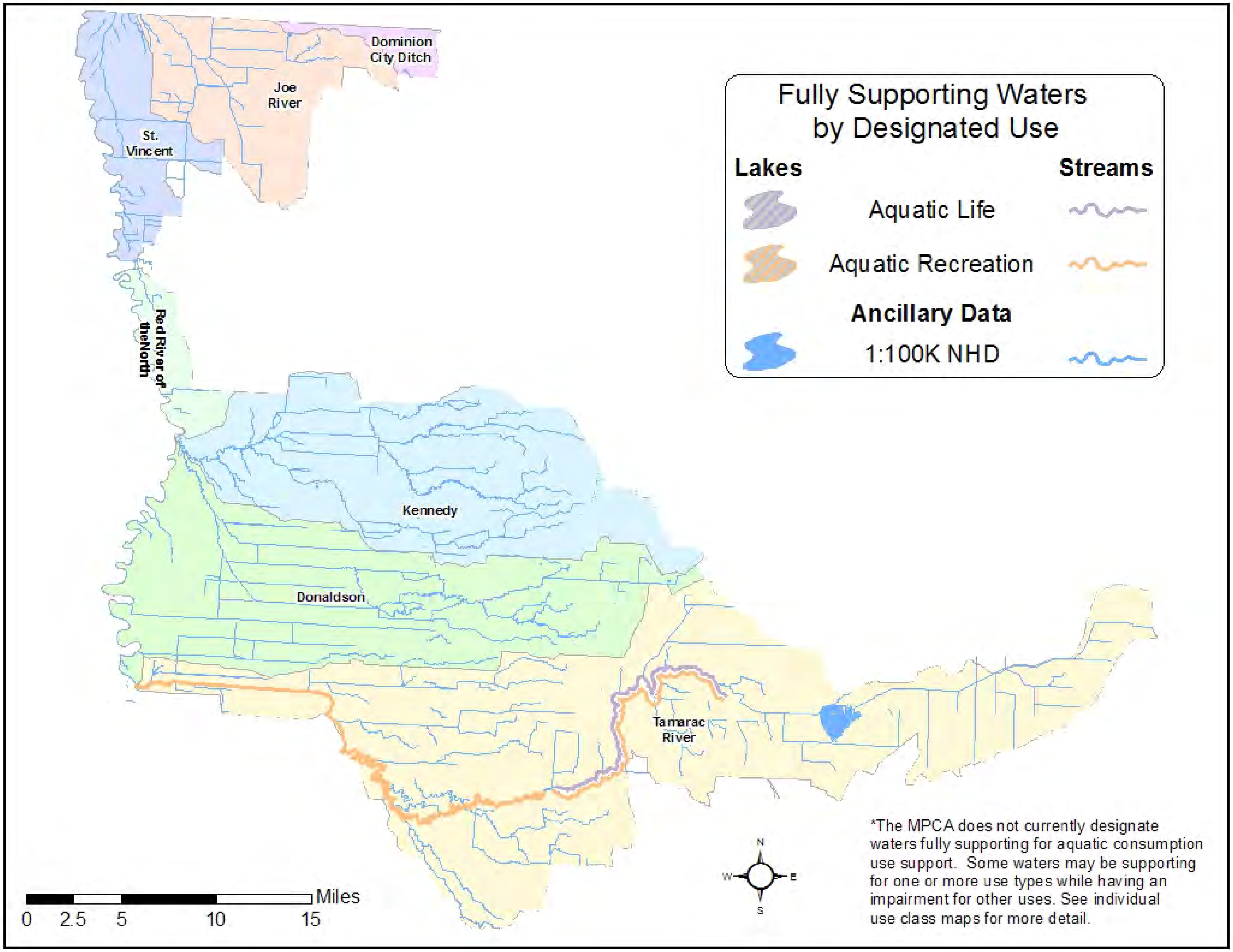

Figure 25. Fully supporting waters by designated use in the Lower Red River of the North Watershed

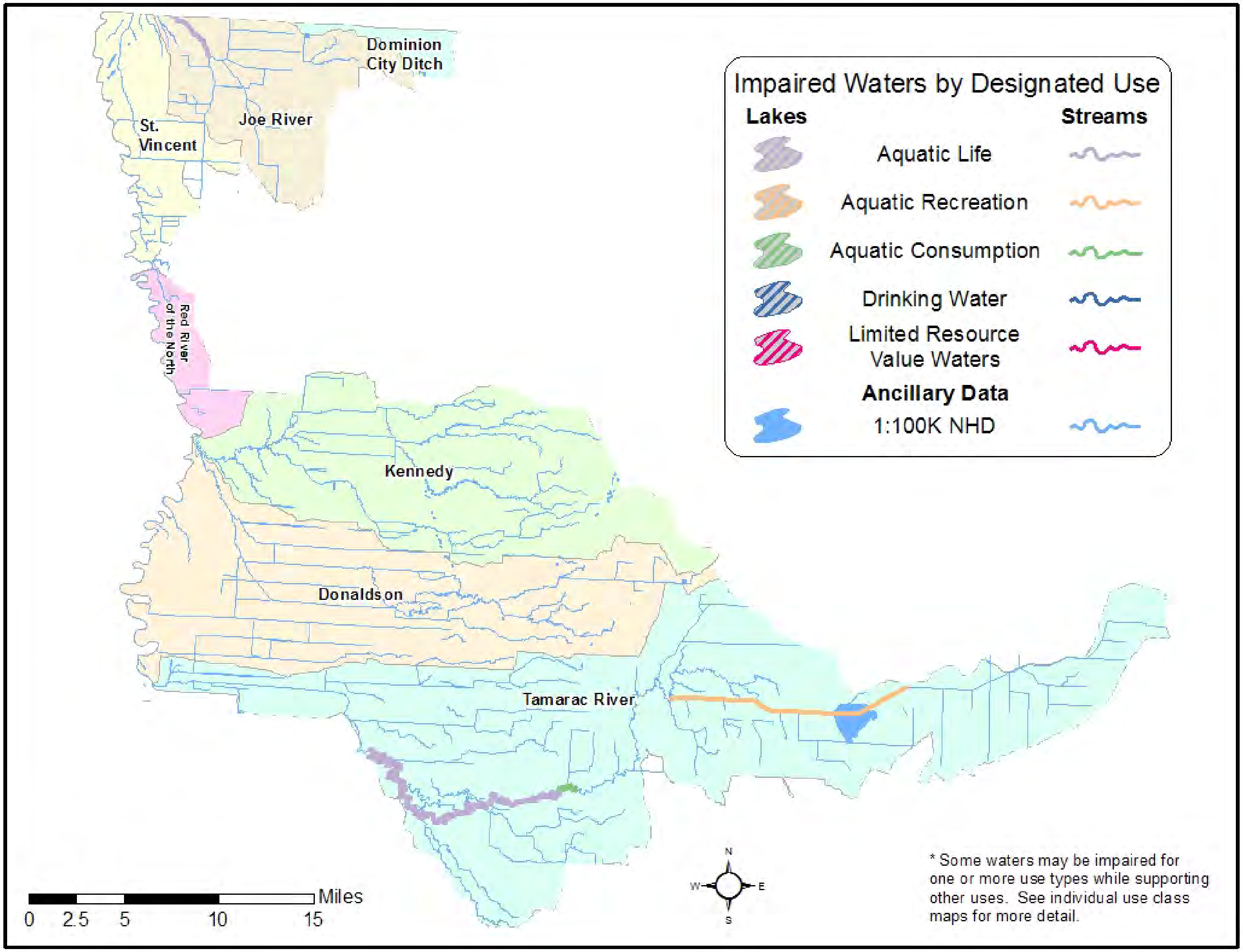

Figure 26. Impaired waters by designated use in the Lower Red River of the North Watershed

VIII. Summaries and Recommendations

The Lower Red River of the North once known for its vast tall grass prairie and wetlands has seen a widespread conversion into agricultural lands throughout the last century. The prevailing land use is agriculture with 95 percent of the land within the watershed being in private ownership (NRCS 2011). Many of the streams in the watershed have become destabilized due to the high degree of channelization and agricultural drainage in the watershed combined with inadequate riparian buffers. As a consequence, dramatic fluctuations of water levels have resulted in higher peak flows and lower base flows. This instability causes significant bank erosion and high rates of sedimentation during wet periods and insufficient flows during dry periods, a combination of conditions that places a significant stress on aquatic communities.

Due primarily to the low flow conditions during the sampling period, only 21 sites (15 AUIDs) out of 44 were sampled for biology. Of those 15 AUIDs, only two were assessed, the majority of biological assessments being deferred because of channelization. One AUID was found to be impaired for support of biology and the other was fully supportive. Various water chemistry parameters, used to assess aquatic life, also suggested problems. The Tamarac River and County Ditch 27 (09020311-505 and 09020311-509) were found to be impaired due to high turbidity. Other water chemistry indicators such as chloride, pH, pesticides, and NH3 all met their respective thresholds for the majority of the AUIDs. However, the Joe River had a previous impairment for chloride which, when elevated, can inhibit plant growth, impair reproduction, and reduce the diversity of organisms in a river. Dissolved oxygen (DO) was not assessed at any of AUIDs due to insufficient information. Regarding aquatic recreation, three of the AUIDs supported aquatic recreation and one was non-supportive (Judicial Ditch 19, 09020311-516).

Habitat throughout the watershed was generally observed to be in poor condition and the MSHA scores supported those findings. Even though quality habitat may exist in a few isolated areas throughout the watershed, it is likely that the generally poor habitat combined with flow instability throughout the majority of the watershed may negate the positive influences those areas may have. It is likely that the higher IBI scores sometimes found in the larger streams may be due to the year round flows that may provide a degree of stability and may offset the negative influence of poor habitat.

While improvements have been made to the water quality of the Lower Red River of the North Watershed over the last thirty years with regards to point source discharges, many of its waterbodies struggle to attain water quality standards. With the high volumes of suspended sediment and nutrients throughout the watershed, it is not only important to note the possible negative influence they may have on the river's aesthetic and recreational value, but also on its adjoining downstream waters and the biological communities that reside there. In order to see measureable improvements in water quality, actions must be taken to address non-point source pollution across the watershed. Because stream habitat has such a profound effect on aquatic life, steps should be taken to minimize habitat loss, possibly by reducing and/or limiting the amount of channelization, drainage, and tiling occurring within the watershed. An effort to reduce the amount of runoff from agricultural fields, pastures, and residential area would also be beneficial to water quality.

Due to the large amount of private land within this watershed, it will be very difficult to improve surface water resources without landowner participation. A strong effort to involve landowners, citizens, and natural resource managers is needed to find solutions for the widespread problems that exist within this watershed. Perhaps by working with landowners to target BMPs and improve conditions along riparian corridors, significant water quality improvements can be attained. Protection strategies should be developed to protect remaining forested areas and natural landscapes throughout the watershed. Protection efforts should focus on the few areas where aquatic biological diversity appears to be marginally better. The continued efforts to monitor, evaluate, and document declining or improving conditions is needed to focus efforts and improve water quality where it is needed most.

Additional monitoring should include investigating the extent of existing and new impairments and the effects of BMP implementation. Studies to identify the potential of dam retrofitting or removal to improve stream connectivity, and to examine the effects of groundwater withdrawal in areas of the watershed where there is a strong interaction between surface and groundwater could be beneficial. More targeted stream chemistry monitoring is needed in areas where sufficient data for assessment is lacking to determine the extent of the chemical impairments and the identification of pollution sources.

A watershed wide TMDL and Watershed Restoration and Protection Strategy (WRAPS) are anticipated to begin in 2014. The TMDL will focus primarily on the ongoing turbidity and bacteria impairments within the watershed. With a large proportion (79 percent) of the watershed in agricultural production, the TMDL study will focus on the reduction of runoff to waterways.

IX. Literature Cited

Groshens, T. G. 2007. Red River Basin Stream Survey Report: Snake River and Tamarac River Watersheds 2006. Minnesota Department of Natural Resources (MNDNR).75 p.

Krenz, G. and J. Leitch. 1993. A River Runs North: Managing an International River. Red River Water Resources Council. 174 p.

Marschner, F. J. 1975. The Original Vegetation of Minnesota (map). U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station, St. Paul, MN.

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 Natural Resources (MNDNR). 2007. Watershed (WAT) Mapbooks: Red River - Tamarac River (69). Lower Red (09020311). http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/wsmb69.pdf

Minnesota Department of Natural Resources (MNDNR).2011. Ecological Classification Systems: Ecological Land Classification Hierarchy. http://www.dnr.state.mn.us/ecs/index.html

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

Minnesota Pollution Control Agency (MPCA). 2007a. Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment 305(b) Report and 303(d) List. Environmental Outcomes Division, Minnesota Pollution Control Agency, St. Paul, Minnesota.

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

Minnesota Pollution Control Agency (MPCA). 2008a. 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). 2010. Guidance Manual for Assessing the Quality of Minnesota Surface Water for the Determination of Impairment: 305(b) Report and 303(d) List. Environmental Outcomes Division, Minnesota Pollution Control Agency, St. Paul, Minnesota.

National Resource Conservation Service (NRCS). 2007. Rapid Watershed Assessment: Lower Red (Minnesota)
09020311.NRCS.USDA.http://www.mn.nrcs.usda.gov/technical/rwa/Assessments/reports/lower_red.pdf

Robinson, E. B. 1966. History of North Dakota. University of Nebraska Press, Lincoln, Nebraska.

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

Topp, D. 2001. Special Stream Survey 2000: Tamarac River. Minnesota Department of Natural Resources (MDNR), Baudette, Minnesota.

USDA. 2006. Major Land Resource Regions Custom Report. USDA Agriculture Handbook 296. ftp://ftp-fc.sc.egov.usda.gov/NSSC/Ag_Handbook_296/Handbook_296_high.pdf

Waters, T.F. 1977. The Rivers and Streams of Minnesota. University of Minnesota Press, Minneapolis, Minnesota.

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

X. Appendix 1-Water Chemistry Definitions

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

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

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

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

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

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

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

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

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

Total Suspended Solids (TSS) – TSS and turbidity are highly correlated. Turbidity is a measure of the lack of transparency or "cloudiness" of water due to the presence of suspended and colloidal materials such as clay, silt, finely divided organic and inorganic matter and plankton or other microscopic organisms. The greater the level of TSS, the murkier the water appears and the higher the measured turbidity. Higher turbidity results in less light penetration which may harm beneficial aquatic species and may favor undesirable algae species. An overabundance of algae can lead to increases in turbidity, further compounding the problem.

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

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.

XI. Appendix 2-Intensive Watershed Monitoring Stations

Biological Station ID	STORET ID	Waterbody Name	Location	11-digit HUC
08RD001	S002-100	Tamarac River	Tamarac River at CSAH-220, 11 mi. W of Stephen	09020311170
08RD002	S004-875	Judicial Ditch 16	JD #16 at CSAH 23, 6.5 mi. SW of Kennedy	09020311180
08RD003	S004-876	Trib. to Red River	Unn str (Trib to Red River) at Unn Rd, 1.5 mi SW of Mattson	09020311190
NONE	NONE			09020311200
NONE	NONE			09020311210
93RD400	S002-359	Joe River	Joe River at CSAH-16, 5 mi NE of St. Vincent	09020311220
NONE	NONE			09020311230

XII. Appendix 3-AUID Table of Results (by parameter and beneficial use)

				USES				BIOLOGICAL CRITERIA		WATER QUALITY STANDARDS										ECOREGION EXPECTATIONS			
National Hydrography Dataset (NHD) Assessment Segment AUID	**Stream Segment Name**	**Segment Description**	**NHD Length (Miles)**	**Use Class**	**Aquatic Life**	**Aquatic Recreation**	**Aquatic Consumption**	**Fish**	**Macroinvertebrates**	**Acetochlor**	**Alachlor**	**Atrazine**	**Chloride**	**Bacteria (Aquatic Recreation)**	**Metolachlor**	**Dissolved Oxygen**	**pH**	**Turbidity**	**Un-ionized ammonia**	**Oxygen Demand (BOD)**	**Nitrite/Nitrate**	**Total Phosphorous**	**Suspended Solids**
HUC 11: 090203111170 (Tamarac River)																							
09020311-503	Tamarac River	*Florian Park Reservoir to Stephen Dam*	36.41	2Bd	NS	FS		+	-				+	+		IF	+	-	+				
09020311-505	Tamarac River	*Stephen Dam to Red R*	15.86	2B	IF	FS		-	-				+	+		IF	+	-	+		+		
09020311-507	Red River of the North	*Park R (ND) to Tamarac R*	2.87	2Bd	NA	NA																	
09020311-510	Tamarac River	*Florian Park Reservoir (45-0119-00)*	0.77	2B	NA	NA																	
09020311-511	Tamarac River	*Headwaters to Florian Park Reservoir*	26.19	2Bd	FS	FS		+	+				+	+		IF	+	+	+		+		
09020311-516	Judicial Ditch 19	*Headwaters to Tamarac R*	12.92	2B	IF	NS							+	-		IF	+	+	+				
09020311-526	State Ditch 90	*Unnamed ditch to Lateral Ditch 5*	1.9	2B	NA	NA																	
09020311-527	Lateral Ditch 5	*Headwaters to State Ditch 90*	6.33	2B	NA	NA																	
09020311-528	State Ditch 90	*Lateral Ditch 5 to Tamarac R*	2.56	2B	IF	NA																	
09020311-529	County Ditch 16	Unnamed ditch to Tamarac R	3.21	2B	NA	NA																	

09020311-541	Judicial Ditch 19	*Unnamed ditch to Unnamed ditch*	3.76	2B	NA	NA																			
09020311-542	Judicial Ditch 19	*Unnamed ditch to Unnamed ditch*	0.56	2B	NA	NA																			
09020311-543	Judicial Ditch 19	*Unnamed ditch to Unnamed ditch*	1.14	2B	NA	NA																			
09020311-544	Judicial Ditch 19	*Unnamed ditch to Unnamed ditch*	1.05	2B	NA	NA																			
09020311-545	Judicial Ditch 19	*Unnamed ditch to Unnamed ditch*	1.53	2B	NA	NA																			
09020311-546	Judicial Ditch 19	*Unnamed ditch to Unnamed ditch*	2	2B	NA	NA																			
09020311-547	Unnamed creek	*Unnamed ditch to Tamarac R*	0.9	2B	NA	NA																			
09020311-548	Unnamed ditch	*Unnamed cr to Unnamed cr*	1.77	2B	NA	NA																			
HUC 11: 09020311180 (Donaldson)																									
09020311-502	Red River of the North	*Tamarac R to Drayton Dam*	16.5	2Bd	IF	NA			+	-				+			IF	+	-	+			+		
09020311-508	Red River of the North	*Drayton Dam to Unnamed cr*	12.18	2Bd	NA	NA																			
09020311-512	County Ditch 10	*Headwaters to Unnamed cr*	7.69	2B	NA	NA																			
09020311-518	County Ditch 10	*Unnamed cr to Unnamed cr*	4.44	2B	NA	NA																			
09020311-519	County Ditch 10	Unnamed cr to Unnamed cr	4.62	2B	NA	NA																			

09020311-520	Judicial Ditch 10	Unnamed cr to Unnamed cr	3.11	2B	NA	NA																			
09020311-521	Judicial Ditch 10	*Unnamed cr to CD 16*	7.94	2B	NA	NA																			
09020311-522	Judicial Ditch 10	CD 16 to CD 7	1.28	2B	NA	NA																			
09020311-523	Judicial Ditch 10	CD 7 to Unnamed ditch	0.3	2B	NA	NA																			
09020311-524	Judicial Ditch 10	Unnamed ditch to CD 19	2.43	2B	IF	IF										IF					+				
09020311-525	Judicial Ditch 10	CD 19 to Unnamed cr	5.21	2B	NA	NA																			
09020311-530	Judicial Ditch 10	JD 3 to Red R	5.06	2B	NA	NA																			
09020311-531	Judicial Ditch 3	Headwaters to JD 10	11.48	2B	NA	NA																			
09020311-532	Judicial Ditch 27	Headwaters to JD 8	10.29	2B	NA	NA																			
09020311-533	Judicial Ditch 8	JD 27 to Red R	2.1	2B	NA	NA																			
09020311-534	Judicial Ditch 8	CD 11 to JD 27	8.08	2B	NA	NA																			
09020311-540	Unnamed creek	Unnamed cr to CD 10	2.23	2B	NA	NA																			
HUC 11: 09020311190 (Kennedy)																									
09020311-514	Unnamed creek	*Headwaters to Unnamed cr*	1.42	2B	NA	NA								+											
09020311-535	Unnamed creek	Headwaters to Unnamed cr	5.45	2B	NA	NA																			
09020311-536	Unnamed creek	Unnamed cr to Unnamed cr	5.28	2B	NA	NA																			
09020311-537	Unnamed creek	Unnamed cr to State Ditch 1	3.94	2B	NA	NA																			
09020311-538	State Ditch 1	*Unnamed cr to Unnamed*	6.53	2B	NA	NA																			

		cr																							
09020311-539	Unnamed creek	Unnamed cr to Unnamed cr	1.86	2B	NA	NA																			
HUC 11: 09020311200 (Red River of the North)																									
09020311-506	Red River of the North	Unnamed cr to Two R	16.55	2Bd	NA	NA																			
09020311-509	Unnamed creek (County Ditch 27)	*Headwaters to Red R*	32.26	2B	IF	IF			-						IF		IF	+	-	+					
HUC 11: 09020311210 (St Vincent)																									
09020311-501	Red River of the North	*Pembina R (ND) to MN/Canada border*	3	2Bd	NA	IF								+	IF		IF	+					+		
09020311-504	Red River of the North	*Two R to Pembina R (ND)*	17.52	2Bd	NA	NA			+					+			NR	+	-	+			+		
HUC 11: 09020311220 (Joe River)																									
09020311-513	Joe River	*Salt Coulee to MN/Canada border*	3.31	2C	NS	IF								-	IF		IF	+		+					
09020311-515	Joe River	Headwaters to Salt Coulee	9.83	2C	NA	NA																			
09020311-517	Salt Coulee	Unnamed cr to Joe R	1.62	2B	NA	NA																			
HUC 11: 09020311XXX (Various)																									
·	*Unassessed*	09020311-999	696.92	2B	NA	NA																			

XIII. Appendix 4.1-Minnesota Statewide IBI Thresholds and Confidence Limits

Class #	Class Name	Use Class	Threshold	Confidence Limit	Upper	Lower
Fish						
1	Southern Rivers	2B	46	±11	57	35
2	Southern Streams	2B	45	±9	54	36
3	Southern Headwaters	2B	51	±7	58	44
4	Northern Rivers	2B	35	±9	44	26
5	Northern Streams	2B	50	±9	59	41
6	Northern Headwaters	2B	40	±16	56	24
7	Low Gradient	2B	40	±10	50	30
10	Southern Coldwater	2A	45	±13	58	32
11	Northern Coldwater	2A	37	±10	47	27
Invertebrates						
1	Northern Forest Rivers	2B	43	±10.8	53.8	32.2
2	Prairie Forest Rivers	2B	30.7	±10.8	41.5	19.9
3	Northern Forest Streams RR	2B	50.3	±12.6	62.9	37.7
4	Northern Forest Streams GP	2B	52.4	±13.6	66	38.8
5	Southern Streams RR	2B	35.9	±12.6	48.5	23.3
6	Southern Forest Streams GP	2B	46.8	±13.6	60.4	33.2
7	Prairie Streams GP	2B	38.3	±13.6	51.9	24.7
8	Northern Coldwater Streams	2A	26	±12.4	38.4	13.6
9	Southern Coldwater Streams	2A	46.1	±13.8	59.9	32.3

XIV. Appendix 4.2-Biological Monitoring Results-Fish IBI

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: 09020311170 (Tamarac River Watershed)							
09020311-503	05RD179	Tamarac River	229.90	2	45	42	28-Jun-06
09020311-503	05RD042	Tamarac River	199.56	2	45	51	29-Jun-06
09020311-503	05RD179	Tamarac River	229.90	2	45	49	08-Aug-06
09020311-503	08RD015	Tamarac River	198.00	2	45	44	16-Jul-08
09020311-503	08RD007	Tamarac River	234.61	2	45	34	03-Sep-08
09020311-503	08RD031	Tamarac River	281.71	2	45	30	03-Sep-08
09020311-505	08RD001	Tamarac River	356.67	1	46	52	09-Sep-08
09020311-511	08RD042	Tamarac River	168.81	5	50	51	15-Jul-08
HUC 11: 09020311180 (Donaldson Watershed)							
09020311-502	06RD007	Red River of the North	30410.44	1	46	74	18-Sep-06
HUC 11: 09020311190 (Kennedy Watershed)							
09020311-509	08RD003	Trib. to Red River	165.81	2	45	0	17-Jul-08
09020311-509	08RD003	Trib. to Red River	165.81	2	45	36	04-Sep-08
HUC 11: 09020311210 (St Vincent Watershed)							
09020311-504	06RD008	Red River of the North	32129.77	1	46	49	19-Sep-06

*** Channelized site assessed for biology in 2006, utilizing Upper Mississippi Basin IBI prior to the adoption of policy decisions to defer assessments on channelized streams until after the adoption of Tiered Aquatic Life Uses.**

XV. Appendix 4.3-Biological Monitoring Results-Macroinvertebrate IBI

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Invert Class	Threshold	MIBI	Visit Date
HUC 11: 09020311170 (Tamarac River Watershed)							
09020311-503	05RD042	Tamarac River	199.56	7	38.3	71.15	29-Sep-05
09020311-503	05RD179	Tamarac River	229.90	7	38.3	33.82	16-Aug-06
09020311-503	08RD015	Tamarac River	198.00	7	38.3	33.46	10-Sep-08
09020311-503	08RD007	Tamarac River	234.61	7	38.3	20.99	10-Sep-08
09020311-503	08RD031	Tamarac River	281.71	7	38.3	26.23	11-Sep-08
09020311-505	08RD001	Tamarac River	356.67	7	38.3	23.58	08-Sep-08
09020311-511	08RD042	Tamarac River	168.81	5	35.9	71.79	09-Sep-08
HUC 11: 09020311180 (Donaldson Watershed)							
09020311-502	06RD007	Red River of the North	30410.44	2	30.7	8.80	16-Aug-06

*** Channelized site assessed for biology in 2006, utilizing Upper Mississippi Basin IBI prior to the adoption of policy decisions to defer assessments on channelized streams until after the adoption of Tiered Aquatic Life Uses.**

XVI. Appendix 5.1-Good/Fair/Poor Thresholds for Biological Stations on Non-Assessed Channelized AUIDs

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

Class #	Class Name	Good	Fair	Poor
Fish				
1	Southern Rivers	>45	45-31	<31
2	Southern Streams	>44	44-30	<30
3	Southern Headwaters	>50	50-36	<36
4	Northern Rivers	>34	34-20	<20
5	Northern Streams	>49	49-35	<35
6	Northern Headwaters	>39	39-25	<25
7	Low Gradient Streams	>39	39-25	<25
10	Southern Coldwater Streams	>44	44-30	<30
11	Northern Coldwater Streams	>36	36-21	<21
Invertebrates				
1	Northern Forest Rivers	>42	42-27	<27
2	Prairie Forest Rivers	>30.6	30.6-14.7	<14.7
3	Northern Forest Streams RR	>50.2	50.2-34.3	<34.3
4	Northern Forest Streams GP	>52.3	52.3-36.4	<36.4
5	Southern Streams RR	>35.8	35.8-20.9	<20.9
6	Southern Forest Streams GP	>46.7	46.7-30.8	<30.8
7	Prairie Streams GP	>38.2	38.2-22.3	<22.3
8	Northern Coldwater Streams	>25	25-14	<14
9	Southern Coldwater Streams	>46	46-30.1	<30.1

XVII. Appendix 5.2-channelized Stream AUID IBI Score Fish

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Fish Class	Good	Fair	Poor	FIBI	Visit Date
HUC 11: 09020311170 (Tamarac River Watershed)									
09020311-505	08RD024	Tamarac River	308.95	1	100 – 46	45-31	30 - 0	42	16-Jul-08
09020311-516	08RD014	Judicial Ditch 19	109.89	5	100 – 50	49-35	34 - 0	33	15-Jul-08
09020311-516	08RD014	Judicial Ditch 19	109.89	5	100 – 50	49-35	34 - 0	44	09-Sep-08
09020311-526	08RD010	State Ditch 90	5.07	7	100 – 40	39-25	24 - 0	56	04-Sep-08
09020311-527	08RD011	Lateral Ditch 5	7.06	6	100 – 40	39-25	24 - 0	78	17-Jun-08
09020311-527	08RD011	Lateral Ditch 5	7.06	6	100 – 40	39-25	24 - 0	48	02-Sep-08
09020311-541	08RD016	Judicial Ditch 19	15.02	6	100 – 40	39-25	24 - 0	38	17-Jul-08
09020311-545	08RD004	Judicial Ditch 19	45.75	6	100 – 40	39-25	24 - 0	40	17-Jun-08
HUC 11: 09020311180 (Donaldson Watershed)									
09020311-518	08RD036	County Ditch 10	18.81	7	100 – 40	39-25	24 - 0	44	17-Jun-08
09020311-521	08RD035	Judicial Ditch 10	61.76	2	100 – 45	44-30	29 - 0	0	16-Jul-08
09020311-521	08RD035	Judicial Ditch 10	61.76	2	100 – 45	44-30	29 - 0	0	03-Sep-08
09020311-524	08RD002	Judicial Ditch 16	100.08	2	100 – 45	44-30	29 - 0	0	15-Jul-08
09020311-540	08RD037	Trib. to County Ditch 10	19.19	7	100 – 40	39-25	24 - 0	41	16-Jul-08
HUC 11: 09020311190 (Kennedy Watershed)									
09020311-509	08RD027	County Ditch 27	57.39	2	100 – 45	44-30	29 - 0	0	16-Jul-08
09020311-509	08RD027	County Ditch 27	57.39	2	100 – 45	44-30	29 - 0	0	04-Sep-08
09020311-538	08RD023	State Ditch 1	53.37	2	100 – 45	44-30	29 - 0	30	16-Jun-08
HUC 11: 09020311220 (Joe River Watershed)									
09020311-513	93RD400	Joe River	101.91	2	100 – 45	44-30	29 - 0	0	14-Jul-08

XVIII. Appendix 5.3-Channelized Stream AUID IBI Score Macroinvertebrate

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Invert Class	Good	Fair	Poor	MIBI	Visit Date
HUC 11: 09020311170 (Tamarac River Watershed)									
09020311-505	08RD024	Tamarac River	308.95	7	100 – 38.2	38.2-22.3	22.2 - 0	23.88	11-Sep-08
09020311-516	08RD014	Judicial Ditch 19	109.89	7	100 – 38.2	38.2-22.3	22.2 - 0	69.92	10-Sep-08
09020311-526	08RD010	State Ditch 90	5.07	7	100 – 38.2	38.2-22.3	22.2 - 0	27.98	10-Sep-08
09020311-527	08RD011	Lateral Ditch 5	7.06	7	100 – 38.2	38.2-22.3	22.2 - 0	17.17	09-Sep-08
09020311-541	08RD016	Judicial Ditch 19	15.02	5	100 – 35.9	35.8-20.9	20.8 - 0	43.44	09-Sep-08
HUC 11: 09020311180 (Donaldson Watershed)									
09020311-521	08RD035	Judicial Ditch 10	61.76	7	100 – 38.2	38.2-22.3	22.2 - 0	22.60	11-Sep-08
09020311-521	08RD035	Judicial Ditch 10	61.76	7	100 – 38.2	38.2-22.3	22.2 - 0	15.77	11-Sep-08
09020311-524	08RD002	Judicial Ditch 16	100.08	7	100 – 38.2	38.2-22.3	22.2 - 0	10.53	11-Sep-08
09020311-540	08RD037	Trib. to County Ditch 10	19.19	7	100 – 38.2	38.2-22.3	22.2 - 0	25.91	10-Sep-08
HUC 11: 09020311190 (Kennedy Watershed)									
09020311-509	08RD027	Unnamed creek (County Ditch 27)	57.39	7	100 – 38.2	38.2-22.3	22.2 - 0	19.44	09-Sep-08
HUC 11: 09020311220 (Joe River Watershed)									
09020311-513	93RD400	Joe River	101.91	7	100 – 38.2	38.2-22.3	22.2 - 0	9.26	09-Sep-08

XIX. Appendix 6.1-Biological Monitoring Results-fish Species, Stations Collected at, and Total Number of Individuals Collected

Fish Species	Stations Collected At	Number of Individuals
Fathead Minnow	21	3228
White Sucker	13	1259
Northern Pike	13	31
Brook Stickleback	12	872
Central Mudminnow	12	290
Common Shiner	11	1330
Northern Redbelly Dace	11	1188
Creek Chub	10	1261
Blackside Darter	10	472
Finescale Dace	9	123
Johnny Darter	8	844
Brassy Minnow	8	137
Pearl Dace	7	420
Black Bullhead	7	93
Sand Shiner	6	458
Shorthead Redhorse	6	59
Spotfin Shiner	5	505
Sauger	5	29
Rock Bass	5	26
Common Carp	5	14
Blacknose Dace	4	85
Tadpole Madtom	4	10
Goldeye	3	64
Channel Catfish	3	10
Emerald Shiner	2	33
Iowa Darter	2	20

Fish Species	Stations Collected At	Number of Individuals
Quillback	2	8
Bigmouth Buffalo	2	5
Freshwater Drum	2	4
Walleye	2	4
White Bass	2	3
Trout-Perch	1	14
Silver Chub	1	6
Golden Redhorse	1	5
Hybrid Sunfish	1	5
Silver Redhorse	1	3
Hybrid Minnow	1	2
Black Crappie	1	1
Carmine Shiner	1	1
Gen: Notropis	1	1
Pumpkinseed	1	1

XX. Appendix 6.2-Biological Monitoring Results-Macroinvertebrate Families and Total Number of Individuals Collected

Family Name	Number of Individuals	Family Name	Number of Individuals	Family Name	Number of Individuals
Chironomidae	7961928	Drytiscidae	106834	Taeniopterygidae	23556
Baetidae	2277002	Limnephilidae	102700	Ephemeridae	23192
Hyalellidae	1940172	Ephemerellidae	101218	Gomphidae	20436
Hydropsychidae	1775540	Philopotamidae	99944	Psychomyiidae	16744
Physidae	1351402	Ceratopogonidae	90012	Capniidae	14482
Elmidae	1157390	Ephydridae	88400	Perlodidae	14482
Simuliidae	954876	Empididae	87958	Potamanthidae	14248
Caenidae	883792	Haliplidae	80418	Gyrinidae	14118
Heptageniidae	754312	Tipulidae	71318	Psychodidae	12948
Tricorythidae	497198	Pleidae	66742	Dryopidae	12714
Coenagrionidae	463736	Lepidostomatidae	54418	Pyralidae	11986
Gammaridae	459264	Polycentropodidae	50830	Gerridae	11778
Leptophlebiidae	442338	Perlidae	47658	Sialidae	11440
Pisidiidae	337064	Rhyacophilidae	46072	Scirtidae	11336
Planorbidae	261326	Glossosomatidae	45734	Pteronarcidae	11232
Ancylidae	257140	Isonychiidae	42692	Tabanidae	10660
Corixidae	244764	Culicidae	42432	Corduliidae	10452
Brachycentridae	236106	Valvatidae	41704	Sciomyzidae	10400
Leptoceridae	222300	Aeshnidae	39832	Leuctridae	9438
Hydroptilidae	203060	Athericidae	39780	Hydridae	9204
Lymnaeidae	176722	Hydrophilidae	36894	Viviperidae	8606
Bithyniidae	147602	Dixidae	35724	Stratiomyidae	7488
Hydrobiidae	146120	Cambaridae	30914	Corydalidae	7332
Asellidae	132262	Belostomatidae	30238	Veliidae	6630
Calopterygidae	126516	Phryganeidae	30186	Libellulidae	6318
Helicopsychidae	111878	Hydraenidae	23998	Baetiscidae	6162

Family Name	Number of Individuals	Family Name	Number of Individuals	Family Name	Number of Individuals
Muscidae	6110	Molannidae	1170	Lestidae	286
Dresissenidae	5694	Cordulegastridae	1144	Curculionidae	260
Unionidae	4862	Ptychopteridae	1118	Siphlonuridae	260
Notonectidae	4732	Chaoboridae	1066	Hydrometridae	208
Sphaeruisidae	4732	Goeridae	1040	Syrphidae	208
Nepidae	4394	Macromiidae	832	Saldidae	182
Crambidae	4316	Sericostomatidae	806	Macroveliidae	156
Crangonyctidae	4056	Metretopodidae	728	Noctuidae	156
Mesoveliidae	2964	Hebridae	702	Phoridae	130
Nemouridae	2652	Pleuroceridae	572	Truncatellidae	78
Polymitarcyidae	2600	Sisyridae	520	Arctiidae	26
Glossiphoniidae	2366	Chrysomelidae	442	Isotomidae	26
Corbiculidae	1638	Branchiobdellidae	416	Nepticulidae	26
Dolichopodidae	1638	Lampyridae	338	Tanyderidae	26
Leptohyphidae	1404	Aphididae	312	Tetrastemmatidae	26
Erpobdellidae	1352	Entomobryidae	286		
Psephenidae	1352	Hirudinidae	286		