Clearwater River Watershed Monitoring and Assessment Report

Minnesota Pollution Control Agency

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List of Acronyms

AUID Assessment Unit Identification Determination

CI Confidence Intervals

CLMP Citizen Lake Monitoring Program

CSMP Citizen Stream Monitoring Program

CWA Clean Water Act

DNR Minnesota Department of Natural Resources

DO Dissolved Oxygen

DTW Depth to Water

EQuIS Environmental Quality Information System

EPA U.S. Environmental Protection Agency

EQuIS Environmental Quality Information System

FIBI Fish Index of Biotic Integrity

HGM Hydrogeomorphically

HUC Hydrologic Unit Code

FIBI Fish Index of Biotic Integrity

IWM Intensive Watershed Monitoring

LRVW Limited Resource Value Water

MCES Metropolitan Council Environmental Services

MDA Minnesota Department of Agriculture

MDH Minnesota Department of Health

MIBI Macroinvertebrate Index of Biotic Integrity

MPCA Minnesota Pollution Control Agency

MSHA Minnesota Stream Habitat Assessment

NCHF North Central Hardwood and Forests Ecoregion

NHD National Hydrologic Dataset

NLF Northern Lakes and Forests Ecoregion

NMW Northern Minnesota Wetlands Ecoregion

SWAG Surface Water Assessment Grant

SWCD Soil and Water Conservation District

TKN TotalKjeldahl Nitrogen

TMDL Total Maximum Daily Load

TSS Total Suspended Solids

UAA Use Attainability Analysis

USGS United states Geological Survey

WIMN What's in My Neighborhood?

WPLMN Watershed Pollutant Load Monitoring Network

Executive summary

The Clearwater River Watershed covers 886,600 acres (1,384 square miles) of northwestern Minnesota. About one third of the watershed lies within the Lake Agassiz Plain Ecoregion – a flat area with fertile soils formed by Glacial Lake Agassiz. As a result, a substantial amount of land (33%) within the watershed is utilized for intensive row crop farming. Another 21% of the land is used for pasture and hay (rangeland). The remainder of the watershed lies within the Northern Minnesota Wetlands Ecoregion (NMW), North Central Hardwood and Forests Ecoregion (NCHF), and Northern Lakes and Forests Ecoregion (NLF). Forests and wetlands are interspersed with cropland throughout the watershed but are more prevalent within the eastern portion. The most expansive wetland area is located in the northeast corner of the watershed; this area is located within the Red Lake Indian Reservation. Major rivers within the Clearwater River Watershed include the Clearwater River, Lost River, Hill River, and Poplar River. Other smaller tributaries within the watershed include Lower Badger Creek, Ruffy Brook, Silver Creek, and Beau Gerlot Creek. Extensive ditching and other hydrologic alterations have occurred within the Clearwater River Watershed. Numerous ditches and drain tiles convey water from agricultural land to rivers and streams. These hydrologic alterations, combined with the loss of historic wetlands and conversion of native prairie to farmland, contribute to frequent flooding in the watershed. Major lakes within the watershed include Clearwater Lake, Pine Lake, Maple Lake, and Kiwosay Pool.

In 2014, the Minnesota Pollution Control Agency (MPCA) began an intensive watershed monitoring (IWM) effort of lakes and streams within the Clearwater River Watershed. Thirty-nine stream sites were sampled for biology at the outlet of variable sized subwatersheds. As part of this effort, MPCA staff joined with local partners to complete stream water chemistry sampling on 15 stream reaches. In 2016, lakes and streams with sufficient data to make an assessment were assessed for aquatic life, aquatic recreation, and aquatic consumption use support. During this process, 32 stream segments were assessed for aquatic life and 28 segments were assessed for aquatic recreation. Thirty-two lakes were assessed for aquatic recreation and nine lakes were assessed for aquatic life.

Twelve stream segments fully supported aquatic life. The remaining 20 segments did not support aquatic life and were determined to be impaired. Fifteen of the segments assessed for aquatic recreation were found to be impaired. Eight aquatic life impairments were the result of poor fish and/or macroinvertebrate communities. Most biological impairments were attributed to poor habitat caused by unstable stream channels and widely varying flow regimes. The unstable stream channels had poor channel development and contained excess fine sediment that covered coarse substrate. Some impairments appear to be the result of excess dissolved oxygen (DO) flux and/or low DO. Hydrologic alterations within the watershed have resulted in a loss of base flow in some systems. The loss of base flow allows for greater DO flux which is a stressor to aquatic life. Barriers to fish passage, such as improperly installed/sized culverts and beaver dams, were also a cause of biological impairments within the Clearwater River Watershed.

Introduction

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

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

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

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

This watershed-wide monitoring approach was implemented in the Clearwater River Watershed beginning in the summer of 2014. This report provides a summary of all water quality assessment results in the Clearwater River Watershed and incorporates all data available for the assessment process including watershed monitoring, volunteer monitoring and monitoring conducted by local government units.

The watershed monitoring approach

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

Intensive watershed monitoring

The intensive watershed monitoring strategy utilizes a nested watershed design allowing the sampling of streams within watersheds from a coarse to a fine scale.

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

River/stream sites are selected near the outlet of each of three watershed scales, 8-HUC, aggregated 12-HUC and 14-HUC (Figure 1).

Within each scale, different water uses are assessed based on the opportunity for that use (i.e., fishing, swimming, supporting aquatic life such as fish and insects). The major river watershed is represented by the 8-HUC scale. The outlet of the major 8-HUC watershed (purple dot in Figure 2 is sampled for biology (fish and macroinvertebrates), water chemistry and fish contaminants to allow for the assessment of aquatic life, aquatic recreation and aquatic consumption use support. The aggregated 12-HUC is the next smaller subwatershed scale, which generally consists of major tributary streams with drainage areas ranging from 75 to 150 mi^2. Each aggregated 12-HUC outlet (green dots in Figure 4 sampled for biology and water chemistry for the assessment of aquatic life and aquatic recreation use support. Within each aggregated 12-HUC, smaller watersheds (14 HUCs, typically 10-20 mi^2), are sampled at each outlet that flows into the major aggregated 12-HUC tributaries. Each of these minor subwatershed outlets is sampled for biology to assess aquatic life use support (red dots in Figure 2).

Figure 1. The Intensive Watershed Monitoring Design

Lakes most heavily used for recreation (all those greater than 500 acres and at least 25% of lakes 100-499 acres) are monitored for water chemistry to determine if recreational uses, such as swimming and wading, are being supported and where applicable, where fish community health can be determined. Lakes are prioritized by size, accessibility (can the public access the lakes), and presence of recreational use. Specific locations for sites sampled as part of the intensive monitoring effort in the Clearwater River Watershed are shown in Figure 2 and are listed in Appendices 2.1 and 2.2.

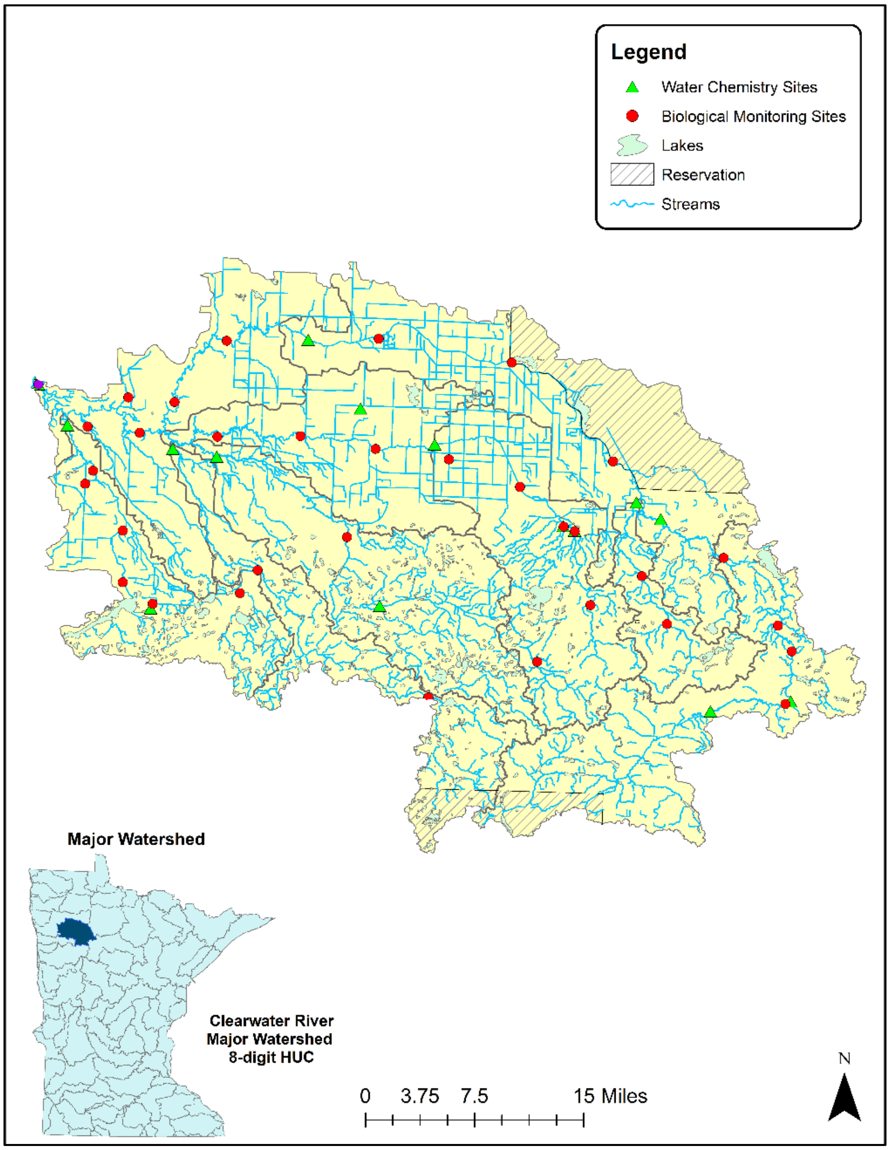

Figure 2. Intensive Watershed Monitoring Sites for Streams in the Clearwater River Watershed.

Citizen and local monitoring

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

The MPCA also coordinates two programs aimed at encouraging long term citizen surface water monitoring: the Citizen Lake Monitoring Program (CLMP) and the Citizen Stream Monitoring Program (CSMP). Like the permanent load monitoring network, having citizen volunteers monitor a given lake or stream site monthly and from year to year can provide the long-term picture needed to help evaluate current status and trends. Citizen monitoring is especially effective at helping to track water quality changes that occur in the years between intensive monitoring years. Figure 3 provides an illustration of the locations where citizen monitoring data were used for assessment in the Clearwater River Watershed.

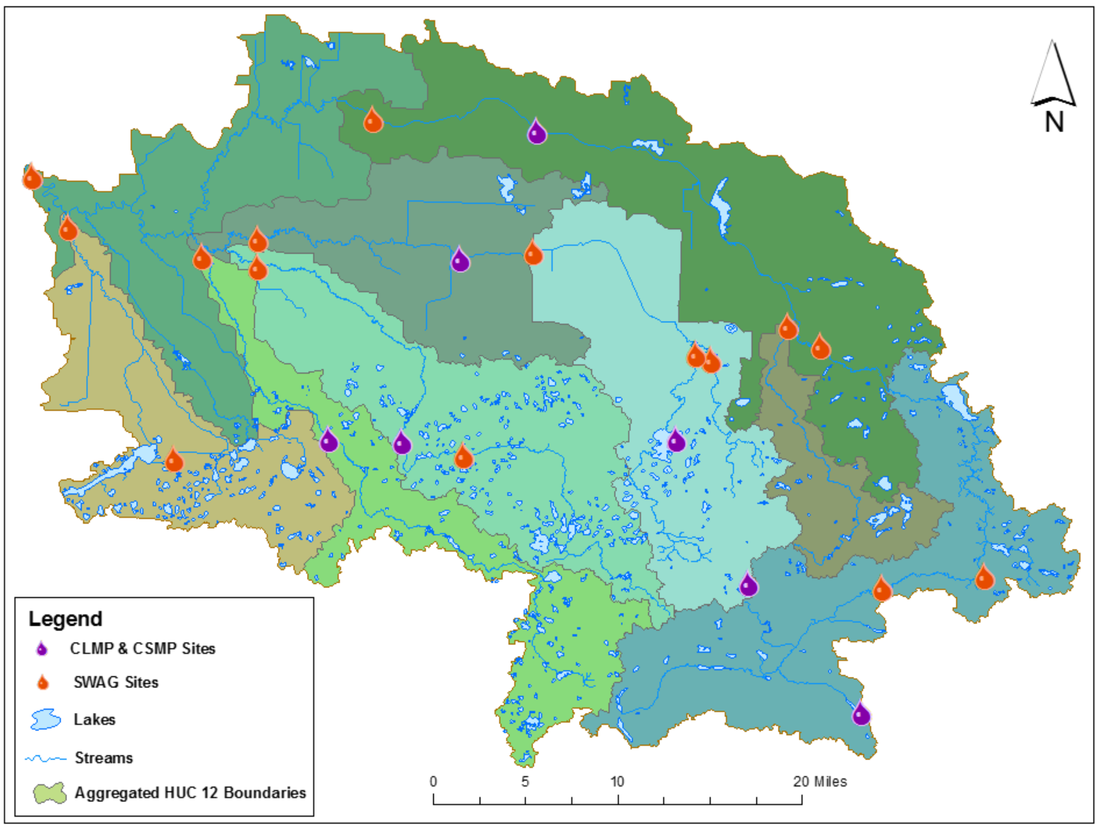

Figure 3. Monitoring Locations of Local Groups, Citizens, and the MPCA Lake Monitoring Staff in the Clearwater River Watershed.

Assessment methodology

The Clean Water Act requires states to report on the condition of the waters of the state every two years. This biennial report to Congress contains an updated list of surface waters that are determined to be supporting or non-supporting of their designated uses as evaluated by the comparison of monitoring data to criteria specified by Minnesota Water Quality Standards (Minn. R. ch. 7050 2008; https://www.revisor.leg.state.mn.us/rules/?id=7050). The assessment and listing process involves dozens of MPCA staff, other state agencies and local partners. The goal of this effort is to use the best data and best science available to assess the condition of Minnesota's water resources. For a thorough review of the assessment methodologies see: Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment 305(b) Report and 303(d) List (MPCA 2012). https://www.pca.state.mn.us/sites/default/files/wq-iw1-04.pdf.

Water quality standards

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

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

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

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

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

Table 1. Table of Proposed Tiered Aquatic Life Use Standards.

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

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

Assessment units

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

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

Determining use attainment

For beneficial uses related to human health, such as drinking water or aquatic recreation, the relationship is well understood and thus the assessment process is a relatively simple comparison of monitoring data to numeric standards. In contrast, assessing whether a waterbody supports a healthy aquatic community is not as straightforward and often requires multiple lines of evidence to make use attainment decisions with a high degree of certainty. Incorporating a multiple lines of evidence approach into MPCA's assessment process has been evolving over the past few years. The current process used to assess the aquatic life use of rivers and streams is outlined below and in Figure 4.

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

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

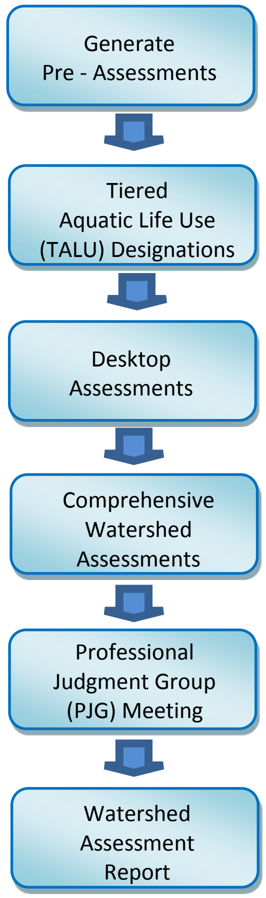

Figure 4. Flowchart of Aquatic Life Use Assessment Process.

The next step in the process is a Comprehensive Watershed Assessment meeting where reviewers convene to discuss the results of their desktop assessments for each individual waterbody. Implementing a comprehensive approach to water quality assessment requires a means of organizing and evaluating information to formulate a conclusion utilizing multiple lines of evidence. Occasionally, the evidence stemming from individual parameters are not in agreement and would result in discrepant assessments if the parameters were evaluated independently. However, the overall assessment considers each piece of evidence to make a use attainment determination based on the preponderance of information available. See the *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment 305(b) Report and 303(d) List* (MPCA 2016) https://www.pca.state.mn.us/sites/default/files/wq-iw1-04i.pdf for guidelines and factors considered when making such determinations.

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

Watershed overview

The Clearwater River Watershed covers 886,600 acres (1,385 square miles) of land in Northwestern Minnesota. One third of the land within the watershed is used for row crop production and has been subject to hydrologic alterations to improve drainage. Forests and wetlands are interspersed with cropland throughout the watershed but are more prevalent within the eastern portion. The majority of the watershed is within the counties of Red Lake, Polk, and Clearwater; however, smaller portions sprawl into Beltrami, Mahnomen, and Pennington County. Approximately 75 square miles of land within the northeastern portion of the watershed lies within the Red Lake Reservation. A small portion of the watershed also lies within the White Earth Reservation. The Clearwater River originates from a wetland area six miles southwest of Bagley and flows east/northeast for 30 miles along the southern edge of the watershed. The river becomes a cold water trout stream, turns north, and flows for 11 miles before returning to a warm water stream. The river continues north and enters Clearwater Lake. After exiting Clearwater Lake, the Clearwater River flows west/northwest for eighteen miles before becoming channelized. At this location, the Clearwater River also forms the boundary of the Red Lake Reservation. The channelized reach of the river is 34 miles long and spans almost the entire northern edge of the watershed. The river returns to a natural channel and continues flowing west before turning toward the southwest and passing by the community of Plummer. Downstream of Plummer, the river winds generally west before passing through Red Lake Falls and joining the Red Lake River. Numerous tributaries enter the Clearwater River along it is 146-mile path to the Red Lake River. Major tributaries include the Hill River, Poplar River, Lost River, and Ruffy Brook. Other smaller tributaries of the Clearwater River include Walker Brook, Terrebone Creek, Beau Gerlot Creek, and Lower Badger Creek. Major lakes within the watershed (> 300 acres) include Maple, Oak, Turtle, Cross, Pine, West Four-Legged, East Four-Legged, King, and Clearwater Lake. Many small unnamed lakes are found throughout the southern half of the watershed. Municipalities within the watershed include Red Lake Falls, Terrebonne, Mentor, Erskine, Plummer, Trail, McIntosh, Lengby, Gonvick, Clearbrook, Brooks, and Bagley.

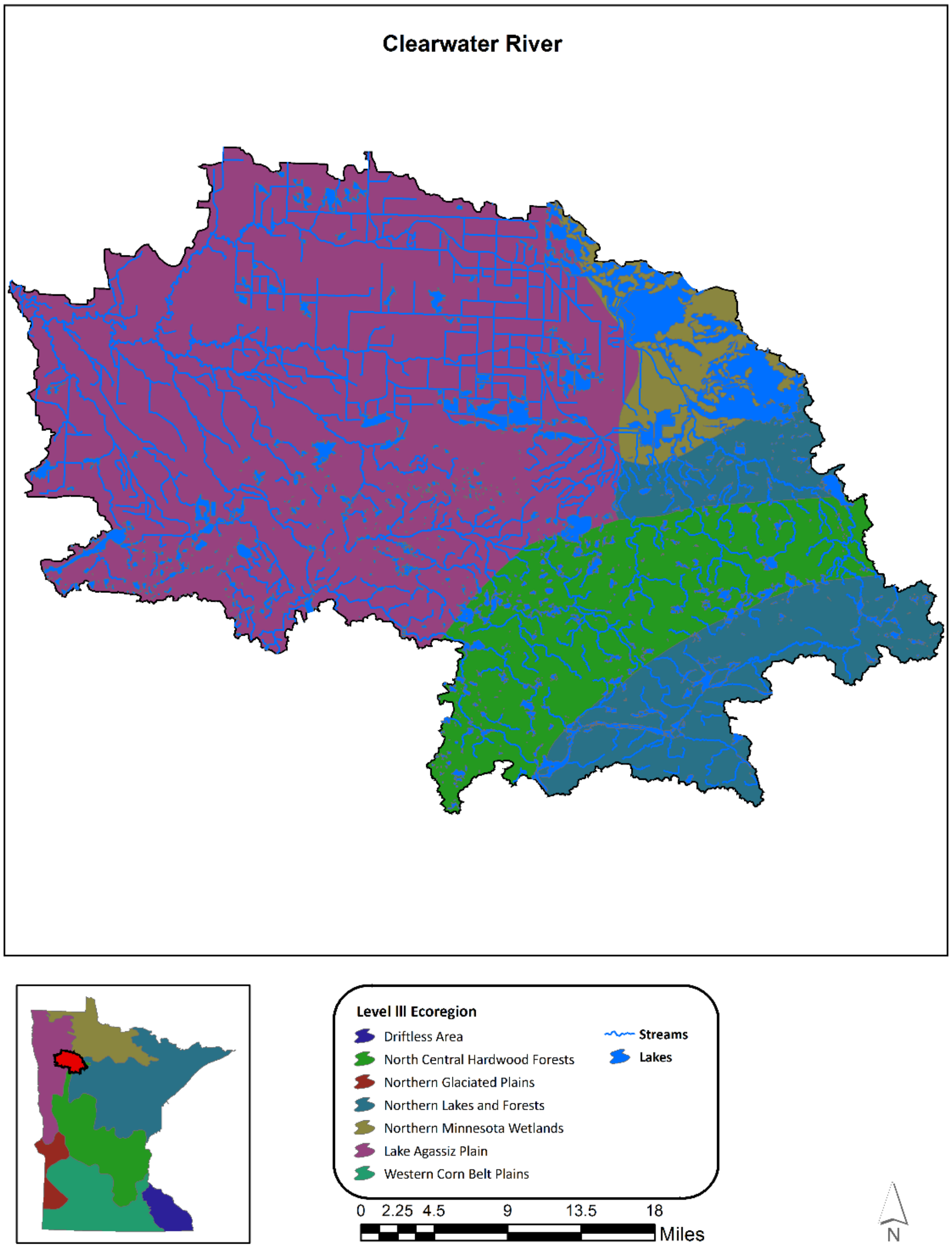

Figure 5. The Clearwater River Watershed within the Lake Agassiz Plain Ecoregion, North Central Hardwood Forests Ecoregion, Northern Minnesota Wetlands Ecoregion, and Northern Lakes and Forests Ecoregion.

The Clearwater River Watershed lies within four ecoregions – the Lake Agassiz Plain (LAP), Northern Minnesota Wetlands (NMW), North Central Hardwood Forests (NCHF), and Northern Lakes and Forests Ecoregion (NLF) (Figure 5). The majority of the watershed lies within the LAP ecoregion. The thick layers of lake sediments deposited by Glacial Lake Agassiz formed fertile soils in the LAP ecoregion (Krenz 1993). For this reason, most of the intensive row crop farming occurs within this region of the Clearwater Watershed. Typical of many remnant lake beds, the LAP ecoregion is very flat and featureless. The northeast region of the watershed (primarily within the Red Lake Reservation) lies within the NMW ecoregion. The NMW ecoregion is characterized by extensive areas of standing water and flat topography; wetland and boreal forest dominate the landscape (Omernik *et al.* 1988). The NCHF ecoregion extends in a band from the headwaters of the Clearwater River toward the northeast to the region just south of Clearwater Lake. The soils within the NCHF ecoregion are generally fertile and suitable to row crop agriculture. Forests, wetlands, lakes, pasture, and croplands are all found within this ecoregion. The far southeastern portion of the watershed, as well as a small portion of the watershed located above the band of NCHF ecoregion, is within the NLF ecoregion. Moraine hills, undulating till plains, and lacustrine basins occur in the NLF ecoregion (Omernik *et al.* 1988). Both hardwood forests and coniferous forests commonly occur within this ecoregion (Omernik et al. 1988). Lakes within this region are often clear due to low nutrient input from the infertile soil and forested watersheds.

Land use summary

Historically the large portion of the Clearwater River Watershed within the Lake Agassiz Plain Ecoregion was covered in prairie. This flat region of the watershed with poorly drained soils also had numerous areas of permanent and temporary wetlands (Krenz 1993). The eastern portion of the watershed was forested and contained a number of lakes and wetlands. Members of the Dakota tribe inhabited the area until the early 1700s when the Ojibway gained control of the land (Krenz 1993). French Canadians and other fur traders visited this area in the late 17th century and into the 18th century. By the mid-18th century, this region was part of the prominent fur trading industry in Minnesota. During the mid to late 1800s, steamboats and the railroad fostered settlement within the area (Krenz 1993). In the 1880s, the Red Lake Band of Ojibwe began giving up land through negotiations with the US government (Hagg 1972). The negotiations and agreements, along with the Nelson Act of 1889, opened new areas to logging (Hagg 1972). These ceded lands included the forests within the Clearwater River Watershed. As a result, logging became a prominent industry within this area during the late 1800s. Agricultural land drainage began as early as the mid-1800s to make more land within the Red River basin (and the Clearwater River Watershed) available for agricultural production. Extensive ditching and other hydrologic alterations have occurred throughout the watershed. These ditches convey water from agricultural land to rivers and streams. Most of the original wetlands have been lost to agricultural drainage; today wetlands account for 13% of the land within the watershed. The greatest portion of wetland occurs within the northeast portion of the watershed on the Red Lake Reservation. Approximately 33% of the land within the Clearwater River Watershed is currently used for row crop production and another 21% is used for pasture/hay (Figure 6). The NRCS estimates that there are 1002 farms within the watershed and approximately 41% are less than 180 acres in size (USDA). Only 2.5% of the watershed consists of open water. Numerous small lakes and wetland ponds are present throughout the southern half of the watershed. Forested land accounts for 25.4% of the watershed. Most of the forested land is located within the eastern portion of the watershed; however, small parcels of forest are scattered throughout the watershed. Four percent of the land within the Clearwater River Watershed is developed.

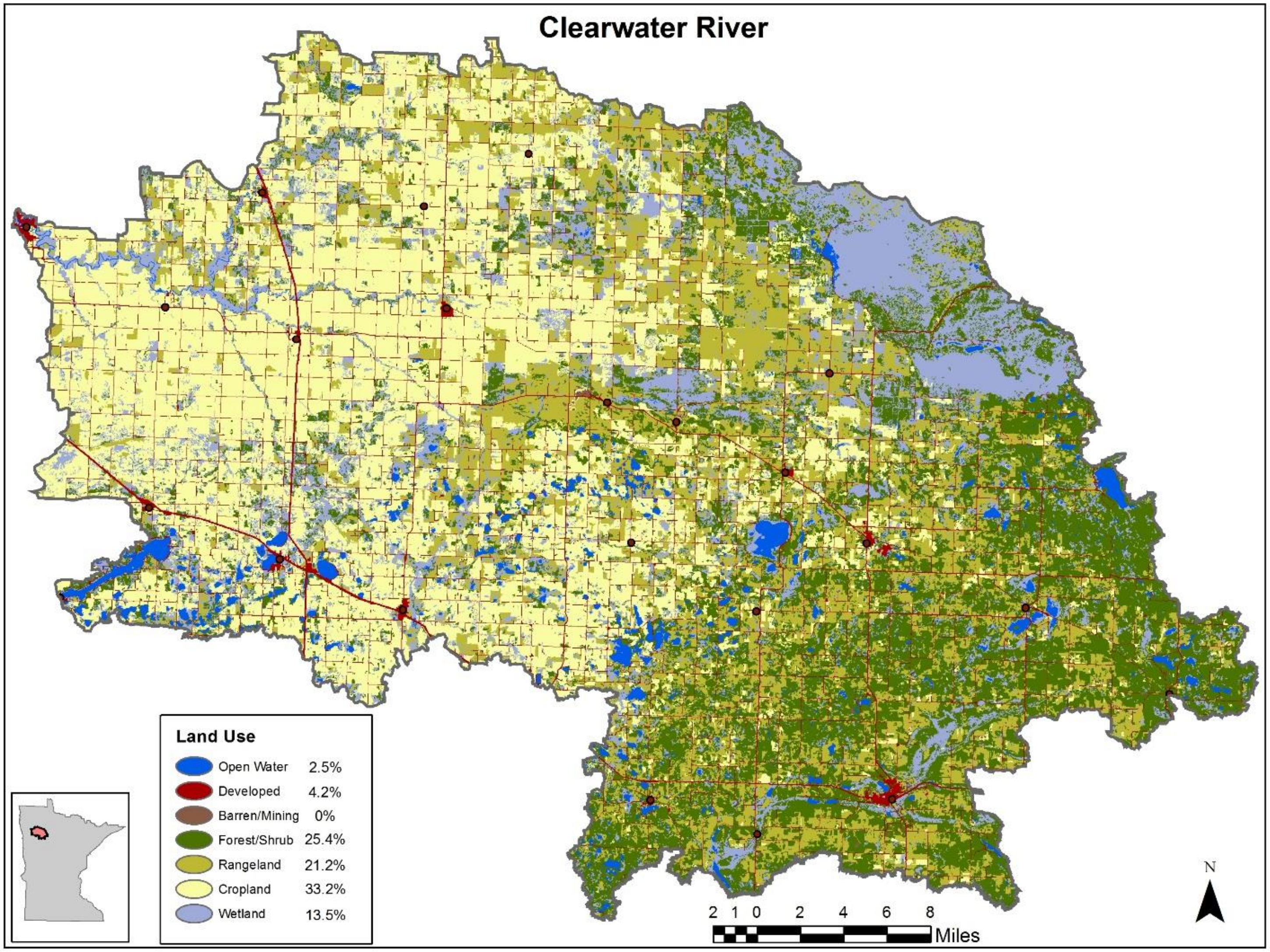

Figure 6. Land Use in the Clearwater Watershed.

Surface water hydrology

The Clearwater River originates from a wetland located southwest of Ebro. Early in its course, the Clearwater River is a low gradient stream with a wetland riparian. The river flows north for a short distance and then turns toward the east. The river continues flowing east through wetlands for approximately five miles before turning northeast near the community of Bagley. A small low gradient tributary stream called Walker Brook joins with the Clearwater River at this location. The Clearwater River continues flowing northeast for approximately thirteen miles before turning toward the east. Stream gradient increases at this location and the river begins to lose its low gradient character. The river continues flowing east for several miles before transitioning to a rocky, cold-water stream that supports a trout fishery. Eventually the river turns toward the north and stream gradient decreases. After approximately 10 miles, the Clearwater River transitions back to a warm water stream. The river continues winding northward through heavily forested land before entering Clearwater Lake. After Clearwater Lake the river continues flowing west/northwest for eighteen miles before being joined by the tributary Ruffy Brook. Ruffy Brook drains 54 square miles of the eastern portion of the Clearwater River Watershed. Flowing from south to north, the stream passes through numerous hayfields and woodlots before joining with the Clearwater River. At this point in its course, the channel of the Clearwater River has been straightened (altered). For the next 14 miles, the river serves as the western boundary of the Red Lake Indian Reservation. Extensive wetlands occur on the reservation lands adjacent to the river. The channelized portion of the Clearwater River extends for 34 miles across the northern portion of the watershed. Extensive agricultural land use occurs in this region; as a result, hydrologic alterations were made throughout this area to improve drainage. Approximately 66% of the streams within the Clearwater River Watershed are channelized (Figure 7). Numerous ditches drain into the Clearwater River from the north and south along the entire channelized reach.

The Clearwater River transitions back to a natural channel and winds west for 8 miles before turning toward the southwest. The river continues flowing southwest for 17 miles, passing by the community of Plummer before being joined by a major tributary called the Lost River. The Lost River and its tributaries the Hill River and Poplar River drain a collective 586 square miles of land. At this location, the Clearwater River receives water from approximately 42% of its total watershed area. The Lost River originates southwest of Clearbrook and drains 292 square miles of the central portion of the Clear Water River Watershed. The Lost River flows north for 24 miles, passing through Pine Lake before being joined by the tributary Silver Creek. Silver Creek originates near the headwaters of the Lost River and flows north for 19 miles before joining the Lost River. The Lost River becomes channelized immediately after the confluence of Silver Creek. Numerous ditches flow into the Lost River all along the channelized portion. The river continues northwest for six miles before turning west. The Lost River flows west for 32 miles before being joined by the tributary the Hill River. The Hill River originates from a wetland located northwest of Bagley and drains 177 square miles of the central portion of the Clear Water River Watershed. The river flows west/northwest for 57 miles before joining the Lost River. The Hill River passes through several lakes along its course to the Lost River – the majority of the lakes in the Clearwater River Watershed are located in this area. After the confluence of the Hill River, the Lost River continues west for approximately three miles and is joined by the Poplar River. The Poplar River drains 116 square miles of the Clearwater River Watershed. Originating from Spring Lake, the Poplar River winds north for 8 miles, passing through Poplar Lake before turning toward the west. The river continues winding west/northwest for 46 miles before joining with the Lost River. Both the Poplar and Hill River pass through extensive areas of agricultural land before emptying into the Lost River. After the confluence of the Hill River, the Lost River continues flowing west for a short distance and empties into the Clearwater River.

The Clearwater River turns west after joining with the Lost River and flows for 3.2 miles before being joined by the tributary Terrebonne Creek. County Ditch 4 originates 7 miles south of the Terrebone Creek headwaters and drains into the headwaters of Terrebone Creek. Terrebone Creek then flows toward the northwest for 4.5 miles before emptying into the Clearwater River. After the confluence of Terrebone Creek, the Clearwater River continues west/northwest for approximately 7 miles before being joined by the tributary Beau Gerlot Creek. Beau Gerlot Creek actually begins as Upper Badger Creek and flows from southeast to northwest for 19 miles before emptying into the Clearwater River. The Clearwater River continues west another 1.2 miles and is joined by the tributary Lower Badger Creek. Lower Badger Creek originates near Erskine and flows from southeast to northwest for 20 miles before emptying into the Clearwater River. Large portions of both Lower Badger Creek and Beau Gerlot Creek are channelized. After the confluence of Lower Badger Creek, the Clearwater River winds northwest for another 6 miles, passing through Red Lake Falls before emptying into the Red Lake River. From its headwaters to the Red Lake River, the Clearwater River has a 147-mile flow length. Major lakes within the watershed (> 300 acres) include Maple, Oak, Turtle, Cross, Pine, West Four-Legged, East Four-Legged, King, and Clearwater Lake. Many small unnamed lakes are found throughout the southern half of the watershed.

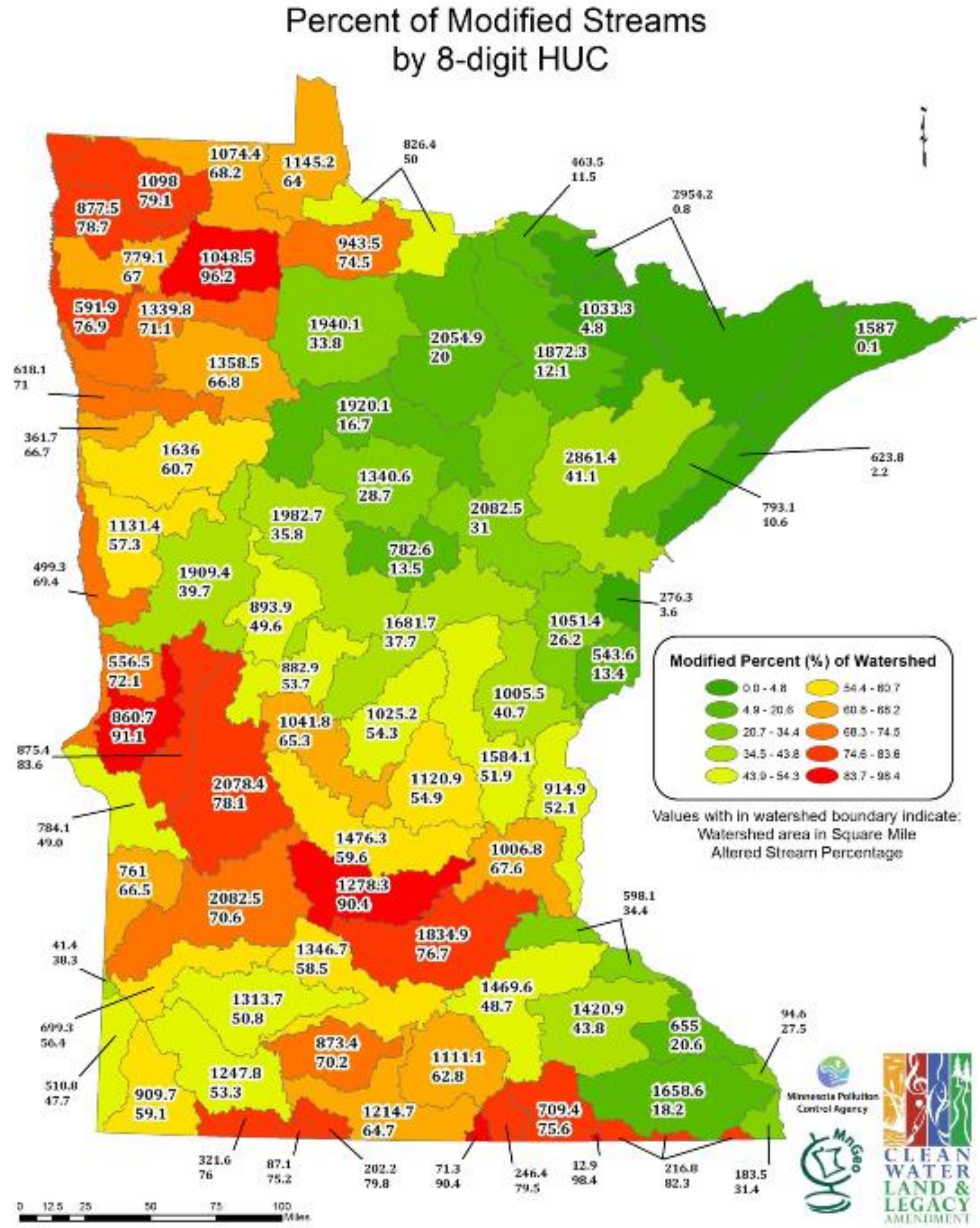

Figure 7. Map of Percent Modified Streams by Major Watershed (8-HUC).

Climate and precipitation

Minnesota has a continental climate, marked by warm summers and cold winters. The mean annual temperature for Minnesota is 4.6˚C (NOAA, 2016); the mean summer (June-August) temperature for the Clearwater River Watershed is 17.8˚C and the mean winter (December-February) temperature is -13.3˚ C (MDNR: Minnesota State Climatology Office, 2003).

Precipitation is an important source of water input to a watershed. Figure 8 displays two representations of precipitation for calendar year 2014. On the left is total precipitation, showing the typical pattern of increasing precipitation toward the eastern portion of the state. According to this figure, the Clearwater River Watershed area received 20 inches of precipitation in 2014. The display on the right shows the amount that precipitation levels departed from normal. The Clearwater River Watershed area experienced precipitation that ranged from 4 to 6 inches below normal in 2014.

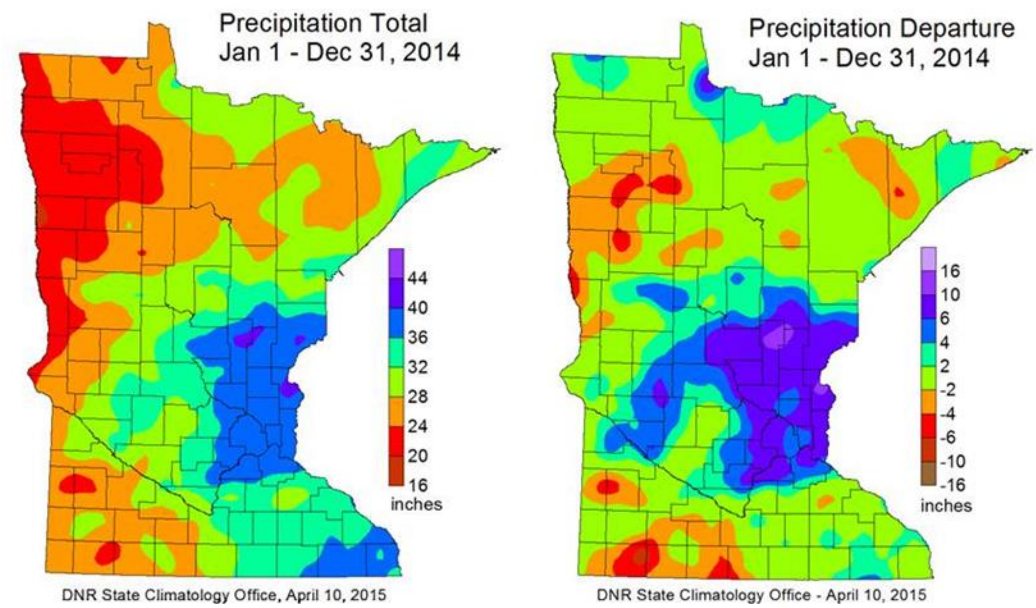

Figure 8. Statewide Precipitation Total (left) and Precipitation Departure (right) during 2014 (Source: MDNR State Climatology Office, 2015)

The Clearwater River Watershed is located in the Northwest precipitation region. Figure 9 and Figure 10 display the areal average representation of precipitation in Northwest Minnesota for 20 and 100 years, respectively. An areal average is a spatial average of all the precipitation data collected within a certain area presented as a single dataset. Though rainfall can vary in intensity and time of year, rainfall totals in the Northwest region display no significant trend over the last 20 years. However, precipitation in Northwest Minnesota exhibits a significant rising trend over the past 100 years ($p<0.01$). This is a strong trend and matches similar trends throughout Minnesota.

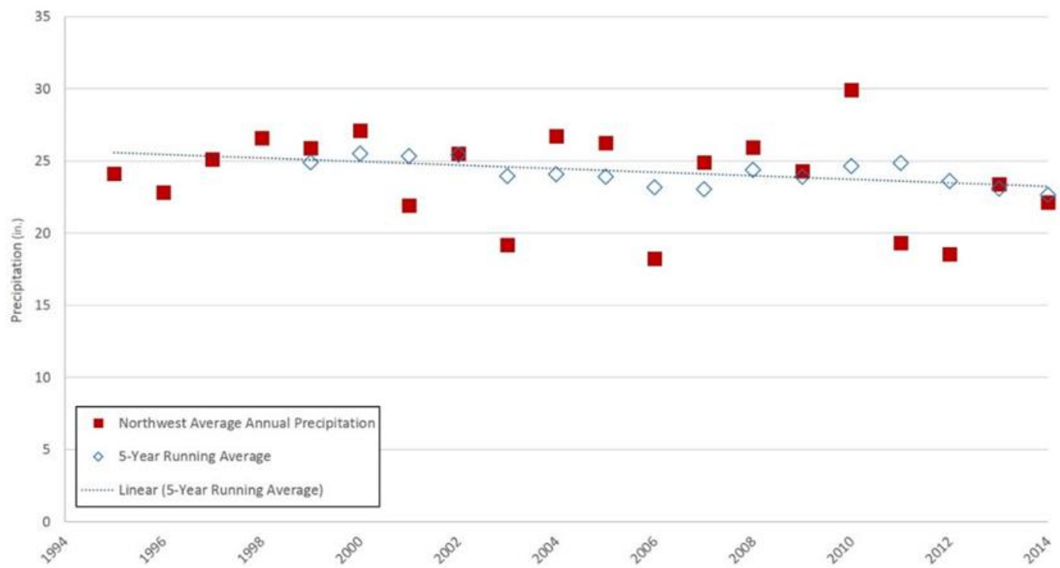

Figure 9. Precipitation Trends in Northwest Minnesota (1995-2014) with 5-Year Running Average (source: WRCC, 2016).

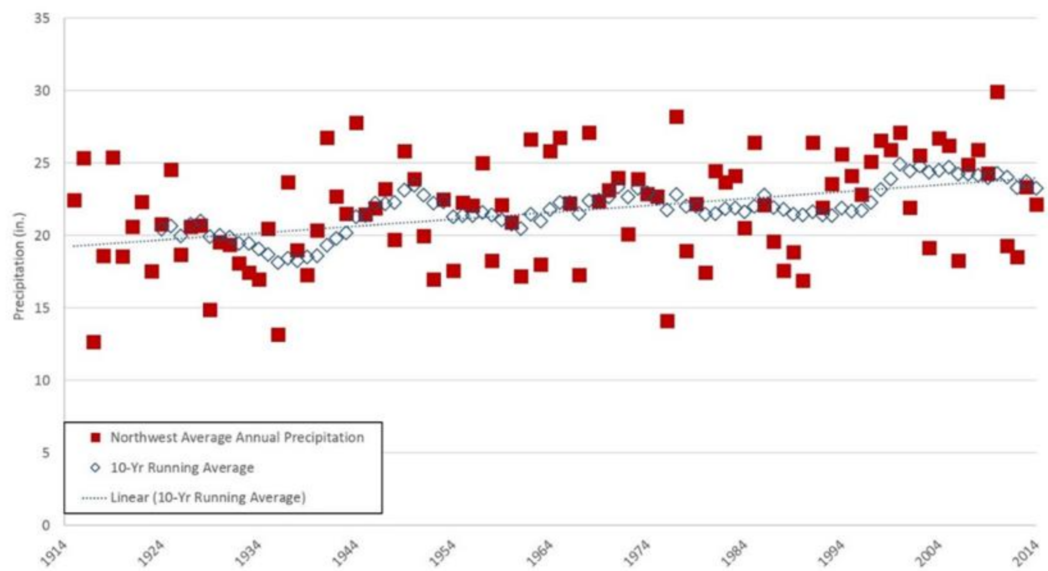

Figure 10. Precipitation Trends in Northwest Minnesota (1915-2014) With 10-Year Running Average (Source: WRCC, 2016).

Hydrogeology and groundwater quality and quantity

Hydrogeology is the study of the interaction, distribution and movement of groundwater through the rocks and soil of the earth. The geology of a region strongly influences the quantity of groundwater available, the quality of the water, the sensitivity of the water to pollution, and how quickly the water will be able to recharge and replenish the source aquifer. This branch of geology is important to understand as it indicates how to manage groundwater withdrawal and land use and can determine if mitigation is necessary.

Surficial and Bedrock Geology

Surficial geology is identified as the earth material located below the topsoil and overlying the bedrock. Glacial sediment is at the surface in much of the Clearwater River Watershed and is the parent material for the soils that have developed since glaciation. The depth to bedrock ranges from 170 feet to nearly 800 feet and is buried by deposits of the various ice lobes that reached this watershed during the last glacial period, as well as during previous glaciations in the last 2.58 million years. The deposits at the surface are associated with two ice lobes, the Des Moines and Wadena lobes, and post-glacial alterations to that sediment, including soil formation and peat accumulation. The geomorphology includes glacial lake sediment (sand and gravel), lake modified till, stagnation and ground moraines (Wadena-Itasca, Des Moines-Erskine, Des Moines-Big Stone), peat, outwash and alluvium (Holocene) (Figure 11, *left*) (Hobbs & Goebel, 1982). The glacial sediment consists of sand and gravel stream sediment and silty calcareous till with a predominantly clayey texture.

Bedrock is the main mass of rocks that form the Earth, located underneath the surficial geology and can only be seen in only a few places where weathering has exposed the bedrock. Precambrian bedrock lies under the extent of the Clearwater River Watershed, displaying evidence of volcanic activity. The main terrane groups include Quetico Subprovince and the Wabigoon, Wawa and Wabigoon, and Wawa Subprovinces (Jirsa et al., 2011). Mafic plug-like intrusions are also scattered throughout the watershed. The rock types that are found in the uppermost bedrock include anorthosite, basalt, gabbro, granite, greywacke, mafic metavolcanic rock and monzonite (Figure 11, *right*) (Morey & Meints, 2000).

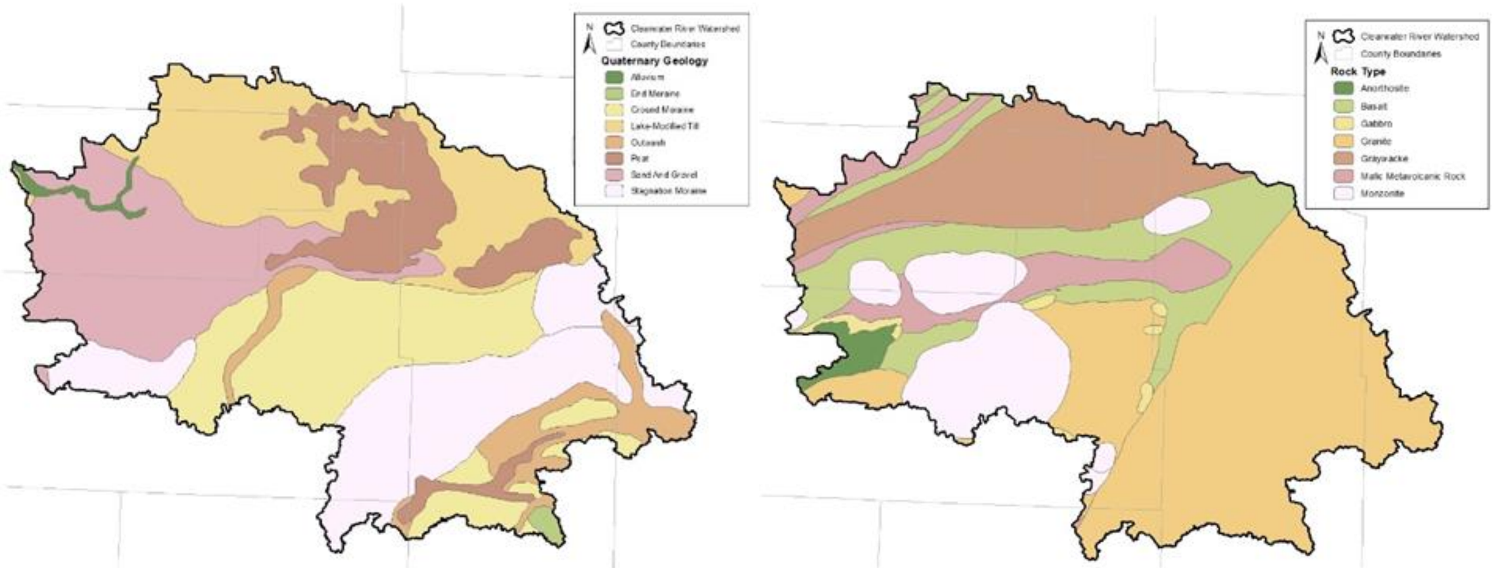

Figure 11. Quaternary Geology (left) and Bedrock Geology Rock Types (right) within the Clearwater River Watershed (GIS Source: Hobbs & Goebel, 1982; Morey & Meints, 2000).

Aquifers

Groundwater aquifers are layers of water-bearing units that readily transmit water to wells and springs (USGS, 2016a). As precipitation hits the surface, it infiltrates through the soil zone and into the void spaces within the geologic materials underneath the surface, saturating the material and becoming groundwater (Zhang, 1998). The water table is the uppermost portion of the saturated zone, where the pore-water pressure is equal to local atmospheric pressure. The geologic material determines the permeability and availability of water within the aquifer. Minnesota's groundwater system is comprised of three types of aquifers: 1) igneous and metamorphic bedrock aquifers, 2) sedimentary rock aquifers, and 3) glacial sand and gravel aquifers (MPCA, 2005). The Clearwater River Watershed has fractured igneous and metamorphic bedrock aquifers lying deep beneath clayey and sandy unconsolidated sediments (MDNR, 2016a). The Clearwater River Watershed's water sources are predominately made up of glacial sand and gravel aquifers with the Quaternary Buried Artesian Aquifer and the Quaternary Water Table Aquifer as the primary sources for groundwater withdrawals. The general availability of groundwater for this watershed can be categorized as good to moderate in the surficial sands, moderate to limited in the buried sands, and limited in the bedrock (MDNR, 2016a)

Groundwater pollution sensitivity

Since bedrock aquifers are typically covered with thick till, they would normally be better protected from contaminant releases at the land surface. It is also less likely that withdrawals from these wells would have a direct and significant impact on local surface water bodies. In contrast, surficial aquifers are typically more likely to 1) be vulnerable to contamination, 2) have direct hydrologic connections to local surface water, and 3) influence the quality and quantity of local surface water. The DNR is working on a hydrogeological atlas focused on the pollution sensitivity of the bedrock surface. It is being produced county-by-county, and awaiting completion for those counties within the Clearwater River Watershed. Until the hydrogeological atlas is finished, a 2016 statewide evaluation of pollution sensitivity of near-surface materials completed by the DNR is utilized to estimate pollution vulnerability up to ten feet from the land surface. This display is not intended to be used on a local scale, but as a coarse-scale planning tool. According to this data, the Clearwater River Watershed is estimated to have primarily ultra-low to low with some high pollution sensitivity areas scattered throughout the watershed, most likely due to the presence of sand and gravel quaternary geology (Figure 12) (MDNR, 2016b).

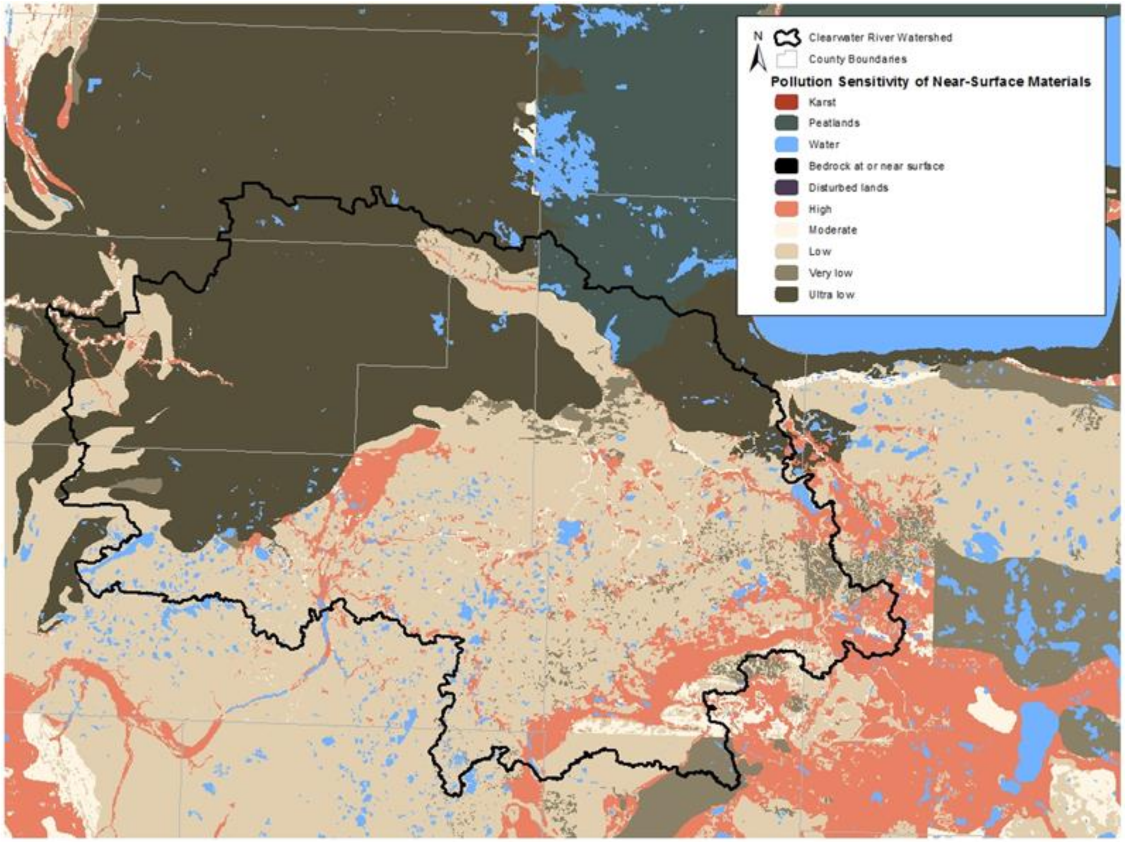

Figure 12. Pollution Sensitivity of Near Surface Materials for the Clearwater River Watershed (GIS Source: MDNR, 2016b).

Groundwater potential recharge

Groundwater recharge is one of the most important parameters in the calculation of water budgets, which are used in general hydrologic assessments, aquifer recharge studies, groundwater models, and water quality protection. Recharge is a highly variable parameter, both spatially and temporally, making accurate estimates at a regional scale difficult to produce. The MPCA contracted the US Geological Survey to develop a statewide estimate of recharge using the SWB – Soil-Water-Balance Code. The result is a gridded data structure of spatially distributed recharge estimates that can be easily integrated into regional groundwater studies. The full report of the project as well as the gridded data files are available at: https://gisdata.mn.gov/dataset/geos-gw-recharge-1996-2010-mean.

Recharge of these aquifers is important and limited to areas located at topographic highs, those with surficial sand and gravel deposits, and those along the bedrock-surficial deposit interface (Figure 13). Typically, recharge rates in unconfined aquifers are estimated at 20 to 25% of precipitation received, but can be less than 10% of precipitation where glacial clays or till are present (USGS, 2007). For the Clearwater River Watershed, the average annual potential recharge rate to surficial materials ranges from 0.19 to 8.58 inches per year, with an average of 3.73 inches per year (Figure 14). The statewide average potential recharge is estimated to be 4 inches per year with 85% of all recharge ranging from 3 to 8 inches per year (Figure 15). When compared to the statewide average potential recharge, the Clearwater River Watershed receives approximately the same average potential recharge.

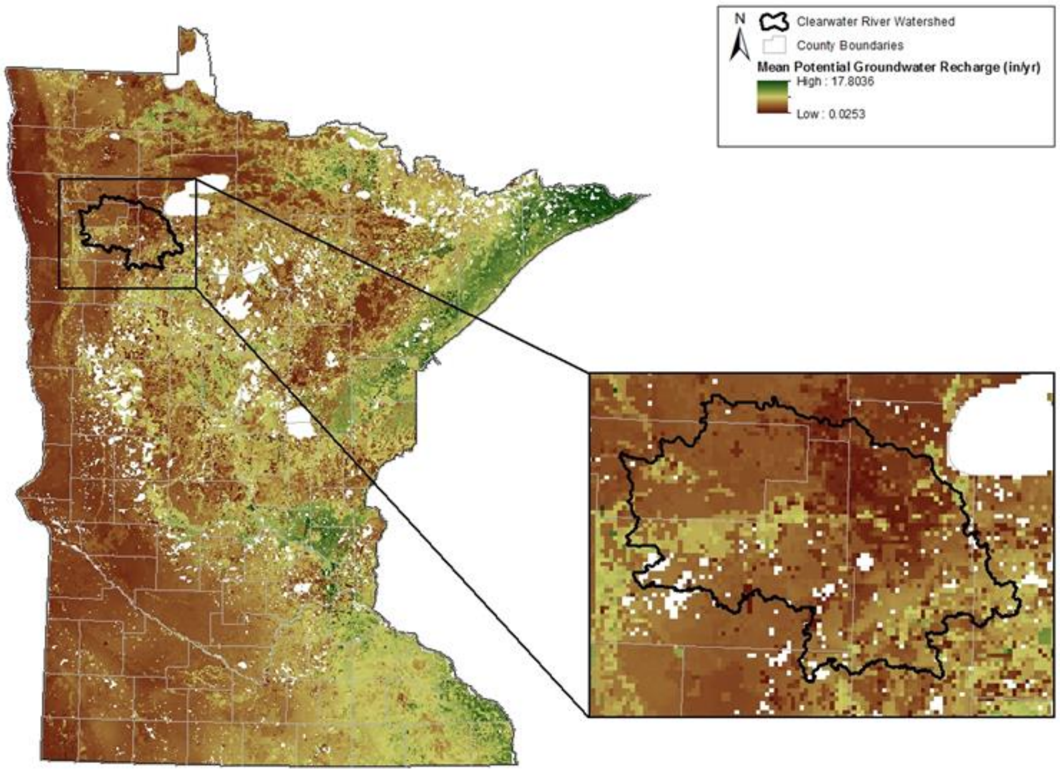

Figure 13. Average Annual Potential Recharge Rate to Surficial Materials in Clearwater River Watershed (1996-2010) (GIS Source: USGS, 2015)

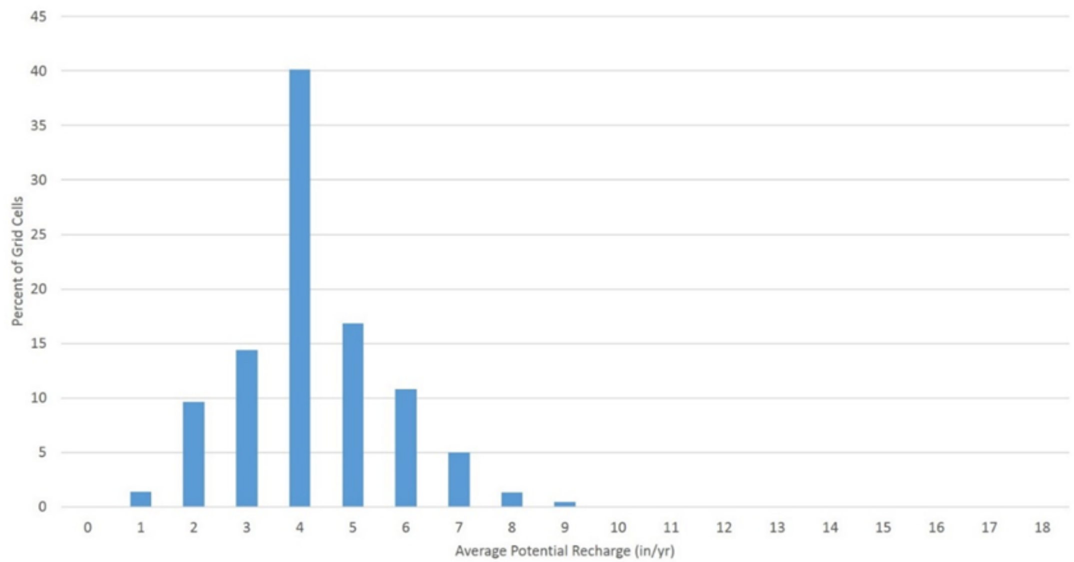

Figure 14. Average Annual Potential Recharge Rate Percent of Grid Cells in the Clearwater River Watershed (1996-2010).

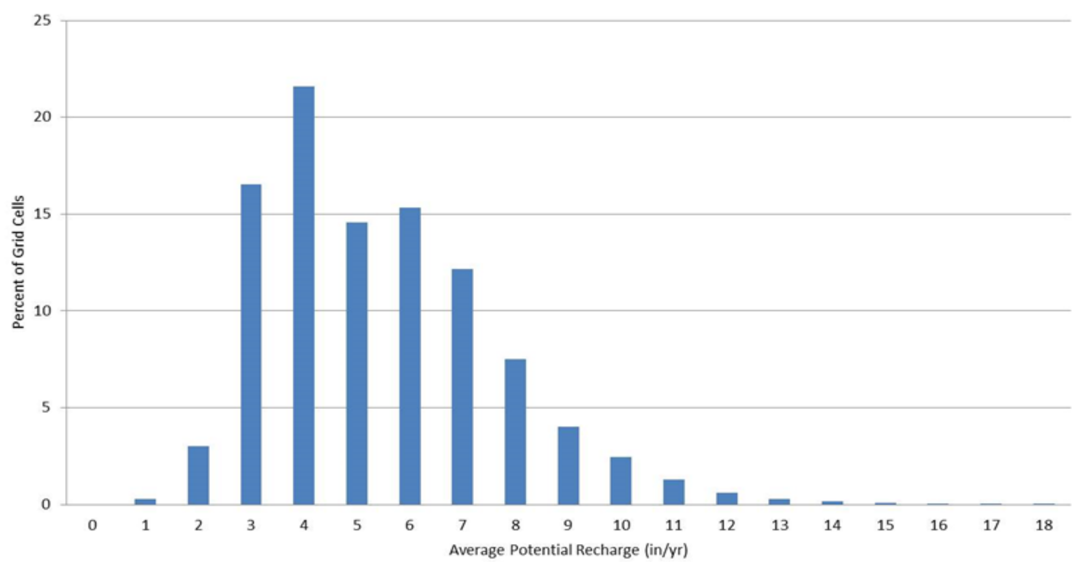

Figure 15. Average Annual Potential Recharge Rate Percent of Grid Cells Statewide (1996-2010).

Groundwater quality

Approximately 75% of Minnesota's population receives their drinking water from groundwater, undoubtedly indicating that clean groundwater is essential to the health of its residents. The MPCA's Ambient Groundwater Monitoring Program monitors trends in statewide groundwater quality by sampling for a comprehensive suite of chemicals including nutrients, metals, and volatile organic compounds. These ambient groundwater wells represent a mix of deeper domestic wells and shallow monitoring wells. The shallow wells interact with surface waters and exhibit impacts from human activities more rapidly. Available data from federal, state and local partners are used to supplement reviews of groundwater quality in the region.

There are currently three MPCA ambient groundwater monitoring wells (two monitoring, one domestic) within the Clearwater River Watershed (Figure 16). Data collection for the network ranges from 2004 to 2016; however, the wells within this watershed were added in 2012. Therefore, due to the limited amount of data available, data analysis was not conducted on the current MPCA ambient groundwater wells within the Clearwater River Watershed.

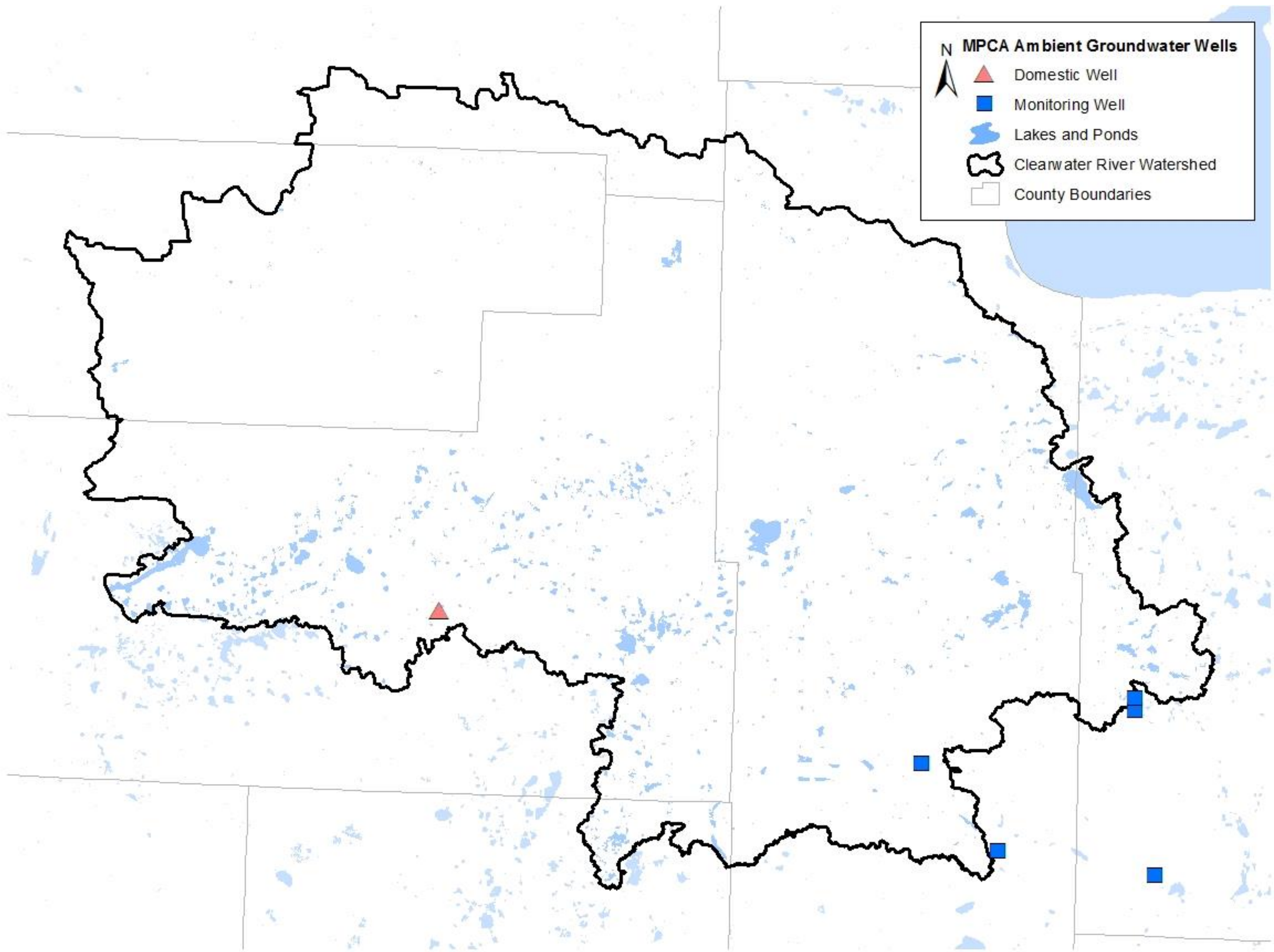

Figure 16. MPCA Ambient Groundwater Monitoring Well Locations within the Clearwater River Watershed.

Regional groundwater quality

From 1992 to 1996, the MPCA conducted baseline water quality sampling and analysis of Minnesota's principal aquifers. The Clearwater River Watershed lies entirely within the Northwest Region, which was identified as having higher concentrations of chemicals in the sand and gravel aquifers when compared to other areas with similar aquifers. The greatest indicator of poor water quality in this region was the presence of Cretaceous bedrock, which is not present in this watershed. The number of exceedances of drinking criteria for arsenic, barium, boron, manganese, nitrate and selenium ranged from one to twelve, depending on the aquifer (MPCA, 1999). Nitrate was identified as the chemical of greatest concern in this hydrogeologic region, with probable anthropogenic sources contributing to the elevated concentrations. Volatile organic compounds were also detected with chloroform as the most commonly detected compound, which is correlated with well disinfection (MPCA, 1999).

Another source of information on groundwater quality comes from the Minnesota Department of Health (MDH). Mandatory testing for arsenic, a naturally occurring but potentially harmful contaminant for humans, of all newly constructed wells has found that 10.7% of all wells installed from 2008 to 2015 have arsenic levels above the maximum contaminant level (MCL) for drinking water of 10 micrograms per liter (MDH, 2016a). In the Clearwater River Watershed, the majority of new wells are within the water quality standards for arsenic levels, but there are exceedances to the MCL. When observing concentrations of arsenic by percentage of wells that exceed the MCL of 10 micrograms/liter per county, the watershed lies within counties that range from less than five to greater than 20%. By county, the percentages of wells identified with concentrations exceeding the MCL are as follows: Mahnomen (37.8%), Red Lake (19.3%), Polk (16.7%), Clearwater (12.4%), Beltrami (10.8%), and Pennington (6.9%) (MDH, 2016b) (Figure 17). It is important to reiterate that the percentages of arsenic concentration exceedances are per county, not specifically for Clearwater River Watershed. For more information on arsenic in private wells, please refer to the MDH's website: https://apps.health.state.mn.us/mndata/arsenic_wells.

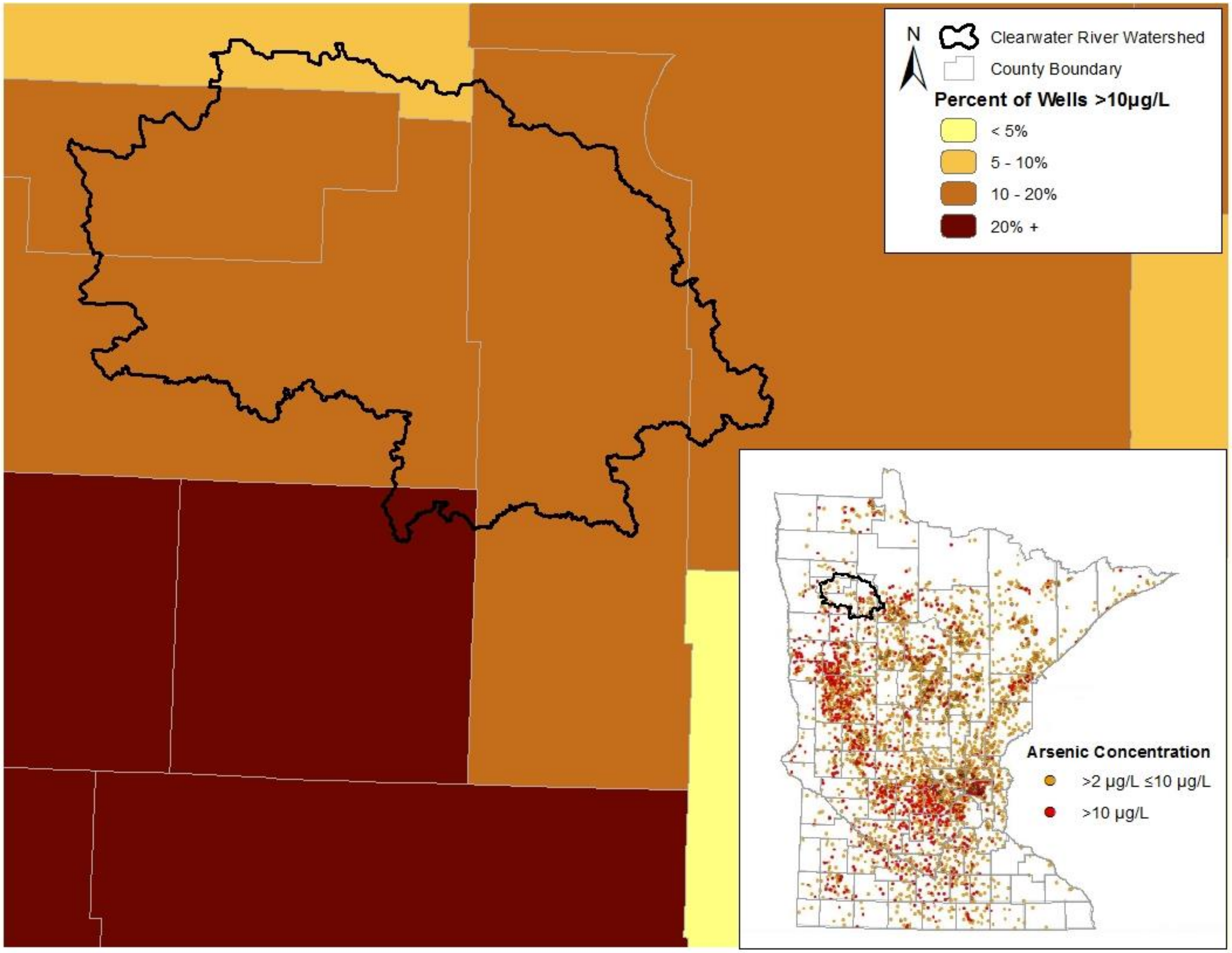

Figure 17. Percent Wells with Arsenic Occurrence Greater than the MCL for the Clearwater River Watershed (2008-2015) (Source: MDH, 2016b).

A statewide dataset of potentially contaminated sites and facilities with environmental permits and registrations is available at the MPCA's website, through a web-based application called, "What's In My Neighborhood" (WIMN). This MPCA resource provides the public with a method to access a wide variety of environmental information about communities across the state. The data is divided into two groups. The first is potentially contaminated sites, and includes contaminated properties, formerly contaminated sites, and those that are being investigated for suspicion of being contaminated. The second category is made up of businesses that have applied for and received different types of environmental permits and registrations from the MPCA. An example of an environmental permit would be for a business acquiring a permit for a storm water or wastewater discharge, requiring it to operate within limits established by the MPCA. In the Clearwater River Watershed, there are currently 390 active sites identified by WIMN: 204 feedlots sites, 87 tanks and leaks, 44 hazardous, 40 water quality sites (construction and industrial stormwater permits and wastewater discharge), 8 air quality sites, 4 solid waste sites, and 3 investigation and cleanup sites (Figure 18). For more information regarding "What's in My Neighborhood", refer to the MPCA webpage at http://www.pca.state.mn.us/index.php/data/wimn-whats-in-my-neighborhood/whats-in-my-neighborhood.html.

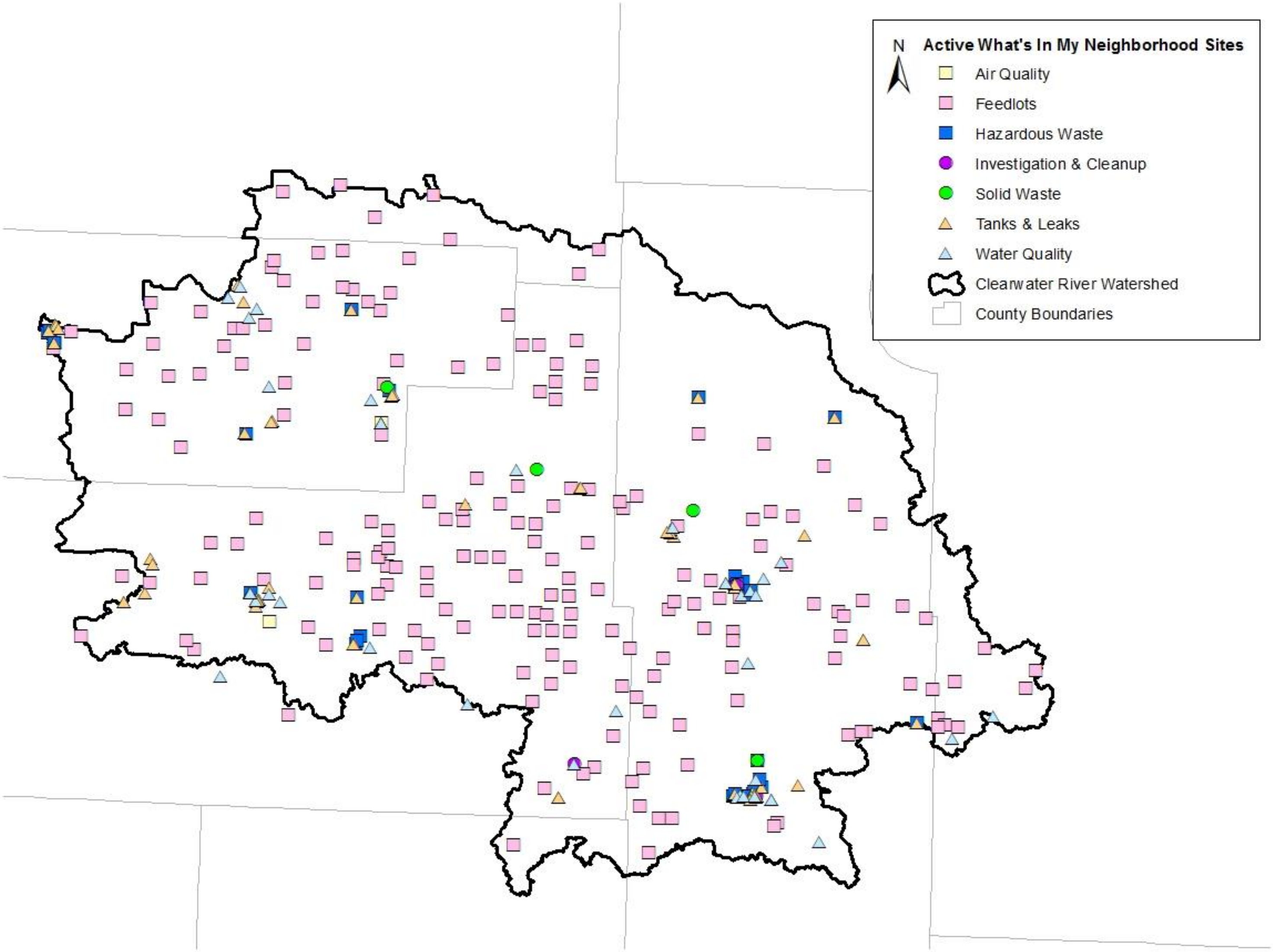

Figure 18. Active "What's In My Neighborhood" Site Programs and Locations for the Clearwater River Watershed (Source: MPCA, 2016).

Groundwater quantity

The DNR permits all high capacity water withdrawals where the pumped volume exceeds 10,000 gallons per day or one million gallons per year. Permit holders are required to track water use and report back to the DNR annually. The changes in withdrawal volume detailed in this groundwater report are a representation of water use and demand in the watershed and are taken into consideration when the DNR issues permits for water withdrawals. Other factors not discussed in this report but considered when issuing permits include: interactions between individual withdrawal locations, cumulative effects of withdrawals from individual aquifers, and potential interactions between aquifers. This holistic approach to water allocations is necessary to ensure the sustainability of Minnesota's groundwater resources.

The three largest permitted consumers of water in the state for 2014 are (in order) power generation, public water supply (municipals), and irrigation (MDNR, 2016c). According to the most recent DNR Site-specific Water-Use Data System, in 2013 the withdrawals within the Clearwater River Watershed are primarily utilized for agricultural irrigation (89.4%), such as crops and wild rice irrigation. The remaining withdrawals include: water supply (5.8%), industrial processing (3.2%), water level maintenance (0.7%), non-crop irrigation (golf course irrigation) (0.6%), and special categories including pipeline and tank testing, aquaculture, construction non-dewatering, sewage treatment and pollution containment (0.2%). From 1994 to 2013, withdrawals associated with agricultural irrigation and special categories have decreased significantly ($p<0.001$), while industrial processing, non-crop irrigation and water supply have increased statistically over this time period ($p<0.01$, $p<0.1$ and $p<0.1$, respectively). Water level maintenance displayed no indication of increasing or decreasing trends, primarily due to sporadic records of withdrawal data. Only 6 of the last 20 years had water level maintenance data available.

Figure 19 displays total high capacity withdrawal locations within the watershed with active permit status in 2013. Permitted groundwater withdrawals are displayed below as blue triangles and surface water withdrawals as red squares. During 1994 to 2013, groundwater withdrawals within the Clearwater River Watershed exhibit a significant increasing withdrawal trend ($p<0.01$) (Figure 20, *top*), while surface water withdrawals exhibit a statistically significant decreasing trend ($p<0.001$) (Figure 20, *bottom*).

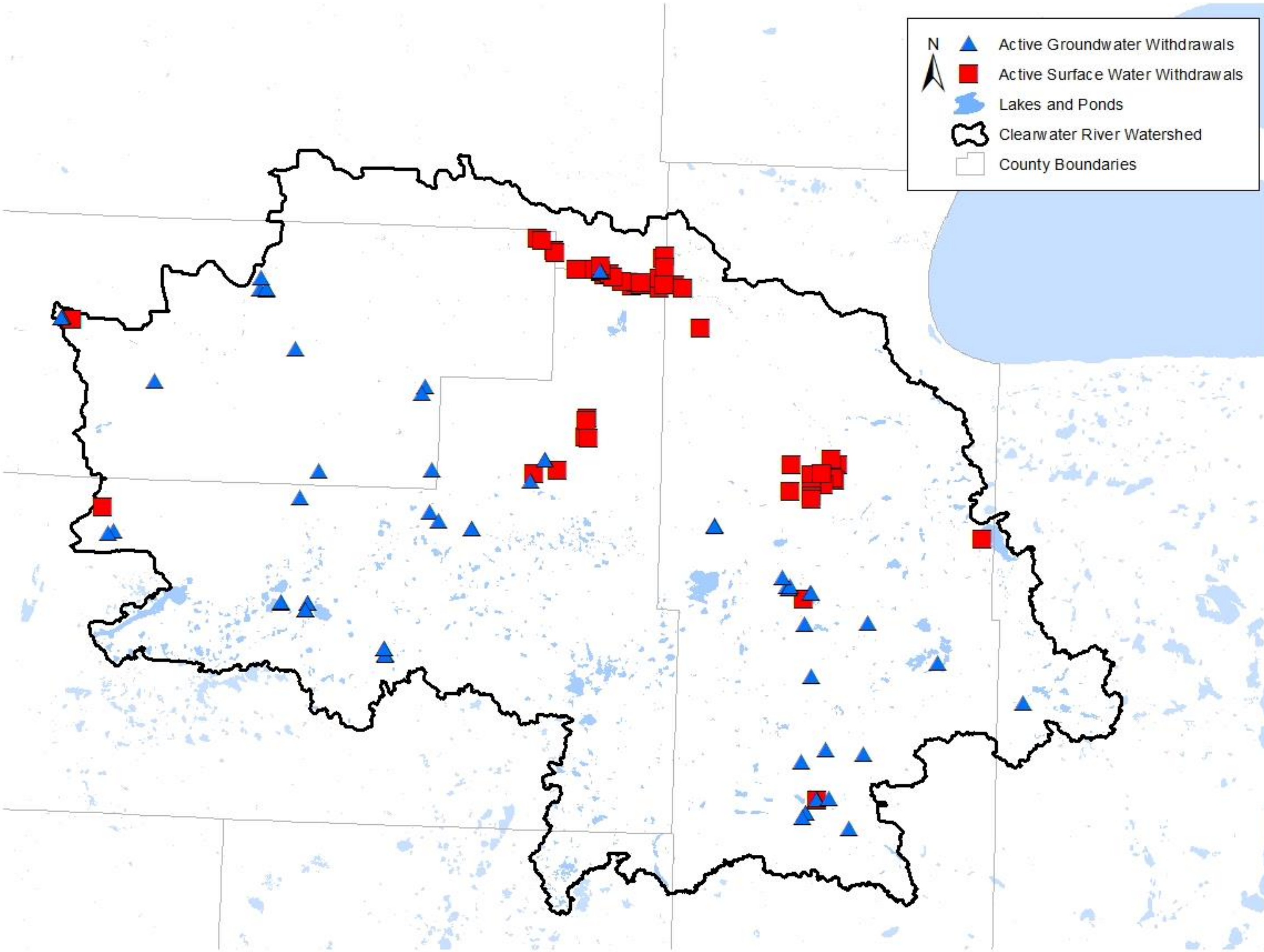

Figure 19. Locations of Active Status Permitted High Capacity Withdrawals in 2013 within the Clearwater River Watershed.

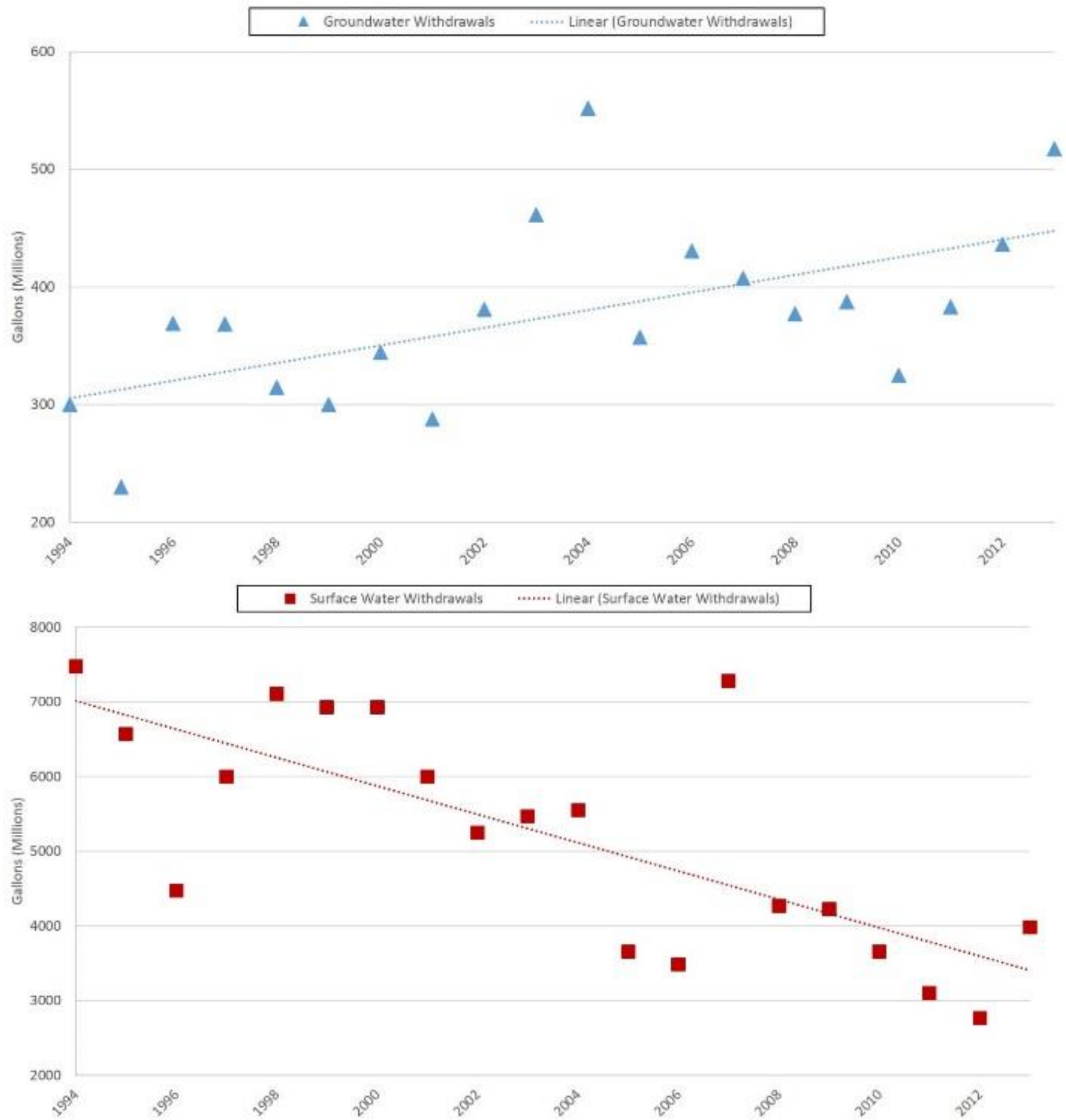

Figure 20. Total Annual Groundwater (top) and Surface Water (bottom) Withdrawals in the Clearwater River Watershed (1994-2013).

Minnesota Department of Natural Resources Observation Wells

Monitoring wells from the DNR Observation Well Network track the elevation of groundwater across the state. The elevation of groundwater is measured as depth to water (DTW) in feet and reflects the fluctuation of the water table as it rises and falls with seasonal variations and anthropogenic influences. To access the DNR Observation Well Network, please visit http://www.dnr.state.mn.us/waters/cgm/index.html.

Two of the four DNR Observation Wells (60004 and 15005) within the Clearwater River Watershed were chosen based on data availability and geologic location as representative of depth to groundwater throughout the watershed (Figure 21). DTW was collected on a monthly basis and the average annual DTW was calculated. For observation well 60004 located near Trail in the central region of the watershed there is a significant decrease in depth to groundwater on an average annual basis from 1997 to 2016 ($p<0.001$), while observation well 15005 near Bagley in the southeastern area of the watershed exhibits no statistical trend in depth to groundwater on an average annual basis.

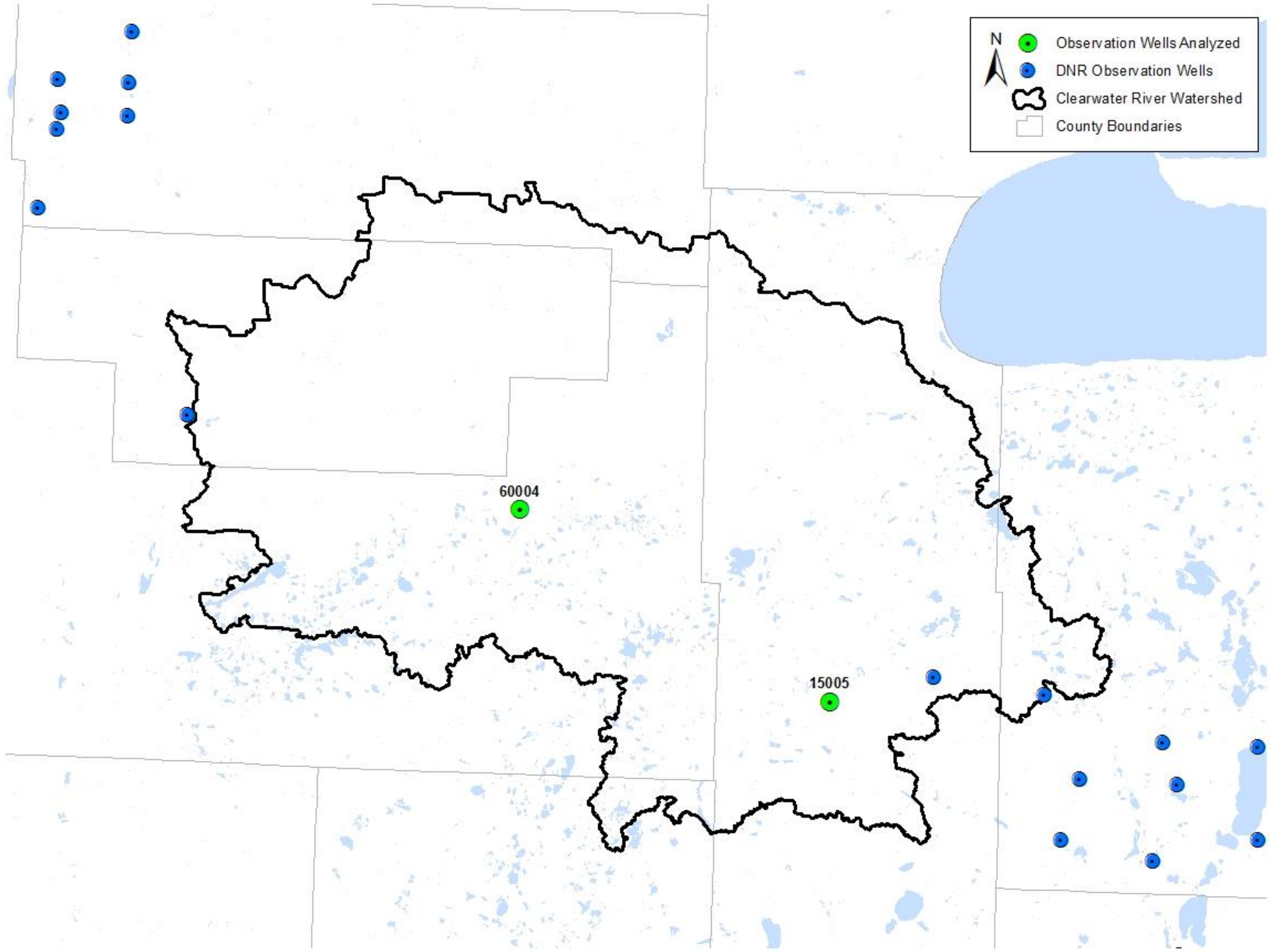

Figure 21. DNR Quaternary Water Table Observation Well Locations within the Clearwater River Watershed.

Wetlands

Wetlands are common but variably distributed in the Clearwater River Watershed. There are an estimated 139,420-wetland acres in the watershed—or about 16% of the watershed land area—according to National Wetlands Inventory (NWI) data (Figure 22). This coverage rate is slightly lower than the statewide rate of 19% (Kloiber and Norris 2013). The majority of the wetlands are located in the northeastern quarter of the watershed. It should be noted, however, that a significant portion of these mapped wetlands (approximately 10,000 acres) are artificially maintained/manipulated for wild rice and other crop production—mostly occurring in proximity with the channelized portion of the Clearwater River as it forms the boundary of and exits the Red Lake Indian Reservation. Approximately 50% of the current wetland extent are emergent wetlands (fresh meadows and marshes). Scrub-Shrub wetlands (dominated by willows and/or alder) are also a common wetland type.

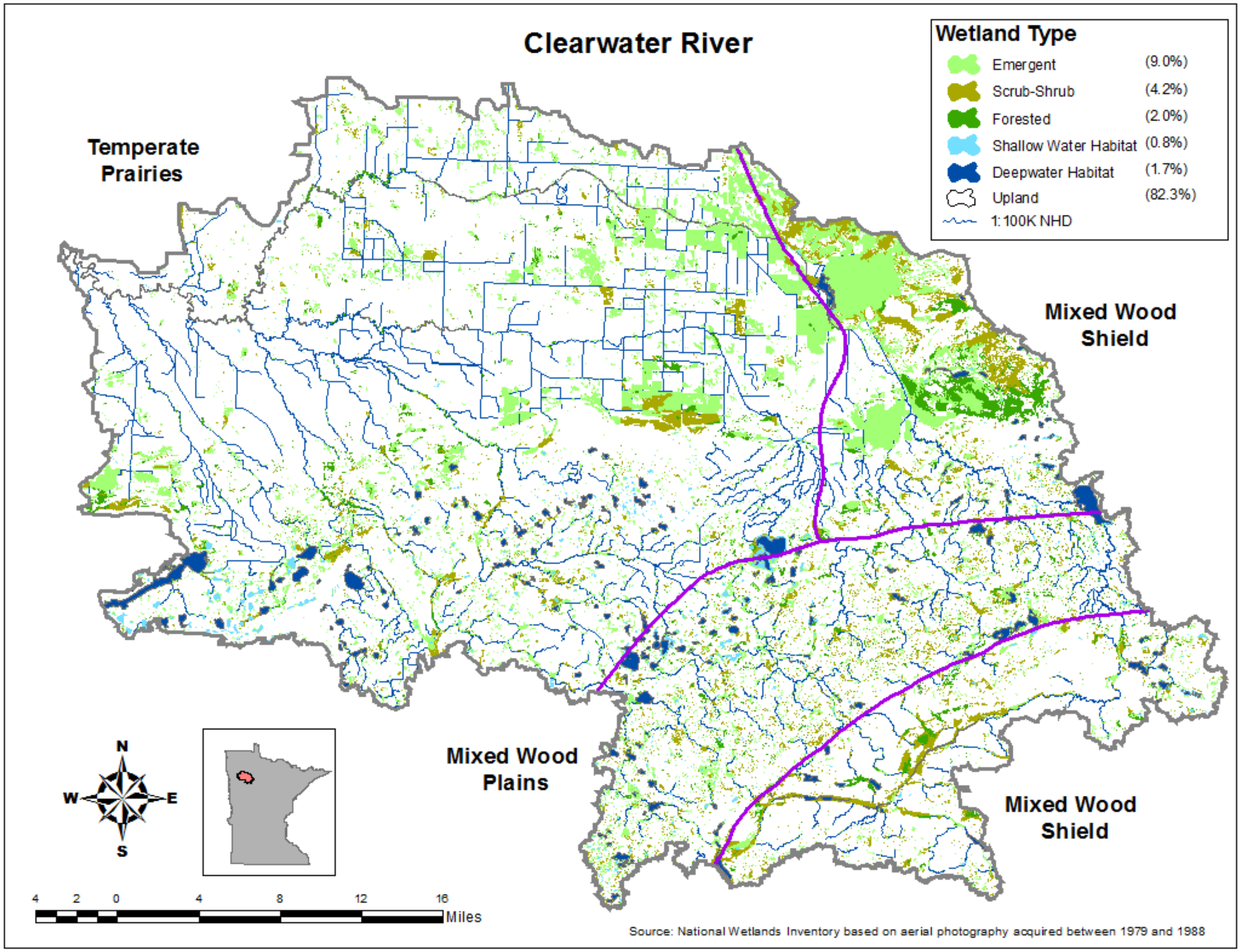

Figure 22. Wetlands and Surface Water in the Clearwater River Watershed. Level II Ecoregion Boundaries have been included (purple). The Mixed Wood Shield (Northern Forest), Mixed Wood Plains (Central Hardwood Forest), and Temperate Prairies Ecoregions occur within the Watershed. Wetland Data are from the National Wetlands Inventory.

Prior to European settlement, wetlands were much more prevalent throughout the watershed. As wetland soil features typically persist after artificial drainage, soil survey data can be used to estimate historical wetland extent. Complete soil survey data are available for eight of the nine subwatersheds (excluding the Middle Clearwater River sub-watershed) in the Clearwater Watershed. This prohibits generating a historical wetland extent estimate for the watershed as a whole, but the wetland loss estimate of the eight sub-watershed totals approximately 221,000 acres—a 71% historical wetland loss rate. Historical wetland losses by sub-watershed increase from east to west in the watershed (Figure 23) as it transitions from the Mixed Wood Shield (northern forest) and Plains (central hardwood forest) ecoregions to the Temperate Prairies (former prairie) ecoregion (Figure 22).

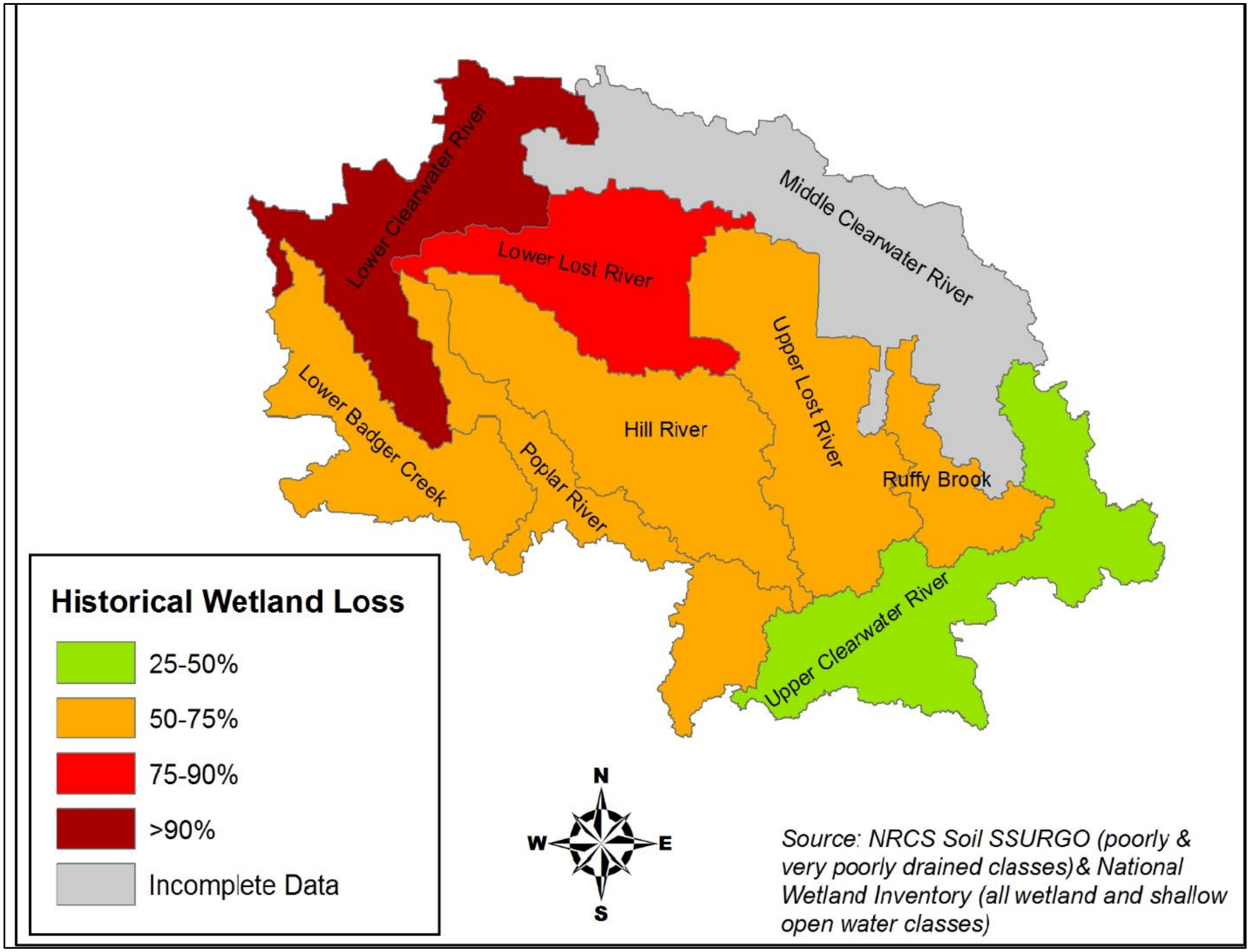

Figure 23. Historic Wetland Loss by Sub-watershed in the Clearwater River Watershed.

Ecoregion differences and two glacial landforms have largely influenced the historical/current extent, distribution, and predominant kinds of hydrogeomorphically (HGM) functioning types of wetlands in the Clearwater River Watershed. The southern half of the watershed predominantly consists of terminal and ground moraine landforms created by glacial advancement (MNGS 1997). The hill and basin topography of the moraine landform produces numerous lakes and depressional wetlands. Depressional wetland hydrology may be dominated by surface flow, precipitation, and/or groundwater depending on the local setting and whether the basin has a surface water connection (Smith et al. 1995). In many cases, they provide (or contribute significantly) to stream source waters. The moraine portion of the watershed includes all three major ecoregions. Most of the wetlands are intact where it corresponds with the Mixed Wood Shield ecoregion as development pressures are less. The Mixed Wood Plains portion of the watershed (Figure 22) is a transition zone between the northern forests and the prairie that also corresponds with a terminal moraine. Agricultural development and wetland drainage is moderate here, perhaps in part due to local topography limitations (Figure 23). The Temperate Prairies ecoregion and the gentler topography of a ground moraine begins northwest of the terminal moraine (Figure 22). Depressional wetlands were also once prevalent here; however, the vast majority have been drained due to more favorable conditions for farming. The northern half of the watershed is a glacial lake plain landform created by Glacial Lake Agassiz (MNGS 1997). The extremely flat landscape that remained following Lake Agassiz had little capacity to drain surface water—promoting saturated soil conditions over expansive areas. Vast organic and mineral flat HGM type wetlands (Smith et al. 1995) formed in the glacial lake plain where soils were saturated at or near the surface. Where the Mixed Wood Shield ecoregion corresponds with the glacial lake plain landform in the watershed—the organic flat type wetlands are almost entirely intact. Conversely, the large majority of historical wetlands have been effectively drained primarily via surface ditching in the Temperate Prairies portion. There are also several relatively narrow bands of glacial lake beach ridges within the larger glacial lake plain. The beach ridges support wetlands where water accumulates behind downstream ridges (depressional HGM type); as well as, where groundwater discharge saturates a sloping soil surface and peat accumulates (slope HGM type; Smith et al. 1995). Wetlands continue to exist in the beach ridges, as drainage and agriculture are less practical compared to the glacial lake plain.

The Clearwater River Watershed supports some notable wetland features. Wild rice populations have been documented on a number of lakes, ponds, and streams mostly in the southeast and southwest portions of the watershed (MPCA Protecting Wild Rice Waters). This includes the upper portion of the Clearwater River. In addition, calcareous fens—an uncommon type of wetland with alkaline (pH > 6.7) peat that can form where groundwater discharge is mineral-rich—are found in the watershed typically associated with the glacial lake beach ridges. Calcareous fens support a unique community of plant species (many are rare) and receive additional protections as state Outstanding Resource Value Waters (ORVW; Minn. R. ch. 7050; https://www.revisor.leg.state.mn.us/rules/?id=7050). The DNR has identified nine calcareous fens in the watershed, one of which is designated as an ORVW.

Watershed-wide data collection methodology

Lake water sampling

The MPCA sampled eight lakes in 2014 and 2015, as part of the Clean Water Legacy Surface Water Monitoring project for the purpose of enhancing the dataset for lake assessment of aquatic recreation. There are currently three volunteers enrolled in the MPCA's Citizens Lake Monitoring Program (CLMP) that are conducting lake monitoring within the watershed. Sampling methods are similar among monitoring groups and are described in the document entitled "MPCA Standard Operating Procedure for Lake Water Quality" found at http://www.pca.state.mn.us/publications/wq-s1-16.pdf. The lake water quality assessment standard requires eight observations/samples within a 10-year period (June to September) for phosphorus, chlorophyll-a and Secchi depth.

Stream water sampling

Fifteen water chemistry stations were sampled from May thru September in 2014, and again June thru August of 2015, to provide sufficient water chemistry data to assess all components of the aquatic life and recreation use standards. Following the IWM design, water chemistry stations were placed at the outlet of each aggregated HUC-12 subwatershed that was >40 square miles in area (purple circle and green triangles in Figure 2). A Surface Water Assessment Grant (SWAG) was awarded to the Red Lake Watershed District and they collected water chemistry at the IWM subwatershed sites (See Appendix 2.1 for locations of stream water chemistry monitoring sites). See Appendix 1 for definitions of stream chemistry analytes monitored in this study).

Stream flow methodology

MPCA and the DNR joint stream water quantity and quality monitoring data for dozens of sites across the state on major rivers, at the mouths of most of the state's major watersheds, and at the mouths of some aggregated 12-HUC subwatersheds are available at the DNR/MPCA Cooperative Stream Gaging webpage at: http://www.dnr.state.mn.us/waters/csg/index.html.

Lake biological sampling

A total of 12 lakes were monitored for fish community health in the Clearwater River Watershed. While data from the last 10 years contributed to the watershed assessments, the majority of data utilized for the 2016 assessment was collected in 2013-2015. Waterbody assessments to determine aquatic life use support were completed for 11 lakes.

To measure the health of aquatic life at each lake, a fish index of biological integrity (IBI) was calculated based on monitoring data collected in the lake. A fish classification framework was developed to account for natural variation in community structure, which is attributed to area, maximum depth, alkalinity, shoreline complexity, and geographic location. As a result, an IBI is available for four different groups of lake classes (Schupp Lake Classification, MDNR). Each IBI class uses a unique suite of metrics, scoring functions, impairment thresholds, and confidence intervals (CIs). IBI scores higher than the impairment threshold and upper CI indicate that the lake supports aquatic life. Scores below the impairment threshold and lower CI indicate that the lake does not support aquatic life. When an IBI score falls within the upper and lower confidence limits additional information may be considered when making the impairment decision such as the consideration of potential local and watershed stressors and additional monitoring information (e.g., water chemistry, physical habitat, plant surveys, and observations of local land use activities).

Stream biological sampling

The biological monitoring component of the intensive watershed monitoring in the Clearwater River Watershed was completed during the summer of 2014. A total of 24 sites were newly established across the watershed and sampled. These sites were located near the outlets of most minor HUC-14 watersheds. Three stations were newly established in 2015 as part of the EMAP (Environmental Monitoring and Assessment Program). In addition, six existing biological monitoring stations within the watershed were revisited in 2014 or 2015. These monitoring stations were initially established as part of a survey to collect data for biocriteria development, or as part of a 2007 survey which investigated the quality of channelized streams with intact riparian zones. While data from the last 10 years contributed to the watershed assessments, the majority of data utilized for the 2016 assessment was collected in

2014 and 2015. A total of 27 AUIDs were sampled for biology in the Clearwater River Watershed. Waterbody assessments to determine aquatic life use support were conducted for 32 AUIDs. Biological information that was not used in the assessment process will be crucial to the stressor identification process and will also be used as a basis for long term trend results in subsequent reporting cycles.

To measure the health of aquatic life at each biological monitoring station, indices of biological integrity (IBIs), specifically Fish and Invert IBIs, were calculated based on monitoring data collected for each of these communities. A fish and macroinvertebrate classification framework was developed to account for natural variation in community structure which is attributed to geographic region, watershed drainage area, water temperature and stream gradient. As a result, Minnesota's streams and rivers were divided into seven distinct warm water classes and two cold water classes, with each class having its own unique Fish IBI and Invert IBI. Each IBI class uses a unique suite of metrics, scoring functions, impairment thresholds, and confidence intervals (CIs) (For IBI classes, thresholds and CIs, see Appendix 3.1). IBI scores higher than the impairment threshold and upper CI indicate that the stream reach supports aquatic life. Contrarily, scores below the impairment threshold and lower CI indicate that the stream reach does not support aquatic life. When an IBI score falls within the upper and lower confidence limits additional information may be considered when making the impairment decision such as the consideration of potential local and watershed stressors and additional monitoring information (e.g., water chemistry, physical habitat, observations of local land use activities). For IBI results for each individual biological monitoring station, see Appendices 4.1 and 4.2.

Fish contaminants

The DNR fisheries staff collect most of the fish for the Fish Contaminant Monitoring Program. In addition, MPCA's biomonitoring staff collect up to five piscivorous (top predator) fish and five forage fish as part of the Intensive Watershed Monitoring. All fish collected by the MPCA are analyzed for mercury and the two largest individual fish of each species are analyzed for polychlorinated biphenyls (PCBs).

Captured fish were wrapped in aluminum foil and frozen until they were thawed, scaled (or skinned), filleted, and ground to a homogenized tissue sample. Homogenized fillets were placed in 60 mL glass jars with Teflon™ lids and frozen until thawed for lab analysis. The Minnesota Department of Agriculture Laboratory analyzed the samples for mercury and PCBs. If fish were tested for perfluorochemicals (PFCs), whole fish were shipped to AXYS Analytical Laboratory, which analyzed the homogenized fish fillets for 13 PFCs. Of the measured PFCs, only perfluorooctane sulfonate (PFOS) is reported because it bioaccumulates in fish to levels that are potentially toxic and a reference dose has been developed.

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

Monitoring of fish contaminants in the 1970s and 1980s showed high concentrations of PCBs were primarily a concern downstream of large urban areas in large rivers, such as the Mississippi River, and in Lake Superior. Therefore, PCBs are now tested where high concentrations in fish were measured in the past and the major watersheds are screened for PCBs in the watershed monitoring collections.

Before 2006, mercury in fish tissue was assessed for water quality impairment based on MDH's fish consumption advisory, the same as PCBs. With the adoption of a water quality standard for mercury in edible fish tissue, a waterbody has been classified as impaired for mercury in fish tissue if 10% of the fish samples (measured as the 90th percentile) exceed 0.2 mg/kg of mercury. At least five fish samples of the same species are required to make this assessment and only the last 10 years of data are used for the assessment. MPCA's Impaired Waters List includes waterways that were assessed as impaired prior to 2006 as well as more recent impairments.

Load monitoring

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 (Red, Rainy, St. Croix, Mississippi, and Minnesota). The WPLMN coverage includes the outlets of the major tributaries (8 digit HUC scale) draining to these rivers and the outlets of the subwatersheds within these major watersheds. Intensive water quality sampling occurs at all WPLMN sites. Thirty-five samples per year are allocated for basin and major watershed sites and 25 samples per season (ice out through October 31) for subwatershed sites. Water sample results and daily average flow data are coupled in the FLUX32 pollutant load model to estimate the transport (load) of nutrients and other water quality constituents past a sampling station over a given period of time. Loads and flow weighted mean concentrations (FWMCs) are calculated for total suspended solids (TSS), TP, dissolved orthophosphate, nitrate plus nitrite nitrogen (NO_3+NO_2-N), and total Kjeldahl nitrogen (TKN). More information can be found at the WPLMN website.

Groundwater monitoring

The MPCA maintains an ambient groundwater monitoring network that monitors the aquifers that are most likely to be polluted with non-agricultural chemicals. This network primarily targets the shallow aquifers that underlie the urban parts of the state, due to their higher tendency of vulnerability to pollution. The MPCA's ambient groundwater monitoring network as of 2016, when this report was produced, consisted of approximately 250 wells that are primarily located in the sand and gravel and Prairie du Chien- Jordan aquifers.

Some wells in the MPCA's network are used to discern the effect of urban land use on groundwater quality and comprise an early warning network. Most wells in this early warning network contain water that was recently recharged into the groundwater, some even less than one year old. The wells in the early warning network are distributed among several different settings to determine the effect land use has on groundwater quality. These assessed land use settings are: 1) sewered residential, 2) residential areas that use subsurface sewage treatment systems (SSTS) for wastewater disposal, and 3) commercial or industrial, and 4) undeveloped. The data collected from the wells in the undeveloped areas provide a baseline to assess the extent of any pollution from all other land use settings.

Water samples from the MPCA's ambient groundwater monitoring network wells generally are collected annually by MPCA staff. This sampling frequency provides sufficient information to determine trends in groundwater quality. The water samples are analyzed to determine the concentrations of over 100 chemicals, including nitrate, chloride, and VOCs.

Information on groundwater monitoring methodology is taken from Kroening and Ferrey's report: The Condition of Minnesota's Groundwater, 2007-2011 (2013). To download ambient groundwater monitoring data, please refer to: https://www.pca.state.mn.us/data/groundwater-data.

Wetland monitoring

The MPCA is actively developing methods and building capacity to conduct wetland quality monitoring and assessment. Our primary approach is biological monitoring—where changes in biological communities may be indicating a response to human-caused impacts. The MPCA has developed Indices of Biological Integrity (IBIs) to monitor the macroinvertebrate condition of depressional wetlands that have open water and the Floristic Quality Assessment to assess vegetation condition in all of Minnesota's wetland types. For more information about the wetland monitoring (including technical background reports and sampling procedures), please visit the MPCA Wetland monitoring and assessment webpage. The MPCA currently does not monitor wetlands systematically by watershed. Alternatively, the overall status and trends of wetland quality in the state and by major ecoregion is being tracked through probabilistic monitoring. Probabilistic monitoring refers to the process of randomly selecting sites to monitor; from which, an unbiased estimate of the resource can be made. Regional probabilistic survey results can provide a reasonable approximation of the current wetland quality in the watershed.

Individual aggregated 12-HUC subwatershed results

Aggregated 12-HUC subwatersheds

Assessment results for aquatic life and recreation use are presented for each Aggregated HUC-12 subwatershed within the Clearwater River Watershed. The primary objective is to portray all the full support and impairment listings within an aggregated 12-HUC subwatershed resulting from the complex and multi-step assessment and listing process. This scale provides a robust assessment of water quality condition at a practical size for the development, management, and implementation of effective TMDLs and protection strategies. The graphics presented for each of the aggregated HUC-12 subwatersheds contain the assessment results from the 2016 assessment cycle as well as any impairment listings from previous assessment cycles. Discussion of assessment results focuses primarily on the 2014 intensive watershed monitoring effort, but also considers available data from the last ten years.

The proceeding pages provide an account of each aggregated HUC-12 subwatershed. Each account includes a brief description of the aggregated HUC-12 subwatershed, and summary tables of the results for each of the following: a) stream aquatic life and aquatic recreation assessments, and b) lake aquatic life and recreation assessments. Following the tables is a narrative summary of the assessment results and pertinent water quality projects completed or planned for the aggregated HUC-12 subwatershed. A brief description of each of the summary tables is provided below.

Stream assessments

A table is provided in each section summarizing aquatic life and aquatic recreation assessments of all assessable stream reaches within the aggregated HUC-12 subwatershed (i.e., where sufficient information was available to make an assessment). Primarily, these tables reflect the results of the 2012 assessment process 2014 EPA reporting cycle); however, impairments from previous assessment cycles are also included and are distinguished from new impairments via cell shading (see footnote section of each table). These tables also denote the results of comparing each individual aquatic life and aquatic recreation indicator to their respective criteria (i.e., standards); determinations made during the desktop phase of the assessment process (see Figure 4). Assessment of aquatic life is derived from the analysis of biological (fish and invert IBIs), DO, total suspended solids, chloride, pH, total phosphorus, chlorophyll-a, biochemical oxygen demand and un-ionized ammonia (NH3) data, while the assessment of aquatic recreation in streams is based solely on bacteria (Escherichia coli) data. Included in each table is the specific aquatic life use classification for each stream reach: cold water community (2A); cool or warm water community (2B); or indigenous aquatic community (2C). Where applicable and sufficient data exists, assessments of other designated uses (e.g., class 7, drinking water, aquatic consumption) are discussed in the summary section of each aggregated HUC-12 subwatershed as well as in the Watershed-wide results and discussion section.

Lake assessments

A summary of lake water quality is provided in the aggregated HUC-12 subwatershed sections where available data exists. This includes aquatic recreation (phosphorus, chlorophyll-a, and Secchi) and aquatic life, where available (chloride and fish IBI). Similar to streams, parameter level and over all use decisions are included in the table.

Upper Clearwater River Aggregated 12-HUC HUC 0902030501-01

The Upper Clearwater River Subwatershed contains the headwaters of the Clearwater River and drains 182 square miles of land within the southeastern portion of the watershed. The Clearwater River originates as a channelized ditch draining from a wetland located southwest of Ebro. The river flows east for a short distance before transitioning to a low gradient natural stream channel. The river turns and flows north for approximately two miles before again turning east. The river continues flowing east through wetlands for approximately five miles before turning northeast near the community of Bagley. The small tributary called Walker Brook joins with the Clearwater River at this location. The Clearwater River then enters an extensive wetland complex located just northeast of Bagley. The river continues flowing northeast for approximately thirteen miles before turning toward the east. Stream gradient increases at this location and the river begins to lose its low gradient character. The river continues east for several miles before transitioning to a rocky, cold-water stream that supports a trout fishery. Near the community of Pinewood, the river turns toward the north and passes under CSAH 22. Stream gradient decreases as the river continues flowing north. After approximately 10 miles, the Clearwater River transitions back to a warm water stream. The river continues winding northward for approximately 5.8 miles before entering Clearwater Lake. The Clearwater River passes through Clearwater Lake and continues flowing west for five miles before entering the next subwatershed. Numerous small tributaries flow into the Clearwater River throughout the subwatershed. Major lakes (> 100 acres) within the subwatershed include Clearwater Lake, Whitefish Lake, and Buzzle Lake. Land use within the subwatershed is primarily forest (55.3 %) followed by rangeland (25.9 %), wetland (9.2 %), developed (4.2 %), open water (2.5 %), and cropland (2.4 %). In 2014, the MPCA collected biological samples from four stations located on two stream segments. Water chemistry was intensively monitored at one station.

Table 2. Aquatic Life and Recreation Assessments on Stream Reaches: Upper Clearwater River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

AUID ***Reach Name*****,** *Reach Description*	**Biological Station ID**	**Reach Length (miles)**	**Use Class**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides ***	Eutrophication	**Aquatic Life**	**Aquatic Rec. (Bacteria)**
09020305-517 **Clearwater River** **Headwaters to T148 R36W S36, east line**	-	30.32	WWg	-	-	EXS	MTS	IF	MTS	MTS	MTS	-	IF	IMP	SUP

09020305-639 **Unnamed creek** **Lk Lomond to Clearwater R**	-	1.46	WWg	-	-	NA	-	-	-	NA	-	-	NA	NA	-
09020305-509 **Walker Brook** **Walker Brook Lk to Clearwater R**	-	5.23	WWg	-	-	EXS	-	MTS	-	MTS	-	-	--	IMP	-
09020305-638 **Unnamed ditch** **Unnamed ditch to Clearwater R**	-	0.39	WWg	-	-	NA	-	-	-	NA	-	-	NA	NA	-
09020305-653 **Clearwater River** **T148 R35W S31, west line to Unnamed cr**	10RD081 14RD273 14RD302 09RD065	11.84	CWg	MTS	MTS	IF	MTS	MTS	MTS	MTS	MTS	-	IF	SUP	SUP
09020305-654 **Clearwater River** **Unnamed cr to Clearwater Lk**	10EM085	5.82	WWg	MTS	MTS	IF	IF	IF	-	IF	IF	-	IF	SUP	-
09020305-649 **Clearwater River** **Clearwater Lk to Unnamed cr**	14RD209	4.90	WWg	MTS	MTS	IF	IF	IF	-	IF	IF	-	IF	SUP	SUP

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: = existing impairment, listed prior to 2014 reporting cycle; = new impairment; = full support of designated use; = insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional,
LRVW = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 3. Lake Assessments for Upper Clearwater River Aggregated 12-HUC.

Lake Name	DNR ID	Area (acres)	Max Depth (ft)	Assessment Method	Ecoregion	Secchi Trend	Aquatic Life Indicators:			Aquatic Recreation Indicators:			Aquatic Life Use	Aquatic Recreation Use
							Fish IBI	Chloride	Pesticides ***	Total Phosphorus	Chlorophyll-a	Secchi		
Long	04-0295-00	85	--	Deep Lake	NLF	--	--	--	--	EX	EX	IF	--	NS
Buzzle	04-0297-00	201	83	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Little Buzzle	04-0298-00	76	40	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Bagley	15-0040-00	104	39	Deep Lake	NCHF	--	--	MTS	--	MTS	MTS	MTS	IF	FS
Clearwater	04-0343-00	997	65	Deep Lake	NLF	NT	MTS	--	--	MTS	MTS	MTS	FS	FS
Funkley	04-0299-00	115	21	Shallow Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Whitefish	04-0300-00	117	30	Deep Lake	NLF	--	MTS	MTS	--	MTS	MTS	MTS	FS	FS
Spring	04-0303-00	20	31	Deep Lake	NLF	--	--	--	--	IF	IF	IF	--	IF
Walker Brook	15-0060-00	93	45	Deep Lake	NLF	NT	MTS	MTS	--	MTS	EX	MTS	FS	FS

Lomond	15-0081-00	93	42	Deep Lake	NLF	NT	MTS	--	--	MTS	MTS	MTS	FS	FS
Minnow	15-0137-00	110	24	Deep Lake	NCHF	--	MTS	MTS	--	MTS	MTS	MTS	FS	FS
Sabe	15-0138-00	49	--	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
First	15-0139-00	59	36	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Second	15-0140-00	71	47	Deep Lake	NLF	--	--	--	--	MTS	EX	MTS	--	FS

Abbreviations for Ecoregion: DA = Driftless Area, NCHF = North Central Hardwood Forest, NGP = Northern Glaciated Plains, NLF = Northern Lakes and Forests, NMW = Northern Minnesota Wetlands, RRV = Red River Valley, WCBP = Western Corn Belt Plains
Abbreviations for Secchi Trend: D = decreasing/declining trend, I = increasing/improving trend, NT = no detectable trend, -- = not enough data
Abbreviations for Indicator Evaluations: -- = No Data, **MTS** = Meets Standard; **EX** = Exceeds Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **FS** = Full Support (Meets Criteria); **NS** = Not Support (Impaired, exceeds standard)
Key for Cell Shading: = existing impairment, listed prior to 2014 reporting cycle; = new impairment; = full support of designated use; = insufficient information.

Summary

Stations 09RD065, 10RD081, 14RD273, and 14RD302 were all located on the cold water designated segment of the Clearwater River that runs from CSAH 17 (Clearline Rd) to the confluence of Unnamed Creek (approx. 0.3 miles north of Aure Rd). Stations 10RD081 and 14RD273 were located furthest upstream near Pinewood. Station 10RD081 was visited in 2010 and station 14RD273 was visited in 2014. Both stations had good FIBI scores. Brown trout, rainbow trout, and mottled sculpin were present at both stations along with moderate numbers of warm water fish species. Both stations had good MIBI scores, with cold water obligate taxa present at both stations. Excellent stream habitat was present within both sampling reaches; the MSHA scores (>75) for the stations were among the highest in the Clearwater River Watershed. Station 14RD302 was located near the middle of the segment off the end of Nelson Dam Road. The 2014 visit FIBI score was good. Temperature data collected from 2014 and 2015 indicate that this station was marginal for trout growth and survival. The fish sample, which consisted primarily of warm water species, contained two brown trout and one rainbow trout. Stream habitat within the sampling reach consisted of sand and sparse cover; no coarse substrate was present. The MIBI score was fair and likely a

Station 10EM085 was located approximately three miles upstream of Clearwater Lake on the segment of the Clearwater River that runs from the confluence of Unnamed Creek to Clearwater Lake. Fish and macroinvertebrates were each sampled once in 2011 and 2015. The FIBI scores were exceptional. Numerous sensitive and lithophilic spawning species were present in both samples. The substrate consisted primarily of sand and silt; limited amounts of coarse substrate were present within the sampling reach. Good cover was present in the form of undercut banks, aquatic vegetation, deep pools, and woody debris. The 2011 visit MIBI score was poor. A low number of taxa were present in the sample and a high percentage of those taxa were tolerant. The same habitat types were sampled in 2015 and the resulting MIBI score was exceptional. Compared to the 2011 sample, 24 more taxa were collected in 2015 and less tolerant taxa were present in the sample.

Station 14RD209 was located three miles downstream of Clearwater Lake on the segment of the Clearwater River that runs from the outlet of Clearwater Lake to the confluence of Unnamed creek. The FIBI score was almost exceptional. Twenty-three species of fish were present in the sample. Good numbers of lithophilic spawning species and several sensitive species were present in the sample. Several types of aquatic vegetation were present within the sampling reach along with good amounts of cover. Some coarse substrate was also present. The MIBI score was good. Good numbers of stoneflies, caddis flies, and mayflies were present in the sample. Lots of mussels were also observed in the sampling reach.

There were two assessable stream segments in the watershed where only water chemistry monitoring was conducted (i.e. biological sampling was not conducted). The segment of the Clearwater River that runs from its headwaters to the Clearwater/Beltrami County line (09020305-517) was found to be impaired for aquatic life. The existing DO impairment on this reach will be retained. DO measurements exceeded the standard in 37.5% of the samples taken during the assessment period, with readings as low as 0.20 mg/L. Walker Brook was originally listed for DO in 2002. Removal of the impairment from the impaired waters list is contingent on a feedlot being in compliance, and the agency has not been able to determine compliance. Phosphorus is elevated in the Clearwater River; however, there was not enough data available to determine if it was causing increased productivity in the stream. *E. coli* data were available from three of the Clearwater River reaches; low levels of bacteria in all of the sampled reaches indicate that they support aquatic recreation.

Fourteen lakes were assessed for aquatic recreation in the subwatershed; five of these lakes were also assessed for aquatic life. Long Lake was the only lake in the Upper Clearwater River Subwatershed that did not meet aquatic recreation standards. TP and chlorophyll-a measurements taken during the assessment period exceeded the NLF ecoregion standard. Second Lake and Walker Brook Lake have elevated chlorophyll-a, but TP and Secchi data from these lakes were meeting the standards. Both of these lakes would benefit from protection efforts that would prevent increases in phosphorus. Clearwater Lake, Whitefish Lake, Walker Brook Lake, Lomond Lake, and Minnow Lake were assessed for aquatic life; all five lakes met aquatic life standards. The FIBI scores on these lakes were positively influenced by several factors, including: low numbers of tolerant and omnivorous species; high numbers of insectivorous species; high numbers and proportions of small benthic species; and high proportions of predator biomass (such as Northern Pike). The FIBI scores were negatively influenced by the lack of intolerant species. FIBI scores in Clearwater Lake, Whitefish Lake, and Minnow Lake were exceptionally high. Species such as the Iowa Darter and Blacknose Shiner were among some of the intolerant species found in the subwatershed. Aquatic plant surveys from all of the analyzed lakes in the subwatershed indicated healthy plant communities.

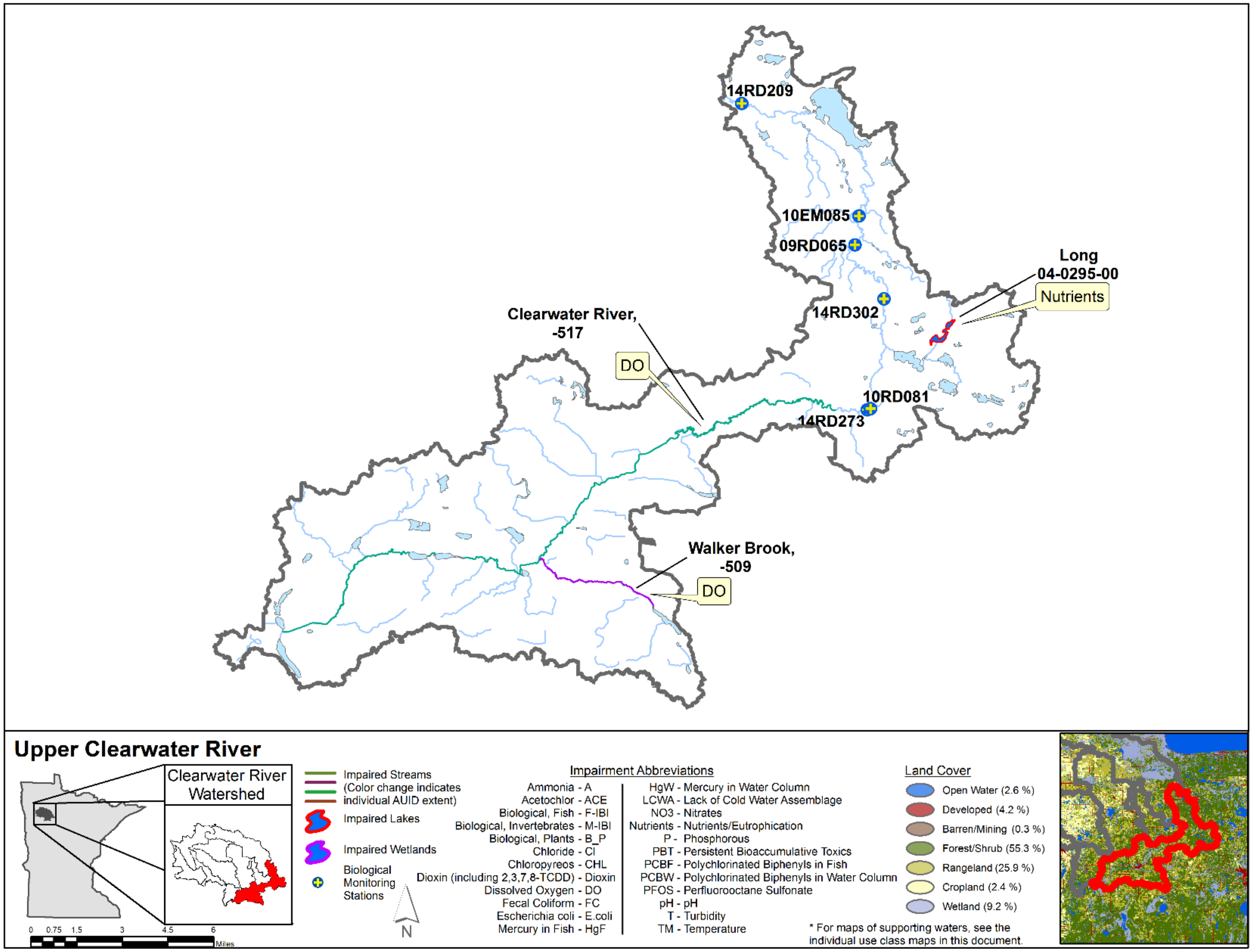

Figure 24. Currently Listed Impaired Waters by Parameter and Land Use Characteristics in the Upper Clearwater Aggregated 12-HUC.

Middle Clearwater River Aggregated 12-HUC HUC 0902030502-01

The Middle Clearwater River Subwatershed drains 251 square miles of land across the northern portion of the Clearwater River Watershed. The Clearwater River enters the southeastern portion of the subwatershed and winds northwest for 12 miles before becoming channelized. The river continues flowing north / northwest for one mile before being joined by the tributary Ruffy Brook. Ruffy Brook originates near Leonard and flows toward the north for 26 miles before joining the Clearwater River. The Ruffy Brook Subwatershed drains 54 square miles of land that is primarily pasture and forest. After the confluence of Ruffy Brook, the Clearwater River continues flowing northwest for one mile and forms the western boundary of the Red Lake Reservation. The river continues northwest for another mile and is joined by the small tributary, Butcher Knife Creek. Butcher Knife Creek flows west through an extensive area of wetland within the Red Lake Reservation before emptying into the Clearwater River. The Clearwater River continues flowing northwest along the reservation for 12 miles before turning toward the west. The river flows west for 17 miles before transitioning back to a natural channel and entering the next subwatershed. An extensive network of ditching occurs throughout the Middle Clearwater River Subwatershed. The numerous ditches drain agricultural land and enter the Clearwater River along most of its 34 mile flow length. Major lakes within the subwatershed include Nels Olson, Fourth, and Spike lakes. Land use within the subwatershed is primarily wetland (32.1 %) followed by forest (24.9 %), rangeland (22.0 %), cropland (16.9 %), developed (2.8 %), and open water (1.2 %). In 2014, the MPCA sampled biology at five monitoring stations located on two stream segments. Water chemistry was intensively monitored at one station.

Table 4. Aquatic Life and Recreation Assessments on Stream Reaches in Middle Clearwater River Aggregated 12-HUC. Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

AUID *Reach Name*, *Reach Description*	Biological Station ID	Reach Length (miles)	Use Class	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides ***	Eutrophication	**Aquatic Life**	**Aquatic Rec. (Bacteria)**
09020305-650 Clearwater River Unnamed cr to Ruffy Bk	14RD208	13.17	WWg	MTS	MTS	MTS	IF	MTS	MTS	MTS	MTS	-	IF	SUP	SUP
09020305-592 Unnamed ditch Unnamed ditch to Unnamed ditch	07RD030	2.51	WWg	-	-	IF	IF	IF	-	IF	IF	-	IF	IF	-
09020305-647 Clearwater River Ruffy Bk to JD 1	14RD200 07RD017 14RD203 14RD205 14RD207	34.62	WWg	MTS	MTS	MTS	EXS	IF	MTS	MTS	MTS	-	EXS	IMP	IMP

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

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

Key for Cell Shading: = existing impairment, listed prior to 2014 reporting cycle; = new impairment; = full support of designated use; = insufficient information.

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

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

Table 5. Lake Water Aquatic Recreation Assessments in Middle Clearwater River Aggregated 12-HUC.

Lake Name	DNR ID	Area (acres)	Max Depth (ft)	Assessment Method	Ecoregion	Secchi Trend	Aquatic Life Indicators: Fish IBI	Aquatic Life Indicators: Chloride	Aquatic Life Indicators: Pesticides ***	Aquatic Recreation Indicators: Total Phosphorus	Aquatic Recreation Indicators: Chlorophyll-a	Aquatic Recreation Indicators: Secchi	Aquatic Life Use	Aquatic Recreation Use
Spike	15-0035-00	84	35	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Nels Olson	15-0037-00	179	--	Deep Lake	NCHF	--	--	--	--	MTS	MTS	MTS	--	FS
Falk	15-0038-00	69	33	Deep Lake	NCHF	--	--	--	--	MTS	MTS	MTS	--	FS
Long	15-0050-00	56	36	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Fourth	15-0062-00	125	12	Shallow Lake	NMW	--	--	--	--	IF	IF	IF	--	IF
Johnson	15-0086-00	59	70	Deep Lake	NLF	--	--	MTS	--	MTS	MTS	MTS	IF	FS

Abbreviations for Ecoregion: DA = Driftless Area, NCHF = North Central Hardwood Forest, NGP = Northern Glaciated Plains, NLF = Northern Lakes and Forests, NMW = Northern Minnesota Wetlands, RRV = Red River Valley, WCBP = Western Corn Belt Plains
Abbreviations for Secchi Trend: D = decreasing/declining trend, I = increasing/improving trend, NT = no detectable trend, -- = not enough data
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Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **FS** = Full Support (Meets Criteria); **NS** = Not Support (Impaired, exceeds standard)
Key for Cell Shading: ☐ = existing impairment, listed prior to 2014 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐= insufficient information.

Summary

All biological monitoring stations on the Clearwater River, except station 14RD208, were located on the 34 mile long channelized portion that extends from the southeast corner of the Red Lake Indian Reservation to the subwatershed boundary. With the exception of 07RD017 (sampled once in 2007), all monitoring stations were visited in 2014. Station 14RD208 was located on the thirteen-mile long natural segment of river in the upstream portion of the subwatershed. Fish were sampled in July and September of 2014. The July visit FIBI score was almost exceptional and the September visit FIBI score was exceptional. Both samples contained a diverse community of 23 species of fish. Almost half of the species present in both samples were lithophilic spawners. Numerous insectivorous species and sensitive species were also present. Coarse substrate, good channel development, and a variety of cover types were present within the sampling reach. The diverse habitat likely contributed to the development of the great macroinvertebrate community at this station. The MIBI score (77.1) was exceptional, and was the highest MIBI score in the Clearwater River Watershed. The macroinvertebrate sample contained 61 unique taxa, including 9 caddis taxa, 10 mayfly taxa, 4 stonefly taxa, and 4 riffle beetle taxa.

Stations 14RD205 and 14RD207 were located on the section of river that borders the Red Lake Reservation. The FIBI score at station 14RD207 was just below passing. The sample contained 25 species of fish and was the most diverse sample in the Clearwater Watershed. An unusually high number of fathead minnows (a very tolerant, generalist species) was present in the sample. The sample also contained several sensitive species, good numbers of lithophilic spawners, and multiple insectivorous species. The fish community indicated support for aquatic life. Habitat within the sampling reach consisted of sand and gravel substrate, woody debris, undercut banks, and fair channel development. The FIBI score at station 14RD205 was good. The fish community and habitat at this station was similar to station 14RD207. MIBI scores at both 14RD205 and 14RD207 were good, with macroinvertebrate communities representative of a healthy stream ecosystem.

Stations 14RD200, 14RD203, and 07RD017 were located along the last 10 miles of river within the western portion of the subwatershed. The FIBI score was good at all of the stations. Good numbers of insectivores and lithophilic spawners along with some sensitive species were present in the samples. Compared to the monitoring stations located further upstream, the stream habitat quality declines at these stations. These stations had fewer cover types, less channel stability, fewer coarse substrate types, and less depth variability than the stations located further upstream. The reduction in habitat complexity may be the result of direct channel modification or the extensive hydrologic alteration (ditching) present in the subwatershed. Numerous ditches enter the Clearwater River between station 14RD205 and 14RD203; as a result, stations located downstream of this ditch network (14RD203, 07RD017, and 14RD200) may be experiencing increased flow volume and flow velocity. The MIBI scores were good at all of the stations. Water chemistry data available from this reach indicate elevated nutrients and sediment levels are present. Total phosphorus and the response variable DO flux exceeded the river nutrient standard and over 10% of TSS samples exceeded the 30 mg/L threshold. This reach will be listed for eutrophication and TSS. This reach has a previous aquatic life impairment due to low DO concentrations. Recent continuous DO monitoring data indicate low DO concentrations are no longer impacting aquatic life. Exceedances of the DO concentration standard occurred in only 1.3% of the early morning measurements; the DO impairment will be removed from this reach. Elevated bacteria levels during the summer months resulted in an aquatic recreation impairment on this reach.

Six lakes within the subwatershed were assessed for aquatic recreation. With the exception of Fourth Lake, all lakes were fully supporting of aquatic recreation. These lakes are all deep, and are able to trap nutrients at depth, preventing summer algal blooms from occurring. Fourth Lake had little data. A single sample from 2010 does indicate that the lake is likely low in nutrients and algae; however, since this basin is shallow any increases in watershed runoff will impact the lake.

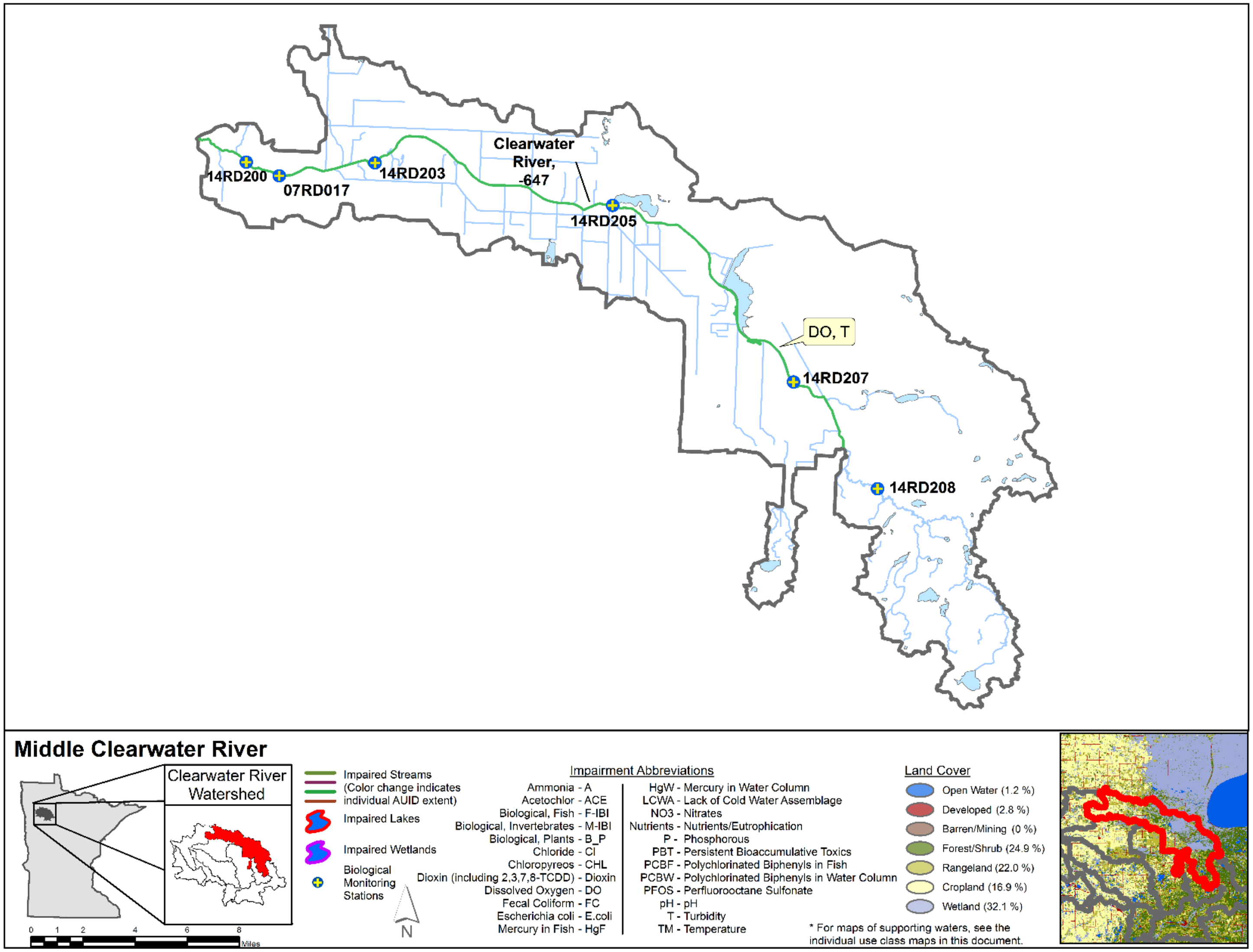

Figure 25. Currently Listed Impaired Waters by Parameter and Land Use Characteristics in the Middle Clearwater River Aggregated 12-HUC.

Lower Clearwater River Aggregated 12-HUC HUC 0902030507-01

The Lower Clearwater River Subwatershed drains 161 square miles of land within the western portion of the Clearwater River Watershed. The Clearwater River transitions from a modified channel to a natural channel as it enters this subwatershed. As the river winds west / southwest, several ditches including County Ditch 31 and Judicial Ditch 41 flow into it. After flowing westward for approximately 8 miles, the river turns toward the southwest. The river continues winding southwest for 12 miles, passing near the community of Plummer before encountering the major tributary known as the Lost River. The Lost River flows for over 40 miles through the central portion of the Clearwater River Watershed. The Upper and Lower Lost River Subwatersheds drain a combined 292 square miles of land. The Hill River and Poplar River also drain into the Lost River just before the Lost River enters the Clearwater River. The Clearwater River receives water from roughly 586 square miles of land or 42% of the total watershed area at this location. After the confluence of the Lost River, the Clearwater River turns and flows west. The river continues west for 11 miles before being joined by the tributary, Terrebonne Creek. County Ditch 4 originates 7 miles south of the Terrebonne Creek headwaters and drains into Terrebonne Creek. Terrebonne Creek then flows northwest for 4.5 miles and empties into the Clearwater River. After the confluence of Terrebonne Creek, the Clearwater River flows toward the north for three miles before being joined by County Ditch 23. The river then turns and winds toward the west for approximately 4 miles before being joined by the tributary, Beau Gerlot Creek. Beau Gerlot Creek actually originates as Upper Badger Creek and flows northwest for 19 miles. The Clearwater River continues west another 1.2 miles and is joined by the tributary Lower Badger Creek. Lower Badger Creek originates near Erskine and flows northwest for 20 miles. The Lower Badger Creek Subwatershed drains 122 square miles of land in the west / southwest portion of the Clearwater River Watershed. After the confluence of Lower Badger Creek, the Clearwater River winds northwest for another 6 miles, passing through Red Lake Falls before emptying into the Red Lake River. There are no major lakes in the watershed. Land use within the subwatershed is primarily cropland (63.1 %) followed by wetland (14.6 %), rangeland (11.5 %), forest (5.6 %), developed (4.5 %), and open water (0.7 %). The MPCA collected biological samples from 7 stations located on five stream segments. Water chemistry was intensively monitored at one station within the Lower Clearwater River Subwatershed.

Table 6. Aquatic Life and Recreation Assessments on Stream Reaches in the Lower Clearwater River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

AUID *Reach Name*, *Reach Description*	Biological Station ID	Reach Length (miles)	Use Class	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides ***	Eutrophication	Aquatic Life	Aquatic Rec. (Bacteria)
09020305-648 **Clearwater River** **JD 1 to Lost R**	14RD262 15RD209 14RD261	25.1	WWg	MTS	MTS	MTS	EXS	IF	-	MTS	MTS	-	IF	IMP	SUP
09020305-508 **County Ditch 57** **Unnamed ditch to Clearwater R**	-	0.36	WWg	-	-	IF	IF	-	-	IF	IF	IF	IF	IF	IF
09020305-511 **Clearwater River** **Lost R to Beau Gerlot Cr**	14RD271	11.76	WWg	MTS	MTS	IF	EXS	IF	-	MTS	MTS	-	MTS	IMP	SUP
09020305-658 **County Ditch 23** **-96.1479 47.8855 to Clearwater R**	14RD260 16RD050	1.98	WWg	EXS	-	IF	IF	IF	-	IF	IF	-	IF	IMP	-
09020305-651 **Beau Gerlot Creek** **Upper Badger Cr to -96.1947 47.8413**	-	8.26	WWg	-	-	IF	MTS	-	-	IF	MTS	-	MTS	IF	IMP
09020305-652 **Beau Gerlot Creek** **-96.1947 47.8413 to Clearwater R**	14RD255	2.02	WWg	EXS	EXS	IF	IF	IF	-	IF	IF	-	IF	IMP	IF
09020305-574 **Terrebonne Creek** **CD 4 to CD 58**	-	3.23	WWg	-	-	MTS	MTS	IF	-	MTS	MTS	-	MTS	IF	IMP
09020305-501 **Clearwater River** **Lower Badger Cr to Red Lake R**	94RD512	7.17	WWg	MTS	MTS	MTS	EXS	IF	MTS	MTS	MTS	-	MTS	IMP	SUP

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

Summary

Stations 14RD262, 15RD209, and 14RD261 were located on the segment of the Clearwater River that extends from Judicial Ditch One (upstream subwatershed boundary) to the Lost River. Station 14RD262 was located furthest upstream, about 2 miles northeast of Plummer. The 2014 visit FIBI score was good. Numerous insectivores and lithophilic spawners as well as several sensitive species were present in sample. Good habitat, including cobble riffles and a variety of cover types, was present within the sampling reach. The MIBI score was good. The macroinvertebrate sample contained 4 riffle beetle taxa, 3 stonefly taxa, 10 mayfly taxa, and 7 caddis fly taxa. Station 15RD209 was located one mile north of Plummer. This station is part of a long term biological monitoring site network and was sampled in 2015. The FIBI score met exceptional use criteria and was the third highest FIBI score in the Clearwater River Watershed. The fish sample contained good numbers of sensitive species, insectivores, and lithophilic spawners. Cobble and gravel substrate was present throughout the sampling reach along with sparse amounts of woody debris and aquatic vegetation. The MIBI score was almost exceptional and was the second highest MIBI score in the Clearwater River Watershed. The diverse macroinvertebrate sample contained 55 unique taxa, including 13 caddis fly taxa, 2 stonefly taxa, and 6 mayfly taxa. Several sensitive taxa were present. Station 14RD261 was located 3.5 miles upstream of the confluence of the Lost River and Clearwater River. The FIBI score met exceptional use criteria. Numerous insectivores and lithophilic spawners as well as several sensitive species were present in sample. Stream habitat consisted of gravel and sand substrate, woody debris, and sparse amounts of aquatic vegetation. The MIBI score was good. The macroinvertebrate sample had good diversity and contained 10 caddis fly taxa, 4 riffle beetle taxa, 2 stonefly taxa, and 11 mayfly taxa. This reach of the Clearwater River was previously listed as impaired for aquatic life due to low dissolved oxygen concentrations. Current water chemistry data available on this reach indicate DO concentrations no longer exceed the standard. The DO impairment will be removed from this reach. Phosphorus was elevated, but there was not data available to determine if productivity (algal growth or excess vegetation) was an issue. Excessive sediment levels were found at locations on the Clearwater River resulting in a new impairment for total suspended solids.

Station 14RD271 was located on the segment of the Clearwater River that extends from the confluence of the Lost River to the confluence of Beau Gerlot Creek. The station was approximately 2.5 miles downstream of the confluence of the Lost River and Clearwater River. The FIBI score met exceptional use criteria. The fish sample, which contained 21 species of fish, had high numbers of sensitive and lithophilic spawning species. Extensive cobble riffle habitat, several cover types, and good channel development was present within the sampling reach. The MIBI score was good. The sample contained 58 unique taxa, including 4 stonefly taxa, 11 caddis fly taxa, and 16 mayfly taxa. Despite good biology scores and sufficient habitat, TSS was found to be impaired along this reach. Eutrophication met standards on this reach, indicating that productivity (excess algae or rooted vegetation) was not impacting aquatic life. Bacteria counts along this reach were low; recreation use is supported.

Station 14RD260 was located on County Ditch 23. The 2014 visit FIBI score was poor. The sample contained only nine fish that were mostly tolerant and generalist species. Stream habitat consisted of a variety of cover types, small patches of coarse substrate, and good channel development. Habitat does not appear to be a limiting factor. Macroinvertebrates were not sampled at station 14RD260 due to insufficient flow later in the summer. In 2016, additional monitoring was conducted on County Ditch 23 approximately 0.35 miles upstream of the confluence of the Clearwater River. The FIBI was poor and the fish community was very similar to the community at 14RD260. This reach is impaired for aquatic life based on the fish community.

Station 14RD255 was located on Beau Gerlot Creek, approximately 1.3 miles upstream of its confluence with the Clearwater River. Fish were sampled in 2014 and 2015; both visit FIBI scores were very poor (the 2015 FIBI score was 0). Both samples contained low numbers of fish and were dominated by tolerant individuals. Good habitat, including cobble riffles and wide variety of cover types, was present throughout the reach. Habitat was not a limiting factor. Macroinvertebrates were also sampled in 2014 and 2015; both visit MIBI scores were poor. Tolerant black flies and midges dominated the macroinvertebrate sample. Bank sloughing and channel incision, both indications of excess flow velocity / volume, were present within the reach. Hydrologic alterations within the Beau Gerlot Creek watershed may be having a negative effect on the biology at station 14RD255. The reach is impaired for aquatic life based on the fish and macroinvertebrate community. Water chemistry data available on the upstream portion of Beau Gerlot Creek (-651) did indicate that eutrophication and sediment were meeting standards. Bacteria concentrations were elevated during the summer months; as a result, this upper reach is impaired for aquatic recreation.

Station 94RD512 was the furthest downstream station on the Clearwater River, located approximately 1.1 miles from its confluence with the Red Lake River. The 2014 visit FIBI score met exceptional use criteria and was the highest FIBI score in the Clearwater River Watershed. Over 50% of the taxa present in the fish sample were insectivores; 40% of the total individuals in the sample were sensitive species. Fairly extensive riffle habitat, coarse substrate, woody debris, and good channel development were present within the sampling reach. The MIBI score was good. The macroinvertebrate sample had good diversity and included some sensitive EPT taxa. Dissolved oxygen and eutrophication met their respective standards, which help promote the healthy aquatic community observed. Though IBI scores were good, the TSS data indicated an aquatic life use impairment (similar to the other two reaches of the Clearwater in this subwatershed). This might be a sign that impacts to the biotic community have not yet been realized. Recreation use is supported on the Clearwater River; bacteria levels were low.

Water chemistry data was available on County Ditch 57 and Terrebonne Creek; no biological data was collected from these water bodies. County Ditch 57 is intermittent and often goes stagnant; however, dissolved oxygen concentrations still exceed the standard when the stream has flow. The 2002 DO impairment on County Ditch 57 will remain. Terrebonne Creek had data from a 2015 sonde deployment indicate daily minimum DO concentration values do occasionally fall below the standard. While this does not indicate impairment, it is close to the impairment threshold. Terrebonne Creek exhibited excess *E. coli* concentrations throughout summer months (some extreme values were observed); this confirmed the preexisting aquatic recreation impairment on this reach.

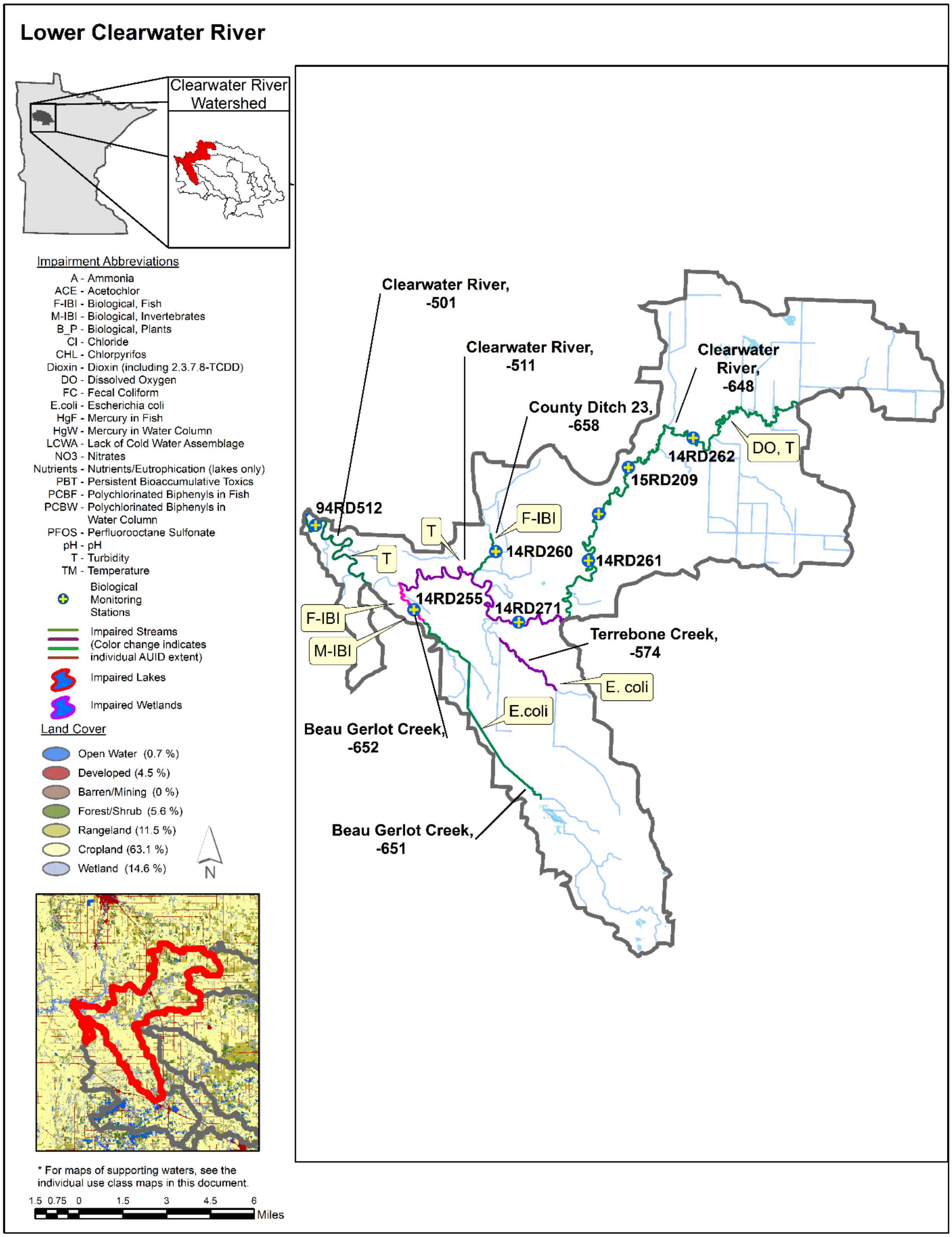

Figure 26. Currently Listed Impaired Waters by Parameter and Land Use Characteristics in the Lower Clearwater River Aggregated 12-HUC.

Ruffy Brook Aggregated 12-HUC

HUC 0902030502-02

The Ruffy Brook Subwatershed drains 54 square miles of land within the eastern portion of the Clearwater River Watershed. Ruffy Brook originates from a wetland located east of CSAH 47, approximately 5.2 miles northeast of Bagley. The stream passes under CSAH 47 and flows northeast through a series of wetland ponds before entering Solberg Lake. Ruffy Brook exits Solberg Lake and winds north for 2.2 miles before turning toward the northwest. The stream flows northwest for 2.2 miles before turning back toward the north. The stream continues winding north/northwest for approximately 8.5 miles before becoming a channelized stream. Ruffy Brook continues north as a channelized stream for 2 miles before transitioning back to a natural channel. The stream continues north for one mile and empties into the Clearwater River. Numerous small, unnamed tributaries flow into Ruffy Brook along its 26 mile flow length. Three prominent lakes are in the watershed; East and West Four-Legged and Peterson. Land use within the subwatershed is primarily forest (44 %) followed by rangeland (33.5 %), wetland (9.8 %), cropland (5.6 %), developed (4.4 %), and open water (2.6 %). In 2014, the MPCA collected biological samples from two stations located on one stream segment. Water chemistry was monitored at one location in the Ruffy Brook Subwatershed.

Table 7. Aquatic Life and Recreation Assessments on Stream Reaches in the Ruffy Brook Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

AUID *Reach Name*, *Reach Description*	**Biological Station ID**	**Reach Length (miles)**	**Use Class**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia $-NH_3$	Pesticides ***	Eutrophication	**Aquatic Life**	**Aquatic Rec. (Bacteria)**
09020305-513 **Ruffy Brook** **Headwaters to Clearwater R**	14RD303 14RD234	26.41	WWg	MTS	MTS	MTS	MTS	MTS	MTS	MTS	MTS	-	IF	SUP	IMP

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: = existing impairment, listed prior to 2014 reporting cycle; = new impairment; = full support of designated use; = insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 8. Lake Assessments in Ruffy Brook Aggregated 12-HUC.

Lake Name	DNR ID	Area (acres)	Max Depth (ft)	Assessment Method	Ecoregion	Secchi Trend	Aquatic Life Indicators:			Aquatic Recreation Indicators:			Aquatic Life Use	Aquatic Recreation Use
							Fish IBI	Chloride	Pesticides ***	Total Phosphorus	Chlorophyll-a	Secchi		
East Four-Legged	15-0027-00	261	5.9	Shallow Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
West Four-Legged	15-0028-00	402	15	Shallow Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Peterson	15-0083-00	100	74	Deep Lake	NCHF	--	--	MTS	--	MTS	MTS	MTS	IF	FS

Abbreviations for Ecoregion: DA = Driftless Area, NCHF = North Central Hardwood Forest, NGP = Northern Glaciated Plains, NLF = Northern Lakes and Forests, NMW = Northern Minnesota Wetlands, RRV = Red River Valley, WCBP = Western Corn Belt Plains
Abbreviations for Secchi Trend: D = decreasing/declining trend, I = increasing/improving trend, NT = no detectable trend, -- = not enough data
Abbreviations for Indicator Evaluations: -- = No Data, **MTS** = Meets Standard; **EX** = Exceeds Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **FS** = Full Support (Meets Criteria); **NS** = Not Support (Impaired, exceeds standard)
Key for Cell Shading: = existing impairment, listed prior to 2014 reporting cycle; = new impairment; = full support of designated use; = insufficient information.

Summary

Stations 14RD234 and 14RD303 were located on Ruffy Brook; both were visited for fish and macroinvertebrates in 2014. Station 14RD303 was located farthest upstream, approximately 3.5 miles southeast of Clearbrook. The FIBI score was good. The two most abundant species sampled were tolerant and generalist species; however, good numbers of sensitive, headwaters species were also present. Excellent habitat present within the sampling reach produced one of the highest MSHA scores (75.4) in the Clearwater River Watershed. Good channel development, a variety of cover types, and boulder/cobble riffle habitat was present within the sampling reach. The MIBI score met exceptional use criteria. Many sensitive caddis fly taxa were present in the sample along with several cold water taxa (suggesting groundwater influence). Station 14RD234 was located approximately 7 miles upstream of the confluence of the Clearwater River. The FIBI score was good. The fish sample was similar to the sample collected at station 14RD234. Like station 14RD234, the stream habitat at station 14RD303 was excellent. The MSHA score (82.75) was the highest in the Clearwater River Watershed. Extensive riffle habitat, excellent channel development, and a variety of cover types (including undercut banks and deep pools) were present within the sampling reach. Though passing, the MIBI score at this station was considerably lower than the score at station 14RD303. Compared to the sample from station 14RD303, the sample from 14RD234 contained less caddis fly taxa and no odonate taxa. Several cold water taxa were also present in this sample. Phosphorus concentrations were elevated along this reach. Daily flux values for oxygen indicate the productivity is not causing an oxygen sag on this reach. Other data available on Ruffy Brook suggest that water chemistry is not limiting aquatic life. High levels of bacteria were present– confirming an existing aquatic recreation impairment from 2008.

Three lakes in the Ruffy Brook Subwatershed were assessed for aquatic recreation– all were found to be meeting their respective ecoregion lake standards. Peterson Lake is a deep lake, with wetland and forest on the ends of the lake and pasture/crop and development along the middle of the lake. Deep lakes can assimilate phosphorus at depth, and limit algae blooms. Work should be done to ensure buffers and shoreline habitat are intact. According to local management plans, East and West Four-Legged Lakes will be utilized as flood damage reduction projects to impound water during high water events. It should be noted that shallow basins are more likely to produce algae, as the bottom sediments can resuspend nutrients into the water column throughout the summer.

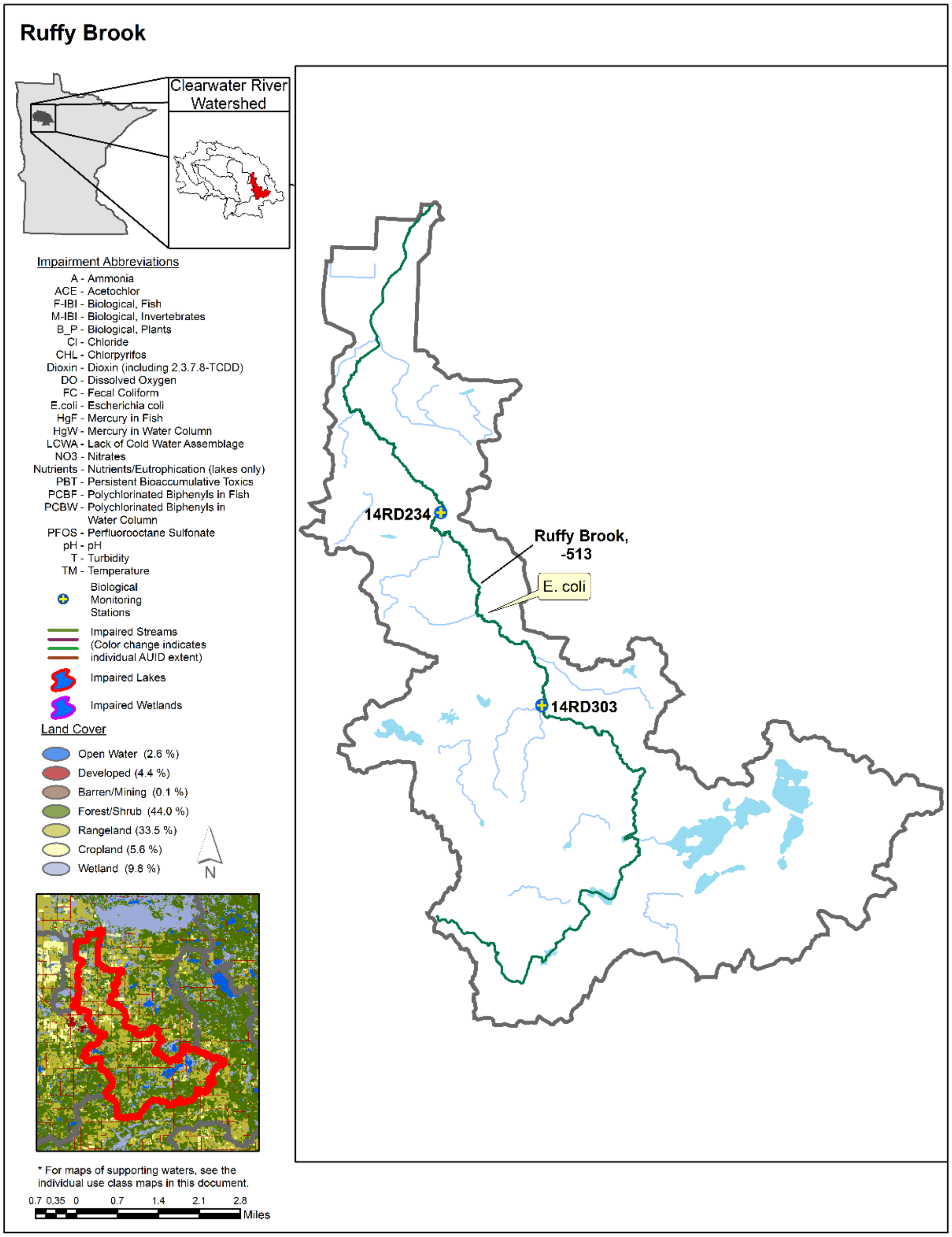

Figure 27. Currently Listed Impaired Waters by Parameter and Land Use Characteristics in the Ruffy Brook Aggregated 12-HUC

Upper Lost River Aggregated 12-HUC HUC 0902030505-02

The Upper Lost River Subwatershed drains 163 square miles of land within the east-central portion of the Clearwater River Subwatershed. The Lost River originates from a wetland located approximately 6 miles southwest of Clearbrook. At its headwaters, several small unnamed tributaries converge with the Lost River as the stream winds west/northwest. The river continues flowing west/northwest for approximately 4.2 miles before turning toward the north. After flowing north for 5.5 miles, the river enters a shallow lake called Pine Lake. The river passes through Pine Lake and continues north for 7.5 miles before entering a small wetland pond called Anderson Lake. Many small, unnamed tributaries join with the Lost River between Pine Lake and Anderson Lake. Silver Creek, a 19-mile long tributary that drains 32 square miles of land, also flows into Anderson Lake. Silver Creek originates near the headwaters of the Lost River and flows north. The Lost River exits Anderson Lake as a modified channel and continues flowing mainly toward the northwest. After flowing northwest for 3 miles, the river enters a part of the subwatershed that has extensive hydrologic alteration (primarily ditching). The river continues northwest for 4 miles and then turns toward the west. The river flows west for 4.5 miles and passes into the Lower Lost River Subwatershed. Numerous ditches enter the Lost River from both the north and south along the last 4.5-mile long segment. Land within the subwatershed is primarily rangeland (35.5 %), followed by forest (27.5 %), cropland (17.5 %), wetland (12.4%), developed (4.7 %), and open water (2.3 %). The communities of Gonvick and Clearbrook are within the subwatershed. There are six lakes in this subwatershed with monitoring data; the most prominent being Pine Lake, in Clearwater County. In 2014 and 2015, the MPCA collected biological samples from 9 monitoring stations. Water chemistry was intensively monitored at two stations within the Upper Lost River Subwatershed.

Table 9. Aquatic Life and Recreation Assessments on Stream Reaches in Upper Lost River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

AUID ***Reach Name***, *Reach Description*	Biological Station ID	Reach Length (miles)	Use Class	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides ***	Eutrophication	**Aquatic Life**	**Aquatic Rec. (Bacteria)**
09020305-530 **Lost River** **Unnamed cr to T148 R38W S20, north line**	14RD299	4.46	WWg	MTS	-	EXS	IF	MTS	-	MTS	IF	-	IF	IMP	IMP

09020305-545 **Unnamed creek (Nassett Creek)** **T148 R38W S28, south line to Lost R**	-	1.65	WWg	-	-	EXS	-	EXS	-	MTS	-	-	--	IMP	IMP
09020305-626 **Unnamed creek (Lost River Tributary)** **Headwaters (Hegre Lk 15-0145-00) to Lost R**	-	1.82	WWg	-	-	NA	-	-	-	NA	-	-	--	NA	-
09020305-529 **Lost River** **T148 R38W S17, south line to Pine Lk**	15EM066	9.87	WWg	MTS	MTS	EXS	MTS	MTS	-	MTS	MTS	-	IF	IMP	IMP
09020305-512 **Lost River** **Pine Lk to Anderson Lk**	14RD230	10.23	WWg	MTS	MTS	MTS	MTS	MTS	MTS	MTS	MTS	-	MTS	SUP	IMP
09020305-572 **Unnamed creek** **Headwaters to Unnamed cr**	-	1.46	WWg	-	-	IF	IF	IF	-	IF	-	-	IF	IF	IF
09020305-526 **Unnamed Creek (Clear Brook)** **Headwaters to Silver Cr**	-	1.68	WWg	-	-	EXS	MTS	IF	-	MTS	MTS	-	MTS	IMP	IMP
09020305-527 **Silver Creek** **Headwaters to Anderson Lk**	15EM098 14RD235 14RD231	15.65	WWg	MTS	EXS	MTS	MTS	MTS	MTS	MTS	MTS	-	IF	IMP	IMP
09020305-645 **Lost River** **Anderson Lk to Unnamed cr**	07RD024 14RD226	12.27	WWg	EXS	MTS	EXS	MTS	MTS	MTS	MTS	MTS	-	MTS	IMP	SUP
09020305-643 **Unnamed ditch** **Unnamed ditch to Lost R**	14RD228	1.17	WWg	MTS	-	IF	IF	IF	-	IF	IF	-	IF	SUP	-

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
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Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional,
LRVW = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 10. Lake Assessments in the Upper Lost River Aggregated 12-HUC.

Lake Name	DNR ID	Area (acres)	Max Depth (ft)	Assessment Method	Ecoregion	Secchi Trend	Aquatic Life Indicators:			Aquatic Recreation Indicators:			Aquatic Life Use	Aquatic Recreation Use
							Fish IBI	Chloride	Pesticides ***	Total Phosphorus	Chlorophyll-a	Secchi		
Lone	15-0104-00	71	70	Deep Lake	NCHF	NT	--	--	--	MTS	MTS	MTS	--	FS
Deep	15-0090-00	45	76	Deep Lake	NCHF	--	--	--	--	MTS	MTS	MTS	--	FS
Lindberg	15-0144-00	88	19	Deep Lake	NCHF	--	--	--	--	MTS	MTS	MTS	--	FS
Pine	15-0149-00	1240	15	Shallow Lake	NCHF	NT	IF	--	--	MTS	MTS	MTS	IF	FS
Stony	15-0156-00	67	--	Shallow Lake	NCHF	--	--	--	--	EX	EX	MTS	--	NS
Unnamed	15-0293-00	17	14	Shallow Lake	NCHF	--	--	--	--	IF	IF	IF	--	IF

Abbreviations for Ecoregion: DA = Driftless Area, NCHF = North Central Hardwood Forest, NGP = Northern Glaciated Plains, NLF = Northern Lakes and Forests, NMW = Northern Minnesota Wetlands, RRV = Red River Valley, WCBP = Western Corn Belt Plains
Abbreviations for Secchi Trend: D = decreasing/declining trend, I = increasing/improving trend, NT = no detectable trend, -- = not enough data
Abbreviations for Indicator Evaluations: -- = No Data, **MTS** = Meets Standard; **EX** = Exceeds Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **FS** = Full Support (Meets Criteria); **NS** = Not Support (Impaired, exceeds standard)
Key for Cell Shading: ☐ = existing impairment, listed prior to 2014 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐= insufficient information.

Summary

Station 14RD299 was located on an upper segment (09020305-530) of the Lost River. The station was sampled for fish in 2014 and 2015. The 2014 visit FIBI was poor. Numerous tolerant species were present in the fish sample along with few lithophilic spawning species and no sensitive species. The sample was collected early during the sampling season and a late spring occurred in 2014. The FIBI score from 2015 was good. Higher numbers of lithophilic spawning species were present along with one sensitive, headwaters species (northern redbelly dace). Shifting sand and silt substrate was present throughout the sampling reach; coarse substrate (cobble) was severely embedded. Limited amounts of cover, including deep pools and woody debris, were available. Bank failures were occurring at several locations within the sampling reach. The loose, shifting sediment and bank failures are indicators of low channel stability. Excess sedimentation is likely having a negative effect on biology at this location. Macroinvertebrates were not sampled at station 14RD299 due to insufficient flow later in the year.

Station 15EM066 was located on the 9.8-mile long segment of the Lost River that runs from CSAH 18 to Pine Lake. The 2015 visit FIBI almost met exceptional use criteria. The fish sample contained moderate numbers of simple lithophilic spawning species and insectivorous species, along with two sensitive headwaters species. Habitat within the sampling reach was indicative of a low gradient stream – fine substrate, slow flow velocity, and abundant aquatic vegetation. The MIBI score (74) met exceptional use criteria, and was one of the highest scores in the Clearwater River Watershed. The macroinvertebrate sample contained good numbers of sensitive caddisfly taxa.

Station 14RD230 was located on the 10-mile long segment of the Lost River that runs from Pine Lake to Anderson Lake. The 2014 visit FIBI was good. Good numbers of insectivorous species and lithophilic spawners were present in the sample. Three blackchin shiners (a sensitive, intolerant species) were collected at this station, which is rare occurrence is this watershed. Riffle habitat, several forms of coarse substrate, and good channel development were present in the sampling reach. The macroinvertebrate sample was dominated by tolerant simulids (black flies); however, the MIBI score was still good. The abundance of simulids was likely due to the sample being collected in late July. Water chemistry data available on this reach indicate DO concentrations support aquatic life. Total phosphorus had a mean concentration of 38.4 ug/L, which easily meets the standard. Due to higher concentrations of *E. coli*, this reach will be impaired for aquatic recreation.

Stations 07RD024 and 14RD226 were located on the channelized portion of the Lost River that extends from Anderson Lake to unnamed creek (09020305-645). Station 07RD024 was located furthest upstream near Gully. Fish and macroinvertebrates were sampled in 2007 and 2014. The 2014 visit FIBI score was considerably higher than the 2007 FIBI score; however, both scores were poor. Both fish samples contained high numbers of serial spawning species along with moderate numbers of tolerant species. More sensitive species and insectivores were present in the 2014 fish sample. Stream habitat within the sampling reach consisted of unstable sand and gravel substrate along with sparse amounts of cover. Channel stability was ranked low on this sampling reach. Both the 2007 and the 2014, MIBI scores were good. The 2007 MIBI score was significantly higher than the 2014 score because more habitat types were sampled. Lower water levels during 2014 made some habitat types inaccessible to invertebrates. Station 14RD226 was located on the far downstream edge of the subwatershed. The 2015 visit FIBI score was poor. The fish sample was dominated by black bullhead (a tolerant, generalist species). Three other tolerant species were present in low numbers. The sample did contain five sensitive species but all were present in low numbers. Macroinvertebrates were not sampled at this station since it was too deep to wade. This segment of the Lost River is impaired for aquatic life due to the poor fish communities present at both monitoring stations. Water chemistry data available on this reach indicate that the DO concentration routinely exceeds the 5 mg/L standard; this indicates an impairment for aquatic life. Bacteria levels remained below the standard; this reach supports aquatic recreation.

Stations 14RD231, 14RD235, and 15EM098 were located on Silver Creek. Station 15EM098 was located furthest upstream near CSAH 6, approximately one mile southwest of Clearbrook. The 2015 visit FIBI score was low but passing. The most abundant species present in the sample (creek chub) was a generalist species. Good numbers of lithophilic spawners were also present. Stream habitat within the sampling reach included several coarse substrate types, riffle habitat, and multiple cover types. The channel at this location was deeply incised. The MIBI score almost attained exceptional use criteria. Several sensitive mayfly and caddis fly taxa were present in the macroinvertebrate sample. Station 14RD235 was located one mile downstream of station 15EM098. The 2014 visit FIBI score was good, despite high numbers of central mudminnows and creek chubs (tolerant and generalist species) in the fish sample. Good numbers of lithophilic spawners along with a few sensitive species helped support a passing FIBI score. The stream habitat at this station was similar to the habitat found at station 15EM098 although there was less coarse substrate. The channel in this sampling reach was also deeply incised. The MIBI score was poor. The macroinvertebrate sample was dominated by tolerant midge taxa. Station 14RD231 was located one mile upstream of Anderson Lake. The 2014 visit FIBI score was good. The fish community was similar to the community found at station 14RD235. Compared to the upstream stations, the stream habitat at this sampling reach contained more coarse substrate; more cover types, and more riffle habitat. Similar to the other sites in this reach, the channel was deeply incised. Macroinvertebrates were sampled at this station in 2014 and 2016; both samples fail the MIBI. The 2014 macroinvertebrate sample was dominated by tolerant chironomidae (midge) taxa and mayfly taxa. The 2016 macroinvertebrate sample contained higher numbers of tolerant taxa from several orders. This segment of Silver Creek is impaired for aquatic life based on the MIBI scores. Water chemistry data available on this segment indicate total phosphorus concentration far exceeds the standard. High dissolved oxygen flux was also observed; additional monitoring would help confirm if eutrophication is impacting aquatic life on this reach. High levels of bacteria were found on this reach, confirming the existing aquatic recreation impairment from 2006.

Station 14RD228 was located on an unnamed ditch (trib to Lost River) approximately five miles northwest of Gully. The 2014 visit FIBI score was good. The fish sample contained a good number of lithophilic spawning species, several insectivores, and two sensitive species. Stream habitat within the sampling reach was poor – most coarse substrate was severely embedded, channel development was poor, and filamentous algae was covering most vegetation. Surprisingly, the MIBI score was good. The macroinvertebrate sample contained 42 unique taxa, including some sensitive caddisfly and mayfly taxa.

Ten stream reaches in the Upper Lost River Subwatershed have chemistry data available over the assessment period. Low DO is a recurring aquatic life use impairment in this subwatershed. Three of the four assessed reaches of the Lost River, Clear Brook, and Nassett Creek were determined to be impaired for DO. The surrogate TSS data also suggested that Nassett Creek has a sediment problem and is considered impaired for TSS. Excess bacteria is a common problem in the Upper Lost River Subwatershed as well. Of the eight reaches that have *E. coli* data, six (i.e. Silver Creek, Clear Brook, Nassett Creek, and three reaches of the Lost River) had bacteria levels during the summer months that were over the standard.

Six lakes were assessed for aquatic recreation in the Upper Lost River Subwatershed. Stony lake was the only lake determined to be impaired for aquatic recreation. TP and chlorophyll-a both were well over the NCHF ecoregion standard with concentrations of 136 ug/L and 46.1 ug/L, respectively. This is a shallow lake, with limited buffer and considerable crop land in the immediate watershed. Internal loading, caused by wind mixing, will keep phosphorus available all summer at the surface and promote algal blooms. Many of the lakes in this watershed are shallow, it will be important to address watershed contributions of phosphorus help minimize the impacts of internal loading.

Pine Lake was sampled to determine aquatic life support. A number of tolerant species were found in the fish survey, such as Common Carp, which resulted in a poor FIBI score. The age structure of some species in the fish community suggest there was a partial winterkill on Pine, and there was low success in sampling the nearshore habitat. As a result, it was determined that there was not sufficient information to assess for aquatic life. The aquatic plant survey on Pine Lake indicates a healthy plant community.

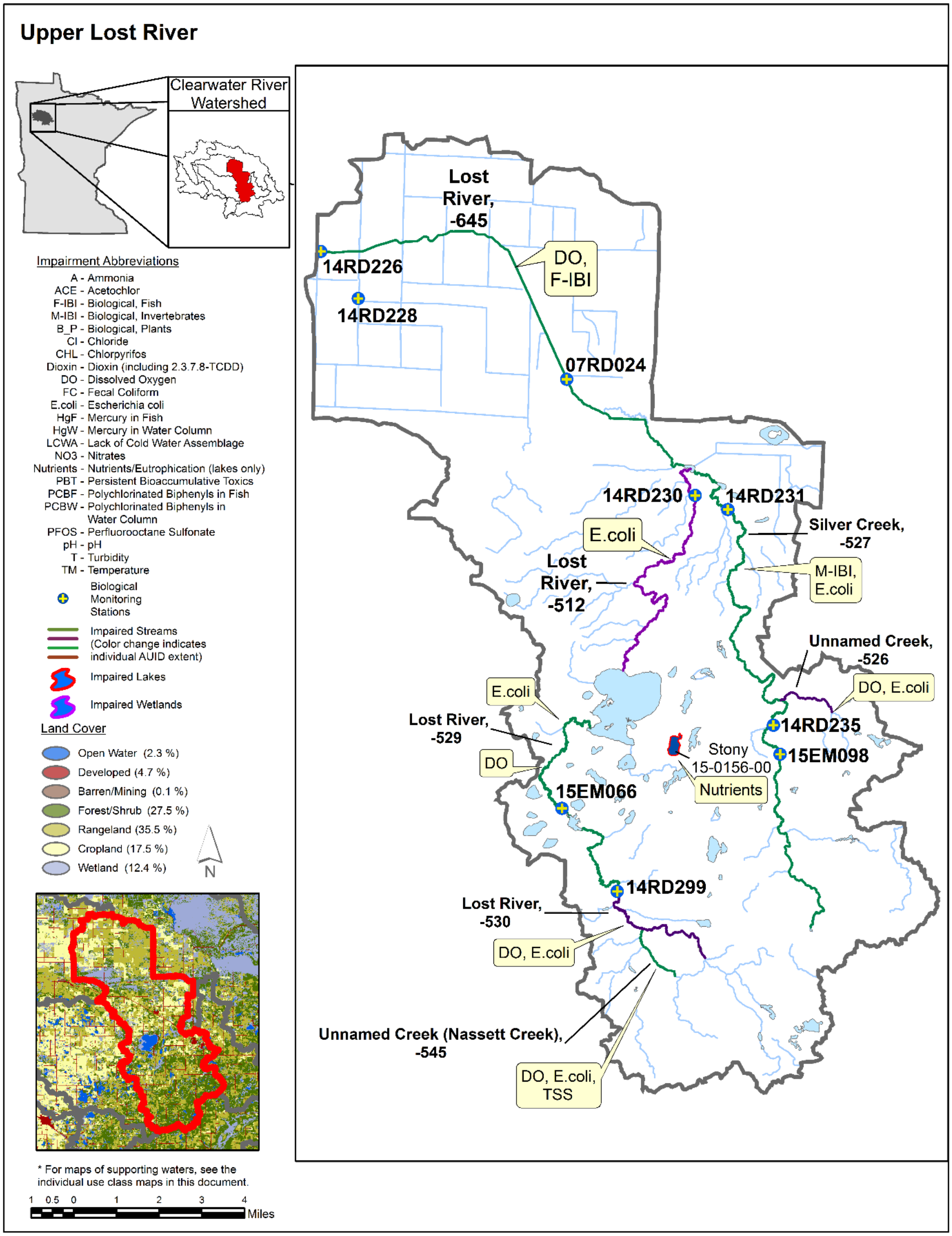

Figure 28. Currently Listed Impaired Waters by Parameter and Land Use Characteristics in the Upper Lost River Aggregated 12-HUC.

Lost River Aggregated 12-HUC HUC 0902030505-01

The Lower Lost River Subwatershed drains 129 square miles of land within the central portion of the Clearwater River Watershed. The Lost River crosses the eastern edge of the subwatershed and flows west for 10 miles before transitioning from a modified channel to a natural channel. The Lost River continues winding west for approximately 13 miles before being joined by a large tributary called the Hill River. The Hill River flows from southeast to northwest for 34 miles and drains a 177 square mile subwatershed. After the confluence of the Hill River, the Lost River continues flowing west for another 1.8 miles before being joined by the tributary called the Poplar River. The Poplar River flows from southeast to northwest for 53 miles and drains a 116 square mile subwatershed. The Lost River flows northwest for 1 mile after the confluence of the Poplar River and enters the Clearwater River. Numerous ditches enter the Lost River from the north and south along its entire 32 mile flow length. Land within the subwatershed is primarily cropland (55.1 %) followed by rangeland (19.6 %), wetland (11.9 %), forest (7.9 %), developed (4.6 %), open water (0.6 %), and barren (0.2 %). The communities of Trail, Gully, and Oklee are within the subwatershed. In 2014, the MPCA collected biological samples from three monitoring stations located on one stream segment. Water chemistry was intensively monitored at one station in the Lower Lost River Subwatershed.

Table 11. Aquatic Life and Recreation Assessments on Stream Reaches in the Lower Lost River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

AUID ***Reach Name,*** *Reach Description*	Biological Station ID	Reach Length (miles)	Use Class	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides ***	Eutrophication	**Aquatic Life**	**Aquatic Rec. (Bacteria)**
09020305-646 **Lost River** **Unnamed cr to Hill R**	14RD225 05RD046 05RD061 14RD259	28.75	WWg	MTS	MTS	MTS	MTS	IF	MTS	MTS	MTS	-	MTS	SUP	SUP

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: ☐ = existing impairment, listed prior to 2014 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐= insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Summary

Stations 14RD259, 14RD225, 05RD046, and 05RD061 were located on the segment of the Lost River that extends from Unnamed creek to the confluence of the Hill River and Lost River. Station 14RD225 was located furthest upstream, approximately four miles east of Oklee. The 2014 visit FIBI score was low but met the aquatic life goal. The diverse fish sample of 22 species contained moderate numbers of generalist species, serial spawning species, and insectivorous species. The sample also contained a number of sensitive species. Sparse amounts amount of woody debris and aquatic vegetation were present within the sampling reach. Most of the substrate consisted of sand with limited areas of gravel and cobble. The MIBI score was good. The macroinvertebrate sample contained sensitive taxa from the orders Ephemeroptera, Trichoptera, and Plecoptera. Station 05RD046 was located approximately 1.5 miles west of Oklee. The station was sampled for fish twice in 2006 and once in 2015. All FIBI scores are passing; however, the fish community really changes from 2006 to 2015. Only 10 species of fish were collected in 2015 (as compared to 17 in 2006). The 2015 fish sample contained much lower numbers of lithophilic spawners and fewer sensitive species. A comparison between the 2006 and 2015 MSHA data indicates sedimentation may be occurring within this sampling reach. Further investigation (including geomorphological work) will be conducted at this station to determine if aggradation is occurring. Macroinvertebrates were sampled in 2005 and 2015; the 2005 data is expired but useful for comparative purposes. The 2015 visit MIBI score was passing; however, only 27 taxa were present in the 2015 sample (as compared to 47 in the 2005 sample). Flow dependent riffle beetle and mayfly taxa were present in the 2005 sample and absent from the 2015 sample. Greater numbers of taxa associated with slow flow were present in the 2015 sample. Like the fish community, the change in macroinvertebrate community structure may be an early indication of degradation. Station 05RD061 was located 9.5 miles upstream of the confluence of the Hill River and Lost River. The station was sampled for fish in 2006. The FIBI score was poor but likely due to a hyperdominance of a generalist species (1405 common shiners). The diverse fish sample contained 24 species, including two intolerant species and several sensitive species. The fish community indicates support for aquatic life. Stream habitat within this sampling reach included cobble riffles, deep pools, woody debris, and good channel development. Macroinvertebrates were not sampled at this station. Station 14RD259 was located furthest downstream, approximately 4.5 miles upstream of the confluence of the Hill River and Lost River. The 2014 visit FIBI score met exceptional use criteria. Over 40% of the fish species in the sample were insectivores; 38% of the species were sensitive and/or lithophilic spawners. Good stream habitat, including boulder and cobble substrate, riffles, and woody debris was present throughout the reach. The MIBI score was good. The presence of coarse substrate and riffle habitat create favorable conditions for a good macroinvertebrate community. In addition, the water quality of Lost River was excellent. DO, nutrient, and sediment concentrations all indicated that water quality was supportive of aquatic life. Bacteria concentrations were low across the open water season indicating support for water recreation activities.

Station 07RD004 was located on State Ditch 61 approximately 0.3 miles upstream of the confluence of the Lost River and State Ditch 61. Fish and macroinvertebrates were sampled at this station in 2007. The FIBI score was good. The fish sample contained numerous lithophilic spawning species and one sensitive species. An extensive amount of cover was present within the sampling reach. Channel development was poor; the entire reach consisted of a run with sand and silt substrate. Despite the poor habitat, the MIBI score met exceptional use criteria. The macroinvertebrate sample contained 55 unique taxa, including several sensitive mayfly and caddis fly taxa.

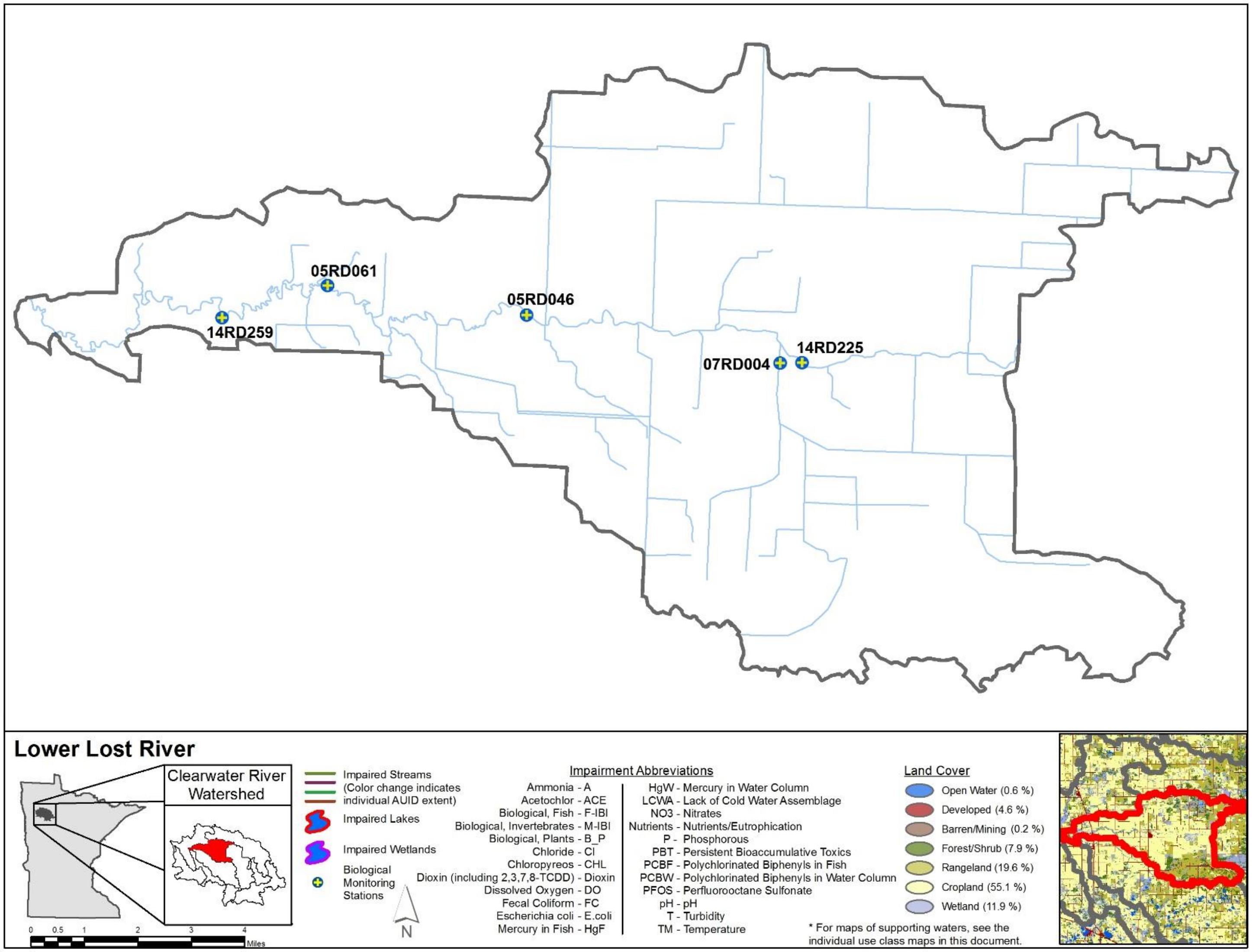

Figure 29. Currently Listed Impaired Waters by Parameter and Land Use Characteristics in the Lower Lost River Aggregated 12-HUC.

Hill River Aggregated 12-HUC HUC 0902030503-01

The Hill River Subwatershed drains 177 square miles of land within the central portion of the Clearwater River Watershed. The Hill River originates from a wetland located 6 miles northwest of Bagley. The river winds west/northwest for approximately 10 miles before flowing through Two Connections Lake and Cross Lake. The river flows over a dam on the north end of Cross Lake and continues flowing north for 4 miles before turning toward the west. The river winds west for 8 miles and enters Hill River Lake. The river passes through a dam on the west end of Hill River Lake and flows southwest briefly before turning toward the north. The river flows north for 8 miles and turns toward the northwest. The river winds northwest for 8.5 miles before turning west. The river continues flowing west for seven miles, passing near the community of Brooks before joining with the Lost River. The tributary Brooks Creek joins the Hill River before the confluence of the Hill River and Lost River. Numerous other small unnamed tributaries flow into the Hill River along its entire 57 mile flow length. The Hill River Subwatershed contains more lakes than any other subwatershed in the Clearwater River Watershed. Over 100 lakes greater than 10 acres in size are present within the subwatershed; many of the lakes are small wetland ponds. Prominent lakes include Hill River, Turtle, and Cross lakes. The land within the subwatershed is primarily cropland (48 %) followed by rangeland (19.6 %), forest (12.5 %), wetland (10.9 %), developed (4.5 %), and open water (4.4 %). The community of Brooks is within the subwatershed. In 2014, the MPCA collected biological samples from three monitoring stations located on two stream segments. Water chemistry was intensively monitored at one station within the Hill River Subwatershed.

Table 12. Aquatic Life and Recreation Assessments on Stream Reaches in the Hill River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

AUID ***Reach Name***, *Reach Description*	Biological Station ID	Reach Length (miles)	Use Class	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides ***	Eutrophication	**Aquatic Life**	**Aquatic Rec. (Bacteria)**
09020305-535 **Hill River** **South Connection Lk to Cross Lk**	-	0.48	WWg	-	-	NA	-	NA	-	NA	-	-	NA	NA	-
09020305-655 **Hill River** **Cross Lk to Unnamed cr**	-	4.91	WWg	-	-	NA	-	NA	-	NA	-	-	NA	NA	-
09020305-656 **Hill River** **Unnamed cr to Hill River Lk**	14RD246	8.18	WWg	EXS	MTS	EXS	MTS	MTS	MTS	MTS	MTS	-	IF	IMP	SUP
09020305-539 **Hill River** **Hill River Lk to Lost R**	05RD026 14RD253 14RD221	34.06	WWg	EXS	MTS	MTS	MTS	MTS	MTS	MTS	MTS	-	MTS	IMP	IMP
09020305-578 **Brooks Creek** **Unnamed cr to Hill R**	-	1.95	WWg	-	-	IF	IF	-	-	IF	MTS	-	IF	IF	IMP
09020305-641 **Unnamed creek** **Unnamed cr to Hill R**	10EM021	0.32	WWg	-	-	IF	IF	IF	-	IF	IF	-	IF	IF	-

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: ☐ = existing impairment, listed prior to 2014 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐= insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional,
LRVW = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 13. Lake Assessments in the Hill River Aggregated 12-HUC.

Lake Name	DNR ID	Area (acres)	Max Depth (ft)	Assessment Method	Ecoregion	Secchi Trend	Aquatic Life Indicators:			Aquatic Recreation Indicators:			Aquatic Life Use	Aquatic Recreation Use
							Fish IBI	Chloride	Pesticides ***	Total Phosphorus	Chlorophyll-a	Secchi		
Cross (Main Basin)	60-0027-02	169	19	Shallow Lake	NCHF	--	IF	MTS	--	MTS	IF	MTS	IF	FS
Turtle	60-0032-00	526	13	Shallow Lake	NCHF	NT	--	MTS	--	MTS	EX	IF	IF	IF
Unnamed	60-0099-00	38	4.9	Shallow Lake	RRV	--	--	--	--	--	--	IF	--	IF
Unnamed (Syverson)	60-0129-00	22	13.1	Shallow Lake	RRV	--	--	IF	--	IF	IF	IF	IF	IF
Unnamed (Jeppson)	60-0139-00	40	42	Deep Lake	RRV	--	--	--	--	--	--	IF	--	IF
Hill River	60-0142-00	113	60	Deep Lake	NCHF	--	MTS	--	--	--	--	--	FS	--

Abbreviations for Ecoregion: DA = Driftless Area, NCHF = North Central Hardwood Forest, NGP = Northern Glaciated Plains, NLF = Northern Lakes and Forests, NMW = Northern Minnesota Wetlands, RRV = Red River Valley, WCBP = Western Corn Belt Plains
Abbreviations for Secchi Trend: D = decreasing/declining trend, I = increasing/improving trend, NT = no detectable trend, -- = not enough data
Abbreviations for Indicator Evaluations: -- = No Data, **MTS** = Meets Standard; **EX** = Exceeds Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **FS** = Full Support (Meets Criteria); **NS** = Not Support (Impaired, exceeds standard)
Key for Cell Shading: ☐ = existing impairment, listed prior to 2014 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐= insufficient information.

Summary

Stations 14RD221, 05RD026, and 14RD253 were located on the segment of the Hill River that extends from Hill River Lake to the confluence of the Lost River and Hill River. Station 05RD026 was located furthest upstream, approximately 3.5 miles upstream of Hill River Lake. The station was sampled in 2006; the FIBI score was poor. The fish sample contained high numbers of tolerant and generalist species; no sensitive species were present in the sample. Habitat within the sampling reach consisted of fine substrate, extensive amounts of cover (woody debris and vegetation), and good channel development. The 2005 MIBI score was poor; this data was expired and not used for assessment. Station 14RD253 was located approximately 6.5 miles southeast of Oklee. Fish samples were collected in 2014 and 2016. Both visit FIBI scores were poor. The fish samples contained a high number of generalist species and few sensitive species. Substrate within the sampling reach consisted of sand and gravel. Submergent and emergent vegetation was abundant throughout the sampling reach; limited amounts of woody debris were present. The 2014 MIBI score was good. Station 14RD221 was located approximately 2.7 miles upstream of the confluence of the Hill River and Lost River. The 2014 visit FIBI score met exceptional use criteria. The diverse fish sample contained 22 species – 47% of those species were insectivorous, 23% were sensitive, and 28% were lithophilic spawners. The stream habitat included a variety of cover types, riffles, and good channel development. Compared to stations located upstream, more coarse substrate was present at station 14RD221. The increased availability of coarse substrate helped support a robust macroinvertebrate community. The 2014 MIBI score met exceptional use criteria. The macroinvertebrate sample contained 65 unique taxa, including 4 stone fly taxa, 10 caddis fly taxa, and 16 mayfly taxa. This segment is impaired for aquatic life based on the fish communities at stations 14RD253 and 05RD026. DO concentration in this reach supports aquatic life. High concentrations of *E.coli* were measured during the summer months; this reach is impaired for aquatic recreation. Brooks Creek, a tributary to this reach of the Lost River, also is impaired for aquatic recreation due to high levels of bacteria. Livestock have access to both of these stream reaches and are a probable source of elevated bacteria.

Station 14RD246 was located furthest upstream, approximately two miles upstream of Hill River Lake. Fish samples were collected in 2014 and 2015. The 2014 FIBI score was poor. Only seven species of fish were collected, and the sample contained 20 fish total. The 2015 visit yielded similar results – only four species of fish were collected and the sample contained eight fish total. The stream habitat included a variety of cover types, riffles, limited amounts of coarse substrate, and good channel development. Habitat did not appear to be a limiting factor. The macroinvertebrate sample was dominated by tolerant simulids, but enough sensitive taxa were present to support a passing MIBI score. Dissolved oxygen concentrations were as low as 2.0 mg/L. During 2015 monitoring with continuous sonde deployment, the DO concentration fell below the standard during 25.9 % of the deployment time. Phosphorus was elevated; however, more data is needed to determine if eutrophication is impacting aquatic life. Altered hydrology in the headwaters region may be causing a reduction in base flow and an increase in nutrient loading on this segment of the Hill River. This segment is impaired for aquatic life based on the fish community and exceedances of the DO standard.

Six lakes within the Upper Lost River Subwatershed had water chemistry data available for assessment; of these, only Cross Lake had sufficient data to assess for aquatic recreation. TP and Secchi depth meet the eutrophication standard indicating that Cross Lake supports aquatic recreation. Chlorophyll-a (a measure of algae) is right at the standard so the lake should be considered a higher priority for protection; algae blooms are likely to become more evident with a small increase in phosphorus. Cross Lake and Hill River Lake were the only two lakes in the subwatershed assessed for aquatic life. Hill River Lake supports aquatic life but may be susceptible to impairment. The FIBI score was positively influenced by the low percent of tolerant species biomass in the trap nets. The FIBI score was negatively influenced by the low number of intolerant species sampled, the high number of omnivorous species sampled, and by the high omnivorous biomass percentage. Cross Lake had a poor fish community. The low FIBI score resulted from a low amount of intolerant species, low insectivorous biomass, high numbers of omnivores, and high tolerant species biomass. A severe winterkill occurred on Cross Lake in 2004 and the structure of the fish community suggests that other winter kills have occurred since 2004. Because of the lakes propensity for winter kills, aquatic life was not assessed based on the FIBI. Plant surveys, however, indicate healthy aquatic plant communities on both lakes.

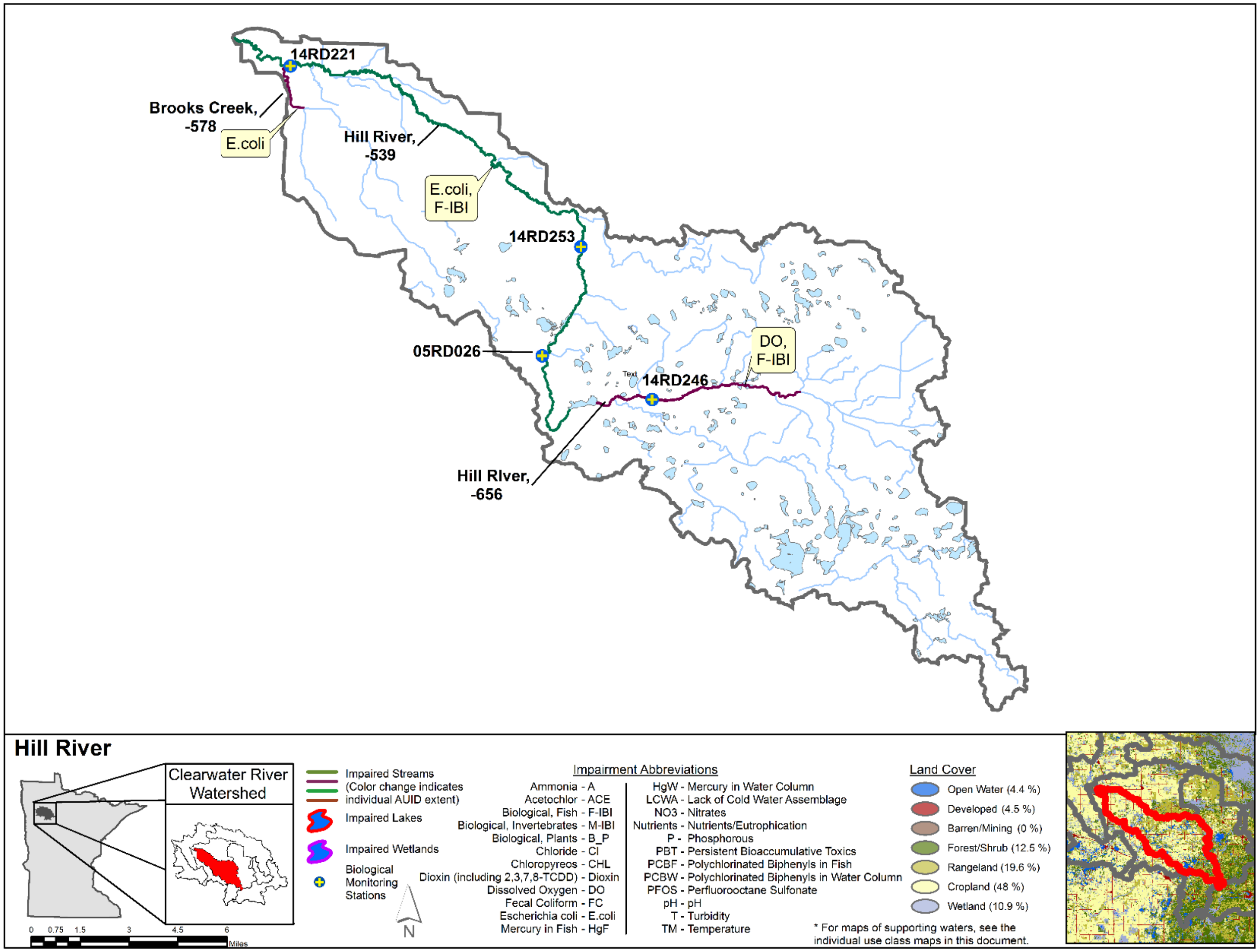

Figure 30. Currently Listed Impaired Waters by Parameter and Land Use Characteristics in the Hill River Aggregated 12-HUC.

Poplar River Aggregated 12-HUC HUC 0902030504-01

The Poplar River Subwatershed drains 116 square miles of land within the Clearwater River Watershed. The Poplar River originates from Spring Lake and winds north for 8 miles, passing through Poplar Lake before turning toward the west. The river continues winding west for 15 miles and turns north near the community of McIntosh. The river flows north for approximately 3 miles and then turns toward the northwest. The river continues toward the northwest for 27 miles and joins with the Lost River. Numerous short, unnamed tributaries flow into the Poplar River along its entire 53-mile long flow length. The land within the subwatershed is primarily cropland (38.4 %) followed by forest (23.9 %), rangeland (17.2 %), wetland (12.5 %), developed (4.9 %), and open water (3.0 %). Prominent lakes in the watershed include Spring Lake and Whitefish Lake. In 2014, the MPCA collected biological samples from three stations located on two stream segments. Water chemistry was intensively monitored at one station in the Poplar River Subwatershed.

Table 14. Aquatic Life and Recreation Assessments on Stream Reaches in the Poplar River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

AUID ***Reach Name***, *Reach Description*	**Biological Station ID**	**Reach Length (miles)**	**Use Class**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides ***	Eutrophication	**Aquatic Life**	**Aquatic Rec. (Bacteria)**
09020305-518 **Poplar River** **Spring Lk to Highway 59**	14RD218 14RD216	39.28	WWg	EX	EXS	EXS	MTS	MTS	-	MTS	MTS	-	IF	IMP	SUP
09020305-504 **Poplar River** **Highway 59 to Lost R**	14RD215	14.25	WWg	MTS	MTS	IF	MTS	MTS	MTS	MTS	MTS	-	IF	SUP	IMP

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: = existing impairment, listed prior to 2014 reporting cycle; = new impairment; = full support of designated use; = insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 15. Lake Assessments in the Poplar River Aggregated 12-HUC.

Lake Name	DNR ID	Area (acres)	Max Depth (ft)	Assessment Method	Ecoregion	Secchi Trend	Aquatic Life Indicators: Fish IBI	Aquatic Life Indicators: Chloride	Aquatic Life Indicators: Pesticides ***	Aquatic Recreation Indicators: Total Phosphorus	Aquatic Recreation Indicators: Chlorophyll-a	Aquatic Recreation Indicators: Secchi	Aquatic Life Use	Aquatic Recreation Use
Spring	60-0012-00	137	35	Deep Lake	NCHF	--	MTS	MTS	--	MTS	MTS	MTS	FS	FS
Whitefish	60-0015-00	231	18	Shallow Lake	NCHF	--	MTS	MTS	--	MTS	EX	MTS	FS	FS

Abbreviations for Ecoregion: DA = Driftless Area, NCHF = North Central Hardwood Forest, NGP = Northern Glaciated Plains, NLF = Northern Lakes and Forests, NMW = Northern Minnesota Wetlands, RRV = Red River Valley, WCBP = Western Corn Belt Plains
Abbreviations for Secchi Trend: D = decreasing/declining trend, I = increasing/improving trend, NT = no detectable trend, -- = not enough data
Abbreviations for Indicator Evaluations: -- = No Data, **MTS** = Meets Standard; **EX** = Exceeds Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **FS** = Full Support (Meets Criteria); **NS** = Not Support (Impaired, exceeds standard)
Key for Cell Shading: ☐ = existing impairment, listed prior to 2014 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐= insufficient information.

Summary

Stations 14RD218 and 14RD216 were located on the segment of the Poplar River that extends from Spring Lake to Highway 59. Station 14RD218 was located furthest upstream, near Whitefish Lake. Fish samples were collected in 2014 and 2015; both FIBI scores were poor. Both fish samples contained few fish and were dominated by tolerant species. Stream habitat within the sampling reach consisted of gravel and sand substrate, dense aquatic vegetation, woody debris, and deep pools. Habitat was not a limiting factor. Macroinvertebrates were sampled in 2014 and 2016; both MIBI scores were poor. Both macroinvertebrate samples were dominated by taxa that are tolerant of low dissolved oxygen concentrations. Station 14RD216 was located 20 miles downstream of station 14RD218. The 2014 visit FIBI score was good. Many lithophilic spawning species and two sensitive species were present in the fish sample. Woody debris and aquatic vegetation were abundant in the sampling reach. The substrate within the reach was primarily sand with limited amounts of gravel. Macroinvertebrates were sampled in 2014, 2015, and 2016. The 2014 MIBI was poor. The sample was collected under low flow conditions and unstable overhanging bank habitat was sampled; less emphasis was placed on this data during assessments. Macroinvertebrate sampling in subsequent years indicated a healthy macroinvertebrate community. Compared to the 2014 sample, considerably more taxa overall and more sensitive taxa were present in 2015 and 2016 samples. Continuous DO monitoring data available on this reach indicate DO concentrations often exceed the standard. DO concentrations as low as 1.70 mg/L have been measured on this reach, confirming an existing DO impairment. Phosphorus was elevated, but more data is necessary to determine if eutrophication is impacting aquatic life. Sediment concentrations were low. This segment is impaired for aquatic life based on the poor biology and low dissolved oxygen concentration. Bacteria concentrations were low on this portion of the river; indicating support for aquatic recreation activities.

Station 14RD215 was located on the segment of the Poplar River that extends from Highway 59 to the confluence of the Lost River and Hill River. The 2014 FIBI score (73.6) exceeded exceptional use criteria and was among the highest FIBI scores in the Clearwater River Watershed. Numerous lithophilic spawners, insectivores, and sensitive species were present in the fish sample. Excellent stream habitat was present at this station. Large deep pools, a variety of cover types, and extensive riffles comprised of boulder and cobble substrate were present within the sampling reach. The 2014 visit MIBI score was good. Varieties of mayfly and riffle beetle taxa were present in the sample. Water chemistry data available on this reach indicate that phosphorus is elevated. Oxygen levels are generally good and sediment concentrations were low. High *E. coli* concentrations were present in samples collected during the summer months; this reach is impaired for aquatic recreation.

Two lakes in the Poplar River Subwatershed (both are in the NCHF Ecoregion) were assessed for aquatic recreation and aquatic life. Spring Lake met recreation use standards. The lake is deep and has a mix of forest, urban, and agricultural land it drains. For Whitefish Lake, TP and Secchi depth met aquatic reaction standards; however, chlorophyll-a exceeded the shallow lake standard (mean concentration = 35.2 ug/L). Although TP data suggested support for aquatic recreation, some of the surface total phosphorus concentration values were as high as 95 ug/L during the summer months. In shallow lakes such as Whitefish, resuspension of sediment can lead to periodic increases in phosphorus and algal blooms. These lakes would benefit from protection efforts to reduce inputs of phosphorus from the surrounding watershed.

Whitefish Lake and Spring Lake were assessed for aquatic life. Both lakes contain healthy fish communities and support aquatic life. An exceptional fish community was identified in Spring Lake. The FIBI score was positively influenced by the high number of small benthic-dwelling species and the low proportion of omnivore biomass. Intolerant species such as the Iowa Darter and Banded Killifish were sampled. The score was negatively influenced by the low species richness of vegetation-dwelling species and the presence of two tolerant species. The FIBI score for Whitefish Lake was positively influenced by the richness of small benthic and vegetation-dwelling species and by the ratio of small benthic fish sampled nearshore. A low proportion of insectivore biomass negatively influenced the score. Aquatic plant surveys conducted on these lakes indicate healthy plant communities.

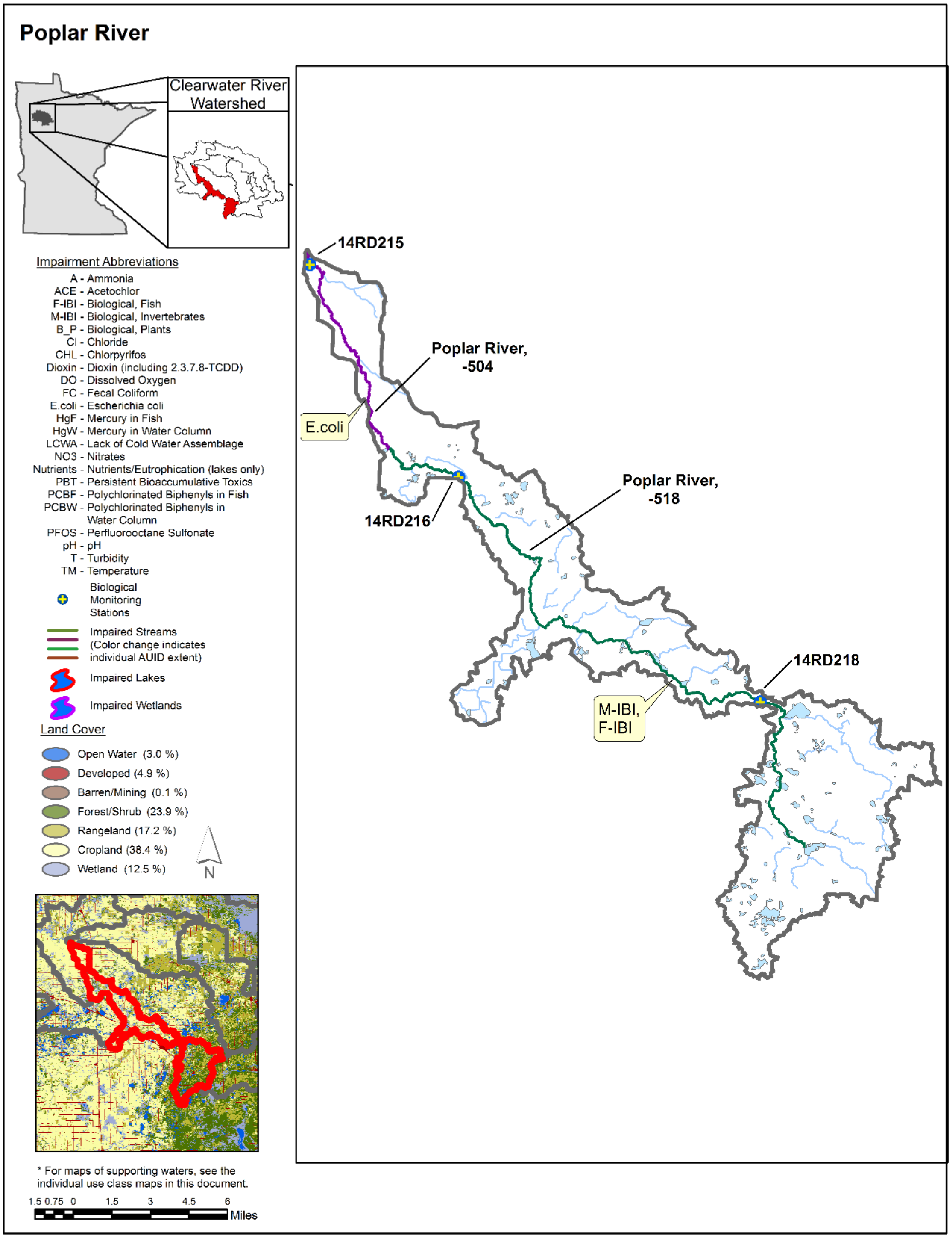

Figure 31. Currently Listed Impaired Waters by Parameter and Land Use Characteristics in the Poplar River Aggregated 12-HUC.

Lower Badger Creek Aggregated 12-HUC HUC 0902030506-01

The Lower Badger Creek Subwatershed drains 122 square miles of land within the western portion of the Clearwater River Watershed. Lower Badger Creek originates as a small channelized stream near the community of Erskine and flows northwest. The stream continues northwest for 7 miles before being joined by County Ditch 14. County Ditch 14 flows north out of Maple Lake and has a 7-mile flow length. Together with its tributary ditches, County Ditch 14 has an 80 square mile drainage area. After joining with County Ditch 14, Lower Badger Creek continues flowing northwest for 4 miles before being joined by Judicial Ditch 64. Judicial Ditch 64 flows from south to north and has an 8.5-mile flow length. After joining with Judicial Ditch 64, Lower Badger Creek transitions to a natural stream channel. The stream continues to wind northwest for 5 miles before joining with the Clearwater River. Other streams within the subwatershed include Judicial Ditch 73, the Poplar River Diversion Channel, and numerous unnamed tributaries. Major lakes (> 100 acres) within the subwatershed include Maple, Oak, Badger, Cameron, Mitchell, Crystal, and Bee. Many other small lakes are present within the southern region of the subwatershed. The land within the subwatershed is primarily cropland (59.1 %) followed by wetland (14.8 %), forest (7.4 %), developed (6.3 %), and rangeland (5.3 %). The communities of Erskine and Mentor are within the subwatershed. The MPCA collected biological samples from ten monitoring stations located on four stream segments. Water chemistry was intensively monitored at two locations within the Lower Badger Creek Subwatershed.

Table 16. Aquatic Life and Recreation Assessments on Stream Reaches in the Lower Badger Creek Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

AUID ***Reach Name***, *Reach Description*	**Biological Station ID**	**Reach Length (miles)**	**Use Class**	**Aquatic Life Indicators:**										**Aquatic Life**	**Aquatic Rec. (Bacteria)**
				Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides ***	Eutrophication		
09020305-553 **Unnamed creek** **Oak Lk to Gerdin Lk**	-	0.76	WWg			NA	NA			NA		-	NA	NA	-
09020305-561 **Unnamed creek** **Gerdin Lk to Poplar R Diversion**	14RD243	2.35	WWm	EXS		IF	IF	IF		IF	IF	-	IF	IMP	-

09020305-543 **Poplar River Diversion** **Unnamed ditch to Badger Lk**	-	1.48	WWg			EXS	IF	IF		MTS	MTS	-	IF	IMP	IF
09020305-542 **Unnamed creek** **Mitchell Lk to Badger Lk**	-	0.36	WWg			NA	NA	NA		NA	NA	-	NA	NA	IF
09020305-541 **Unnamed creek** **Eighteen Lk to Bee Lk**	-	1.31	WWg			NA		NA		NA		-	--	NA	-
09020305-551 **Unnamed creek (Bee Lake Outlet)** **Bee Lk to JD 73**	-	0.69	WWg			NA		NA		NA		-	--	NA	-
09020305-550 **Judicial Ditch 73** **Unnamed ditch to Tamarack Lk**	14RD241	1.7	WWm	MTS	MTS	EXS	MTS	MTS	MTS	MTS	MTS	-	IF	IMP	IMP
09020305-523 **County Ditch 14** **Headwaters (Maple Lk 60-0305-00) to Lower Badger Cr**	14RD242 15EM096 07RD005 14RD272	6.67	WWm	MTS	MTS	IF	MTS	MTS		MTS	MTS	-	MTS	SUP	SUP
09020305-549 **Unnamed creek** **Tamarack Lk to Maple Lk**	-	0.52	WWg			NA	NA	NA		NA	NA	-	NA	NA	SUP
09020305-548 **Judicial Ditch 64** **Unnamed ditch to Lower Badger Cr**	14RD238	5.18	WWg			IF	IF	IF		IF	IF	-	IF	IF	-
09020305-502 **Lower Badger Creek** **CD 14 to Clearwater R**	07RD026 14RD239 14RD237	12.66	WWg	MTS	MTS	MTS	MTS	IF	MTS	MTS	MTS	-	MTS	SUP	IMP

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Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 17. Lake Assessments in the Lower Badger Creek Aggregated 12-HUC.

Lake Name	DNR ID	Area (acres)	Max Depth (ft)	Assessment Method	Ecoregion	Secchi Trend	Aquatic Life Indicators:			Aquatic Recreation Indicators:			Aquatic Life Use	Aquatic Recreation Use
							Fish IBI	Chloride	Pesticides ***	Total Phosphorus	Chlorophyll-a	Secchi		
Unnamed	60-0721-00	9	--	--	RRV	--	--	--	--	IF	--	IF	--	IF
Unnamed	60-0255-00	23	--	Shallow Lake	RRV	--	--	--	--	IF	--	IF	--	IF
Unnamed	60-0256-00	13	--	Shallow Lake	RRV	--	--	--	--	IF	--	IF	--	IF
Unnamed	60-0257-00	54	--	--	RRV	--	--	--	--	IF	--	IF	--	IF
Unnamed	60-0258-00	20	--	--	RRV	--	--	--	--	IF	--	IF	--	IF
Unnamed	60-0275-00	54	--	Deep Lake	RRV	--	--	IF	--	IF	IF	IF	IF	IF
Maple	60-0305-00	1582	14	Shallow Lake	NCHF	NT	MTS	MTS	--	MTS	MTS	MTS	FS	FS
Cameron	60-0189-00	226	8.5	Shallow Lake	NCHF	--	--	MTS	--	EX	EX	EX	IF	NS
Bee	60-0192-00	101	--	Shallow Lake	NCHF	--	--	--	--	IF	--	IF	--	IF

Eighteen	60-0199-00	87	--	--	RRV	--	--	--	--	IF	--	--	--	IF
Unnamed (Engemoen)	60-0211-00	32	--	Shallow Lake	RRV	--	--	IF	--	IF	IF	IF	IF	IF
Badger	60-0214-00	259	19	Shallow Lake	NCHF	--	NA	MTS	--	MTS	MTS	MTS	IF	FS
Dorr	60-0219-00	53	--	--	RRV	--	--	--	--	IF	IF	IF	--	IF
Unnamed (Tamarack)	60-0247-00	39	--	Shallow Lake	RRV	--	--	--	--	IF	--	IF	--	IF
Unnamed	60-0248-00	46	--	Shallow Lake	RRV	--	--	--	--	IF	--	IF	--	IF
Unnamed	60-0249-00	21	--	Shallow Lake	RRV	--	--	--	--	IF	--	IF	--	IF

Abbreviations for Ecoregion: DA = Driftless Area, NCHF = North Central Hardwood Forest, NGP = Northern Glaciated Plains, NLF = Northern Lakes and Forests, NMW = Northern Minnesota Wetlands, RRV = Red River Valley, WCBP = Western Corn Belt Plains
Abbreviations for Secchi Trend: D = decreasing/declining trend, I = increasing/improving trend, NT = no detectable trend, -- = not enough data
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Key for Cell Shading: ☐ = existing impairment, listed prior to 2014 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐= insufficient information.

Summary

Stations 14RD237, 14RD239, and 07RD026 were located on the segment of Lower Badger Creek that extends from County Ditch 14 to the Clearwater River. Station 07RD026 was located furthest upstream on the channelized portion of this segment. Fish were sampled in 2007 and 2016; both FIBI scores were poor. The 2007 fish sample contained numerous tolerant, serial spawning species and only one sensitive species. The 2016 sample contained two sensitive species and numerous tolerant, generalist species. Good cover was present throughout the reach; however, most of the coarse substrate was embedded. The 2016 MIBI score was good. Further investigation will be conducted on this section of Lower Badger Creek to determine the cause of the poor fish community at station 07RD026. Biological data collected at other stations located on Lower Badger Creek indicate support of aquatic life. Station 14RD239 was located three miles downstream of station 07RD026. The 2014 visit FIBI score was good. The most abundant species in the sample was a generalist species (creek chub); however, four sensitive species and a moderate number of lithophilic spawners were also present in the sample.

The stream habitat at this station was good – cobble substrate was present throughout the sampling reach along with a variety of cover types. The 2014 visit MIBI score was good. The macroinvertebrate sample contained 54 unique taxa, including sensitive taxa from the orders Ephemeroptera and Trichoptera. Station 14RD237 was located 1.3 miles upstream of the confluence of Clearwater River and Lower Badger Creek. The 2015 visit FIBI score was good. The diverse fish sample contained 23 species of fish. Multiple insectivorous species, sensitive species, and lithophilic spawning species were present in the sample. The stream habitat at this station consisted of a variety of coarse substrates (boulder, cobble, and gravel), multiple cover types, riffles, and good channel development. The 2016 visit MIBI score was good. The most abundant taxa sampled were tolerant (Simuliiudae and Hyalellidae); however, sensitive taxa from the orders Ephemeroptera and Trichoptera were present in the sample. Water chemistry data available on this reach indicate excellent water quality. Nutrients and sediment are low, and dissolved oxygen concentrations remain high enough to support a healthy aquatic community. Bacteria concentrations exceeded the standard throughout the summer months; this segment is impaired for aquatic recreation.

Station 14RD243 was located on the Tributary to the Poplar River Diversion Ditch. The 2014 visit FIBI score was zero. Only central mudminnows, a very tolerant species, were collected. Stream habitat within the reach was very poor. Extensive aquatic macrophytes, covered in filamentous algae, were present throughout the reach. Substrate consisted of clay and silt; there was no coarse substrate. Macroinvertebrates were not sampled here due to stagnant flow later in the summer. Water chemistry data was limited to measurements taken during the fish sampling visit. The dissolved oxygen concentration on the date of the fish visit (6/10/2014) was 16.32 mg/L. The super saturation of DO is likely the result of the excess vegetation and filamentous algae. This reach is impaired for aquatic life based on the poor fish community.

Station 14RD241 was located on Judicial Ditch 73, approximately 0.6 miles upstream of Tamarack Lake. The 2014 visit FIBI score was low but passing. Only seven species of fish were sampled; the sample exhibits some lake influence. Biology was assessed using modified use standards. The stream habitat within the sampling reach was poor – heavy silt, wetland vegetation, and poor channel development were present. The wetland like habitat and poor channel development resulting from ditching activities limits the development of biological communities in this stream segment. The 2014 MIBI score was also low but passing. The macroinvertebrate sample was dominated by taxa that are tolerant of low DO. Dissolved oxygen concentrations frequently exceed the standard. Concentrations as low as 0.30 mg/L have been measured. This reach is impaired for aquatic life based on exceedances of the DO standard. Phosphorus and sediment concentrations were low on Judicial Ditch 73. *E. coli* concentrations were high during the summer months; this reach is impaired for aquatic recreation.

Stations 07RD005, 14RD272, 14RD242, and 15EM096 were located on County Ditch 14. Stations 14RD242 and 15EM096 were located furthest upstream near the community of Mentor. At station 14RD242, fish were sampled twice in 2014 and once in 2015; all visits were non-reportable due to difficulties obtaining good sampling equipment performance. Only low numbers of primarily tolerant species were collected but samplers observed schools of other species running past them. Stream habitat within this reach consisted of sand and gravel substrate, a variety of cover types, and poor channel development. The MIBI score was good. Station 15EM096 was sampled once in 2015; the FIBI score was good. The fish sample contained high numbers of sensitive species and tolerant, generalist species. The stream habitat at this station was similar to the habitat at station 14RD242; less cover and coarse substrate was present at station 15EM096. The MIBI score was good. Stations 07RD005 and 14RD272 were located in close proximity of one another near the confluence of Lower Badger Creek and County Ditch 14. Station 07RD005 was sampled for fish and macroinvertebrates in 2007. The FIBI score was good. Several sensitive species, low numbers of insectivores, and some very tolerant species were present in the fish sample. The stream habitat at this station included riffles, coarse substrate, a variety of cover types, and good channel development. The MIBI score was good. Station 14RD272 was sampled for fish and macroinvertebrates in 2014. The FIBI score was good. Most of the seven species present in the fish sample were lithophilic spawners. The stream habitat at this station was similar to the habitat found at station 07RD005. The MIBI score was poor. The sample contained an unusual amount of tolerant taxa (Hyalella, Simulids, and Baetids). This data was not given as much consideration during the assessment process due to the unusual hyperdominance of certain taxa and the presence of supporting communities both upstream and downstream of the station. Water quality data indicated supporting conditions for aquatic communities. Nutrients and sediment concentrations were low. Bacteria counts were also low; indicating support for water recreation activities.

Water chemistry data was available on the Poplar River Diversion Channel, Judicial Ditch 64, and several unnamed streams. Five of the unnamed stream reaches were not assessed due to their short length (longest being 1.31 mi), close proximity to upstream lakes, and/or being short connectors between lakes. The water chemistry observed on such streams would be representative of the upstream lakes instead of actual stream conditions. Two of these short lake connectors (the reaches from Eighteen Lake to Bee Lake and Mitchell Lake to Badger Lake) were listed as impaired for DO in 2006. Since the chemistry data from these reaches is not appropriate for assessment purposes, formal corrections for the DO impairments will be proposed. The Poplar River Diversion channel exhibited low dissolved oxygen concentrations; it was originally listed for DO concentration exceedances in 2006. The data from this assessment period confirms that listing. Though wetlands border this reach, there is also pasture and cropland along the Poplar River Diversion so low dissolved oxygen cannot only be attributed to wetland influence.

Water chemistry data was available on sixteen lakes within the Lower Badger Creek Subwatershed; only Cameron Lake, Badger Lake, and Maple Lake had sufficient data to assess for aquatic recreation. Cameron Lake was previously listed for eutrophication in 2008. Mean TP, chlorophyll-a, and Secchi depth values all exceed the shallow lake standard, indicating nuisance algae blooms are present throughout much of the summer. Badger and Maple Lake both meet aquatic recreation standards. All the lakes in this watershed are shallow. Wind mixing and internal loading will increase the presence of algal blooms on the lakes. Maple and Cameron lakes both have considerable residential development on their shores; working to maintain natural shorelines, maintaining septic systems, and reductions in overland runoff of phosphorus will be important to maintain or improve the quality of the lakes. Maple Lake was also assessed for aquatic life. The most recent Maple Lake fish survey indicated a healthy fish community is present. The FIBI score was positively influenced by the low number of tolerant species, the high number of small benthic-dwelling species, the high percent of insectivorous biomass in trap nets, the low percent of tolerant species biomass in trap nets, and the high percent of top carnivore biomass in the gill nets (Northern Pike). The fish community in Badger Lake was indicative of a lake that undergoes periodic winterkill; therefore, the lake was not assessed. The aquatic plant survey data from both lakes indicate healthy plant communities.

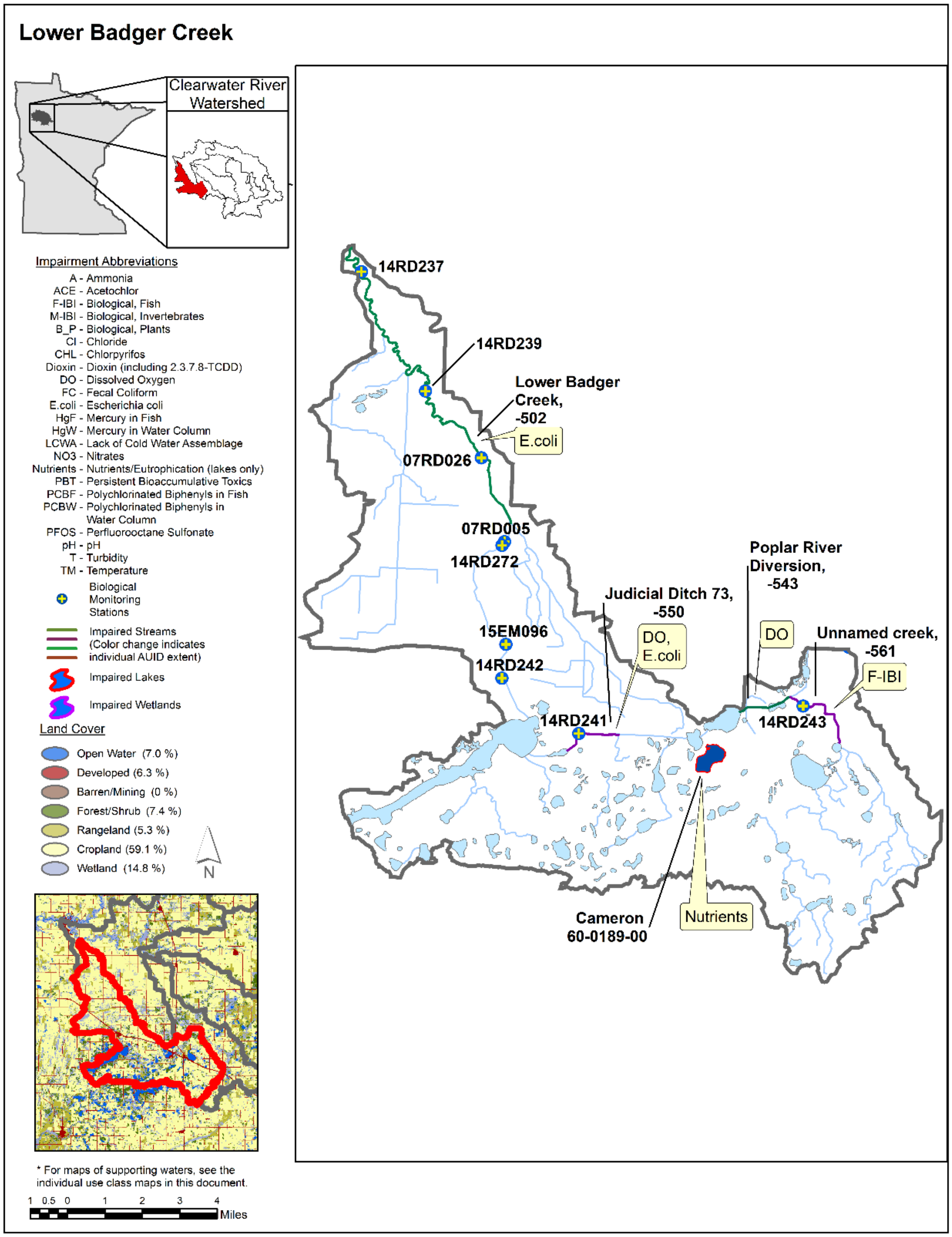


Figure 32. Currently Listed Impaired Waters by Parameter and Land Use Characteristics in the Lower Badger Creek Aggregated 12-HUC.

Watershed-wide results and discussion

Assessment results and data summaries are included below for the entire HUC-8 watershed unit of the Clearwater River, grouped by sample type. Summaries are provided for lakes, streams, and rivers in the watershed for the following: aquatic life and recreation uses, aquatic consumption results, load monitoring data results, transparency trends, and remote sensed lake transparency. Additionally, groundwater and wetland monitoring results are included where applicable.

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

Stream water quality

Forty-two of the 50 stream segments (AUIDs) were assessed (Table 18). Of the assessed streams, only 12 streams fully supported of aquatic life and 13 streams fully supported aquatic recreation. Three of the stream segments were classified as limited resource waters.

Throughout the watershed, 35 segments do not support aquatic life and/or recreation. Of those segments, 20 do not support aquatic life and 15 do not support aquatic recreation.

Table 18. Assessment Summary for Stream Water Quality in the Clearwater River Watershed.

				Supporting		Non-supporting			
Watershed	**Area (acres)**	**# Total AUIDs**	**# Assessed AUIDs**	**# Aquatic Life**	**# Aquatic Recreation**	**# Aquatic Life**	**# Aquatic Recreation**	**Insufficient Data**	**# Delistings**
09020305	**869464**	**50**	**42**	**12**	**13**	**20**	**15**	**8 AL, 5 AR**	**5 AL, 0 AR**
0902030501-01	116857	7	5	3	3	1	0	1 AL, 0 AR	2 AL, 0 AR
0902030502-01	161006	3	3	1	1	1	1	1 AL, 0 AR	1 AL, 0 AR
0902030507-01	103385	8	8	0	3	6	2	2 AL, 2 AR	1 AL, 0 AR
0902030502-02	34590	1	1	1	0	0	1	0 AL, 0 AR	0 AL, 0 AR
0902030505-02	104689	10	9	2	1	6	6	1 AL, 1 AR	0 AL, 0 AR
0902030505-01	82607	2	2	2	1	0	0	0 AL, 0 AR	0 AL, 0 AR
0902030503-01	113406	6	4	0	1	2	2	2 AL, 0 AR	0 AL, 0 AR
0902030504-01	74728	2	2	1	1	1	1	0 AL, 0 AR	0 AL, 0 AR
0902030506-01	78196	11	8	2	2	3	2	1 AL, 2 AR	1 AL, 0 AR

Lake water quality

Fifty-three lakes within the Clearwater River Watershed were assessed for either aquatic life and/or aquatic recreation (Table 19). Of the assessed lakes, 29 fully supported aquatic recreation and nine fully supported aquatic life. Three lakes do not support aquatic recreation.

Table 19. Assessment Summary for Lake Water Chemistry in the Clearwater River Watershed.

			Supporting		Non-supporting			
Watershed	**Area (acres)**	**Lakes >10 Acres**	**# Aquatic Life**	**# Aquatic Recreation**	**# Aquatic Life**	**# Aquatic Recreation**	**Insufficient Data**	**# Delistings**
09020305	**869464**	**53**	**9**	**29**	**0**	**3**	**11 AL, 20 AR**	**0 AL, 0 AR**
0902030501-01	116857	14	5	12	0	1	1 AL, 1 AR	0 AL, 0 AR
0902030502-01	161006	6	0	5	0	0	1 AL, 1 AR	0 AL, 0 AR
0902030507-01	103385	0	0	0	0	0	0 AL, 0 AR	0 AL, 0 AR
0902030502-02	34590	3	0	3	0	0	1 AL, 0 AR	0 AL, 0 AR
0902030505-02	104689	6	0	4	0	1	1 AL, 1 AR	0 AL, 0 AR
0902030505-01	82607	0	0	0	0	0	0 AL, 0 AR	0 AL, 0 AR
0902030503-01	113406	6	1	1	0	0	3 AL, 4 AR	0 AL, 0 AR
0902030504-01	74728	2	2	2	0	0	0 AL, 0 AR	0 AL, 0 AR

Fish contaminant results

Mercury was analyzed in fish tissue samples collected from the Clearwater River and three lakes in the watershed. Polychlorinated biphenyls (PCBs) were measured in fish from the river and two lakes (Lomond and Maple). Twelve fish species were tested for contaminants. A total of 253 fish were collected for contaminant analysis between 1990 and 2015. Contaminant concentrations are summarized by waterway, fish species, and year (Table 20). "Total Fish" indicates the total number of fish analyzed and "N" indicates the number of samples. The number of fish exceeds the number of samples when fish are combined into a composite sample (this was typically done for panfish, such as bluegill sunfish and yellow perch). "Anatomy" refers to the type of sample; since 1989, most of the samples have been skin-on fillets (FILSK) or for fish without scales (catfish and bullheads), skin-off fillets (FILET).

The Clearwater River and the three lakes were listed as impaired for mercury in fish tissue in the MPCA's 2016 Draft Impaired Waters List. Lomond Lake and Maple Lake, as well as the Clearwater River were added to the Statewide Mercury TMDL. Mercury concentrations in Pine Lake were not high enough to qualify for the Statewide TMDL. None of the waters in this watershed are listed as impaired for PCBs in fish tissue. PCB concentrations in fish tissue were near or below the reporting limit (0.01 - 0.03 mg/kg). Fish consumption advice, developed by the Minnesota Department of Health, has meal advice of "unrestricted" for PCBs in fish less than or equal to 0.05 mg/kg. Overall, mercury concentrations in fish remain a concern for the Clearwater

River and the three lakes tested in the watershed. The Fish Contaminant Monitoring Program will continue to retest the fish from impaired waters to assess if mercury levels are changing.

Table 20. Fish Contaminants Table.

DOWID	Waterway	Species	Year	Anatomy[1]	Total Fish	No. Samples	Length (in) Mean	Length (in) Min	Length (in) Max	Mercury (mg/kg) Mean	Mercury (mg/kg) Min	Mercury (mg/kg) Max	PCBs (mg/kg) N	PCBs (mg/kg) Mean	PCBs (mg/kg) Max	< RL
09020305-	CLEARWATER R.	Channel catfish	2014	FILSK	3	3	22.7	22.4	23.3	0.277	0.269	0.286	2	0.03	0.03	Y
501, -510, -		Golden redhorse	2014	FILSK	5	1	15.6	15.6	15.6	0.403	0.403	0.403	1	0.03	0.03	Y
511, -514, -		Smallmouth bass	2014	FILSK	3	3	10.0	8.6	12.0	0.178	0.141	0.251	2	0.03	0.03	Y
516, -517, -		Northern pike	1992	FILSK	2	2	18.8	16.1	21.4	0.310	0.220	0.400	1	0.044	0.044	
519 *		White sucker	1992	FILSK	24	4	11.6	10.8	13.7	0.113	0.072	0.140	1	0.043	0.043	
15008100*	LOMOND	Bluegill sunfish	1993	FILSK	10	1	7.3	7.3	7.3	0.082	0.082	0.082				
		Northern pike	1993	FILSK	14	4	26.2	18.0	37.0	0.415	0.170	0.790	1	0.01	0.01	Y
		Walleye	1993	FILSK	4	3	22.2	19.1	26.0	0.460	0.320	0.600	1	0.01	0.01	Y
		White sucker	1993	FILSK	6	2	18.6	15.5	21.6	0.056	0.041	0.071	1	0.01	0.01	Y
15014900**	PINE	Bluegill sunfish	2003	FILSK	10	1	8.1	8.1	8.1	0.157	0.157	0.157				
			2013	FILSK	5	1	9.3	9.3	9.3	0.140	0.140	0.140				
		Black crappie	2013	FILSK	4	1	11.7	11.7	11.7	0.318	0.318	0.318				
		Northern pike	2003	FILSK	5	5	24.6	20.1	29.5	0.480	0.401	0.573				
			2013	FILSK	8	8	24.9	19.2	33.2	0.558	0.344	0.959				
15014900**	PINE (continued)	White sucker	2003	FILSK	5	1	17.4	17.4	17.4	0.089	0.089	0.089				
			2013	FILSK	5	1	17.3	17.3	17.3	0.057	0.057	0.057				
60030500*	MAPLE	Bluegill sunfish	1990	FILSK	12	3	7.0	6.5	8.0	0.073	0.042	0.130	3	0.01	0.01	Y
			2010	FILSK	10	2	7.1	6.9	7.3	0.043	0.041	0.044				
			2015	FILSK	10	1	10.9	10.9	10.9	0.035	0.035	0.035				
		Black bullhead	1990	FILET	7	3	7.8	7.6	8.0	0.025	0.020	0.036	3	0.01	0.01	Y
		Black crappie	1990	FILSK	2	2	8.3	8.1	8.4	0.023	0.020	0.025	2	0.01	0.01	Y
			2015	FILSK	6	1	8.7	8.7	8.7	0.068	0.068	0.068				
		Common Carp	1990	FILSK	18	9	21.0	18.0	26.8	0.028	0.020	0.058	9	0.017	0.045	
		Largemouth bass	2015	FILSK	1	1	13.9	13.9	13.9	0.190	0.190	0.190				

DOWID	Waterway	Species	Year	Anat-omy[1]	Total Fish	No. Sam-ples	Length (in)			Mercury (mg/kg)			PCBs (mg/kg)			
							Mean	Min	Max	Mean	Min	Max	N	Mean	Max	< RL
		Northern pike	1990	FILSK	8	6	19.1	15.4	25.3	0.188	0.110	0.280	6	0.01	0.01	Y
			2010	FILSK	8	8	21.3	14.3	30.4	0.099	0.034	0.211				
			2015	FILSK	9	9	23.0	21.0	26.5	0.202	0.115	0.425				
		Walleye	1990	FILSK	15	6	16.9	11.2	26.1	0.186	0.024	0.420	6	0.013	0.026	Y
			2010	FILSK	8	8	18.6	13.5	28.5	0.152	0.059	0.393				
			2015	FILSK	7	7	16.6	10.9	21.5	0.132	0.083	0.206				
		White sucker	1990	FILSK	1	1	17.6	17.6	17.6	0.020	0.020	0.020	1	0.01	0.01	Y
			2010	FILSK	5	1	17.2	17.2	17.2	0.021	0.021	0.021				
			2015	FILSK	4	2	18.7	17.8	19.6	0.030	0.023	0.036				
		Yellow perch	2015	FILSK	9	1	7.0	7.0	7.0	0.049	0.049	0.049				

*** Impaired for mercury in fish tissue as of 2016 Draft Impaired Waters List; categorized as EPA Class 4a for waters covered by the Statewide Mercury TMDL.**

**** Impaired for mercury in fish tissue as of 2014 Draft Impaired Waters List; categorized as EPA Class 5 for waters needing a TMDL.**

1 Anatomy codes: FILSK – edible fillet, skin-on; FILET—edible fillet, skin-off; PLUG—dorsal muscle piece, without skin; WHORG—whole organism

Pollutant load monitoring

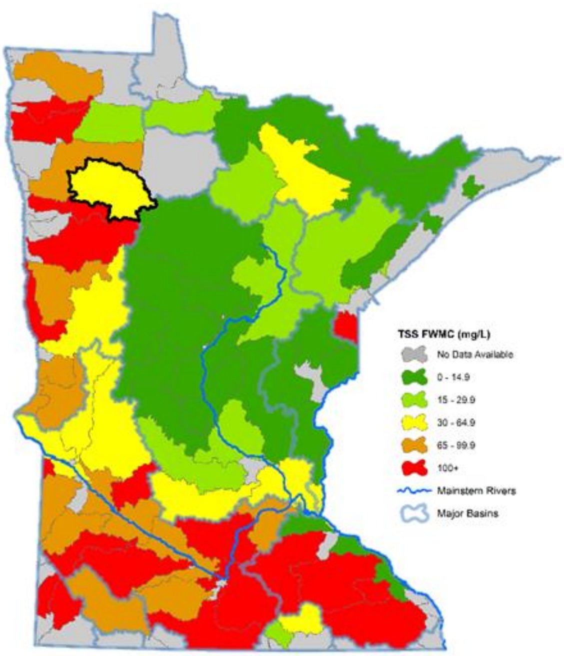
The WPLMN has three sites within the Clearwater River Watershed as shown in Table 21.

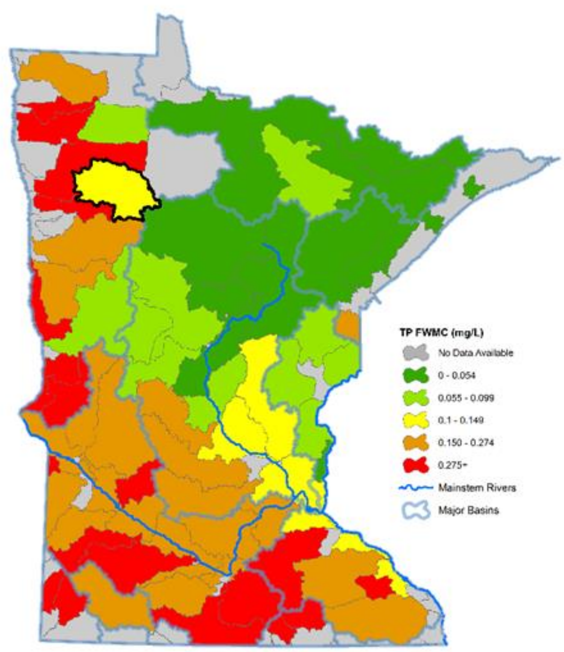
Table 21. WPLMN Stream Monitoring Sites for the Clearwater River Watershed.

Site Type	Stream Name	USGS ID	DNR/MPCA ID	EQuIS ID
Major Watershed	Clearwater River at Red Lake Falls, Bottineau Ave	05078500	E66050001	S002-118
Subwatershed	Clearwater at Plummer, CR126	05078000	E66041001	S002-124
Subwatershed	Lost River nr Brooks, CR119	NA	H66048001	S002-133

Average annual FWMCs of TSS, TP, and NO_3+NO_2-N for major watershed stations statewide are presented below, with the Clearwater River Watershed highlighted. Water runoff, a significant factor in pollutant loading, is also shown. Water runoff is the portion of annual precipitation that makes it to a river or stream; this it can be expressed in inches.

As a general rule, elevated levels of TSS and NO_3+NO_2-N are regarded as "non-point" source derived pollutants originating from many small diffuse sources such as urban or agricultural runoff. Excess TP can be attributed to both non-point as well as point sources such as industrial or wastewater treatment plants. Major "non-point" sources of phosphorus include dissolved phosphorus from fertilizers and phosphorus adsorbed to and transported with sediment during runoff. Excessive TSS, TP, and NO_3+NO_2-N in surface waters impacts fish and other aquatic life, as well as fishing, swimming and other recreational uses. Elevated levels of NO_3+NO_2-N is a concern for drinking water.





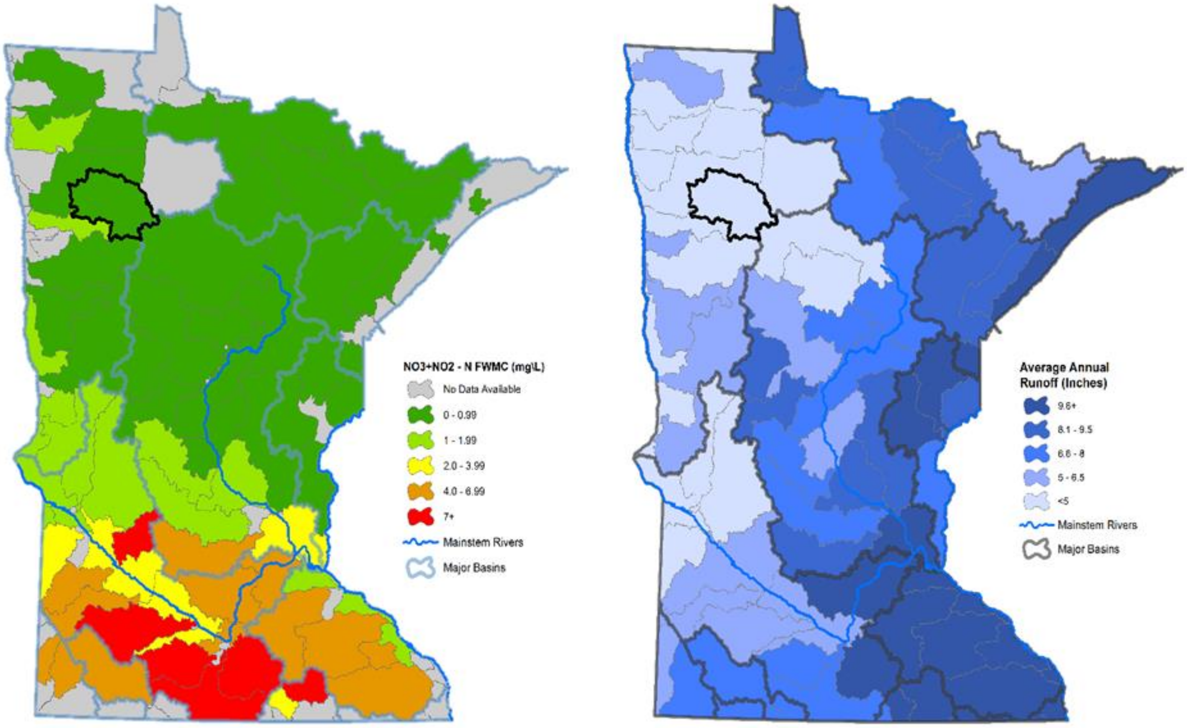
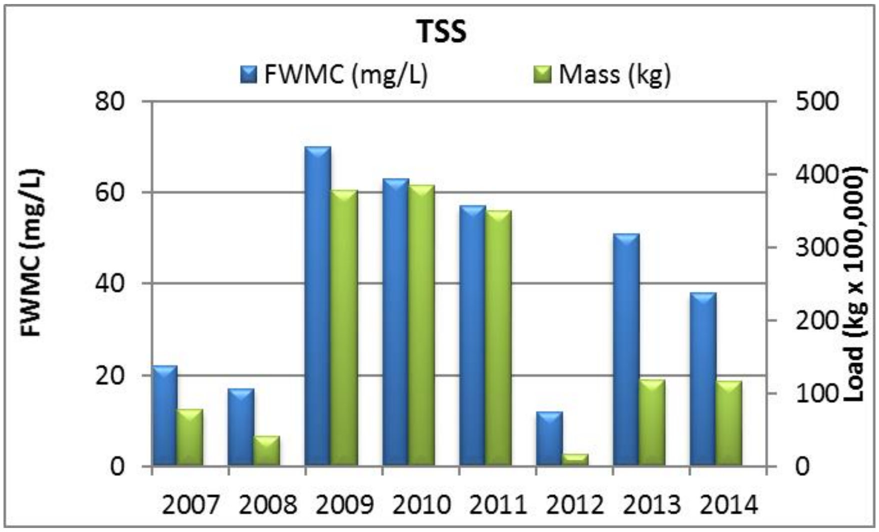


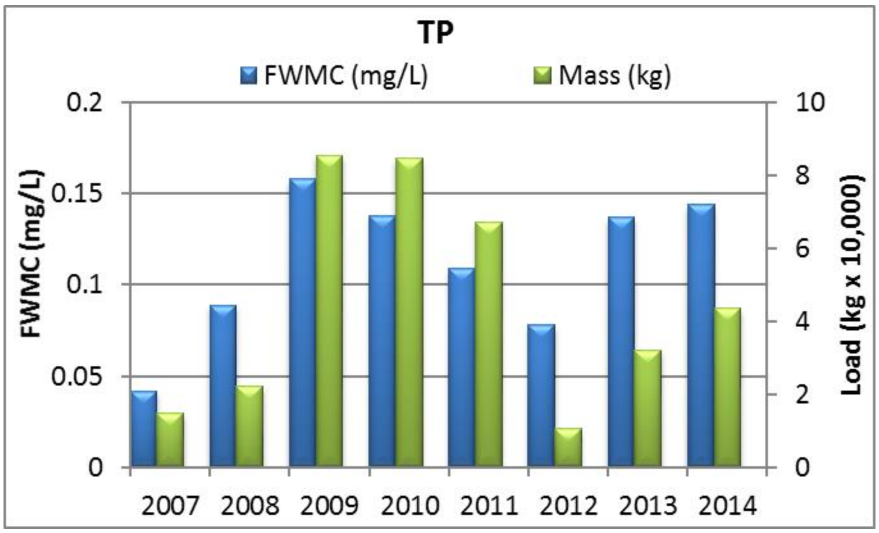
Figure 33. 2007-2014 Average Annual TSS, TP, and NO3-NO2-N Flow Weighted Mean Concentrations and Runoff by Major Watershed.

When compared with other major watersheds throughout the state, Figure 33 shows the average annual TSS and TP FWMCs to be several times higher for the Clearwater River Watershed than watersheds in north central and northeast Minnesota, but in line with the agriculturally rich watersheds found in the northwest and southern regions of the state. NO_3+NO_2-N FWMCs are more in line with the watersheds in north central and northeast Minnesota but are expected to trend upward as subsurface drainage practices increase.

More information, including results for subwatershed stations, can be found at the WPLMN website.

Substantial year-to-year variability in water quality occurs for most rivers and streams, including the Clearwater River. Results for individual years are shown in the charts below.





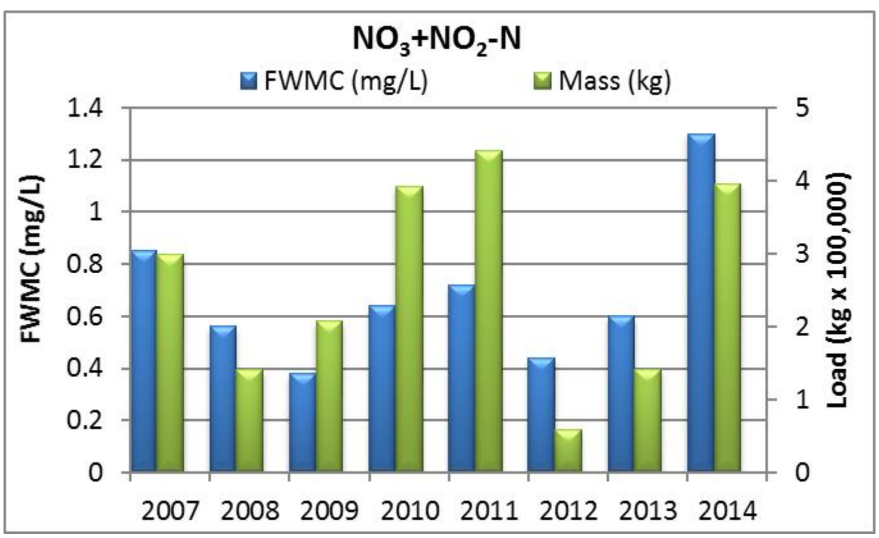


Figure 34. TSS, TP, and NO3+NO2-N Flow Weighted Mean Concentrations and Loads for the Clearwater River at Red Lake Falls, Minnesota.

Groundwater monitoring

Stream flow

Stream flow data from the United States Geological Survey's real-time streamflow gaging stations for two rivers in the Clearwater River Watershed were analyzed for annual mean discharge and summer monthly mean discharge (July and August). Figure 35 (*left*) is a display of the annual mean discharge for the Clearwater River at Plummer, Minnesota from water years 1996 to 2015. The data shows that although streamflow appears to be decreasing over time, there is no statistically significant trend ($p<0.1$). Figure 35 (*right*) displays July and August mean flows for the same time frame, for the same water body. Graphically, the data appears to be decreasing in July and August, but neither at a statistically significant rate. Figure 36 is the annual (*left*) and monthly (*right*) mean streamflow for Lost River at Oklee, Minnesota for the same water years. Annual and monthly streamflow for July and August all appear to be declining, but only at a slightly significant rate ($p<0.05$). By way of comparison at a state level, summer month flows have declined at a statistically significant rate at a majority of streams selected randomly for a study of statewide trends (Streitz, 2011). For additional streamflow data throughout Minnesota, please visit the USGS website: http://waterdata.gov/mn/nwis/rt.

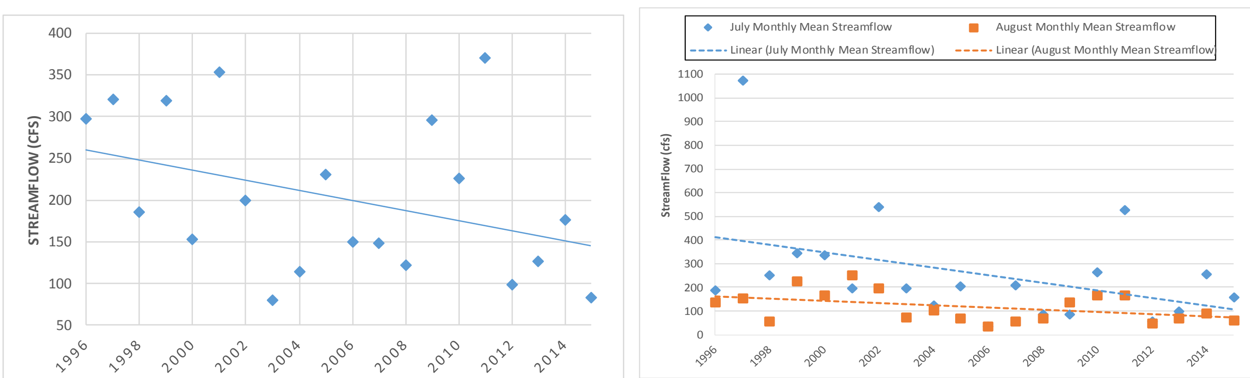


Figure 35. Annual Mean (left) and Monthly Mean (right) Streamflow for Clearwater River at Plummer, Minnesota (1996-2015). (Source: USGS, 2016b)

Figure 36. Annual Mean (left) and Monthly Mean (right) Streamflow for Lost River at Oklee, Minnesota (1996-2015). (Source: USGS, 2016c)

Wetland condition

Wetland vegetation quality is generally high in Minnesota (Table 22). This is driven by the large share of wetlands located in Mixed Wood Shield (i.e., northern forest) ecoregion where development and resulting stressors are much less widespread (and wetland condition is largely intact) compared to the rest of the state. Wetlands in exceptional or good biological condition have few (if any) changes in their expected native species composition or abundance distribution. Wetland vegetation quality is largely degraded in the remainder of the state, where non-native invasive plant species (most notably Reed Canary Grass and Narrow Leaf or Hybrid Cattail) have replaced native wetland plant communities over the majority of the remaining wetland extent (MPCA 2015). The high abundance of non-native invasive plant species is associated with a broad spectrum of wetland stressors and may also occur in the absence of stressors.

Table 22. Biological Wetland Condition Statewide and by Major Ecoregions According to Vegetation and Macroinvertebrate Indicators*.

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

Macroinvertebrate Condition in Depressional Wetlands			
Condition Category	Mixed Wood Plains + Temperate Prairies	Mixed Wood Plains	Temperate Prairies
Good	45%	46%	41%
Fair	33%	34%	30%
Poor	22%	20%	27%

*Vegetation results are expressed by extent (i.e., percentage of wetland acres) and include virtually all wetland types (MPCA 2015). Macroinvertebrate results represent natural depressional wetlands (e.g., prairie potholes) that typically have open water and are expressed as the percentage of wetland basins (Genet 2015). Depressional wetland monitoring is focused in Mixed Wood Plains and Temperate Prairie ecoregions (as opposed to statewide) where it is a more prevalent type.

The overall macroinvertebrate quality of natural depressional wetlands in the Mixed Wood Plains and Temperate Prairies ecoregions (where depressional wetlands are more prevalent) is moderate (Table 22). Approximately 41% - 46% of natural depressional wetland basins (man-made ponds were excluded from the results) are in good macroinvertebrate condition between the two ecoregions. Natural depressional wetlands have much higher rates of good macroinvertebrate condition compared to the rate of exceptional-good vegetation condition in this part of Minnesota.

Wetland quality in the Clearwater River Watershed is expected to vary from east to west as all three of Minnesota's major ecoregions occur in the watershed (Figure 22, Table 22). The large majority of the wetlands located within the Mixed Wood Shield ecoregion portions of the watershed, likely are in exceptional-good vegetation condition. Wetlands with degraded vegetation are probably limited to localized impacts in this area. Conversely, the large majority of wetlands in the Mixed Wood Plains portion of the watershed likely have fair-poor (or degraded) vegetation condition. Natural depressional wetlands are numerous in this part of the watershed (as it coincides with a terminal moraine) and likely of moderate overall macroinvertebrate condition. Finally, the few remaining wetlands in the Temperate Prairies ecoregion portion of the watershed are likely in degraded vegetation condition with intact plant communities limited to specific locations (e.g., calcareous fens in the glacial lake beach ridges). Depressional wetlands in this part of the watershed are a decreasingly common type from east to west (as the moraine landform gives way to the glacial lake plain) and are expected to have moderate overall macroinvertebrate condition.

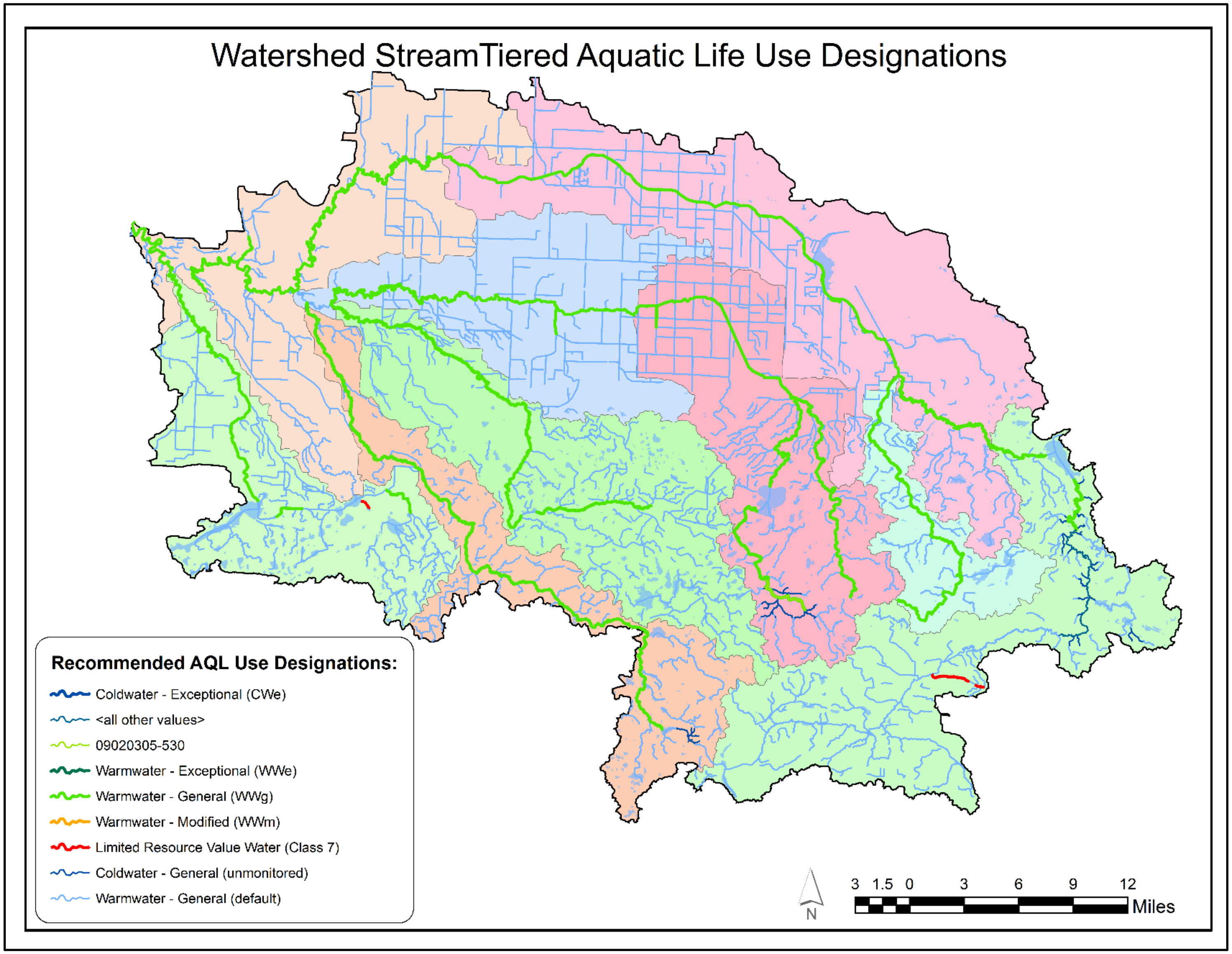


Figure 37. Stream Tiered Aquatic Life Use Designations in the Clearwater River Watershed.

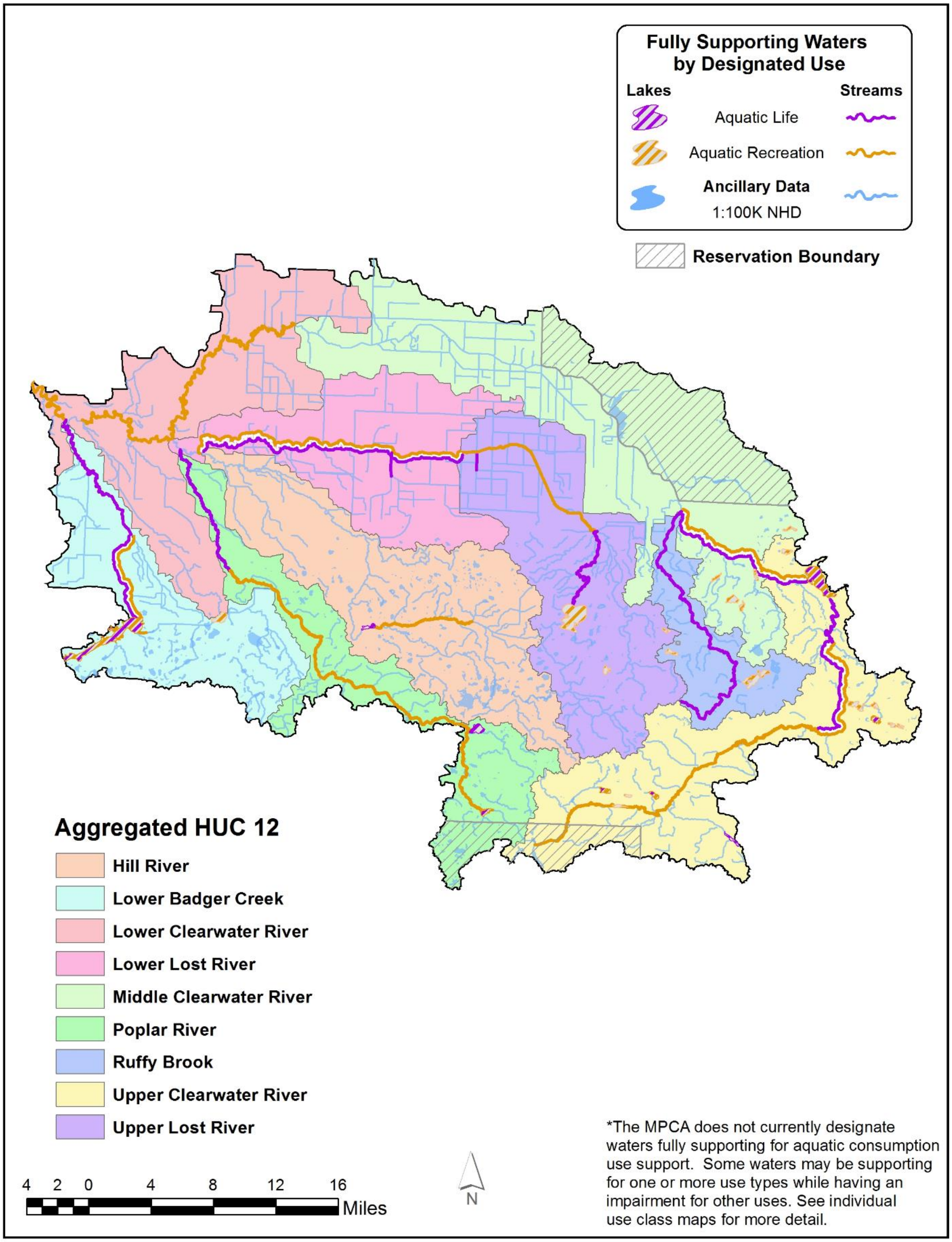


Figure 38. Fully Supporting Waters by Designated Use in the Clearwater River Watershed.

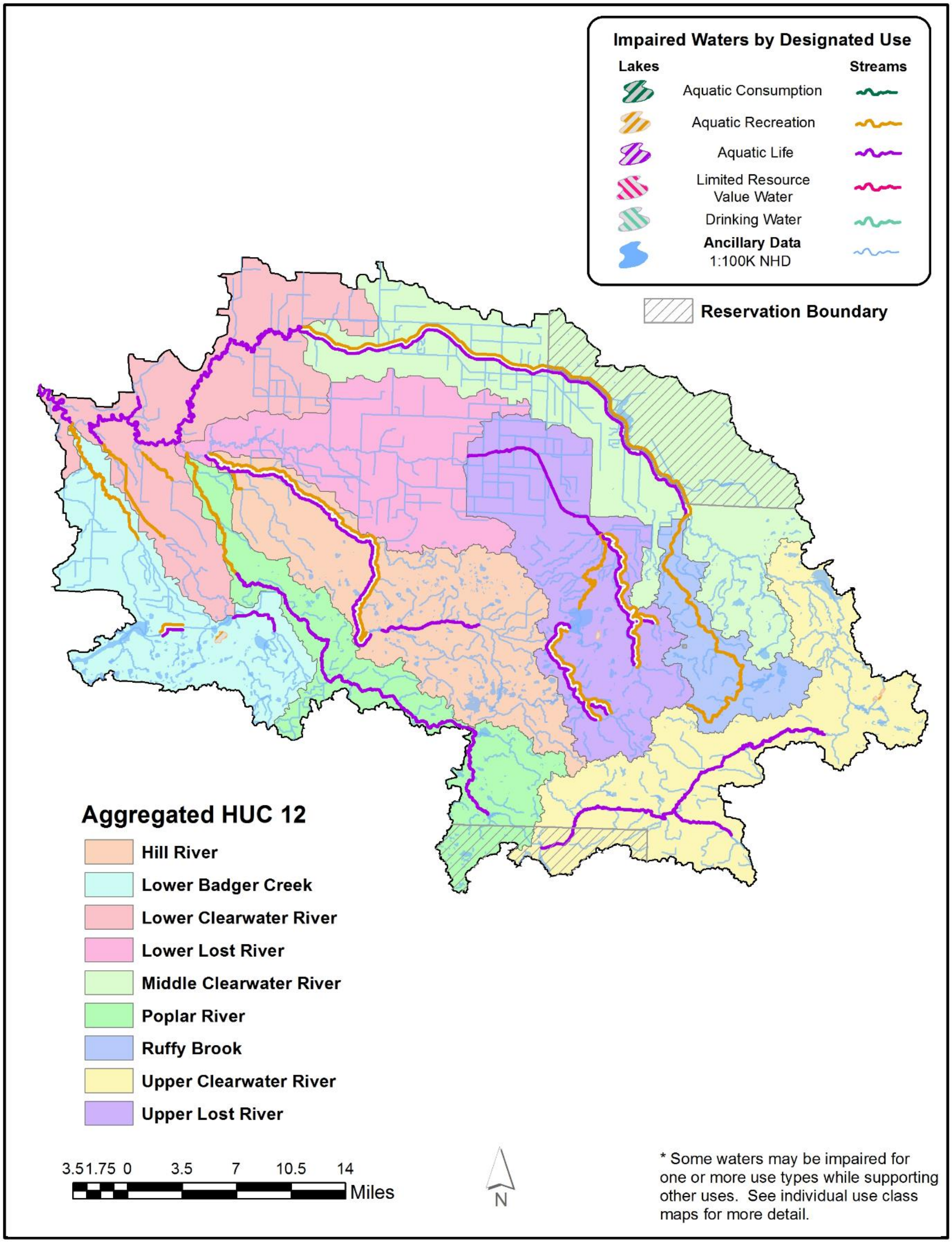


Figure 39. Impaired Waters by Designated Use in the Clearwater River Watershed.

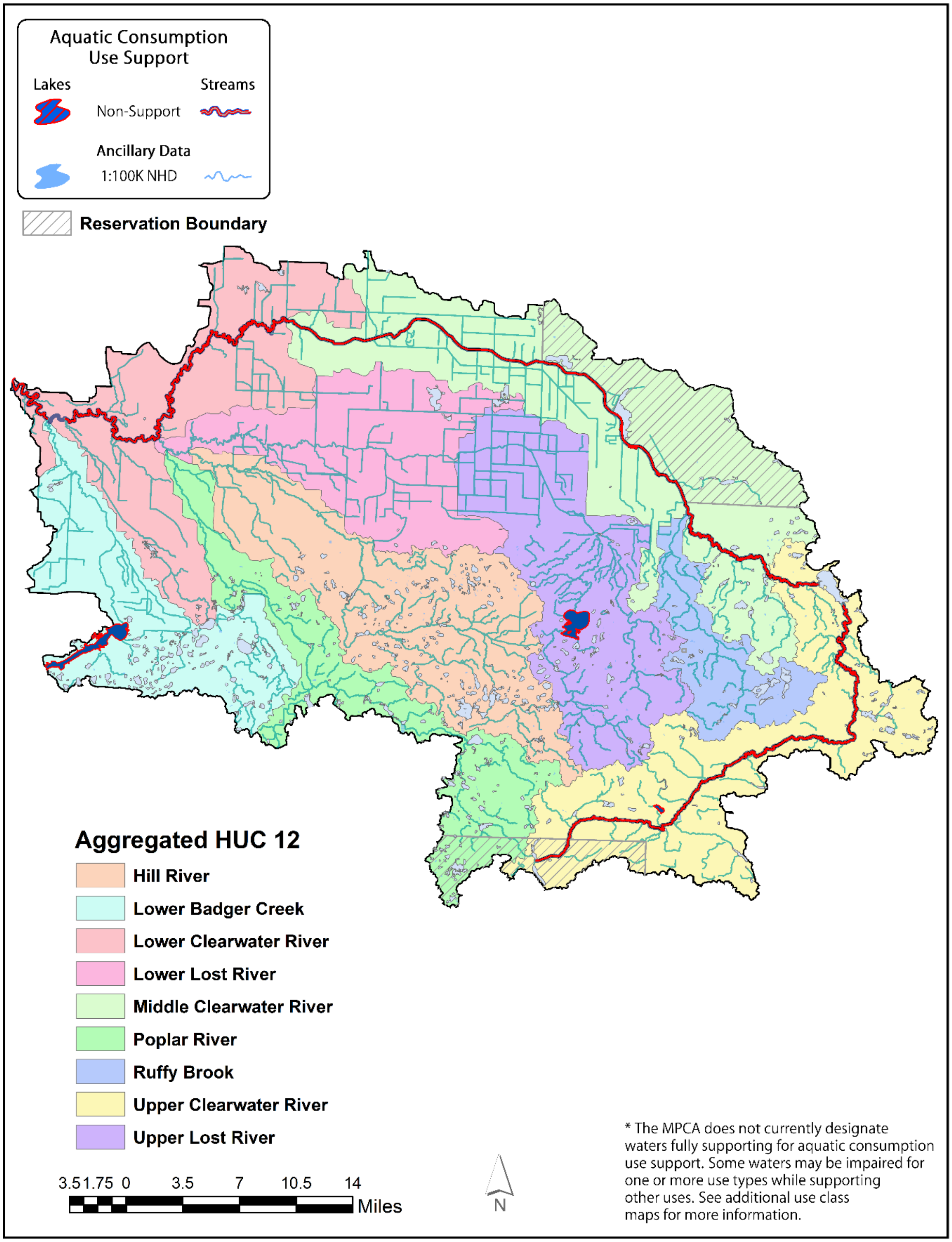


Figure 40. Aquatic Consumption Use Support in the Clearwater River Watershed.

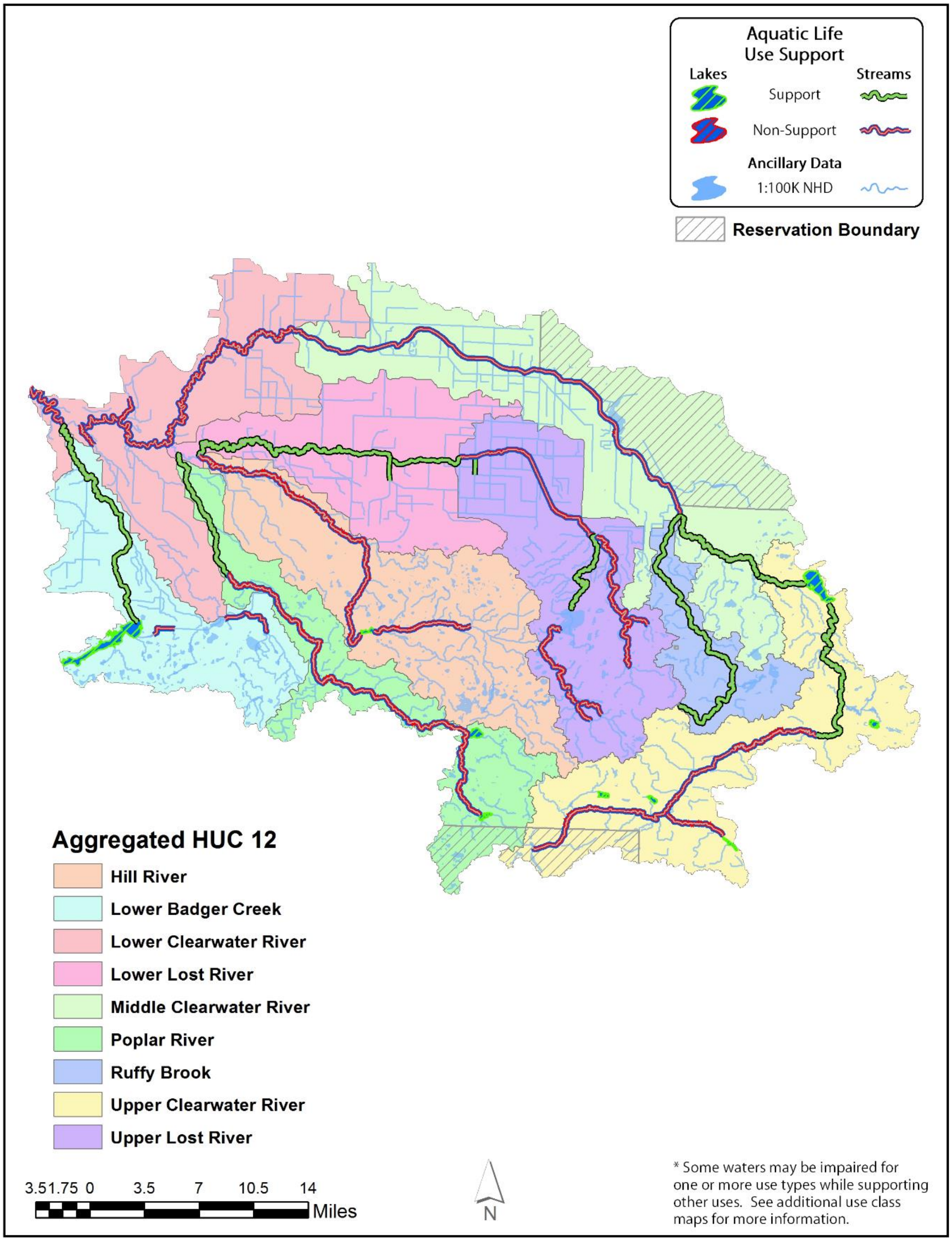


Figure 41. Aquatic Life Use Support in the Clearwater River Watershed.

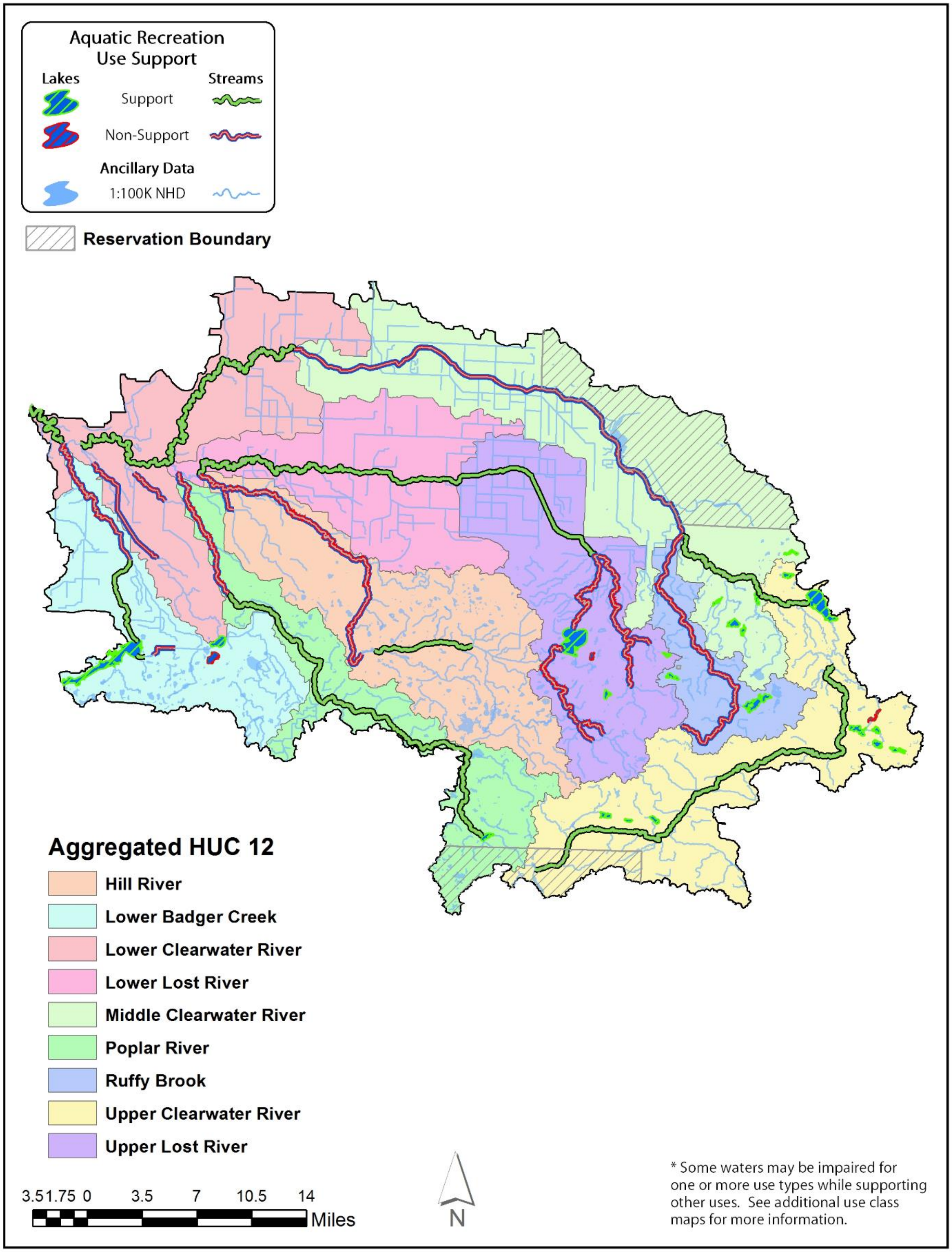


Figure 42. Aquatic Recreation Use Support in the Clearwater River Watershed.

Transparency trends for the Clearwater River Watershed

MPCA completes annual trend analysis on lakes and streams across the state based on long-term transparency measurements. The data collection for this work relies heavily on volunteers across the state and also incorporates any agency and partner data submitted to EQuIS.

The trends are calculated using a Seasonal Kendall statistical test for waters with a minimum of eight years of transparency data; Secchi disk measurements in lakes and Secchi Tube measurements in streams.

There are four volunteers enrolled in the CSMP to provide stream transparency data. Three lakes in the watershed have volunteers in the CLMP. Water clarity has shown no trend at any of these volunteer sites (Table 23). Important to note, the River Watch Citizen Monitoring Program (in partnership with International Water Institute) is conducted throughout the Red River Basin. This citizen program has water chemistry data available from streams, ditches, lakes, and impoundments throughout the Red River Basin. Information on these sites can be found at http://riverwatch.wq.io/.

Citizen volunteer monitoring occurs at four streams and three lakes in the watershed. Water clarity has shown no trend.

Table 23. Water Clarity Trends at Citizen Stream Monitoring Sites.

Clearwater River HUC 09020305	Citizen Stream Monitoring Program	Citizen Lake Monitoring Program
number of sites w/ increasing trend	0	0
number of sites w/ decreasing trend	0	0
number of sites w/ no trend	4	3

In June 2014, the MPCA published its final trend analysis of river monitoring data located statewide based on the historical Milestones Network. The network is a collection of 80 monitoring locations on rivers and streams across the state with good, long-term water quality data. The period of record is generally more than 30 years, through 2010, with monitoring at some sites going back to the 1950s. While the network of sites is not necessarily representative of Minnesota's rivers and streams as a whole, they do provide a valuable and wide-spread historical record for many of the state's waters. Starting in 2017, the MPCA will be switching to the Pollutant Load Monitoring Network for long term trend analysis on rivers and streams. Data from this program has much more robust sampling and will cover over 100 sites across the state.

Remote sensing for lakes in the Clearwater River Watershed

The University of Minnesota, in partnership with MPCA, conducts remote sensing of lake clarity. The information provides a snapshot of water transparency during late summer over a span of 30 years. Secchi disk transparency data is paired with satellite imagery to come up with estimates of water clarity across the state. While there are limitations to the data, such as cloud cover, vegetation, or stained water altering the estimated Secchi transparency, it does provide information to help prioritize monitoring and protection efforts on lakes, which do not have, water quality data. Lakes with this remote sensing information in the Clearwater River Watershed, as illustrated in Figure 43 by the red, yellow, and green Secchi disks, include Turtle, Maple, Clearwater, and Kiwosay Pool. Lakes with poor transparency had mean Secchi depths below their respective ecoregion standard over the course of the remote sensing study. Lakes with fair transparency had mean Secchi depths that ranged from their standard up to 50% above their standard. Lakes with good transparency had mean Secchi depths over 50% above their standard.

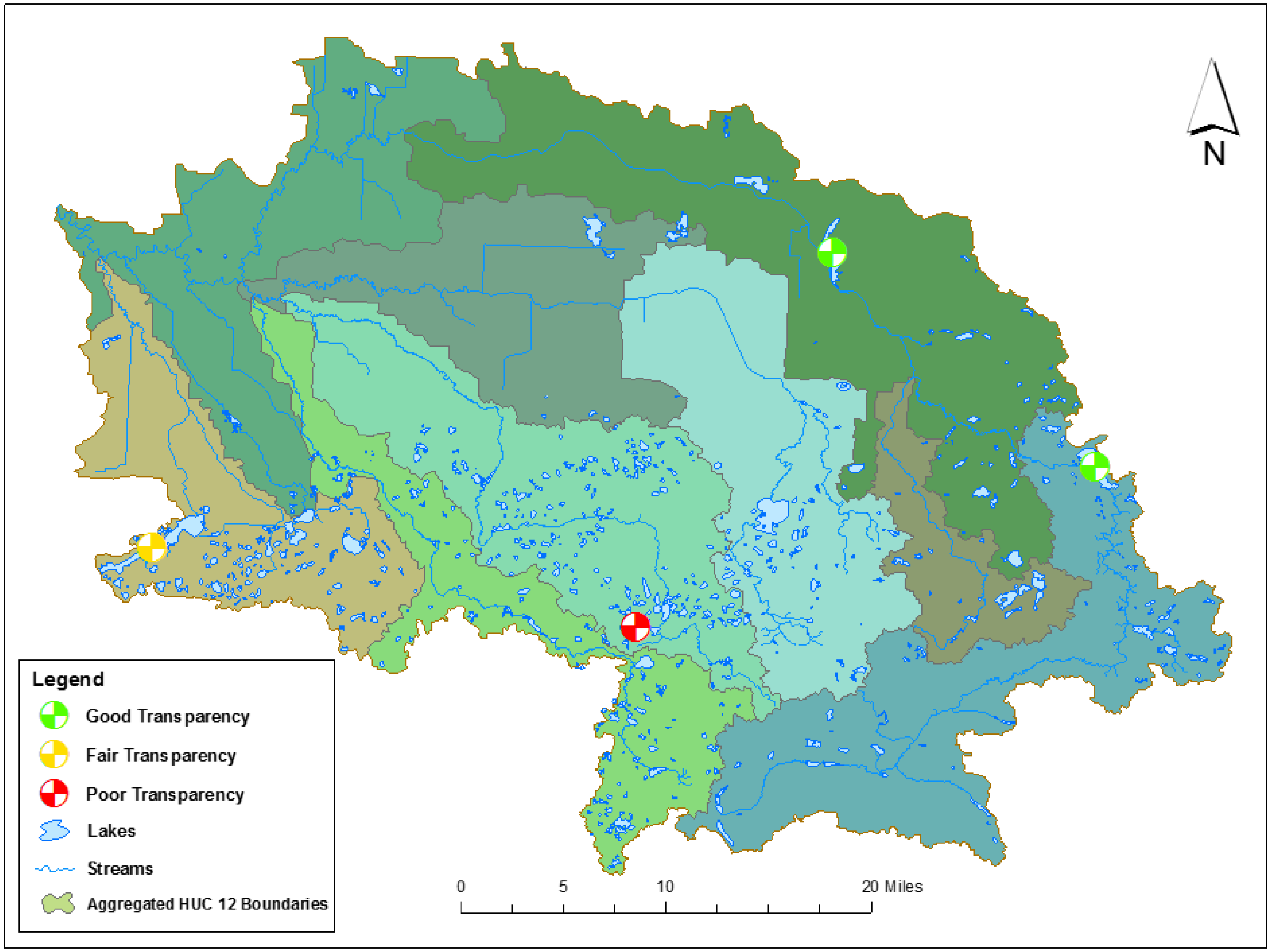


Figure 43. Remotely Sensed Secchi Transparency on Lakes in the Clearwater River Watershed.

Summaries and recommendations

Eighty-six species of fish have been documented in the Red River Basin. MPCA biological monitoring crews captured 58 species of fish during the IWM stream sampling in the Clearwater River Watershed. The majority of the fish samples collected within the watershed contained 12 – 18 species; 12 samples contained over 20 species. Common shiners, central mudminnows, johnny darters, white suckers, and creek chubs were the most commonly sampled species within the watershed. These species were present at 35 or more monitoring locations; all of them are commonly found throughout the Midwest. Common shiners were the most abundant species sampled (over 3,000 individuals). Common shiners use a wide range of habitats; however, they are most often found in small to medium sized clear water streams with sand and gravel substrate. The Clearwater River, as well as many other streams within the watershed, contain such habitat. The central mudminnow prefers stagnant or slow flowing, vegetated waters commonly associated with wetlands and low gradient streams. Their preferred habitat is very common along the margins of lakes and streams throughout the Clearwater River Watershed. White suckers inhabit streams of various gradients as well as many lakes. The species can adapt well to different habitats and is tolerant of higher levels of turbidity. The johnny darter inhabits both lakes and streams but prefers smaller streams with sand and gravel substrate. Most of the headwater streams, as well as many larger streams within the watershed provide ideal habitat. Creek chubs have habitat preferences similar to that of the johnny darter. The creek chub is tolerant of wide variety of environmental conditions and can persist in degraded environments. Other commonly sampled species within the Clearwater River Watershed included blacknose dace, blackside darter, hornyhead chub, and northern pike. All of these species are commonly found in clear water lakes and streams throughout the Midwest.

Almost every sample collected from the Clearwater River main stem contained 40% or greater insectivorous taxa. Over half of these samples contained 47% or greater insectivorous taxa. Species such as the hornyhead chub, as well as most darter and redhorse species are insectivores. Insectivores feed exclusively upon invertebrates and rely on the existence of a stable invertebrate population. Any disturbances within a watershed that cause a reduction in invertebrate abundance will also cause a reduction in insectivorous fish species. The persistence of a stable macroinvertebrate community at many locations on the Clearwater River indicate good water quality and low disturbance. Many of these insectivorous species are also simple lithophilic spawners. Simple lithophilic spawners require clean coarse substrate to spawn. The abundance and persistence of simple lithophilic spawning species is dependent upon a stable environment. Excess sedimentation and/or channel instability would cover coarse substrates and reduce their abundance. Intolerant taxa were present in almost every sample collected from these same stations. Intolerant species are very sensitive to environmental degradation (especially increased turbidity) and are the first species to disappear due to disturbance. Across their native range, many of these species are either threatened or extirpated. The most commonly encountered intolerant species were the chestnut lamprey, longnose dace, and blacknose shiner. All three of these species were present in each sample collected upstream of the confluence of Ruffy Brook and the Clearwater River; this is the upstream portion of the Clearwater River that features a natural channel. Intolerant species (and sensitive species in general) were markedly less abundant at stations located on the channelized portion of the Clearwater River. The presence of these intolerant species at so many locations on the Clearwater River is an indication that this river is a high quality resource. Other high quality resources (based on the fish community) within the Clearwater River Watershed include Ruffy Brook, the lower portion of the Hill River, and the lower portion of the Poplar River. Most of the fish samples collected from stations located on these reaches featured high portions of insectivores, sensitive species, and simple lithophilic spawners.

Macroinvertebrate communities within the watershed ranged from excellent to poor. Similar to fish, healthy macroinvertebrate communities were generally found in locations with good habitat heterogeneity and less disturbance. In total, 306 unique macroinvertebrate taxa were collected. No threatened, endangered, or species of special concern were identified during IWM macroinvertebrate sampling in the Clearwater River Watershed. *Dolophilodes*, *Lype,* and *Ephemerella* are all sensitive coldwater obligate taxa, which are relatively rare in the largely warmwater Red River Basin. Tolerant blackfly larva (*Simulium)* numerically dominated many samples collected during summer of 2014. These organisms are found in high abundance in many streams across northern Minnesota due to their life history strategies and fecundity.

Most streams within the Clearwater River Watershed featured biological communities that were in good condition. Areas of clean coarse substrate and a variety of cover types were present in many streams. The various substrate and cover types combined with good channel development increase habitat heterogeneity. This increased habitat heterogeneity (or complexity) allows for the development of diverse aquatic communities. Excellent habitat was present on portions of the Lost River, Ruffy Brook, and Hill River. Good habitat was also present at most stations located on the natural channel of the Clearwater River. Compared to stations located on the natural channel, stations located on the channelized portion of the Clearwater River often had poorer channel development and fewer cover types. In general, the FIBI scores were lower at these stations. Extensive ditching and other hydrologic alterations in the surrounding watershed alter the stream habitat and biological communities located on the channelized reach of the Clearwater. Most of the streams with poor biological communities were channelized; they had poor channel development, low channel stability, and embedded coarse substrate. Hydrologic alterations within the watershed (and to the stream channels themselves) have increased flow variability and channel instability on these reaches. Excess sediment (covering of coarse substrate), unstable flow patterns, and reduced habitat complexity favor biological communities that are tolerant of disturbance. Species with specialized trophic and habitat requirements (i.e., lithophilic spawners and insectivores) are dependent upon a stable environment. These species are often scarce or absent in these systems. In some of these systems, and at other locations within the watershed, fluctuations in dissolved oxygen appear to negatively influence the biology. Excessive DO flux often occurred during periods of low flow in streams where hydrologic modifications have reduced base flow. During periods of reduced flow and stagnation, algal biomass and bacteria have more time to utilize nutrients and increase production (Rankin *et al*. 1999). Excess nutrients (phosphorus) were present in some of these reaches and were likely the cause of the dissolved oxygen flux. On portions of the Poplar River and Hill River, wetland influence is likely causing low dissolved oxygen levels. The decomposition of the organic matter present in wetlands consumes dissolved oxygen. Larger precipitation events can flush this water and organic matter into streams causing dissolved oxygen levels to decrease. Other biological impairments within the Clearwater River Watershed were caused by a lack of connectivity. Barriers to fish migration, such as beaver dams and improperly installed culverts, prevent certain species of fish from migrating upstream. These barriers can also alter habitat by slowing flow, causing sediment to settle out over the stream reach and channel development to be reduced.

There are some notable concerns for aquatic life related to water chemistry. Chemical impairments occurred on 16 of the 42 assessed reaches; with dissolved oxygen being the most prevalent, occurring on ten stream reaches. Excess sediment and high nutrient levels also occurred in portions of the watershed. The Clearwater River Watershed lies within four major ecoregions: Northern Lakes & Forests Ecoregion to the east and Northern Minnesota Wetlands Ecoregion to the northeast transitioning to North Central Hardwood Forests Ecoregion in the central part of the watershed then to Lake Agassiz Plain Ecoregion to the west. As such, land use drastically changes from east to west from coniferous forests and wetlands to a mixture of hardwood, deciduous forests and pasture lands, to mainly row crops. This is significant since the majority of chemistry impairments were found in the central and western portions of the watershed where livestock and crops dominate the landscape.

Bacteria (*E. coli*) concentrations are a concern; 15 stream reaches exceeded the aquatic recreation standards. High bacteria concentrations were found throughout the summer months on these problematic reaches resulting in the *E. coli* impairments or confirmation of existing fecal coliform or *E. coli* impairments. A possible contributor to the bacteria impairments is the presence of livestock access to the streams. Another cause for elevated bacteria could be from wildlife such as waterfowl and nesting birds. For example, where bridges cross the streams, cliff swallows can congregate and nest in high numbers early in the summer – their leavings can significantly increase bacteria concentrations.

Lake water chemistry was generally good across the Clearwater Watershed. Only three of the 53 lakes assessed exceeded aquatic recreation standards. The three impaired lakes were all small, shallow basins and all three of these lakes have evident anthropogenic influences that could be attributing to the poor water quality on these lakes. Long (04-0295-00) has a small catchment and approximately half the land use surrounding the lake is pasture and cropland. Stony (15-0156-00) is primarily bordered by pasture and cropland, and there are minimal shoreline buffers. Unrestricted access by livestock has been observed on Stony Lake as well. Cameron (60-0189-00) is bordered by the city of Erskine. The western shore is bordered by cropland, while light to heavy residential and commercial development surrounds the north, east, and south shorelines. Cameron Lake has marginal shoreline buffers and ringed by several impervious surfaces (parking lots, driveways, streets, highways, etc.) which could intensify surface runoff. Fish were assessed on twelve lakes within the watershed; none of them exceeded standards and nine fully supported aquatic life.

Some examples of land management practices that could assist in the recovery and protection of streams and lakes throughout the watershed consist of:

- Establishment and reintroduction of riparian zones and shorelines using native vegetation, trees, and shrubs
- Protect any current riparian buffer zones, shorelines, and exceptional aquatic habitats
- Institute agricultural best management practices to improve reaches with sedimentation and erosion issues and to prevent additional sedimentation
- Restrict livestock access to streams
- Continuation of chemistry and biological monitoring to evaluate and document declining or improving conditions
- Continuous DO monitoring on several stream reaches to determine if low DO concentrations are affecting biological communities

Groundwater protection should be considered both for quantity and quality. Quantity is based on the amount of water withdrawn versus the amount of water being recharged to the aquifer. Groundwater withdrawals in the watershed have increased by 42% from 1994 to 2013, this is a statistically significant rate ($p<0.01$). Additionally, water table elevation for one of the DNR observation wells within the watershed has a significant decreasing trend over the most recent 20 years of data collected ($p<0.001$). Development pressure is moderate in most areas of the watershed where land is converted from farms and timberland to recreation and lake and country homes (USDA NRCS). The shift in land use coincides with a significant decrease in agricultural irrigation ($p<0.001$) and an increase in non-crop irrigation (golf courses) and water supply ($p<0.1$). Overall groundwater withdrawals have been increasing; the average potential groundwater recharge rate is below the state average, and the watershed's water table has exhibited some signs of decline. While fluctuations due to seasonal variations are normal, long term changes in elevations should not be ignored.

There is limited amount of groundwater quality data available specifically for the Clearwater River Watershed. Baseline water quality data indicated that the northwest region has a higher concentration of chemicals in the sand and gravel aquifers; however, this is primarily associated with Cretaceous bedrock, which is not present in the Clearwater Watershed. There were relatively high numbers of exceedances to the arsenic MCL for drinking water in private wells for this area. Arsenic is primarily naturally occurring and can be linked to the presence of a clay layer and low DO levels, often associated with the Des Moines glacial lobe till, which is abundant in this region. Furthermore, the ultra-low to low levels of pollution sensitivity of near-surface materials throughout the watershed may appear to limit the risk of groundwater contamination, monitoring of sensitive area should continue to inhibit possible water pollution. Additional and continued monitoring will increase the understanding of the health of the watershed and its groundwater resources and aid in identifying the extent of the issues present and risk associated.

Literature cited

Becker, George C. 1983. Fishes of Wisconsin. University of Wisconsin Press, Madison.

Genet, J.A. 2015. Status and Trends of Wetlands in Minnesota: Depressional Wetland Quality Assessment (2007-2012). wq-bwm1-08. Minnesota Pollution Control Agency. St. Paul, MN. https://www.pca.state.mn.us/sites/default/files/wq-bwm1-08.pdf

Hobbs, H.C. and Goebel, J. E. (1982), Geologic Map of Minnesota, Quaternary Geology, S-01. Minnesota Geological Survey. Using: *ArcGIS* [GIS software]. Version 10.3.1. Redlands, CA: Environmental Systems Research Institute. Retrieved from https://conservancy.umn.edu/handle/11299/60085

Jirsa, M.A., Boerboom, T. J., Chandler, V.W., Mossler, J. H., Runkel, A. C. and Setterholm, D. R. (2011), Geologic Map of Minnesota, Bedrock Geology, S-21. Minnesota Geological Survey. Using: *ArcGIS* [GIS software]. Version 10.3.1. Redlands, CA: Environmental Systems Research Institute. Retrieved from https://conservancy.umn.edu/handle/11299/101466

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

Kroening, S. and Ferrey, M. (2013), The Condition of Minnesota's Groundwater, 2007-2011. Document number: wq-am1-06. Retrieved from https://www.pca.state.mn.us/sites/default/files/wq-am1-06.pdf

Minnesota Department of Health (2016b), Private Wells - Arsenic. Retrieved from https://apps.health.state.mn.us/mndata/webmap/wells.html

Minnesota Department of Health (2016a), Arsenic in Private Wells: Facts & Figures. Retrieved from https://apps.health.state.mn.us/mndata/arsenic_wells

Minnesota Department of Natural Resources (2016a), Groundwater Provinces. Retrieved from http://dnr.state.mn.us/groundwater/provinces/index.html

Minnesota Department of Natural Resources (2016b), Pollution Sensitivity of Near-Surface Materials. County Geologic Atlas Program. Using: *ArcGIS* [GIS software]. Version 10.3.1. Redlands, CA: Environmental Systems Research Institute. Retrieved from https://gisdata.mn.gov/dataset/geos-hydrogeology-atlas-hg02

Minnesota Department of Natural Resources: State Climatology Office (2003), Climate. Retrieved from http://www.dnr.state.mn.us/faq/mnfacts/climate.html

Minnesota Department of Natural Resources: State Climatology Office (2015), Annual Precipitation Maps. Retrieved from http://climate.umn.edu/doc/annual_pre_maps.htm

Minnesota Department of Natural Resources (2016c), Water use- Water Appropriations Permit Program. Retrieved from http://www.dnr.state.mn.us/waters/watermgmt_section/appropriations/wateruse.html

Minnesota Geological Survey (MNGS). 1997. Minnesota at a Glance—Quaternary Glacial Geology. Minnesota Geological Survey, University of Minnesota, St. Paul, MN. https://conservancy.umn.edu/handle/11299/59427

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

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

Minnesota Pollution Control Agency (MPCA). 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.

Minnesota Pollution Control Agency (2005), Minnesota's Ground Water [PowerPoint slides]. Retrieved from https://www.pca.state.mn.us/sites/default/files/pp-mngroundwater.pdf

Minnesota Pollution Control Agency (MPCA). 2010d. Minnesota Milestone River Monitoring Report. http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/streams-and-rivers/minnesota-milestone-river-monitoring-program.html.

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). 2010e. Regionalization of Minnesota's Rivers for Application of River Nutrient Criteria. http://www.pca.state.mn.us/index.php/view-document.html?gid=6072.

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

Minnesota Pollution Control Agency (2016), What's In My Neighborhood. Retrieved from https://www.pca.state.mn.us/data/whats-my-neighborhood

Minnesota Pollution Control Agency (MPCA). 2008a. Watershed Approach to Condition Monitoring and Assessment. Appendix 5.2 *in* Biennial Report of the Clean Water Council. Minnesota Pollution Control Agency, St. Paul, Minnesota.

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.

Morey, G.B., and Meints, J. (2000), Geologic Map of Minnesota, Bedrock Geology, S-20. Minnesota Geological Survey. Using: *ArcGIS* [GIS software]. Version 10.3.1. Redlands, CA: Environmental Systems Research Institute. Retrieved from https://mrdata.usgs.gov/geology/state/state.php?state=MN

National Oceanic and Atmospheric Administration: National Centers for Environmental Information (NOAA) (2016), Climate at a Glance: Time Series. Retrieved from http://www.ncdc.noaa.gov/cag/time-series/us/21/0/tavg/12/12/1895-2015?base_prd=true&firstbaseyear=1895&lastbaseyear=2000

Krenz, G. and J. Leitch. 1993, 1998. A River Runs North: Managing an International River. Red River Water Resources Council.

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

Rankin, E., B. Miltner, C. Yoder and D. Mishne. 1999. Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams. OEPA Technical Bulletin No. MAS/1999-1-1. Ohio EPA, Division of Surface Water, Ecological Assessment Section, Columbus, Ohio.

Smith, D.R., A. Ammann, C. Bartoldus, and M.M. Brinson. 1995. An approach for assessing wetland functions using hydrogeomorphic classification, reference wetlands, and functional indices. Wetlands Research Technical Report WRP-DE-9. US Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Streitz, A. (2011), Minnesota Pollution Control Agency. Retrieved from http://www.mgwa.org/newsletter/mgwa2011-4.pdf

United States Department of Agriculture, Natural Resources Conservation Service (No Date), Rapid Watershed Assessment: Clearwater (MN) HUC: 09020305. Retrieved from https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_022746.pdf

United States Geological Survey (2016a), Aquifers and Groundwater. Retrieved from http://water.usgs.gov/edu/earthgwaquifer.html

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

United States Geological Survey (2015), Mean Annual Potential Groundwater Recharge Rates from 1996-2010 for Minnesota. Methodology documented in Smith, E.A. and Westernbroek, S.M., 2015 Potential groundwater recharge for the state of Minnesota using the Soil-Water-Balance model, 1996-2010: U.S. Geological Survey Investigations Report 2015-5038. Using: *ArcGIS* [GIS software]. Version 10.3.1. Redlands, CA: Environmental Systems Research Institute. Retrieved from https://conservancy.umn.edu/handle/11299/60085

United States Geological Survey (2016b), USGS 0507800 Clearwater River at Plummer, MN. Retrieved from https://waterdata.usgs.gov/mn/nwis/inventory/?site_no=05078000

United States Geological Survey (2016c), USGS 05078230 Lost River at Oklee, MN. Retrieved from https://waterdata.usgs.gov/mn/nwis/inventory/?site_no=05078230

Western Regional Climate Center (WRCC) (2016), U.S.A. Divisional Climate Data. Retrieved from http://www.wrcc.dri.edu/spi/divplot1map.html

Zhang, H. (1998), Geologic Atlas of Stearns County, Minnesota: Hydrogeology of the Quaternary Water Table System. County Atlas Series, Atlas C-10, part B, Plate 8 of 10, Hydrogeology of the Quaternary Water-table System.

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 wastewater 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.

Total Kjeldahl 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.

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

Appendix 2.1 – Intensive watershed monitoring water chemistry stations in the Clearwater River Watershed

EQuIS ID	Biological Station ID	AUID	Waterbody Name	Location	Aggregated 12-digit HUC
S000-924	14RD230	09020305-512	Lost River	At 139th Ave, 2 mi N of Gonvick	0902030505-02
S001-020	14RD231	09020305-527	Silver Creek	At 520th St, 2 mi NE of Gonvick	0902030505-02
S001-908	--	09020305-517	Clearwater River	At CR 2, 4 mi N of Shevlin	0902030501-01
S002-118	94RD512	09020305-501	Clearwater River	At Klondike Bridge/Bottineau Ave in Red Lake Falls	0902030507-01
S002-133	14RD259	09020305-646	Lost River	At CR 119, 2.5 mi N of Brooks	0902030505-01
S002-134	14RD221	09020305-539	Hill River	At CR 119, 0.5 mi NW of Brooks	0902030503-01
S002-752	--	09020305-650	Clearwater River	At CSAH 11, 9 mi NE of Clearbrook	0902030502-01
S002-916	14RD200	09020305-647	Clearwater River	At CR 127, 5 mi W of Roland	0902030502-01
S002-929	10RD081	09020305-653	Clearwater River	At CSAH 22, 1.5 mi W of Pinewood	0902030501-01
S003-318	--	09020305-550	Judicial Ditch 73	At 330th St SE, 2 mi SE of Mentor	0902030506-01
S004-837	14RD237	09020305-502	Lower Badger Creek	At CR 114, 4.5 mi W of Terrebonne	0902030506-01
S007-608	14RD215	09020305-504	Poplar River	At CR 118, 3.5 mi W of Brooks	0902030504-01
S007-849	14RD226	09020305-645	Lost River	At CSAH 28, 4 mi N of Trail	0902030505-02
S007-848	14RD233	09020305-513	Ruffy Brook	Adjacent to 189th Ave, 4 mi E of Berner	0902030502-02
S007-847	14RD246	09020305-656	Hill River	At 335th Ave SE, 7 mi NE of McIntosh	0902030503-01

Appendix 2.2 – Intensive watershed monitoring biological monitoring stations in the Clearwater River Watershed

AUID	Biological Station ID	Waterbody Name	Biological Station Location	County	Aggregated 12-digit HUC
09020305-653	09RD065	Clearwater River	Upstream of Aure Rd, 5 mi. NW of Leonard	Beltrami	0902030501-01
09020305-653	10RD081	Clearwater River	Upstream of Hwy 22 (Pinewood Rd), 1 mi. W of Pinewood	Beltrami	0902030501-01
09020305-654	10EM085	Clearwater River	1 mi. N of CR 24, 2.5 mi. W of Aure	Beltrami	0902030501-01
09020305-649	14RD209	Clearwater River	Upstream of CSAH 14, 6 mi. N of Leonard	Clearwater	0902030501-01
09020305-653	14RD302	Clearwater River	Upstream from end of Nelson Dam Rd, 2.25 mi. SW of Aure	Beltrami	0902030501-01
09020305-653	14RD273	Clearwater River	Upstream of Hwy 22 (Pinewood Rd), 1 mi. W of Pinewood	Beltrami	0902030501-01
09020305-647	14RD200	Clearwater River	Upstream of CR 127, 5 mi. W of Roland	Red Lake	0902030502-01
09020305-647	14RD203	Clearwater River	Downstream of CSAH 10, in Roland	Red Lake	0902030502-01
09020305-647	14RD205	Clearwater River	Upstream end of 420th Ave SE, 9.5 mi. E of Roland	Clearwater	0902030502-01
09020305-647	14RD207	Clearwater River	Upstream of CR 5 on border of Red Lake Res., 3 mi. NE of Berner	Clearwater	0902030502-01
09020305-650	14RD208	Clearwater River	Upstream of CSAH 11, 9 mi. NE of Clearbrook	Clearwater	0902030502-01
09020305-647	07RD017	Clearwater River	Upstream of CR 5, 4 mi. W of Roland	Red Lake	0902030502-01
09020305-501	94RD512	Clearwater River	USGS site at Red Lake Falls, field#05078500	Red Lake	0902030507-01
09020305-511	14RD271	Clearwater River	Upstream of Hwy 12, 1 mi. NE of Terrebone	Red Lake	0902030507-01
09020305-648	14RD261	Clearwater River	Downstream of CR 20, 3 mi. SW of Plummer	Red Lake	0902030507-01
09020305-658	14RD260	Trib. to Clearwater River	Upstream of CR 1, 6 mi. E of Red Lake Falls	Red Lake	0902030507-01
09020305-648	14RD262	Clearwater River	North of CR 126, 2 mi. NE of Plummer	Red Lake	0902030507-01
09020305-652	14RD255	Beau Gerlot Creek	Upstream of CR 114, 3.5 mi. NW of Terrebonne	Red Lake	0902030507-01
09020305-649	15RD209	Clearwater River	Downstream of Hwy 59 (Minnesota St), 1 mi. N of Plummer	Red Lake	0902030507-01
09020305-658	16RD050	County Ditch 23	Downstream of CR 1, 6 mi. E of Red Lake Falls	Red Lake	0902030507-01
09020305-513	14RD303	Ruffy Brook	Upstream of CR 3, 3 mi. NE of Leonard	Clearwater	0902030502-02
09020305-513	14RD234	Ruffy Brook	Downstream of 480th St, 3 mi. NE of Clearbrook	Clearwater	0902030502-02
09020305-645	07RD024	Lost River	Upstream of 550th St, 3 mi. NE of Gully	Clearwater	0902030505-02
09020305-527	14RD235	Silver Creek	Upstream of CR 74, 1 mi. W of Clearbrook	Clearwater	0902030505-02
09020305-530	14RD299	Lost River	Upstream of CSAH 18, 1.5 mi. SE of Weme	Clearwater	0902030505-02
09020305-527	14RD231	Silver Creek	Upstream of 520th St, 2 mi. NE of Gonvick	Clearwater	0902030505-02
09020305-512	14RD230	Lost River	Upstream of 139th Ave, 2 mi. N of Gonvik	Clearwater	0902030505-02
09020305-643	14RD228	Trib. to Lost River	Adjacent to 380th Ave SE, 5 mi. NW of Gully	Polk	0902030505-02
09020305-645	14RD226	Lost River	Upstream of CSAH 28, 4.5 mi. N of Trail	Polk	0902030505-02
09020305-527	15EM098	Silver Creek	Downstream of CSAH 6, 1 mi. SW of Clearbrook	Clearwater	0902030505-02

09020305-529	15EM066	Lost River	2 mi. upstream of CSAH 6, 6 mi. SW of Clearbrook	Polk	0902030505-02
09020305-646	05RD046	Lost River	Just downstream of CR 133, 1.3 mi. W of Oklee	Red Lake	0902030505-01
09020305-646	05RD061	Lost River	Downstream of CR 129, ~3 mi. SE of Plummer	Red Lake	0902030505-01
09020305-590	07RD004	State Ditch 61	Downstream of 230th St (CR 33), 2.5 mi. E of Oklee	Polk	0902030505-01
09020305-646	14RD225	Lost River	Upstream of CSAH 33, 4 mi. E of Oklee	Polk	0902030505-01
09020305-646	14RD259	Lost River	Upstream of CR 119, 2.5 mi. N of Brooks	Red Lake	0902030505-01
09020305-539	05RD026	Hill River	Downstream of CR 35, 4.5 mi. NE of McIntosh	Polk	0902030503-01
09020305-656	14RD246	Hill River	Downstream of 335th Ave SE, 7 mi. NE of McIntosh	Polk	0902030503-01
09020305-539	14RD253	Hill River	Downstream of 190th Ave, 6.5 mi. SE of Oklee	Polk	0902030503-01
09020305-539	14RD221	Hill River	Upstream of CR 119, 0.5 mi. NW of Brooks	Red Lake	0902030503-01
09020305-518	14RD218	Poplar River	Upstream of driveway off of CSAH 27, 3.5 mi. NE of Fosston	Polk	0902030504-01
09020305-518	14RD216	Poplar River	Downstream of 315th St SE, 6 mi. NW of McIntosh	Polk	0902030504-01
09020305-504	14RD215	Poplar River	Upstream of CR 118, 4 mi. W of Brooks	Red Lake	0902030504-01
09020305-523	07RD005	County Ditch 14	Downstream of 290th St, 3.5 mi. N of Mentor	Polk	0902030506-01
09020305-502	07RD026	Lower Badger Creek	Upstream of CR 29, 6 mi. N of Mentor	Red Lake	0902030506-01
09020305-550	14RD241	Judicial Ditch 73	Adjacent to 340th St SE, 3 mi. SE of Mentor	Polk	0902030506-01
09020305-561	14RD243	Trib. to Poplar River Diversion Ditch	Downstream of 230th Ave, 2.5 mi. NE of Erskine	Polk	0902030506-01
09020305-502	14RD239	Lower Badger Creek	Upstream of CR 14, 3 mi. SW of Terrebonne	Red Lake	0902030506-01
09020305-502	14RD237	Lower Badger Creek	Downstream of CR 114, 3 mi. SW of Red Lake Falls	Red Lake	0902030506-01
09020305-523	14RD272	County Ditch 14	Upstream of 290th St., 3.5 mi N of Mentor	Polk	0902030506-01
09020305-523	15EM096	County Ditch 14	Downstream of Hwy 2, 0.5 mi. N of Mentor	Polk	0902030506-01

Appendix 3.1 – Minnesota statewide IBI thresholds and confidence limits

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

Appendix 3.2 – Biological monitoring results – fish IBI (assessable reaches)

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi²	Fish Class	Threshold	FIBI	Visit Date
HUC 12: 0902030501-01 (Upper Clearwater River)							
09020305-653	10RD081	Clearwater River	120.18	11	35	48.51	09-Aug-10
09020305-653	14RD273	Clearwater River	120.23	11	35	53.82	09-Jul-14
09020305-653	14RD302	Clearwater River	149.23	11	35	39.42	27-Aug-14
09020305-653	09RD065	Clearwater River	153.23	11	35	33.95	22-Sep-14
09020305-653	09RD065	Clearwater River	153.23	11	35	45.72	09-Jul-14
09020305-654	10EM085	Clearwater River	160.13	5	47	63.21	24-Jun-15
09020305-654	10EM085	Clearwater River	160.13	5	47	67.19	28-Jul-11
09020305-649	14RD209	Clearwater River	181.55	5	47	56.04	22-Jul-14
09020305-649	14RD209	Clearwater River	181.55	5	47	64.64	01-Jul-14
HUC 12: 0902030502-01 (Middle Clearwater River)							
09020305-650	14RD208	Clearwater River	216.03	5	47	58.57	23-Sep-14
09020305-650	14RD208	Clearwater River	216.03	5	47	62.35	22-Jul-14
09020305-647	14RD207	Clearwater River	316.90	5	47	44.21	18-Aug-14
09020305-647	14RD205	Clearwater River	391.54	4	38	41.91	19-Aug-14
09020305-647	14RD203	Clearwater River	443.07	4	38	51.78	04-Aug-14
09020305-647	07RD017	Clearwater River	479.08	4	38	53.13	08-Aug-07
09020305-647	14RD200	Clearwater River	483.41	4	38	57.13	06-Aug-14
HUC 12: 0902030507-01 (Lower Clearwater River)							
09020305-658	14RD260	Trib. to Clearwater River	8.29	6	42	0.00	23-Jun-14
09020305-658	16RD050	County Ditch 23	8.54	6	42	5.56	23-Jun-16
09020305-652	14RD255	Beau Gerlot Creek	24.16	6	42	0.05	23-Jun-15
09020305-652	14RD255	Beau Gerlot Creek	24.16	6	42	13.88	17-Jul-14
09020305-648	14RD262	Clearwater River	540.66	4	38	59.17	19-Aug-14
09020305-648	15RD209	Clearwater River	553.51	4	38	73.05	20-Aug-15
09020305-648	14RD261	Clearwater River	560.90	4	38	67.64	07-Aug-14
09020305-511	14RD271	Clearwater River	1158.81	4	38	66.55	05-Aug-14

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi²	Fish Class	Threshold	FIBI	Visit Date
09020305-501	94RD512	Clearwater River	1358.07	4	38	76.69	20-Aug-14
HUC 12: 0902030507-01 (Ruffy Brook)							
09020305-513	14RD303	Ruffy Brook	33.62	6	42	60.93	27-Aug-14
09020305-513	16RD234	Ruffy Brook	42.52	6	42	59.89	16-Jul-14
HUC 12: 0902030505-02 (Upper Lost River)							
09020305-530	14RD299	Lost River	20.62	6	42	29.93	11-Jun-14
09020305-530	14RD299	Lost River	20.62	6	42	45.71	17-Jun-15
09020305-529	15EM066	Lost River	26.08	7	42	65.66	03-Aug-15
09020305-512	14RD230	Lost River	54.76	5	47	48.71	16-Jul-14
09020305-645	07RD024	Lost River	108.91	5	47	27.62	08-Aug-07
09020305-645	07RD024	Lost River	108.91	5	47	44.15	08-Jul-14
09020305-643	14RD228	Trib to Lost River	3.00	6	42	58.68	10-Jun-14
09020305-645	14RD226	Lost River	154.40	5	47	32.72	10-Aug-15
09020305-527	15EM098	Silver Creek	14.17	6	42	41.48	17-Jun-15
09020305-527	14RD235	Silver Creek	16.29	6	42	52.19	10-Jun-14
09020305-527	14RD231	Silver Creek	31.95	6	42	57.94	16-Jul-14
HUC 12: 0902030505-01 (Lower Lost River)							
09020305-590	07RD004	State Ditch 61	32.28	6	42	50.72	21-Aug-07
09020305-646	14RD225	Lost River	176.84	5	47	46.82	08-Jul-14
09020305-646	05RD046	Lost River	264.11	5	47	59.02	11-Jul-06
09020305-646	05RD046	Lost River	264.11	5	47	61.03	23-Aug-06
09020305-646	05RD046	Lost River	264.11	5	47	65.21	06-Aug-15
09020305-646	05RD061	Lost River	278.90	5	47	36.37	22-Jun-06
09020305-646	14RD259	Lost River	285.62	5	47	65.13	17-Jul-14
HUC 12: 0902030503-01 (Hill River)							
09020305-656	14RD246	Hill River	60.06	5	47	0.00	14-Jul-15
09020305-656	14RD246	Hill River	60.06	5	47	31.43	10-Jun-14
09020305-539	05RD026	Hill River	103.34	5	47	33.39	10-Jul-06
09020305-539	14RD253	Hill River	116.76	5	47	38.41	19-Jul-16

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi²	Fish Class	Threshold	FIBI	Visit Date
09020305-539	14RD253	Hill River	116.76	5	47	43.68	15-Jul-14
09020305-539	14RD221	Hill River	151.50	5	47	69.71	08-Jul-14
HUC 12: 0902030504-01 (Poplar River)							
09020305-518	14RD218	Poplar River	49.31	6	42	23.13	16-Jun-15
09020305-518	14RD218	Poplar River	49.31	6	42	23.16	15-Jul-14
09020305-518	14RD216	Poplar River	93.28	5	47	58.88	05-Aug-14
09020305-504	14RD215	Poplar River	116.45	5	47	73.58	09-Jul-14
HUC 12: 0902030506-01 (Lower Badger Creek)							
09020305-561	14RD243	Trib. to Poplar River Diversion Ditch	25.44	7	42	0.00	10-Jun-14
09020305-548	14RD238	County Ditch 64	15.64	6	42	22.22	11-Jun-14
09020305-502	07RD026	Lower Badger Creek	91.70	5	47	32.73	09-Aug-07
09020305-550	14RD241	Judicial Ditch 73	49.76	7	42	36.68	16-Jul-14
09020305-502	07RD026	Lower Badger Creek	91.70	5	47	37.07	22-Jun-16
09020305-523	15EM096	County Ditch 14	71.63	5	47	43.11	16-Jun-15
09020305-523	07RD005	County Ditch 14	75.96	5	7	48.59	09-Aug-07
09020305-502	14RD237	Lower Badger Creek	121.94	5	47	50.55	17-Jun-15
09020305-502	14RD239	Lower Badger Creek	95.34	5	47	50.87	05-Aug-14
	14RD272	County Ditch 14	75.94	5	47	56.38	09-Jun-14

Appendix 3.3 – Biological monitoring results-macroinvertebrate IBI (assessable reaches)

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Invert Class	Threshold	MIBI	Visit Date
HUC 12: 0902030501-01 (Upper Clearwater River)							
09020305-653	10RD081	Clearwater River	120.18	8	32	53.57	21-Sep-10
09020305-653	14RD273	Clearwater River	120.23	8	32	53.82	30-Jul-14
09020305-653	14RD302	Clearwater River	149.23	8	32	39.42	27-Aug-14
09020305-653	09RD065	Clearwater River	153.23	8	32	33.95	07-Oct-09
09020305-653	09RD065	Clearwater River	153.23	8	32	45.72	28-Jul-14
09020305-654	10EM085	Clearwater River	160.13	4	51	63.21	05-Aug-15
09020305-654	10EM085	Clearwater River	160.13	4	51	67.19	08-Aug-11
09020305-649	14RD209	Clearwater River	181.55	3	53	56.04	30-Jul-14
HUC 12: 0902030502-01 (Middle Clearwater River)							
09020305-650	14RD208	Clearwater River	216.03	5	37	77.13	30-Jul-14
09020305-647	14RD207	Clearwater River	316.90	7	41	50.39	18-Aug-14
09020305-647	14RD205	Clearwater River	391.54	7	41	53.96	19-Aug-14
09020305-647	14RD203	Clearwater River	443.07	5	37	36.75	05-Aug-14
09020305-647	07RD017	Clearwater River	479.08	7	41	50.82	14-Aug-07
09020305-647	14RD200	Clearwater River	483.41	4	51	60.23	05-Aug-14
HUC 12: 0902030507-01 (Lower Clearwater River)							
09020305-652	14RD255	Beau Gerlot Creek	24.16	5	37	31.00	05-Aug-15
09020305-652	14RD255	Beau Gerlot Creek	24.16	5	37	26.79	29-Jul-14
09020305-648	14RD262	Clearwater River	540.66	2	31	57.51	19-Aug-14
09020305-648	15RD209	Clearwater River	553.51	2	31	61.00	20-Aug-15
09020305-648	14RD261	Clearwater River	560.90	2	31	55.99	05-Aug-14
09020305-511	14RD271	Clearwater River	1158.81	2	31	48.79	05-Aug-14
09020305-511	14RD271	Clearwater River	1158.81	2	31	51.66	05-Aug-14
09020305-501	94RD512	Clearwater River	1358.07	2	31	56.51	05-Aug-14

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi²	Invert Class	Threshold	MIBI	Visit Date
HUC 12: 0902030507-01 (RuffyBrook)							
09020305-513	14RD303	Ruffy Brook	33.62	5	37	34.27	30-Jul-14
09020305-513	16RD234	Ruffy Brook	42.52	5	37	62.03	27-Aug-14
HUC 12: 0902030505-02 (Upper Lost River)							
09020305-529	15EM066	Lost River	26.08	7	41	74.00	03-Aug-15
09020305-512	14RD230	Lost River	54.76	7	41	49.31	29-Jul-14
09020305-645	07RD024	Lost River	108.91	7	41	66.04	14-Aug-07
09020305-645	07RD024	Lost River	108.91	7	41	45.68	29-Jul-14
09020305-645	07RD024	Lost River	108.91	7	41	57.53	14-Aug-07
09020305-643	14RD228	Trib to Lost River	3.00	7	41	46.23	29-Jul-14
09020305-527	15EM098	Silver Creek	14.17	5	37	60.00	05-Aug-15
09020305-527	14RD235	Silver Creek	16.29	6	43	50.14	30-Jul-14
09020305-527	14RD231	Silver Creek	31.95	5	37	31.90	30-Jul-14
HUC 12: 0902030505-01 (Lower Lost River)							
09020305-590	07RD004	State Ditch 61	32.28	7	41	70.84	14-Aug-07
09020305-646	14RD225	Lost River	176.84	7	41	53.88	29-Jul-14
09020305-646	05RD046	Lost River	264.11	7	41	58.50	24-Aug-05
09020305-646	05RD046	Lost River	264.11	7	41	40.00	06-Aug-15
09020305-646	14RD259	Lost River	285.62	5	37	43.11	29-Jul-14
HUC 12: 0902030503-01 (Hill River)							
09020305-656	14RD246	Hill River	60.06	6	43	53.83	30-Jul-14
09020305-539	14RD253	Hill River	116.76	6	43	56.45	30-Jul-14
09020305-539	14RD221	Hill River	151.50	5	37	68.64	29-Jul-14
HUC 12: 0902030504-01 (Poplar River)							
09020305-518	14RD218	Poplar River	49.31	6	43	8.8	14-Sep-16
09020305-518	14RD218	Poplar River	49.31	6	43	25.73	06-Aug-14
09020305-518	14RD216	Poplar River	93.28	7	41	67.00	17-Aug-15
09020305-518	14RD216	Poplar River	93.28	7	41	27.63	04-Aug-14
09020305-518	14RD216	Poplar River	93.28	7	41	75.40	13-Sep-16

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi²	Invert Class	Threshold	MIBI	Visit Date
09020305-504	14RD215	Poplar River	116.45	5	43	38.09	29-Jul-14
HUC 12: 0902030506-01 (Lower Badger Creek)							
09020305-502	07RD026	Lower Badger Creek	91.70	7	41	50.67	13-Sep-16
09020305-502	14RD239	Lower Badger Creek	95.34	5	37	55.46	05-Aug-14
09020305-502	14RD237	Lower Badger Creek	121.94	5	37	45.07	13-Sep-16
09020305-523	14RD242	County Ditch 14	70.74	7	41	38.38	04-Aug-14
09020305-523	14RD272	County Ditch 14	75.94	7	41	19.70	04-Aug-14
09020305-523	07RD005	County Ditch 14	75.96	5	37	27.15	15-Aug-07
09020305-523	07RD005	County Ditch 14	75.96	5	37	33.98	15-Aug-07
09020305-550	14RD241	Judicial Ditch 73	49.76	7	41	21.47	04-Aug-14

Appendix 4.1 – Fish species found during biological monitoring surveys

Common Name	Quantity of Stations Where Present	Quantity of Individuals Collected
bigmouth shiner	7	15
black bullhead	10	141
black crappie	14	45
blackchin shiner	1	3
blacknose dace	27	998
blacknose shiner	5	44
blackside darter	29	873
bluegill	21	248
bluntnose minnow	9	54
brassy minnow	3	9
brook stickleback	16	161
brown bullhead	6	13
brown trout	3	6
carmine shiner	11	302
central mudminnow	37	481
channel catfish	7	22
chestnut lamprey	8	22
common carp	1	2
common shiner	39	3427
creek chub	34	1707
emerald shiner	1	1
Fam: lamprey	5	23
fathead minnow	17	687
finescale dace	1	1
Gen: Notropis	1	1
Gen: redhorses	7	45
golden redhorse	17	163
golden shiner	1	1
green sunfish	1	3
hornyhead chub	25	729
hybrid sunfish	1	1
Iowa darter	5	17
johnny darter	34	833
lamprey ammocoete	7	80
largemouth bass	10	63
logperch	2	10
longnose dace	11	195
mimic shiner	1	5
mottled sculpin	4	29
northern brook lamprey	2	17

Common Name	Quantity of Stations Where Present	Quantity of Individuals Collected
northern pike	27	93
northern redbelly dace	15	161
pearl dace	7	35
pumpkinseed	5	39
rainbow trout	2	5
rock bass	25	259
sand shiner	4	13
shorthead redhorse	16	60
silver lamprey	3	5
silver redhorse	1	1
smallmouth bass	13	122
spotfin shiner	4	22
spottail shiner	1	1
stonecat	14	50
tadpole madtom	13	63
walleye	4	4
weed shiner	4	10
white sucker	43	1176
yellow bullhead	1	1
yellow perch	27	600

Appendix 4.2 – Macroinvertebrate species found during biological monitoring surveys

Taxonomic Name	Quantity of Stations Where Present	Quantity of Individuals Collected
Turbellaria	3	3
Hirudinea	17	42
Nemata	5	7
Acari	36	140
Trepaxonemata	9	34
Anafroptilum	1	2
Labiobaetis dardanus	4	8
Labiobaetis propinquus	29	431
Labiobaetis frondalis	12	105
Iswaeon	36	842
Lethocerus	2	2
Caenis diminuta	14	161
Thienemannimyia Gr.	19	75
Telopelopia okoboji	1	1
Somatochlora walshii	1	1
Epitheca canis	1	1
Clinocerinae	1	1
Enchytraeus	1	1
Maccaffertium exiguum	1	1
Maccaffertium vicarium	2	6
Maccaffertium mexicanum	4	6
Hydropsyche placoda	4	38
Oecetis furva	3	5
Oecetis testacea	4	9
Libellula quadrimaculata	1	1
Sympetrum vicinum	1	1
Nais	6	13
Tubificinae	5	13
Promenetus exacuous	2	2
Promenetus umbilicatellus	1	1
Planorbula armigera	2	2
Odontomyia /Hedriodiscus	1	1
Hyalella	30	823
Ferrissia	14	82
Lymnaeidae	8	9
Lymnaea stagnalis	4	4
Fossaria	3	3
Pseudosuccinea columella	1	3
Stagnicola	8	22
Physidae	3	6

Taxonomic Name	Quantity of Stations Where Present	Quantity of Individuals Collected
Physa	6	29
Physella	35	377
Planorbidae	3	23
Gyraulus	6	20
Helisoma anceps	1	1
Planorbella	5	9
Helichus	3	5
Dytiscidae	3	5
Dytiscus	1	1
Graphoderus	1	1
Hygrotus	2	2
Laccophilus	3	4
Liodessus	9	16
Neoporus	1	2
Elmidae	4	7
Stenelmis	36	250
Dubiraphia	50	339
Optioservus	18	135
Macronychus	5	10
Macronychus glabratus	20	119
Gyrinus	6	8
Dineutus	1	1
Haliplus	6	15
Peltodytes	3	4
Hydraena	9	20
Ochthebius	1	1
Gymnochthebius	3	3
Hydrophilidae	4	4
Berosus	4	39
Laccobius	1	1
Anacaena	2	5
Paracymus	1	1
Tropisternus	2	2
Enochrus	4	5
Helophorus	1	1
Hydrochus	3	3
Hydrobius	2	3
Scirtidae	1	1
Cambaridae	2	2
Orconectes	25	28
Atherix	12	53
Ceratopogonidae	1	1
Atrichopogon	4	9

Taxonomic Name	Quantity of Stations Where Present	Quantity of Individuals Collected
Ceratopogoninae	7	15
Chaoborus	1	2
Chironomidae	2	5
Tanypodinae	20	37
Clinotanypus	1	1
Natarsia	1	1
Ablabesmyia	22	49
Conchapelopia	8	8
Labrundinia	18	51
Larsia	1	2
Nilotanypus	2	3
Paramerina	2	5
Pentaneura	8	16
Thienemannimyia	30	113
Trissopelopia ogemawi	1	5
Zavrelimyia	1	1
Procladius	7	11
Potthastia	3	3
Orthocladiinae	13	19
Acricotopus	1	3
Brillia	11	24
Cardiocladius	1	1
Corynoneura	8	11
Cricotopus	43	240
Diplocladius cultriger	1	1
Doncricotopus	1	3
Eukiefferiella	9	14
Limnophyes	2	2
Lopescladius	1	2
Nanocladius	8	11
Orthocladius	7	25
Parakiefferiella	2	4
Parametriocnemus	10	38
Rheocricotopus	14	41
Thienemanniella	22	85
Tvetenia	24	91
Xylotopus par	1	2
Chironomini	10	11
Chironomus	7	196
Cryptochironomus	6	6
Cryptotendipes	1	1
Dicrotendipes	15	74
Endochironomus	2	2

Taxonomic Name	Quantity of Stations Where Present	Quantity of Individuals Collected
Glyptotendipes	2	6
Microtendipes	22	69
Parachironomus	4	6
Paracladopelma	1	1
Paralauterborniella nigrohalterale	1	1
Paratendipes	6	7
Phaenopsectra	12	29
Polypedilum	52	639
Saetheria	1	1
Stenochironomus	19	55
Stictochironomus	2	2
Tribelos	1	5
Xenochironomus xenolabis	3	26
Pseudochironomus	2	2
Tanytarsini	14	20
Cladotanytarsus	5	9
Micropsectra	21	93
Paratanytarsus	23	173
Rheotanytarsus	48	775
Stempellina	3	3
Stempellinella	24	78
Tanytarsus	41	307
Orthocladius (Symposiocladius)	2	2
Culicidae	1	1
Anopheles	2	12
Dixa	1	2
Dixella	3	4
Empididae	4	5
Hemerodromia	13	36
Ephydridae	2	2
Sciomyzidae	2	2
Simuliidae	1	2
Simulium	51	2552
Tabanidae	2	3
Chrysops	1	1
Tipulidae	1	1
Tipula	10	15
Antocha	8	21
Hexatoma	1	1
Baetidae	17	181
Pseudocloeon	6	302

Taxonomic Name	Quantity of Stations Where Present	Quantity of Individuals Collected
Baetis	17	191
Acentrella	4	11
Baetis intercalaris	14	271
Baetis brunneicolor	5	35
Baetis flavistriga	20	170
Callibaetis	4	5
Acerpenna pygmaea	19	132
Procloeon	14	72
Acerpenna	15	176
Labiobaetis	6	13
Plauditus	17	547
Acentrella turbida	8	26
Pseudocloeon propinquum	1	132
Acentrella parvula	15	79
Baetisca	2	4
Caenis	11	83
Caenis tardata	1	2
Caenis hilaris	12	61
Ephemerellidae	3	9
Ephemerella	3	54
Eurylophella temporalis	1	1
Hexagenia	1	1
Heptageniidae	11	33
Heptagenia	7	11
Leucrocuta	5	14
Nixe	3	7
Stenacron	19	70
Maccaffertium	28	252
Maccaffertium modestum	2	3
Maccaffertium mediopunctatum	4	5
Maccaffertium terminatum	5	7
Isonychia	8	31
Leptophlebiidae	12	74
Paraleptophlebia	4	40
Ephoron	1	1
Tricorythodes	37	553
Oligochaeta	19	125
Limnodrilus	1	1
Aulodrilus	3	7
Naididae	2	2
Dero	1	7
Ophidonais serpentina	1	1

Taxonomic Name	Quantity of Stations Where Present	Quantity of Individuals Collected
Belostoma	5	5
Belostoma flumineum	9	9
Corixidae	7	40
Sigara	6	6
Ranatra	2	2
Neoplea	3	3
Neoplea striola	5	11
Microvelia	1	1
Valvata	3	56
Crambidae	2	2
Parapoynx	1	1
Sialis	2	3
Amnicola	4	70
Hydrobiidae	27	359
Aeshnidae	4	4
Anax	1	1
Anax junius	3	3
Aeshna	5	6
Aeshna umbrosa	7	8
Boyeria vinosa	1	1
Calopterygidae	6	14
Hetaerina	1	6
Hetaerina americana	1	3
Calopteryx	16	55
Calopteryx aequabilis	4	5
Coenagrionidae	16	94
Enallagma	1	1
Cordulegaster	1	1
Somatochlora	2	2
Somatochlora minor	1	1
Gomphidae	5	6
Gomphus	2	2
Dromogomphus	1	1
Ophiogomphus	2	2
Ophiogomphus rupinsulensis	3	3
Capniidae	1	1
Perlidae	4	5
Acroneuria	5	7
Acroneuria lycorias	1	1
Acroneuria abnormis	2	2
Paragnetina	3	4
Paragnetina media	6	9
Perlesta	6	9

Taxonomic Name	Quantity of Stations Where Present	Quantity of Individuals Collected
Perlodidae	4	6
Isoperla	6	33
Pteronarcys	15	19
Taeniopteryx	3	32
Trichoptera	2	4
Brachycentridae	2	2
Brachycentrus	3	12
Brachycentrus numerosus	11	261
Micrasema	5	15
Micrasema rusticum	1	2
Glossosomatidae	1	1
Helicopsyche	7	65
Helicopsyche borealis	17	113
Hydropsychidae	24	209
Cheumatopsyche	28	311
Hydropsyche	16	138
Hydropsyche betteni	8	28
Hydropsyche frisoni	1	1
Ceratopsyche	12	169
Ceratopsyche bronta	9	43
Ceratopsyche morosa	12	255
Ceratopsyche slossonae	5	17
Ceratopsyche sparna	1	2
Ceratopsyche alhedra	3	74
Hydroptilidae	11	36
Hydroptila	25	185
Ochrotrichia	4	18
Oxyethira	3	41
Lepidostoma	2	28
Leptoceridae	7	10
Triaenodes	10	24
Mystacides	1	2
Oecetis	7	16
Oecetis avara	8	24
Nectopsyche	4	5
Nectopsyche diarina	21	87
Ceraclea	7	28
Limnephilidae	5	11
Pycnopsyche	9	12
Molanna	2	2
Philopotamidae	1	1
Chimarra	8	32
Dolophilodes	1	5

Taxonomic Name	Quantity of Stations Where Present	Quantity of Individuals Collected
Phryganeidae	4	4
Ptilostomis	3	4
Polycentropodidae	5	5
Polycentropus	8	11
Neureclipsis	11	35
Psychomyiidae	1	1
Lype	1	1
Protoptila	6	29
Stylaria	1	2
Unionidae	1	1
Pisidiidae	34	163

Appendix 5 – Minnesota Stream Habitat Assessment results

Habitat information documented during each fish sampling visit is provided. This table convey the results of the Minnesota Stream Habitat Assessment (MSHA) survey, which evaluates the section of stream sampled for biology and can provide an indication of potential stressors (e.g., siltation, eutrophication) impacting fish and macroinvertebrate communities. The MSHA score is comprised of five scoring categories including adjacent land use, riparian zone, substrate, fish cover and channel morphology, which are summed for a total possible score of 100 points. Scores for each category, a summation of the total MSHA score, and a narrative habitat condition rating are provided in the tables for each biological monitoring station. Where multiple visits occur at the same station, the scores from each visit have been averaged. The final row in each table displays average MSHA scores and a rating for the aggregated HUC-12 subwatershed.

# Visits	Biological Station ID	Reach Name	Land Use	Riparian	Substrate	Fish Cover	Channel Morph.	MSHA Score	MSHA Rating
1	10RD081	Clearwater River	4	11.5	22	12	28	77.5	Good
2	14RD273	Clearwater River	5	10.7	20.5	14	25.5	75.8	Good
3	09RD065	Clearwater River	5	10.8	19.2	14	22.3	71.3	Good
2	14RD302	Clearwater River	4	11	12	6	11	44	Poor
3	10EM085	Clearwater River	5	10.6	14.7	13.3	19.6	63.4	Fair
2	14RD209	Clearwater River	4.5	12.5	17	14	22.5	70.5	Good
Average Habitat Results: ***Upper Clearwater River Aggregated 12 HUC***			**2.9**	**11.2**	**17.6**	**12.2**	**21.5**	**67.1**	**Good**
3	14RD208	Clearwater River	2.1	8.6	18.6	14.7	20	64.1	Fair
2	14RD207	Clearwater River	5	11	19	12	17	64	Fair
2	14RD205	Clearwater River	5	10.5	18	11	13	57.5	Fair
2	14RD203	Clearwater River	0.8	7.8	15	6.5	9	39	Poor
1	07RD017	Clearwater River	0	7.5	14	7	11	39.5	Poor
2	14RD200	Clearwater River	0	8	17.1	9.5	10.5	45.1	Fair
Average Habitat Results: ***Middle River Aggregated 12 HUC***			**2.1**	**8.9**	**16.9**	**10.1**	**13.4**	**51.5**	**Fair**
2	14RD261	Clearwater River	2.5	9.5	19	7.5	16	54.5	Fair
2	14RD262	Clearwater River	3.5	11.5	19.1	14	23	71.1	Good
3	14RD271	Clearwater River	0	9.3	20.1	9.6	18.6	57.8	Fair
2	15RD209	Clearwater River	2.5	9.2	21.8	7	21	61.5	Fair
1	16RD050	County Ditch 23	5	14	22.5	14	24	79.5	Good
1	14RD260	Trib. to Clearwater	2.5	10.5	13	13	16	55	Fair
4	14RD255	Beau Gerlot Creek	1	9.8	16.5	13.3	16	56.4	Fair
2	94RD512	Clearwater River	2.8	6.3	19.6	12	22.5	63.0	Fair
Average Habitat Results: ***Lower Clearwater River Aggregated 12 HUC***			**2.5**	**10.0**	**18.9**	**11.3**	**19.6**	**62.3**	**Fair**
2	14RD234	Ruffy Brook	3.6	11.5	20.7	13.5	24.5	73.8	Good
2	14RD303	Ruffy Brook	5	12.5	20.4	15	22	74.9	Good
Average Habitat Results: ***Ruffy Brook Aggregated 12 HUC***			**4.3**	**12**	**20.5**	**14.3**	**23.3**	**74.4**	**Good**
3	07RD024	Lost River	1.2	9.2	18	9.7	12.3	50.3	Fair
1	14RD226	Lost River	2.5	10	16	12	7	47.5	Fair
2	14RD228	Trib. to Lost River	3.5	9	8.5	12.5	4	37.5	Poor
2	14RD230	Lost River	1.3	10.3	20.1	13	22	66.5	Good

3	14RD231	Silver Creek	0.8	9.2	21.4	15	21.3	67.7	Good
2	14RD235	Silver Creek	1.3	12.3	13	12.5	18	57	Fair
2	14RD299	Lost River	2.5	9.3	10.4	11	15.5	48.7	Fair
2	15EM066	Lost River	5	12	8	14	14	53	Fair
2	15EM098	Silver Creek	2.5	11.8	15.4	12	14.5	56.1	Fair
Average Habitat Results: Upper Lost River Aggregated 12 HUC			**2.3**	**10.3**	**14.5**	**12.4**	**14.3**	**53.8**	**Fair**
4	05RD046	Lost River	1.8	8	16.4	9.8	10	45.9	Fair
1	05RD061	Lost River	0	11	18.5	8	26	63.5	Fair
1	07RD004	State Ditch 61	0	7	10	14	14	45	Fair
2	14RD225	Lost River	0	8.5	16	8.5	10.5	43.5	Poor
2	14RD259	Lost River	1.3	8.8	21.4	11	20.5	62.9	Fair
Average Habitat Results: Lower Lost River Aggregated 12 HUC			**0.6**	**8.7**	**16.5**	**10.3**	**16.2**	**52.2**	**Fair**
2	14RD215	Poplar River	1.3	10	20.6	14	23.5	69.3	Good
4	14RD216	Poplar River	2.8	11.1	12	12.5	14.5	52.9	Fair
4	14RD218	Poplar River	0.9	8.8	15.5	12.3	15.5	52.9	Fair
Average Habitat Results: Poplar River Aggregated 12 HUC			**1.6**	**9.9**	**16.0**	**12.9**	**17.8**	**58.3**	**Fair**
1	05RD026	Hill River	5	11	6.6	13	27	62.5	1
2	14RD221	Hill River	2.3	9.8	19.1	14	16	61.1	2
3	14RD246	Hill River	1.7	10.5	13.7	14.3	19.3	59.6	3
3	14RD253	Hill River	3.2	9.8	15.8	14.7	16	59.5	3
Average Habitat Results: Hill River Aggregated 12 HUC			**3.3**	**10.3**	**13.8**	**14**	**19.6**	**60.7**	**Fair**
1	07RD005	County Ditch 14	5	11	20	12	25	73	Good
3	07RD026	Lower Badger	1.7	8.8	15.4	13.3	9.3	48.6	Fair
2	14RD237	Lower Badger	2.5	11	18.9	13	22.5	67.9	Good
2	14RD239	Lower Badger	2.5	10.5	19.6	10.5	19	62.1	Fair
2	14RD241	Judicial Ditch 73	0	8.3	4	10	5.5	27.8	Poor
1	14RD242	County Ditch 14	2	8	17	9	7	43	Poor
1	14RD243	Trib. to Poplar	2.5	9	5	11	1	28.5	Poor
2	14RD272	County Ditch 14	0.4	7.5	18	9	12	46.9	Fair
1	15EM096	County Ditch 14	2.5	10	17	6	11	46.5	Fair
Average Habitat Results: Lower Badger Creek Aggregated 12 HUC			**2.1**	**9.3**	**14.9**	**10.4**	**12.5**	**49.4**	**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)