Clearwater River Watershed

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Clearwater River Watershed Restoration and Protection Strategy Report

MINNESOTA POLLUTION CONTROL AGENCY

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Contents

Key terms and abbreviations

Assessment Unit Identifier (AUID): The unique water body identifier for each river reach comprised of the USGS eight-digit HUC plus a three-character code unique within each HUC.

Aquatic life impairment: The presence and vitality of aquatic life is indicative of the overall water quality of a stream. A stream is considered impaired for impacts to aquatic life if the fish Index of Biotic Integrity (IBI), macroinvertebrate IBI, dissolved oxygen, turbidity, or certain chemical standards are not met.

Aquatic recreation impairment: Streams are considered impaired for impacts to aquatic recreation if *E. coli* bacteria standards are not met. Lakes are considered impaired for impacts to aquatic recreation if TP, chl-a, or Secchi disc depth standards are not met.

Hydrologic Unit Code (HUC): A Hydrologic Unit Code (HUC) is assigned by the USGS for each watershed. HUCs are organized in a nested hierarchy by size. For example, the Red River of the North Basin is assigned a HUC-4 of 0902 and the Red Lake River Watershed is assigned a HUC-8 of 09020303.

Impairment: Water bodies are listed as impaired if water quality standards are not met for designated uses including aquatic life, aquatic recreation, and aquatic consumption.

Index of Biotic integrity (IBI): A method for describing water quality using characteristics of aquatic communities, such as the types of fish and invertebrates found in the waterbody. It is expressed as a numerical value between 0 (lowest quality) to 100 (highest quality).

Protection: This term is used to characterize actions taken in watersheds of waters not known to be impaired to maintain conditions and beneficial uses of the waterbodies.

Restoration: This term is used to characterize actions taken in watersheds of impaired waters to improve conditions, eventually to meet water quality standards and achieve beneficial uses of the waterbodies.

Source (or Pollutant Source): This term is distinguished from ‘stressor’ to mean only those actions, places or entities that deliver/discharge pollutants (e.g., sediment, phosphorus, nitrogen, pathogens).

Stressor (or Biological Stressor): This is a broad term that includes both pollutant sources and non-pollutant sources or factors (e.g., altered hydrology, dams preventing fish passage) that adversely impact aquatic life.

Total Maximum Daily Load (TMDL): A calculation of the maximum amount of a pollutant that may be introduced into a surface water and still ensure that applicable water quality standards for that water are met. A TMDL is the sum of the wasteload allocation for point sources, a load allocation for nonpoint sources and natural background, an allocation for future growth (i.e., reserve capacity), and a margin of safety as defined in the Code of Federal Regulations.

Executive Summary

The Clearwater River (United States Geological Survey (USGS) Hydrologic Unit Code (HUC) 09020305) is a tributary of the Red Lake River in northwest Minnesota in the Red River of the North Basin. It is a diverse watershed that spans portions of four ecoregions (Lake Agassiz Plain, Northern Minnesota Wetlands, North Central Hardwood Forests, and Northern Lakes and Forests). The watershed has been divided into seven HUC-10 subwatersheds: Upper Clearwater River, Middle Clearwater River, Lower Clearwater River, Lost River, Hill River, Poplar River, and Lower Badger Creek subwatersheds.

The 2018 List of Impaired Waters included waters that were found to be impaired during the Minnesota Pollution Control Agency's (MPCA) 2016 water quality assessment of the Clearwater River Watershed. The Clearwater River Watershed Total Maximum Daily Load (TMDL) report addressed 44 impairments of aquatic life and/or recreation found within 27 stream reaches and 3 lakes within the watershed. Five total suspended solids (TSS) impairments were found along the Clearwater River and Nassett Creek. Aquatic life impairments due to low dissolved oxygen (DO) were identified in 10 reaches of Clearwater River tributaries. Five DO-impaired reaches have been requested for reclassification and may not require TMDLs. Low index of biological integrity (IBI) scores have resulted in macroinvertebrate IBI (M-IBI) impairments for three reaches and fish IBI (F-IBI) impairments for seven stream reaches. A river eutrophication impairment was identified in one reach of the Clearwater River. Impairments of recreational safety due to chronically high concentrations of *E. coli* bacteria were found along 15 reaches of the Clearwater River and its tributaries. Aquatic recreation was impaired by eutrophication (excess nutrients) in 3 lakes.

Strategies are recommended in this report for reducing nonpoint contributions of TSS using various erosion control strategies and best management practices (BMPs). Sources of *E. coli* pollution have been identified and described in this report along with strategies for addressing those sources. Strategies are also described for improving DO levels, aquatic habitat, fish passage, and other projects to improve conditions for aquatic life. Examination of data and evidence found no pollutant-based stressors that would necessitate TMDLs for DO or biological impairments. The causes of water quality impairments and threats to unimpaired streams were investigated and summarized. Protection considerations were compiled for unimpaired waters throughout the watershed. Multiple tools are available for prioritizing and targeting restoration and protection projects. Assessment statistics informed prioritization of barely impaired and nearly impaired streams. Spatial analysis and the Hydrological Simulation Program – Fortran - Scenario Application Manager (HSPF-SAM) tool helped identify areas with high rates of pollutant runoff and erosion. Those areas will be targeted for implementation of BMPs and other projects. The sources of water quality problems were investigated through longitudinal sampling, a fluvial geomorphology study, and microbial source tracking. Stressor identification (SID) found that insufficient base flow was the most common stressor for aquatic biology within impaired Clearwater River tributaries and it magnified the effects of other stressors like DO.

Efforts were made to inform and involve the public throughout the Clearwater River Watershed Restoration and Protection Strategy (WRAPS) project. Recent civic engagement efforts and plans are described in this document. There is currently excellent cooperation among local and state agencies for project implementation and monitoring. Water chemistry and stage/flow data will continue to be regularly collected throughout the watershed by local and state organizations.

What is the WRAPS Report?

Minnesota has adopted a watershed approach to address the state's 80 major watersheds. The Minnesota watershed approach incorporates water quality assessment, watershed analysis, public participation, planning, implementation, and measurement of results into a 10-year cycle that addresses both restoration and protection.

As part of the watershed approach, the MPCA developed a process to identify strategies to address threats to water quality in each of these major watersheds. This process is called WRAPS development. WRAPS reports have two parts: impaired waters have strategies for restoration, and waters that are not impaired have strategies for protection.

Waters not meeting state standards are listed as impaired and TMDL studies are developed for them. TMDLs are incorporated into WRAPS. In addition, the watershed approach process facilitates a more cost-effective and comprehensive characterization of multiple water bodies and overall watershed health, including both protection and restoration efforts. A key aspect of this effort is to develop and utilize watershed-scale models and other tools to identify strategies for addressing point and nonpoint source pollution that will cumulatively achieve water quality targets. For nonpoint source pollution, this report informs local planning efforts, but ultimately the local partners decide what work will be included in their local plans. This report also serves as the basis for addressing the U.S. Environmental Protection Agency's (EPA) Nine Minimum Elements of watershed plans, to help qualify applicants for eligibility for Clean Water Act Section 319 implementation funds.

Purpose

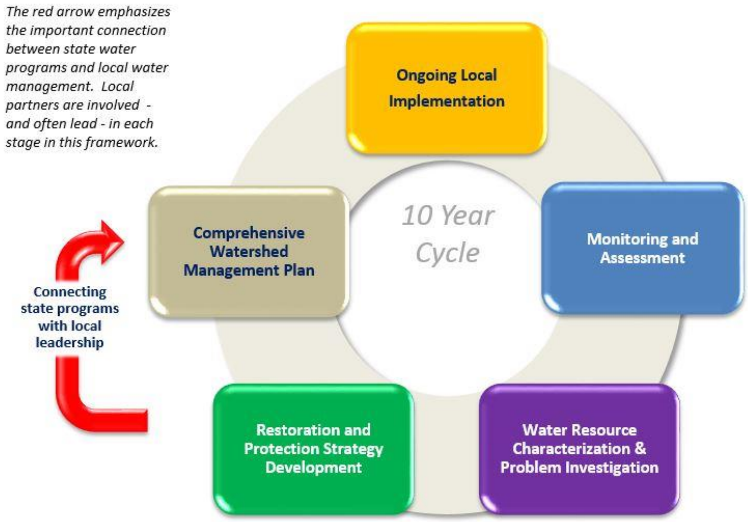
- Support local working groups and jointly develop scientifically-supported restoration and protection strategies to be used for subsequent implementation planning
- Summarize Watershed Approach work done to date including the following reports:
  - *Clearwater River Watershed Monitoring and Assessment*
  - *Clearwater River Watershed Stressor Identification*
  - *Clearwater River Fluvial Geomorphology Report*
  - *Clearwater River Watershed Total Maximum Daily Load*

Scope

- Impacts to aquatic recreation and impacts to aquatic life in streams
- Impacts to aquatic recreation in lakes

Audience

- Local working groups (SWCDs, watershed districts, counties, etc.)
- State agencies (MPCA, DNR, BWSR, etc.)
- Local leaders and decision makers
- Concerned and motivated citizens



The information in the WRAPS report is organized into four primary sections. The following is a summary of the information included in each section.

1. Watershed Background and Description

This section describes the watershed to familiarize the reader with watershed features, history, conditions, previous studies, and issues.

2. Watershed Conditions

This section includes the detailed water quality assessment results from the 2016 water quality assessment (2006 through 2015 data). Water quality trends were also calculated, and some strong trends were revealed. The current impaired waters are identified and TMDL summaries are included in this section. This section provides guidance for addressing stressors and sources of pollutant sources for all subwatersheds, regardless of impairment status. The results of investigative monitoring efforts are also described.

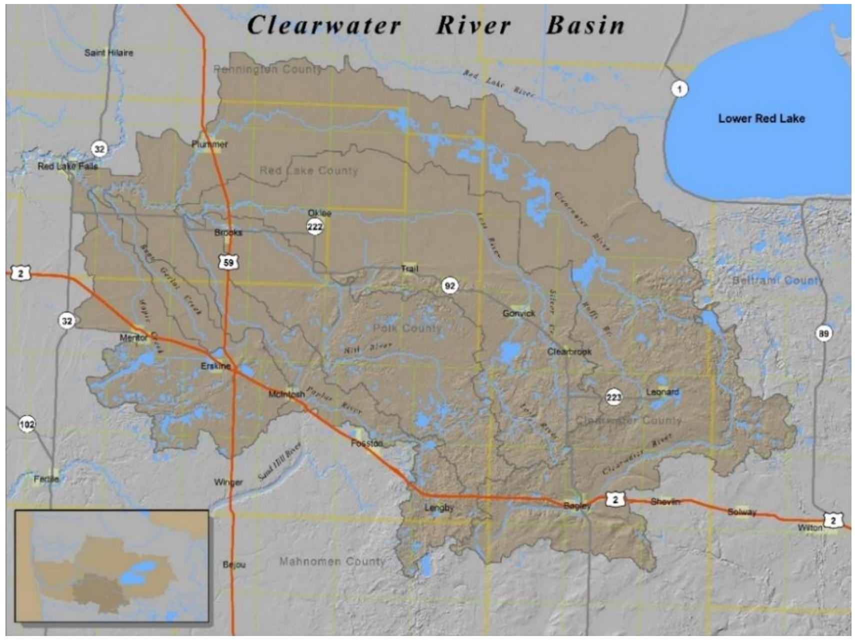
3. Prioritizing and Implementing Restoration and Protection

Water quality models simulated runoff in the watershed and identified areas that are likely the most significant sources of pollutants. HSPF, Prioritize Target and and Measure Application (PTMApp), Stream Power Index (SPI), and SID analysis pinpointed locations that are in need of repair or protection. A Minnesota Department of Natural Resources (DNR) geomorphological assessment made recommendations for stream stabilization projects. State and local staff also created lists of projects to address water quality restoration and protection needs. The lists are organized into tables for watershed-wide strategies and specific strategies for each HUC-10 subwatershed.

4. Monitoring Plan

This section provides a detailed summary of monitoring site locations (flow, water quality, etc.), programs, and organizations. It also provides a description of data collection goals.

1. Watershed Background and Description



The Clearwater River is a tributary of the Red Lake River in northwest Minnesota, within the Red River of the North Basin. The diverse watershed spans 1,385 square miles across portions of four ecoregions (Lake Agassiz Plain, Northern Minnesota Wetlands, North Central Hardwood Forests, and Northern Lakes and Forests). The Clearwater River begins near the small community of Ebro and flows past Bagley in its eastern headwaters. It flows through the town of Plummer and joins the Red Lake River in the city of Red Lake Falls. The prevalent land use transitions from forest and rangeland in the eastern portion of the watershed to cultivated cropland in the western portion of the watershed. The USGS assigned HUC-8 09020305 to the Clearwater River Watershed. The Clearwater River Watershed has been divided into seven HUC-10 subwatersheds that include the Upper Clearwater River, Middle Clearwater River, Lower Clearwater River, Lost River, Hill River, Poplar River, and Lower Badger Creek subwatersheds. Many lakes can be found in the southern and eastern portions of the watershed.

The watershed falls within the jurisdiction of multiple local government units (LGUs), including the Red Lake Watershed District (RLWD), Clearwater Soil and Water Conservation District (SWCD), Red Lake SWCD, Beltrami SWCD, and East Polk SWCD. Portions of the watershed are located within the Red Lake and White Earth Nations where water resources are managed by the Red Lake Department of Natural Resources and the White Earth Division of Natural Resources. Additional smaller parcels, outside of Red Lake Nation boundaries, are owned and managed by Red Lake Nation (Figure 1-2).

Additional Clearwater River Watershed resources

U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Rapid Watershed Assessment for the Clearwater Watershed: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_022746.pdf

Minnesota Pollution Control Agency Website for the Clearwater River Watershed: https://www.pca.state.mn.us/water/watersheds/clearwater-river

General information about the Clearwater River (document, previous studies, photos, contacts, links): https://www.rlwdwatersheds.org/cw-watershed

1.1 Subwatersheds

The Clearwater River HUC-8 major watershed encompasses seven HUC-10 subwatersheds. The Upper Clearwater River, Middle Clearwater River, Lower Clearwater River, Lost River, Hill River, and Lower Badger Creek HUC-10 subwatersheds are shown in Figure 1-1.

The Upper Clearwater River Subwatershed (0902030501) includes the headwaters of the Clearwater River, trout stream reach, Clearwater Lake, and the natural reach of the river upstream of the channelized reach. Walker Brook joins the Clearwater River near Bagley. Lakes in this subwatershed include (Clearwater Lake, Buzzle Lake, Little Buzzle Lake, Walker Brook Lake, Long Lake, etc.).

The Middle Clearwater River Subwatershed (0902030502) includes the entirety of the channelized portion of the Clearwater River, Ruffy Brook, and a network of drainage ditches. Wild rice production is a unique feature of the Middle Clearwater River Subwatershed.

The Hill River Subwatershed (0902030503) begins in the Cross Lake drainage area, flows through Hill River Lake, then west to the Lost River (near Brooks). Water quality conditions vary greatly throughout the Hill River Subwatershed. Channelization and low gradients in portions of the river are limiting factors for DO concentrations and aquatic life. Aerial photo analysis, windshield surveys, and microbial source tracking analysis indicate livestock operations contribute to high *E. coli* concentrations. Water quality (DO, TSS, and IBI) improves within the downstream portion of the river.

The Poplar River Subwatershed (0902030504) begins at the outlet of Spring Lake near the town of Lengby. It flows northwest to its confluence with the Lost River. It flows near the towns of Fosston and McIntosh and receives wastewater discharge from both of those communities. Water quality conditions in the river are affected, in part, by variations in gradient along the river. The concentration of DO decreases within areas of low gradient, but recovers where there is sufficient gradient. The Poplar River Subwatershed includes some lakes, like Spring Lake, Whitefish Lake, and Poplar Lake.

The Lost River Subwatershed (0902030505) begins in the Pine Lake drainage area, which also includes Nassett Creek. The Lost River then flows from Pine Lake, through the town of Gonvick, and into Anderson Lake. Silver Creek begins southwest of the town of Clearbrook and also flows into Anderson Lake. The Lost River then flows out of Anderson Lake and through a channelized reach (RLWD Project 4 drainage system). The river regains a natural channel approximately two miles west of Oklee and continues flowing west to its confluences with the Hill River, Poplar River, and Clearwater River.

The Lower Badger Creek Subwatershed (0902030506) begins in the Erskine area in a series of drainage ditches that bring water into Badger Lake, Mitchell Lake, Judicial Ditch 73 (JD 73), and Maple Lake. Polk County Ditch 14 flows from the outlet of Maple Lake to Lower Badger Creek. This subwatershed includes many lakes, including the nutrient-impaired Cameron Lake.

The Lower Clearwater River Subwatershed (0902030507) includes the Clearwater River between the channelized reach and the Red Lake River confluence. The Clearwater River receives drainage from the Lost River (which includes the Hill River and Poplar River subwatersheds) and Lower Badger Creek subwatersheds. This subwatershed also includes smaller tributary streams like Terrebonne Creek, Beau Gerlot Creek, and Red Lake County Ditch 23 (CD 23).

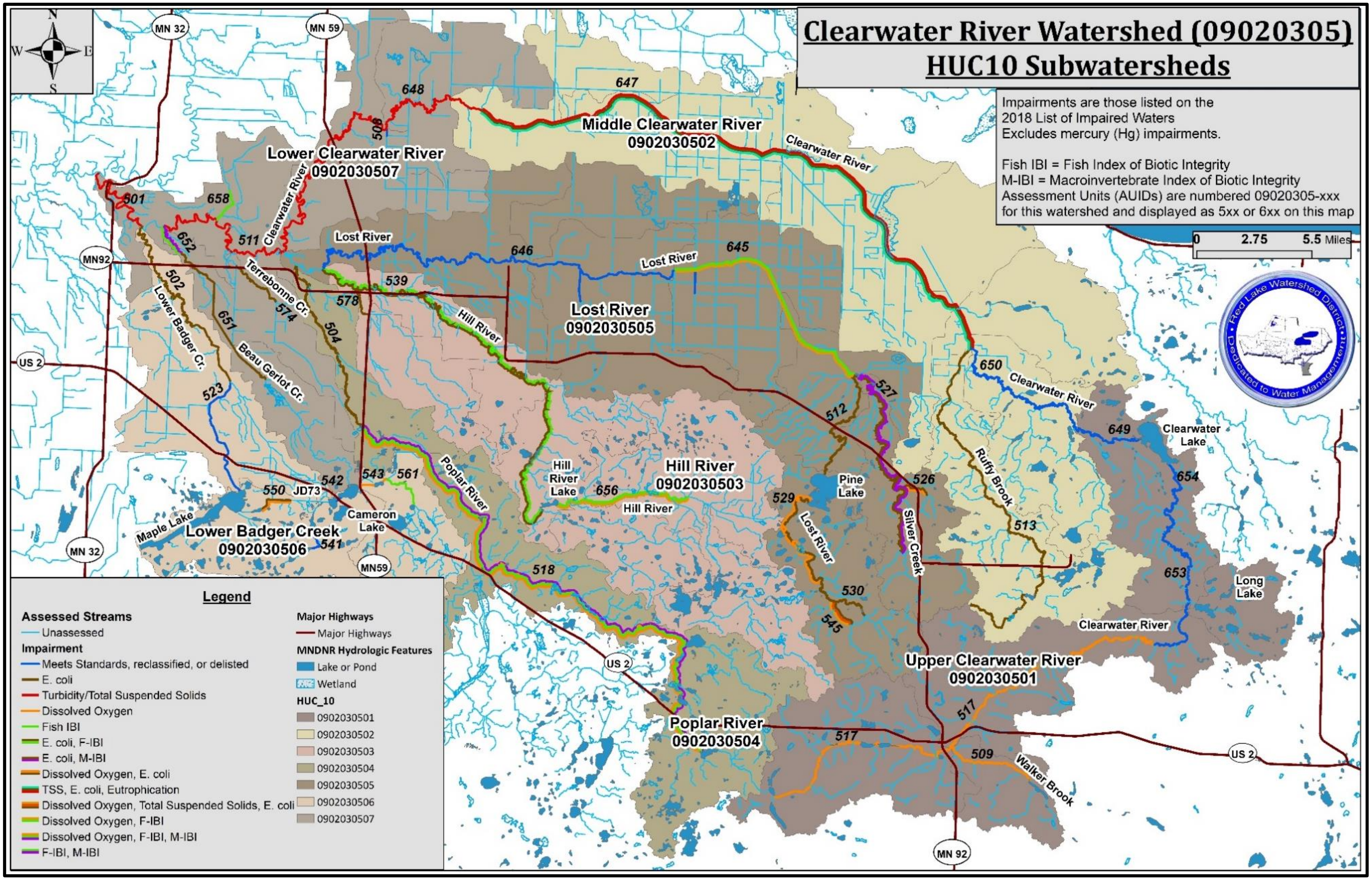


Figure 1-1. Map of Clearwater River Watershed HUC-10 Subwatersheds

1.2 Land Use

The Clearwater River Watershed is a diverse watershed that spans portions of four ecoregions (Lake Agassiz Plain, Northern Minnesota Wetlands, North Central Hardwood Forests, and Northern Lakes and Forests). Lake Agassiz beach ridges are found in the transition between the hilly headwaters of the watershed (North Central Hardwoods and Northern Lakes and Forests ecoregions) and the Red River Valley along the western edge of the watershed. Large tracts of public land include Rydell National Wildlife Refuge, state-owned land along the Clearwater River upstream of Clearwater Lake, wildlife management areas (WMAs), scientific and natural areas (SNAs), and waterfowl production areas.

The prevalent land use transitions from forest and forage crops in the eastern portion of the watershed to cultivated cropland with a prevalence of row crops in the western portion of the watershed (Figure 1-2 and Figure 1-3). According to pre-European settlement data, the watershed has experienced significant deforestation (Table 1-1). Current forest cover is approximately half the extent of pre-settlement forests that covered nearly 40% of the watershed. Approximately two-thirds of the pre-settlement prairie and wetlands have been converted to other land uses. Tile drainage of cultivated fields has been increasing in the watershed. The effects of tile drainage on water quality in this watershed were examined during the Red Lake River Watershed Farm to Stream Tile Drainage Water Quality Study that was completed in 2009 (http://www.redlakewatershed.org/projects/Red%20Lake%20Watershed%20Farm%20to%20Stream%20Tile%20Drainage%20Study%20Final%20Report%20R3.pdf).

A unique feature of the Clearwater River Watershed is the wild rice paddies located along a portion of the Clearwater River. Wild rice farming is described in more detail in Section 1.6 of this report.

Table 1-1. Table of pre-European settlement and current land use within the Clearwater River Watershed

Clearwater River Watershed Land Use Summary		
National Land Cover Database Category	**Pre-Settlement***	**Percent of Watershed - 2011****
Developed, Open Space		3.92%
Developed, Low Intensity		0.44%
Developed, Medium Intensity		0.06%
Developed, High Intensity		0.02%
Barren Land		0.09%
Shrub/Scrub	24.90%	0.87%
Grassland/Herbaceous	9.89%	2.87%
Deciduous Forest	24.55%	19.32%
Evergreen Forest	11.45%	2.65%
Mixed Forest	3.74%	0.01%
Pasture/Hay		18.06%
Cultivated Crops		33.56%
Woody Wetlands	7.53%	5.28%
Emergent Herbaceous Wetlands	17.24%	10.28%
Open Water	0.70%	2.57%

*Land use categories are named differently in the DNR presettlement data and the NLCD data. Presettlement values were placed into the categories that seemed most appropriate. The *Natural Vegetation of Minnesota* document from the DNR was used as guidance.
**2011 National Land Cover Database

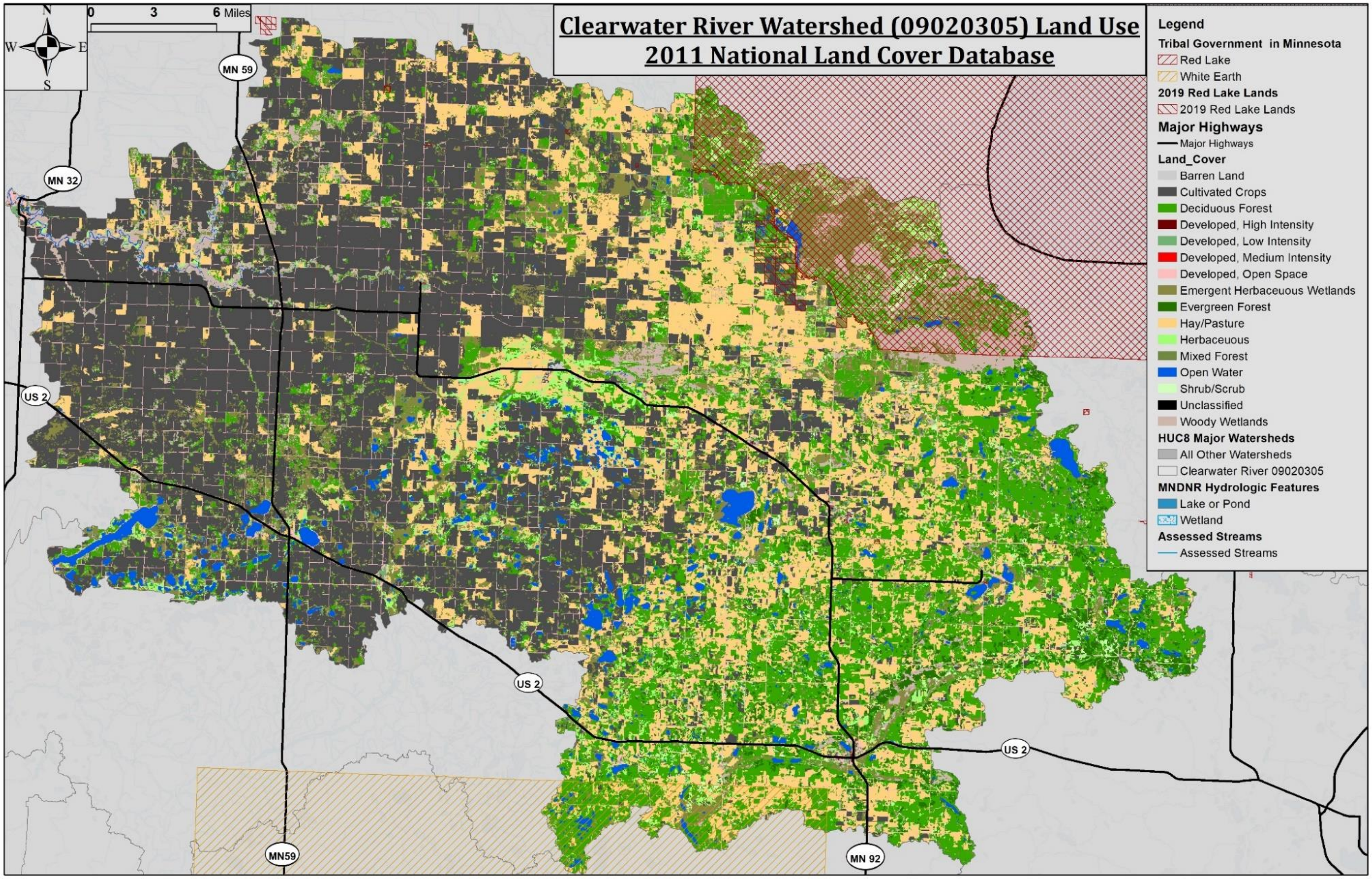


Figure 1-2. Map of land use in the Clearwater River Watershed

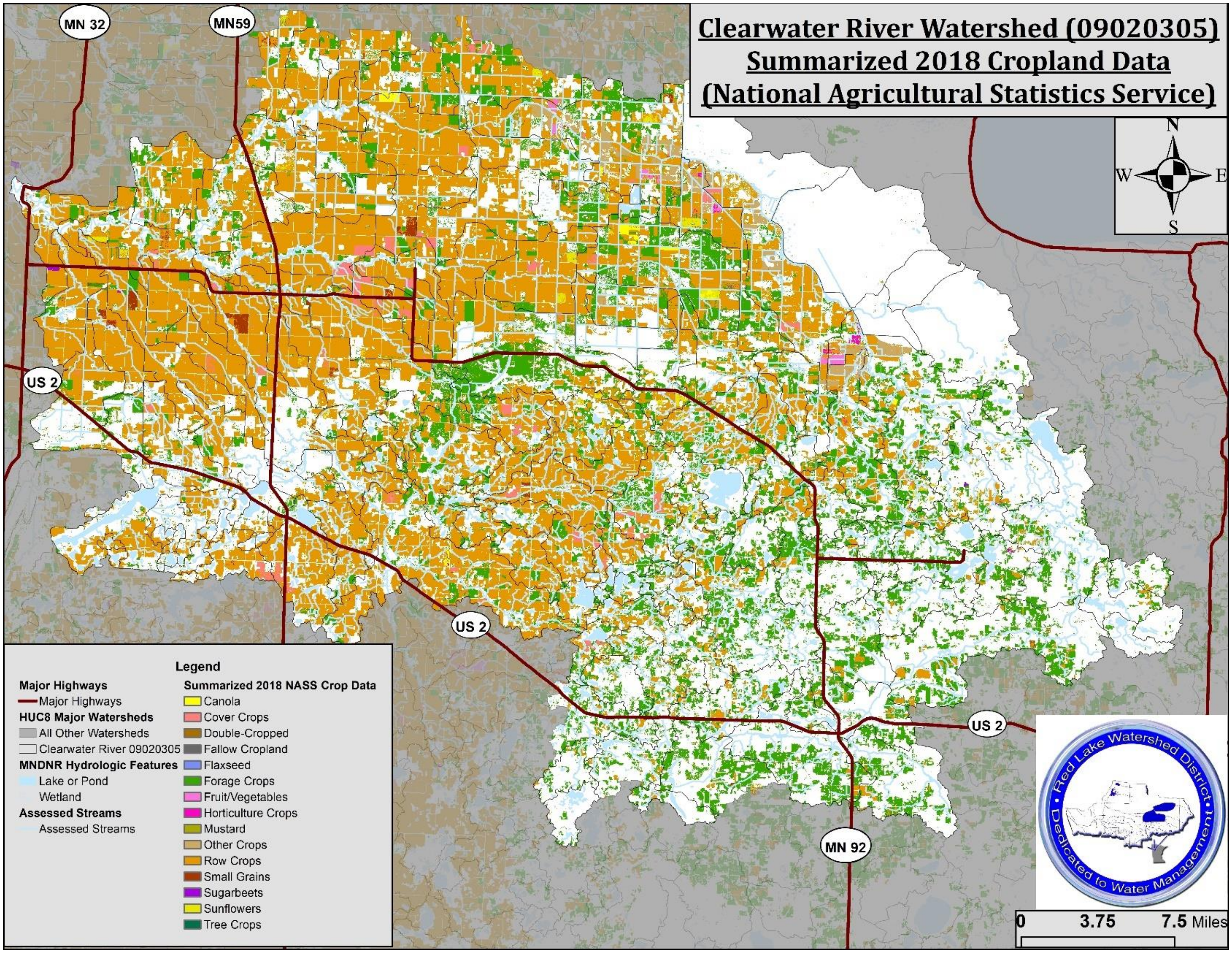


Figure 1-3. Summarized 2018 United States Department of Agriculture, National Agricultural Statistics Service Cropland Data.

1.3 Streams

The Clearwater River Watershed is comprised of a diverse network of streams. The main channel of the Clearwater River forms the "backbone" of the watershed and it is joined, along its path, by tributaries that vary in size and morphology. There are designated trout streams in the watershed and one of them (Nassett Creek) is impaired by low DO, high *E. coli*, and high TSS. Stream channel gradient varies throughout the watershed. The gradient of the Clearwater River increases as it flows between Plummer and Red Lake Falls. Although there is a long stretch without a public access, the river treats paddlers to great scenery, occasional rapids, and a good fishery. Multiple streams are influenced by low gradient reaches that have wetland characteristics (including low DO).

More than half of the main channel of the Clearwater River is impaired by high concentrations of TSS, beginning with the channelized reach of the Clearwater River and continuing downstream through assessed AUIDS to the confluence with the Red Lake River. Near the confluence of the Clearwater River and Red Lake River in Red Lake Falls, water quality assessment statistics from the two rivers are similar. Both rivers have exceedance rates (percentages) of the 30 mg/L TSS standard that are in the mid-20s. Low DO has not been recorded in either river from 2006 through 2015. The Clearwater River had a slightly higher average total phosphorus (TP) concentration, but the Red Lake River had a higher maximum monthly geometric mean *E. coli* concentration. Good F-IBI and M-IBI scores were recorded in both rivers near the confluence.

Several streams with *E. coli* impairments converge near the town of Brooks and the Lost River's confluence with the Clearwater River. The lower reaches of the Hill River and Poplar River are both impaired by high concentrations of *E. coli* bacteria. Brooks Creek is a small tributary of the Hill River that is also impaired by high *E. coli*. The three assessed tributaries that flow directly into the south side of the Clearwater River between the Lost River confluence and Red Lake Falls are also impaired by *E. coli*. Terrebonne Creek is the smallest of those three and has been affected by channelization. Beau Gerlot Creek has been affected by channelization and has a biological impairment. Brooks Creek, Terrebonne Creek, and Beau Gerlot Creek are smaller streams that typically stop flowing in the late summer. Lower Badger Creek is a relatively large tributary with its own HUC-10 subwatershed. It typically flows throughout the year but can become stagnant due to downstream beaver dams. Overland erosion can contribute large amounts of sediment and other pollutants to this stream during runoff events. Although the results of biological sampling in the lower portion of Lower Badger Creek were good, a low score was recorded in an upstream, channelized portion of the stream. It was not listed as impaired but was addressed in the Clearwater River Watershed SID Report. The outlet of Red Lake County Ditch (CD 23) is an intermittent stream that flows into a natural channel before entering the Clearwater River from the north. Drainage system outlets, like the natural channel outlet of the CD 23 drainage system, need grade stabilization. As the Clearwater River approaches Red Lake Falls and its gradient steepens, the steep gradient between a tributary's last grade control point (usually a road culvert) and the Clearwater River causes the formation of large gullies and mass wasting due to stream channel instability and degradation.

Biological and low DO impairments are found in the upstream and headwaters reaches of the Clearwater River, Hill River, Lost River, Poplar River, Lower Badger Creek Watershed. Some of those impairments will not require TMDLs because evidence examined during the 2016 water quality assessment process and development of the 2018 List of Impaired Waters indicated that those impairments were caused by non-pollutant factors (Walker Brook, Red Lake County Ditch 57, and the Poplar River Diversion). Some previously listed impairments (Bee Lake Inlet, Badger-Mitchell Lake Channel) have been removed from the 2018 List of Impaired Waters because they represented lake/wetland water quality more than they represented stream water quality. Further investigation of other biological and low DO impairments found that the other, listed impairments are also caused by non-pollutant factors that include a lack of flow, lack of gradient (wetland characteristics), lack of habitat, and fish passage problems.

A cluster of impairments can be found in the headwaters of the Lost River near Pine Lake and the town of Gonvick. Low DO impairments were found in the Pine Lake drainage area, even though that subwatershed contains multiple reaches that are designated trout streams. Investigation of the designated trout stream portion of the Lost River found that it currently does not provide cold water habitat due to high temperatures and frequently low DO. Investigation of Nassett Creek found that there was sufficient DO in the lower portion of the stream, but not in upper reaches (partially due to stagnant water caused by beaver dams). Livestock operations upstream and downstream of Pine Lake have likely contributed to *E. coli* impairments in streams (Lost River upstream of Pine Lake, Lost River downstream of Pine Lake, and Nassett Creek) and a lake impairment (Stony Lake) (see Section 2.3). Silver Creek flows north, roughly parallel and east of the Lost River's path, and joins with the Lost River at Anderson Lake. Silver Creek can experience intermittent flow and is impaired by high *E. coli*.

Ruffy Brook is a tributary of the Clearwater River in Clearwater County. It begins in Dudley Township, near the town of Leonard, and flows north through Holst, Leon, and Greenwood Townships before entering the Clearwater River. A portion of Ruffy Brook within Leon Township was once a designated trout stream. After state-owned land along the stream was sold and much was cleared for pasture, the stream has been degraded such that it is no longer able to support trout. There has been some local interest in restoring the stream to conditions that would support trout.

The headwaters portion of the Clearwater River, near Bagley, has a low gradient. The cause of the low DO levels in the Clearwater River and Walker Brook have been investigated in previous TMDL studies. Examination of the area's geology found that the low DO levels in that area are natural conditions. In addition to the low gradient, the streams are fed by ancient groundwater that has very little DO. Both streams are lined by fens in which DO is consumed by the processes that decay organic matter.

Approximately 66% of the streams within the Clearwater River Watershed are channelized. Significant, altered natural watercourses include portions of the Clearwater River (34 miles), Hill River, Lost River, Lower Badger Creek, Beau Gerlot Creek, Ruffy Brook. The Clearwater River and its tributaries receive drainage from networks of ditches that include Judicial Ditch 72, Judicial Ditch 2A, Judicial Ditch 2B, Red Lake County Ditch 57, Red Lake County Ditch 23, and many others. Figure 1-4 shows the ditches in the northern half of the watershed, with artificial watercourses that were constructed along a grid of section lines and roads rather than natural flow paths.

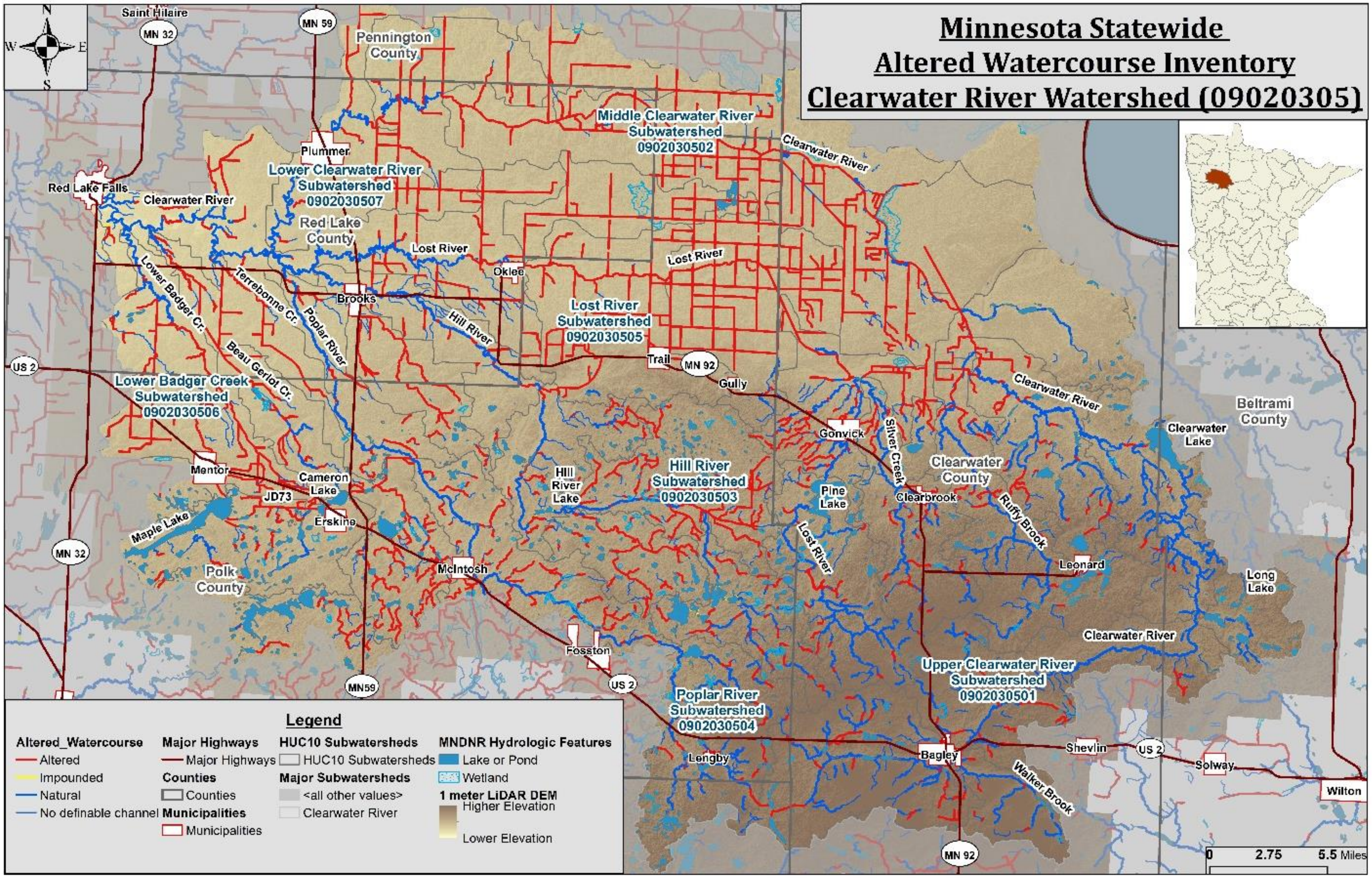


Figure 1-4. Map of altered waterways in the Clearwater River Watershed (Minnesota Statewide Altered Watercourse Inventory)

1.4 Lakes

Many lakes of varying sizes and depths are located in the southern and eastern portions of the Clearwater River Watershed. The 2016 water quality assessment evaluated 32 lakes for aquatic recreation and 9 lakes for aquatic life. Twenty-nine lakes were fully supporting for aquatic recreation. The deepest assessed lake was Buzzle Lake (83 feet). The shallowest assessed lake was East Four-Legged Lake (4.9 feet). The watershed's largest lakes that were assessed in 2016 were Maple Lake (1,582 acres) and Clearwater Lake (1,240 acres). The watershed's smallest assessed lake in 2016 was Deep Lake (45 acres). The best Secchi disk transparency reading (8.5 m) and lowest average chlorophyll-a (chl-*a*) concentration (1.7 µg/L) in lakes that were assessed with 2006 through 2015 data were recorded in Lone Lake, north of the city of Bagley. Buzzle Lake, Lone Lake, Deep Lake, and Long Lake (15-0050-00) all had average TP concentrations that were <10 µg/L. Stony Lake had the highest average TP concentration at 137 µg/L

Cameron Lake had the lowest average Secchi disk transparency (<0.3 m) and highest average chl-*a* concentration of all the assessable lakes. Several unnamed lakes (15-0293, 60-0099, and 60-0257) were not assessed due to a lack of sufficient data but also had transparency readings that were 0.3 m or less.

Three lakes in the Clearwater River Watershed have been identified as impaired for aquatic recreation by high concentrations of nutrients and chl-*a*, and low Secchi disk transparency depths. All three of the lakes have relatively small drainage areas. The sources of pollutants were identifiable for Cameron Lake and Stony Lake, but harder to identify for Long Lake (see Section 2.3). Follow-up sampling will be needed to determine sources for Long Lake.

Maple Lake, Clearwater Lake, Pine Lake, Lake Lomond, and Cameron Lake are some lakes with significant amounts of lakeshore development. The Maple Lake Improvement District (MLID), Clearwater Lake Area Association (CLAA), and Property Owners of Pine Lake Association (POOPLA) are active lake associations within the watershed. The RLWD and the Gully Sportsman's Club work together to monitor winter DO levels and operate an aerator on Pine Lake.

Volunteer monitoring has been critical to the long-term collection of water quality data from lakes in the Clearwater River Watershed. Much of the lake sampling has been made possible by grants from the MPCA. The RLWD has collected samples in some lakes and has funded collection by volunteers and other local organizations.

1.5 Previous Studies

The Clearwater River Watershed has been the subject of numerous intensive studies. This section lists the water quality studies that have been completed in the Clearwater River Watershed and some recommendations and/or highlights of the studies.

- Maple Lake Assessment Report (1991)
    - Although water quality in Maple Lake was better than expected for a lake with the physical characteristics and the land use in its watershed, the report cautioned that changes in conditions around Maple Lake would cause an increase in TP concentrations causing conditions in the lake to worsen. The report discussed the importance of wetlands in the lake's watershed that filter sediment and nutrients from runoff before it

enters the lake. It also discussed the importance of vegetation in the lake for tying up nutrients, and cautioned that removal of vegetation could lead to reduced water clarity. The report mentioned that sediment could be stirred-up by boating, wave action, and bottom-feeding rough fish. Emergent vegetation helps neutralize wave action from wind and boats that cause shoreline erosion and sediment disturbance. The East Polk SWCD Lake Leader newsletter and other educational efforts are essential for raising awareness of water quality issues.

- Clearwater River Environmental Study (1991)
    - The purpose of the study was to "improve the knowledge and understanding of agricultural producers in the Clearwater River Basin and propose to them how they can alter their land management practices to provide a greater degree of surface water, groundwater, and other natural resources protection." A total of nine educational workshops were held during and after the study. The report found that wild rice cultivation can have adverse impacts upon water quality, but the effects dissipate as the river travels downstream. Channelization of the river may have helped with flooding in certain areas at certain times, but increased flows might increase potential for erosion.
    - http://www.redlakewatershed.org/projects/ClearwaterRiverEnvironmentalStudy.pdf
- Clearwater River Nonpoint Study (1994)
    - The data collected in 1992 - 1993 for this study led to the first impairment listings in the Clearwater River Watershed. The study characterized water quality conditions, diagnosed the sources of water quality problems, and recommended corrective measures. Phase II of the Clearwater Nonpoint Study involved acquisition of funding to implement projects to improve water quality (streambank stabilization, wild rice BMPs, public education, and riparian buffers).
    - http://www.redlakewatershed.org/waterquality/Clearwater_River_Nonpoint_Study.pdf
- Cameron Lake Investigative Study (1997)
    - This report was the source of much of the background information about Cameron Lake that is featured in the Clearwater River TMDL report. The report discussed former activities that deposited pollutants into the lake and identified two stormwater inlets and another inlet channel as the primary sources of current TP loads to the lake.
    - http://www.redlakewatershed.org/waterquality/Cameron%20Lake%20Report.pdf
- Cross Lake and Turtle Lake Water Quality Study (2000)
    - When homesteaders first settled around the lakes in 1883, they tried to partially drain the lakes to gain more land. The little land they gained was mostly unproductive. Winterkill of fish was common in Turtle Lake. Cross Lake was a good, reliable fishing lake during the 1950s and 1960s. County Ditch 68 was constructed to further drain the lakes. There was an attempt in the 1920s to have the lakes restored. Dams were constructed in 1933. Drought prevented the lakes from being filled with water and completely restored until the fall of 1941.

    - Flow directions within the cluster of lakes (Turtle Lake, Perch Lake, South Connection Lake, Cross Lake, and North Connection Lake) were mapped.
    - The report recommended future monitoring of water quality in the lakes, monitoring of the inlets and outlets of the lakes, monitoring of lake depths, an inventory of watershed characteristics and pollution sources, and characterization of fishery resources.
- Clearwater Lake Water Quality Model Study (2003)
    - This study focused on the watershed upstream of Clearwater Lake.
    - The two subwatersheds (upstream of Clearwater Lake) with the highest contributions to the sediment and nutrient loads in the river are the 3-mile road subwatershed (Bagley) and the Clearwater Lake inlet subwatershed (excluding the Buzzle Lake Watershed and everything upstream of 3-mile road). The sediment loads coming from the 3-mile road subwatershed should be decreased by the Bagley Urban Runoff Reduction Project, for which three stormwater treatment ponds have been constructed. In the Clearwater Lake inlet subwatershed, it appears that the areas with the highest runoff potential are located next to streams and ditches.
    - http://www.redlakewatershed.org/waterquality/Clearwater%20Lake%20Water%20Quality.pdf
- Red River Basin Stream Survey Report: Red Lake River Watershed (2004)
    - Although this report was written for the Red Lake River Watershed, the majority of the sample collection occurred within the Clearwater River Watershed. The Clearwater River fish sampling was completed by RLWD and Red Lake DNR staff as part of a local biological study of the Clearwater River Watershed. Samples were collected throughout the Clearwater River, in the Poplar River, and the Lost River. The report made recommendations for habitat protection and enhancement:
        - Establish and/or protect riparian corridors along all waterways, including ditches using native vegetation whenever possible.
        - Implement seasonal aquatic community-based instream flow incremental methodologies to develop protected flow levels.
        - Stop or mitigate future activities that will continue to disrupt the hydrology.
        - Identify and take actions to correct the sources of biotic impairments.
        - To the extent possible, augment base flows and attenuate peak flows in streams throughout the watershed to attain more natural hydrographs.
        - Protect and enhance the quality and accessibility of lake sturgeon habitat.
        - Re-establish natural functioning streams channels wherever possible using natural channel design principles.
        - Rehabilitate the channelized reaches, especially the Clearwater River and Lost River.

    - Define areas critical for sustaining base stream flows.
    - Implement agricultural BMPs to reduce erosion and sedimentation and to facilitate natural channel evolution.
    - Work with appropriate entities to alleviate water quality problems that are affecting aquatic communities.
    - Encourage the accumulation of woody material in streams to enhance habitat. Recommend following American Fisheries Society guidelines.
    - Though it wasn't used for the stream survey report and sampling methods used were different than current MPCA methods, some interesting patterns can be seen in the macroinvertebrate sampling results. Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) macroinvertebrate orders (EPT) are sensitive to pollutants and other stressors. High numbers of those EPT could indicate good water quality and habitat conditions. The numbers of EPT were highest within the trout stream reach of the Clearwater River (stations near CSAH 22 and CSAH 24), downstream of Clearwater Lake (near S005-284 and 219th Ave). The numbers were relatively high within the Clearwater River between Plummer and Terrebonne Creek. The EPT numbers were relatively low in Walker Brook and near the upstream end of the channelized reach of the Clearwater River (upstream of CSAH 5 near 14RD207).
  - The fisheries report also made recommendations for future data collection and monitoring:
    - Monitor the potential expansion of smallmouth bass populations throughout the watershed
    - Monitor the potential expansion of common carp populations throughout the watershed.
    - Monitor lake sturgeon recovery efforts in the watershed. Monitor the effects of dam removal projects on fish communities and individual species populations.
    - Identify and protect important stream spawning locations and enhance the quality of habitat in these locations when possible.
    - Monitor the fish community in the Poplar River immediately downstream of Fosston.
    - Track land use changes in the watershed, particularly the continuous sign-up CRP and CREP lands.
    - Survey culverts in the basin (dimensions and slope).
    - Spring trap-net surveys in the watershed to assess northern pike and walleye spawning runs.
    - Conduct pre- and post-project monitoring of approved natural resource enhancement and flood damage reduction projects.

- Clearwater River Walker Brook Impaired Waters Project & Clearwater River Trout Stream Fecal Coliform Study (2007 through 2009)
    - The study found that the trout stream reach met state and federal water quality standards for fecal coliform bacteria and recommended that the reach should be removed from Minnesota's 2006 303(d) list. However, the project team recommended implementation of a series of BMPs to assure that current conditions were maintained.
    - The study also found that DO in Walker Brook was naturally low due to the influence of groundwater and the fens that lined the stream.
- Clearwater River SWAT Model (2009)
    - A Soil and Water Assessment Tool (SWAT) model was developed during the Clearwater River DO and Fecal Coliform TMDL study to identify the areas where the highest rates of pollutant runoff were occurring and to evaluate the effectiveness of BMPs.
    - http://www.redlakewatershed.org/waterquality/BK-Clearwater%20Modeling%20May09.pdf
- Silver Creek SWAT Model (2009)
    - This project refined the calibration of the Clearwater River SWAT model for the purpose of targeting and evaluating the effectiveness of BMPs in the Silver Creek Watershed. The optimum scenario for reducing fecal coliform concentrations would be achieved through cattle exclusion from streams and waterways. Grassed waterways and wetland restoration also showed potential to reduce fecal coliform concentrations. Simulated buffer strip implementation resulted in significant reductions in sediment concentrations.
    - http://www.redlakewatershed.org/waterquality/EERC%20Silver%20Creek%20SWAT.pdf
- Red Lake River Farm to Stream Tile Drainage Water Quality Study (2009)
    - The study was initiated because of a desire to understand how an increasing amount of tile drainage in the Red River Basin might affect water quality. Theoretically, the tile drainage in the Red River Basin would have lower TSS and TP concentrations, generally, because tile in the basin typically did not use surface inlets. Tile drainage was compared to surface drainage from fields in Red Lake County that drained to the Hill River and Lost River. Tile drainage from wild rice paddies was also examined. The study confirmed theories that tile drainage in that area (with no surface inlets) had very low TSS and TP concentrations compared to surface runoff and concentrations in receiving waters. Nitrate concentrations, however, were very high from tile that was draining cultivated fields. The wild rice paddy sampling revealed that main line tile was a mutually beneficial practice for the farmer and water quality. Main line tile and elimination of surface drainage ditches was necessary to achieve water quality benefits from tile in wild rice paddies. Any type of internal drainage in wild rice paddies resulted in extremely high concentrations of TSS and other pollutants in discharge from the paddy. The discharge from main line tile, however, was low in TSS, TP, and even nitrates.

- Clearwater DO and Fecal Coliform TMDL Study (2007 through 2009)
  - Fecal coliform impairments were addressed for reaches of the Lost River, Silver Creek, and the Clearwater River. Re-assessment of the reaches included continuous DO data, which provided a record of true daily minimum values. *E. coli* samples were collected to assess the reaches that had aquatic recreation impairments.
  - The study found that the reach of the Clearwater River was meeting state standards for both *E. coli* and DO. The study also found that the Lost River was meeting the state standards for the protection of aquatic recreation. High *E. coli* concentrations still occurred in both the Lost River and Clearwater River, so there was room for improvement. Although the reports for these reaches won't be submitted to the EPA as TMDLs, they'll be used to create protection plans for the reaches.
  - Silver Creek was found to be exceeding the state aquatic recreation protection standard for *E. coli*. Concentrations were consistently high near the town of Clearbrook, where Silver Creek receives stormwater drainage from the town and is influenced by direct cattle access. The Poplar River was found to be impaired by low DO throughout the assessed reach. The pollutant with the best connection to DO was found to be orthophosphorus (OP). Draft TMDL reports were written and submitted to the EPA for comments. The completion of the TMDLs were postponed until the WRAPS because of the initiation of the watershed approach to restoring and protecting Minnesota's waters. Information from the draft Silver Creek and Poplar River TMDL reports was incorporated into the Clearwater River Watershed TMDL (2020).
- Clearwater River Watershed Monitoring and Assessment Report (2017)
  - This report summarized the results of the MPCA's 2016 assessment of water chemistry and biological data that was collected during the years 2006 through 2015. This report provided information that was used throughout the Clearwater Watershed TMDL and WRAPS reports.
  - https://www.pca.state.mn.us/sites/default/files/wq-ws3-09020305b.pdf
- Clearwater River Watershed SID Report (2017)
  - This report investigated the causes, or stressors, of aquatic life impairments in the Clearwater River Watershed that were triggered by poor F-IBI and M-IBI. The information in this report was summarized in Section 4 of the Clearwater River Watershed TMDL and Section 2.3 of this WRAPS. The findings also guided the development of restoration and protection strategies.
  - https://www.pca.state.mn.us/sites/default/files/wq-ws5-09020305a.pdf
- Clearwater River Watershed Fluvial Geomorphology Study (2014 through present)
  - Reconnaissance and streambank assessments, and other measurements were collected along representative reaches of the Clearwater River, Lost River, and Hill River. Intensive surveying at representative stations along those channels was also completed. Additional surveying was conducted on the Poplar River to provide information for the

2017 SID study. A draft report has been completed but has not been finalized. The initial findings and recommendations of the study were summarized in Section 4.1.2 of the Clearwater River Watershed TMDL and Section 3.2 of this WRAPS report.

1.6 Wild Rice Farming

A unique feature of the Clearwater River Watershed is the wild rice paddies that are located in peatlands along a portion of the Clearwater River that forms the border with the Red Lake Nation near the northeastern edge of the watershed. Wild rice, as a domesticated agricultural grain crop, is grown in paddies flooded with water to an average depth of about one foot. Wild rice agriculture began along the Clearwater River in 1968, but did not expand to its current size until the mid-1970s. The paddies are mostly located along the portion of the Clearwater River between the Ruffy Brook confluence and the CSAH 10 crossing (Figure 1-5). In the 10 years between 1973 and 1983, development of wild rice cultivation increased from 6,000 acres to 11,000 acres. There were 11,709 permitted acres in 1988. There currently are approximately 15,700 acres of wild rice paddies in the Clearwater River Watershed. On average, approximately 50% of these paddies are being used to grow rice in a given year. The remaining paddies are not flooded (rotation for disease prevention) and are used to grow other crops including soybeans, potatoes, and horseradish.

The paddies influence flow and water quality conditions within the river. Water is pumped from the River to fill the paddies prior to the start of the growing season. Approximately 30 inches of water is required annually to saturate the subsoil, initially fill the paddies, and make up for water lost through evaporation. Most of the water is appropriated during spring runoff and through the month of June. The paddies are drained during July and August to facilitate harvest.

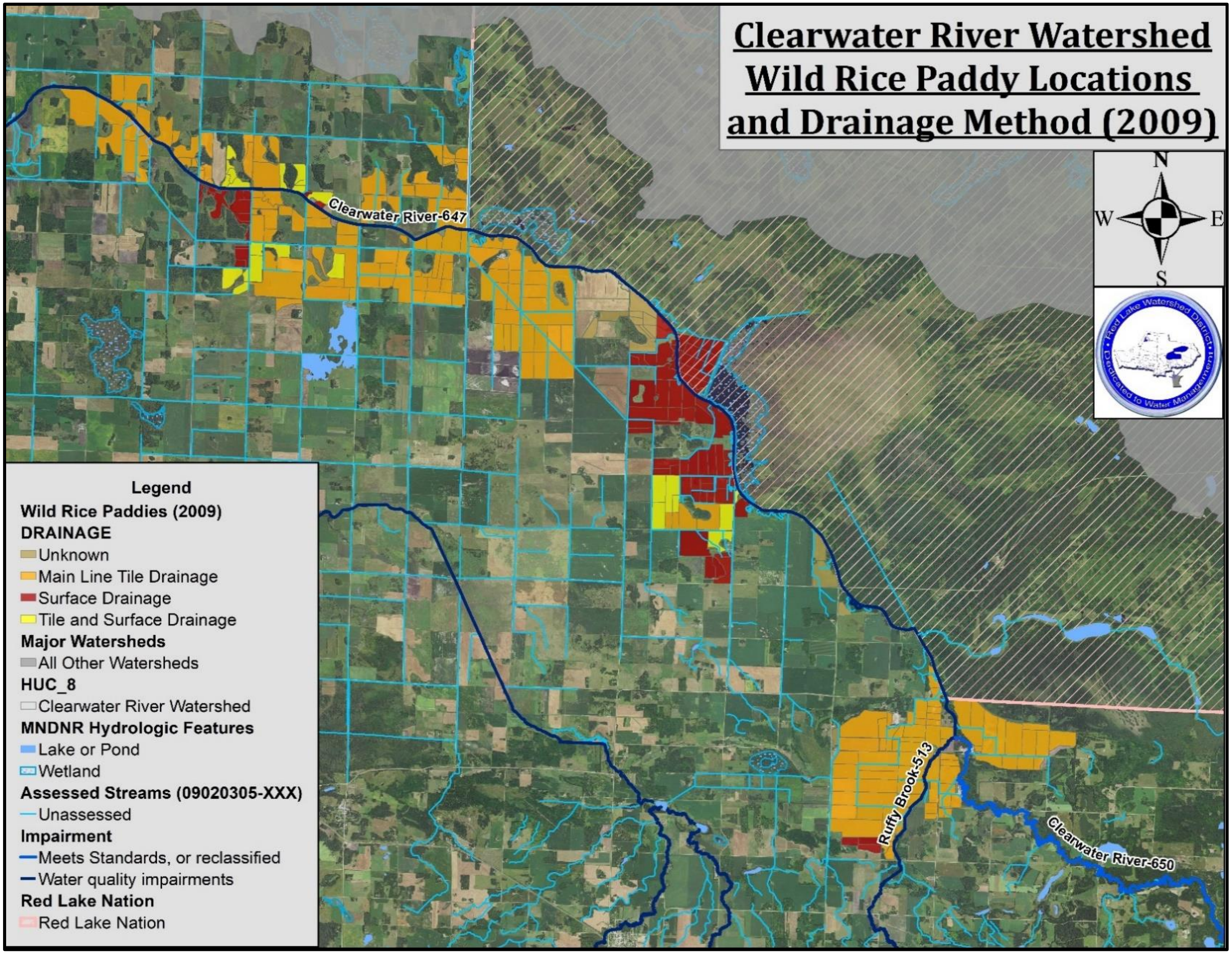


Figure 1-5. Locations of Clearwater River wild rice paddies and the types of drainage systems that are utilized (as of 2009).

2. Watershed Conditions

A formal water quality assessment was conducted in 2016 and the impairments identified by that assessment were included in the 2018 List of Impaired Waters. The Clearwater River Watershed TMDL report addressed 44 impairments of aquatic life and/or recreation that have been found within 23 stream reaches and 3 lakes within the watershed. TSS impairments were found in 5 reaches along the Clearwater River and a portion of Nassett Creek. Aquatic life impairments due to low DO levels have been identified in 10 reaches of tributaries to the Clearwater River. Five of these DO-impaired reaches have reclassification requests pending at the MPCA and, if approved, will not require TMDLs. Low IBI scores have resulted in M-IBI impairments for 3 reaches and F-IBI impairments for 7 stream reaches. A river eutrophication impairment was identified in one reach of the Clearwater River. Impairments of recreational safety due to chronically high concentrations of *E. coli* bacteria have been found along 15 reaches of the Clearwater River and its tributaries. Aquatic recreation was impaired by eutrophication (excess nutrients) in 3 lakes.

The causes of water quality impairments and threats to unimpaired streams have been investigated and are summarized in Section 2.3. Protection considerations were compiled for unimpaired waters throughout the watershed and are summarized in Section 2.5. Multiple tools were available for prioritizing and targeting restoration and protection projects. Assessment statistics identified and prioritized nearly restored and nearly impaired streams. Spatial analysis of the watershed identified areas with high rates of pollutant runoff and erosion. Tools like the SWAT model, HSPF model, and HSPF-Scenario Application Manager (HSPF-SAM) tool were utilized to identify areas where BMPs and other projects should be targeted throughout the watershed. The sources of water quality problems were also investigated through direct measurements like longitudinal sampling, a fluvial geomorphology study, and microbial source tracking. SID found that insufficient base flow was the most common stressor for aquatic biology within impaired Clearwater River tributaries, and it exacerbated the effects of other stressors like DO.

The maps in Figures 2-1 through 2-5 show the water quality conditions that were found throughout the watershed. The locations of impaired waters are shown in Figure 2-1. The average biological scores, by location, are shown in Figures 2-2 and 2-4. Expectations for biology varied throughout the watershed due to stream type, location, and sampling results. It can be difficult to compare scores from stations with different classifications. To more fairly compare and prioritize locations across the watershed, maps were created to show how biological sampling results compared to expectations, as an alternative to directly comparing scores from different locations. Scores are typically not comparable among different streams because different classifications of streams may be assessed with different metrics. The relative quality of biological sampling results compared to applicable standards and confidence intervals are shown in Figures 2-3 and 2-5.

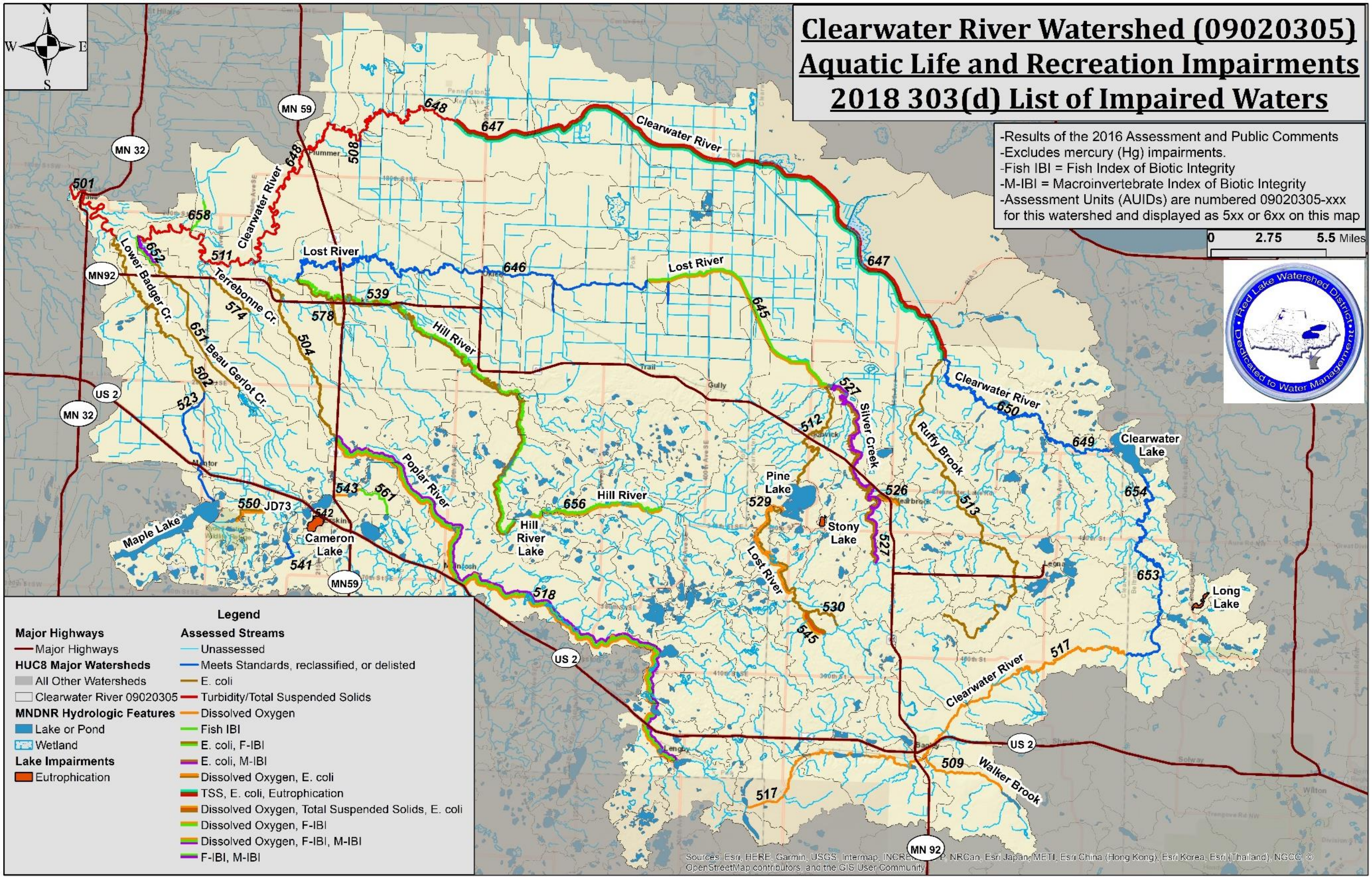


Figure 2-1. Impaired waters in the Clearwater River Watershed

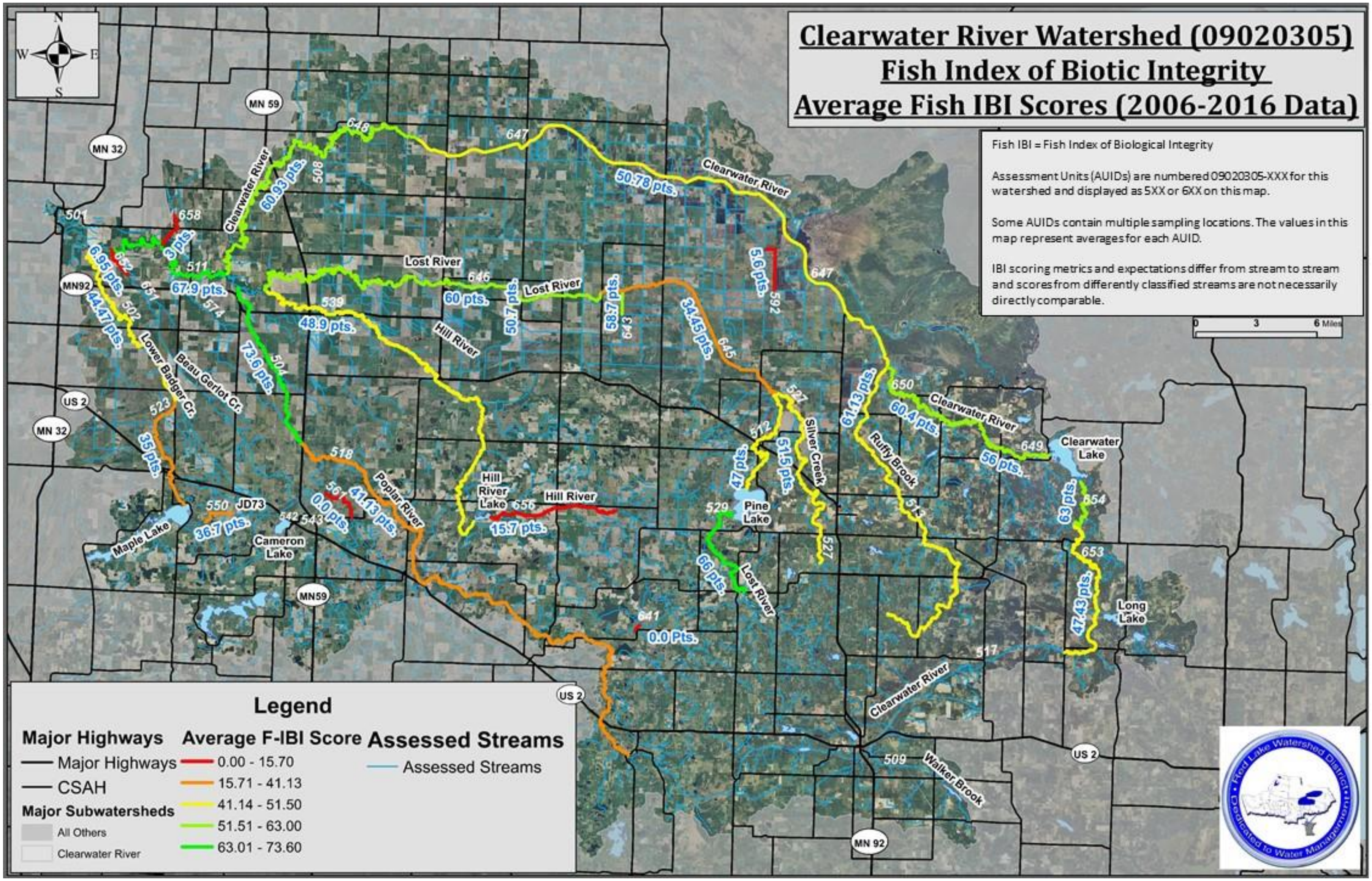


Figure 2-2. Clearwater River Watershed Average F-IBI Scores for Each Assessed AUID

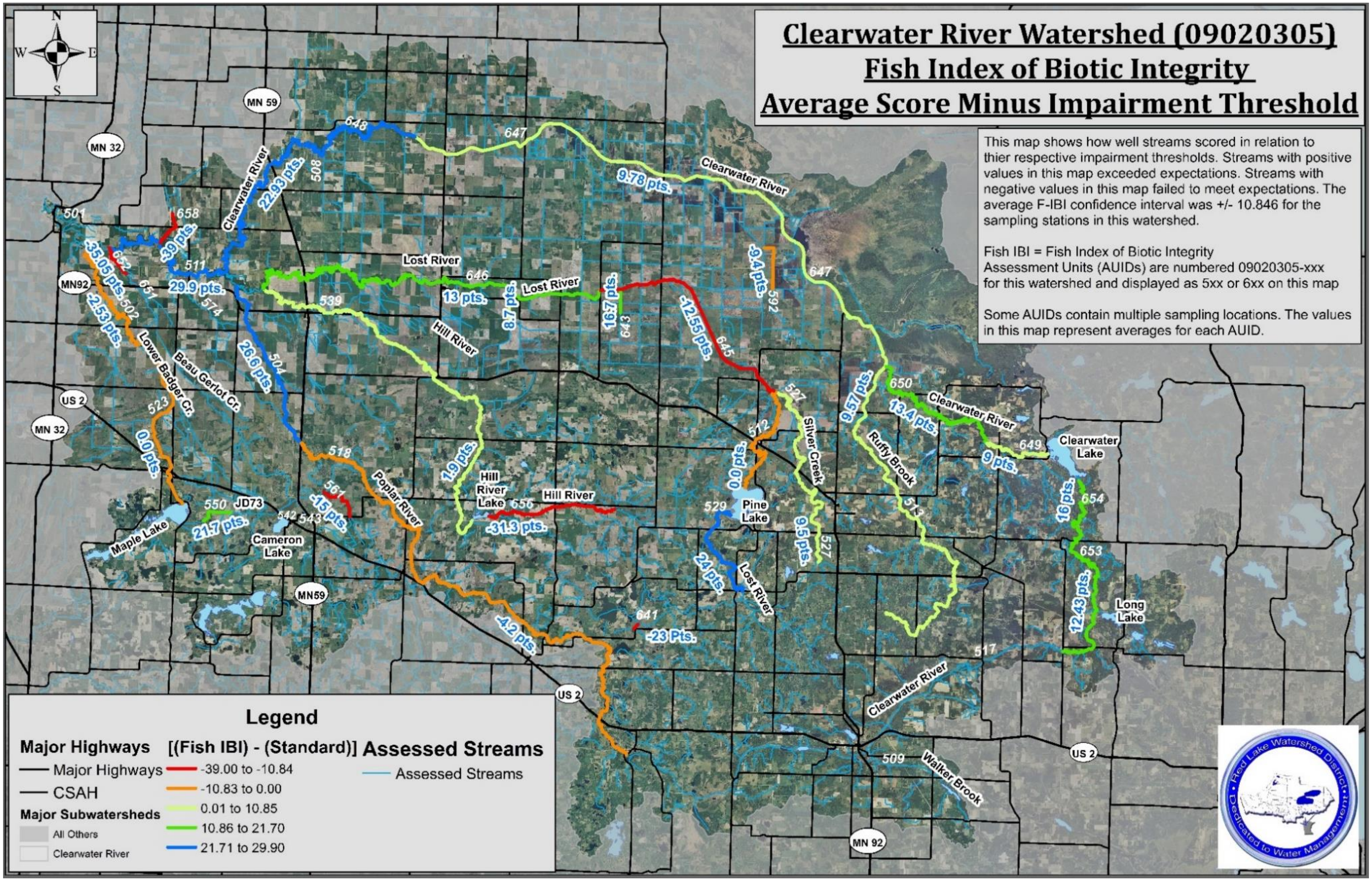


Figure 2-3. Map of how F-IBI scores in the Clearwater River Watershed compared to expectations (Average F-IBI score minus impairment threshold)

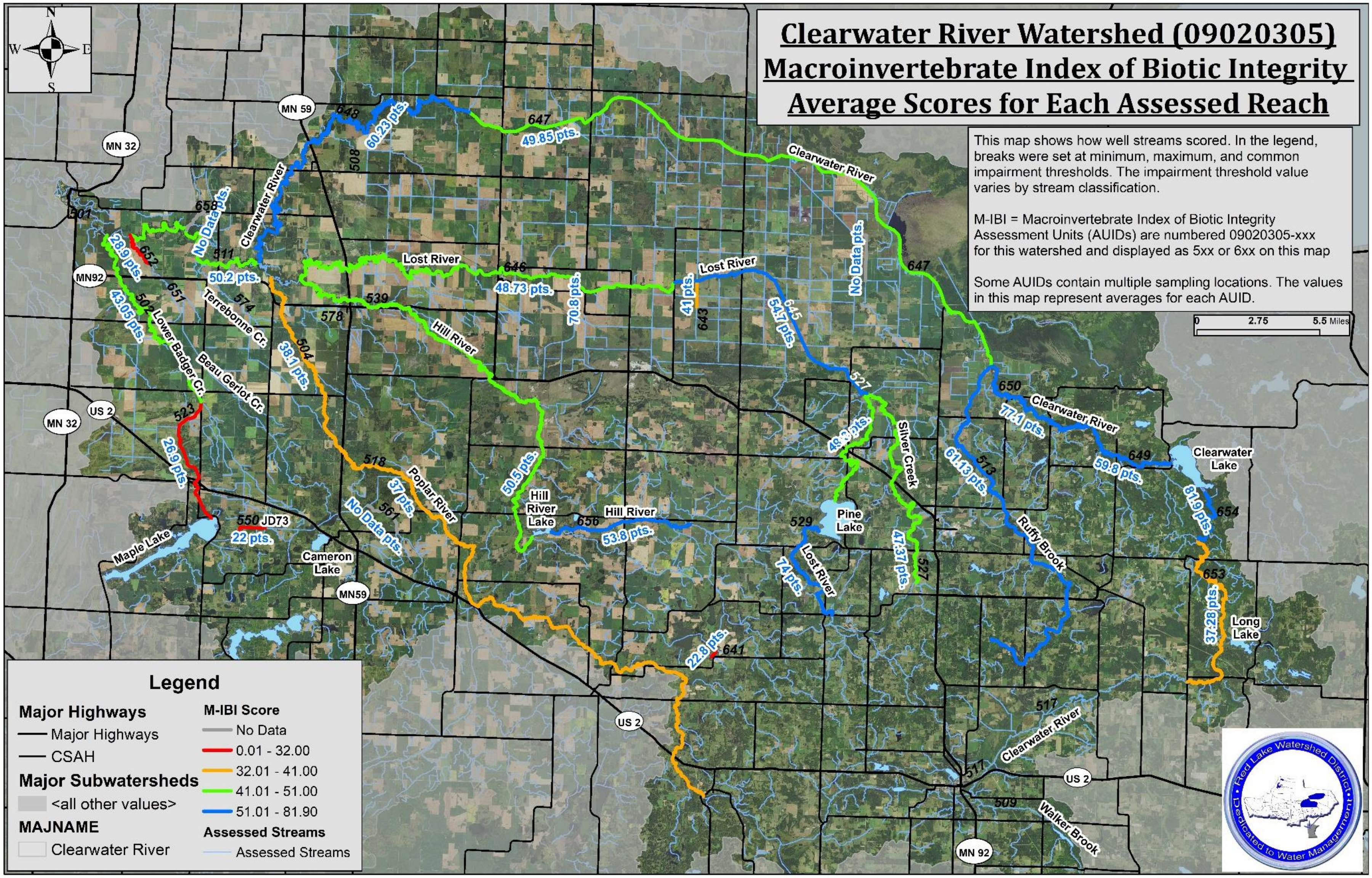


Figure 2-4. Average M-IBI scores for each assessed reach in the Clearwater River Watershed

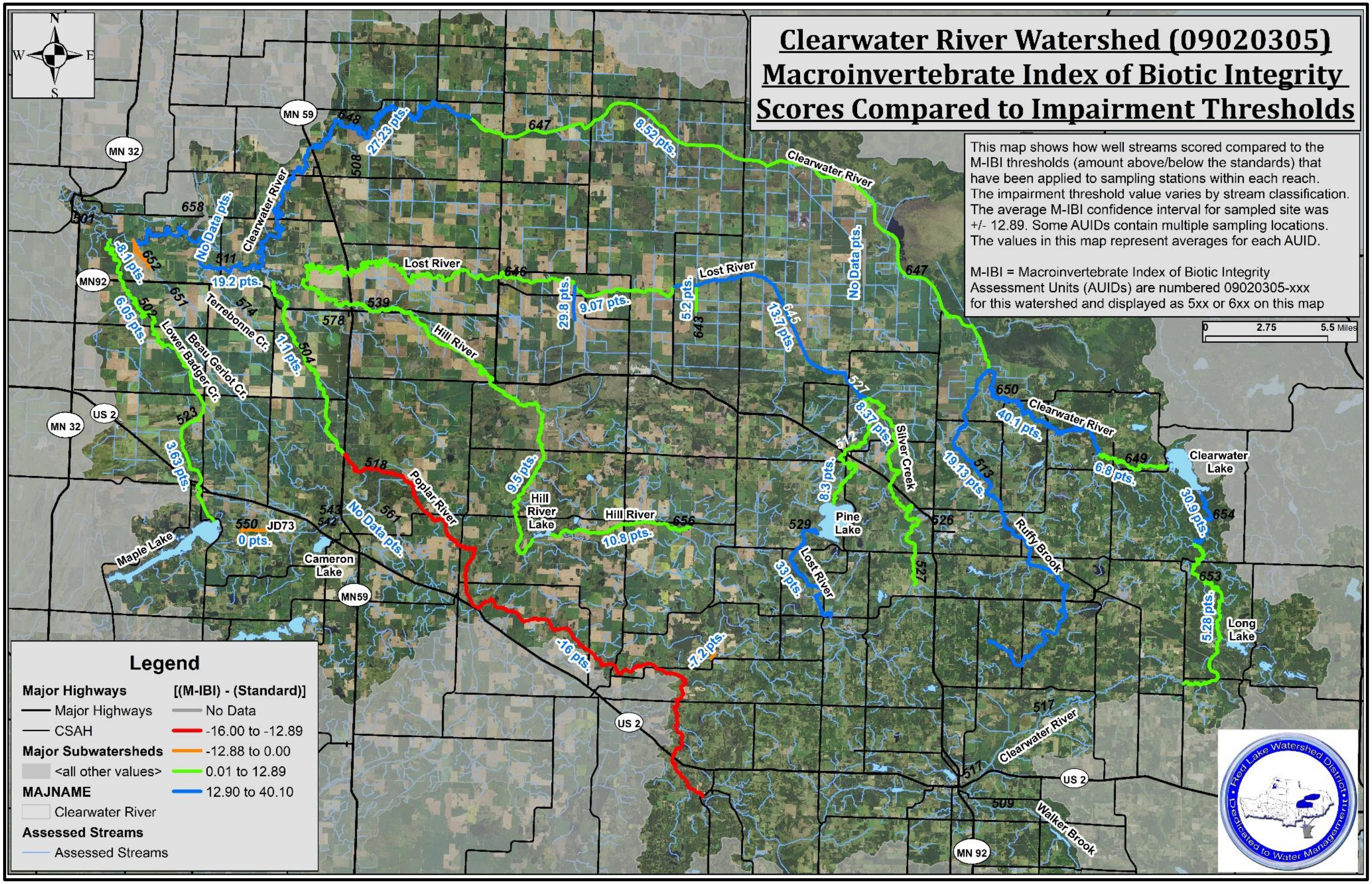


Figure 2-5. Map of how M-IBI scores in assessed reaches compared to impairment thresholds

2.1 Condition Status

The results of the 2016 water quality assessment of 2006 through 2015 data were summarized in Table 2-1 and 2-2. The tables were based upon the information in the Clearwater River Watershed Monitoring and Assessment Report. Subsequent changes, like reclassification of stream reaches, have also been incorporated into the table. The tables in Section 3.1 further analyze the assessment statistics, and other quantifiable characteristics, to identify reaches that were nearly impaired or nearly restored, so that those streams could be targeted for projects that will improve water quality and habitat. Some of the waterbodies in the Clearwater River Watershed are impaired by mercury; however, this report does not cover toxic pollutants. For more information on mercury impairments see the statewide mercury TMDL at: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/special-projects/statewide-mercury-tmdl-pollutant-reduction-plan.html.

Streams

As shown in Table 2-1, many stream reaches in the Clearwater River Watershed were examined during the 2016 water quality assessment. There also were reaches where more data were needed. Some reaches were assessed for the first time in 2016. Many of the new impairments in the watershed were from *E. coli* bacteria, which was assessable (met minimum data requirements) for the first time because local sampling efforts for that parameter began in 2005. Biological assessments were also completed for the first time in this watershed during the 2016 stream assessments. Some small streams and ditches that were sampled for biology had very little, if any, water chemistry. In response to the biological impairments found on some small streams and ditches, additional data were subsequently collected on those reaches for the SID process.

The flow paths of some smaller ditch and tributary AUIDs in the watershed may need ground-truthing. The flow paths in AUID GIS data sometimes differ from the flow paths depicted in aerial photos or other GIS layers. An extensive ground-truthing process will occur during the development of the Clearwater River PTMApp. That process will include an inventory of culverts and verification of flow paths. The relatively complex drainage systems within and around the wild rice farms (like AUID 592) will be clarified through in-the-field observations.

Table 2-1. Assessment status of stream reaches in the Clearwater River Watershed

HUC-10 Subwatershed	AUID (Last 3 digits)	Stream	Reach Description	Aquatic Life: Fish Index of Biotic Integrity	Aquatic Life: Macroinvertebrate Index of Biotic Integrity	Aquatic Life: Dissolved Oxygen	Aquatic Life: Secchi/Turbidity/TSS	Aquatic Life: Eutrophication (TP)	Aqu Rec: *E. coli* Bacteria
Upper Clearwater River	509	Walker Brook	Walker Brook Lake to Clearwater River	IF	IF	NA	Sup	IF	IF
	517	Clearwater River	Headwaters to T148 R36W S36, East line	IF	IF	Imp	Sup	IF	Sup
	649	Clearwater River	Clearwater lake to unnamed creek	Sup	Sup	IF	IF	IF	Sup
	653	Clearwater River	T148 R35W S31, west line to unnamed creek	Sup	Sup	IF	Sup	IF	Sup
	654	Clearwater River	Unnamed creek to Clearwater Lake	Sup	Sup	IF	IF	IF	IF
	655	Hill River (CD 68/81)	Cross Lake to Unnamed Creek (Branch 4 CD 81 near Olga)	IF	IF	IF	IF	IF	IF
Middle Clearwater River	513	Ruffy Brook	Headwaters to Clearwater River	Sup	Sup	Sup	Sup	IF	Imp
	592	Unnamed ditch	Unnamed ditch to unnamed ditch (near Red Lake Nation Foods wild rice farm)	NA	NA	IF	IF	IF	IF
	647	Clearwater River	Ruffy Brook to JD 1	Sup	Sup	Sup	Imp	Imp	Imp
	650	Clearwater River	Unnamed creek to Ruffy Brook	Sup	Sup	Sup	IF	IF	Sup
Hill River	539	Hill River	Hill river Lake to Lost River	Imp	Sup	Sup	Sup	Sup	Imp
	578	Brooks Creek	Unnamed creek to Hill River	IF	IF	IF	IF	IF	Imp
	641	Unnamed ditch	Hill River tributary ditch that drains wetlands by South Connection Lake	NA	NA	IF	IF	IF	IF
	656	Hill River	Unnamed creek to Hill River Lake	Imp	Sup	Imp	Sup	IF	Sup
Poplar River	504	Poplar River	Highway 59 to Lost River	Sup	Sup	IF	Sup	IF	Imp
	518	Poplar River	Spring Lake to Highway 59	Imp	Imp	Imp	Sup	IF	Sup
Lost River	512	Lost River	Pine Lake to Anderson Lake	Sup	Sup	Sup	Sup	Sup	Imp
	526	Clear Brook	Headwaters to Silver Creek	IF	IF	Imp	Sup	Sup	Imp
	527	Silver Creek	Headwaters to Anderson Lake	Sup	Imp	Sup	Sup	IF	Imp
	529	Lost River	T148 R38W S17, south line to Pine Lake	Sup	Sup	Imp	Sup	IF	Imp
	530	Lost River	Unnamed creek to T148 R38W S20, north line	Sup	IF	Imp	Sup	IF	Imp
	545	Nassett Creek	T148 R38W S28, south line to Lost River	IF	IF	Imp	Imp	IF	Imp
	590	CD 61	Unnamed ditch to Lost River	Sup	Sup	IF	IF	IF	IF
	643	JD 72 Outlet	Unnamed ditch to Lost River	Sup	Sup	IF	IF	IF	IF
	645	Lost River	Anderson Lake to unnamed creek	Imp	Sup	Imp	Sup	Sup	Sup
	646	Lost River	Unnamed creek to Hill River	Sup	Sup	Sup	Sup	Sup	Sup
Lower Badger Creek	502	Lower Badger Creek	CD 14 to Clearwater River	Sup	Sup	Sup	Sup	Sup	Imp
	523	Polk County Ditch 14	Maple Lake to Lower Badger Creek	Sup	Sup	IF	Sup	Sup	Sup
	541	Unnamed creek (Bee Lake inlet)	Eighteen Lake to Bee Lake	IF	IF	NA	IF	IF	IF

HUC-10 Subwatershed	AUID (Last 3 digits)	Stream	Reach Description	Aquatic Life					Aqu Rec
				Fish Index of Biotic Integrity	Macroinvertebrate Index of Biotic Integrity	Dissolved Oxygen	Secchi/Turbidity/TSS	Eutrophication (TP)	*E. coli* Bacteria
	542	Unnamed creek (JD73)	Mitchell Lake to Badger Lake	IF	IF	NA	NA	NA	IF
	543	Poplar River Diversion	Unnamed ditch to Badger Lake	IF	IF	NA	IF	IF	IF
	549	Unnamed creek (JD73)	Tamarac Lake to Maple Lake	IF	IF	NA	NA	NA	Sup
	550	JD 73	Unnamed ditch (upstream of 187th Ave NE) to Tamarac Lake	Sup	Sup	Imp	Sup	IF	Imp
	551	Unnamed creek (Bee Lake outlet)	Bee lake to JD 73	IF	IF	NA	IF	IF	IF
	561	Tributary to Poplar River Diversion	Gerdin Lake to Poplar River Diversion	Imp	IF	IF	IF	IF	IF
Lower Clearwater River	501	Clearwater River	Lower Badger Creek to Red Lake River	Sup	Sup	Sup	Imp	Sup	Sup
	508	County Ditch 57	Unnamed ditch to Clearwater River	IF	IF	NA	IF	IF	IF
	511	Clearwater River	Lost River to Beau Gerlot Creek	Sup	Sup	IF	Imp	Sup	Sup
	574	Terrebonne Creek	CD 4 to CD 58	IF	IF	Sup	Sup	Sup	Imp
	648	Clearwater River	JD 1 to Lost River	Sup	Sup	Sup	Imp	IF	Sup
	651	Beau Gerlot Creek	Upper Badger Creek to -96.1947 47.8413 (channelized portion)	IF	IF	IF	Sup	Sup	Imp
	652	Beau Gerlot Creek	-96.1947 4.8413 to Clearwater River	Imp	Imp	IF	IF	IF	IF
	658	Red Lake CD 23	-96.1479 47.8855 to Clearwater River	Imp	IF	IF	IF	IF	IF

Sup = found to meet the water quality standard, Imp = does not meet the water quality standard and, therefore, is impaired, IF = the data collected was insufficient to make a finding, NA = not assessed, IC = Inconclusive

Lakes

The 2016 water quality assessment examined 32 lakes throughout the Clearwater River Watershed. Only three of those lakes were impaired by excess nutrients, excess chl-*a*, and/or poor water clarity (Secchi disk transparency). Table 2-2 shows whether lakes met standards, were impaired, or were in need of additional data collection. Section 3.1 further analyzes assessment statistics to identify nearly impaired lakes that are not currently impaired but have TP, chl-*a*, or Secchi disk transparencies that are close to the impairment threshold values.

Table 2-2 Assessment status of lakes in the Clearwater River Watershed

HUC-10 Subwatershed	Lake ID	Lake	Aquatic Recreation	Aquatic Life
Upper Clearwater River	04-0295	Long (Buzzle Twp.)	Imp	--
	04-0297	Buzzle	Sup	--
	04-0298	Little Buzzle	Sup	--
	15-0040	Bagley	Sup	IF
	04-0343	Clearwater	Sup	Sup
	04-0299	Funkley	Sup	--
	04-0300	Whitefish	Sup	Sup
	04-0303	Spring	IF	IF
	15-0060	Walker Brook	Sup	Sup
	15-0081	Lomond	Sup	Sup
	15-0137	Minnow	Sup	Sup
	15-0138	Sabe	Sup	--
	15-0139	First	Sup	--
	15-0140	Second	Sup	--
Middle Clearwater River	15-0027	East Four-Legged	Sup	--
	15-0028	West Four-Legged	Sup	--
	15-0035	Spike	Sup	--
	15-0037	Nels Olson	Sup	--
	15-0038	Falk	Sup	--
	15-0050	Long (Clover Twp.)	Sup	--
	15-0062	Fourth	IF	--
	15-0083	Peterson	Sup	IF
	15-0086	Johnson	Sup	IF
Hill River	60-0027-02	Cross (Main Basin)	Sup	IF
	60-0032	Turtle	IF	IF
	60-0099	Unnamed	IF	IF
	60-0129	Unnamed (Syverson)	IF	IF
	60-0139	Unnamed (Jeppson)	IF	--
	60-0142	Hill River	--	Sup
Poplar River	60-0012	Spring	Sup	Sup
	60-0015	Whitefish	Sup	Sup
Lost River	15-0104	Lone	Sup	--
	15-0090	Deep	Sup	--
	15-0144	Lindberg	Sup	--
	15-0149	Pine	Sup	IF
	15-0156	Stony	Imp	--
	15-0293	Unnamed	IF	--
Lower Badger Creek	Unnamed Lakes 60-0721, 60-0255, 60-0256, 60-0257, 60-0258		IF	--
	60-0275	Unnamed	IF	IF
	60-0305	Maple	Sup	Sup
	60-0189	Cameron	Imp	IF
	60-0192	Bee	IF	--

Imp = impaired for impacts to aquatic recreation, Sup = fully supporting aquatic recreation, IF = insufficient data to make an assessment, "—" = no data

Systematic assessments of biological data from lakes in the Clearwater River Watershed were first completed during the 2016 assessment. The MPCA and DNR coordinated to collect and assess biological data from 12 lakes throughout the Clearwater River Watershed in the years 2010 through 2015. Fish-based IBI scores were calculated to assess the quality of fish populations within lakes. None of the lakes that were formally assessed were found to be impaired during the assessment, but some were considered nearly impaired. There were some lakes that had low F-IBI scores but were not assessed due to recent winterkills (Pine Lake and Badger Lake). The SID Report was written to address the lakes that had scores that were below the impairment threshold (they needed to be below the lower confidence level (CL) to be considered impaired (summarized in Table 2-3 and Figure 2-6)). Cross Lake and Hill River Lake were considered vulnerable due to their proximity to the impairment threshold. Those lakes were the focus of the SID Report due to their vulnerability to future impairment.

Table 2-3. Summary of F-IBI assessment results for lakes in the Clearwater River Watershed

Lake ID	Lake Name	County	Year of Survey	Notes	DNR GIS Acres	% Littoral	FIBI Score	Below Impairment Threshold	Within 90% Confidence Interval of Impairment Threshold
04-0300	Whitefish	Beltrami	2015	June and August	125	42%	77, 66	No	No, No
04-0343	Clearwater	Beltrami	2013		999	34%	73	No	No
15-0060	Walker Brook	Clearwater	2015	Limited sampling	95	42%	48	No	No
15-0081	Lomond	Clearwater	2013	Limited sampling	95	47%	59	No	No
15-0137	Minnow	Clearwater	2014	Limited sampling	110	87%	71	No	No
15-0149	Pine	Clearwater	2014	Limited sampling winterkill	1238	100%	15	Yes	Yes
60-0012	Spring	Polk	2014		130	33%	67	No	No
60-0015	Whitefish	Polk	2015	June and August	243	81%	43, 43	No	Yes
60-0027	Cross	Polk	2014		166	90%	40	No	Yes
60-0142	Hill River	Polk	2014		103	68%	28	No	Yes
60-0214	Badger	Polk	2010	Recent winterkill	255	100%	6	Yes	No
60-0305	Maple	Polk	2010, 2015		1576	100%	31, 67	Yes, No	Yes, No
≤ lower CL		> lower CL & ≤ Threshold			> threshold & ≤ upper CL			> upper CL	NA = Not available

Though evidence suggested that agricultural land use and nutrient loading from the contributing watersheds of those two lakes may have had the greatest impact upon fish communities, the shoreline habitat of Cross and Hill River Lakes has been minimally altered by development. Pollutants are likely coming from the watersheds upstream of the lakes. Connectivity could have been an issue that was affecting the fish populations in these lakes. The Hill River connects these two lakes and portions of the river are impaired by low DO levels and poor F-IBI scores downstream of each of those lakes. The report recommended water quality data collection within the lakes, enhancement of lakeshore habitat, improvement of lakeshore buffers, and an examination of fish passage at the Hill River Lake Dam.

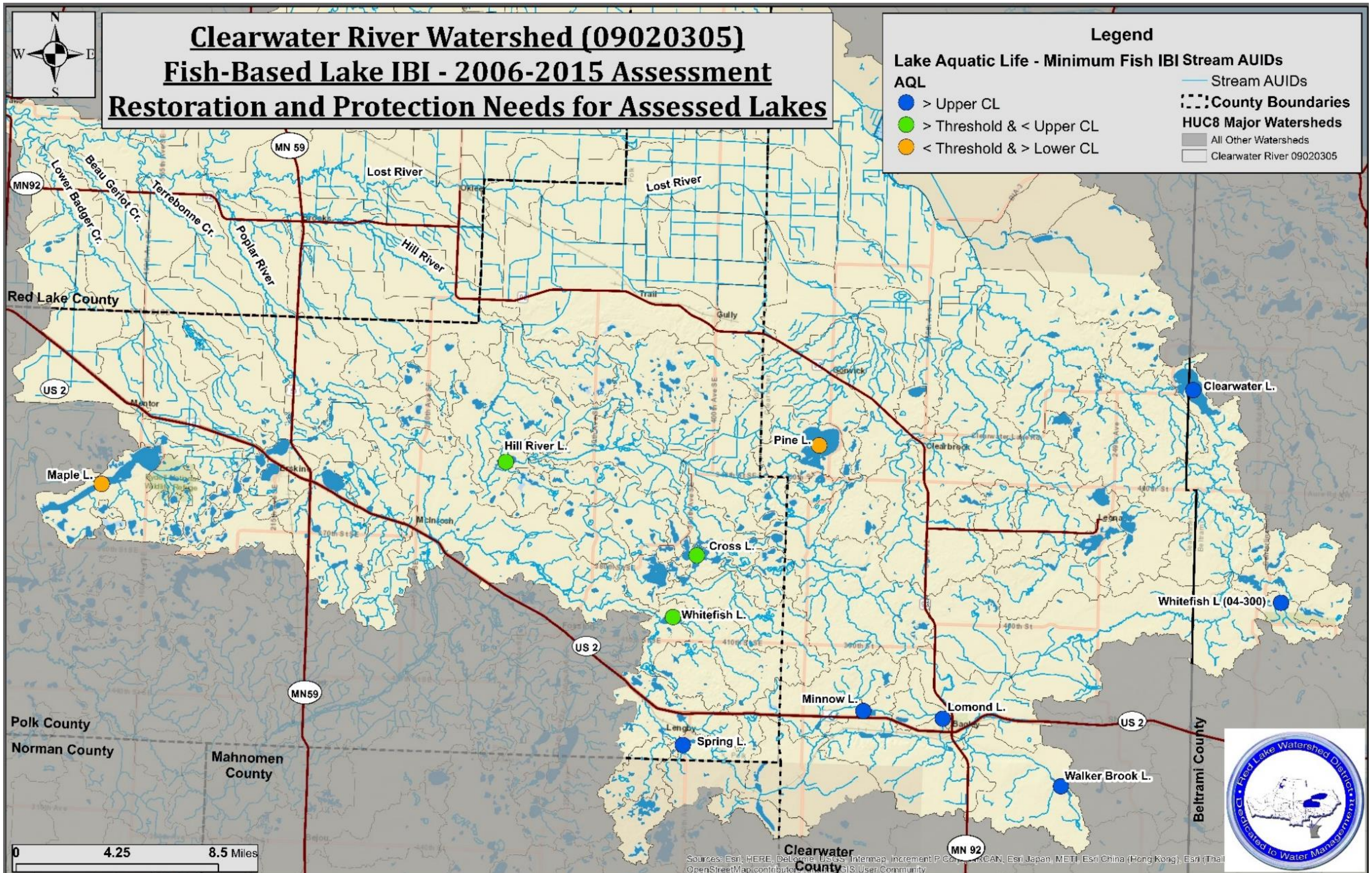


Figure 2-6. Map of protection needs that were identified by fish-based lake IBI assessment results. Lake identification numbers are shown in Table 2-3 and noted on the map to identify lakes with identical names.

2.2 Water Quality Trends

Water quality monitoring efforts in the Clearwater River have collected a significant amount of data on many reaches of the Clearwater River and its tributaries. A Mann-Kendall analysis was performed for all the locations in the watershed that have been sampled for more than 10 years. The stations where trends could be analyzed are shown in Figure 2-7.

The Mann-Kendall test is a non-parametric test for identifying trends in time series data. The data values were evaluated as an ordered time series. Each data value was compared to all subsequent data values. An Excel spreadsheet was created to calculate Mann-Kendall statistic - S, the variance of S - VAR(S), normalized test statistic – Z, and the probability associated with the normalized test statistic – f(z) values for each period. The trend was shown to be decreasing if the Z value was negative and computed probability was greater than 90%. The trend was shown as an increasing if the Z value was positive and the computed probability was greater than 90%. A series of data points that produced a probability of significance that was greater than 99% was considered to be a strong trend. Interesting trends were called out and shown in time-series graphs.

Sites where water quality appears to be improving, overall:

- Clearwater River near Plummer on (AUID 648)
- Silver Creek (AUID 527)
- Clearwater River at CSAH 10 (AUID 647)
- Clearwater River at CSAH 14 (AUID 649)
- Clearwater River at the Clearwater Lake outlet (AUID 649)
- Clearwater River near the Clearwater Lake inlet (AUID 653)
- Clearwater Lake (04-0343-00)
- Clearwater River at CSAH 2 (AUID 517)
- Clearwater River at CSAH 25 (AUID 517)
- Maple Lake (60-0305-00)
- Poplar River Diversion at the inlet to Badger Lake (AUID 543)
- Poplar River at CSAH 30 (AUID 518)
- Hill River at CR 119 (AUID 539)
- Lost River at CR 119 (AUID 646)
- Lost River at Oklee (AUID 646)
- Clear Brook at CSAH 92 (AUID 526)

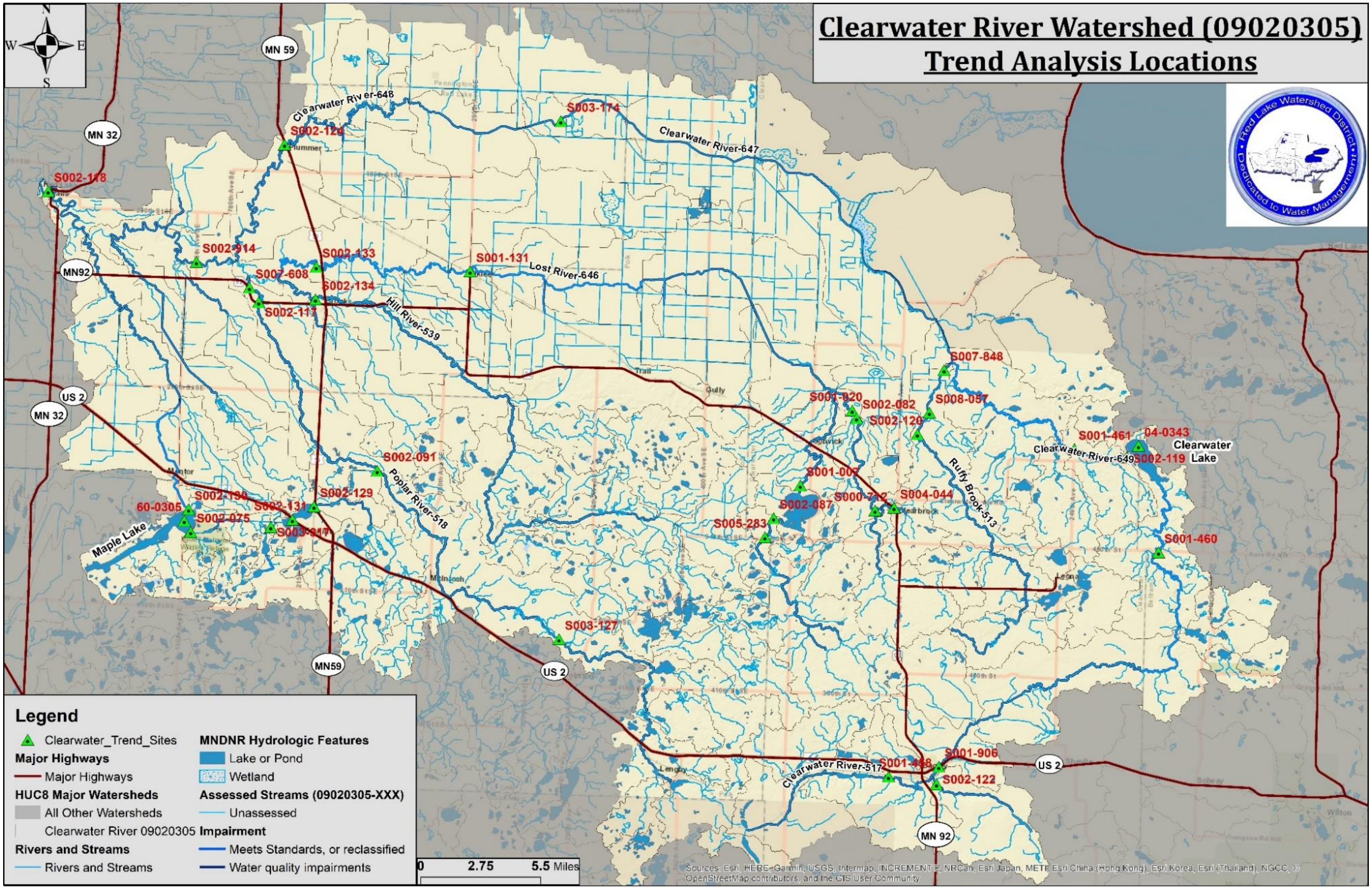


Figure 2-7. Map of water quality sampling stations for which trend analysis was completed

Sites where water quality appears to be declining, overall:

- Clearwater River in Red Lake Falls (AUID 501) – TSS and *E. coli*
- Maple Lake Outlet (AUID 523) – *E. coli*
- Maple Lake Inlet (AUID 549) – TSS, DO, *E. coli*
- Poplar River near its pour point (AUID 504) – TP and *E. coli*
- Poplar River at 315th St. SE (AUID 518) – TSS and TP
- Walker Brook at CSH 19 (AUID 509)

Increasing trends in *E. coli* concentrations may be due to increased sampling efforts along impaired tributaries. There were more stations with improving water quality than stations with decreasing water quality. There were some monitoring stations with mixed trend results.

Some trends at the pour point of the Clearwater River Watershed are cause for concern, as shown in Table 2-4. Average annual TSS concentrations were increasing (Figure 2-8). DO fluctuation may have been increasing because annual maximum DO concentrations were increasing, and annual minimums were decreasing.

Table 2-4. Detailed seasonal trend analysis results for the Clearwater River at Red Lake Falls (AUID 501).

Trends of Seasonal Averages Using Seasonal Mann-Kendall Analysis				
Clearwater River in Red Lake Falls (S002-118)	**Total Suspended Solids**	**Dissolved Oxygen**	**Total Phosphorus**	***E. coli***
Years	1990-2016	1990-2016	1995-2016	1992-2016
Annual Avg (All Months)	$\color{red}\triangle$	$\color{green}\triangle$	**X**	**X**
Annual Max (All Months)	$\color{red}\blacktriangle$	$\color{green}\blacktriangle$	$\color{red}\blacktriangle$	$\color{red}\triangle$
Annual Min (All Months)		$\color{red}\triangledown$		
Summer (May - Sept.)	$\color{red}\triangle$	$\color{green}\triangle$	**X**	**X**
April	**X**	**X**	**X**	Data <10
May	**X**	$\color{green}\triangle$	**X**	**X**
June	**X**	$\color{green}\triangle$	**X**	**X**
July	**X**	$\color{green}\triangle$	**X**	**X**
August	**X**	$\color{green}\triangle$	$\color{green}\triangledown$	**X**
September	**X**	$\color{green}\triangle$	$\color{green}\triangledown$	**X**
October	$\color{red}\triangle$	**X**	$\color{green}\triangledown$	Data <10
X = No Trend				
$\color{red}\blacktriangle$ = Strong Upward Trend (Getting Significantly Worse)				
$\color{red}\triangle$ = Upward Trend (Getting Worse)				
$\color{red}\triangledown$ = Downward Trend (Getting Worse)				
$\color{green}\blacktriangle$ = Strong Upward Trend (Getting Significantly Better)				
$\color{green}\triangle$ = Upward Trend (Getting Better)				
$\color{green}\triangledown$ = Downward Trend (Getting Better)				

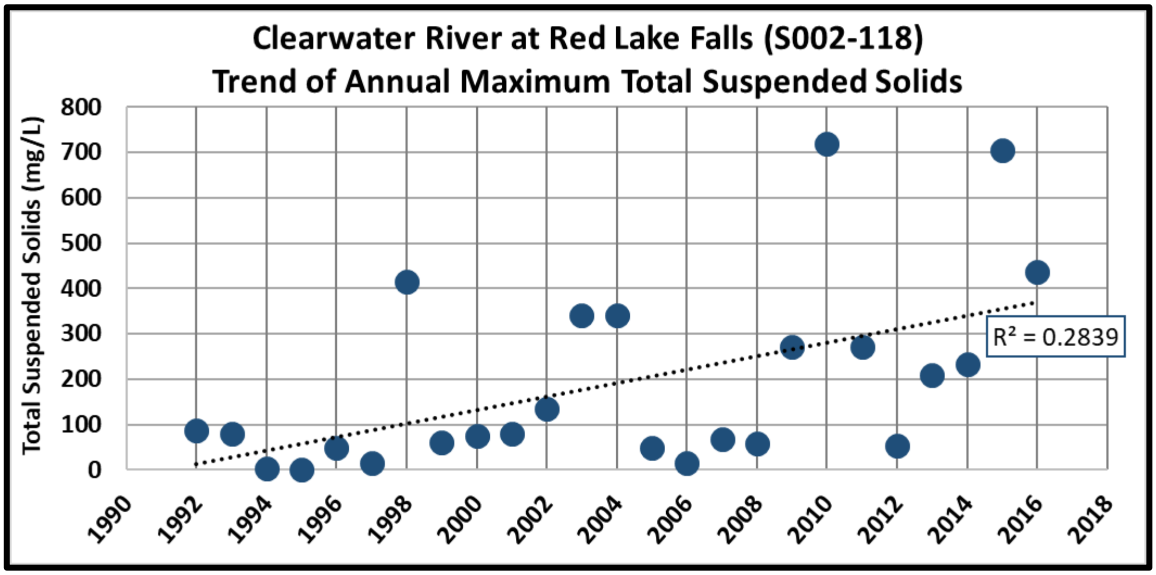


Figure 2-8. Time series plot that shows the upward trend in annual maximum TSS in the Clearwater River at Red Lake Falls.

Upstream of Red Lake Falls, at the CSAH 12 crossing near Terrebonne (S002-914), water quality within the Clearwater River appeared to be improving significantly (Table 2-5). The Red Lake SWCD collected much of the data at this location, and the RLWD added the site to its long-term monitoring program in recent years. It was an important monitoring site because it was the only crossing on the "Lost River to Beau Gerlot Creek" (AUID 511) segment of the river. No trends were identified in annual average or maximum *E. coli* concentrations. At least one additional year of sampling was needed to obtain the minimum amount of data points needed to conduct seasonal Mann-Kendall trend analysis for *E. coli* at this site. High nitrite+nitrate (NO2+NO3) concentrations have been found at this site. Therefore, trend analysis results for NO2+NO3 sampling were shown in the following table instead of *E. coli* trend analysis results. There may be interest in nitrate concentrations in rivers of the Clearwater River Watershed due to increasing tile drainage in the Clearwater River and its tributaries. The trend analysis revealed that NO2+NO3 concentrations have been increasing in the Clearwater River at CSAH 12.

Table 2-5. Detailed seasonal trend analysis results for the Clearwater River near Terrebonne (AUID 511)

Trends of Seasonal Averages Using Seasonal Mann-Kendall Analysis				
Clearwater River near Terrebonne (S002-914)	**Total Suspended Solids**	**Dissolved Oxygen**	**Total Phosphorus**	**Nitrates + Nitrites**
Years	1992-2016	1992-2016	1992-2016	1998-2016
Annual Avg (All Months)	▽	▲	**X**	△
Annual Max (All Months)	▼	**X**	▼	**X**
Annual Min (All Months)		▲		
Summer (May - Sept.)	▽	▲	**X**	△
April	Data <10	Data <10	Data <10	Data <10
May	△	**X**	▲	△
June	**X**	**X**	**X**	△
July	▽	▲	▽	**X**
August	▼	△	▼	**X**
September	▽	△	▽	**X**
October	Data <10	Data <10	Data <10	Data <10
X = No Trend				
▲= Strong Upward Trend (Getting Significantly Worse)				
△ =Upward Trend (Getting Worse)				
▲= Strong Upward Trend (Getting Significantly Better)				
▼= Strong Downward Trend (Getting Significantly Better)				
△= Upward Trend (Getting Better)				
▽= Downward Trend (Getting Better)				

There was a very robust history of sampling in the Clearwater River USGS gaging site, north of Plummer (S002-124). Late summer and fall TSS concentrations have been decreasing (Table 2-6). October samples have been collected for 17 years. The average October TSS concentration was lower than the reporting limit in 8 of those 17 years. DO and TP concentrations have been improving. Because data showed improving water quality conditions in the Clearwater River at Terrebonne and Plummer, investigation of causes of water quality degradation in the Clearwater River could focus on the portion that flows between CSAH 12 and the Red Lake River. The tributaries that enter the Clearwater River along that reach (Terrebonne Creek, Beau Gerlot Creek, and Lower Badger Creek) should also be examined.

Table 2-6. Detailed seasonal trend analysis results for the Clearwater River near Plummer (AUID 648)

Trends of Seasonal Averages Using Seasonal Mann-Kendall Analysis				
Clearwater River near Plummer (S002-124)	**Total Suspended Solids**	**Dissolved Oxygen**	**Total Phosphorus**	***E. coli***
Years	1992-2016	1991-2016	1991-2016	1992-2016
Annual Avg (All Months)	X	▲	X	X
Annual Max (All Months)	X	▲	X	X
Annual Min (All Months)		X		
Summer (May - Sept.)	X	▲	X	X
April	X	△	X	Data <10
May	X	X	X	X
June	X	△	X	X
July	▽	△	▽	X
August	▽	▲	▼	X
September	▽	▲	▽	Data <10
October	▽	△	▽	Data <10
X = No Trend				
▲ = Strong Upward Trend (Getting Significantly Better)				
▼ = Strong Downward Trend (Getting Significantly Better)				
△ = Upward Trend (Getting Better)				
▽ = Downward Trend (Getting Better)				

The trend analysis for sites near the pour point of Ruffy Brook (Table 2-7) yielded mixed results. Although average DO levels have increased, concentrations of pollutants have increased. There is a possibility that recent changes in monitoring strategy have contributed to the increases. The frequency of sampling has increased during the Clearwater River WRAPS and SWAG projects. The long-term monitoring site location was moved downstream from S002-120 to S008-057. Record high concentrations of pollutants (for Ruffy Brook) were found in 2016 (24,916 MPN/100ml *E. coli*, 0.493 mg/L TP, and 397 mg/L TSS). At least one more year of *E. coli* sampling was needed to compile the minimum of 10 years of data for any individual calendar month that is needed to conduct Mann-Kendall trend analysis. Analysis of average annual *E. coli* concentrations did not reveal a trend. However, analysis of annual maximum *E. coli* concentrations revealed an increasing trend (Figure 2-9).

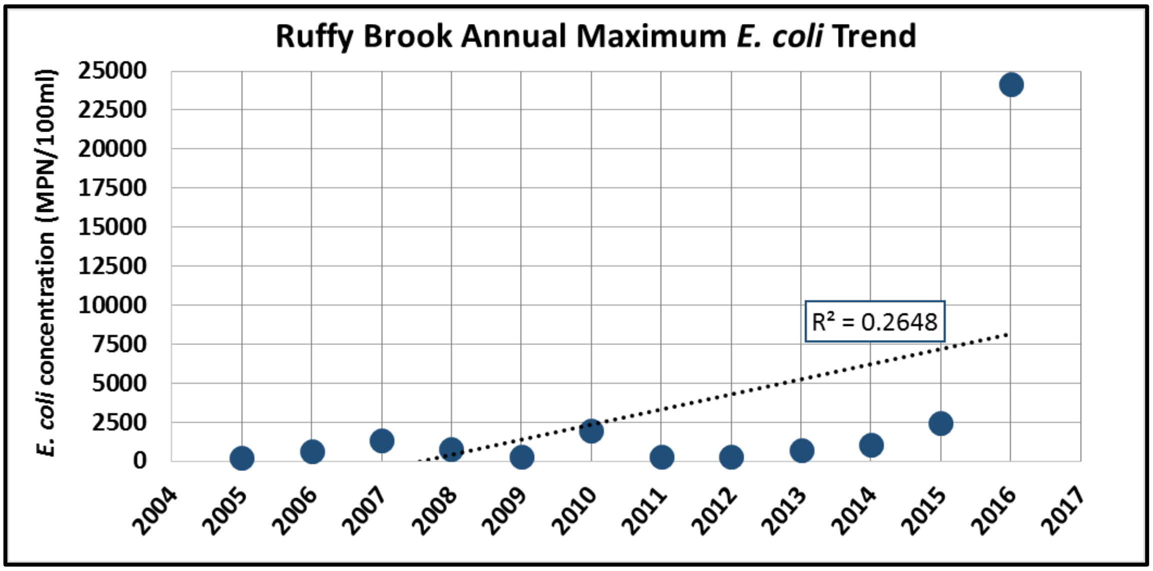


Figure 2-9. Time series of annual maximum *E. coli* concentrations in Ruffy Brook

Table 2-7. Detailed seasonal trend analysis results for Ruffy Brook (AUID 513)

Trends of Seasonal Averages Using Seasonal Mann-Kendall Analysis				
Ruffy Brook (S007-848, S008-057, S002-120)	**Total Suspended Solids**	**Dissolved Oxygen**	**Total Phosphorus**	***E. coli***
Years	1992-2016	1984-2016	1988-2016	2005-2016
Annual (All Months)	X	X	▲	X
Summer (May - Sept.)	△	△	△	X
April	▽	△	X	Data <10
May	X	▲	X	Data <10
June	△	X	X	Data <10
July	X	X	△	Data <10
August	X	X	△	Data <10
September	Data <10	Data <10	X	Data <10
October	X	X	X	Data <10

X = No Trend
▲= Strong Upward Trend (Getting Significantly Worse)
△= Upward Trend (Getting Worse)
▲= Strong Upward Trend (Getting Significantly Better)
△= Upward Trend (Getting Better)
▽= Downward Trend (Getting Better)

Water quality conditions seem to be improving, overall, near the pour point of Silver Creek (Table 2-8). The exceptions were a strong increasing trend in August TP concentrations and increasing annual average *E. coli* concentrations. The increasing August TP trend was influenced by high concentrations that were recorded in 2012 and 2013. More *E. coli* samples are needed to calculate seasonal trends using monthly averages.

The 159th Avenue crossing of Silver Creek (S000-712), west of Clearbrook, was first sampled during the Clearwater River DO and Fecal Coliform TMDL Study. The *E. coli* concentrations found at this station were some of the highest that had been found by the RLWD monitoring program, at that time. The site is located downstream of a livestock operation. The Clearwater SWCD helped a landowner implement a project to reduce runoff from pens near the farm's building site. However, cattle still have access to the stream in the pasture portion of the property and are often seen wading in the stream. There are additional *E. coli* sources within the Clear Brook drainage area and further upstream portions of Silver Creek that contribute to high *E. coli* concentrations at the S000-712 sampling site. The two lowest *E. coli* concentrations at this location were recently recorded in July and September of 2016. Despite the recently recorded low concentrations and the project that was implemented, no trends were found among the annual record of 12-month and summer average or maximum concentrations. Analysis of individual measurement data (not summarized by month or season) also failed to identify any trends. As of the 2016 sampling season, there was insufficient data (<10 years) to conduct Mann-Kendall trend analysis for any calendar months.

Table 2-8. Detailed seasonal trend analysis results for Silver Creek (AUID 527)

Trends of Seasonal Averages Using Seasonal Mann-Kendall Analysis				
Silver Creek Pour Point (S002-082, S001-020)	**Total Suspended Solids**	**Dissolved Oxygen**	**Total Phosphorus**	***E. coli***
Years	1985-2016	1984-2016	1984-2016	2005-2016
Annual (All Months)	**X**	**X**	**X**	$\color{red}\triangle$
Summer (May - Sept.)	**X**	$\color{green}\triangle$	**X**	**X**
April	**X**	$\color{green}\blacktriangle$	$\color{green}\triangledown$	Data <10
May	$\color{green}\triangledown$	$\color{green}\triangle$	$\color{green}\triangledown$	Data <10
June	**X**	**X**	**X**	Data <10
July	**X**	**X**	**X**	Data <10
August	**X**	$\color{green}\triangle$	$\color{red}\blacktriangle$	Data <10
September	**X**	**X**	**X**	Data <10
October	$\color{green}\triangledown$	**X**	**X**	Data <10
X = No Trend				
$\color{red}\blacktriangle$ = Strong Upward Trend (Getting Significantly Worse)				
$\color{red}\triangle$ = Upward Trend (Getting Worse)				
$\color{green}\blacktriangle$ = Strong Upward Trend (Getting Significantly Better)				
$\color{green}\triangle$ = Upward Trend (Getting Better)				
$\color{green}\triangledown$ = Downward Trend (Getting Better)				

The CSAH 10 crossing of the Clearwater River is located on the channelized portion of the river, downstream of the wild rice farms that line a portion of the Clearwater River. The Clearwater River Nonpoint Study identified wild rice operations as a source of pollution in the Clearwater River during the late-summer paddy drainage that occurs prior to harvest. A tile drainage study conducted by the RLWD confirmed that wild rice paddies discharge very high concentrations of sediment and other pollutants if they are drained with internal surface drainage ditches. The tile drainage study also found that the main-line tile drainage that has been installed within wild rice paddies discharges much cleaner water than paddies that have internal surface drainage ditches. The main-line tile also has many benefits for the farmers, especially when the main-line is directly connected to a control structure. Benefits to the farmer include, but are not limited to: more evenness of rice quality and maturity, less ditch maintenance, better and more controlled drainage, less sedimentation in the drainage ditches, fewer ruts during harvesting, and reduced loss of soil. Wild rice producers have also been mindful of the importance of water quality in the Clearwater River by working with LGUs to keep the river buffered and to support streambank stabilization projects. Concentrations of TSS, TP, and DO have all seen improvements (especially in the late summer months) (Table 2-9) due to the efforts that have been made by the wild rice producers, but some of the drainage continues to negatively impact water quality (Table 2-9).

Despite improving trends in water quality within the channelized reach, further improvement is needed due to multiple impairments. The 09020305-647 AUID of the Clearwater River (channelized portion between Ruffy Brook and JD1) is impaired by high concentrations of TSS and *E. coli*. Low DO levels have been regularly recorded, particularly in July and August. Despite reductions in pollutants from wild rice paddy drainage through changes in drainage methods, some of that discharge continues to negatively affect water quality in the river. Landowners and users of the river have complained about water quality during the wild rice paddy discharge. The difference in water quality, due to TSS concentrations, from upstream of the paddies to downstream is still very noticeable.

Table 2-9. Detailed seasonal trend analysis results for the Clearwater River at CSAH 10 (AUID 647)

Trends of Seasonal Averages Using Seasonal Mann-Kendall Analysis				
Clearwater River at CSAH 10 (S003-174)	**Total Suspended Solids**	**Dissolved Oxygen**	**Total Phosphorus**	***E. coli***
Years	1998-2016	1998-2016	1998-2016	2005-2016
Annual Avg (All Months)	▼	△	▽	Data <10
Annual Max (All Months)	▼	X	▼	Data <10
Annual Min (All Months)	X	▲	X	Data <10
Summer (May - Sept.)	▼	▲	▽	Data <10
April	Data <10	Data <10	Data <10	Data <10
May	X	Data <10	X	Data <10
June	▽	△	X	Data <10
July	▼	△	X	Data <10
August	X	△	▼	Data <10
September	▽	▲	X	Data <10
October	Data <10	Data <10	Data <10	Data <10

X = No Trend
▲ = Strong Upward Trend (Getting Significantly Better)
▼ = Strong Downward Trend (Getting Significantly Better)
△ = Upward Trend (Getting Better)
▽ = Downward Trend (Getting Better)

The CSAH 14 crossing of the Clearwater River (S001-461, Table 2-10) had been monitored (field measurements only) by the Clearbrook-Gonvick River Watch program since 1998, creating a long record of DO measurements at the site. Sampling recently resumed at the site when the RLWD moved its long-term monitoring site for that portion of the Clearwater River from the Clearwater Lake outlet to CSAH 14. The move better represents water quality in the river. The samples collected at the Clearwater Lake outlet were essentially samples of lake water. Water quality at CSAH 14 has been excellent in the samples that have been collected in recent years. Water has been exceptionally clear at this location. Analysis of the long-term record of DO measurements revealed that concentrations have been improving.

Table 2-10. Detailed seasonal trend analysis results for the Clearwater River at CSAH 14 (AUID 649)

Trends of Seasonal Averages Using Seasonal Mann-Kendall Analysis				
Clearwater River at CSAH 14 (S001-461)	**Total Suspended Solids**	**Dissolved Oxygen**	**Total Phosphorus**	***E. coli***
Years	2015-16	1998-2016	1998-02,15-16	2006, 15-16
Annual Avg (All Months)	Data <10	▲	Data <10	Data <10
Annual Max (All Months)	Data <10	X	Data <10	Data <10
Annual Min (All Months)	Data <10	▲	Data <10	Data <10
Summer (May - Sept.)	Data <10	▲	Data <10	Data <10
April	Data <10	Data <10	Data <10	Data <10
May	Data <10	Data <10	Data <10	Data <10
June	Data <10	Data <10	Data <10	Data <10
July	Data <10	Data <10	Data <10	Data <10
August	Data <10	Data <10	Data <10	Data <10
September	Data <10	Data <10	Data <10	Data <10
October	Data <10	Data <10	Data <10	Data <10
X = No Trend				
▲ = Strong Upward Trend (Getting Significantly Better)				

The available data from CSAH 14 indicated that water quality conditions downstream of Clearwater Lake could continue to improve as they had been improving at the Clearwater Lake outlet. Water leaving the lake was very clean. DO and TP concentrations have been improving (Table 2-11). Changes in *E. coli* and TSS concentrations were not as substantial because the concentrations have been minimal. The average *E. coli* concentration at S002-119 was 3.4 MPN/100ml. The average TSS concentration at S002-119 was 2.4 mg/L. Clearwater Lake (04-0343-00) also meets the state's water quality standards and TP concentrations are trending downward (Table 2-12).

The trends from basic water quality parameters were analyzed for the water flowing into Clearwater Lake and summarized in Table 2-13. Water quality monitoring data has been collected upstream of the lake at the CSAH 24 (S001-460) crossing of the Clearwater River for long-term and intensive water quality sampling efforts. Significant water quality problems were noted in the 1990s. High concentrations of nutrients and other pollutants (overflows from the Bagley WWTF) were found in the Clearwater River during the floods of 1997. Clearwater Lake subsequently experienced eutrophication problems after that influx of nutrients. Since then, milestones have been reached for the improvement of water quality. An *E. coli* impairment was delisted in 2006 and an ammonia impairment was delisted in 2018. Data indicates that DO, TP, and *E. coli* near the inlet to Clearwater Lake have been improving.

Table 2-11. Detailed seasonal trend analysis results for the Clearwater River at CSAH 4 (AUID 649)

Trends of Seasonal Averages Using Seasonal Mann-Kendall Analysis				
Clearwater Lake Outlet (S001-119)	**Total Suspended Solids**	**Dissolved Oxygen**	**Total Phosphorus**	***E. coli***
Years	1998-2016	1998-2016	1998-2016	1992-2016
Annual Avg (All Months)	X	△	▼	X
Annual Max (All Months)	X	△	▼	▽
Annual Min (All Months)	X	△	▼	X
May - September Avg.	X	△	▼	X
April	Data <10	△	X	Data <10
May	Data <10	△	X	Data <10
June	▽	X	▽	Data <10
July	Data <10	Data <10	X	Data <10
August	X	X	▼	Data <10
September	Data <10	Data <10	Data <10	Data <10
October	X	X	▽	Data <10
X = No Trend				
▲ = Strong Upward Trend (Getting Significantly Better)				
▼ = Strong Downward Trend (Getting Significantly Better)				
△ = Upward Trend (Getting Better)				
▽ = Downward Trend (Getting Better)				

Table 2-12. Detailed seasonal trend analysis results for Clearwater Lake (04-0343-00)

Trends of Seasonal Averages Using Seasonal Mann-Kendall Analysis				
Clearwater Lake (04-0343-00)	**Chlorophyll-a**	**Secchi Depth**	**Total Phosphorus**	**Trophic State**
Years	1992-2015	1987-2015	1998-2015	1992-2015
Annual Avg (All Months)	X	X	▼	X
Annual Max (All Months)	X	X	▼	▽
Annual Min (All Months)	X	X	X	X
May - September Avg.	X	X	▽	X
April	X	X	Data <10	Data <10
May	Data <10	Data <10	X	X
June	X	X	X	△
July	X	X	X	X
August	X	X	X	X
September	X	X	▽	X
October	Data <10	X	Data <10	Data <10
X = No Trend				
△ = Upward Trend (Getting Worse)				
▼ = Strong Downward Trend (Getting Significantly Better)				
▽ = Downward Trend (Getting Better)				

Table 2-13. Detailed seasonal trend analysis results for the Clearwater River at CSAH 24 (AUID 653)

Trends of Seasonal Averages Using Seasonal Mann-Kendall Analysis				
Clearwater Lake Inlet (S001-911, S001-460, S006-909)	**Total Suspended Solids**	**Dissolved Oxygen**	**Total Phosphorus**	***E. coli***
Years	1998-2016	1998-2016	1998-2016	1992-2016
Annual Avg (All Months)	X	△	▼	X
Annual Max (All Months)	X	▲	▽	▽
Annual Min (All Months)	X	X	X	X
May - September Avg.	X	▲	▽	X
April	Data <10	X	X	Data <10
May	X	▲	X	Data <10
June	X	△	▽	Data <10
July	Data <10	△	X	Data <10
August	X	▲	▼	Data <10
September	Data <10	△	▼	Data <10
October	X	X	X	Data <10
X = No Trend				
▲ = Strong Upward Trend (Getting Significantly Better)				
▼ = Strong Downward Trend (Getting Significantly Better)				
△ = Upward Trend (Getting Better)				
▽ = Downward Trend (Getting Better)				

The water in the headwaters of the Clearwater River has generally been very clean. Long-term water quality monitoring stations have been sampled upstream and downstream of Bagley. The station downstream of Bagley was changed from the U.S. Highway 2 crossing (S001-906) to the CSAH 2 crossing (S001-908), which was closer to the AUID pour point and was safer to sample. The overall historical average TSS concentration at the Hwy 2 crossing of the Clearwater River (Table 2-14) was only 3.1 mg/L. There will be limited room for improvement upon current TSS concentrations. However, DO concentrations have been showing a downward trend during June sampling events. Similar results were found in the Clearwater River at CSAH 25 (S001-458) (Table 2-15), upstream of the city of Bagley. The maximum TSS concentration at that location was just 14 mg/L. The average TSS concentration has been 2.4 mg/L. For reference, the minimum reporting limit for TSS at RMB Environmental Laboratories (where samples from this location are analyzed) was 1 mg/L. Low DO concentrations continue to occur in the warm summer months of June through September. The overall trends that were found in DO data (increasing) and TP data (decreasing) offer hope for improvement.

Table 2-14. Detailed seasonal trend analysis results for the Clearwater River at CSAH 2 (AUID 517)

Trends of Seasonal Averages Using Seasonal Mann-Kendall Analysis				
Clearwater River at Highway 2 (S001-906)	**Total Suspended Solids**	**Dissolved Oxygen**	**Total Phosphorus**	***E. coli***
Years	1992-2015	1987-2015	1998-2015	1992-2015
Annual Avg (All Months)	**X**	$\color{green}\triangle$	$\color{green}\blacktriangledown$	**X**
Annual Max (All Months)	**X**	$\color{green}\triangle$	$\color{green}\blacktriangledown$	**X**
Annual Min (All Months)	**X**	**X**	$\color{green}\triangledown$	$\color{green}\triangledown$
May - September Avg.	**X**	$\color{green}\triangle$	$\color{green}\triangledown$	**X**
April	**X**	$\color{green}\triangle$	**X**	Data <10
May	Data <10	Data <10	Data <10	Data <10
June	**X**	$\color{red}\triangledown$	**X**	Data <10
July	**X**	**X**	$\color{red}\triangle$	Data <10
August	**X**	**X**	**X**	Data <10
September	Data <10	Data <10	**X**	Data <10
October	$\color{green}\blacktriangledown$	**X**	**X**	Data <10

X = No Trend
$\color{red}\triangle$ = Upward Trend (Getting Worse)
$\color{red}\triangledown$ = Downward Trend (Getting Worse)
$\color{green}\blacktriangledown$ = Strong Downward Trend (Getting Significantly Better)
$\color{green}\triangle$ = Upward Trend (Getting Better)
$\color{green}\triangledown$ = Downward Trend (Getting Better)

Table 2-15. Detailed seasonal trend analysis results for the Clearwater River at CSAH 25 (AUID 517)

Trends of Seasonal Averages Using Seasonal Mann-Kendall Analysis				
Clearwater River at CSAH 25 (S001-458)	**Total Suspended Solids**	**Dissolved Oxygen**	**Total Phosphorus**	***E. coli***
Years	1992-2016	1992-2016	1987-2016	2005-2016
Annual Avg (All Months)	**X**	$\color{green}\triangle$	$\color{green}\blacktriangledown$	**X**
Annual Max (All Months)	**X**	$\color{green}\triangle$	$\color{green}\blacktriangledown$	**X**
Annual Min (All Months)	**X**	$\color{green}\triangle$	**X**	$\color{green}\blacktriangledown$
May - September Avg.	**X**	**X**	$\color{green}\blacktriangledown$	**X**
April	**X**	**X**	**X**	Data <10
May	$\color{red}\triangle$	$\color{green}\triangle$	$\color{green}\triangledown$	Data <10
June	**X**	**X**	$\color{green}\blacktriangledown$	Data <10
July	**X**	**X**	**X**	Data <10
August	**X**	**X**	**X**	Data <10
September	**X**	**X**	$\color{green}\triangledown$	Data <10
October	$\color{green}\blacktriangledown$	$\color{red}\triangledown$	**X**	Data <10

X = No Trend
$\color{red}\triangle$ = Upward Trend (Getting Worse)
$\color{red}\triangledown$ = Downward Trend (Getting Worse)
$\color{green}\blacktriangledown$ = Strong Downward Trend (Getting Significantly Better)
$\color{green}\triangle$ = Upward Trend (Getting Better)
$\color{green}\triangledown$ = Downward Trend (Getting Better)

Water quality conditions within Maple Lake (60-0305-00) have shown statistical improvement since monitoring began in the 1980s and early 1990s, as shown in Table 2-16. There is still room for improvement. The maximum depth within Maple Lake (listed at 14 feet on the MPCA's website) is close to the threshold that differentiates shallow lakes from other lakes for assessment purposes. Maple Lake is highly developed, and is heavily used for aquatic recreation. There is a local desire for water quality improvements that will lessen the intensity of algae blooms and maintain adequate water quality for aquatic recreation. Though the 10-year average for Secchi depth meets the 1-meter standard, more than one third (38%, 8 out of 21 years) of the years in the lake's monitoring history have had summer average Secchi depths that were less than 1 meter. Summer average TP concentrations have always been lower than the 60 mg/L impairment threshold. Summer average chl-*a* exceeded the 20 mg/L standard just once, during the summer of 1991. If the more stringent aquatic recreation standards for deeper lakes (<40 µg/L TP, <14 µg/L chl-a, >1.4 m Secchi depth) were applied as local goals, the lake would barely meet standards due to TP concentrations that currently meet expectations in 2006 through 2015 data. As recent as the 2004 through 2013 10-year period, the summer average values for TP (41 µg/L), chl-*a* (14.49 µg/L), and Secchi depth (1.16 m) all failed to meet the standards for lakes that are more than fifteen feet deep. Summer average Secchi depths currently fall short of the >1.4 m goal for deeper lakes. The more stringent standards for deeper lakes do not officially apply to Maple Lake but may serve as targets for local water quality protection efforts.

Table 2-16. Detailed seasonal trend analysis results for Maple Lake (60-0305-00)

Trends of Seasonal Averages Using Seasonal Mann-Kendall Analysis				
Maple Lake (60-0305-00, all sites)	**Chlorophyll-a**	**Secchi Depth**	**Total Phosphorus**	**Trophic State**
Years	1989-2016	1989-2016	1992-2016	1989-2016
Annual Avg (All Months)	X	△	▽	▽
Annual Max (All Months)	X	X	▽	X
Annual Min (All Months)	X	△	X	▽
May - September Avg.	▽	△	▽	X
April	X	Data <10	Data <10	Data <10
May	Data <10	X	Data <10	X
June	Data <10	△	Data <10	X
July	Data <10	▲	X	▽
August	X	X	X	X
September	Data <10	△	Data <10	▽
October	Data <10	X	Data <10	Data <10
X = No Trend				
▲ = Strong Upward Trend (Getting Significantly Better)				
△ = Upward Trend (Getting Better)				
▽ = Downward Trend (Getting Better)				

Two significant trends in water quality conditions were found at the outlet of Maple Lake (S002-130, Table 2-17). There was good news that that TP concentrations had been trending downward. However, *E. coli* concentrations had been trending upward. Exceedances of the chronic *E. coli* standard have become more common in recent years. One possible explanation is that waterfowl in the pond between the lake and the sampling site could be contributing to the *E. coli* problem. Samples were collected at the outlet structure on the lake (5.2 MPN/100ml) and at CSAH 10 (124.6 MPN/100ml) to bracket the wetland area and a significant upstream-to-downstream increase was discovered. The investigative samples indicated that the *E. coli* was not coming from the lake but seemed to be coming from the wetland between the lake and the monitoring station.

Table 2-17. Detailed seasonal trend analysis results for Polk CD 14 near the Maple Lake outlet (AUID 523)

Seasonal Water Quality Trends from Seasonal Mann-Kendall Analysis				
Maple Lake Outlet (S002-130)	**Total Suspended Solids**	**Dissolved Oxygen**	**Total Phosphorus**	***E. coli***
Years	1992-2016	1992-2016	1984-2016	2004-2016
Annual Avg (All Months)	X	X	▽	▲
Annual Max (All Months)	X	X	X	▲
Annual Min (All Months)	△	X	X	X
May - September Avg.	X	X	▽	△
April	Data <10	X	▽	Data <10
May	Data <10	X	X	Data <10
June	▽	X	X	Data <10
July	X	X	▽	Data <10
August	X	X	X	Data <10
September	Data <10	X	X	Data <10
October	X	X	▽	Data <10

X = No Trend
▲= Strong Upward Trend (Getting Significantly Worse)
△= Upward Trend (Getting Worse)
▽= Downward Trend (Getting Better)

Although TP concentrations may be improving during the late fall at the inlet to Maple Lake, the trends identified for DO, *E. coli*, and TSS are decreasing or getting worse (Table 2-18).

Table 2-18. Detailed seasonal trend analysis results for JD 73 near the Maple Lake inlet (AUID 549)

Seasonal Water Quality Trends from Seasonal Mann-Kendall Analysis				
Maple Lake Inlet (S002-075)	**Total Suspended Solids**	**Dissolved Oxygen**	**Total Phosphorus**	***E. coli***
Years	1994-2016	1991-2016	1989-2016	2005-2016
Annual Avg (All Months)	X	X	X	△
Annual Max (All Months)	△	X	X	X
Annual Min (All Months)	X	X	X	X
May - September Avg.	X	X	X	△
April	Data <10	X	X	Data <10
May	Data <10	▽	X	Data <10
June	X	X	X	Data <10
July	X	▽	X	Data <10
August	X	X	▽	Data <10
September	X	X	▼	Data <10
October	X	▽	X	Data <10

X = No Trend
△= Upward Trend (Getting Worse)
▽= Downward Trend (Getting Worse)
▼= Strong Downward Trend (Getting Significantly Better)
▽= Downward Trend (Getting Better)

The Win-E-Mac River Watch program and the RLWD have monitored the inlet and outlet of Badger Lake (Tables 2-19 and 2-20) for more than 10 years. A significant portion of that data was limited to field measurements (like DO). At the inlet to Badger Lake (S002-129), DO concentrations have been improving (Table 2-19). The outlet of Badger Lake is a channel that flows from Badger Lake to Mitchell Lake that was constructed for the Poplar River Diversion Project. The samples are collected at the Hwy 2 crossing of that channel (S002-131). Data shows that it has a decreasing trend in TP concentrations, but TSS concentrations had been increasing (Table 2-20).

Table 2-19. Detailed seasonal trend analysis results for the Poplar River Diversion at the inlet to Badger Lake (AUID 543)

Seasonal Water Quality Trends from Seasonal Mann-Kendall Analysis				
Poplar R. Diversion at the Badger Lake Inlet (S002-129)	**Total Suspended Solids**	**Dissolved Oxygen**	**Total Phosphorus**	***E. coli***
Years	1994-2015	1991-2016	1991-2015	2004-2015
Annual Avg (All Months)	X	△	X	Data <10
Annual Max (All Months)	X	▲	X	Data <10
Annual Min (All Months)	X	X	X	Data <10
May - September Avg.	X	△	X	Data <10
April	Data <10	X	Data <10	Data <10
May	Data <10	△	Data <10	Data <10
June	Data <10	X	Data <10	Data <10
July	Data <10	X	Data <10	Data <10
August	Data <10	X	Data <10	Data <10
September	Data <10	△	Data <10	Data <10
October	Data <10	X	Data <10	Data <10

X = No Trend
▲= Strong Upward Trend (Getting Significantly Better)
△= Upward Trend (Getting Better)

Table 2-20. Detailed seasonal trend analysis results for the Badger-Mitchell Lake channel (AUID 542)

Seasonal Water Quality Trends from Seasonal Mann-Kendall Analysis				
Badger-Mitchell Lake Channel (S002-131)	**Total Suspended Solids**	**Dissolved Oxygen**	**Total Phosphorus**	***E. coli***
Years	1994-2015	1984-2016	1984-2015	2005-2015
Annual Avg (All Months)	△	X	▼	Data <10
Annual Max (All Months)	△	X	▼	Data <10
Annual Min (All Months)	X	X	▼	Data <10
May - September Avg.	△	X	▼	Data <10
April	Data <10	X	▽	Data <10
May	Data <10	X	Data <10	Data <10
June	Data <10	X	Data <10	Data <10
July	Data <10	X	▽	Data <10
August	Data <10	▽	Data <10	Data <10
September	Data <10	△	Data <10	Data <10
October	Data <10	X	X	Data <10

X = No Trend
△= Upward Trend (Getting Worse)
▽= Downward Trend (Getting Worse)
▼= Strong Downward Trend (Getting Significantly Better)
△= Upward Trend (Getting Better)

Bee Lake is a small lake located within the eastern drainage area of Maple Lake, approximately one mile west of Cameron Lake and the city of Erskine. Water quality has been monitored at the inlet (Station

S002-086 on AUID 541) and outlet (S003-317 AUID 551) of Bee Lake, mostly through volunteer monitoring by the Win-E-Mac River Watch program. Although there were too few years of sampling data from either station to calculate trends for pollutants like TP, TSS, or *E. coli*, sufficient field measurements have been collected for some trend analysis of DO and transparency. The inlet to Bee Lake (AUID 541) had been listed as impaired by low DO on past impaired waters lists (2006 through 2016) until the reach was recategorized from EPA category 5 to category 3 for the 2018 303(d) List of Impaired Waters. Annual average and annual minimum DO concentrations at the Bee Lake Inlet showed increasing (improving) trends in data collected from 1991 through 2016. Reduced transparency levels (Secchi tube and transparency tube data) have been found at times and there were decreasing (getting worse) trends in annual average and annual minimum transparency levels. Different results were found at the outlet of Bee Lake (Station S003-317 on AUID 551). Downward (worsening) trends in DO concentrations were identified along the Bee Lake outlet in three seasonal categories: annual minimum, May through September average, and the month of October. Transparency data from the outlet of Bee Lake did not show any significant trends.

In the DO-impaired AUID 518, DO concentrations have been improving at both long-term monitoring stations S003-127 and S002-091 (Tables 2-21 and 2-22). However, TP concentrations have been increasing at station S002-091.

Table 2-21. Detailed seasonal trend analysis results for the Poplar River at CSAH 30 (AUID 518)

Seasonal Water Quality Trends from Seasonal Mann-Kendall Analysis				
Poplar River at CSAH 30 (S003-127)	**Total Suspended Solids**	**Dissolved Oxygen**	**Total Phosphorus**	***E. coli***
Years	2002-2016	2001-2016	2001-2016	2007-2016
Annual Avg (All Months)	Data <10	X	Data <10	Data <10
Annual Max (All Months)	Data <10	△	Data <10	Data <10
Annual Min (All Months)	Data <10	X	Data <10	Data <10
May - September Avg.	Data <10	X	Data <10	Data <10
April	Data <10	Data <10	Data <10	Data <10
May	Data <10	Data <10	Data <10	Data <10
June	Data <10	X	Data <10	Data <10
July	Data <10	Data <10	Data <10	Data <10
August	Data <10	Data <10	Data <10	Data <10
September	Data <10	Data <10	Data <10	Data <10
October	Data <10	Data <10	Data <10	Data <10
X = No Trend				
△ = Upward Trend (Getting Better)				

Table 2-22. Detailed seasonal trend analysis results for the Poplar River at 315th Street Southeast (AUID 518)

Seasonal Water Quality Trends from Seasonal Mann-Kendall Analysis				
Poplar River at 315th St. SE (S002-091)	**Total Suspended Solids**	**Dissolved Oxygen**	**Total Phosphorus**	***E. coli***
Years	1994-2015	1991-2016	1984-2016	2005-2015
Annual Avg (All Months)	X	△	X	X
Annual Max (All Months)	X	△	X	X
Annual Min (All Months)	X	△	△	X
May - September Avg.	X	△	△	X
April	△	△	△	Data <10
May	Data <10	Data <10	Data <10	Data <10
June	X	X	X	Data <10
July	X	X	△	Data <10
August	X	X	▲	Data <10
September	Data <10	Data <10	Data <10	Data <10
October	X	X	X	Data <10
X = No Trend				
▲ = Strong Upward Trend (Getting Significantly Worse)				
△ = Upward Trend (Getting Worse)				
△ = Upward Trend (Getting Better)				

The lower reach of the Poplar River has shown increasing trends in *E. coli* and TP concentrations while DO levels have been improving (Table 2-23). The increasing *E. coli* concentrations could be influenced by some cattle operations near the river. There are some TSS and TP sources between station S002-117 (upstream sampling location) and S007-608 (downstream sampling location). Though average TP concentrations were lower in the 2013 - 2015 data at S007-608 than it was in the 2006 - 2012 data from S002-117, average TSS concentrations have been higher at sampling location S007-608. Neither station has recorded exceedances of the 30 mg/L TSS standard, but the S007-608 sampling location has more frequently (five samples, 20%) exceeded 15 mg/L TSS than the upstream S002-117 station (one sample, 4.5%). There are notable erosion problems between the two stations that could be contributing to the higher average TSS concentrations at the downstream monitoring station.

Table 2-23. Detailed seasonal trend analysis results for the Poplar River near its pour point (AUID 504)

Seasonal Water Quality Trends from Seasonal Mann-Kendall Analysis				
Poplar River near the Pour Point (S002-117 & S007-608)	**Total Suspended Solids**	**Dissolved Oxygen**	**Total Phosphorus**	***E. coli***
Years	1988-2016	1991-2016	1988-2016	1992-2016
Annual Avg (All Months)	X	X	▲	△
Annual Max (All Months)	X	▲	△	▲
Annual Min (All Months)	X	X	△	▲
May - September Avg.	X	△	▲	△
April	▽	△	▲	Data <10
May	X	X	△	X
June	X	X	▲	Data <10
July	X	X	X	Data <10
August	X	X	△	X
September	X	Data <10	X	Data <10
October	X	X	X	Data <10

X = No Trend
▲ = Strong Upward Trend (Getting Significantly Worse)
▲ = Strong Upward Trend (Getting Significantly Better)
△ = Upward Trend (Getting Better)
▽ = Downward Trend (Getting Better)

Some positive seasonal trends for TSS and DO were discovered in data from the furthest downstream crossing of the Hill River (Table 2-24). *E. coli* concentrations have been reaching increasingly higher annual maximum concentrations.

Table 2-24. Detailed seasonal trend analysis results for the Hill River at CR 119 (AUID 539)

Seasonal Water Quality Trends from Seasonal Mann-Kendall Analysis				
Hill River at CR 119 (S002-134)	**Total Suspended Solids**	**Dissolved Oxygen**	**Total Phosphorus**	***E. coli***
Years	1992-2016	1992-2016	1992-2016	2007-2016
Annual Avg (All Months)	▽	X	X	X
Annual Max (All Months)	X	X	X	△
Annual Min (All Months)	X	△	X	▽
May - September Avg.	▽	X	X	X
April	Data <10	X	Data <10	Data <10
May	▽	△	X	Data <10
June	X	X	X	Data <10
July	X	X	X	Data <10
August	▽	X	X	Data <10
September	Data <10	X	Data <10	Data <10
October	X	x	X	Data <10

X = No Trend
△ = Upward Trend (Getting Worse)
△ = Upward Trend (Getting Better)
▽ = Downward Trend (Getting Better)

Trend analysis of the furthest downstream, long-term monitoring site (S002-133) on the Lost River provided some good news about water quality in the river (Table 2-25). This site is located near the downstream end of AUID 09020305-646. DO concentrations have been improving in multiple seasonal categories (annual maximum, May through September average, May, and July). The reach meets water quality standards for all of the parameters that were examined. The TSS values for annual minimums and October averages were all at or near the laboratory's minimum reporting limit of 1 mg/L.

Table 2-25. Detailed seasonal trend analysis results for the Lost River at CR 119 (AUID 646)

Seasonal Water Quality Trends from Seasonal Mann-Kendall Analysis				
Lost River at CR 119 (S002-133)	**Total Suspended Solids**	**Dissolved Oxygen**	**Total Phosphorus**	***E. coli***
Years	2002-2016	2001-2016	2001-2016	2005-2016
Annual Avg (All Months)	**X**	**X**	**X**	**X**
Annual Max (All Months)	**X**	▲	**X**	**X**
Annual Min (All Months)	**X**	**X**	**X**	**X**
May - September Avg.	**X**	△	**X**	**X**
April	Data <10	**X**	Data <10	Data <10
May	Data <10	△	Data <10	Data <10
June	Data <10	**X**	Data <10	Data <10
July	Data <10	△	Data <10	Data <10
August	Data <10	**X**	Data <10	Data <10
September	Data <10	**X**	Data <10	Data <10
October	**X**	**X**	Data <10	Data <10
X = No Trend				
▲= Strong Upward Trend (Getting Significantly Better)				
△= Upward Trend (Getting Better)				

The S002-131 monitoring site at the CSAH 5 crossing in Oklee has been an important long-term monitoring site and is also the location of a USGS gaging station. Every trend in water quality conditions in the Lost River in Oklee has shown improvement for each of the parameters that were examined (Table 2-26). The river was formerly listed as impaired by fecal coliform. Intensive sampling of *E. coli* was completed during a previous TMDL study to achieve minimum data requirements for *E. coli* (*E. coli* sampling began in 2005). That sampling effort found that the river was meeting water quality standards for aquatic recreation.

Table 2-26. Detailed seasonal trend analysis results for the Lost River at Oklee (AUID 646)

Seasonal Water Quality Trends from Seasonal Mann-Kendall Analysis				
Lost River at Oklee (S001-131)	**Total Suspended Solids**	**Dissolved Oxygen**	**Total Phosphorus**	***E. coli***
Years	2002-2016	2001-2016	2001-2016	2005-2016
Annual Avg (All Months)	▼	▲	▼	X
Annual Max (All Months)	▽	▲	▼	▽
Annual Min (All Months)	▽	X	▼	X
May - September Avg.	▽	△	▼	X
April	▽	X	▽	Data <10
May	Data <10	X	X	Data <10
June	X	X	X	Data <10
July	▽	X	▽	Data <10
August	▼	X	▽	Data <10
September	Data <10	△	▼	Data <10
October	▼	X	X	Data <10

X = No Trend

▲ = Strong Upward Trend (Getting Significantly Better)

▼ = Strong Downward Trend (Getting Significantly Better)

△ = Upward Trend (Getting Better)

▽ = Downward Trend (Getting Better)

The RLWD has been sampling *E. coli* at the 159th Avenue crossing of Silver Creek (S000-712) since 2007. The station is located west of Clearbrook and less than half of a mile downstream of the Clear Brook confluence. Projects have been implemented to help reduce the impact of livestock operations. However, the trend analysis for *E. coli* concentrations at that site yielded no trends, so there has not been a statistically significant improvement in *E. coli* concentrations. *E. coli* was the only parameter for which there was sufficient data for analysis.

E. coli concentrations in Clear Brook have been improving (Table 2-27), but one more year of data is needed to have 10 data points needed for the Mann-Kendall trend analysis. DO concentrations have been improving and annual TSS concentrations have been decreasing (for the most part). Summer TSS concentrations (storm event runoff) have been increasing. A stormwater pond has recently been constructed within Clearbrook to treat some stormwater runoff from the town.

Table 2-27. Detailed seasonal trend analysis results for Clear Brook (AUID 526)

Seasonal Water Quality Trends from Seasonal Mann-Kendall Analysis				
Clear Brook at CSAH 92 (S004-044)	**Total Suspended Solids**	**Dissolved Oxygen**	**Total Phosphorus**	***E. coli***
Years	2004-2016	2004-2016	2004-2016	2007-2016
Annual Avg (All Months)	▽	△	**X**	Data <10
Annual Max (All Months)	▼	△	**X**	Data <10
Annual Min (All Months)	▽	**X**	**X**	Data <10
May - September Avg.	△	▲	**X**	Data <10
April	Data <10	Data <10	Data <10	Data <10
May	Data <10	Data <10	Data <10	Data <10
June	Data <10	Data <10	Data <10	Data <10
July	Data <10	Data <10	Data <10	Data <10
August	Data <10	Data <10	Data <10	Data <10
September	Data <10	Data <10	Data <10	Data <10
October	Data <10	Data <10	Data <10	Data <10

X = No Trend
△ = Upward Trend (Getting Worse)
▲ = Strong Upward Trend (Getting Significantly Better)
▼ = Strong Downward Trend (Getting Significantly Better)
△ = Upward Trend (Getting Better)
▽ = Downward Trend (Getting Better)

Very strong downward trends in TP were found during trend analysis for the Lost River near the outlet of Pine Lake (S001-007, Table 2-28). The strong statistical trends that were found in analysis of the entire historical record were influenced by very high TP concentrations that were recorded in the 1980s. An average concentration of exactly 1 mg/L was recorded for three consecutive years (1985, 1986, and 1987), which raised suspicions about the quality of that historical data. Therefore, the time frame of TP analysis was changed from 1984 through 2016 to 1990 through 2016. The trends became less significant in the 1990 through 2016 data. Water quality conditions in Pine Lake could have influenced TP concentrations in this part of the Lost River. The 1980s water quality data for DO also could also not be verified. As a result, the trend analysis for DO was limited to data from 1992 through 2016.

Table 2-28. Detailed seasonal trend analysis results for the Lost River near the Pine Lake outlet (AUID 512)

Seasonal Water Quality Trends from Seasonal Mann-Kendall Analysis				
Lost River near the Pine Lake Outlet (S001-007)	Total Suspended Solids	Dissolved Oxygen	Total Phosphorus	*E. coli*
Years	1994-2016	1992-2016	1990-2016	1992-2016
Annual Avg (All Months)	X	X	X	Data <10
Annual Max (All Months)	△	X	X	Data <10
Annual Min (All Months)	X	X	▽	Data <10
May - September Avg.	X	X	▽	Data <10
April	Data <10	Data <10	Data <10	Data <10
May	Data <10	X	Data <10	Data <10
June	Data <10	X	Data <10	Data <10
July	Data <10	X	Data <10	Data <10
August	Data <10	Data <10	Data <10	Data <10
September	Data <10	Data <10	Data <10	Data <10
October	X	X	X	Data <10
X = No Trend				
△ = Upward Trend (Getting Worse)				
▽ = Downward Trend (Getting Better)				

There were few trends identified in the Lost River near the inlet to Pine Lake (S002-087 and S005-283). Conflicting trends were identified in separate categories for DO and *E. coli* (Table 2-29).

Table 2-29. Detailed seasonal trend analysis results for the Lost River near the Pine Lake inlet (AUID 529)

Seasonal Water Quality Trends from Seasonal Mann-Kendall Analysis				
Lost River near the Pine Lake Inlet (S002-087 & S005-283)	Total Suspended Solids	Dissolved Oxygen	Total Phosphorus	*E. coli*
Years	1994-2016	1992-2016	1992-2016	2005-2016
Annual Avg (All Months)	X	X	X	X
Annual Max (All Months)	X	▲	X	△
Annual Min (All Months)	X	X	X	▽
May - September Avg.	X	X	▽	Data <10
April	Data <10	X	Data <10	Data <10
May	Data <10	X	Data <10	Data <10
June	X	▽	X	Data <10
July	X	X	X	Data <10
August	Data <10	▽	Data <10	Data <10
September	Data <10	X	Data <10	Data <10
October	X	X	X	Data <10
X = No Trend				
△ = Upward Trend (Getting Worse)				
▽ = Downward Trend (Getting Worse)				
▲ = Strong Upward Trend (Getting Significantly Better)				
▽ = Downward Trend (Getting Better)				

The only parameter for Walker Brook that had enough data for analysis was DO. Downward trends were identified in DO levels (S002-122, Table 2-30). Although DO levels above 5 mg/L are found in April and October when water temperatures were low (Figure 2-10), summer DO measurements in Walker Brook have been consistently lower than 5 mg/L.

Table 2-30. Detailed seasonal trend analysis results for Walker Brook (AUID 509)

Seasonal Water Quality Trends from Seasonal Mann-Kendall Analysis				
Walker Brook at CSAH 19 (S002-122)	Total Suspended Solids	Dissolved Oxygen	Total Phosphorus	*E. coli*
Years	1992-2002	1992-2016	1998-2008	1992, 2016
Annual Avg (All Months)	Data <10	▼	Data <10	Data <10
Annual Max (All Months)	Data <10	▽	Data <10	Data <10
Annual Min (All Months)	Data <10	▽	Data <10	Data <10
May - September Avg.	Data <10	▼	Data <10	Data <10
April	Data <10	▽	Data <10	Data <10
May	Data <10	X	Data <10	Data <10
June	Data <10	▼	Data <10	Data <10
July	Data <10	▽	Data <10	Data <10
August	Data <10	▽	Data <10	Data <10
September	Data <10	▽	Data <10	Data <10
October	Data <10	X	Data <10	Data <10
X = No Trend				
▼ = Strong Downward Trend (Getting Significantly Worse)				
▽ = Downward Trend (Getting Worse)				

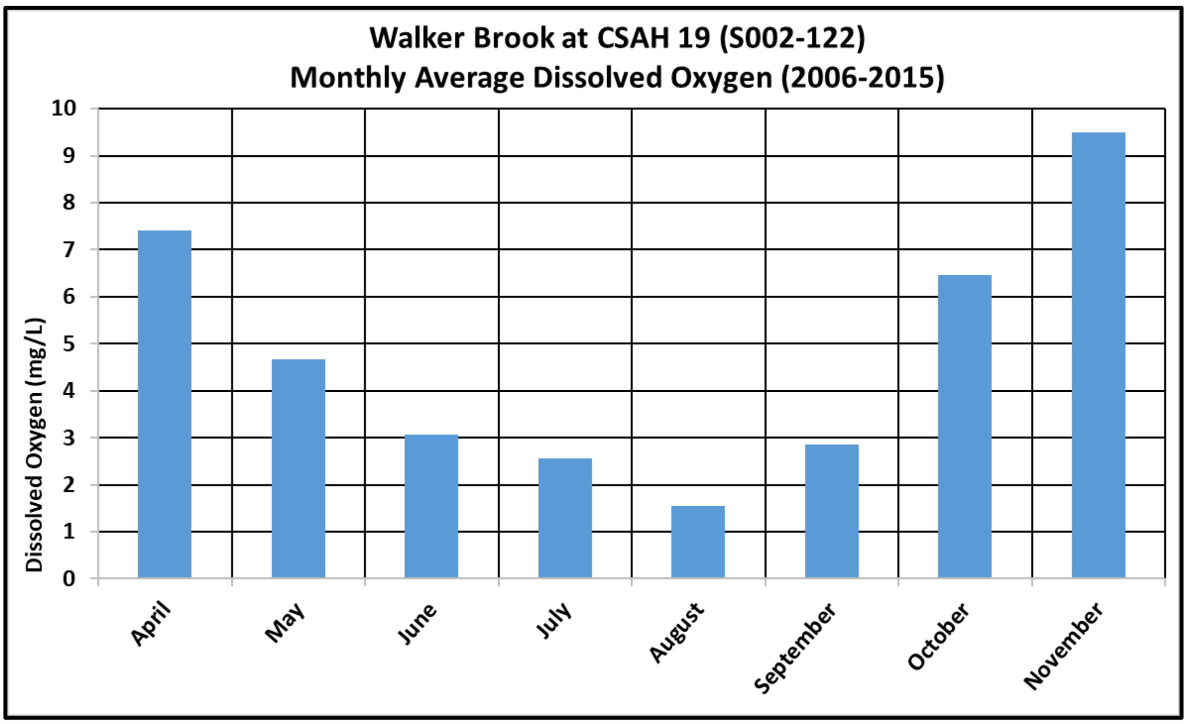


Figure 2-10. Monthly average DO concentrations in Walker Brook

2.3 Stressors and Sources

In order to develop appropriate strategies for restoring or protecting waterbodies, the stressors and/or sources impacting or threatening them must be identified and evaluated. Biological SID evaluated pollutant and non-pollutant factors that were potentially limiting aquatic life (e.g. altered hydrology, fish passage, habitat) in streams with either fish or macroinvertebrate biota impairments. Pollutant source assessments are done for the typical pollutant impairment listings and for waters for which a biological SID process identifies a pollutant as a stressor.

Nonpoint sources of pollution were the dominant source of pollutants in the watershed. Current knowledge of nonpoint pollutant sources for impaired reaches and reaches in need of protection (nearly impaired streams) is shown in Table 2-32. Much of the investigation of pollutant sources during the WRAPS process focused on impaired waters that are in need of restoration. There are some high-quality streams and lakes where sources of pollutants have been identified as part of this WRAPS process and in previous studies, due to the local importance of the waterbody, past impairments, or special resource concerns (trout streams). A column is included in the table to indicate locations where further investigation of pollutant sources is necessary.

The WWTFs that discharge into the Clearwater River and its tributaries are listed in Table 2-31. Figure 2-11 displays the relatively small amount of pollution that is contributed by point source WWTFs to the Clearwater River. The TSS pie chart in Figure 2-11 was created by using permitted discharge calculations for the Plummer WWTF and total sediment loads that were estimated by HSPF. The charts were created with average annual source load figures from the entire watershed that were estimated by the 1996 through 2016 HSPF model.

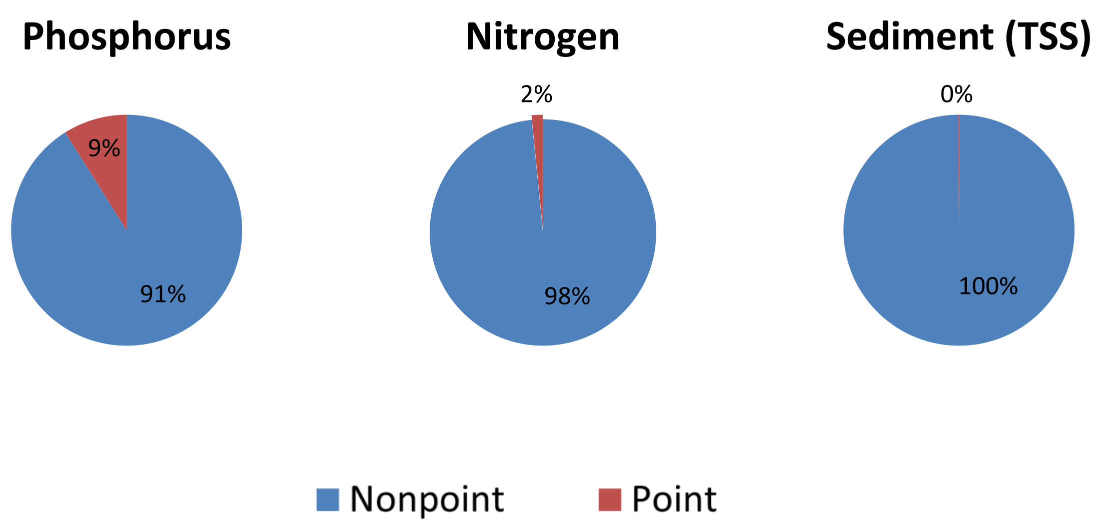


Figure 2-11. Overall breakdown of nonpoint source vs. point source pollution in Clearwater River Watershed.

Table 2-31: Point Sources in the Clearwater River Watershed

HUC-10 Subwatershed	Point Source			Pollutant reduction needed beyond current permit conditions/limits?	TMDLs Pollutant Stream AUID
	Name	Permit #	Type		
Upper Clearwater 0902030501	Bagley WWTF	MN0022691-SD-1 MN0022691-SD-2	Municipal wastewater	No	None
Middle Clearwater 0902030502	Clearbrook WWTF	MNG580098-SD-2	Municipal wastewater	No	*E. coli, TP* Ruffy Brook Clearwater River 513, 647
Poplar River 0902030504	Fosston WWTF	MN0022128-SD-1 MN0022128-SD-2	Municipal wastewater	No	*E. coli* Poplar River 504

HUC-10 Subwatershed	Point Source			Pollutant reduction needed beyond current permit conditions/limits?	TMDLs Pollutant Stream AUID
	Name	**Permit #**	**Type**		
Poplar River 0902030504	McIntosh WWTF	MNG580031-SD-1	Municipal wastewater	No	*E. coli* Poplar River 504
Lost River 0902030505	Gonvick WWTF	MN0020541-SD-1	Municipal wastewater	No	*E. coli* Lost River 512
Lower Clearwater 0902030507	Plummer WWTF	MN0024520-SD-2	Municipal wastewater	No	TSS Clearwater River 648, 511, 501
Lower Clearwater 0902030507	Oklee WWTF	MNG580038-SD-1	Municipal wastewater	No	TSS Clearwater River 511, 501
Upper Clearwater 0902030501	Beltrami County Construction and Industrial wastewater (Permits vary from year to year)			No	TP Long Lake (04-0295)
Middle Clearwater 0902030502 Lost River 0902030505 Lower Clearwater 0902030507	Clearwater County Construction and Industrial wastewater (Permits vary from year to year)			No	TP Stony Lake 15-0156 TSS Nassett Creek, Clearwater River 545, 647, 648, 511, 501
Lower Badger 0902030506 Lower Clearwater 0902030507 Middle Clearwater 0902030502	Polk County Construction and Industrial wastewater (Permits vary from year to year)			No	TP Cameron Lake 60-0189 TSS Clearwater River 501, 511, 648, 647
Lower Clearwater 0902030507 Middle Clearwater 0902030502	Red Lake County Construction and Industrial wastewater (Permits vary from year to year)			No	TSS Clearwater River 501, 511, 648, 647
Lower Clearwater 0902030507	Pennington County Construction and Industrial wastewater (Permits vary from year to year)			No	TSS Clearwater River 501, 511, 648

Table 2-32: Nonpoint Sources in the Clearwater River Watershed. Relative magnitudes of contributing sources are indicated.

HUC-10 Subwater-shed	Stream/ Reach (AUID) or Lake (ID)	Pollutant	Pollutant Sources														
			Fertilizer & manure run-off	**Livestock near the water**	**Failing septic systems**	**Wildlife**	**Poor riparian vegetation cover**	**Streambank and Shoreline Erosion**	**Eroding Ditch Outlets**	**Channel Instability or Disturbance**	**Upland soil erosion**	**Wild Rice Paddy Discharge**	**Wind Erosion**	**Stormwater Runoff**	**Natural Sources**	**Internal Loading**	**More Investigation Recommended**
Upper Clearwater River	Walker Brook (509)	Bacteria				○									○		
	Clearwater River (517)	Bacteria		○		○								○	○		
		TP		○			○	○						○	○		

HUC-10 Subwatershed	Stream/ Reach (AUID) or Lake (ID)	Pollutant	Pollutant Sources														
			Fertilizer & manure run-off	Livestock near the water	Failing septic systems	Wildlife	Poor riparian vegetation cover	Streambank and Shoreline Erosion	Eroding Ditch Outlets	Channel Instability or Disturbance	Upland soil erosion	Wild Rice Paddy Discharge	Wind Erosion	Stormwater Runoff	Natural Sources	Internal Loading	More Investigation Recommended
	Clearwater River (649)	Bacteria		○													
	Clearwater River (653)	Bacteria		**○**													
		TSS		○			○	○									
	Long Lake (04-0295)	TP*		○												**○**	
	Clearwater L. (04-0343)	TP/Chl-a		○				**○**								○	
	Walker Brook Lake (15-0060)	TP													○		✓
	First Lake (15-0139)	TP													○		✓
	Second Lake (15-0140)	TP													○		✓
Middle Clearwater River	Ruffy Brook (513)	Bacteria*		●													
		TP	○	○			○	○			○						
	Clearwater River (647)	TSS*					○	●		●	**○**	●	○				
	Clearwater River (650)	TSS						○									
	Spike Lake (15-0035)	TP									○						
	Johnson Lake (15-0086)	TP									○						
Hill River	Hill River (539)	Bacteria*		●	○	○											
	Brooks Creek (578)	Bacteria*	○		○												✓
	Hill R. (655)	Bacteria		**○**													✓
	Hill River (656)	Bacteria		**○**													
		TP	○	○			○		○		○		○				
	Cross Lake (60-0027-02)	TP									**○**					○	✓
	Turtle Lake (60-0032)	TP									○					○	✓
Poplar River	Poplar River (504)	Bacteria*	○	**○**	○	○											✓
		TP	○	○	○						**○**						
	Poplar River (518)	Bacteria	○	○		○											
		TP	○								○				○		
	Spring Lake (60-0012)	TP												○		○	✓
	Whitefish Lake (60-0015)	TP									**○**					**○**	✓
Lost River	Lost River (512)	Bacteria*		●	○	○								○			

HUC-10 Subwater-shed	Stream/ Reach (AUID) or Lake (ID)	Pollutant	Pollutant Sources														
			Fertilizer & manure run-off	Livestock near the water	Failing septic systems	Wildlife	Poor riparian vegetation cover	Streambank and Shoreline Erosion	Eroding Ditch Outlets	Channel Instability or Disturbance	Upland soil erosion	Wild Rice Paddy Discharge	Wind Erosion	Stormwater Runoff	Natural Sources	Internal Loading	More Investigation Recommended
	Clear Brook (526)	Bacteria*			◎	○								◎			
		TP			○					○				◎			
	Silver Creek (527)	Bacteria*			◎	○								◎			
		TSS		◎			○	○		○	○						
		TP			○		○	○		○	○			◎			
	Lost River (529)	Bacteria*		◎		◎											
	Lost River (530)	Bacteria*		●													
	Nassett Creek (545)	Bacteria*		●		◎											
		TSS		●						◎							
	Lost River (645)	Bacteria		○		○											
	Lost River (646)	Bacteria	○	○		○											
		TSS					○	◎		○	◎						
	Lindberg Lake (15-0144)	TP					◎				◎						✓
	Stony Lake (15-0156)	TP*	◎	○							◎					●	
Lower Badger Creek	Lower Badger Creek (502)	TSS					◎	◎		○	◎						
		Bacteria*	○			◎											
	Polk CD 14 (523)	Bacteria				○											
		TSS								○							
	JD 73 (550)	Bacteria*	○			◎											
	Cameron Lake (60-0189)	TP*						○						●		●	
	Badger Lake (60-0214)	TP														●	✓
	Maple Lake (60-0305)	TP			○		○	○			◎					●	✓
Lower Clearwater River	Clearwater River (501)	TSS*					○	●	●		●	○	○				
		TP	◎				○	◎	◎		◎	○	○				
	CD 57 (508)	Bacteria	○			○											
	Clearwater River (511)	Bacteria		◎		○											
		TSS*					○	●	●		●	○	○				
		TP	◎				○	◎	◎		◎	○	○				
	Terrebonne Creek (574)	Bacteria*	○			○											✓
	Clearwater River (648)	TSS					◎	◎			◎	◎	○				
	Beau Gerlot Creek (651)	Bacteria*			◎	○											
	Beau Gerlot Creek (652)	Bacteria			◎	○											

HUC-10 Subwater-shed	Stream/ Reach (AUID) or Lake (ID)	Pollutant	Pollutant Sources														
			Fertilizer & manure run-off	Livestock near the water	Failing septic systems	Wildlife	Poor riparian vegetation cover	Streambank and Shoreline Erosion	Eroding Ditch Outlets	Channel Instability or Disturbance	Upland soil erosion	Wild Rice Paddy Discharge	Wind Erosion	Stormwater Runoff	Natural Sources	Internal Loading	More Investigation Recommended
	Red Lake CD 23 (658)	TSS						○		○							✓

Key: ● = High **○** = Moderate ○ = Low

*** =** Reach is impaired by excess concentrations of this pollutant and restoration is needed.

Stressors of Biologically Impaired Stream Reaches

The Clearwater River Watershed SID Report was the product of significant time and effort spent by MPCA, RLWD, and DNR staff to identify the causes of F-IBI and M-IBI impairments in the watershed. There was a strong on-the-ground data collection effort that involved follow-up biological samples, continuous DO loggers, geomorphology assessments, and culvert/fish passage assessments. The MPCA and RLWD staff worked closely to discuss and come to conclusions about the candidate causes of the impairments. The findings of the SID Report are summarized in Table 2-33.

Potential stressors of aquatic life in Lower Badger Creek (502) were investigated. The stream was not listed as impaired, but there was concern about some relatively low F-IBI scores that were found in a channelized portion of the stream. An unimpaired reach of the Lost River (646) was also examined because F-IBI and M-IBI scores were trending downward.

More, detailed information can be found in the Clearwater River Watershed SID Report (https://www.pca.state.mn.us/sites/default/files/wq-ws5-09020305a.pdf).

Table 2-33: Primary stressors to aquatic life in biologically-impaired reaches in the Clearwater River Watershed

HUC-10 Subwatershed	AUID (Last 3 Digits)	River/Stream/ Ditch Name	Reach Description	Impaired by Poor Fish Index of Biological Integrity?	Impaired by Poor Macroinvertebrate Index of Biological Integrity?	Primary Stressors					
						Low Dissolved Oxygen (Due to Low Flow)	Flow Alteration (Insufficient Base Flow)	Insufficient In-Stream Habitat	Elevated Nutrients	Sedimentation	Fish Passage Barriers
Hill River 0902030503	539	Hill River	Hill River Lake to Lost River	F-IBI	No	●		●			●
	656	Hill River	Br4 CD 1 near Olga to Hill River Lake	F-IBI	No	●		●			●
Lower Clearwater River 0902030507	658	Red Lake County Ditch 23	-96.1479 47.8855 to Clearwater River	F-IBI	No		●	●			●
	652	Beau Gerlot Creek	-96.1947 47.8413 to Clearwater River	F-IBI	M-IBI		●	●			●
Poplar River 0902030504	518	Poplar River	Spring Lake to Highway 59	F-IBI	M-IBI	●	●	●			●
Lower Badger Creek 0902030506	561	Tributary to the Poplar River Diversion Ditch	Gerdin Lake to the Poplar River Diversion	F-IBI	No Data	●	●	●			●
	502	Lower Badger Creek	CD 14 to Clearwater River	No	No	●	●	●			
Lost River 0902030505	645	Lost River	Anderson Lake to unnamed creek along CSAH 28	F-IBI	No	●	●	●	●		●
	646	Lost River	unnamed creek along CSAH 28 to Hill River	No	No		●	●		●	
Silver Creek 0902030505	527	Silver Creek	Headwaters to Anderson Lake	No	M-IBI	●	●		●		

Altered hydrology includes channelization of streams and improved drainage that leads to flashier flows. It also includes base flows that are insufficient or non-existing, often due to reduced storage and drainage projects.

Low dissolved oxygen levels were documented within most of the biologically impaired reaches. The data were collected by discrete measurements and deployments of DO loggers. Most of the low DO levels are associated with low flows and/or low gradients (stagnant water). The low DO levels in portions of the Poplar River; however, appear to be caused by natural processes.

Connectivity may be limited by fish passage barriers in some reaches that are considered impaired due to poor F-IBI scores. Private stream crossings, excessive gradient, and dams are examples of landscape features that could be limiting or preventing fish passage. Beaver dams are present on many of the smaller streams in the watershed, but they are typically temporary.

Poor stream habitat was identified as a stressor for most of the biologically impaired reaches in the Clearwater River Watershed. Channelization, lack of buffers, poor quality substrates, and riparian land use issues are some of the factors that have limited the quality of habitat for aquatic life within impaired streams.

Elevated nutrients were identified in some reaches. In most reaches where high TP levels were found, however, most of the TP was in the orthophosphate (OP) form. That indicated that stagnant conditions were causing the release of dissolved inorganic phosphorus from the sediment during anaerobic conditions.

Sources of *E. coli* bacteria

The sources of *E. coli* bacteria in the Clearwater River Watershed were investigated during the Clearwater River WRAPS process. Nonpoint sources of *E. coli* bacteria in impaired reaches and nearly impaired reaches are summarized in Table 2-32. The WWTFs that discharge upstream of impaired waters are also listed in Table 2-31. There are no MS4 communities within the Clearwater River Watershed. Livestock along streams are the most easily recognizable source in aerial photos and windshield surveys. In addition to the feedlot locations shown in the map in Figure 2-13, smaller livestock operations also contribute to *E. coli* concentrations in streams. WWTFs that discharge to waters impaired by *E. coli* have been assigned a WLA in the TMDL. All of these WWTFs currently have limits in their National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) permits that are consistent with the assigned WLAs. Analysis of samples for fecal DNA markers is a way to identify sources that are otherwise hard to prove like septic systems, wildlife, and pets.

There are sources of natural background bacteria (warm-blooded wild animals) in the Clearwater River and its tributaries that minimally contribute to *E. coli* levels in rivers and streams. In natural settings, wildlife is scattered, and as a result such a small fraction of wild animal waste is "deposited" in waterways that natural background sources are not enough to cause an impairment. The average minimum monthly (May through September) geometric mean *E. coli* concentration in unimpaired streams in data collected from 2006 through 2015 was just 15.0 MPN/100ml. There are; however, situations in which natural sources of bacteria can become a source of excess bacteria. Concentrated populations of animals near a waterway can contribute enough *E. coli* bacteria to create an impaired condition. Birds and waterfowl congregate at locations that provide favorable habitat and food. Flocks of waterfowl congregating in wetlands or in stream/ditch channels can cause high *E. coli* concentrations in downstream waters in some circumstances.

A longitudinal assessment of *E. coli* concentrations on the Clearwater River (Figure 2-12) shows that August *E. coli* concentrations are high within the channelized portion of the river (AUID 647). That timing coincides with the timing of pre-harvest drainage of wild rice paddies. Late summer is when flows (and potential for dilution) are typically low in most streams and streams are more susceptible to high *E. coli* concentrations from any source. There is also cause for concern about high *E. coli* concentrations within a portion of the river between Clearwater Lake and the channelized reach (CSAH 14 crossing).

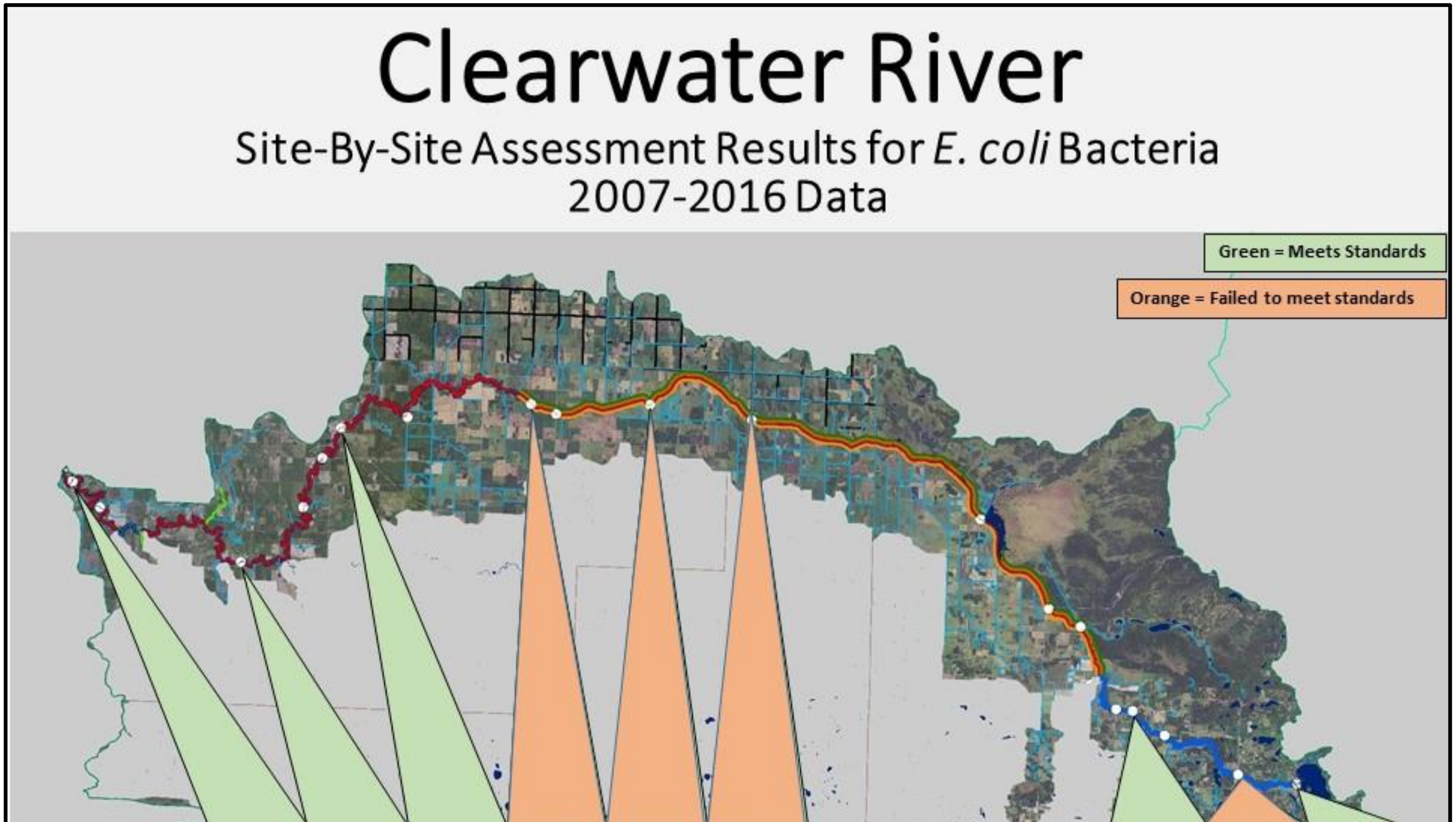
<u>Microbial Source Tracking and Failing Septic Systems</u>

Microbial Source Tracking samples were collected from the Beau Gerlot Creek, Brooks Creek, Hill River, Lost River, JD 73, Terrebonne Creek, Silver Creek, Ruffy Brook, and Clearwater River in July and August

2016. Microbial source tracking is a method for identifying the type of animal that is the source of fecal coliform and *E. coli* pollution. The samples were analyzed by the Source Molecular laboratory in Florida, which specializes in this testing. *E. coli* samples were also collected and sent to RMB Environmental Laboratories in Detroit Lakes to obtain the total concentration of *E. coli* bacteria at the time of sampling and gauge whether the timing of the samples captured exceedances or not. Past data were used as a guide for the timing of sample collection. The tests revealed that human waste is getting into Beau Gerlot Creek, Brooks Creek, Hill River, and Silver Creek. The results of the tests (Table 2-34) have been passed along to agencies that are in charge of regulating septic systems. Very significant contributions from ruminants (cattle, sheep, deer, chamois, and goats) were found in samples collected from the Clearwater River, Ruffy Brook, Silver Creek, and the Hill River. Fecal DNA analysis revealed that birds are contributing to fecal pollution, albeit in trace amounts. Bird fecal DNA markers were discovered at six of the nine sites that were sampled for microbial source tracking. Cliff swallows that are concentrated under bridges and within culverts (living over the water) are a very likely contributor to the bird fecal matter from this analysis.

2-34. Microbial source tracking fecal DNA sampling results from streams in the Clearwater River Watershed

Date	Site Name (AUID)	Site ID Code	*E. coli* (MPN/100 ml)	Analysis Requested	Quantification	DNA Analytical Results
7/14/2016	Beau Gerlot Creek at CR 114 (651, 652)	S008-058	125.9	Bird Fecal ID	<LOQ	Present
				Ruminant Fecal ID	Non-detect	Absent
				Humans 1	<LOQ	Present
				Human 2	<LOD	Absent
7/14/2016	Brooks Creek at CSAH 92 (578)	S006-506	248.1	Bird Fecal ID	<LOQ	Present
				Ruminant Fecal ID	Non-detect	Absent
				Humans 1	<LOQ	Present
				Humans 2	Non-detect	Absent
7/14/2016	Hill River at CR 119 (539)	S002-134	435.2	Bird Fecal ID	<LOQ	Present
				Ruminant Fecal ID	435 copies/100ml	Present
				Humans 1	<LOQ	Present
				Humans 2	Non-detect	Absent
7/28/2016	Lost River at 109th Ave (529)	S005-283	50.4	Bird Fecal ID	<LOQ	Present
				Ruminant Fecal ID	Non-detect	Absent
				Humans 1	Non-detect	Absent
7/28/2016	Judicial Ditch 73 at 343rd St. SE (550)	S003-318	143.9	Bird Fecal ID	<LOQ	Present
				Ruminant Fecal ID	Non-detect	Absent
				Humans 1	Non-detect	Absent
7/28/2016	Terrebonne Creek at CSAH 92 (574)	S004-819	73.3	Bird Fecal ID	Non-detect	Absent
				Ruminant Fecal ID	Non-detect	Absent
				Humans 1	Non-detect	Absent
8/4/2016	Silver Creek at 159th Ave near Clearbrook (527)	S000-712	>2,419.6	Bird Fecal ID	<LOQ	Present
				Canada Goose	Non-detect	Absent
				Ruminant Fecal ID	127,000 copies/100ml	Present (High)
				Dog Fecal ID	517 copies/100ml	Present (Low)
				Humans 1	<LOQ	Present)
				Humans 2	<LOQ	Present
8/4/2016	Ruffy Brook at CSAH 11 (513)	S008-057	>24,196	Bird Fecal ID	Non-detect	Absent
				Ruminant Fecal ID	80,500 copies/100ml	Present (Moderate)
				Humans 1	Non-detect	Absent
				Humans 2	Non-detect	Absent
8/4/2016	Clearwater River at CSAH 10 (647)	S003-174	1,413.60	Bird Fecal ID	Non-detect	Absent
				Canada Goose	Non-detect	Absent
				Ruminant Fecal ID	1,620 copies/100ml	Present (Low)
				Humans 1	Non-detect	Absent
				Humans 2	Non-detect	Absent
<LOD = Below the Limit of Detection (<10 copy numbers per reaction)						
<LOQ = Below the Limit of Quantification (present in a trace amount)						
Humans 1 = Human Bacteroidetes ID 1; Humans 2 = Human Bacteroidetes ID 2						



Site ID:	S002-118	S002-914	S002-124	S002-916	S003-174	S002-121				S002-752	S001-461	S002-119	
AUID (09020305-XXX)	501	511	648	647	647	647				650	649	649	
Street/Road:	Bottineau Ave	CSAH 12	Minnesota St. N	280th Ave SE	CSAH 10	370th Ave SE				CSAH 11	CSAH 14 (249th Ave)	Clearwater Lake Rd.	
May Geomean:	36.7	79.5	14.2	32.7	21.5	8.5				16.7	2	1.8	
June Geomean:	69.5	119.7	48.1	103	73.4	72.4				41.7	87.4	2.1	
July Geomean:	65.2	99.4	80.6	105.7	83.5	121.7				37.9	448	1	
August Geomean:	32.5	86.1	84.1	153	231.8	136.5				38.4	172.3	1.7	
September Geomean:	42.7	72.7	40.5	74.8	116.3	86.2				65.3	24.2	1	
Total # of May-September Days with Samples:	70	35	73	23	31	69				19	6	18	

Figure 2-12. Site-by-site longitudinal assessment of *E. coli* along the Clearwater River

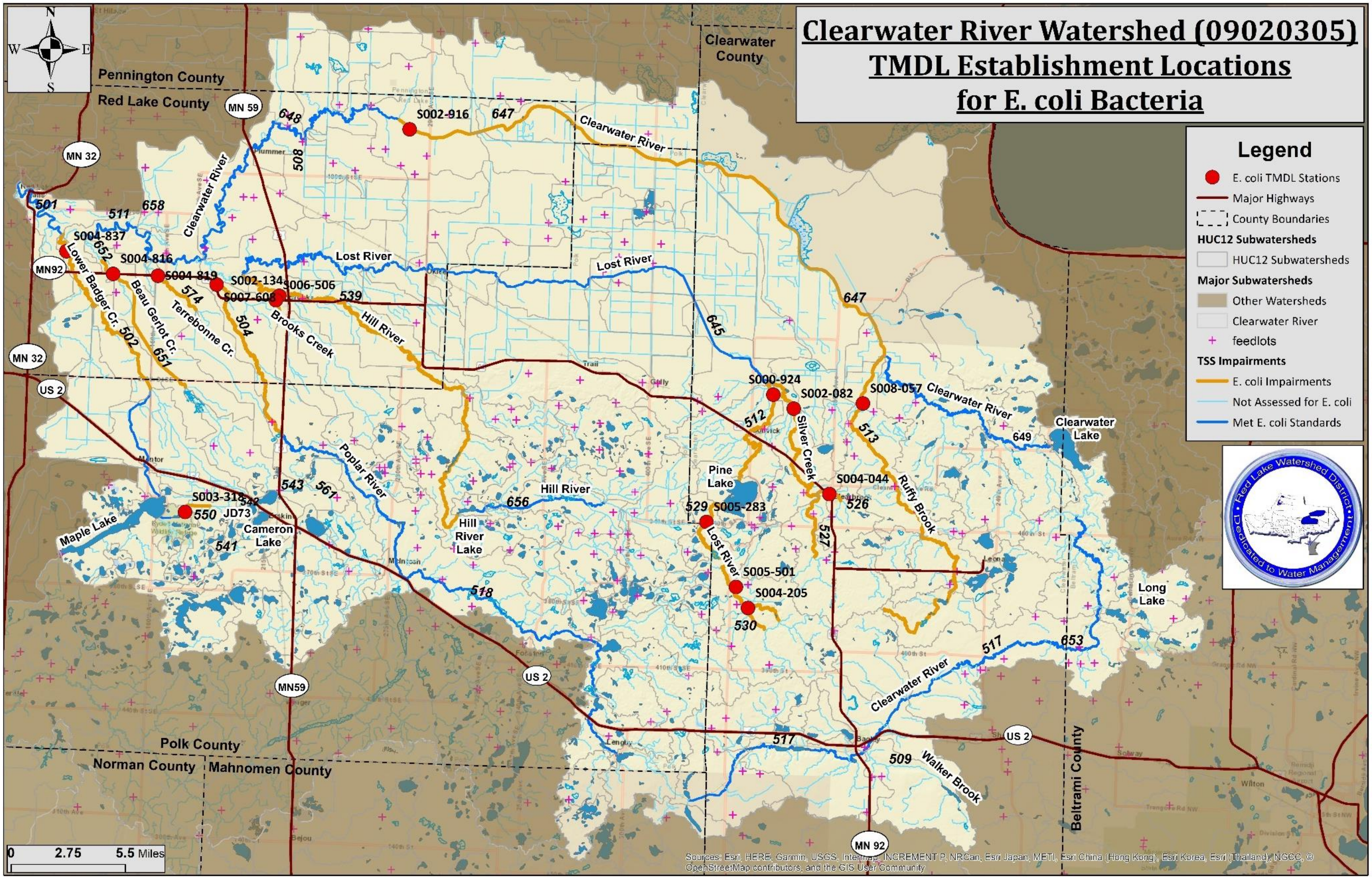


Figure 2-13. Locations of *E. coli* TMDL establishment stations and feedlots (as of 2019) throughout the Clearwater River Watershed

Sources of Total Suspended Solids

There has been an ongoing effort to identify and reduce sediment sources and erosion problems within the Clearwater River Watershed. Sources have been identified by water quality models, spatial analysis, examination of aerial photos, windshield surveys, in-channel reconnaissance, investigative sampling, stream channel stability assessments, and public surveys. Multiple nonpoint sources are contributing to excess TSS concentrations in the Clearwater River. Overland erosion, streambank erosion, wind erosion, and stormwater runoff all contribute to TSS concentrations and loads. Each of these categories of sources has been investigated and documented to some extent. Water quality models have been developed as a means of identifying the areas of the watershed that are contributing the most sediment, particularly from overland erosion. The results of a fluvial geomorphology study can help erosion prevention efforts along the river channels. Longitudinal sampling has provided insight into the locations of sediment sources. Analysis of flow and sampling data in the TMDL (load duration curves, Figure 2-14) showed that exceedances of TSS standards occur during high and very high flows.

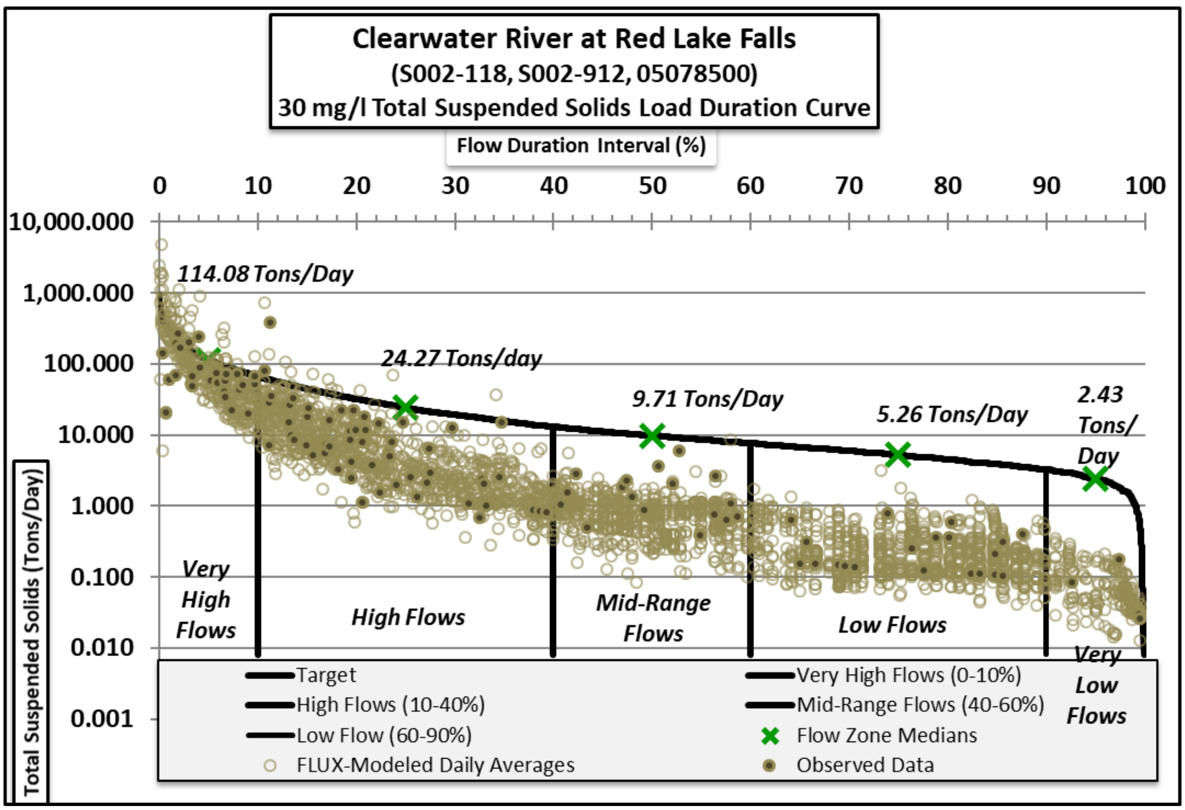


Figure 2-14. Load duration curve and median daily loads for the Clearwater River at Bottineau Avenue Northwest in Red Lake Falls (S002-118) for AUID 09020305-501

Figure 2-15 shows the relative contributions to simulated annual TSS loads from different sources. Loads were simulated for the time period of 1996 through 2016 by the HSPF model that was developed for the Clearwater River Watershed. The majority of overland erosion seems to come from cultivated fields. In-stream erosion was the next largest source of sediment in the Clearwater River. Together, erosion from cultivated land and in-stream erosion accounted for nearly 90% of the sediment in the Clearwater River at Red Lake Falls. Development (urban) was also a significant contributor to TSS loads in the model, despite the limited amount of area within that classification. Figure 3-10 in Section 3.2 is a map of the relative contributions of sediment from sub-basins in the Clearwater River Watershed that were simulated by the HSPF model. The wild rice paddies along the Clearwater River were features of the landscape that were difficult to simulate with a model, but significantly and regularly contributed TSS occurs for limited periods of time in late summer during pre-harvest drainage (where paddies are drained by internal surface drainage ditches).

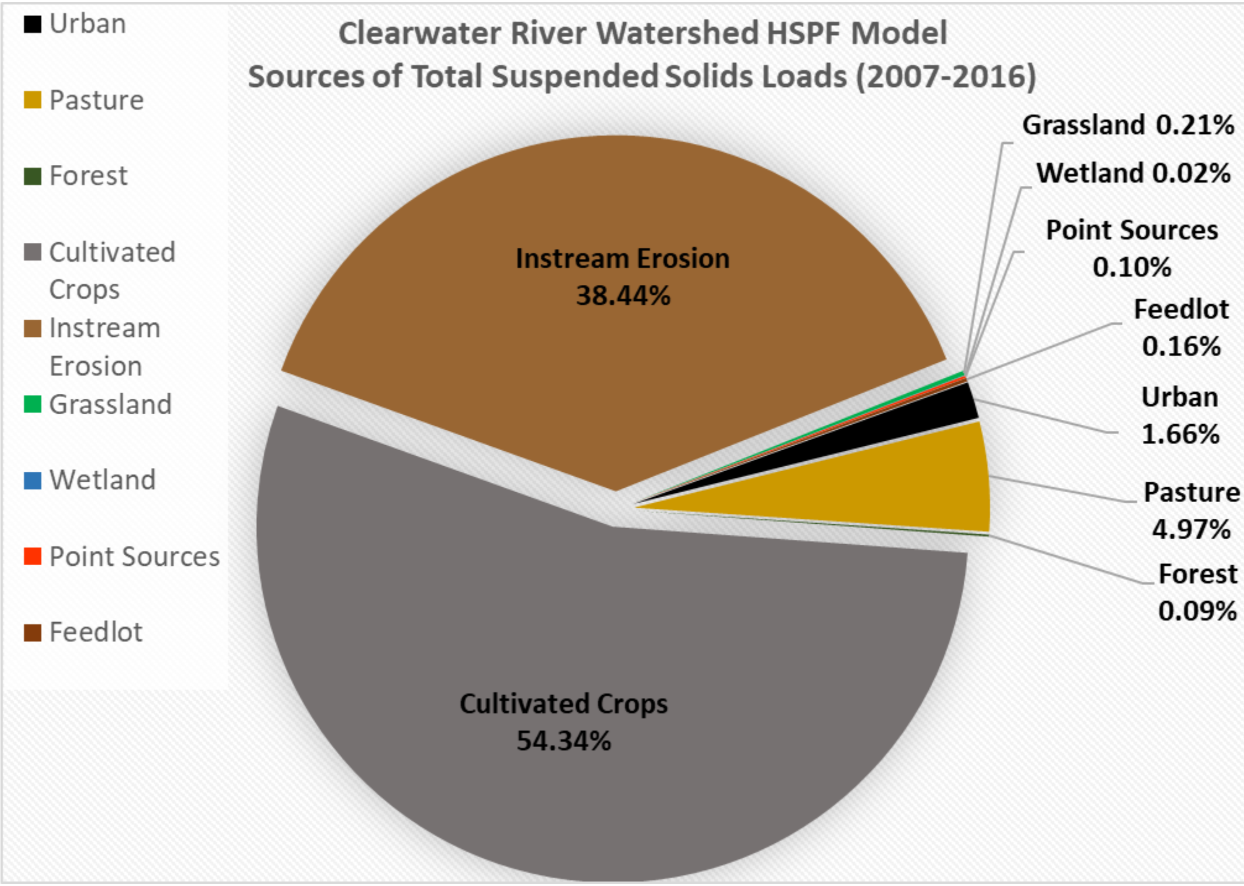


Figure 2-15. Proportions of HSPF-simulated TSS loads attributed to categories of sources

Stream and Ditch Bank Erosion

High, eroding bluffs are a defining feature of the lower reaches of the Clearwater River. The gradient and stream power increase as the river flows toward its confluence with the Red Lake River in Red Lake Falls. Eroding streambanks are found along channels throughout the watershed, including the tributaries of the Clearwater River. The geomorphology study documented the varying severity of in-stream erosion throughout the watershed. Findings of that study are summarized in Section 3.2. Outlets of drainage systems and tributaries of the Clearwater River need to be stabilized along the lower portion of the river. Gradients between the last road crossing of a tributary channel and the Clearwater River can be very steep. The steep gradients cause mass-wasting erosion problems and can impede fish passage. The width and quality of buffers need to be improved in many areas. Sharp contrasts in streambank stability are evident between banks that are protected by woody and deep-rooted vegetation and banks that have been stripped of that vegetation for fields, pastures, development, or aesthetics. Because they are smaller streams, some tributaries of the Clearwater River are sensitive to surface runoff that is disturbed by construction, vegetation removal by livestock, and other causes (lower flow rates and less dilution).

Channel incision (head-cutting) has occurred along the transition from a natural channel to the channelized portion of the Clearwater River. The increased slope of the channelized portion has been causing streambank instability and has threatened to cause meander cut-offs upstream. A project was implemented to install grade stabilization structures, stabilize cut-banks, and restore a floodplain, but more work is needed downstream of that project.

The geomorphology reconnaissance work found that the Lost River is carrying a large load of sand in its lower reaches. That sand is then discharged and deposited into the Clearwater River. A very large sand bar has been deposited near the confluence of the Lost River and the Clearwater River.

Exploration of the Lost River between CR 118 and the confluence with the Clearwater River revealed that a large amount of sand is being transported along the lower portion of the river. Large sediment bars are visible in aerial photos. Reconnaissance via kayak discovered that, in addition to the sediment bars, trees and logs along the bank of the river appeared to have been sandblasted by powerful, sediment-laden streamflow.

In-channel excavation is an action that has left channels and banks of waterways susceptible to erosion. This is done in some places for the purpose of removing beaver dams and log/debris jams in legal ditch systems. Excavation that drains wetlands, poor efforts to revegetate disturbed streambanks, and a lack of BMPs during excavations will likely result in unnecessary pollution of downstream waters.

Upland Sediment Sources

The 1996 through 2016 version of the Clearwater River HSPF model estimated that the largest contribution to TSS to the Clearwater River was sediment runoff from upland sources. The model showed that sediment yields from overland runoff are greatest in the western half of the watershed. There are cultivated fields that encroach upon the river and buffers need to be improved. Prior to the implementation of the Buffer Law, fields were farmed up to the edge of the riverbank in many locations. Without buffers or side water inlets, gullies have formed where private drainage enters public drainage ditches.

The development of detailed water quality models like the PTMApp model (described in Section 3.2) will identify the points on the landscape where BMPs can be most cost-effectively implemented to reduce TSS loads.

Runoff events in the Ruffy Brook and Silver Creek watersheds have washed out driveways (Figure 2-16) where culverts have either been plugged or inadequately sized. Very high TSS concentrations have been recorded in the Clearwater River and its tributaries during spring runoff and June rain events.

Figure 2-16. Photos of gullies and washouts that occurred during runoff events in the Clearwater River Watershed

Staff from the RLWD and SWCDs have taken georeferenced photos of erosion problems throughout the watershed. The Red Lake SWCD has completed an inventory of erosion problems in that county that included public outreach efforts.

Stormwater and Urban Runoff

Stormwater runoff from city streets, parking lots, and other impermeable surfaces often carries high concentrations of sediment to rivers and streams through stormwater drainage systems. The HSPF model estimated that developed land contributes a percentage of the TSS load at Red Lake Falls (4.2%) that is approximately equal to the percentage of land that is developed within the watershed (4.44%). Stormwater runoff from the communities of Plummer and Red Lake Falls may also be contributing to the TSS impairment in the Clearwater River.

Although there are no MS4 NPDES/SDS permitted cities located within the Clearwater River Watershed, some work has been completed within small cities in the watershed to better understand the impact of stormwater runoff and implement projects to reduce its impact upon receiving waters. Stormwater treatment ponds and an infiltration pond were constructed in the city of Bagley after plumes of sediment and sedimentation were found to be entering the Clearwater River. A stormwater study was conducted by the RLWD in the towns of Clearbrook and Gonvick. The effort discovered that runoff was minimally affecting the Lost River as it passes through Gonvick, but high concentrations of sediment in stormwater runoff were negatively affecting water quality in the much smaller Clear Brook (a tributary of Silver Creek). The highest concentration of sediment in Clearbrook's stormwater runoff was discovered at a stormwater outlet that was conveying drainage from the town's industrial zone along the west side of CSAH 5. The Clearwater SWCD and a consultant completed a stormwater assessment of the city and designed several stormwater treatment ponds. Land ownership, land use, infrastructure, and utilities were all obstacles that needed to be addressed to get the project completed in the highest priority location. As a result, only one stormwater pond has been built, which treats runoff from downtown Clearbrook.

Stormwater runoff within other communities in the Clearwater River Watershed has not been assessed. Stormwater runoff in the city of Red Lake Falls, a city with a lot of topography that could lead to rapid runoff, should be assessed. Stormwater runoff within the city of Erskine has been documented as a source of nutrients in the eutrophic Cameron Lake. Most of the city of Fosston is located within the Sand

Hill River Watershed and does not appear to flow toward the Poplar River. In the city of McIntosh, there is a channel that flows through the southeastern portion of the town and into the Poplar River. There is an area along that channel that is being used as a storage area for sand, gravel, soil, etc. Runoff from that area could impact the Poplar River.

Stormwater runoff from construction and industrial activities also contributes to TSS concentrations (minimally). Despite the relatively small portions of the pollutant loads in impaired waters that come from these activities, they were given a separate load allocation within the TMDL because they are regulated by NPDES/SDS permits issued by the MPCA.

Wind Erosion

Wind erosion is a notable type of erosion occurring in the western portion of the Clearwater River Watershed where row crop land use is more common. Dust storms occur, particularly in the spring and early summer. Sediment is deposited in ditches throughout the winter (Figure 2-18) as wind erodes soil from cultivated fields. Fields with buffers and/or crop stubble appeared to have less wind erosion and less sediment deposited within adjoining ditches. Wind erosion has also been a problem after spring runoff, before crops have begun growing. Tree rows and windbreaks are dying and being removed. Removal of wind breaks has the effect of increasing the amount of fetch on fields and exacerbating wind erosion. According to SWCD staff, small root systems, chemicals, fungus issues, and emerald ash borers are contributing to this problem. Some species of trees are reaching the end of their life cycles and are being removed (Chinese elms). Hybrid poplar trees only last about 20 years because they grow too fast and then break. Some re-establishment is occurring, but more is needed.

Figure 2-17. Example of May wind erosion from cultivated fields (especially rolled fields) that can occur before vegetative plant growth is established

Rolled fields (Figure 2-17) are particularly susceptible to wind erosion. Soybean fields are rolled to prevent damage to harvesting equipment. Rolling pushes rocks into the ground and breaks up clumps of soil that might damage cutters on equipment that is set close to the ground. According to an article from the University of Minnesota Extension Service (Dejong-Hughes 2016), this practice poses risks, including potential plant injury, soil sealing, added expense, and erosion.

Figure 2-18. Sediment that has been eroded by wind and deposited into a ditch near the Clearwater River

The Natural Resources Conservation Service (NRCS) wind erodibility index is a numerical value indicating the susceptibility of soil to wind erosion, or the tons per acre per year (tons/ac/yr) that can be expected to be lost to wind erosion (Figure 2-19). Soil erodibility by wind is directly related to the percentage of dry nonerodible surface soil aggregates larger than 0.84 mm in diameter. From this percentage, the wind erodibility index ("I" factor) is determined. There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture and frozen soil layers also influence wind erosion.

Remote sensing technologies were utilized by Board of Water and Soil Resources (BWSR) and the University of Minnesota to assess crop residue cover by calibrating satellite imagery from Landsat 8 (an American satellite) and Sentinel 2 (European satellite) with ground-truthed data. Models from U.S. Department of Agriculture (USDA) (WEPP and RUSLE2) were used to estimate wind and water erosion. 2017 was the first year this process was used in the Clearwater River Watershed. The aerial extent of data was limited by the satellite flight path and cloud cover during the data collection window. Hay and pasture are the primary agricultural land uses in the eastern part of the watershed and would be the reason for the high crop residue numbers for that area. Figure 2-20 reveals that most of the areas with the least crop residue were located along streams. There are a number of variables that impact a farmer’s decision on tillage, so it is important to look at long-term trends when evaluating overall tillage methods in an area.

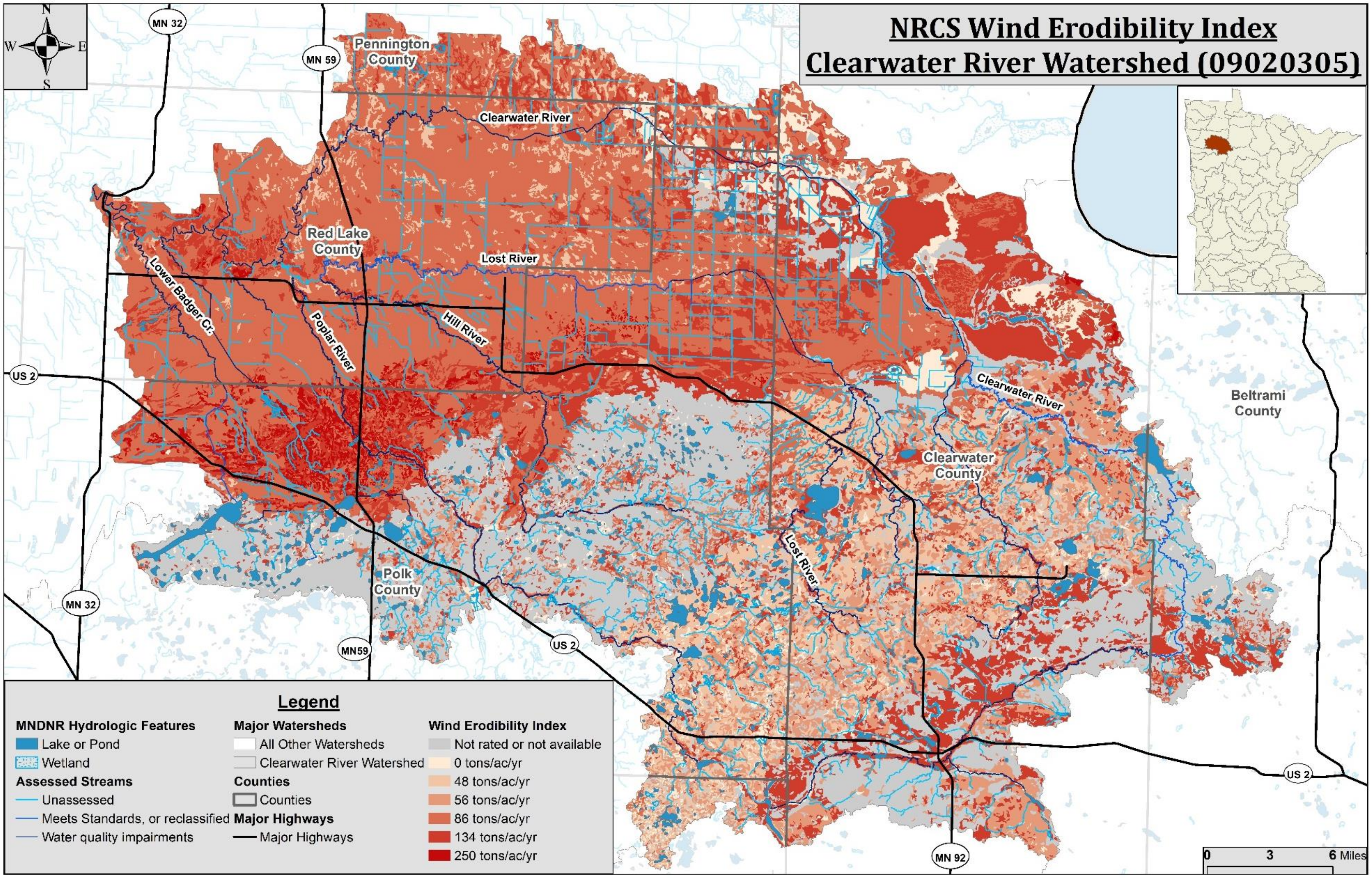


Figure 2-19. Map of Wind Erodibility Index throughout the Clearwater River Watershed

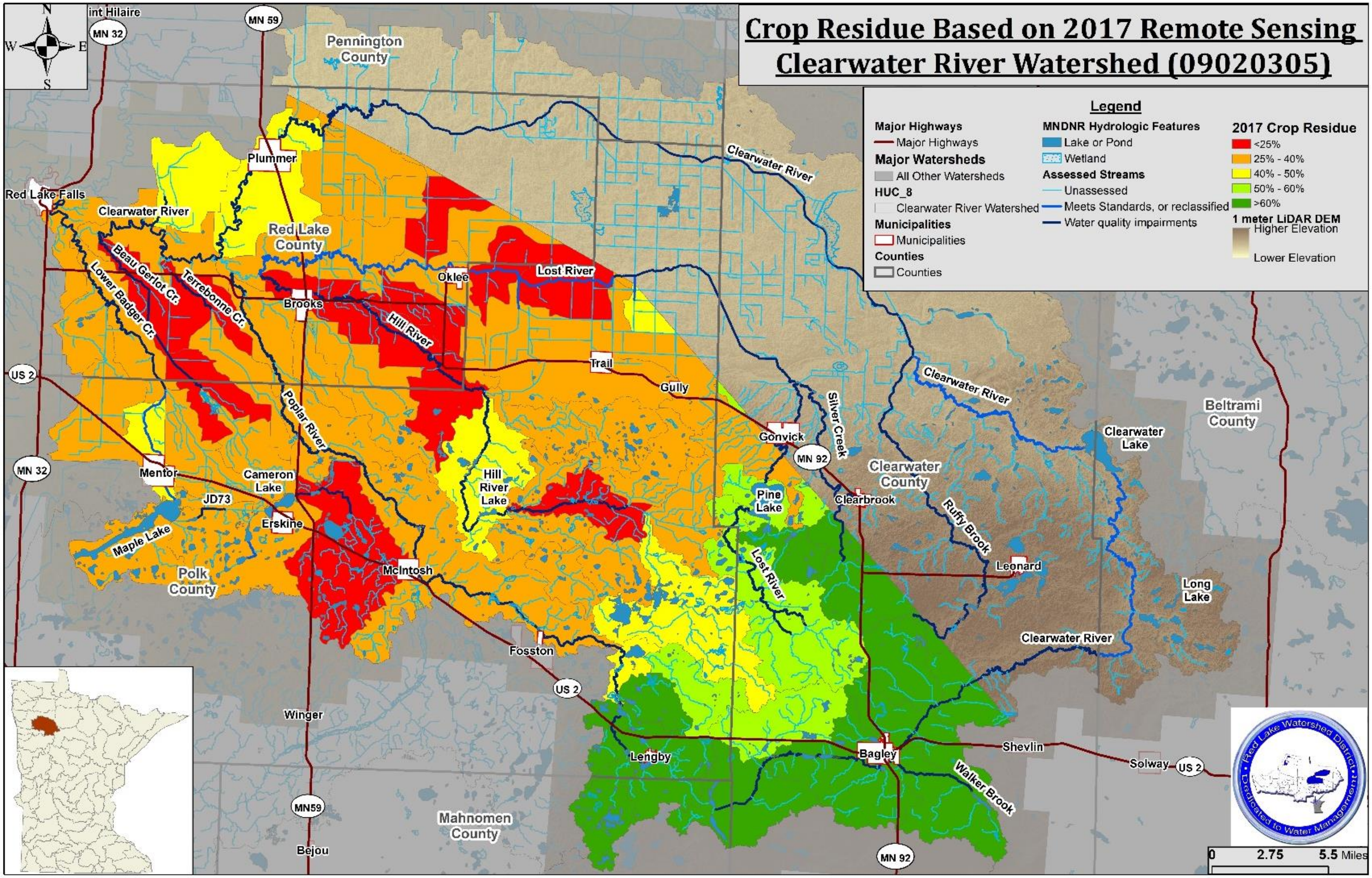


Figure 2-20. Crop residue based on 2017 remote sensing data

Sources of Total Phosphorus

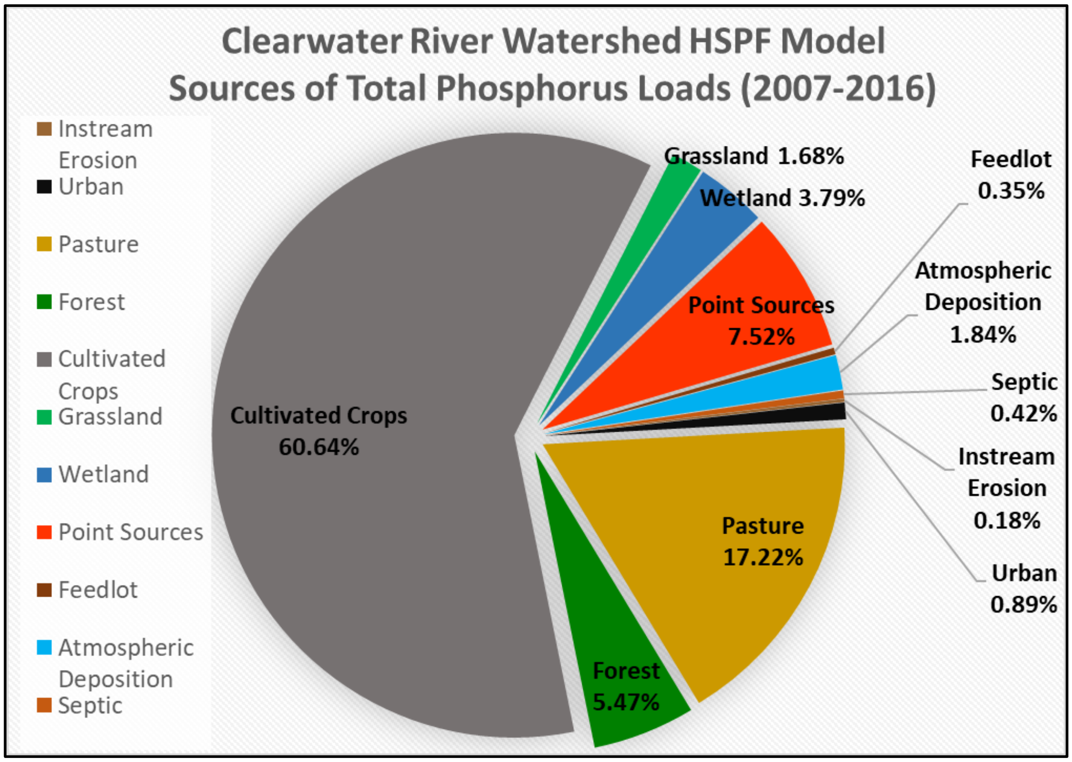


Figure 2-21. Proportions of HSPF-simulated TP loads attributed to categories of sources

One reach of the Clearwater River, AUID 647, is impaired by excess TP. No WWTFs are contributing to the impaired reach. The potential for disturbance of soil from permitted construction and industrial activity was factored into the TMDLs. The nonpoint sources of TP in the river were identical to most of the sources of sediment that were described earlier in Section 2.3. Figure 2-21 shows the relative contributions to simulated annual TP loads from different sources. Those include stream and ditch bank erosion, upland erosion, stormwater runoff, wild rice paddy drainage, and wind erosion. There was a dramatic increase in TP concentrations from the natural reaches of the river downstream of Clearwater Lake to the channelized reach of the river. The abrupt change in water quality from the natural portion of the Clearwater River to the channelized portion is shown in short term, single-day, longitudinal sampling results shown in Figure 2-22 and in long-term summer averages shown in Figure 2-23.

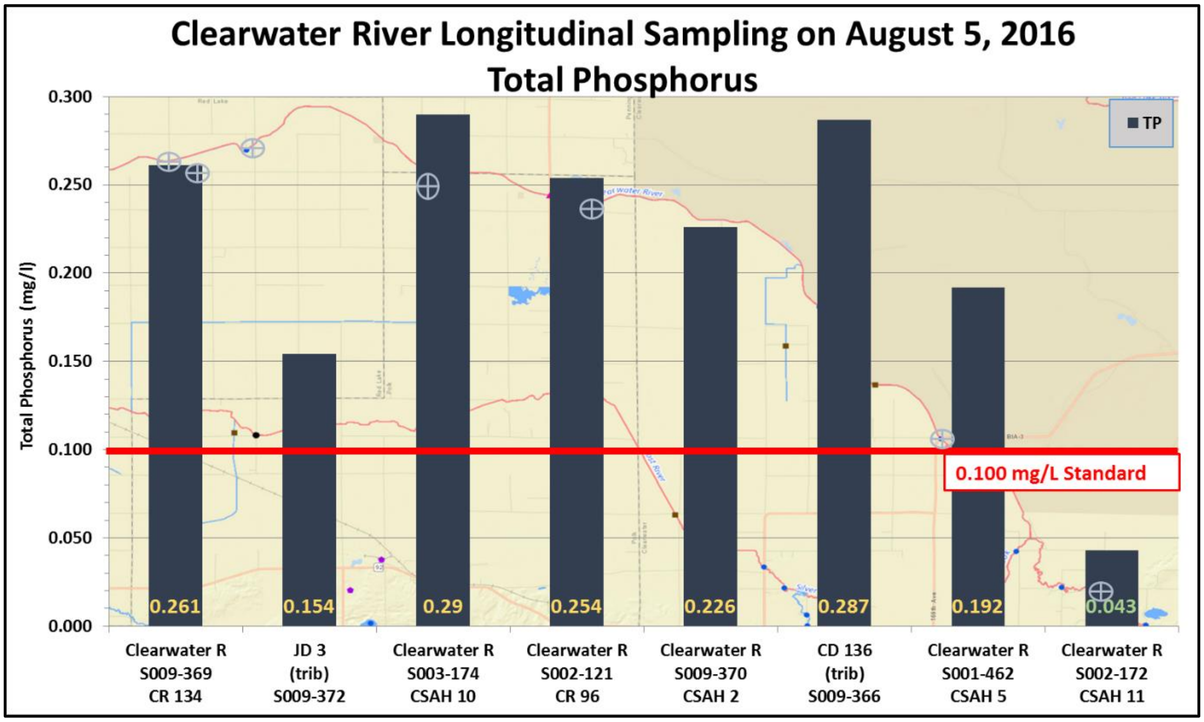


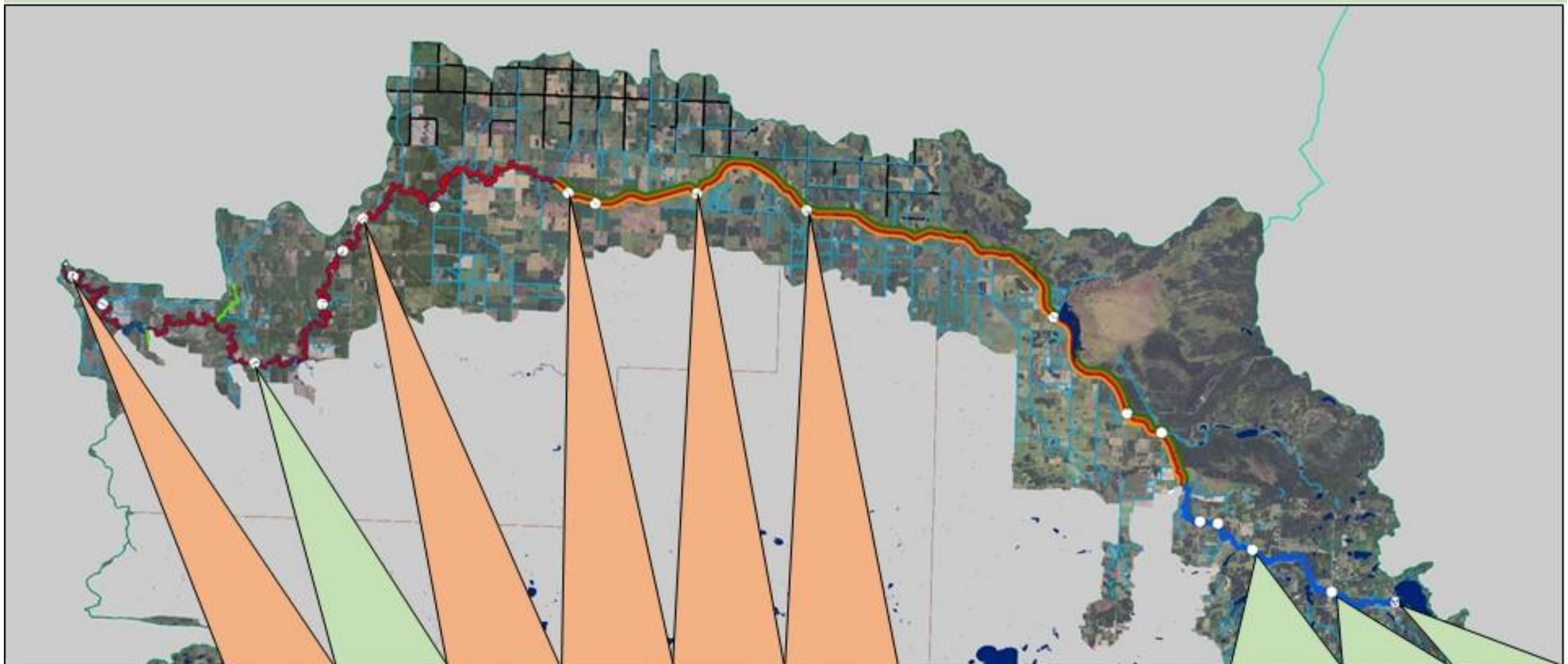
Figure 2-22. Longitudinal TP sampling results from the Clearwater River and tributary ditches on August 5, 2016

Although there are no WWTFs discharging upstream of the one TP impaired reach of the Clearwater River (AUID 647), wastewater is still a source of TP in some locations in the watershed. The highest average TP concentrations in the watershed are found at water quality stations that are located downstream of the cities of Fosston and McIntosh along the Poplar River. High concentrations of TP have been recorded downstream of WWTFs in the past, particularly downstream of the Fosston WWTF, prior to recent improvements, for example. Illicit discharge from a truck wash in the town of Brooks was found to be contributing high concentrations of TP and other pollutants to the Hill River. This discharge was stopped with county enforcement and a new septic system installation in 2018, and the removal of an old pipe in 2020 at the truck stop site. The drainage of wetlands with ditch channels (Poplar River Diversion, for example), can result in situations where organic matter and TP are flushed from the wetlands during high flow events. Release of OP from sediment during stagnant, anoxic conditions contributes to TP concentrations, particularly in tributary streams like the Poplar River.

Overland runoff from the drainage areas of lakes in the watershed is contributing to impairments in lakes and potential future impairments. Past activities like historical wastewater disposal and feedlot/pasture runoff have contributed to TP impairments in lakes. Internal loading of TP from sediment through wave action and boating activity is a primary source of TP within some shallow lakes. Some lakes that are located along rivers receive significant TP loads from those channels and some of those lakes are nearly impaired (Cross Lake and Hill River Lake). Erosion of lakeshore is also contributing to TP concentrations in some lakes. Stormwater within the city of Erskine is contributing to TP concentrations in Cameron Lake. Failing septic systems along a lakeshore may be difficult to identify without inspections but are a source of lake TP that should be considered.

Clearwater River

Site-By-Site Assessment Statistics for Total Phosphorus
2007-2016 Data



Site ID:	S002-118	S002-914	S002-124	S002-916	S003-174	S002-121	S002-752	S001-461	S002-119
AUID (09020305-XXX)	501	511	648	647	647	647	650	649	649
Street/Road:	Bottineau Ave	CSAH 12	Minnesota St. N	280th Ave SE	CSAH 10	370th Ave SE	CSAH 11	CSAH 14 (249th Ave)	Clearwater Lake Rd.
Summer Average TP (mg/L, 2007-2016)	0.107	0.096	0.132	0.134	0.133	0.131	0.026	0.020	0.019
Number of June-Sept. Days with TP Samples:	138	28	78	19	26	39	10	5	15

Figure 2-23. Longitudinal summer average concentrations of TP along the Clearwater River. Sites shaded in orange exceed the TP standard of 0.100 mg/L.

Causes of Low Dissolved Oxygen

The most common causes of low DO in the Clearwater River Watershed are lack of flow (stagnant conditions), low gradient (also contributing to stagnant conditions), groundwater that is naturally low in DO, removal of woody vegetation (less shading and higher temperatures), and fens/wetlands where decomposition of organic material consumes DO. Monitoring has discovered more than 10 DO impairments on portions of rivers and streams in the Clearwater River Watershed (Figure 1-1). In addition to the streams that are officially listed as impaired, there are streams that were not meeting the DO standard but were recategorized or not officially assessed. The low DO levels within recategorized streams were known to be caused by natural conditions or other non-pollutant factors during the 2016 water quality assessment and development of the 2018 List of Impaired Waters. There were some channels with historical DO impairments (AUID 542, Badger-Mitchell Lake channel) that were not officially assessed in 2016 and removed from the list of impaired waters, because sampling stations were evaluating lake water (from Badger Lake) more than they were evaluating stream water quality. Seven of the aquatic life impairments (Table 2-35) were at least partially caused by low DO. Some of those biologically-impaired streams that are stressed by low DO were not determined to be impaired during the 2016 assessment due to a lack of data or a lack of DO logger data (lack of true daily minimum concentration data). Some reaches with recurring low DO problems were not listed as impaired because data indicated that the low-DO conditions were caused by a lack of flow.

Upper Clearwater River Subwatershed

An intensive study of the upper reaches of the Clearwater River, along with Walker Brook, discovered that physical features of this portion of the watershed had a greater effect on DO concentrations than the relatively low pollutant concentrations that have been found in this reach. The headwaters portion of the Clearwater River shares multiple characteristics with the Walker Brook drainage area. The Clearwater River headwaters and Walker Brook are connected and located in the same area of the watershed. They share a geologic history having originated as part of a glacier margin meltwater stream around 15,000 years ago. The headwaters reach has a low gradient. It has riparian wetlands (fens) that are similar to those found along Walker Brook, with a similar redox potential. The fens along the Clearwater River are biologically active (consuming oxygen during decomposition of organic matter) and most of the runoff to the river flows through those fens.

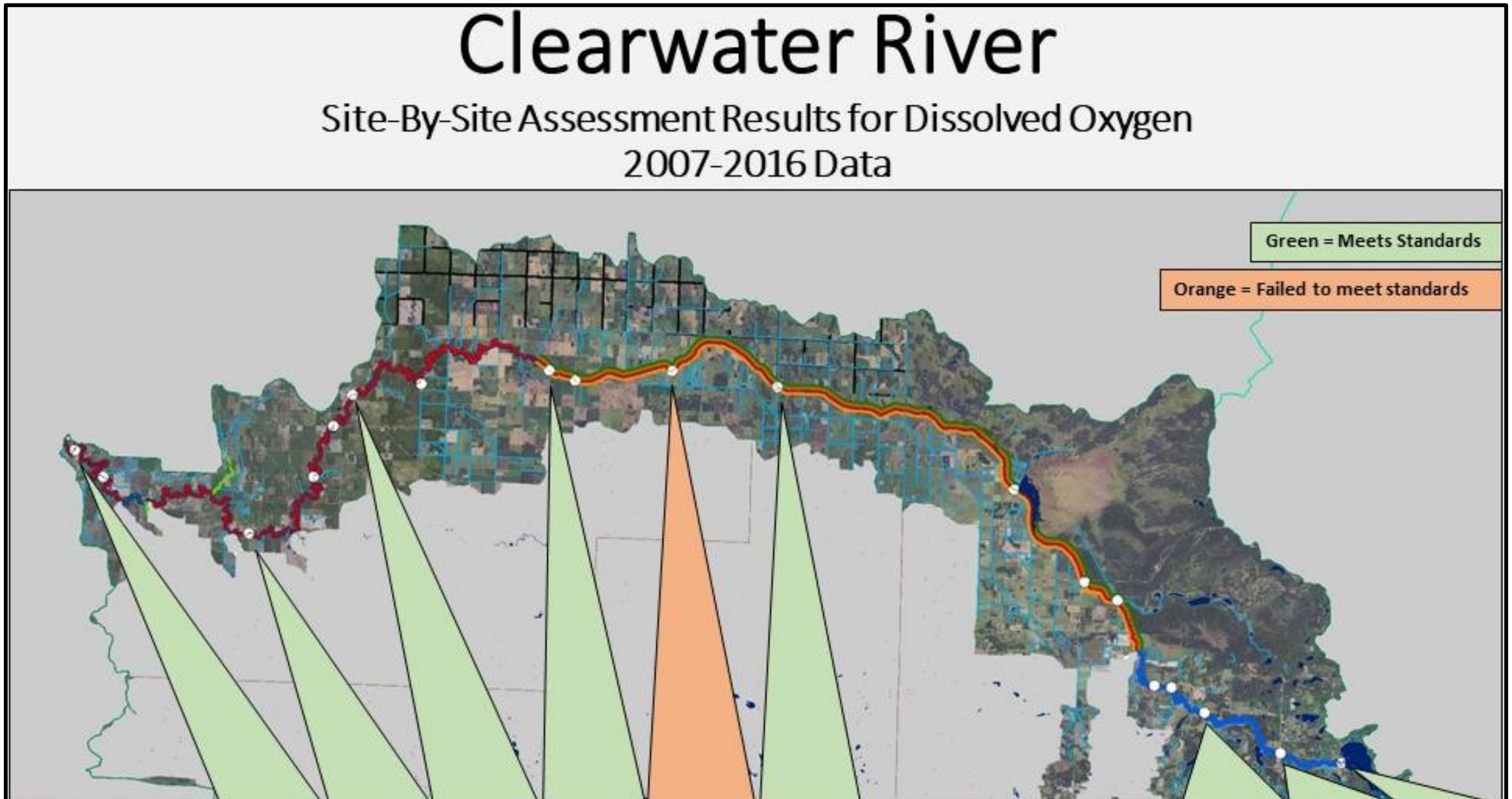
Low DO and warm temperatures are a potential concern in the trout stream portion of the Clearwater River. Discrete DO data and biological sampling results were good, but 2014 DO logger deployments found that DO levels can occasionally drop below the 7 mg/L standard that is applied to the trout stream reach. There are portions of the trout stream reach where woody vegetation has been removed by livestock grazing, resulting in less shading of the stream and increased streambank instability.

Middle Clearwater River Subwatershed

There is a history of low DO problems along the channelized portion of the Clearwater River (AUID 647). The Clearwater River (AUIDs 647 and 648) was listed as impaired for DO in 2002 because low DO levels were recorded within the channelized portion of the Clearwater River. At the time of the 2016 assessment discrete and DO logger data indicated that the river was meeting standards and the DO impairments of AUIDs 647 and 648 were delisted. Further data collection and investigation is recommended. In the past, there have been complaints about summer fish kills in the channelized portion of the Clearwater River. A lack of shading and a lack of channel diversity along the channelized reach are likely limiting DO levels in that portion of the river. A longitudinal assessment of the Clearwater River, in Figure 2-24, shows that the extent of low DO problems is limited. The DO levels seem to recover as the river flows downstream.

Lower Clearwater River Subwatershed

The lower portion of the Clearwater River contains good levels of DO, but some of the river's tributaries have experienced problems with low DO. Low DO levels have been recorded in Terrebonne Creek, but the low DO levels were associated with a lack of flow and stagnant conditions at the CSAH 92 crossing. An analysis of paired flow and DO data found that Terrebonne Creek meets the DO standard as long as there is at least 1 CFS of flow in the channel. Poor buffers within AUID 651 and stagnant water may have caused the occasional low DO levels in the IBI-impaired AUID 652 portion of Beau Gerlot Creek. Low DO was found in Red Lake CD 23 during the 2016 SID process. The low DO in CD 23 was most likely caused by a lack of base flow, especially when the ditch stops flowing in the latter part of summer.



Site ID:	S002-118	S002-914	S002-124	S002-916	S003-174	S002-121		S002-752	S001-461	S002-119
AUID (09020305-XXX)	501	511	648	647	647	647		650	649	649
Street/Road:	Bottineau Ave	CSAH 12	Minnesota St. N	280th Ave SE	CSAH 10	370th Ave SE		CSAH 11	CSAH 14 (249th Ave)	Clearwater Lake Rd.
Discrete and Continuous Dissolved Oxygen Measurements DO5_All (May-September Daily Minimums)										
Days with Data	227	44	182	150	59	101		119	11	20
Daily Minimums <5 mg/L	0	0	2	8	6	3		2	0	0
% of Days with Low DO	0.0%	0.0%	1.1%	5.3%	10.2%	3.0%		1.7%	0.0%	0.0%
Discrete Dissolved Oxygen Measurements Only DO5_All (May-September Daily Minimums)										
Days with Data	208	44	143	47	45	94		35	11	20
Daily Minimums <5 mg/L	0	0	2	0	4	3		0	0	0
% of Days with Low DO	0.0%	0.0%	1.4%	0.0%	8.3%	3.2%		0.0%	0.0%	0.0%

Figure 2-24. Longitudinal, site-specific assessment of DO data along the middle and lower subwatersheds of the Clearwater River

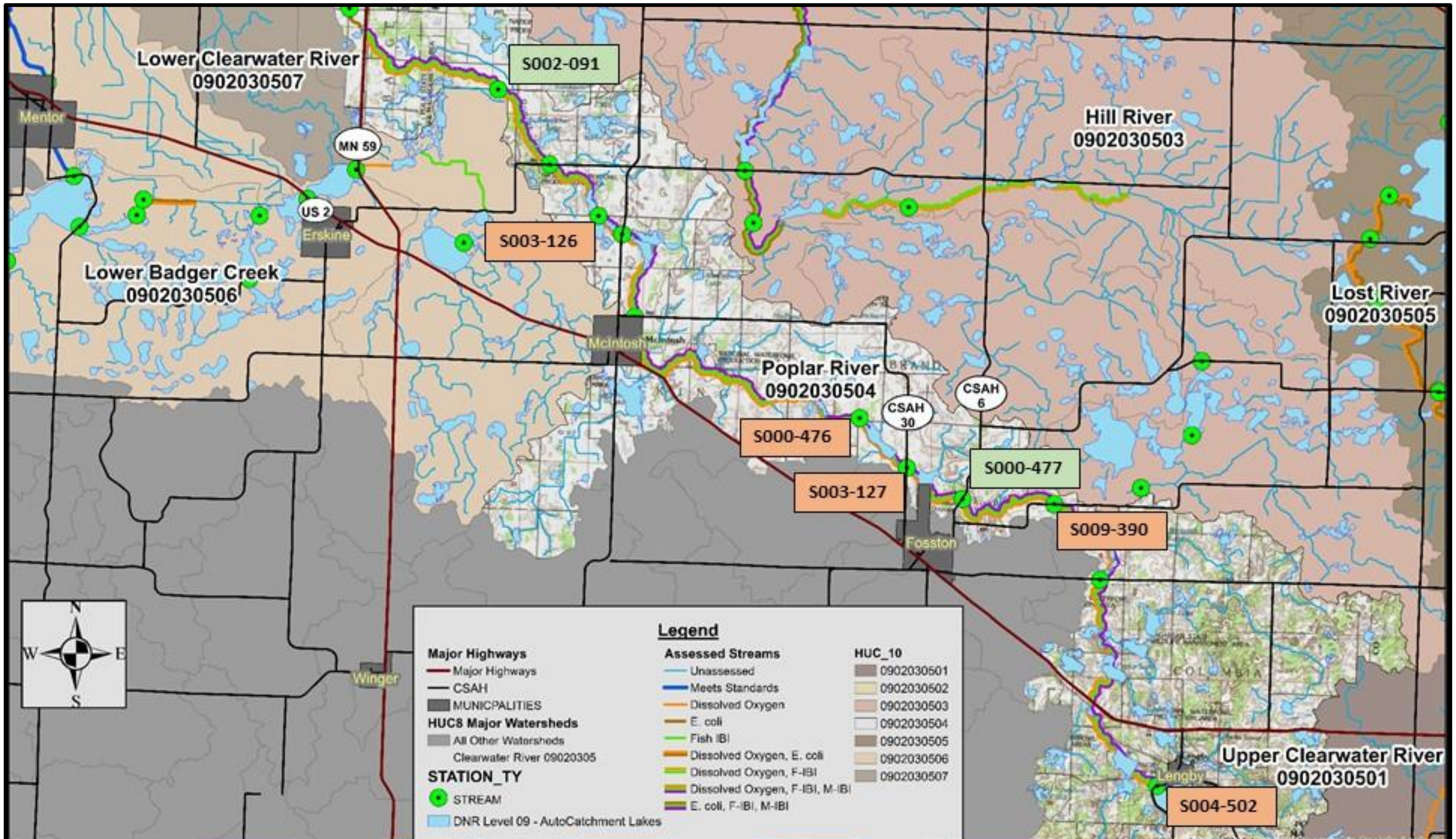
Hill River Subwatershed

The Hill River is impaired by low DO upstream of Hill River Lake (AUID 656). Investigative monitoring, as part of the WRAPS process, discovered that the low DO problem may originate upstream, along the AUID 655 portion of the river downstream of Cross Lake. Potential causes of the low DO problem in the Hill River upstream of Hill River Lake (AUIDs 656 and 655) include flow blockages that are caused by private stream crossings, beaver dams, poor-quality buffers, channelization, and areas with a very low gradient. Low IBI scores were found in a portion of the Hill River downstream of Hill River Lake. The IBI impairments were partially caused by low DO. Portions of the Hill River have a low gradient (Hill River Lake through 310th Avenue Southeast) where low DO concentrations are found in stagnant water. Some research could be done to find ecologically appropriate options for making the channel more suitable for fish and aquatic macroinvertebrates. As the river turns to the west and the gradient increases, DO levels also begin to increase. Near the town of Brooks, DO levels in the Hill River are excellent.

Poplar River Subwatershed

The Poplar River is impaired by low DO between Spring Lake and Highway 59 (AUID 518). Low IBI scores were also identified in this reach and are at least partially caused by low DO. This portion of Poplar River is relatively long and complex. Characteristics like gradient and DO levels vary throughout AUID 518 (Figure 2-26). The river flows through a series of lakes and wetlands. The DO levels are often depressed in those low-gradient areas where the stream is flowing through riparian wetlands, or shortly downstream of those wetland areas. The DO concentrations improve where the river flows between those wetlands due to increased gradient and a more defined channel. The worst F-IBI score along the Poplar River was found upstream of the CSAH 27 (395th Street Southeast) crossing (14RD218). Between CSAH 1 and CSAH 27, the Poplar River flows through a large wetland on the western side of Whitefish Lake where the channel nearly disappears in aerial photos (Figure 2-25).

Figure 2-25. Aerial photo of the Poplar River (AUID 518) where it flows through wetlands on the west end of Whitefish Lake



Site ID:	S002-091	S003-126	S000-476	S003-127	S000-477	S009-390	S004-502
Street/Road:	315th St SE	340th St. SE	380th St. SE	CSAH 30	CSAH 6	CSAH 27	390th St. SE Spring L Outlet
Discrete and Continuous Dissolved Oxygen Measurements DO5_All (May-September Daily Minimums)							
Days with Data	26	80	36	202	45	50	70
Daily Minimums <5 mg/L	2	52	32	74	2	47	41
% of Days with Low DO	7.7%	65.0%	88.9%	36.6%	4.4%	94.0%	58.6%
Discrete Dissolved Oxygen Measurements Only DO5_All (May-September Daily Minimums)							
Days with Data	26	32	14	73	27	12	17
Daily Minimums <5 mg/L	2	7	8	4	1	8	0
% of Days with Low DO	7.7%	21.9%	57.1%	5.5%	3.7%	66.7%	Insufficient Data

Figure 2-26. Longitudinal DO assessment along the Poplar River

Figure 2-26 shows that DO levels are low in the headwaters between Spring Lake and CSAH 27, then recover as it flows west to CSAH 6 near the city of Fosston. Then, DO levels are depressed between the cities of Fosston and McIntosh but recover before the river reaches Highway 59. The DO levels in the Poplar River are generally dependent upon the gradient of the stream as they are depressed in low, wetland-like portions and improve where the river is free-flowing in a defined channel. Low DO levels have also been recorded along the lower portion of the Poplar River (AUID 504) between Highway 59 and the Lost River. Stagnant pools upstream of road crossings and beaver dams are the known factors that could be causing low DO levels in that portion of the river. Investigation of low DO problems along the Poplar River has been limited to the impaired reach (AUID 518). Biological (IBI) scores within the lower reach (AUID 504) were good, which indicated that DO levels were likely adequate for aquatic life.

Lost River Subwatershed

Low DO levels have been found in the Lost River upstream of Pine Lake (AUIDs 529, 530, and 545) and downstream of Anderson Lake (AUID 645). Upstream of Pine Lake, evidence suggests that low DO problems are primarily caused by natural features of the landscape like on-channel wetlands and ponding of water behind beaver dams. A lack of shading could also limit DO levels. Large portions of the riparian area have been cleared of trees. There is a lack of aeration in areas with stagnant water and respiration consumes oxygen as decomposition occurs within the organic soils of on-channel wetlands. There is a possibility of groundwater influence upon flows in streams near Pine Lake. The groundwater would likely be low in DO until the water in the stream was mechanically aerated (flowing over a rock riffle).

Downstream of Anderson Lake, DO logger deployments have discovered that low DO is not only caused by stagnant conditions, but is also caused by high levels of DO flux that may originate in Anderson Lake. Further investigation of Anderson Lake is recommended to confirm that it is the origin of the high DO flux and low daily minimum DO levels and to identify projects that could reduce DO flux or increase DO levels downstream of the lake.

Lower Badger Creek Subwatershed

The headwaters portion of the Lower Badger Creek Subwatershed (upstream and east of Maple Lake) includes multiple ditches that failed to meet DO standards (AUID 550). The low DO problems are mostly caused by physical features of the landscape. Water flowing from shallow lakes and wetlands into the Poplar River diversion channel and into JD 73 has been naturally low in DO. A wetland upstream of the primary JD 73 monitoring site was the most likely cause of the AUID 550 DO impairment. A poor-quality buffer along a channelized portion of Lower Badger Creek may have been a factor in causing frequent low DO levels that were recorded at the 150th Avenue crossing of Lower Badger Creek during DO logger deployments in 2016.

2.4 TMDL Summary

The Clearwater River Watershed TMDL (Tables 2-35 through 2-38) report was completed in late 2020. TMDL establishment sites were chosen for each impaired AUID at frequently monitored sites that are nearest to the pour point of the reach. Measured flow records were used, where available, to calculate the TMDLs. Simulated flows from the 1996 through 2016 version of the Clearwater River Watershed HSPF model were used wherever modeled flow data was unavailable. Monitoring data from the most recent 10 years, where available, was summarized by flow regime to estimate current loads and load reductions. Most of the tributaries are monitored regularly at crossings that are near the pour points of those reaches. The TMDLs addressed the following, pollutant-based impairments:

- 5 TSS impairments
- 15 *E. coli* impairments
- 1 River eutrophication impairment
- 3 Lake eutrophication impairments

The TMDL report summarizes the data analysis and on-the-ground investigation that was conducted to determine the causes of IBI and DO impairments. No connections between DO/IBI impairments and pollutant loading were identified. Investigation of data and physical characteristics found that those impairments have been influenced by non-pollutant factors like a lack of flow, fish passage barriers, and in-stream habitat. The non-pollutant impairments that were not addressed with TMDLs, but may be addressed with other strategies include:

- 8 DO impairments
- 7 F-IBI impairments
- 3 M-IBI impairments

Two low DO impairments were recategorized from Class 5 to 4C because the impairments are caused by non-pollutant causes, but remained on the 2018 List of Impaired Waters.

Table 2-35. Summary of TSS TMDL loading capacities, load allocations, and load reductions

Clearwater River Watershed ● Total Suspended Solids ● Total Maximum Daily Loads ● Tons/Day												
Stream Name AUID Station ID	Pollutant (Standard)	Units	Flow Conditions	Loading Capacity	Allocations						Current Daily Load	Percent Reduction Needed
					Total WWTF Wasteload Allocation	Margin of Safety	Reserve Capacity	Construction & Industrial Stormwater	Upstream Waters	Load Allocation		
Clearwater River 09020305-501 S002-118	Total Suspended Solids (30 mg/l)	Tons/ Day	Very High	114.08	0.19	11.41	5.7	0.02	43.48	53.28	164.57	**30.68%**
			High	24.27	0.19	2.43	1.21	<0.005	11.00	9.44	10.98	0.00%
			Mid	9.71	0.19	0.97	0.49	<0.005	3.05	5.01	0.96	0.00%
			Low	5.26	0.19	0.53	0.26	<0.005	0.78	3.50	0.41	0.00%
			Very Low	2.43	0.19	0.24	0.12	<0.005	0.09	1.79	0.09	0.00%
			Estimated total annual load reduction needed to meet the 30 mg/L standard:								1,842.72	**25.15%**
Clearwater River 09020305-511 S002-914	Total Suspended Solids (30 mg/l)	Tons/ Day	Very High	128.28	0.19	12.83	6.41	0.02	32.70	76.13	304.09	**57.82%**
			High	32.61	0.19	3.26	1.63	0.01	8.61	18.91	18.11	0.0%
			Mid	9.73	0.19	0.97	0.49	<0.005	2.40	5.68	0.75	0.0%
			Low	2.74	0.19	0.27	0.14	<0.005	0.60	1.54	0.59	0.0%
			Very Low	0.48	0.19	0.05	0.02	<0.005	0.08	0.14	Unknown	Unknown
			Estimated total annual load reduction needed to meet the 30 mg/L standard:								6,417.07	**48.61%**
Clearwater River 09020305-648 S002-124	Total Suspended Solids (30 mg/l)	Tons/ Day	Very High	53.24	N/A	5.32	2.66	0.01	13.52	31.73	70.47	**24.45%**
			High	13.92	N/A	1.39	0.70	<0.005	3.27	8.56	12.10	0.0%
			Mid	6.31	N/A	0.63	0.32	<0.005	0.85	4.51	1.06	0.0%
			Low	3.88	N/A	0.39	0.19	<0.005	0.19	3.11	0.29	0.0%
			Very Low	2.27	N/A	0.23	0.11	<0.005	0.02	1.91	0.05	0.0%
			Estimated total annual load reduction needed to meet the 30 mg/L standard:								628.90	**15.69%**
Clearwater River 09020305-647 S002-916	Total Suspended Solids (30 mg/l)	Tons/ Day	Very High	54.66	N/A	5.47	2.73	0.01	13.52	32.93	55.69	**1.85%**
			High	13.35	N/A	1.34	0.67	<0.005	3.27	8.07	16.23	**17.74%**
			Mid	3.62	N/A	0.36	0.18	<0.005	0.85	2.23	2.21	0.00%
			Low	0.96	N/A	0.1	0.05	<0.005	0.19	0.62	0.09	0.00%
			Very Low	0.17	N/A	0.02	0.01	<0.005	0.02	0.12	0.01	0.00%
			Estimated total annual load reduction needed to meet the 30 mg/L standard:								352.96	8.87%
Nassett Creek 09020305-545 S004-205	Total Suspended Solids (10 mg/l)	Tons/ Day	Very High	0.2677	N/A	0.03	N/A	<0.005	N/A	0.24	Unknown	Unknown
			High	0.0607	N/A	0.01	N/A	<0.005	N/A	0.05	Unknown	Unknown
			Mid	0.0172	N/A	<0.005	N/A	<0.005	N/A	0.02	Unknown	Unknown
			Low	0.0048	N/A	<0.005	N/A	<0.005	N/A	<0.005	Unknown	Unknown
			Very Low	0.0005	N/A	<0.005	N/A	<0.005	N/A	<0.005	Unknown	Unknown
			Estimated total annual load reduction needed to meet the 30 mg/L standard:									

Table 2-36. Summary of *E. coli* TMDL loading capacities, load allocations, and load reductions

Clearwater River Watershed ● *Escherichia Coli* Bacteria ● Total Maximum Daily Loads ● Billions of Organisms per Day										
Stream Name AUID Station ID	Pollutant (Standard)	Units	Flow Conditions	Loading Capacity	Allocations				Current Load	Percent Reduction Needed
					WWTF Wasteload Allocation	Margin of Safety	Reserve Capacity	Load Allocation		
Lower Badger Creek 09020305-502 S004-837	*E. coli*, 126 MPN/100ml	Billions of Orgs/Day	Very High	306.21	N/A	61.24	N/A	244.97	798.95	61.67%
			High	122.01	N/A	24.40	N/A	97.61	81.35	0.00%
			Mid	34.49	N/A	6.90	N/A	27.59	23.89	0.00%
			Low	17.53	N/A	3.51	N/A	14.02	6.81	0.00%
			No Flow	0.00	N/A	0.00	N/A	0.00	0.00	0.00%
			Estimated total annual load reduction needed to meet the 126 MPN/100ml standard:						17,985.01	44.59%
Poplar River 09020305-504 S007-608	*E. coli*, 126 MPN/100ml	Billions of Orgs/Day	Very High	280.44	35.51	56.09	14.02	174.82	423.11	33.72%
			High	135.64	35.51	27.13	6.78	66.22	97.03	0.00%
			Mid	55.82	35.51	11.16	2.79	6.36	28.02	0.00%
			Low	24.35	*	4.87	1.22	18.26	8.28	0.00%
			No Flow	0.00	*	0.00	0.00	0.00	0.00	0.00%
			Estimated total annual load reduction needed to meet the 126 MPN/100ml standard:						5,207.46	18.06%
Lost River 09020305-512 S000-924	*E. coli*, 126 MPN/100ml	Billions of Orgs/Day	Very High	254.36	0.48	50.87	12.72	190.29	108.20	0.00%
			High	62.41	0.48	12.48	3.12	46.33	122.17	48.92%
			Mid	19.27	0.48	3.85	0.96	13.98	29.26	34.14%
			Low	4.97	0.48	0.99	0.25	3.25	8.69	42.81%
			Very Low	0.46	0.48	0.09	0.02	0.35	No Data	Unknown
			Estimated total annual load reduction needed to meet the 126 MPN/100ml standard:						7,680.33	37.62%
Ruffy Brook 09020305-513 S008-057	*E. coli*, 126 MPN/100ml	Billions of Orgs/Day	Very High	349.08	5.25	69.82	17.45	256.56	1704.76	79.5%
			High	131.13	5.25	26.23	6.56	93.09	207.39	36.8%
			Mid	37.11	5.25	7.42	1.86	22.58	53.04	30.0%
			Low	14.71	5.25	2.94	0.74	5.78	11.49	0.00%
			No Flow	0.00	0.00	0.00	0.00	0.00	0.00	0.00%
			Estimated total annual load reduction needed to meet the 126 MPN/100ml standard:						58,995.68	65.8%
Clear Brook 09020305-526 S004-044	*E. coli*, 126 MPN/100ml	Billions of Orgs/Day	Very High	29.38	N/A	5.88	N/A	23.5	15.24	0.00%
			High	7.20	N/A	1.44	N/A	5.76	9.12	21.05%
			Mid	2.00	N/A	0.40	N/A	1.60	1.13	0.00%
			Low	0.55	N/A	0.11	N/A	0.44	0.04	0.00%
			Very Low	0.06	N/A	0.01	N/A	0.05	0.03	0.00%
			Estimated total annual load reduction needed to meet the 126 MPN/100ml standard:						210.24	12.80%
Silver Creek 09020305-527 S002-082	*E. coli*, 126 MPN/100ml	Billions of Orgs/Day	Very High	120.76	N/A	24.15	N/A	96.61	38.88	0.00%
			High	30.49	N/A	6.10	N/A	24.39	7.25	0.00%
			Mid	9.71	N/A	1.94	N/A	7.77	5.91	0.00%

Clearwater River Watershed ● *Escherichia Coli* Bacteria ● Total Maximum Daily Loads ● Billions of Organisms per Day										
Stream Name AUID Station ID	Pollutant (Standard)	Units	Flow Conditions	Loading Capacity	Allocations				Current Load	Percent Reduction Needed
					WWTF Wasteload Allocation	Margin of Safety	Reserve Capacity	Load Allocation		
			Low	2.23	N/A	0.45	N/A	1.78	2.70	**17.41%**
			Very Low	0.00	N/A	0.00	N/A	0.00	0.00	0.00%
			Estimated total annual load reduction needed to meet the 126 MPN/100ml standard:						22.46	**0.81%**
Lost River 09020305-529 S005-283	*E. coli*, 126 MPN/100ml	Billions of Orgs/Day	Very High	179.16	N/A	35.83	N/A	143.33	94.81	0.00%
			High	101.39	N/A	20.28	N/A	81.11	48.25	0.00%
			Mid	47.22	N/A	9.44	N/A	37.78	76.46	**38.24%**
			Low	14.30	N/A	2.86	N/A	11.44	8.53	0.00%
			Very Low	0.00	N/A	0.00	N/A	0.00	0.00	0.00%
			Estimated total annual load reduction needed to meet the 126 MPN/100ml standard:						2,134.52	**14.07%**
Lost River 09020305-530 S005-501	*E. coli*, 126 MPN/100ml	Billions of Orgs/Day	Very High	102.00	N/A	20.40	N/A	81.6	37.11	0.00%
			High	23.12	N/A	4.62	N/A	18.50	34.31	**32.61%**
			Mid	6.56	N/A	1.31	N/A	5.25	6.88	**4.65%**
			Low	1.82	N/A	0.36	N/A	1.46	3.08	**40.91%**
			Very Low	0.17	N/A	0.03	N/A	0.14	No Data	Unknown
			Estimated total annual load reduction needed to meet the 126 MPN/100ml standard:						1,386.64	**23.30%**
Hill River 09020305-539 S002-134	*E. coli*, 126 MPN/100ml	Billions of Orgs/Day	Very High	373.47	N/A	74.69	N/A	298.78	200.80	0.00%
			High	125.37	N/A	25.07	N/A	100.3	139.06	**9.84%**
			Mid	58.57	N/A	11.71	N/A	46.86	68.12	**14.02%**
			Low	11.89	N/A	2.38	N/A	9.51	12.05	**1.33%**
			No Flow	0.00	N/A	0.00	N/A	0.00	0.00	0.00%
			Estimated total annual load reduction needed to meet the 126 MPN/100ml standard:						2,212.21	**7.70%**
Nassett Creek 09020305-545 S004-205	*E. coli*, 126 MPN/100ml	Billions of Orgs/Day	Very High	30.6	N/A	6.12	N/A	24.48	29.55	0.00%
			High	6.94	N/A	1.39	N/A	5.55	10.14	**31.56%**
			Mid	1.97	N/A	0.39	N/A	1.58	1.53	0.00%
			Low	0.55	N/A	0.11	N/A	0.44	2.48	**77.82%**
			Very Low	0.05	N/A	0.01	N/A	0.04	No Data	0.00%
			Estimated total annual load reduction needed to meet the 126 MPN/100ml standard:						561.74	**21.84%**

Clearwater River Watershed ● *Escherichia Coli* Bacteria ● Total Maximum Daily Loads ● Billions of Organisms per Day											
					Allocations						
Stream Name AUID Station ID	Pollutant (Standard)	Units	Flow Conditions	Loading Capacity	Total WWTF Wasteload Allocation	Margin of Safety	Reserve Capacity	Upstream Waters	Load Allocation	Current Load	Percent Reduction Needed
Judicial Ditch 73 09020305-550 S003-318	*E. coli*, 126 MPN/100ml	Billions of Orgs/Day	Very High	368.37	N/A	73.67	N/A	N/A	294.7	789.16	**53.32%**
			High	140.71	N/A	28.14	N/A	N/A	112.57	161.37	**12.80%**
			Mid	43.35	N/A	8.67	N/A	N/A	34.68	59.58	**27.24%**
			Low	7.92	N/A	1.58	N/A	N/A	6.34	39.91	**80.16%**
			No Flow	0.00	N/A	0.00	N/A	N/A	0.00	0.00	0.00%
			Estimated total annual load reduction needed to meet the 126 MPN/100ml standard:							21,011.24	**39.22%**
Terrebonne Creek 09020305-574 S004-819	*E. coli*, 126 MPN/100ml	Billions of Orgs/Day	Very High	34.27	N/A	6.85	N/A	N/A	27.42	60.07	**42.95%**
			High	3.37	N/A	0.67	N/A	N/A	2.70	1.37	0.00%
			No Flow	0.00	N/A	0.00	N/A	N/A	0.00	0.00	0.00%
			Estimated total annual load reduction needed to meet the 126 MPN/100ml standard:							941.70	**41.36%**
Brooks Creek 09020305-578 S006-578	*E. coli*, 126 MPN/100ml	Billions of Orgs/Day	Very High	82.72	N/A	16.54	N/A	N/A	66.18	130.03	**36.38%**
			High	21.04	N/A	4.21	N/A	N/A	16.83	24.73	**14.92%**
			Mid	5.79	N/A	1.16	N/A	N/A	4.63	5.87	**1.36%**
			Low	1.53	N/A	0.31	N/A	N/A	1.22	2.97	**48.48%**
			Very Low	0.17	N/A	0.03	N/A	N/A	0.14	No Data	0.00%
			Estimated total annual load reduction needed to meet the 126 MPN/100ml standard:							2,294.39	**27.95%**
Clearwater River 09020305-647 S002-916	*E. coli*, 126 MPN/100ml	Billions of Orgs/Day	Very High	2,082.59	5.25	416.52	N/A	1,030.42	526.27	526.27	0.00%
			High	508.70	5.25	101.74	N/A	249.50	126.78	126.78	0.00%
			Mid	138.08	5.25	27.62	N/A	65.13	33.18	33.18	**12.41%**
			Low	36.57	5.25	7.31	N/A	14.71	7.47	7.47	0.00%
			Very Low	6.57	*	1.31	N/A	1.47	3.46	3.46	0.00%
			Estimated total annual load reduction needed to meet the 126 MPN/100ml standard:							1,428.91	**5.74%**
Beau Gerlot Creek 09020305-651 S004-816	*E. coli*, 126 MPN/100ml	Billions of Orgs/Day	Very High	224.87	N/A	44.97	N/A	N/A	179.90	222.55	0.00%
			High	55.17	N/A	11.03	N/A	N/A	44.14	41.22	0.00%
			Mid	14.62	N/A	2.92	N/A	N/A	11.70	36.47	**59.91%**
			Low	3.97	N/A	0.79	N/A	N/A	3.18	2.31	0.00%
			Very Low	0.03	N/A	0.01	N/A	N/A	0.02	0.00	0.00%
			Estimated total annual load reduction needed to meet the 126 MPN/100ml standard:							1,595.05	**21.64%**
*The calculated WLA for this flow regime exceeded daily loading capacity, so WLA/LA allocations were based on flow volume and the 126 MPN/100mL standard.											

Table 2-37. Summary of river TP TMDL loading capacities, load allocations, and load reductions

Clearwater River Watershed ● Total Phosphorus ● Total Maximum Daily Loads ● Pounds/Day											
					Allocations						
Stream Name AUID Station ID	Pollutant (Standard)	Units	Season or Flow Conditions	Loading Capacity	WWTF Wasteload Allocation	Margin of Safety	Reserve Capacity	Construction & Industrial Stormwater	Load Allocation	Current Daily Load	Percent Reductio n Needed
Clearwater River 09020305-647 S002-916	Total Phosphorus (100 µg/l)	Pounds/Day	Summer Average	51.36	1.50	5.14	2.57	.01	20.01	64.71	13.35%

Table 2-38. Summary of lake TP TMDL loading capacities, load allocations, and load reductions

Clearwater River Watershed ● Total Phosphorus ● Total Maximum Daily Loads ● Pounds/Year												
				Wasteload Allocations			BATHTUB Modeled Loads					
Lake Name Lake ID	Pollutant (Standard)	Units		Const. & Ind. Stormwater WLA	WWTF WLA	SSTS	Nonpoint Runoff	Atm. Deposition	Internal Load	Margin of Safety	Total Load Allocation	Total Load
Cameron Lake 60-0189-00	Total Phosphorus (60 µg/l)	Pounds / Year	Existing TP Load:	0.09	N/A	0.44	209.13	21.38	696.22		927.17	927.26
			Allowable TP Load:	**0.09**	**N/A**	**0.00**	**73.99**	**21.38**	**280.54**	**41.78**	**375.91**	**417.78**
			Estimated Load Reduction:	0.00	N/A	0.44	135.14	0.00	415.68		551.26	509.48
			Percent Load Reduction:	0.00%	N/A	100%	65%	0%	60%		59%	55%
Long Lake 04-0295-00	Total Phosphorus (30 µg/l)	Pounds / Year	Existing TP Load:	0.01	N/A	0.44	303.57	9.04	87.96		401.00	401.02
			Allowable TP Load:	**0.01**	**N/A**	**0.00**	**194.66**	**9.04**	**13.56**	**24.14**	**217.25**	**241.41**
			Estimated Load Reduction:	0.00	N/A	0.44	108.91	0.00	74.40		183.75	159.61
			Percent Load Reduction:	0%	N/A	100%	36%	0%	85%		46%	40%
Stony Lake 15-0156-00	Total Phosphorus (60 µg/l)	Pounds / Year	Existing TP Load:	0.01	N/A	0.26	91.00	7.28	352.29		450.83	450.84
			Allowable TP Load:	**0.01**	**N/A**	**0.00**	**25.78**	**7.28**	**73.08**	**11.80**	**106.14**	**117.95**
			Estimated Load Reduction:	0.00	N/A	0.26	65.22	0.00	279.21		344.69	332.89
			Percent Load Reduction:	0%	N/A	100%	72%	0%	79%		76%	74%

2.5 Protection Considerations

0902030501 Upper Clearwater River

Figure 2-27. Clearwater River (AUID 649), looking downstream from the Clearwater Lake Dam

The Upper Clearwater River HUC-10 includes:

- Headwaters of the Clearwater River (09020305-517)
- Walker Brook (09020305-509)
- Trout stream portion of the Clearwater River (0920305-653)
- Clearwater River near the Clearwater Lake inlet (09020305-654)
- High quality reach of the Clearwater River downstream of Clearwater Lake (09020305-649, Figure 2-27)
- Bagley Lake (15-0040)
- Buzzle Lake (04-0297)
- Clearwater Lake (05-0343)
- First Lake (15-0139)
- Funkley Lake (04-0299)
- Lake Lomond (15-0081)
- Little Buzzle Lake (04-0298)
- Long Lake (04-0295)
- Long lake (15-0050)
- Minnow Lake (15-0137)
- Sabe Lake (15-0138)
- Second Lake (15-0140)
- Spring Lake (04-0303)
- Walker Brook Lake (15-0060)
- Whitefish Lake (04-0300)
- City of Bagley

Stormwater from the city of Bagley flows to the headwaters reach of the Clearwater River, and some residential stormwater runoff flows into Lake Lomond. Stormwater runoff from the city has been treated with three stormwater ponds and an infiltration basin that were installed in 2003. Improvements to the Bagley WWTF after the 1997 flooding have been important for protecting water quality in the headwaters and trout stream reaches of the Clearwater River. An emerging concern in the city of Bagley is the discovery of zebra mussel larvae in Lake Lomond, which outlets to a small stream that eventually flows into the Clearwater River.

Walker Brook was listed as impaired by low DO in 2002. As a result, the subwatershed was intensively studied to identify the cause of the impairment. Natural conditions were found to be causing the low DO and the impairment was recategorized to EPA category 4D which does not require a TMDL. The stream is fed by ancient groundwater that is seeping from aquifers. Decomposition of organic material in riparian wetlands and fens also depletes DO levels in the steam.

Although the trout stream reach (AUID 653) of the Clearwater River is not impaired, there have been concerns about declining water quality and habitat. The DNR has been stocking rainbow and brown trout into the upper portion of the trout stream reach of the Clearwater River (AUID 653) since 1947. There has been a lack of evidence of carryover through the winter, however, and there have been few documented reports of natural reproduction. The loss of most fish in the system during winters and small size of trout (<13 inches) have resulted in angler dissatisfaction with the size structure of fish in their creels.

The DNR initiated a study of the effects of water quality on winter carryover of trout in the Clearwater River in 2007 that involved DO monitoring and tracking of fish with radio telemetry. Some equipment failures hampered the study, but successful DO logger deployments found that DO occasionally dropped below 7 mg/L (the standard for trout streams). Deployments of DO loggers were also completed during the Clearwater WRAPS project in the trout stream reach of the Clearwater River (near CSAH 22 at S002-929) and concentrations occasionally dropped below the 7 mg/L threshold during those deployments (Figure 2-28). A meander cut-off recently occurred upstream of CSAH 22 (S002-929). The stream now bypasses a weir that may have acted as a fish passage barrier in the past, but the increased gradient may also increase erosion. Some unstable streambanks have been found downstream of CSAH 22 and a project was completed to repair one of those banks. Unstable banks have also been found in areas where riparian vegetation has been disturbed by cattle or lawn maintenance between CSAH 3 and CSAH 22.

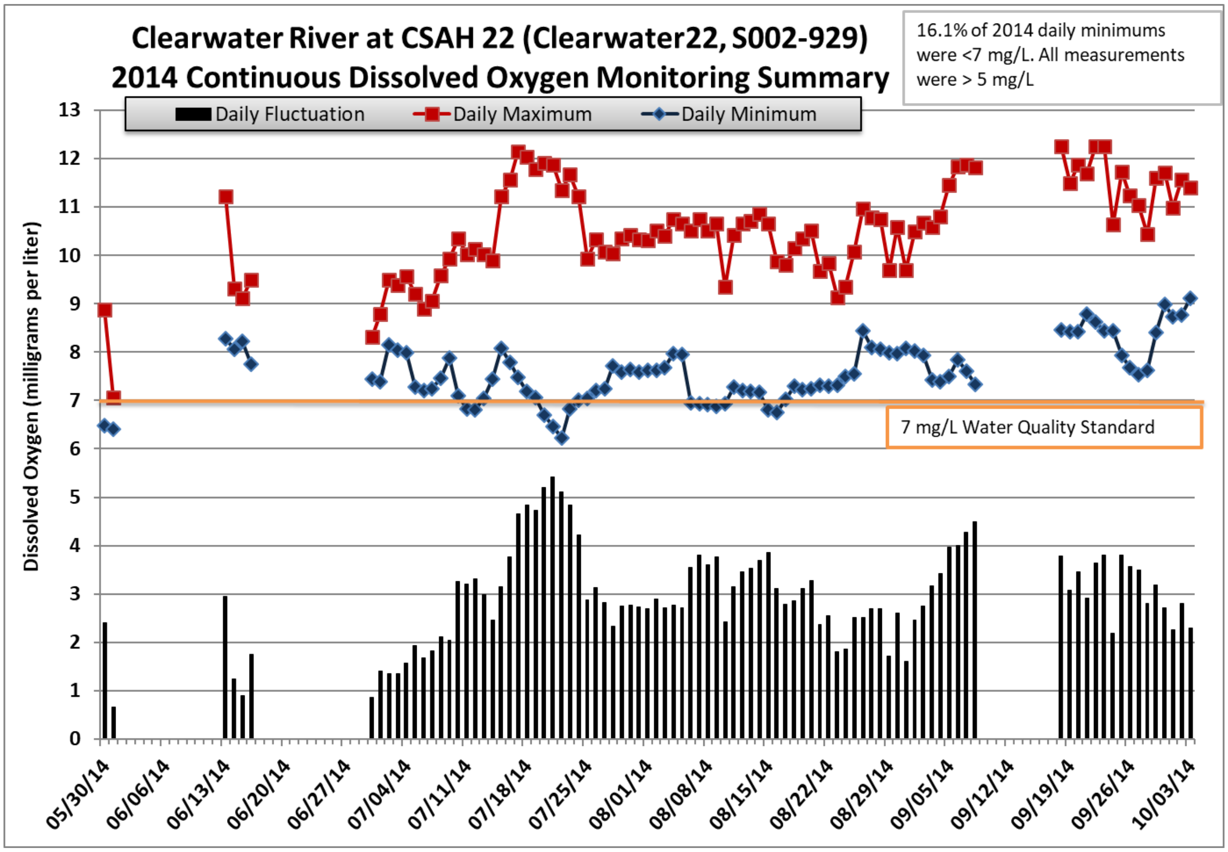


Figure 2-28. 2014 DO logger deployment results from the Clearwater River at CSAH 22 (S002-929 on AUID 653)

The trout stream reach of the Clearwater River has been impaired by fecal coliform and un-ionized ammonia in the past (the last ammonia exceedance occurred in 2002), but has recovered from those impairments. The headwaters reach of the Clearwater River (formerly AUID 517) is one of the top five un-impaired reaches in the watershed that are in the most danger of becoming impaired by *E. coli*. More work is needed in order to prevent either of the reaches that were split from AUID 517 (AUID 653 and AUID 654) from becoming impaired in the future.

A pipeline for crude petroleum crosses the trout stream reach of the Clearwater River northwest of the city of Pinewood. A 10,000-barrel rupture and spill occurred along that pipeline southeast of Pinewood in 1979 and is being used as the "National Crude Oil Spill Research Site in Bemidji" to study the effects of a terrestrial crude oil spill including the physical, chemical and biological processes driving the degradation and transport of crude petroleum.

The MPCA deployed a temperature logger in the lower portion of the designated trout stream reach, downstream of CSAH 24, due to a lack of cold-water species at Station 10EM085. Temperatures were not conducive to trout, so the MPCA split the existing AUID and reclassified the downstream portion (AUID 654) from "cold-water general" to "warm water general." The AUID 654 portion of the Clearwater River between the trout stream reach and Clearwater Lake flows through forested land that is owned by the State of Minnesota. Improving access for aquatic recreation has been discussed by local residents and RLWD for the Clearwater River upstream and downstream of Clearwater Lake.

The Clearwater River, downstream of Clearwater Lake (at CSAH 14), has the clearest water that is found in any river within the RLWD, with an average TSS concentration of just 1.78 mg/L. The lowest concentration that RMB Environmental Laboratories, Inc. can report is 1 mg/L. Despite the great water clarity along that portion of the river, livestock have access to the river and occasionally contribute to elevated concentrations of *E. coli* bacteria.

This subwatershed contains lakes with very good water quality (Buzzle Lake and Little Buzzle Lake). Although water quality is generally very good in Clearwater Lake, significant algae blooms have occurred during the history of monitoring in the lake (Figure 2-29). The CLAA is an active and informed group of citizens that are working to improve conditions within the lake. Local agencies should continue to work with the CLAA to meet the goal of protecting water quality conditions in the lake. The CLAA and the Beltrami SWCD collaborated to submit a successful application for funding to address erosion problems along the shore of Clearwater Lake. Landowners along Clearwater Lake have expressed concern about excess vegetation in parts of the lake. Sedimentation at the inlet has caused that portion of the lake to fill-in with vegetation and a delta has formed where the river enters the lake. Vegetation in Clearwater Lake was mapped and a management plan was completed for the lake in 2003.

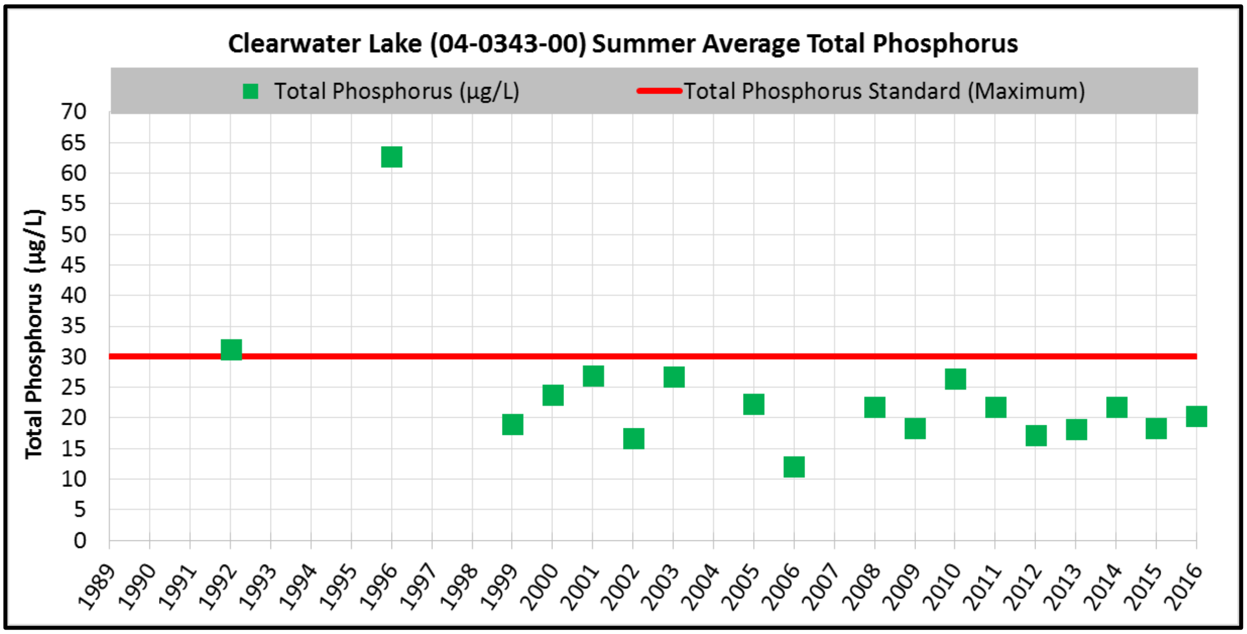


Figure 2-29. Timeline of annual average TP concentrations in Clearwater Lake

Very high TP and high chl-a concentrations have been recorded in Bagley Lake in the past. Water quality conditions have improved in recent years through implementation of BMPs. In 2011 - 2012 the SWCD designed a cattle exclusion/riparian buffer project along the south and west sides of the lake. The SWCD is also planning to use matching funds to improve the public access to reduce runoff to the lake during rain events. Walker Brook Lake, First Lake, and Second Lake are all nearly impaired for TP and chl-*a* even though there has been minimal development around any of those lakes.

0902030502 Middle Clearwater River

The Middle Clearwater River HUC-10 includes:

- Natural channel of the Clearwater River upstream of the channelized reach (09020305-650)
- Channelized portion of the Clearwater River (09020305-647)
- Ruffy Brook (09020305-513)
- East Four-Legged Lake (15-0027)

- West Four-Legged Lake (15-0028)
- Spike Lake (15-0035)
- Nels Olson Lake (15-0037)
- Falk Lake (15-0038)
- Johnson Lake (15-0086)
- Wild rice production
- Town of Leonard

Figure 2-30. Photo of children with seven brook trout that were caught in Ruffy Brook in 1925

Ruffy Brook could be considered a high priority stream for protection efforts related to aquatic habitat. In addition to its nearly impaired status for multiple parameters when compared to current expectations, there is a historical record (pre-1962) of the stream having higher quality, cold-water habitat. It historically supported trout until the mid-twentieth century. After state land was sold and forests were cleared, the stream no longer supported trout. Ruffy Brook rarely failed to meet the 5 mg/L standard in recent water quality data. However, more than 40% of daily minimums from DO loggers and discrete measurements of DO failed to meet the 7 mg/L trout stream standard in recent data. The stream has been the topic of discussion regarding possible efforts to restore the stream to historical conditions. Local residents have memories of catching trout in the stream (Figure 2-30), but the stream no longer supports cold water species. Residents have recalled enjoying swimming holes in the past along Ruffy Brook that are now filled-in with sediment from agricultural runoff. Restoration would require a collective effort among landowners along the river.

According to a report from DNR Area Fisheries in 1992, "the first records available from Ruffy Brook are from 1947. The stream is 20 miles in length and at that time, 5 miles of the river were considered fair to good trout waters." Brook trout were captured in the stream in 1947, at which time the trout stream reach (Figure 2-31) of Ruffy Brook was designated. Brown trout were stocked until 1962. Land use changes led to a decline in the stream's aquatic habitat. State land along Ruffy Brook was sold to private landowners in 1970. Removal of timber and increased cultivation of land led to erosion, sedimentation, and a reduction of the ability of the stream to support trout. A 1967 reconnaissance led to the stream being declared "no longer being able to support trout." As a result, the stream was removed from the designated trout stream list in 1972. The February 9, 1972 DNR Commissioner's Order request states the reconnaissance results, poor water quality for trout, and no attempt to limit access to hogs and cattle as the reasons for delisting the reach.

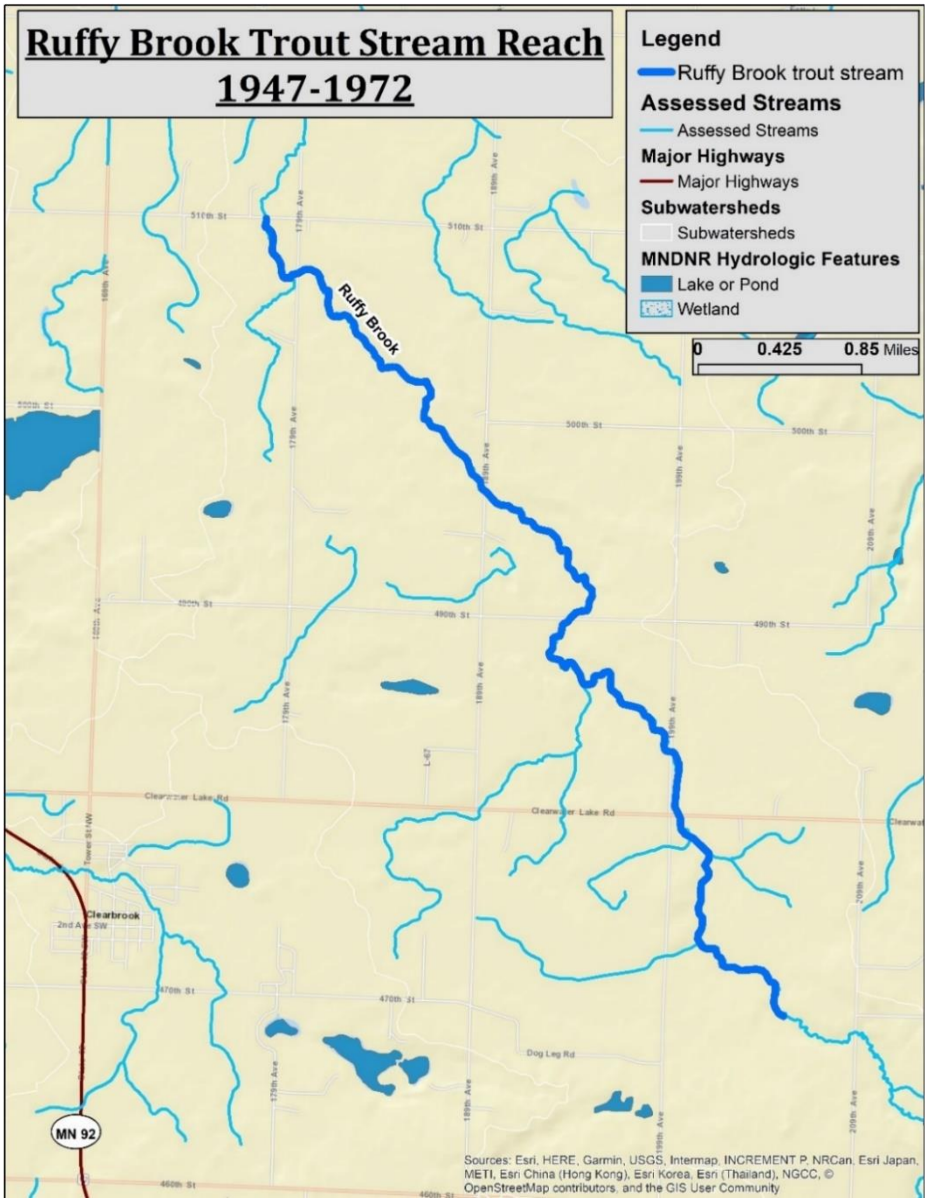


Figure 2-31. Map of the historical designated trout stream reach of Ruffy Brook (along a portion of AUID 513)

There is a history of oil spills from six crude oil pipelines in a single corridor that cross Ruffy Brook between the towns of Clearbrook and Leonard. An investigation of a pipeline break at Leonard, Minnesota on July 21, 1982 revealed a considerable amount of thin crude floating on Ruffy Brook. Another oil spill occurred along Ruffy Brook on July 22, 2000. The oil was burned, and the tarry residue was manually removed. Small amounts of oil remained one year later.

The channelized portion of the Clearwater River will be targeted with restoration efforts that are described in Section 3.4 of this report and Section 9 of the Clearwater TMDL. The original landscape setting of AUID 647 was wet prairie. This reach corresponds to the channelized portion of the Clearwater River. Resource managers believe that channelization has negatively affected water quality and biotic integrity. The channelized reach of the Clearwater River was not impaired by poor IBI scores, but IBI scores and biological metrics were depressed in this portion of the river compared to the high-quality conditions that are found in natural channel upstream and downstream of the channelized reach. Similar results were found during a local biological study that was conducted in 2003 – habitat and biology scores were lower within the channelized reach compared to upstream and downstream portions of the river.

At the September 2017 Clearwater River WRAPS Open House event, multiple attendees mentioned that the quality of fishing in the channelized reach noticeably decreased after the reach was channelized. Complaints of 2016 fish kills in the channelized portion of the Clearwater River were received by the RLWD.

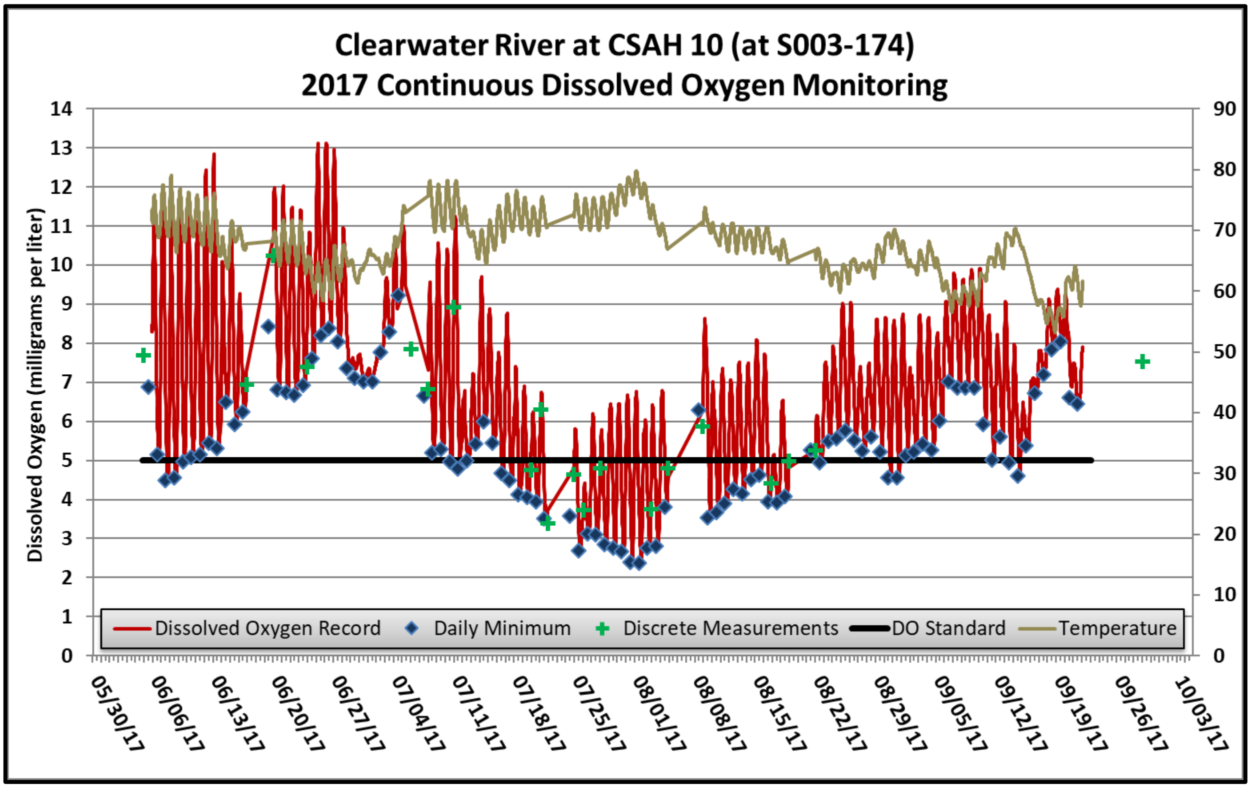


Figure 2-32. Results of 2017 DO logger deployments in the Clearwater River at CSAH 10 on AUID 647

In 2017, a DO logger was deployed at the CSAH 10 crossing (Figure 2-32). Relatively frequent discrete DO measurements were also recorded. The effort discovered that DO frequently dropped below the 5 mg/L impairment threshold in July and August. The former DO impairment on this reach has been delisted, but this data reveals that protection efforts and monitoring should continue. Longitudinal water quality measurements have shown that discharge from wild rice paddies was still negatively affecting water quality along this reach. Many improvements have been accomplished since the Clearwater Nonpoint Study was completed in 1994, but more needs to be done to mitigate the effects of pre-harvest wild rice paddy drawdowns.

0902030503 Hill River

The Hill River HUC-10 includes:

- Hill River upstream of Hill River Lake (09020305-656, 655, 535, 533, 532)
- Hill River downstream of Hill River Lake (09020305-539)
- Brooks Creek (09020305-578)
- Hill River Lake (60-0142)
- Cross Lake (60-0027)

- Turtle Lake (60-0032)
- City of Brooks

Before the Intensive Watershed Monitoring effort and the Clearwater River WRAPS, there was very little monitoring data available from the Hill River upstream of Hill River Lake. Sampling at 335th Avenue (S007-847 on AUID 656) has revealed water quality problems and a poor-quality fish community. A DO impairment was found in AUID 656, but longitudinal sampling revealed that the problem may be coming from upstream in AUID 655. Potential causes of the low DO problem along AUID 655 included flow blockages that were caused by private stream crossings, beaver dams, poor-quality buffers, channelization, and areas with very low gradient. Monitoring within AUID 656 should continue and regular data collection within AUID 655 should be initiated in order to collect robust data for the 2026 water quality assessment.

E. coli bacteria is a concern in the Hill River upstream of Hill River Lake. AUID 656 is nearly impaired by *E. coli* bacteria. There are livestock operations, including a feedlot, that are very close to the stream and could potentially contribute to elevated *E. coli* concentrations.

Table 2-39. Summary of 2018 lake sampling in Hill River Watershed lakes

2018 Lake Sampling Summary						
Lake	Summer Average TP (µg/L)	Summer Average Chl-a (µg/L)	Summer Average Secchi (m)	Applicable TP Standard (µg/L)	Applicable Chl-a Standard (µg/L)	Applicable Secchi Standard (m)
Hill River Lake	107	34.3	1.2	40	14	1.4
Cross Lake	45.5	18.5	4.9	40	14	1.4
Turtle Lake	60.2	10.6	2.1	60	20	1

Water quality in Hill River Lake had not been sampled at the time of the 2016 water quality assessment. Fish sampling results indicated that it was vulnerable to future biological impairments. The East Polk SWCD began sampling Hill River Lake in 2018 (Table 2-39) and found that it had very high concentrations of TP and chl-*a* along with low Secchi disk transparency readings. There is a strong possibility that the lake could be listed as impaired on the 2026 List of Impaired Waters. Fish passage could also be evaluated at the outlet of Hill River Lake. Cross Lake was found to be vulnerable to future biological impairments and was nearly impaired for recreation due to water chemistry and clarity levels that nearly violated water quality standards. The 2018 Cross Lake sampling results exceeded water quality standards for TP and chl-*a*.

A ditch that drains a wetland upstream of South Connection Lake (AUIDs 640 and 641) was sampled for fish and macroinvertebrates in 2010 and 2015. The results were very poor. The reach was not formally assessed. That ditch and the wetlands it drains represent an opportunity to restore large wetlands to create open water habitat for waterfowl, reduce peak flows downstream, and reduce runoff to the nearly impaired Cross Lake. There are some indications that there may be landowner support for a habitat improvement project. Portions of the wetlands lining the AUID 640/641 channel have been excavated and a landowner has also completed a significant amount of tree planting on the property.

Plumes of septic-smelling pollutants have been entering the Hill River on the downstream side of the CR 119 crossing, from the south bank of the river. Leaking septic systems were ruled-out and the problem was traced to a discharge from a truck washing station. New septic system installation at the truck wash did not resolve the problem because a plume (that smelled like diesel fuel) was again entering the river in October 2018 (Figure 2-33). The county has been working with the truck wash owner and the old pipe that drained to the roadside ditch was planned for removal in late 2020.

Figure 2-33. Pollutants entering the Hill River at the CR 119 crossing near Brooks along AUID 539

0902030504 Poplar River

The Poplar River 10-digit HUC includes:

- Poplar River (09020305-518 and 504)
- Spring Lake (60-0012)
- Poplar Lake (60-0006)
- Whitefish Lake (60-0015)
- City of Lengby
- City of Fosston
- City of McIntosh

Low DO levels have been recorded within the lower, unimpaired (by DO) portion of the Poplar River (AUID 504). The reach had good IBI scores, but quality data should be collected with DO loggers to ensure that this reach is meeting the DO standard.

Because of high TP discharges from the Fosston and McIntosh WWTFs in the past, portions of the river should be monitored for possible river eutrophication issues (at CSAH 30, downstream of the Fosston WWTF at site S003-127). High TP concentrations in some parts of the Poplar River are coming from OP being released from sediment during stagnant, low-flow conditions. A portion of the available TP in the channel bottom sediment may be from nonpoint sources, and the historical high TP concentrations in discharges from the Fosston WWTF prior to improvements to the WWTF completed in 2012. Historically, the NPDES/SDS Permit for the Fosston WWTF did not include a TP limit, however since the WWTF improvements were completed a 1.0 mg/L TP limit has been included in the permit.

Figure 2-34. Poplar River at CSAH 27 with poorly vegetated banks due to livestock along AUID 518

The upper assessment unit of the Poplar River (AUID 518) is nearly impaired by *E. coli* bacteria. Livestock have access to the river at multiple locations and have removed vegetation and damaged the stream banks (Figure 2-34). Fecal coliform concentrations in WWTF discharge from Fosston and McIntosh are typically low.

Spring Lake and Whitefish Lake are at risk of becoming impaired due to high TP and chl-*a* concentrations. Sampling of both those lakes resumed in 2018. Both lakes met standards during the 2018 sampling, but Whitefish Lake was very close to the 40 µg/L impairment threshold for TP.

0902030505 Lost River

The Lost River 10-digit HUC includes:

- Nassett Creek (09020305-545)
- Lost River upstream of Pine Lake (09020305-529 and 530)
- Lost River between Pine Lake and Anderson Lake (09020305-512)
- Lost River between Anderson Lake and the Clearwater River (09020305-645, 646, 505, and 503)
- Silver Creek (09020305-527)
- Deep Lake (15-0090)
- Lone Lake (15-0104)
- Lindberg Lake (15-0144)
- Pine Lake (15-0149)
- Stony Lake (15-0156)

Figure 2-35. Erosion and sedimentation in the Lost River downstream of CR 118 (AUID 505)

A network of small streams upstream of Pine Lake, including some designated trout streams, form the headwaters of the Lost River. Existing data has revealed a wide range of water quality and habitat conditions in the headwaters of the Lost River. The WRAPS process and flood damage reduction project planning revealed a need for a more intensive examination of the Lost River and its tributaries upstream of Pine Lake. There are some locations in that network of small streams where biological samples nearly met exceptional use criteria (15EM066) and others that have exceptionally low DO levels. Nassett Creek and a portion of the Lost River were officially designated as trout streams. However, the MPCA biological monitoring, research, and temperature logger deployments found that there was a lack of evidence that the Lost River could support trout in the past or present. The designated trout stream portion of the Lost River did not have temperatures that would support trout.

There were cattle along the small streams that were likely contributing to *E. coli* impairments, but longitudinal sampling revealed that natural sources also needed to be evaluated. Excess sedimentation was noted within AUID 530 during biological sampling. Longitudinal investigative monitoring found that low DO may be a problem in portions of the AUID 530 reach of the Lost River. Water quality upstream, downstream, and within Lost Lake (along AUID 530) were evaluated in 2019 to prepare for a potential Flood Damage Reduction project. The samples collected from Lost Lake met applicable shallow lake water quality standards. Low DO problems were found in the Lost River upstream and downstream of Lost Lake. Continuous DO loggers recorded DO levels that dropped below the 5 mg/L warm water standard. There was a small, but perennially flowing, tributary channel upstream of Lost Lake that produced data that met the 7 mg/L cold water DO standard. Likely due to cattle grazing along those channels and possible natural sources like beaver dams, there were frequently high *E. coli* concentrations in the Lost River and a tributary of the Lost River near Lost Lake.

Winterkill within Pine Lake has been a concern. The Gully Sportsman's Club and the RLWD work together to monitor DO levels and operate an aerator during the winter. Because Pine Lake is a shallow lake within the North Central Hardwood Forest ecoregion, it is held to a lower standard than deeper lakes within the North Central Hardwood Forest and Lake Agassiz Plain ecoregions. The TP impairment threshold for Pine Lake (60 mg/L) is twice as high as the threshold for Northern Lakes and Forest Lakes located several miles to the east. Water quality has been good enough within Pine Lake to meet the stringent standards that are applied to lakes in the Northern Lakes and Forest ecoregion. Clearwater SWCD staff, in 2012, expressed interest in applying more protective standards to the lake. More protective standards could be used as goals in local plans, like the Clearwater River One Watershed, One Plan (1W1P), if LGUs and stakeholders agree on appropriate standards. Samples collected from Pine Lake by the Clearwater SWCD in August and September 2007 found elevated concentrations of fecal coliform (154 FC/100ml and 228 FC/100mL). Because high concentrations of *E. coli* have also been recorded at the inlet and outlet of Pine Lake, lake samples should be analyzed for *E. coli,* to evaluate recreational safety, in addition to TP and chl-*a*.

Lindberg Lake is nearly impaired by TP and chl-*a*. Additional sampling of that lake is recommended. The Pine Lake Watershed has been targeted for water storage for flood damage reduction. An outlet structure was replaced at the Little Pine Lake WMA in 2018 to provide flood storage. Deep Lake, near Clearbrook, has exceptionally good water quality.

Silver Creek is a significant tributary of the Lost River. Diurnal fluctuation of DO levels in Silver Creek was high during 2014 DO logger deployments. This warrants an examination of nutrient concentrations. There are indications that an eutrophication impairment may exist, but data was insufficient. Due to an update in MPCA assessment guidelines, continuous DO data from a second calendar year became a requirement to confirm a river eutrophication impairment. The collection of DO data from two years in the 2016 through 2025 assessment period, prior to the 2026 assessment, is recommended. The collection of BOD data is also recommended. Because low daily minimum DO levels were caused by a lack of base flow, the influence of flow upon DO flux should also be examined.

The channelized portion of the Lost River (AUID 656) downstream of Anderson Lake, should be assessed for river eutrophication due to extremely high levels of DO flux that were discovered during DO logger deployments. Samples could be collected from within Anderson Lake, or at the lake's outlet, to determine the extent to which the lake is contributing to the DO flux and potential eutrophication. Anderson Lake is partially drained by the Main JD 2 ditch (channelized portion of the Lost River). Anderson Lake has been discussed as a potential location for a Flood Damage Reduction (FDR) project.

The reach of the Lost River that extends downstream from Anderson Lake to its confluence with the Hill River (AUID 507) was once listed as impaired by high fecal coliform levels The impairment was based on data that was collected in 1992 and 1993 for the Clearwater River Nonpoint Study. A TMDL Study was conducted in 2007 through 2009 to verify the impairment, define current loads, estimate desired loads, and suggest strategies for attaining water quality goals. *E. coli* sampling was conducted on each end of the reach that yielded five samples per month at each of the two sites. The more complete data set collected during the TMDL study indicated that the Lost River was no longer impaired for aquatic recreation by high bacteria concentrations. The reach was officially delisted in December of 2009. AUID 507 was split into two reaches prior to the 2016 water quality assessment process: AUID 645 (mostly channelized reach between Anderson Lake and an unnamed creek along CSAH 28) and AUID 646 (mostly natural reach between the unnamed creek along CSAH 28 and the Hill River). Both of those reaches met the *E. coli* standard during the 2016 water quality assessment.

A drastic difference in fecal coliform levels before and after the construction of a WWTF for the town of Oklee in the late 1990s indicated that wastewater was the most significant source of the fecal coliform problem. Since the WWTF has been operational, individual samples have not exceeded the 1,260 CFU individual sample maximum standard and monthly geometric means have fallen below the 126 CFU/100ml standard.

Water quality in the Lost River has not always been perfect and high levels of *E. coli* still occasionally occur. Current data shows that both AUID 645 and AUID 646 are nearly impaired by *E. coli*. Feedlots have been identified near the river during windshield surveys of the watershed. Load duration curves showed that high concentrations occurred during high flows. Feedlot or pasture runoff may be the most significant source that is currently contributing to exceedances of the water quality standard. A site-specific assessment of S002-133 (CR 119 crossing of the Lost River north of Brooks) found that the river exceeds the TSS standard near the river's pour point. The Lost River is not listed as impaired by high TSS, but that site-specific assessment and the erosion problems identified during the fluvial geomorphology study indicated that the Lost River is contributing to downstream TSS impairments of the Clearwater River (Figure 2-35).

Crude oil pipeline leaks and a fatal explosion have occurred near the town of Clearbrook, so ecological damage from oil spills is a possibility. Runoff from pipeline construction can temporarily increase TSS levels in streams due to streambank and channel disturbance. A terminal with floating roof oil tanks is located next to Clear Brook, but containment berms surround the tanks to protect surface water.

0902030506 Lower Badger Creek

The Lower Badger Creek 10-digit HUC includes:

- Lower Badger Creek (09020305-502, 524)
- Polk County Ditch 14 (09020305-523)
- Judicial Ditch 73 (09020305-549, 550, 552)
- Poplar River Diversion and its tributaries (09020305-543, 542, 561)
- Cameron Lake (60-0189)
- Badger Lake (60-0214)
- Maple Lake (60-0305)
- Oak Lake (60-0185)
- City of Erskine
- City of Mentor

Figure 2-36. Lower Badger Creek downstream of CR 114 (AUID 502)

Lower Badger Creek (Figure 2-36) was not listed as impaired due to poor IBI scores, but there was enough cause for concern to prompt an examination of the stream in the 2017 SID Report. The sampling sites in the lower, natural portion of the stream met standards. The upper, channelized portion of Lower Badger Creek received a poor F-IBI score. It was very clear that aquatic habitat has been altered along that portion of the stream, and it also had a poor-quality riparian buffer. The lack of riparian cover also led to low DO concentrations within the channelized portion of Lower Badger Creek. Private road crossings may have been affecting fish passage along the stream.

Blue-green algae has been an emerging issue within the Clearwater River Watershed that will require more sampling, communication with the public, investigation of sources, understanding the conditions that allow blooms to occur, and development of solutions for preventing harmful blue-green algal blooms. Measurable concentrations of algal toxins have been discovered in Maple Lake and Cameron Lake. A blue-green algae bloom has also recently been spotted in Badger Lake. Water quality sampling of Oak Lake began in 2018. Oak Lake exceeded standards for TP and chl-*a,* while also having a very low Secchi transparency that was worse than the minimal transparency levels that have been found in Cameron Lake. Cyanotoxin testing in Maple Lake continued in 2019 and will continue during subsequent years as part of the RLWD water quality program. If high levels of algal toxins are found in Maple Lake, other eutrophic or potentially eutrophic lakes in the Clearwater River Watershed (like Oak Lake and Cameron Lake) should be screened for algal toxins.

Wake ordinances or signage may be used to protect shallow (<10 feet) areas of impaired lakes, nearly impaired lakes, or other lakes with water quality concerns. Signage has been discussed for shallow areas (bays) in Maple Lake where jet skis and large boat motors can easily disturb sediment and beneficial emergent vegetation, and mix nutrients into the water column.

Water temperature may be a concern for some streams in the Lower Badger Creek Subwatershed. Temperatures greater than 30˚C have been recorded in CD 14 near the Maple Lake outlet.

0902030507 Lower Clearwater River

The Lower Clearwater River 10-digit HUC includes:

- Clearwater River (09020305-648, 511, 519, and 501)
- Beau Gerlot Creek (09020305-652 and 651)
- Terrebonne Creek (09020305-574)
- Red Lake County Ditch 23 (09020305-658)
- Red Lake County Ditch 57 (09020305-508)
- City of Red Lake Falls
- City of Plummer

Much of the focus within this reach will be on restoration efforts that reduce erosion and help to reduce sediment loading. Achieving water quality goals within the lower reaches of the Clearwater River will require BMPs and erosion control projects in all the subwatersheds that flow into the Lower Clearwater River Subwatershed, whether or not there are TSS impairments in those subwatersheds. Water temperature may be a concern for some streams in the Lower Clearwater River. Temperatures greater than 30˚C have been recorded in the Clearwater River at the CSAH 12 bridge (S002-914). The Clearwater River in AUIDs 501 and 511 (Lost River to Red Lake Falls, Figure 2-37) is nearly impaired by river eutrophication and only had a fair habitat rating. Projects that reduce erosion and TSS loading should also help reduce TP concentrations and can sometimes improve aquatic habitat. Aquatic habitat could also be improved in Beau Gerlot Creek by making improvements to riparian land use, channel stability, and substrate. The Clearwater River is nearly impaired by *E. coli* at the CSAH 12 monitoring site (S002-914). That location is downstream of the confluence with the Lost River which receives water from two impaired reaches (Hill River and Poplar River) before emptying into the Clearwater River. There also is a large cattle operation upstream of that location.


Figure 2-37. Clearwater River along AUID 501 near Red Lake Falls

E. coli bacteria concentrations at the CSAH 12 (S002-914) crossing of the Clearwater River (the only crossing of AUID 09020305-511) have been trending toward impairment. There is a large livestock operation close to the river that is approximately three miles upstream of that crossing. Water quality in that portion of the Clearwater River is also influenced by pollutant concentrations, whether high or low, that are coming from the Lost River, Hill River, and Poplar River subwatersheds.

Aquatic Invasive Species

Worrisome discoveries of aquatic invasive species (AIS) have occurred in neighboring watersheds and in Upper Red Lake. The presence of these species can have negative effects upon native aquatic life, water chemistry, and aquatic recreation. Water quality monitoring activities are also affected by the presence of AIS due to decontamination requirements. Counties along the Clearwater River have received funding and have been implementing plans to combat the spread of aquatic invasive species. In 2014, a county tax bill was passed that provides funds for AIS prevention. Each year, Minnesota counties will receive funding to support AIS prevention programs. County board representatives designate a local government unit within each county to serve as their AIS program coordinator. The designated local government unit works closely with local, state and federal governments, as well as nonprofit and private organizations, to develop and implement AIS prevention programs. Individual counties make decisions on how funds are to be used. The Clearwater SWCD has been collecting early detection samples in Lake Lomond, Clearwater Lake, and Pine Lake using a boat and a plankton net. The SWCD has deployed PVC pipe zebra mussel samplers on all lakes with a dock and have watercraft inspectors on the heavier used lakes in the county.

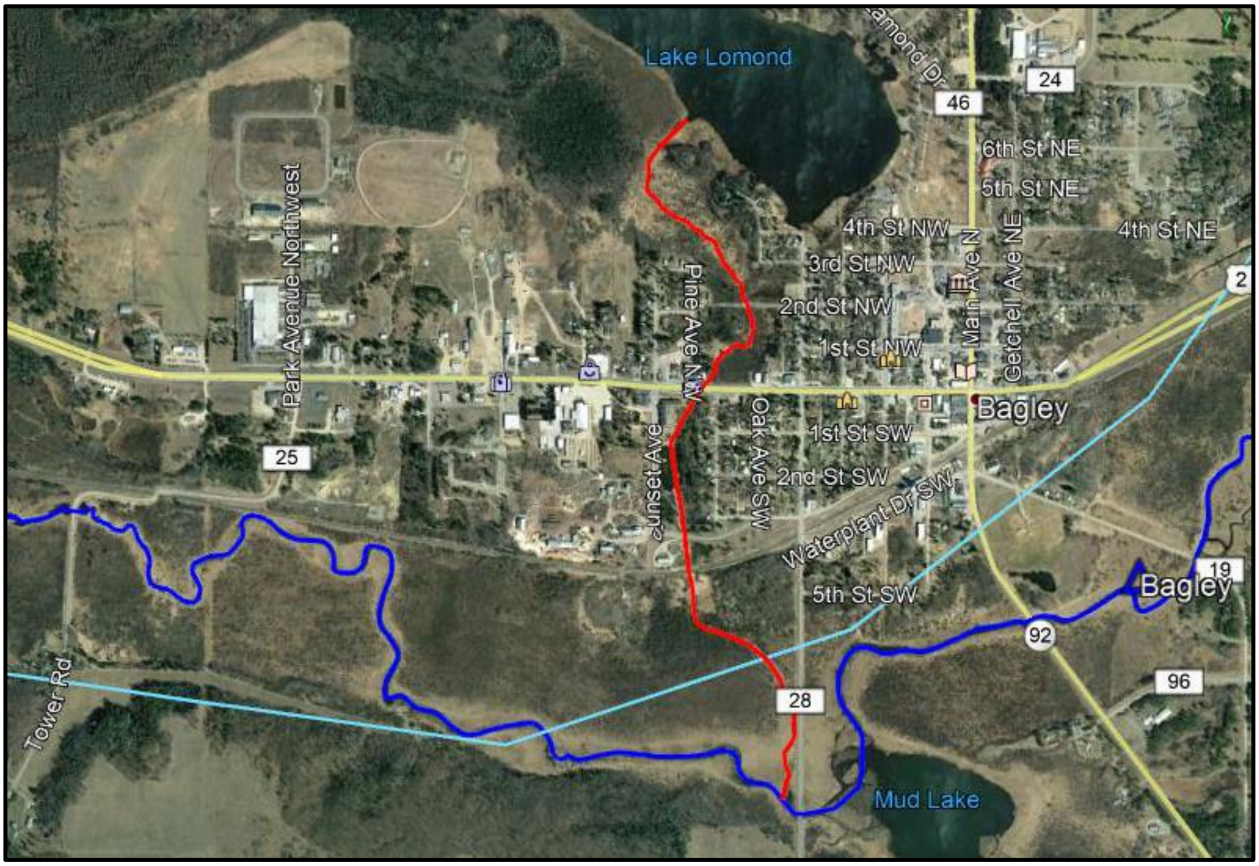


Figure 2-38. Path of drainage from the Lake Lomond outlet to the Clearwater River (AUID 517)

Zebra mussels have been found in one lake within the watershed: Lake Lomond in Bagley. The Lake Lomond zebra mussel veligers were discovered in samples that were collected by the Clearwater SWCD in 2019. The infestation is a threat to the entire Clearwater River because Lake Lomond is part of the headwaters of the river. The outlet of Lake Lomond is a chain of channels, ponds, and wetlands that flows to the Clearwater River (Figure 2-38). There are some obstacles to slow the movement of zebra mussels like thickly vegetated wetlands, a stormwater pond, and intermittently dry channels, but action needs to be taken quickly to stop the downstream spread of zebra mussels.

Established AIS populations and newly discovered AIS in neighboring watersheds are another cause for concern. An established population of Eurasian Watermilfoil (Myriophyllum spicatum) is located in Union Lake just south of Erskine, Minnesota in the Sandhill River Watershed. Zebra mussels (Dreissena polymorpha) are slowly working their way north, hopping from lake to lake (with the help of people) and flowing with the currents of the Red River of the North. In March 2019, the DNR confirmed that zebra mussel veligers were found in Upper Red Lake, upstream of the Red Lake River. In the summer of 2016, starry stonewort (Nitellopsis obtusa) was identified in Turtle Lake, south of Bemidji, Minnesota. It was also discovered in a bay on the eastern edge of Upper Red Lake near the town of Waskish, Minnesota.

Education, prevention, and early detection are some of the key strategies for preventing the spread of AIS to waters in the Clearwater River Watershed. Efforts from county AIS program coordinators are helping to push the “Clean, Drain, Dry” movement. They are flooding the markets with educational materials, hiring summer interns to help inspect watercrafts, purchasing decontamination stations, advertising on billboards, and distributing other educational materials.

Distributed Water Retention

Higher rates of flow within rivers have resulted in greater erosive power. The highest TSS concentrations in the Clearwater River have occurred during the highest rates of flow. One way to decrease stream bank erosion along the Clearwater River is moderation of flows. Storing water temporarily can also improve infiltration. Increased infiltration and storage of water can also help improve base flows that are fed by seepage from groundwater and wetlands. A distributed detention study (RLWD 2013) has been completed. The study involved a rigorous modeling effort that used HEC-HMS (Hydrologic Modeling System from the Hydrologic Engineering Center of the U.S. Army Corps of Engineers). The study investigated spatial and temporal relationships relative to watershed discharge and Red River Valley flooding, as well as contributing watershed areas most greatly contributing to flooding. This study investigated opportunities and potential hydrologic effects of new distributed detention basins to supplement the existing detention facilities within the entire RLWD. In total, 15 off-channel and tributary sites were identified and proposed. A RLWD peak flow reduction goal of 35% at the city of Crookston was identified.

Local USFWS staff have helped landowners restore more than 1,500 wetlands (>90% of those are in the Clearwater River Watershed) over the last 20 years through the Partners for Fish and Wildlife Program. Those wetlands cover approximately 2,200 acres and provide 3,300 acre-feet of storage.

Nutrient Reduction Plans

Since September 2011, with the support of the International Joint Commission (IJC) (including through the International Watershed Initiatives funding), the International Red River Board's (IRRB) Water Quality Committee undertook work to address nutrients in the Red River. The mission was to develop a collaborative, science and watershed-based approach to managing nutrients in the Red River and its watershed with the goal of restoring and protecting aquatic ecosystem health and water uses in the Red River Basin and Lake Winnipeg. The International Red River Board developed loading goals for the Red River at Emerson, Canada (United States and Canada border) of 1,400 tonnes (1 tonne = 2,204.6 tons)/year phosphorus and 9,525 tonnes/year total nitrogen (TN). These loading goals were presented to the IJC in September 2019 for proposed adoption. In May 2020, after public hearings were held, the IJC presented these goals to the Canadian and American governments for consideration of formal addition to the IRRB's current list of Water Quality Objectives. Nutrient concentration objectives were also proposed: 0.15 mg/L phosphorus and 1.15 mg/L TN. The estimated 2015 annual TP load in the Red River at the city of Emerson was 2,480 tonnes/year. The estimated 2015 annual TN load in the Red River at Emerson was 13,500 tonnes/year. A large amount of nutrient reductions will be needed throughout the Red River Basin to reduce current nutrient loading rates to meet the proposed objectives.

The RRBC is developing a nutrient reduction strategy that encompasses the three jurisdictions that make up the Basin - Minnesota, North Dakota, and Manitoba. The proposed effort will bring together citizens, local units of government, state and federal interests to put together a comprehensive plan to address water quality issues within the basin, focusing on sediment and nutrients. The RRBC will partner with agricultural interests as well as local units of government to hold community conversations to build a nutrient reduction strategy that meets the intent of each individual jurisdiction as well as the Red River Basin as a whole with unique nutrient reduction allocations by major watershed.

A phosphorus reduction that is approximately 50% of the current average annual load will be needed to meet proposed Lake Winnipeg objective. This goal is designed to return Lake Winnipeg to the condition that existed in 1990. Nonpoint phosphorus sources in the Red River Watershed contribute 84%, made up of cropland runoff 43%, atmospheric deposition 18%, streambank erosion 6% and non-agricultural rural runoff 17%. Phosphorus contributions from point sources total 16%, made up of domestic/industrial wastewater 11%, urban stormwater 2% and Individual sewage treatment systems 3%.

The State of Minnesota Nutrient Reduction Strategy (NRS) was developed to guide the state in reducing excess nutrients in waters so that in-state and downstream water quality goals are ultimately met. An interagency coordination team representing 11 agencies developed the draft NRS. Public input was sought and used by the interagency coordination team to produce the final NRS in 2014. The NRS prescribes a 10% reduction of phosphorus and a 13% reduction in nitrogen relative to 2003 conditions for waters that drain to Lake Winnipeg (Red River Basin). It places priority on reduction of phosphorus from cropland runoff and nonagricultural rural runoff. The Red Lake River Watershed (Including the Clearwater River), however, is not given a high priority for nutrient reductions relative to other watersheds in the state. Protection efforts for the purpose of nutrient reduction are recommended for this watershed in Section 3.3. These provisional goals were based on the 2003 Lake Winnipeg Action Plan. The reduction goals are expected to change with the completion of new Lake Winnipeg strategies. The NRS –progress report was issued in late 2020. The NRS estimated (derived from SPARROW modeling) the 2003 phosphorus load for the Clearwater River Watershed at 53 metric tons (MT) and the N load at 964.3 MT. For the outlet of the Clearwater River HUC-8 Watershed, the NRS recommends nutrient reductions of 3.2 tonnes/year (7,054.8 pounds/year or 6%) TP and 96.4 tonnes/year (212,525.6 pounds/year or 10%) TN.

Intensive monitoring and modeling by the Watershed Pollutant Load Monitoring Network (WPLMN) produced estimates of annual nutrient loads for the Clearwater River in Red Lake Falls (S002-118). The average annual TP load from the Clearwater River Watershed at S002-118 for the years 2008 through 2017 was 41.93 tonnes/year. The average annual TN load at S002-118 was 602.99 tonnes/year. The HSPF-SAM tool provided an estimate of average annual TP and TN loads from different land use types, point sources, atmospheric deposition, and bed/bank erosion. Phosphorus sources are shown in Figure 2-22. Nitrogen sources are shown in Figure 2-39. The proportional relationship among sources of TN are similar to the sources of TP. Point sources and atmospheric deposition were two sources that notably affected phosphorus loads to a greater degree than they affected nitrogen loads. Cultivated crops were the dominant source of TP and TN. Pastured land was the second highest contributor of nutrients. In-stream erosion contribution to nutrients was relatively small. Atmospheric deposition and septic systems were sources that contributed to nutrient loads in the HSPF-modeled data.

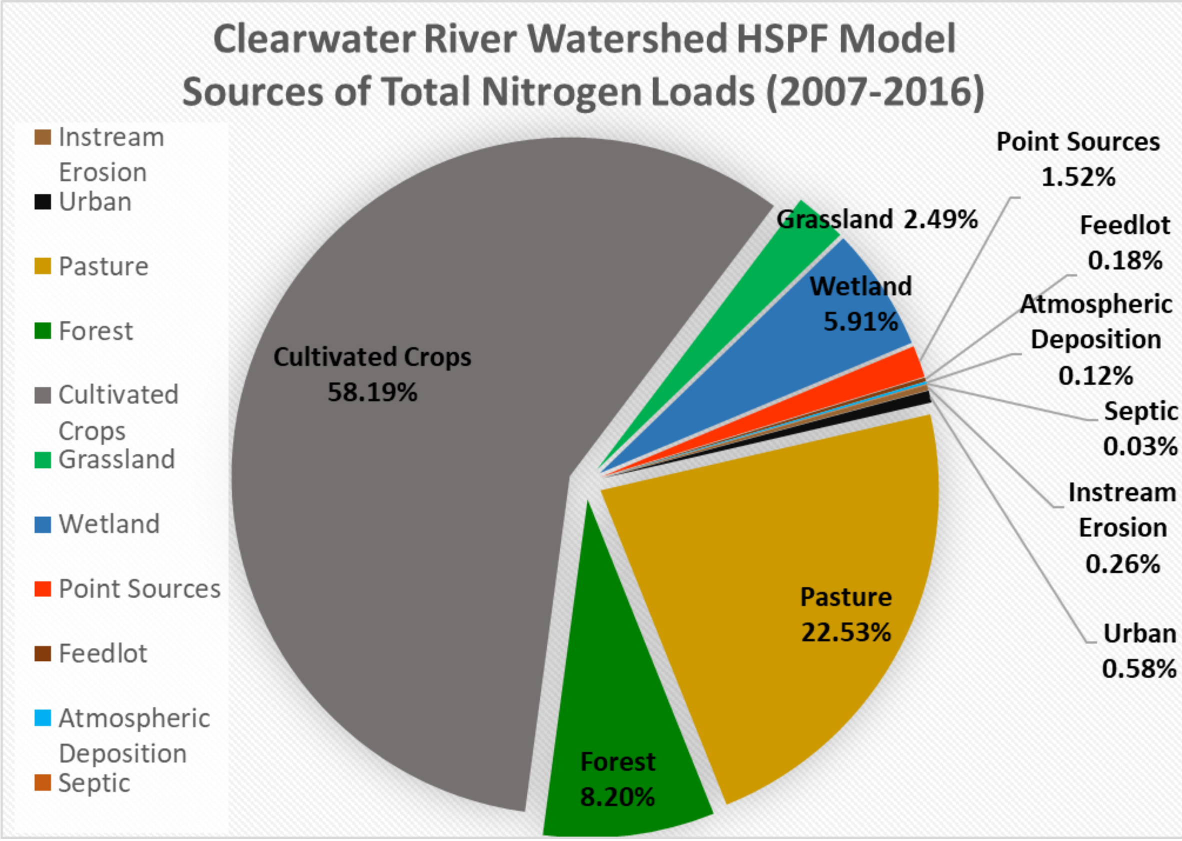


Figure 2-39. Proportions of HSPF-simulated total nitrogen loads attributed to categories of sources

Harmful Algal Blooms (Blue-Green Algae)

Evidence of potentially harmful blue-green algae blooms within the Clearwater River was discovered in 2018. Low levels (5 parts per billion or less) were found in Maple Lake and Cameron Lake in 2018 through samples that were sent to RMB Environmental Laboratories, Inc. for verification and samples that were tested for the presence of algal toxins using Abraxis Algal Toxin (Microcystins) Test Strip Kits. Reducing nutrient runoff to shallow, eutrophic lakes will be very important for reducing the risk of blooms. Diligence from residents and verification by local or state government staff will be important for maintaining public safety through awareness. Social media, direct phone calls, local media, and public meetings have been used as ways to share information about the conditions in the lakes and levels of potential risk. Visual evidence of blue-green algae blooms was also documented in Maple Lake and Oak Lake in early August 2020. Algal toxins were found (5-10 parts per billion) in a 2020 water sample from Oak Lake. Elevated nutrient concentrations from early summer storm runoff, elevated temperatures, and stagnant water are factors that have likely contribute to blue-green algae blooms in these lakes.

3. Prioritizing and Implementing Restoration and Protection

The Clean Water Legacy Act (CWLA) requires that WRAPS reports summarize priority areas for targeting actions to improve water quality, identify point sources and identify nonpoint sources of pollution with sufficient specificity to prioritize and geographically locate watershed restoration and protection actions.

This section of the WRAPS provides the results of such prioritization and strategy development. Because much of the nonpoint source strategies outlined in this section rely on voluntary implementation by landowners, land users and residents of the watershed, it is imperative to create social capital (trust, networks and positive relationships) with those who will be needed to voluntarily implement BMPs. Thus, effective ongoing civic engagement and public participation is fully a part of the overall plan for moving forward.

The implementation strategies provided in this section are the result of data assessment, watershed modeling efforts and professional judgment based on current knowledge and data. Water quality conditions and available information are subject to change (ideally for the better). Thus, those strategies, scales of adoption, and timelines should be considered approximate. Furthermore, many strategies are predicated on needed funding being secured. As such, the proposed actions outlined are subject to adaptive management—an iterative approach of implementation, evaluation, and course correction.

3.1 Categorization and Prioritization for Restoration and Protection

This section provides information that will help with setting goals and planning projects that will restore and protect water quality and aquatic habitat in the Clearwater River Watershed. It uses water quality and biological data to categorize and identify waters that need restoration and protection efforts. Restoration efforts are applied to streams that are included in the Draft 2020 List of Impaired Waters. Actions will be taken to improve conditions in those streams so that they meet water quality standards in future assessments. Protection efforts will be needed to improve water quality and prevent future impairments of streams that are not on the Draft 2020 List of Impaired Waters.

Assessment statistics (exceedance rate, for example) for TSS, *E. coli* bacteria, DO, TP, biochemical oxygen demand (BOD), chl-*a*, F-IBI, M-IBI, and Secchi depth were compared to impairment thresholds and other statistical benchmarks (Table 3-1). Maps were created (Figures 3-1 through 3-8) for a more visual and spatial representation of the assessment results. Waterbodies were categorized according to the proximity of their current condition to the impairment threshold. For example, a stream reach that was exceeding the TSS standard in 9.1% of samples was within 1 percentage point of becoming impaired. That reach should be a high priority for protection efforts because it is nearly impaired. Assessed rivers, streams, ditches and lakes were categorized into four restoration and protection categories (two for impaired waters and two for unimpaired waters). An additional category (poor quality) was added to include streams that failed to meet standards but were not officially listed as impaired during the 2016 water quality assessment.

1. Restoration (Impaired)
2. Nearly Restored (Impaired)
3. Nearly Impaired
4. Highest Quality
5. Poor Quality (non-pollutant or natural causes)

Due to the quantity of water quality impairments within the Clearwater River Watershed, it may be useful to prioritize waterbodies for restoration projects. The waters on the Draft 2020 List of Impaired

Waters were sorted into two categories based upon their assessment statistics. Impaired waters that were relatively close to the impairment threshold were placed into a **nearly restored** category. Those streams are assumed to require the least amount of effort for restoration and short-term goals could potentially results in restoration of good water quality and/or habitat. The rest of the impaired waters will presumably require more effort to restore and will require more short and long-term goals to improve water quality and/or habitat. Those waterbodies that failed to meet standards by a relatively wide margin were sorted into the **restoration** category.

For each parameter, waterways that were not officially impaired were sorted into three different categories. There were some waterbodies that failed to meet numeric standards but were not formally listed as impaired by the state for various reasons. The waters that fit that description were streams of naturally **poor quality** that were not formally assessed due to wetland characteristics, lake influence, groundwater influence, natural features, or other non-pollutant factors that caused low DO or poor IBI scores. Streams that were **nearly impaired** met a water quality standard but were relatively close to a respective impairment threshold. Degradation of water quality could result in future impairments on those reaches. The **highest quality** waterways are those that met water quality standards by a relatively wide margin. There is no immediate concern that the highest quality reaches may become impaired, but protection is still recommended to prevent degradation of water quality.

The MPCA conducts a formal assessment of surface waters in each major watershed once every 10 years. Each waterbody's ability to support aquatic life and aquatic recreation is assessed. Typically, these assessments use data that has been collected throughout the most recent 10 years. Each parameter is assessed separately, and it is possible for a stream to have the highest quality statistics for one designated use (e.g., aquatic life) while being impaired for another use (e.g., aquatic recreation). The Clearwater River Watershed was formally assessed by the MPCA in 2016 using data collected in the years 2006 through 2015. Assessment statistics from that same period were used for this classification process. Assessment statistics for water chemistry were calculated using the same methods that are used by the MPCA. Those methods can be found in the most recent version of the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 305(b) Report and 303(d) List. Data presented in the Watershed Monitoring and Assessment Report (2017) and the SID Report (2017) were used for the classification of streams based on IBI scores and habitat scores.

The clarity of water in Clearwater River streams was assessed in 2016 using **TSS** and Secchi-tube transparency data. The 30 mg/L TSS standard of the Central River Nutrient Region, 15 mg/L standard of the North River Nutrient Region, and the 10 mg/L standard of Class 2A Waters (trout streams) have been applied to portions of the watershed. River nutrient region assignments for this process are based upon information that is publicly available from the MPCA. The classifications can be easily updated for future planning processes (Clearwater River 1W1P process, selected in 2020 for funding) with any updates to the applicable standards or updated monitoring data.

Waterways that exceed respective **TSS** standards in >10% of days (April through September) at the time of a formal assessment are typically listed as impaired on the next Draft 303(d) List of Impaired Waters. The impaired reaches on the Draft 2020 List of Impaired Waters that exceeded their respective TSS standard at a frequency of 12.5% or a greater were sorted into the **restoration** category in Tables 3-2 through 3-5. **Nearly restored** streams are those that were on the Draft 2020 List of Impaired Waters but exceeded standards during <12.5% of days in which they were sampled. Efforts should be made to ensure that **nearly impaired** reaches do not become impaired in the future because they are within 2.5 percentage points of exceeding the 10% impairment threshold. They have exceeded the TSS standard in at least 7.5% of the daily average TSS values. Other streams that exceeded their respective standards at a relatively low frequency (<7.5%) were sorted into the **highest quality** category.

E. coli bacteria is sampled to assess whether a waterbody supports safe aquatic recreation or not. The MPCA has established acute (1,260 MPN/100ml) and chronic (126 MPN/100ml monthly geometric mean) standards for *E. coli*. For this assessment and categorization process, monthly geometric means from data collected in 2006 through 2015 were calculated and compared to the standard. Impaired streams that were currently listed on the Draft 2020 List of Impaired Waters and had a maximum monthly geometric mean of 157.5 MPN/100ml or greater were included in the **restoration** category in Tables 3-2 through 3-5. Impaired streams that were listed on the Draft 2020 List of Impaired Waters and had a maximum monthly geometric mean that was between 126 MPN/100ml and 157.5 MPN/100ml were assigned to the **nearly restored** category. A statistical benchmark at 75% of the chronic standard (0.75*126 MPN/100ml = 94.5 MPN/100ml) was used to separate **nearly impaired** waterways (94.5 – 126 MPN/100ml) from the **highest quality** (<94.5 MPN/100ml) waterways.

Aquatic life needs **DO** to thrive. The 5 mg/L daily minimum MPCA standard applies to most of the waterways of the Clearwater River Watershed, but there are some Class 2A cold water (trout) streams that require 7 mg/L of DO. If a reach of a stream falls below that threshold on at least 10% of the days in which it was sampled, it is usually considered impaired by low DO. Two categories were used to describe and prioritize the waters that are listed as impaired by low DO on the Draft 2020 List of Impaired Waters category in Tables 3-2 through 3-5. Impaired streams that were on the Draft 2020 List of Impaired Waters and had low DO levels in 15% or more days during the months of May through September were placed in the **restoration** category. Impaired streams in the **nearly restored** category exceeded the DO standard in 10-15% of days (May through September, all data, DO5_All) and were included in the Draft 2020 List of Impaired Waters. The DO levels within a waterbody fluctuate throughout a day. It increases during the daylight hours due to photosynthesis and decreases at night. At night, photosynthesis decreases while consumption of DO (respiration, decomposition, oxidation) continues. Most discrete measurements (collected in person) are recorded during working hours, during the daytime while DO concentrations are on the rise. If 5% or more of those discrete measurements are lower than 5 mg/L on a stream that does not currently have a DO impairment, then that is a sign that the stream is **nearly impaired**. Unimpaired streams in which low discrete DO measurements were relatively rare (<5% of days) were assigned to the **highest quality** category. Streams with a relatively low frequency of low DO levels in discrete data were sometimes placed in the **nearly impaired** category if data collected prior to 9:00 am with deployed DO loggers and early-morning discrete measurements revealed a frequency of low DO levels that was greater than 10%. A relatively small number of low measurements could cause the stream to exceed the impairment threshold in nearly impaired streams with limited data sets. There also is a good chance that continuous DO data could capture additional low DO values and cause the waterway to be placed on a future list of impaired waters if more than 5% of the discrete values have been lower than 5 mg/L.

The primary (cause indicator) parameter that is used for the assessment of river eutrophication (excess algae and plant growth due to excess nutrients) is **TP**. Instead of the exceedance rate that is used for other parameters, a growing season (June through September) mean TP concentration is calculated and compared to an impairment threshold. To designate a potential impairment, a reach needed to exceed the TP standard and at least one of the response variable standards. Those response variables are BOD, chl-*a*, and daily DO fluctuation (DO flux). The level of protection for a stream differs by location in the state (River Nutrient Regions). The TP impairment thresholds vary by river nutrient region. The summer average TP for each stream was compared to the impairment threshold for the river nutrient region to which the stream had been assigned. A statistical threshold of 125% of the applied standard(s) was used to separate impaired streams in the **restoration** category from impaired streams in the **nearly restored** category in Tables 3-2 through 3-5. An impaired Central River Nutrient Region stream (100 µg/L standard) would be placed in the **restoration** category for TP if it had a summer average TP concentration greater than 125 µg/L, or it would be placed into the **nearly restored** category for TP if it had a summer average TP concentration that was less than 125 µg/L. There was only one reach on the Draft 2020 List of Impaired Waters. The summer average TP for that reach of the Clearwater River exceeded the standard to an extent (127 µg/L) that placed it into the restoration category. So, no streams were categorized as "nearly restored." There were twelve unimpaired streams that did not meet the requirements for an impairment listing but were placed into the nearly impaired category. The **nearly impaired** category includes streams that had summer average TP concentrations that were 75% of the applicable standard or greater. There is no maximum concentration for the nearly impaired category because it includes streams that exceeded the TP standard but did not exceed any of the response variable standards. Streams that had summer average TP concentrations that were less than 75% as high as their respective TP standards qualified for the **highest quality** category.

Clearwater River Watershed **IBI** scores, stream classifications, impairment thresholds, and confidence limits for each AUID are listed in the SID and Watershed Monitoring and Assessment Reports (Appendix 3.1, 3.2, and 3.3 of the monitoring and assessment report). Published MPCA IBI scores, classifications, impairment thresholds, and confidence limits were used to perform an informal assessment of biological data to assist in setting priorities for this WRAPS project. Confidence limits were used as statistical thresholds to separate impaired waters into two groups and unimpaired waters into two groups in Tables 3-2 through 3-5. The streams in the **poor quality** category are neither officially impaired, nor meeting standards.

The MPCA considers confidence limits when conducting **biological** assessments. Those confidence limits represent ranges of values surrounding (plus/minus) each IBI impairment threshold. If a stream exceeds the impairment threshold by an amount greater than the confidence limit, then there is a relatively high level of confidence that the stream is meeting the standard. If a stream falls below the lower confidence limit, there is a sufficient degree of confidence that the stream is not meeting the IBI standard. Streams with IBI scores that are near enough to the impairment threshold to be within the boundaries set by the confidence limits have a more uncertain status. Average confidence limits for F-IBIs (+/- 11.3 points) and M-IBI (+/- 12.9 points) were calculated for the watershed to create consistent initial, statistical thresholds for quickly sorting and classifying reaches. If individual reaches were within 16 F-IBI points or 13.8 M-IBI points of the impairment threshold, they were examined individually to see if their scores fell within confidence limits or not. Those thresholds were also useful for color-coding IBI results on maps. The differences between IBI scores and impairment thresholds were calculated and compared to those confidence limits. The actual confidence intervals for borderline reaches were also considered, but did not reveal a need to adjust classifications. Some AUIDs were sampled at multiple locations. The IBI classification table and maps show the worst (most degraded) fish or macroinvertebrate community that was sampled along each specific reach.

1. Waterways in the **restoration** category had an IBI score that fell far below expectations and are listed on the Draft 2020 List of Impaired Waters. These waterways produced poor F-IBI scores that failed to reach the impairment threshold by a margin double the value of the average confidence limit (22.6 points), or poor M-IBI scores that failed to reach the impairment threshold by a margin of at least 12.9 points.
2. **Nearly restored** waterways are on the Draft 2020 List of Impaired Waters and have scores that are fewer than 22.6 points below the F-IBI impairment threshold or are greater than the lower M-IBI confidence limit (on average, fewer than 12.9 points below the M-IBI impairment threshold). A lower threshold (double the value of the confidence limit) was chosen for F-IBI scores to make sure some streams could be included in the nearly restored category because there were no impaired streams with F-IBI scores between the impairment threshold and the lower confidence limit.
3. **Nearly impaired** waterways are not considered impaired but have an IBI scores that are lower than the upper confidence limit. The upper confidence limit for F-IBI scores equaled the F-IBI impairment threshold plus the confidence interval (11.3 points, on average). The upper confidence limit for M-IBI scores equaled the impairment threshold plus the water's confidence limit (12.9 points, on average).
4. **Highest quality** waterways exceeded expectations by a significant amount. They produced high F-IBI scores that exceeded respective impairment thresholds by margins greater than upper confidence limits (on average, more than 11.3 points above the F-IBI impairment threshold or 12.9 points above the M-IBI impairment threshold).

For example, a river in the northern streams class has a general use F-IBI impairment threshold of 42 points and confidence limits of +/- 10 points. Scores of 0-19.3 would put an impaired northern stream AUID in the restoration category. Scores of 19.4-42 would put an impaired northern stream AUID in the nearly restored category. Scores of 32-52 points would put an unimpaired stream in the nearly impaired category. Scores between of 52-53.3 points may be identified as nearly impaired in an initial statistical sort using the 11.3-point average upper confidence limit, but could be adjusted up to the highest quality category which would include northern streams that scored more than 52 points.

The Minnesota Stream Habitat Assessment (MSHA) scores, along with Pfankuch stream stability ratings are included in Tables 3-2 through 3-5, as supporting information that could aid the process of planning and prioritizing implementation projects to improve water quality and habitat conditions. One way to improve IBI scores is by improving aquatic habitat. The protection and restoration classification tables include a column with classifications for MSHA scores. The MSHA scores, ratings, and rating criteria from the monitoring and assessment report were used. The "fair" and "poor" categories were each split into two color-coded categories based on whether the AUID had an IBI impairment or not. These classifications bring attention to nearly impaired streams and impaired streams that could be affected by aquatic habitat. Pfankuch stability ratings were also included. Pfankuch ratings were one product of the geomorphic assessment process led by the DNR for select streams in the watershed.

Lake monitoring data was also compiled, summarized, and compared to water quality standards to identify high priority lakes for restoration and protection efforts in Table 3-6. The summer average concentration or depth values were compared to the numerical standards. First, lakes were classified based on TP concentrations and response variable (Secchi depth and chl-*a*). Though TP is the most important parameter for lake water quality assessments, high chl-*a* or low Secchi depth levels could be a warning sign that a lake could become impaired in the future without protection efforts. Then, an overall classification for each lake was based on the parameter that indicated the poorest water quality relative to the applicable standard.

Lakes that met TP and response variable standards by a significant margin were classified as the **highest quality** lakes. The highest quality lakes not listed as impaired on the Draft 2020 List of Impaired Waters that were either close to or exceeding a numerical standard, were classified as **nearly impaired**. Those lakes should be targeted for protection projects. Three lakes exceeded water quality standards by a significant amount. Those highly impaired lakes need **restoration** projects.

There were seven lakes with TP concentrations in the “highest quality” category but that also had response variables in the “nearly impaired” category. An increase in TP concentrations of 8 to 20 µg/L (for reference, the current, 2020 minimum detection limit for the TP laboratory method is 2 µg/L) in those lakes could lead to an impairment. Some of the nearly impaired lakes were very close to exceeding the TP standard. Two lakes had average TP concentrations that were only 2 µg/L below the impairment threshold (Spike Lake 15-0035-00 and Second Lake 15-0140-00). One Lake (Whitefish Lake, 60-0015-00) exceeded standards for multiple parameters, but did not meet data quantity requirements for assessment in 2016. The Secchi depths (water clarity) on two impaired lakes met standards despite being significantly impaired by TP and chl-*a*. Long Lake is the impaired lake that is statistically closest to meeting water quality standards.

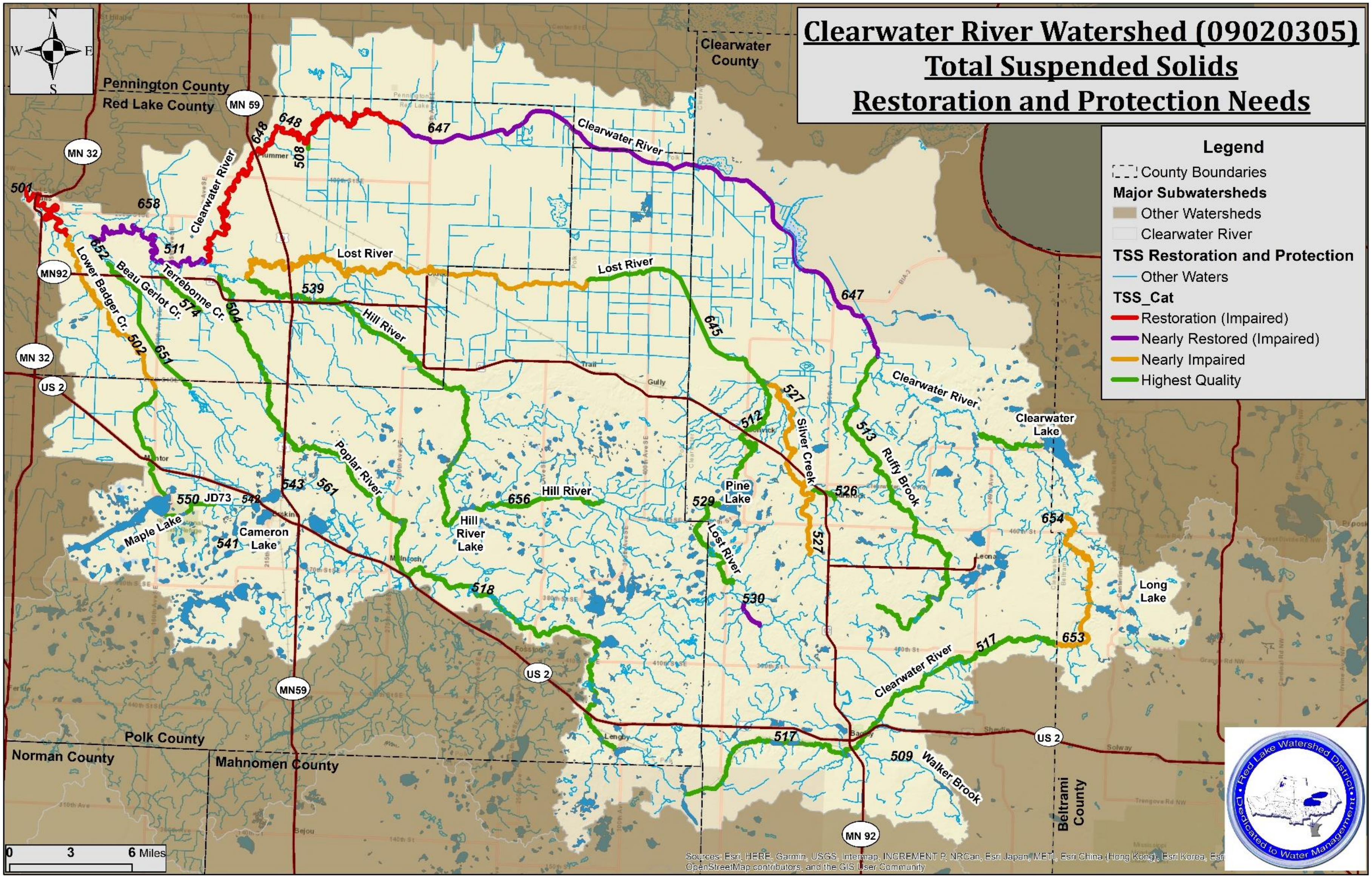


Figure 3-1. Map of Clearwater River Watershed TSS restoration and protection needs (2006-2015 data)

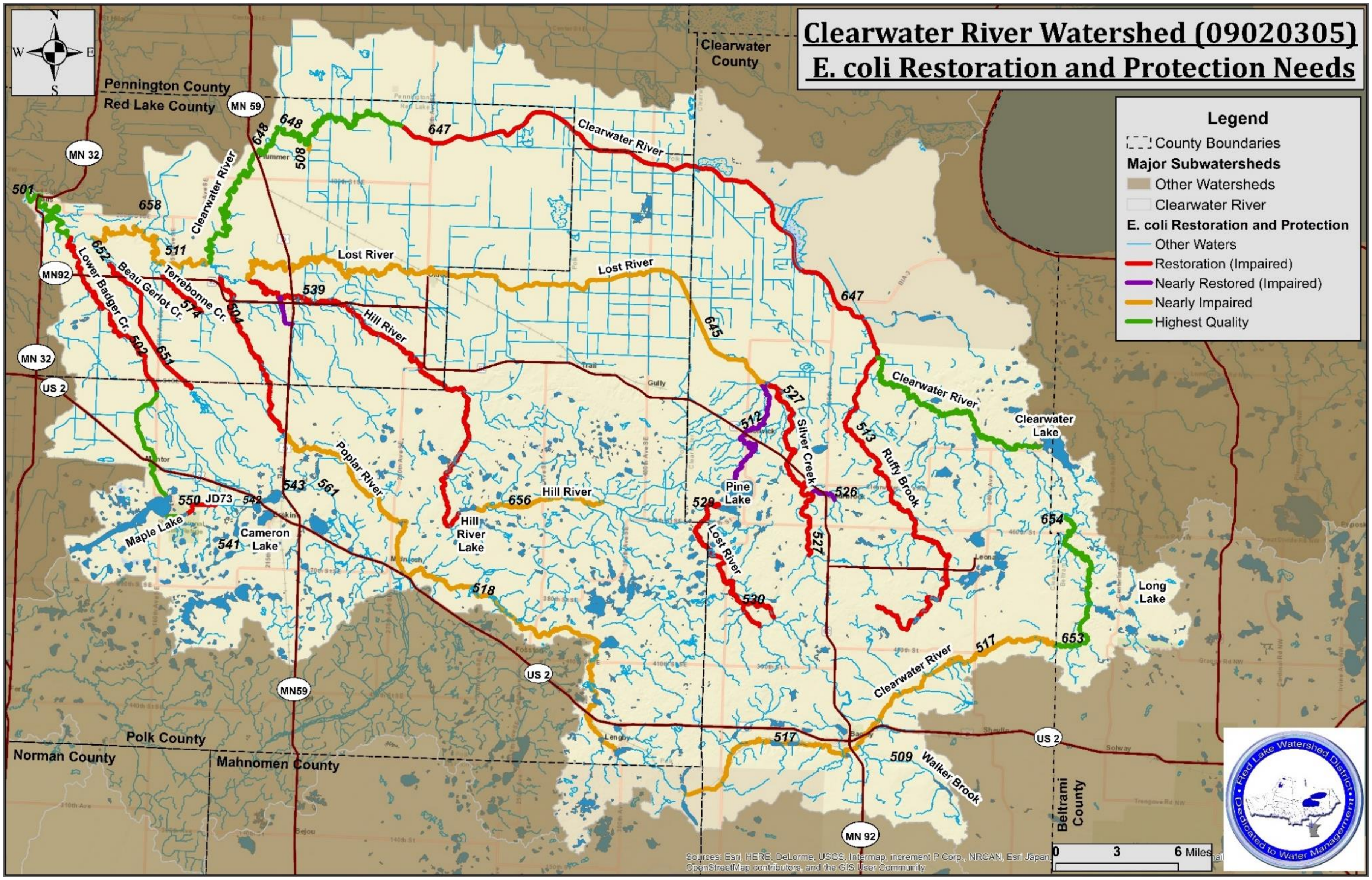


Figure 3-2. Map of Clearwater River Watershed *E. coli* restoration and protection needs (2006-2015 data)

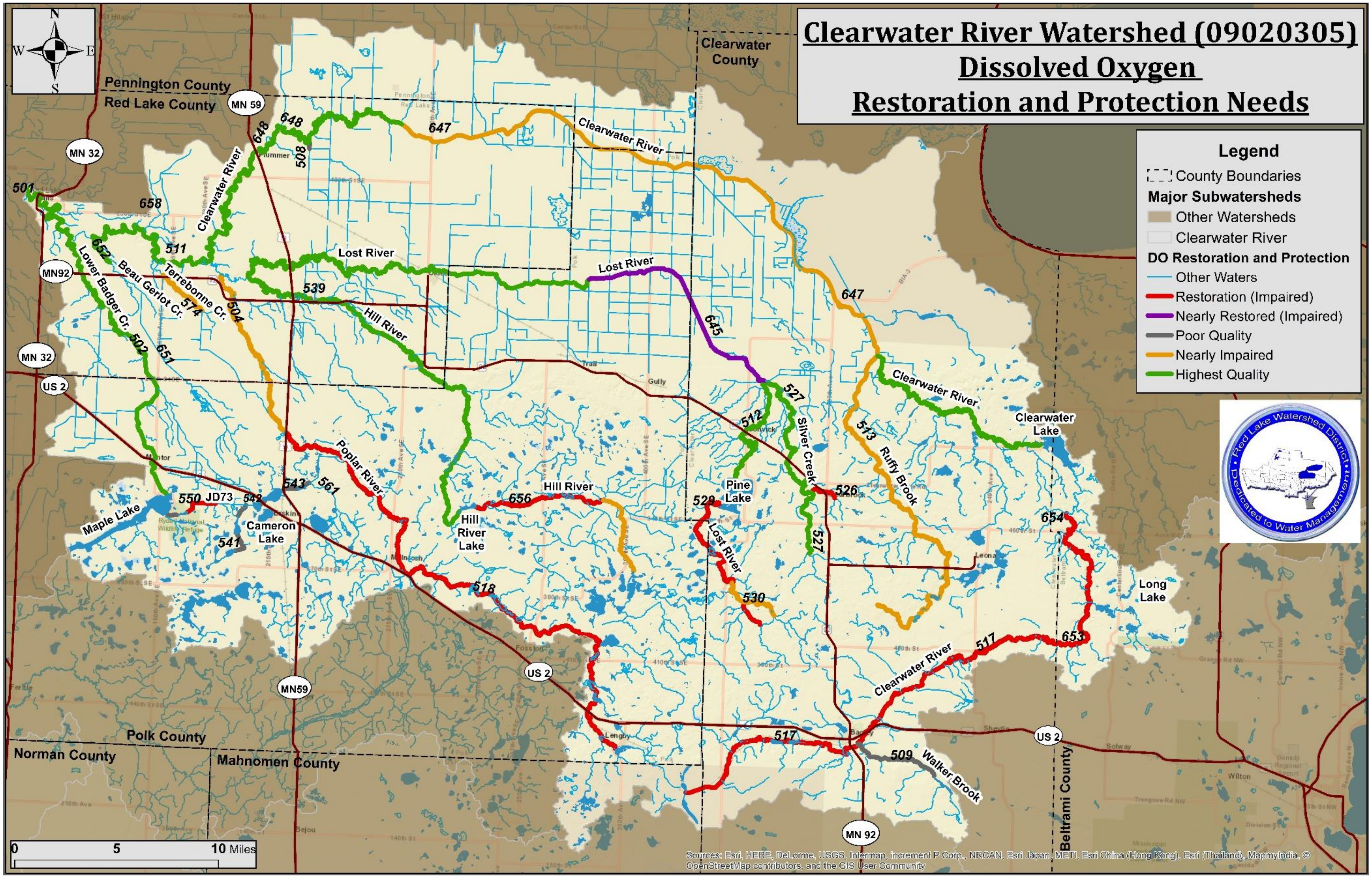


Figure 3-3. Map of Clearwater River Watershed DO restoration and protection needs (2006-2015 data)

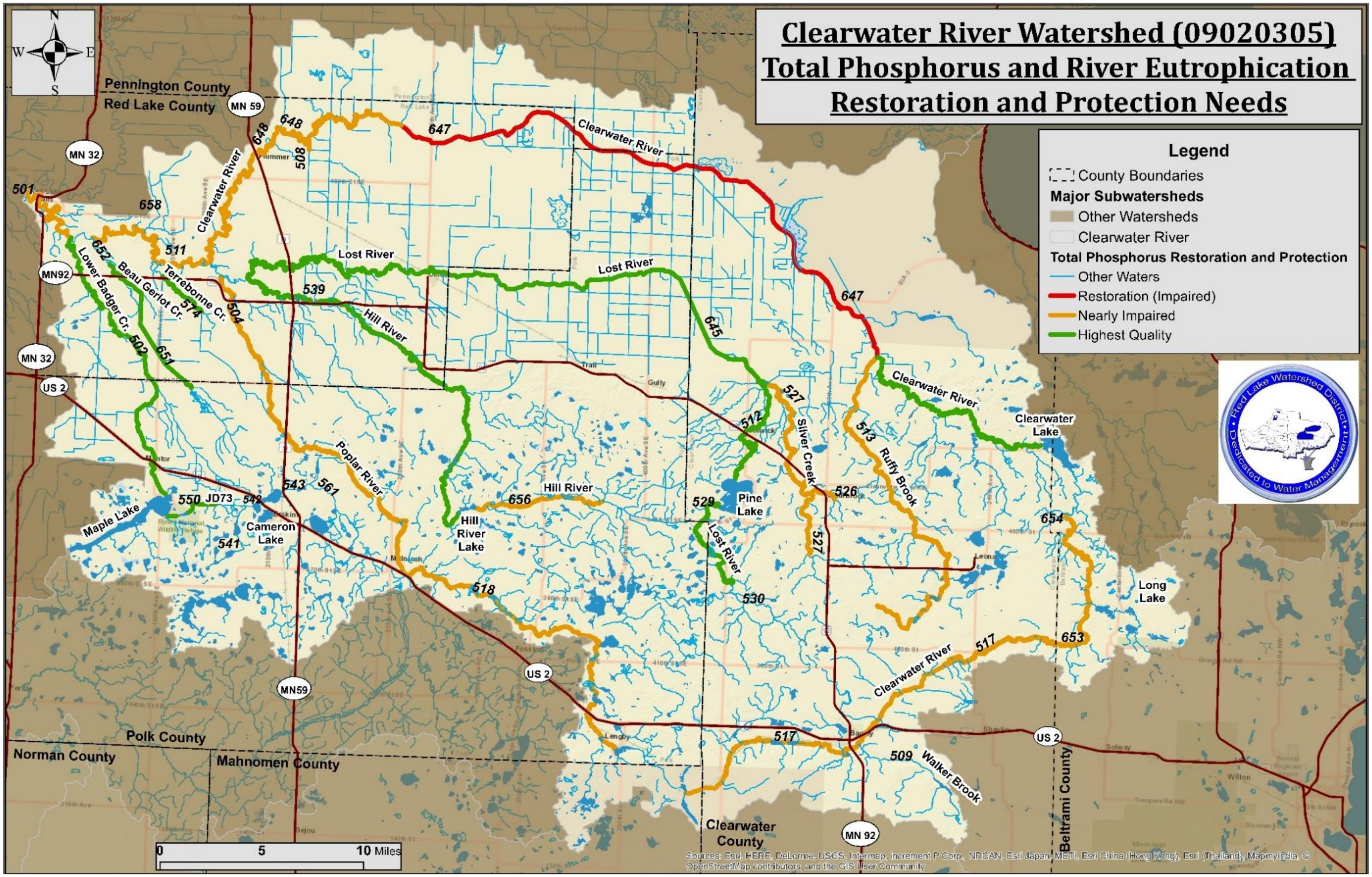


Figure 3-4. Map of Clearwater River Watershed TP and river eutrophication restoration and protection needs (2006-2015 data)

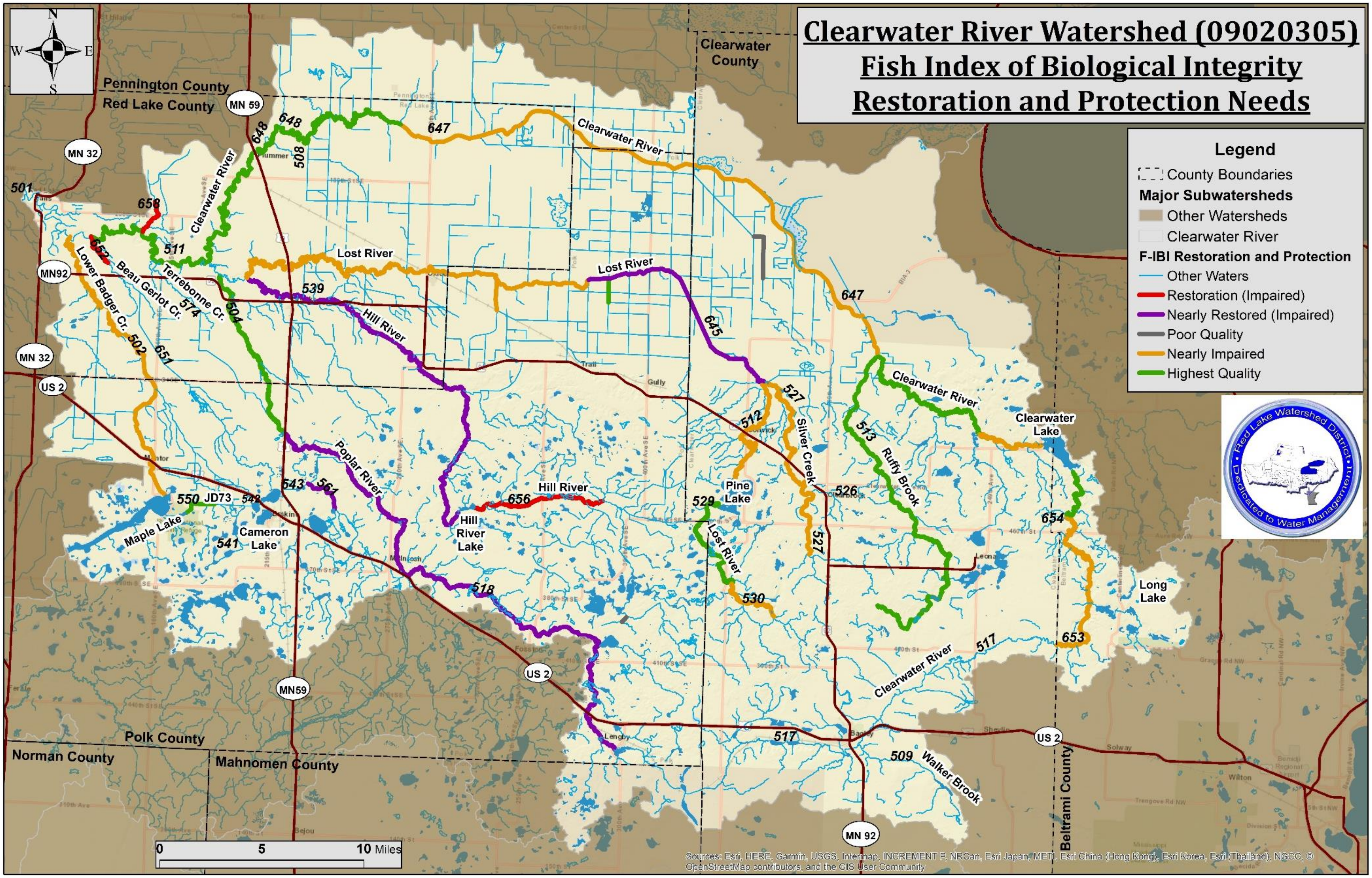


Figure 3-5. Map of Clearwater River Watershed F-IBI restoration and protection needs (2006-2015 data)

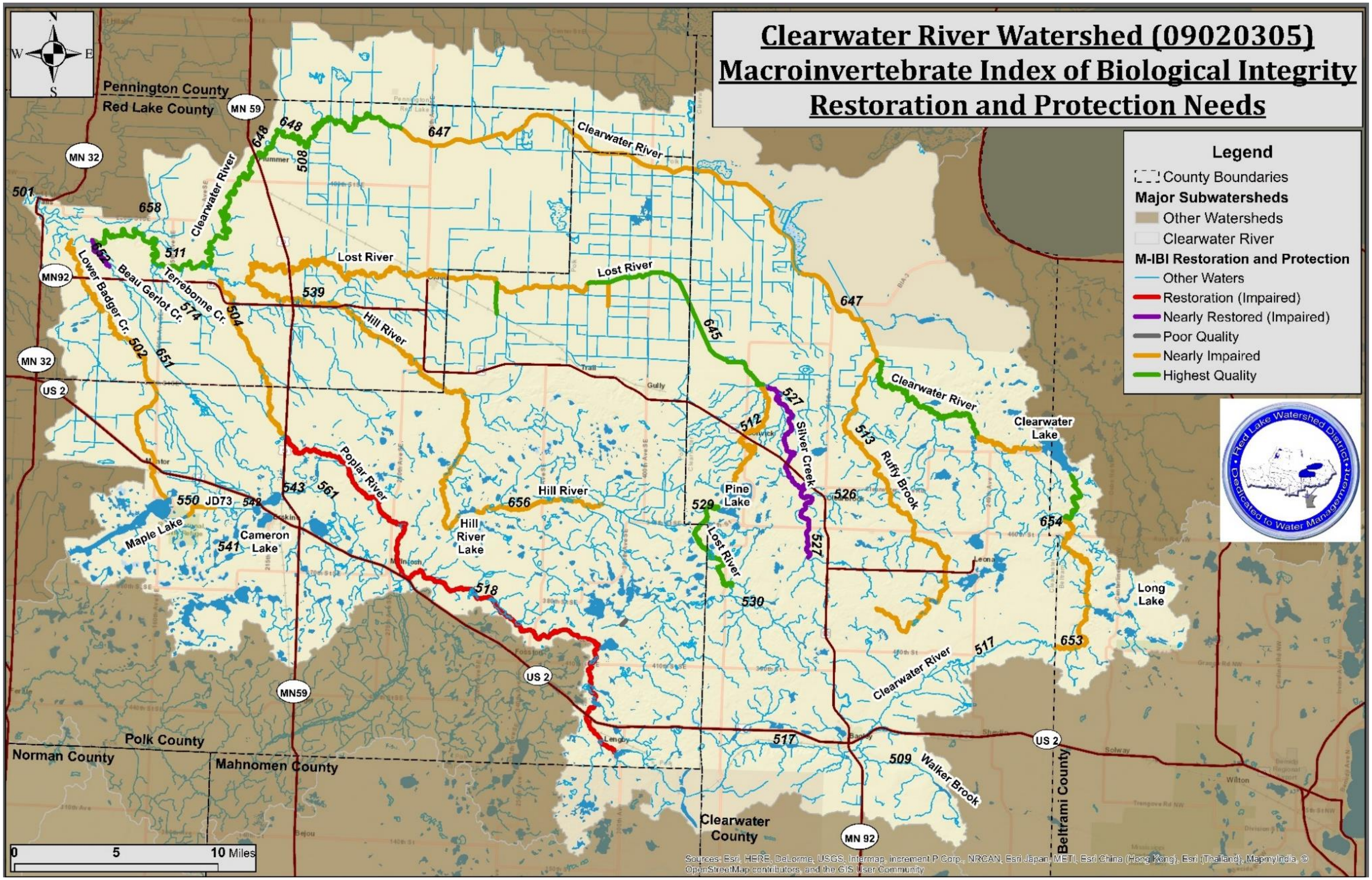


Figure 3-6. Map of Clearwater River Watershed M-IBI restoration and protection needs (2006-2015 data)

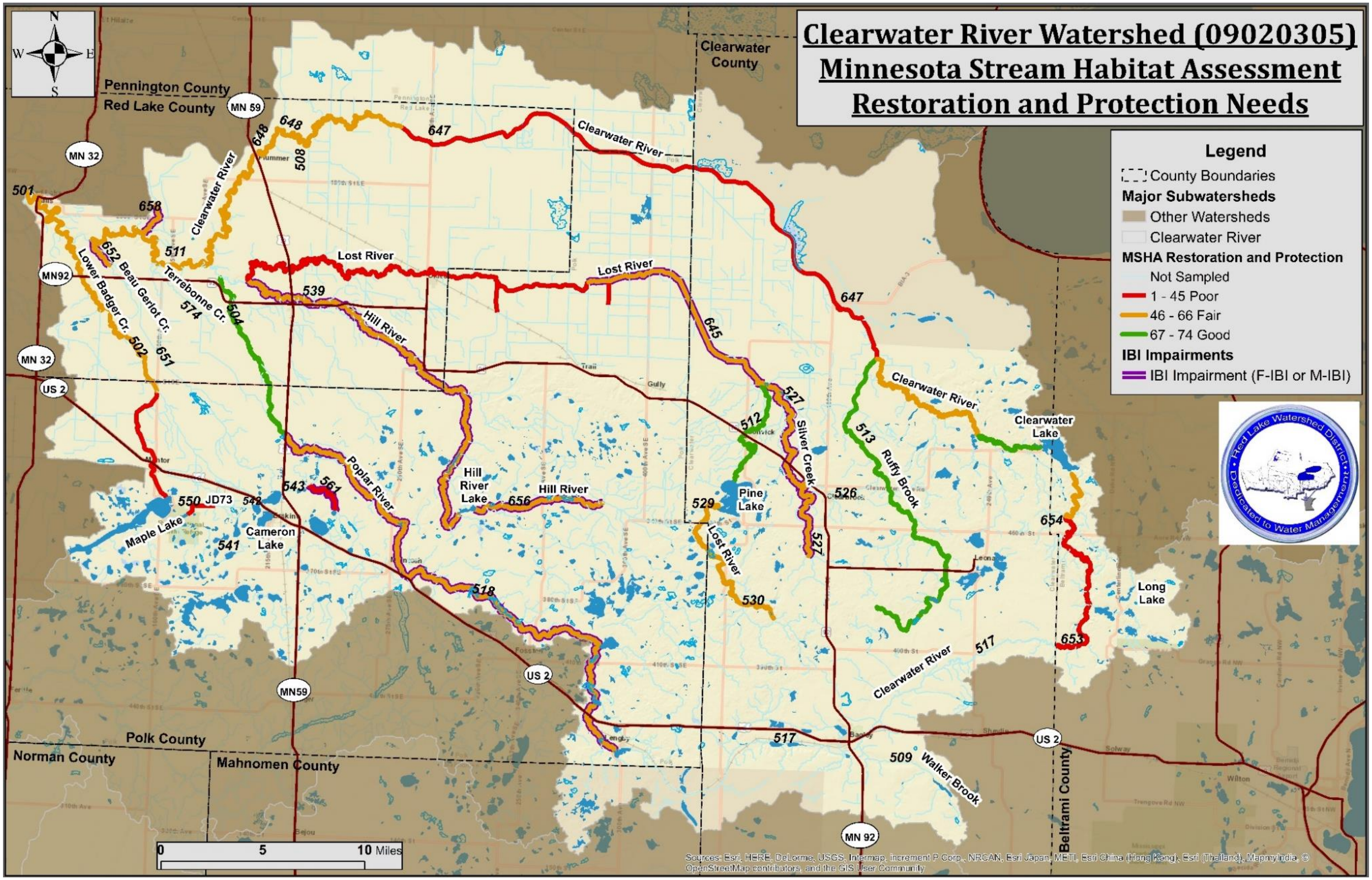


Figure 3-7. Map of Clearwater River Watershed MSHA-based habitat restoration and protection needs (2006-2015 data)

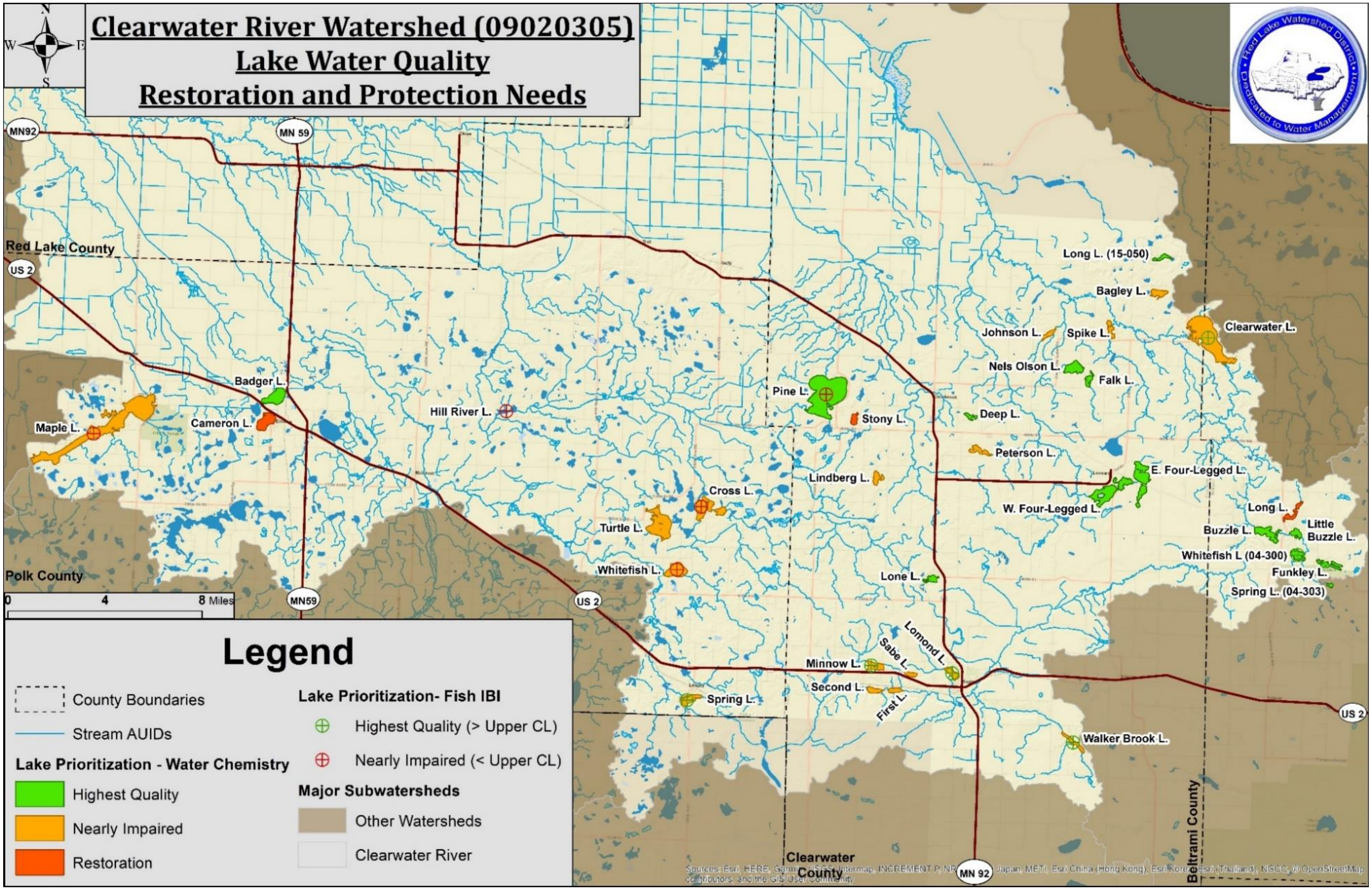


Figure 3-8. Map of Clearwater River Watershed restoration and protection needs for lakes (2006-2015 data). Lake identification numbers are shown in Table 3-6 and noted on the map to identify lakes with identical names.

Table 3-1. Summary of methods used for a data-based categorization and prioritization of streams for restoration and protection

	Parameters								
	Total Suspended Solids	***E. coli* Bacteria**	**Dissolved Oxygen**	**River TP and River Eutrophication**	F-IBI	**Macro-invertebrate IBI**	**Habitat Minimum MSHA**	**Pfankuch Stability**	**Lake Total Phosphorus and Lake Eutrophication**
Statistical Measurement:	Exceedance rate	Maximum monthly geomean	Percentage of days with <5 mg/L daily minimums (DO_5)	Summer average TP, BOD, Chl-a, and/or DO Flux	IBI score minus impairment threshold (Average)	IBI score minus impairment threshold (Average)	Minimum Minnesota Stream Habitat Assessment (MSHA) score & rating	Pfankuch stability rating	Summer Average TP, BOD, Chl-a, and/or DO Flux
Poor Quality (not impaired) =	n/a	n/a	>10%	n/a	<0	<0	Poor score (<45), no IBI impairment	<0	n/a
Restoration (Impaired) =	>12.5%	>157.5	>15%	>(125% of Std)	<-22.6	<-12.9	Poor score (<45) & IBI Impairment	TSS Impairment & Unstable	>(125% of Std)
Nearly Restored (Impaired) =	10%<x<12.5%	126<x<157.5	10%<x<15%	Std<x<(125% of Std)	<0	-12.9<x<0	Fair score (<66) or better and an IBI impairment	TSS impairment & moderately unstable	Std<x<(125% of Std)
Nearly Impaired =	7.5%<x<10%	94.5<x<126	>5%	>Std	<11.3	0<x<12.9	Fair score (45<MSHA<66)	No TSS impairment & moderately unstable, unstable, or mixed results	(75% of Std)<x<Std
Highest Quality =	<7.5%	<94.5	<5%	<(75% of Std)	>11.3	>12.9	Good score (>66)	Stable	<(75% of Std)

Table 3-2. Categorization and prioritization of streams for restoration and protection (AUIDs 501 through 523, 2006-2015 data)

Assessment Unit ID	Waterbody Name	Reach Description	River Nutrient Region (for Local Planning)	Total Suspended Solids	*E. coli* Bacteria	Dissolved Oxygen	River TP and River Eutroph-ication	F-IBI	M-IBI	Habitat Minimum MSHA	Pfankuch Stability
09020305-501	Clearwater River	Lower Badger Creek to Red Lake River	Central	Restoration (Impaired)	Highest Quality	Highest Quality	Nearly Impaired			63, Fair	Unstable
09020305-502	Lower Badger Creek	CD 14 to Clearwater River	Central	Nearly Impaired	Restoration (Impaired)	Highest Quality	Highest Quality	Nearly Impaired	Nearly Impaired	48.6, Fair	
09020305-504	Poplar River	Highway 59 to Lost River	Central	Highest Quality	Restoration (Impaired)	Nearly Impaired	Nearly Impaired	Highest Quality	Nearly Impaired	69.3, Good	
09020305-508	County Ditch 57	Unnamed ditch to Clearwater River	Central	Highest Quality	Nearly Impaired	Poor Quality	Nearly Impaired				
09020305-509	Walker Brook	Walker Brook Lake to Clearwater River	North			Poor Quality					
09020305-511	Clearwater River	Lost River to Beau Gerlot Creek	Central	Nearly Restored (Impaired)	Nearly Impaired	Highest Quality	Nearly Impaired	Highest Quality	Highest Quality	57.8, Fair	Moderately Unstable
09020305-512	Lost River	Pine Lake to Anderson Lake	Central	Highest Quality	Nearly Restored (Impaired)	Highest Quality	Highest Quality	Nearly Impaired	Nearly Impaired	66.5, Good	
09020305-513	Ruffy Brook	Headwaters to Clearwater River	Central	Highest Quality	Restoration (Impaired)	Nearly Impaired	Nearly Impaired	Highest Quality	Nearly Impaired	73.8, Good	
09020305-517	Clearwater River	Headwaters to T148 R36W S36, east line	North	Highest Quality	Nearly Impaired	Restoration (Impaired)	Nearly Impaired				
09020305-518	Poplar River	Spring Lake to Highway 59	Central	Highest Quality	Nearly Impaired	Restoration (Impaired)	Nearly Impaired	Nearly Restored (Impaired)	Restoration (Impaired)	52.9, Fair	Stable
09020305-523	Polk CD 14	Maple Lake to Lower Badger Creek	Central	Highest Quality	Highest Quality	Highest Quality	Highest Quality	Nearly Impaired	Nearly Impaired	43, Poor	

Poor Quality = AUID failed to meet numerical standards due to non-pollutant factors, but it is not on the 2018 List of Impaired Waters.	Poor quality
Restoration (Impaired) = AUID is listed on the 2018 List of Impaired Waters	Poor quality and Impaired
Nearly Restored = AUID failed to meet numerical standards, but is relatively close to the impairment threshold	Fair to Good and impaired
Nearly Impaired = AUID met numerical standards, but only by a small margin	Poor to fair, not impaired
Highest Quality = AUID met numerical standards by a relatively significant margin	Good, not impaired

Table 3-3. Categorization and prioritization of streams for restoration and protection (AUIDs 526 through 549, 2006-2015 data)

Assessment Unit ID	Waterbody Name	Reach Description	River Nutrient Region (for Local Planning)	Total Suspended Solids	*E. coli* Bacteria	Dissolved Oxygen	River TP and River Eutroph-ication	F-IBI	M-IBI	Habitat Minimum MSHA	Pfankuch Stability
09020305-526	Unnamed Creek (Clear Brook)	Headwaters to Silver Creek	Central	Highest Quality	Nearly Restored (Impaired)	Restoration (Impaired)	Nearly Impaired				
09020305-527	Silver Creek	Headwaters to Anderson Lake	North	Nearly Impaired	Restoration (Impaired)	Highest Quality	Nearly Impaired	Nearly Impaired	Nearly Restored (Impaired)	56.1, Fair	Stable, Moderately Unstable
09020305-529	Lost River	T148 R38W S17, south line to Pine Lake	Central	Highest Quality	Restoration (Impaired)	Restoration (Impaired)	Highest Quality	Highest Quality	Highest Quality	53, Fair	
09020305-530	Lost River	Unnamed creek to T148 R38W S20, north line	Central		Restoration (Impaired)	Nearly Impaired		Nearly Impaired		48.7, Fair	
09020305-539	Hill River	Hill River Lake to Lost River	Central	Highest Quality	Restoration (Impaired)	Highest Quality	Highest Quality	Nearly Restored	Nearly Impaired	59.5, Fair	
09020305-541	Unnamed Creek (Bee Lake Inlet)	Eighteen Lake to Bee Lake	Central			Poor Quality					
09020305-542	Unnamed Creek (JD73)	Mitchell Lake to Badger Lake	Central			Poor Quality					
09020305-543	Poplar River Diversion	Unnamed ditch to Badger Lake	Central			Poor Quality					
09020305-545	Unnamed creek (Nassett Creek)	T148 R38W S28, south line to Lost River	Central	Nearly Restored (Impaired)	Restoration (Impaired)	Restoration (Impaired)					
09020305-549	Unnamed Creek (JD73)	Tamarack Lake to Maple Lake	Central	Highest Quality	Highest Quality	Poor Quality	Highest Quality				

Poor Quality = AUID failed to meet numerical standards due to non-pollutant factors, but it is not on the 2018 List of Impaired Waters.	Poor quality
Restoration (Impaired) = AUID is listed on the 2018 List of Impaired Waters	Poor quality and Impaired
Nearly Restored = AUID failed to meet numerical standards, but is relatively close to the impairment threshold	Fair to Good and impaired
Nearly Impaired = AUID met numerical standards, but only by a small margin	Poor to fair, not impaired
Highest Quality = AUID met numerical standards by a relatively significant margin	Good, not impaired

Table 3-4. Categorization and prioritization of streams for restoration and protection (AUIDs 550 through 645, 2006-2015 data)

Assessment Unit ID	Waterbody Name	Reach Description	River Nutrient Region (for Local Planning)	Total Suspended Solids	*E. coli* Bacteria	Dissolved Oxygen	River TP and River Eutroph-ication	F-IBI	M-IBI	Habitat Minimum MSHA	Pfankuch Stability
09020305-550	JD 73	Private ditch near 187th Avenue NE to Tamarack Lake	Central	Highest Quality	Restoration (Impaired)	Restoration (Impaired)	Highest Quality	Highest Quality	Nearly Impaired	27.8, Poor	
09020305-551	Unnamed creek (Bee Lake Outlet)	Bee Lake to JD 73	Central			Poor Quality					
09020305-561	Tributary to Poplar River Diversion	Gerdin Lake to Poplar River Diversion	Central					Nearly Restored (Impaired)		28.5, Poor	
09020305-574	Terrebonne Creek	CD 4 to CD 58	Central	Highest Quality	Restoration (Impaired)	Nearly Impaired	Highest Quality				
09020305-578	Brooks Creek	Unnamed creek to Hill River	Central		Nearly Restored (Impaired)						
09020305-590	SD 61	Unnamed ditch to Lost River	Central					Nearly Impaired	Highest Quality	45, Fair	
09020305-592	Unnamed ditch	Near Red Lake Nation Wild Rice	Central					Poor Quality			
09020305-641	Unnamed ditch (Hill R. tributary)	Ditch draining wetlands by S. Connection Lake	Central					Poor Quality	Poor Quality		
09020305-643	JD 72 Outlet	Unnamed ditch to Lost River	Central					Highest Quality	Nearly Impaired	37.5, Poor	
0920305-645	Lost River	Anderson Lake to unnamed creek	Central	Highest Quality	Nearly Impaired	Nearly Restored (Impaired)	Highest Quality	Nearly Restored (Impaired)	Highest Quality	47.5, Fair	Moderately Unstable

Poor Quality = AUID failed to meet numerical standards due to non-pollutant factors, but it is not on the 2018 List of Impaired Waters.	Poor quality
Restoration (Impaired) = AUID is listed on the 2018 List of Impaired Waters	Poor quality and Impaired
Nearly Restored = AUID failed to meet numerical standards, but is relatively close to the impairment threshold	Fair to Good and impaired
Nearly Impaired = AUID met numerical standards, but only by a small margin	Poor to fair, not impaired
Highest Quality = AUID met numerical standards by a relatively significant margin	Good, not impaired

Table 3-5. Categorization and prioritization of streams for restoration and protection (AUIDs 646 through 658, 2006-2015 data)

Assessment Unit ID	Waterbody Name	Reach Description	River Nutrient Region (for Local Planning)	Total Suspended Solids	*E. coli* Bacteria	Dissolved Oxygen	River TP and River Eutroph-ication	F-IBI	M-IBI	Habitat Minimum MSHA	Pfankuch Stability
09020305-646	Lost River	Unnamed creek to Hill River	Central	Nearly Impaired	Nearly Impaired	Highest Quality	Highest Quality	Nearly Impaired	Nearly Impaired	43.5, Poor	Stable, Moderately Unstable
09020305-647	Clearwater River	Ruffy Brook to JD 1	Central	Nearly Restored (Impaired)	Restoration (Impaired)	Nearly Impaired	Restoration (Impaired)	Nearly Impaired	Nearly Impaired	39, Poor	Moderately Unstable
09020305-648	Clearwater River	JD 1 to Lost River	Central	Restoration (Impaired)	Highest Quality	Highest Quality	Nearly Impaired	Highest Quality	Highest Quality	54.5, Fair	Stable
09020305-649	Clearwater River	Clearwater Lake to Unnamed creek	North	Highest Quality	Highest Quality	Highest Quality	Highest Quality	Nearly Impaired	Nearly Impaired	70.5, Good	
09020305-650	Clearwater River	Unnamed creek to Ruffy Brook	North		Highest Quality	Highest Quality	Highest Quality	Highest Quality	Highest Quality	64.1, Fair	Unstable, Stable
09020305-651	Bee Lake Outlet	Bee Lake to JD 73	Central	Highest Quality	Restoration (Impaired)		Highest Quality				
09020305-652	Beau Gerlot Creek	-96.1947 47.8413 to Clearwater River	Central			Highest Quality		Restoration (Impaired)	Nearly Restored (Impaired)	56.4, Fair	Moderately Unstable
09020305-653	Clearwater River	T148 R35W S31, west line to Unnamed creek	North	Highest Quality	Highest Quality	Restoration (Impaired)	Nearly Impaired	Nearly Impaired	Nearly Impaired	44, Poor	Stable
09020305-654	Clearwater River	Unnamed creek to Clearwater Lake	North					Highest Quality	Highest Quality	63.4, Fair	
09020305-655	Hill River (CD68/81)	Cross Lake to Br 4 CD 81 near Olga	Central			Nearly Impaired					
09020305-656	Hill River	Unnamed creek to Hill River Lake	Central	Highest Quality	Nearly Impaired	Restoration (Impaired)	Nearly Impaired	Restoration (Impaired)	Nearly Impaired	59.6, Fair	
09020305-658	Red Lake CD 23	-96.1479 47.8855 to Clearwater River	Central					Restoration (Impaired)		55, Fair	Stable

Poor Quality = AUID failed to meet numerical standards due to non-pollutant factors, but it is not on the 2018 List of Impaired Waters.	Poor quality
Restoration (Impaired) = AUID is listed on the 2018 List of Impaired Waters	Poor quality and Impaired
Nearly Restored = AUID failed to meet numerical standards, but is relatively close to the impairment threshold	Fair to Good and impaired
Nearly Impaired = AUID met numerical standards, but only by a small margin	Poor to fair, not impaired
Highest Quality = AUID met numerical standards by a relatively significant margin	Good, not impaired

Table 3-6. Classification and prioritization of lakes for restoration and protection (2006-2015 data)

Lake Name Lake ID	Overall Lake Priority	TP Std. (µg/L)	Avg. TP (µg/L)	TP Priority	Chl-a Std.	Avg. Chl-a (µg/L)	Chl-a Priority	Secchi Std. (m)	Secchi (m)	Secchi Priority
Long Lake 04-0295-00	Restoration	30	44	Restoration	9	18.9	Restoration	2	2.0	Nearly Restored
Buzzle Lake 04-0297-00	Highest Quality	30	9	Highest Quality	9	2.2	Highest Quality	2	4.0	Highest Quality
Little Buzzle 04-0298-00	Highest Quality	30	10	Highest Quality	9	2.3	Highest Quality	2	4.6	Highest Quality
Funkley 04-0299-00	Highest Quality	30	19	Highest Quality	9	4.1	Highest Quality	2	2.7	Highest Quality
Whitefish 04-0300-00	Highest Quality	30	19	Highest Quality	9	5.4	Highest Quality	2	3.1	Highest Quality
Spring Lake 04-0303-00	Highest Quality	30	14	Highest Quality	9	6.3	Highest Quality	2	3.2	Highest Quality
Clearwater 04-0343-00	Nearly Impaired	30	19	Highest Quality	9	7.0	Nearly Impaired	2	2.8	Highest Quality
East Four-Legged Lake 15-0027-00	Highest Quality	60	14	Highest Quality	20	2.7	Highest Quality	1	>1.5	Highest Quality
West Four-Legged Lake 15-0028-00	Highest Quality	60	13	Highest Quality	20	3.9	Highest Quality	1	2.3	Highest Quality
Spike Lake 15-0035-00	Nearly Impaired	30	28	Nearly Impaired	9	7.8	Nearly Impaired	2	2.9	Highest Quality
Nels Olson Lake 15-0037-00	Highest Quality	60	26	Highest Quality	20	4.3	Highest Quality	1	2.6	Highest Quality
Falk Lake 15-0038-00	Highest Quality	40	22	Highest Quality	14	6.4	Highest Quality	1.4	3.1	Highest Quality
Bagley Lake 15-0040-00	Nearly Impaired	30	21	Highest Quality	9	6.8	Nearly Impaired	2	3.0	Highest Quality
Long Lake 15-0050-00	Highest Quality	30	10	Highest Quality	9	2.6	Highest Quality	2	5.5	Highest Quality
Walker Brook Lake 15-0060-00	Nearly Impaired	30	24	Nearly Impaired	9	9.5	Nearly Impaired	2	3.3	Highest Quality
Lomond Lake 15-0081-00	Nearly Impaired	30	22	Highest Quality	9	6.8	Nearly Impaired	2	3.2	Highest Quality
Peterson Lake 15-0083-00	Nearly Impaired	40	20	Highest Quality	14	19.0	Nearly Impaired	1.4	3.7	Highest Quality
Johnson Lake 15-0086-00	Nearly Impaired	30	26	Nearly Impaired	9	11.5	Nearly Impaired	2	2.4	Nearly Impaired
Deep Lake 15-0090-00	Highest Quality	40	9	Highest Quality	14	2.5	Highest Quality	1.4	4.6	Highest Quality
Lone Lake 15-0104-00	Highest Quality	40	9	Highest Quality	14	1.7	Highest Quality	1.4	6.1	Highest Quality
Minnow Lake 15-0137-00	Nearly Impaired	30	19	Highest Quality	9	6.9	Nearly Impaired	2	3.1	Highest Quality
Sabe Lake 15-0138-00	Nearly Impaired	30	20	Highest Quality	9	3.3	Highest Quality	2	2.5	Nearly Impaired
First Lake 15-0139-00	Nearly Impaired	30	23	Nearly Impaired	9	9.3	Nearly Impaired	2	2.8	Highest Quality
Second Lake 15-0140-00	Nearly Impaired	30	28	Nearly Impaired	9	10.9	Nearly Impaired	2	2.4	Nearly Impaired

Lake Name Lake ID	Overall Lake Priority	TP Std. (µg/L)	Avg. TP (µg/L)	TP Priority	Chl-a Std.	Avg. Chl-a (µg/L)	Chl-a Priority	Secchi Std. (m)	Secchi (m)	Secchi Priority
Lindberg Lake 15-0144-00	Nearly Impaired	40	35	Nearly Impaired	14	11.7	Nearly Impaired	1.4	2.9	Highest Quality
Pine Lake 15-0149-00	Highest Quality	60	25	Highest Quality	20	6.8	Highest Quality	1	>2.3	Highest Quality
Stony Lake 15-0156-00	Restoration	60	137	Restoration	20	46.4	Restoration	1	2.1	Nearly Restored
Spring Lake (Lengby) 60-0012-00	Nearly Impaired	40	34	Nearly Impaired	14	9.9	Highest Quality	1.4	1.9	Highest Quality
Whitefish Lake 60-0015-00	Nearly Impaired	60	65 (IF)	Nearly Impaired	20	35.2	Nearly Impaired	1	1.2	Nearly Impaired
Cross Lake 60-0027-02	Nearly Impaired	60	51 (IF)	Nearly Impaired	20	20.0	Nearly Impaired	1	1.3	Nearly Impaired
Turtle Lake 60-0032-00	Nearly Impaired	60	33	Highest Quality	20	23.9	Nearly Impaired	1	1.0	Nearly Impaired
Cameron Lake 60-0189-00	Restoration	60	94	Restoration	20	57.9	Restoration	1	0.4	Restoration
Badger Lake 60-0214-00	Highest Quality	60	22	Highest Quality	20	7.3	Highest Quality	1	2.7	Highest Quality
Maple Lake 60-0305-00	Nearly Impaired	60	39	Highest Quality	20	14.1	Highest Quality	1	1.3	Nearly Impaired
Calculation Method:	Poorest water quality indicated by any parameter	Concentration / Standard			Concentration / Standard			Standard / Average Depth		
Restoration		>1.25, Impaired			>1.25, Impaired			>1.25, Impaired		
Nearly Restored		<1.25, Impaired			<1.25, Impaired			<1.25, Impaired		
Nearly Impaired		>.75, Not impaired			>.75, Not impaired			>.75, Not impaired		
Highest Quality		<.75, Not impaired			<.75, Not impaired			<.75, Not impaired		

3.2 Targeting of Geographic Areas

Efforts to improve water quality and habitat can cost-effectively result in measurable change when critical areas are identified by a watershed model, tool, and/or field observations that show areas that are disproportionately contributing pollutant loads or excess flow to surface waters. For protection purposes, such areas may include pollutant reductions for nearly impaired streams and preservation of areas have a high potential for adversely affecting water quality if disturbed.

Several available tools and practical operations may be used to rank and identify areas of the Red Lake River Watershed in need of projects to reduce nonpoint source pollution. In order to accomplish the objectives of the TMDL, WRAPS, and future 1W1P, some combination of the tools and information outlined below will need to be utilized.

- SWAT

- HSPF-SAM
- SPI terrain analysis
- PTMApp
- Zonation
- Longitudinal Sampling
- Fluvial geomorphology study
- Restorable Wetland Inventory

Ideally, HSPF-SAM and zonation should be used to identify subwatersheds or sub-basins to be targeted for projects to reduce TSS and TP loads. Field-scale tools like PTMApp and SPI can be used to pinpoint locations to be targeted for cost-effective implementation of projects. In addition to the tools described in this section, other efforts have been undertaken to help identify critical areas for targeted implementation efforts. Windshield reconnaissance, in-stream (kayak) reconnaissance, examination of aerial photos, and ditch inspections are some of the on-the-ground methods used to identify erosion problems. Rivers can be prioritized for restoration or protection during the 1W1P process based upon priority issues and proximity to water quality standards. Some pollutants and water quality conditions like high *E. coli* and low DO are difficult to model. Targeting for implementation of projects to address those water quality issues can be accomplished through direct measurement like longitudinal sampling and MST sampling (Section 2.3). Targeting of projects for DO improvement require more intensive inspection of the stream and creative projects to address the causes of low DO described in Section 2.3.

SWCDs may use ditch inventories to prioritize ditches for BMP implementation based upon the magnitude of need for side water inlets and buffers. Implementation of the provisions of the State of Minnesota's 2015 Buffer Law will be very beneficial to water quality conditions throughout the watershed. Modeling results indicate that improved buffers will significantly improve water quality. Much of the Clearwater River has been traversed by water quality professionals and a pattern in the relationship between buffer quality and erosion is evident. Although buffers will not stop all erosion, the most severe erosion problems (slumping banks) occur where there is no buffer of deep-rooted perennial vegetation. Trees and deep-rooted vegetation stabilize banks and provide surface protection. Slumping typically occurs where that woody and deep-rooted vegetation has been removed. Ditches and public waters will be inspected for buffer compliance under the law. The next step would be to encourage voluntary improvement of the quality of vegetation along buffers (more woody and native vegetation).

Soil and Water Assessment Tool Model

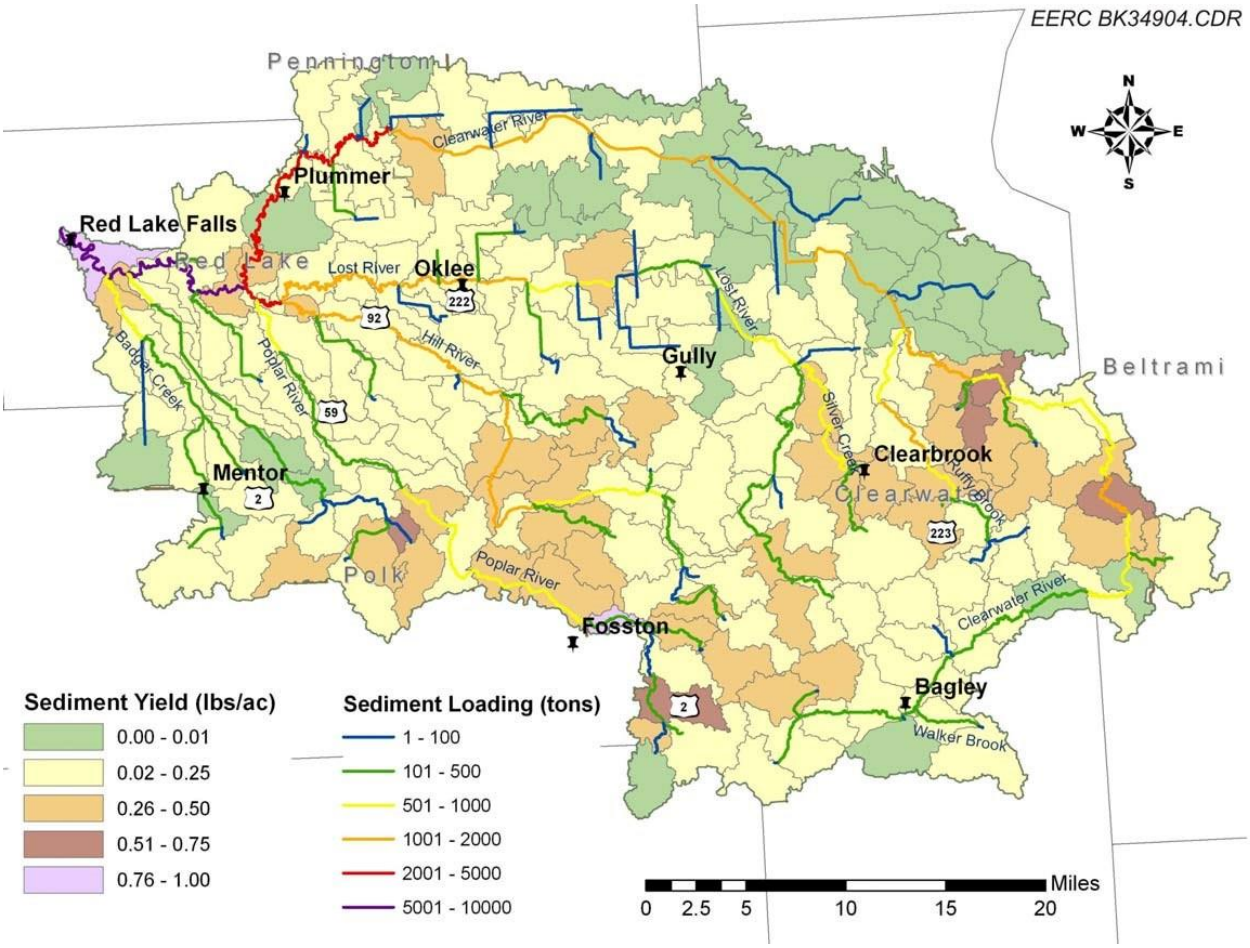


Figure 3-9. The estimated average annual sediment erosion from the landscape of each SWAT subbasin (sediment yield) and the estimated sediment loading within each reach simulated by the Clearwater River Watershed SWAT model.

Prior to the development of the Clearwater River Watershed HSPF model and PTMApp, nearly every major watershed within the Red River Basin was modeled using the SWAT model. The SWAT model simulated water quality at a scale that was similar to the HSPF model. The results of these models have been used to target projects and estimate benefits of BMP implementation. The map in Figure 3-9 from the Clearwater River SWAT model report shows the sub-basins that are contributing the most sediment per acre (sediment yield). According to that map, subwatersheds along the lower reaches of the Clearwater River should be targeted for implementation projects. The Energy and Environmental Research Center also produced a SWAT model for the Silver Creek Subwatershed under a contract with the Clearwater SWCD. The SWAT models were used to plan and successfully apply for grant funding for water quality projects.

Hydrological Simulation Program – FORTRAN Model

An HSPF model of the Clearwater River was developed by the RESPEC consulting firm in 2017. The HSPF model essentially replaces the SWAT model and provides a better simulation of in-channel processes. The HSPF model incorporates watershed-scale and non-point source models into a basin-scale analysis framework. It addresses runoff and constituent loading from pervious land surfaces, runoff and constituent loading from impervious land surfaces, and flow of water and transport/ transformation of chemical constituents in stream reaches. It provides a simulation of watershed hydrology and water quality for both conventional and toxic organic pollutants from pervious and impervious land. It typically used in large watersheds (greater than 100 square miles). The HSPF model also utilized watershed and subwatershed boundaries that were delineated using LiDAR data. The simulation period of the HSPF model was recently updated to simulate water quality from 1996 through 2016.

HSPF Scenario Application Manager (HSPF-SAM)

The HSPF-SAM tool is an interface for the extraction of information from an existing HSPF model. The tool has been developed for the Clearwater River Watershed, and can be used to create strategies tables that quantify the BMPs that are needed in order to achieve pollutant reduction goals. The suitability of BMPs can be estimated on the HUC-12 scale. It is most effective when used in tandem with local scale GIS targeting (PTMApp or ACPF) and local resource manager knowledge. The HSPF-SAM tool, watershed files, and tutorials can be downloaded from the RESPEC website: https://www.respec.com/sam-file-sharing/.

The HSPF-SAM tool was utilized to extract data for use in creating maps of pollutant yields (Figure 3-10), runoff rates and other data for the calculation of TMDLs, and estimation of pollutant reductions that were obtainable through BMP implementation. The different types of data that can be extracted from the HSPF model using the HSPF-SAM tool are listed and described in Table 3-7, which summarizes information provided during an HSPF-SAM training workshop.

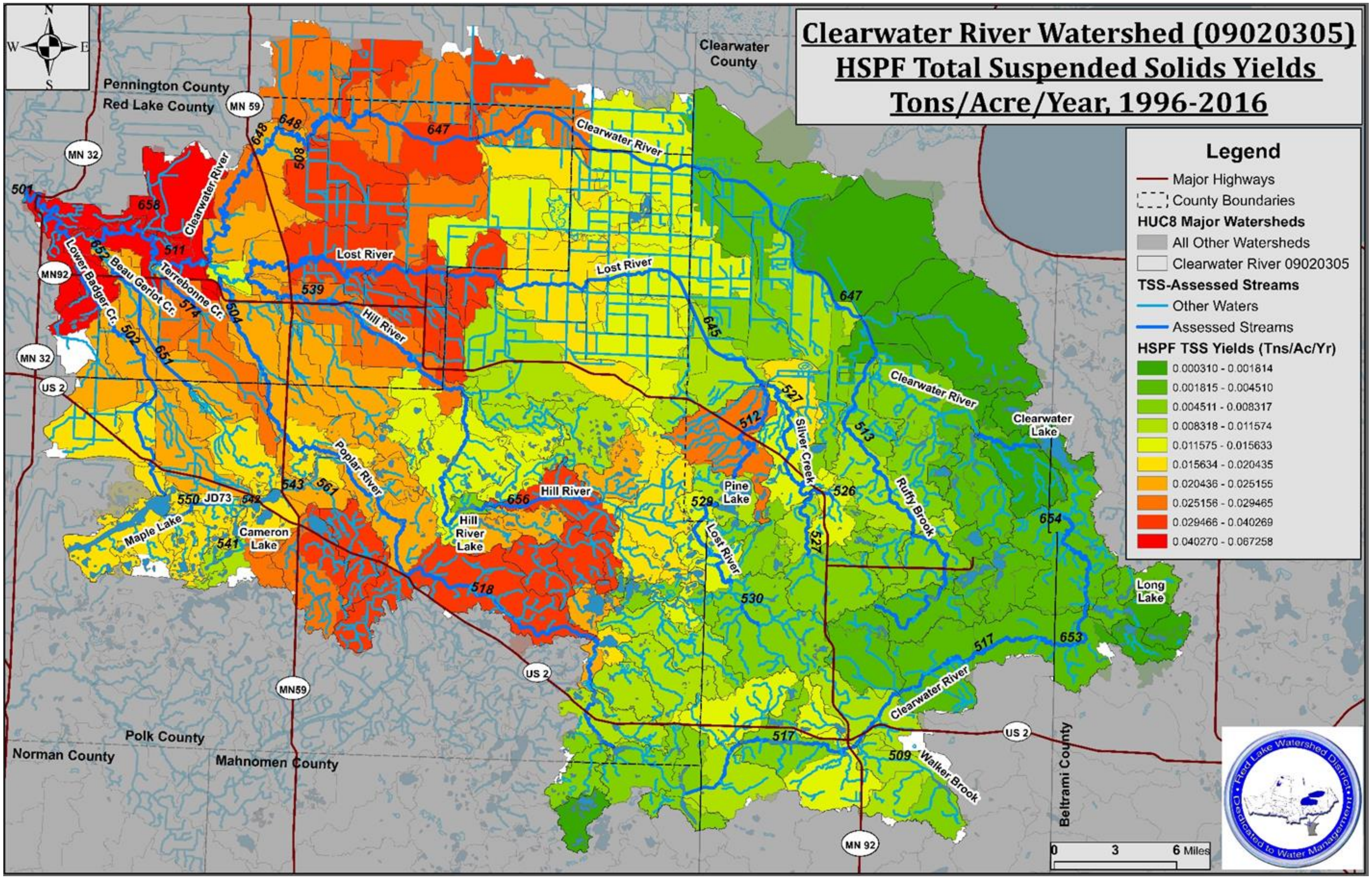


Figure 3-10. Clearwater River Watershed HSPF-Modeled Sediment Yields and Loads by Subwatershed

Table 3-7. Examples of types of data that can be extracted from the HSPF model using the HSPF-SAM tool

Data Type	Description	Units
Reach Concentration	Average concentration of the selected parameter simulated within the modeled stream reach	Cfs, °F, Mg/L, µg/L
Reach Load	Total daily load of the selected parameter simulated at the outlet of the modeled stream reach	Acre-ft/interval, BTU/interval, tons/interval, lbs/interval
Source Load	Constituent load contributed from each different source for the entire watershed	Acre-ft/interval, tons/interval, lbs/interval
Source Load Rate	Constituent load from a given nonpoint source divided by the area of that nonpoint source for the entire watershed	Ft/interval, tons/acre/interval, lbs/acre/interval
Basin Load	Sum of the loading from all point and nonpoint sources within each subwatershed, but does not include loading from upstream	Acre-ft/interval, tons/interval, lbs/interval
Basin Load Rate	Sum of the local area basin loads aggregated at the outlet of each unique sub-basin (Basin Load) and then divided by the sub-basin area in acres	Ft/interval, tons/ace/interval, lbs/acre/interval
Basin Source Rate	Constituent load contributed from each different source (land use category) within a specific sub-basin	Acre-ft/interval, tons/interval, lbs/interval
Basin Source Load Rate	Constituent load contributed from each different source divided by the area of the source within a specific sub-basin	Acre-ft/interval, tons/interval, lbs/interval
Source Fate Contribution	Loading from each source that makes it to the endpoint of the selected reach.	Acre-ft/interval, tons/interval, lbs/interval

Prioritize, Target, and Measure Application (PTMApp)

The International Water Institute and Houston Engineering have developed a tool that can be used to prioritize, target, and measure simulated water quality improvements. The PTMApp tool is a vision for a state-wide desktop and web application, which be used by practitioners to provide the technical bridge between the general description of the types of strategies in a local water plan and the identification of implementable on-the-ground BMPs and Conservation Practices (CPs).

PTMApp can be used by SWCDs, watershed districts, county local water planning, agency staff and decision-makers to PRIORITIZE resources and the issues affecting them, TARGET specific fields to place CPs and BMPs, and MEASURE water quality improvement by tracking the expected nutrient and sediment load reductions delivered to priority resources. The tool enables practitioners to build prioritized and targeted implementation scenarios, measure the cost-effectiveness of the scenario for improving water quality, and report the results to pursue funds for project implementation.

PTMApp breaks the drainage areas into relatively small units and estimates sediment and nutrient loss from each of those small units. Cost information has been incorporated so that projects can be targeted to achieve the greatest amount of pollutant reduction for each dollar spent. PTMApp is best suited to the targeting of practices that reduce pollution from overland runoff because it does not account for in-channel processes. According to modeling experts from RESPEC, an ideal modeling strategy would be to first utilize the HSPF model (and the HSPF-SAM tool) to prioritize sub-basins and estimate the amount of BMP implementation that will be needed within those areas. Then, PTMApp (or a similar fine scale model) can be used to pinpoint and prioritize the ideal, most cost-effective locations for those BMPs.

PTMApp has not yet been developed for the Clearwater River but is being developed for the Clearwater River 1W1P process. A culvert inventory of the watershed is in-progress to prwepare for hydro-conditioning of LiDAR data. Funding will be sought for the completion of the Clearwater River PTMApp. Web and desktop versions of the tool are available (for select watersheds) at https://ptmapp.bwsr.state.mn.us/.

Zonation

Zonation is a values-based model that can help prioritize critical areas within a watershed. The zonation process starts with the identification of watershed goals. The identification of priority areas is based on the quantitative analysis (using Zonation) of a suite of data layers. A group of LGU and state staff (e.g. a 1W1P planning work group) will come to an agreement on which landscape features should be included in the model and assign "weights" to those features based on their importance to stakeholders. The process is framed within the DNR's healthy watershed conceptual model. It incorporates multiple GIS layers, representing resource concerns that may include flooding, erosion, drinking water, ecological connectivity, groundwater, impaired waters, biology, restorable wetlands, prairie plan, rare features, modeled runoff rates, source water assessment areas, pollutant loading, wind erodibility, and more.

This approach recognizes that attempts to solve clean water needs within the watershed are not separate from other natural resource needs. The model identifies priority areas where implementation can provide multiple benefits. The model ranks each parcel of land (30-meter grid) to identify "hotspots" in the watershed where projects can be most beneficial. A zonation model has not been completed for the Clearwater River at this time. Zonation has been completed to aid 1W1P processes throughout the state and could be completed for the Clearwater River 1W1P when that process begins.

Longitudinal Sampling

The collection of longitudinal samples is a method for directly measuring how water quality changes within a stream as it flows past and is affected by potential pollutant sources, especially during runoff events. This sampling has been completed along several streams within the Clearwater River Watershed.

Clearwater River (09020305-501, 511, 647, and 648)

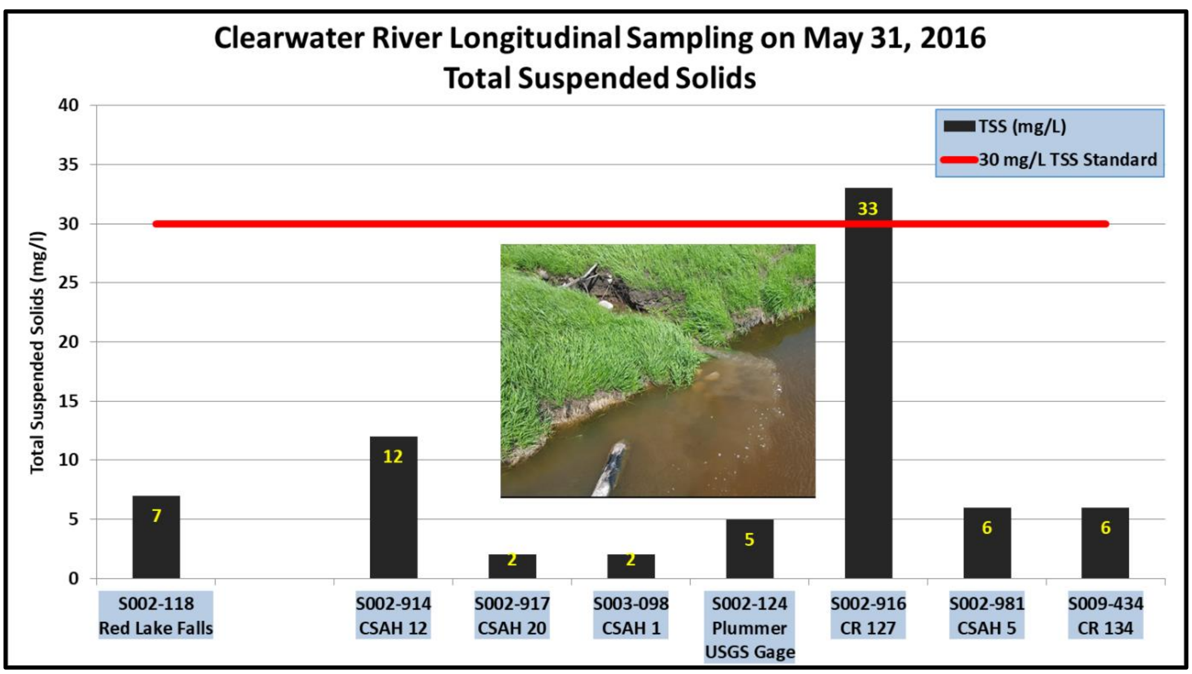


Figure 3-11. Longitudinal TSS sample collection along AUIDs 501, 511, 648, and 647 of the Clearwater River on May 31, 2016

Longitudinal samples were collected along TSS-impaired AUIDs 501, 511, 648, and 647 of the Clearwater River after a rainfall event (approximately one inch) on May 31, 2016 (Figure 3-11). Most of the sampling stations had TSS concentrations that met standards on that day. The TSS concentration at CR 127 (S002-916 on AUID 647) exceeded the standard. Plumes of sediment-laden water were seen where drainage ditches emptied into the Clearwater River near CR 127 (inset photo on Figure 3-11). High concentrations of *E. coli* were found at several locations on May 31, 2016 (Figure 3-12).

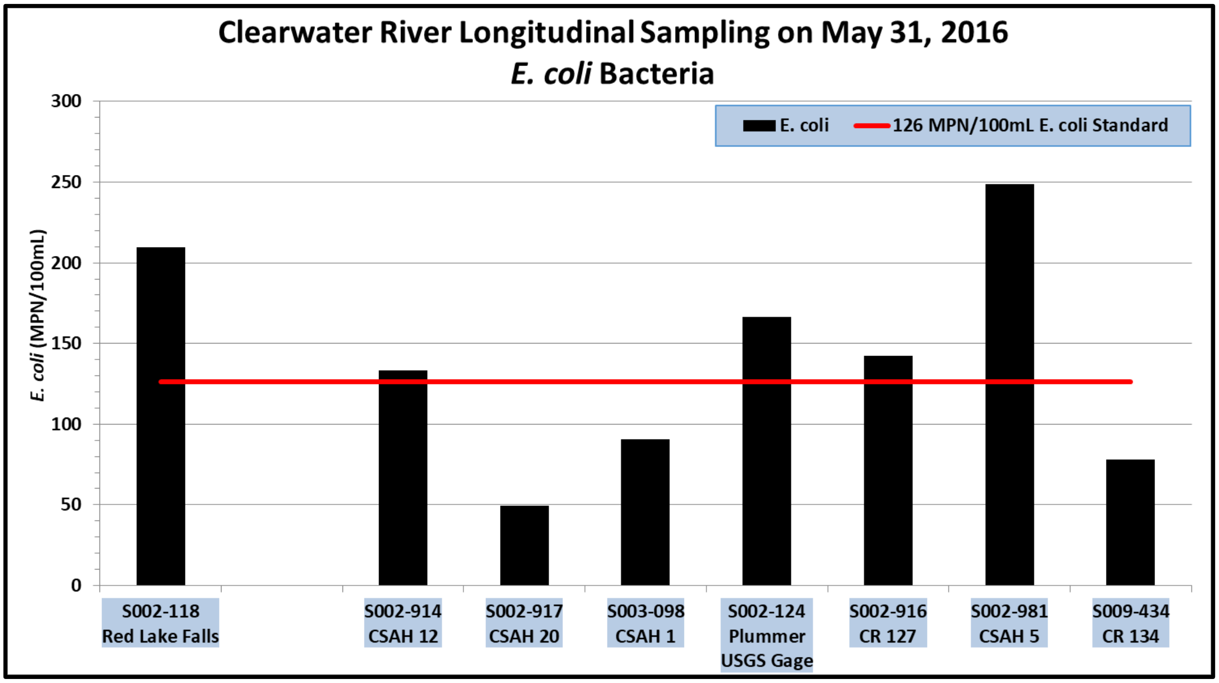


Figure 3-12. Longitudinal *E. coli* sample collection along AUIDs 501, 511, 648, & 647 of the Clearwater River on May 31, 2016

Longitudinal sampling along the Clearwater River and the outlets of its tributaries on June 7, 2016 after a rainfall event did not find any exceedances of the TSS or *E. coli* standards, but did find very high concentrations of nitrates and nitrites in Terrebonne Creek (20.5 mg/L) and Beau Gerlot Creek (10.2 mg/L).

Longitudinal water quality samples and in-situ measurements were collected on August 5, 2016 along the Clearwater River and its tributaries upstream and downstream of wild rice paddies while the paddies were being drained in preparation for harvest. DO levels in the Clearwater River were negatively impacted by drainage from the paddies. DO concentrations in ditches were very low, despite high and “normal” flows. Turbidity and TSS are also increased in the river downstream of the paddies, but only one site exceeded the 30 mg/l TSS standard (Figure 3-13). Nitrogen and TP concentrations increased significantly. The sharp increase in TP concentrations at CSAH 5 is shown in Figure 2-22 within Section 2.3 of this report. Figure 3-14 shows how DO was negatively affected by the discharge from the paddies and low DO in tributary ditches.

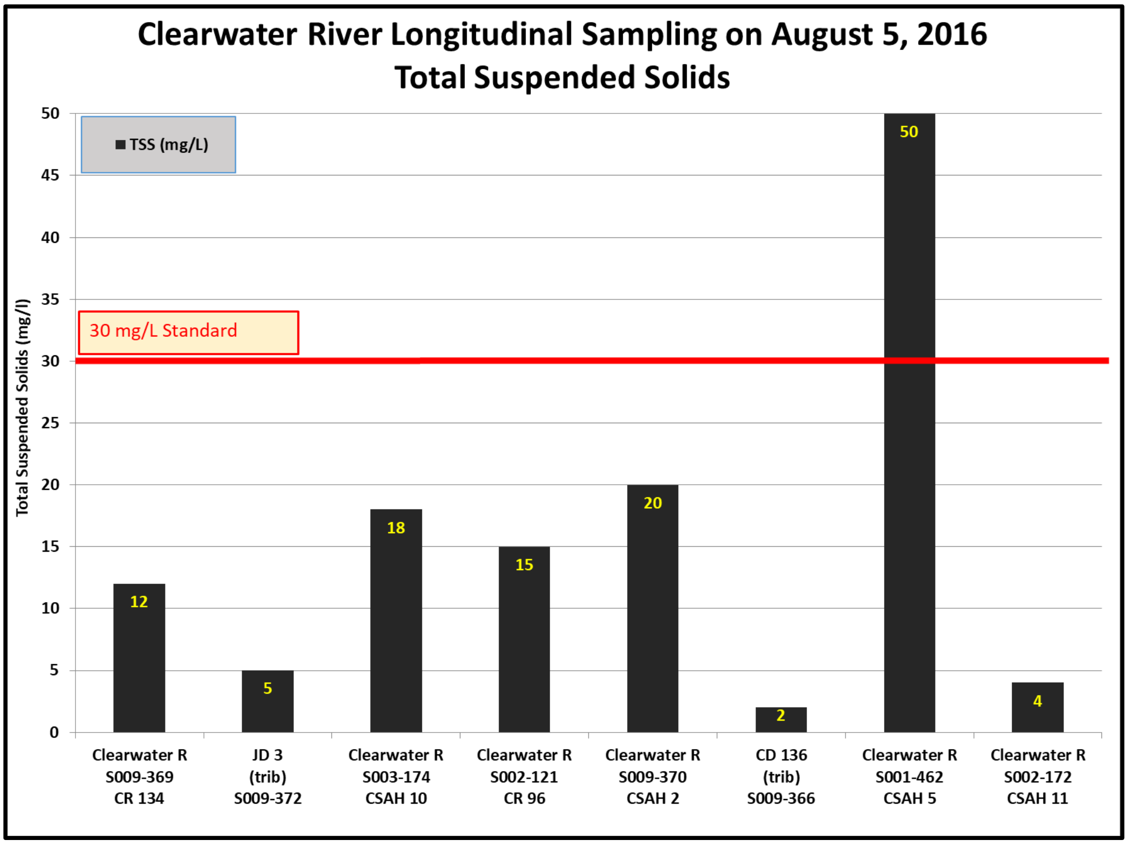


Figure 3-13. Longitudinal sampling of TSS along AUIDs 650 and 647 of the Clearwater River on August 5, 2016

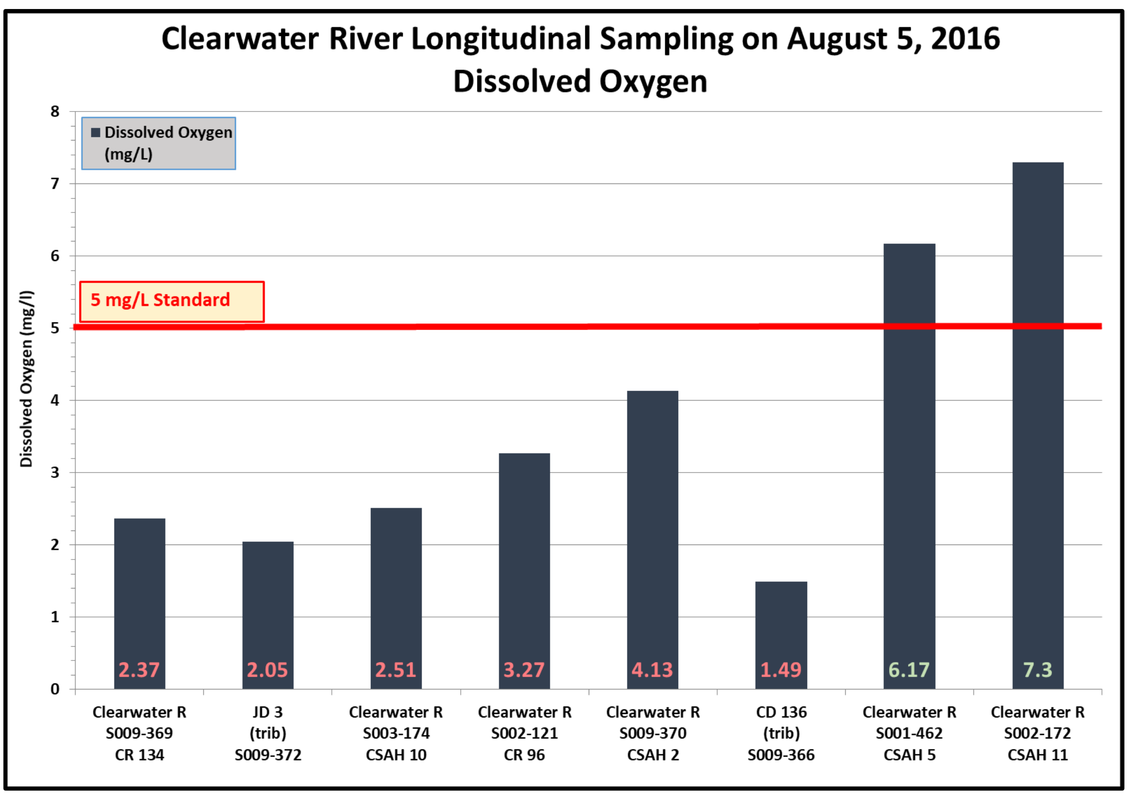


Figure 3-14. Longitudinal DO measurements along AUIDs 650 and 647 of the Clearwater River on August 5, 2016

Lower Badger Creek (09020305-502 and 524)

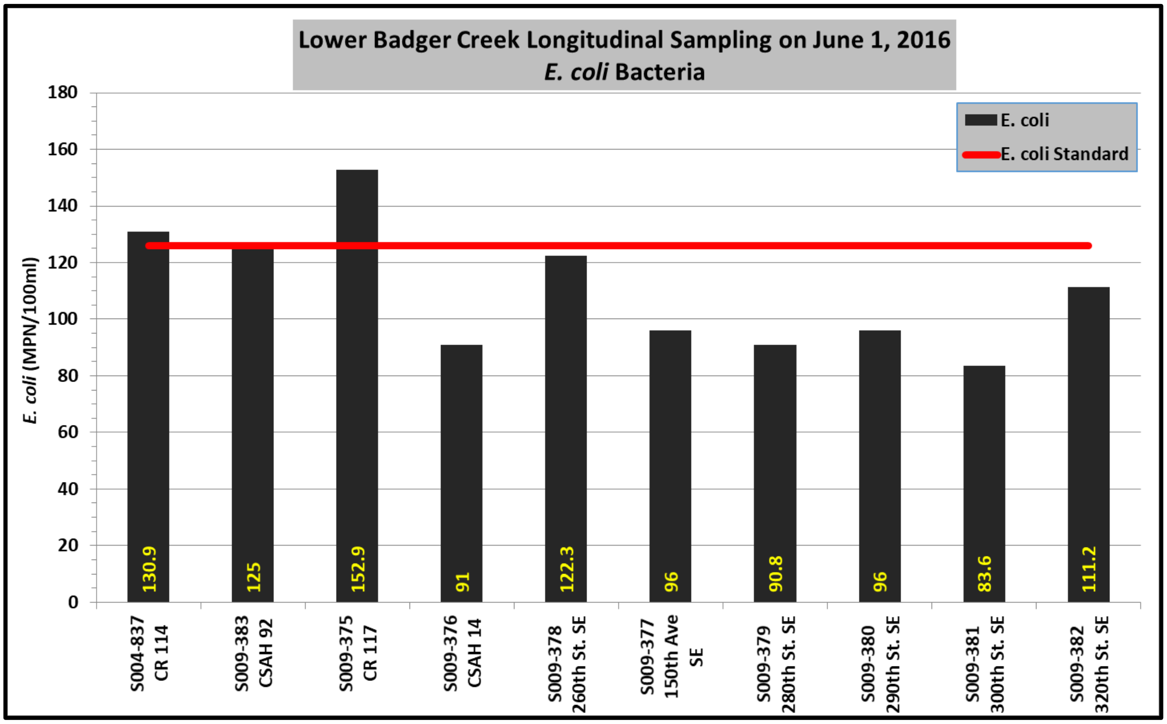


Figure 3-15. Longitudinal *E. coli* samples collected from Lower Badger Creek (AUIDs 502 and 524) on June 1, 2016

Longitudinal samples were collected along Lower Badger Creek on June 1, 2016 after a May 31, 2016 rainfall event (approximately one inch of rain). The TSS concentrations met standards and only increased slightly from 1 mg/L at 320th Street Southeast (S009-382) in AUID 524 to a maximum of 8 mg/L that was found at CSAH 92 (S009-383) and CR 117 (S009-375). Exceedances of the *E. coli* standard, however, were found at the lower three crossings of the stream (Figure 3-15), which indicated that there may be a source of *E. coli* between CSAH 14 and CR 117.

Poplar River (09020305-504 and 518)

Multiple attempts have been made to collect longitudinal snapshots of DO levels along the Poplar River and gain a better understanding of how DO levels change throughout the river. The findings and commonalities of multiple rounds of measurements are summarized in Figure 3-16. Graphs of individual rounds of DO measurements can be found in the August 2006, May 2007, August 2007, July 2016, and August 2016 RLWD monthly water quality reports (http://www.redlakewatershed.org/monthwq.html).

The first set of longitudinal measurements, on August 1, 2006, did not measure every station along AUID 518 but captured multiple locations where DO was low. There were also locations throughout the reach where DO levels were high enough to meet the 5 mg/L standard. A full set of measurements at every crossing from the outlet of Spring Lake to 220th Avenue Southeast was completed on August 16, 2007. Staff began at the downstream end of the watershed and moved upstream from crossing to crossing throughout the day. It is likely that, if all measurements could have been recorded at the same time of the first measurement (9:20 at S004-501), the DO levels at upstream sites (visited later in the day) would have been significantly lower than what was measured. Still, there were multiple sites in the upstream portion of the reach that failed to meet the 5 mg/L standard. Some of the same sites had low DO levels when longitudinal DO measurements were collected again on July 7, 2016. Another full set of measurements at crossings downstream of Spring Lake and 220th Avenue Southeast was completed on May 4, 2007. All of the DO levels were high enough to meet the standard on that day. The lowest DO concentration of 7.72 mg/L for that day was recorded at the Highway 2 crossing.

Overall, the areas with the worst DO levels included the CSAH 1 and CSAH 27 crossings east of the city of Fosston, 380th Street Southeast (downstream of the city of Fosston), and 360th Street Southeast (downstream of the city of McIntosh). DO levels recover between those stations. The reach between CSAH 27 and CSAH 6 and the reach between 380th Street Southeast and 283rd Avenue Southeast are examples of how DO concentrations can steadily improve along portions of the river.

Table 3-8. Longitudinal DO measurement data from the Poplar River

Poplar River Longitudinal Dissolved Oxygen (mg/L) Measurements							
Road Crossing	**Station ID**	**5/4/2007**	**8/1/2006**	**8/16/2007**	**7/7/2016**	**8/1 - 8/3/2016**	**8/11/2016**
CR 118	S007-608					7.36	6.74
CSAH 92	S002-117				2.98	7.66	
250th Avenue SE	S009-385				6.57	7.14	
260th Avenue SE	S009-387				5.71	7.26	
270th Avenue SE	S009-390				7.15	7.11	
CSAH 49	S009-402				7.33	7.29	
290th Street SE	S009-391					7.21	
220th Avenue SE	S004-501	9.92	5.22	6.19	8.22	7.71	
310th Street SE	S009-392	9.51		7.49	5.88	6.76	
315th Street SE	S002-091	10	4.5	4.88	5.51	6.64	
255th Avenue SE	S009-386	10.58		5.98	6.95	6.36	
CSAH 35	S005-320	10.85	6.25	3.93	7.52	5.65	
267th Avenue SE	S009-388	10.78		5.46	5.09	5.4	
340th Street SE	S003-126	9.88		4.81	7.75	8.17	
CSAH 8	S003-497	10.04	7.8	3.76	6.67	4.28	
350th Street SE	S009-395	10.44		7.84	6.06	1.06	
360th Street SE (McIntosh)	S002-915	11.92		1.97	3.8	0.22	
283rd Avenue SE	not established	12.76		7.3			
370th Street SE (W)	S009-398	12.06		9.47	6.28	5.43	
370th Street SE (E)	S009-397	12.17		8.5	4.01	6.57	
310th Avenue SE	S009-393	11.78		7.81	11.87	3.15	
320th Avenue SE	S009-394	11.58		11.03	3.91	2.86	
380th Street SE	S000-476	10.57		3.79	2.45	0.08	
CSAH 30	S003-127	12.49	1.71	10.01	4.31	7	
CSAH 6	S000-477	11.91	6.7	8.33	8.26	4.55	
360th Avenue SE	S009-396	12.06		6.29	7.87	1.45	
CSAH 27	S009-389	10.79		7.31	6.44	1.35	0.12
CSAH 1	S009-384	10.54	0.5	0.85	1.18		0.8
425th Street SE	S009-399	11.26	7.5	9.16	8.73		4.37
Hwy 2, Downstream	not established			8.96			
Hwy 2, Upstream	not established	8.48		4.47			
440th Street SE	S009-400	11.19		4.82	7.83		5.05
450th Street SE	S009-401	11.4		5.91	4.2		2.03
Spring Lake Outlet	S004-502	12.13	6.9	5.62			8.23
Shaded values are below the 5 mg/L standard							

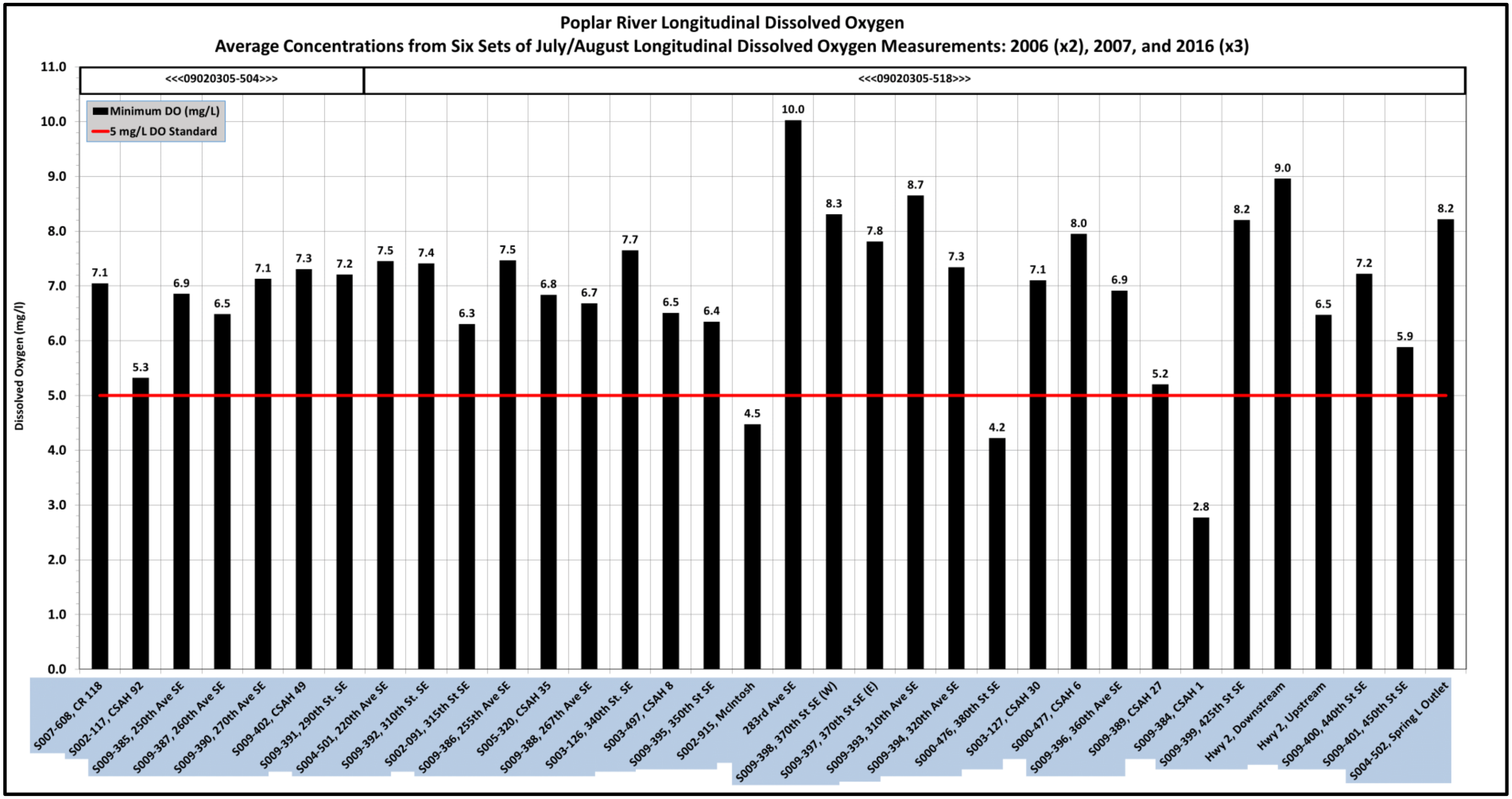


Figure 3-16. Summary of average DO levels that were recorded in longitudinal measurements along the Poplar River AUIDs 504 and 518.

Lost River (09020305-512, 529, 530, 645, 646)

An impaired reach of the Lost River (AUID 512) flows from Pine Lake, past livestock operations, past residences, past the town of Gonvick, and into Anderson Lake. Significant data collection has occurred at three locations along the reach. Site-specific assessment of *E. coli* data in the Lost River shows that conditions worsen from upstream to downstream. Livestock operations along the river are a primary, suspected source of *E. coli* bacteria in the Lost River. There is one registered feedlot (according to publicly available 2016 GIS data) just downstream (northeast) of the town of Gonvick. That feedlot may impact the water quality in the Lost River as cattle have access to the stream and have removed vegetation near the river. Longitudinal samples were collected more recently, along the entire reach (AUID 512), in 2017 (Figure 3-17). Those results showed high concentrations throughout the entire AUID.

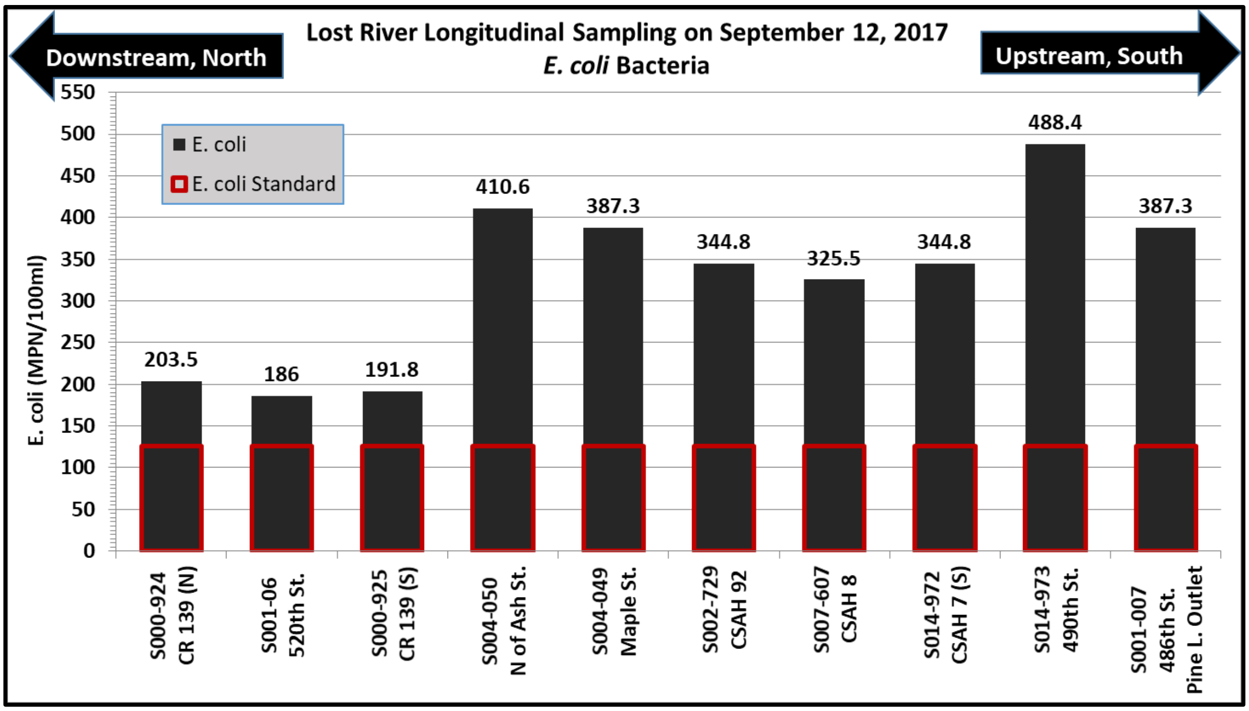


Figure 3-17. Lost River AUID 512 Longitudinal *E. coli* sampling results from September 12, 2017

Another water quality concern in the Lost River is low DO along AUID 645. Continuous DO monitoring has found that multiple locations along that reach experience frequent occurrences of low DO concentrations. The high DO flux at CSAH 7 may indicate that that the low DO problem originates within Anderson Lake. Longitudinal DO measurements collected in July of 2017 (Figure 3-18) revealed that DO levels were extremely low at the inlet and outlet of Anderson Lake, even during the daytime hours in which the measurements were recorded.

Longitudinal samples were collected along AUID 646 of the Lost River (from 330th Avenue Southeast to CR 118) after a runoff event of approximately one inch of rain on May 31, 2016. Concentrations of TSS were low (1-3 mg/L) throughout the reach. The only notable change was an increase in *E. coli* concentrations from Station S003-500 at 330th Avenue Southeast (40.4 MPN/100mL) to Station S001-131 at the city of Oklee (114.5 MPN/100mL). *E. coli* concentrations decreased downstream of 270th Avenue Southeast (S001-128).

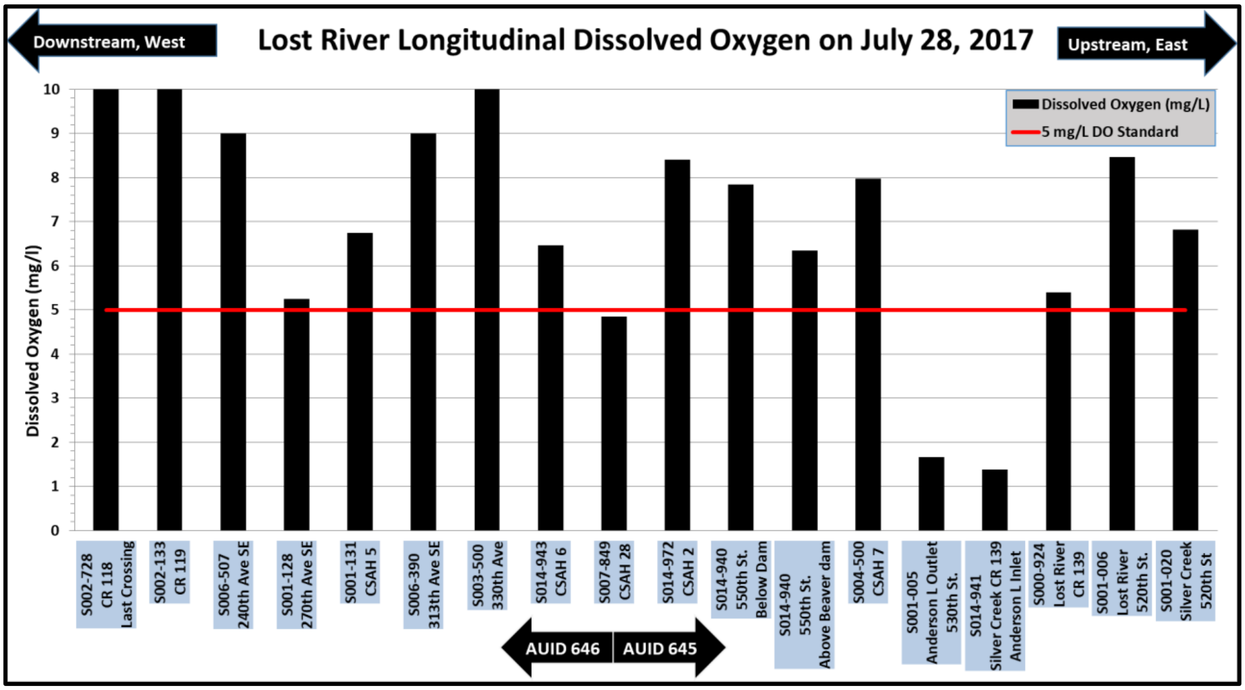


Figure 3-18. Longitudinal DO measurements along AUIDs 645 and 646 of the Lost River on July 28, 2017

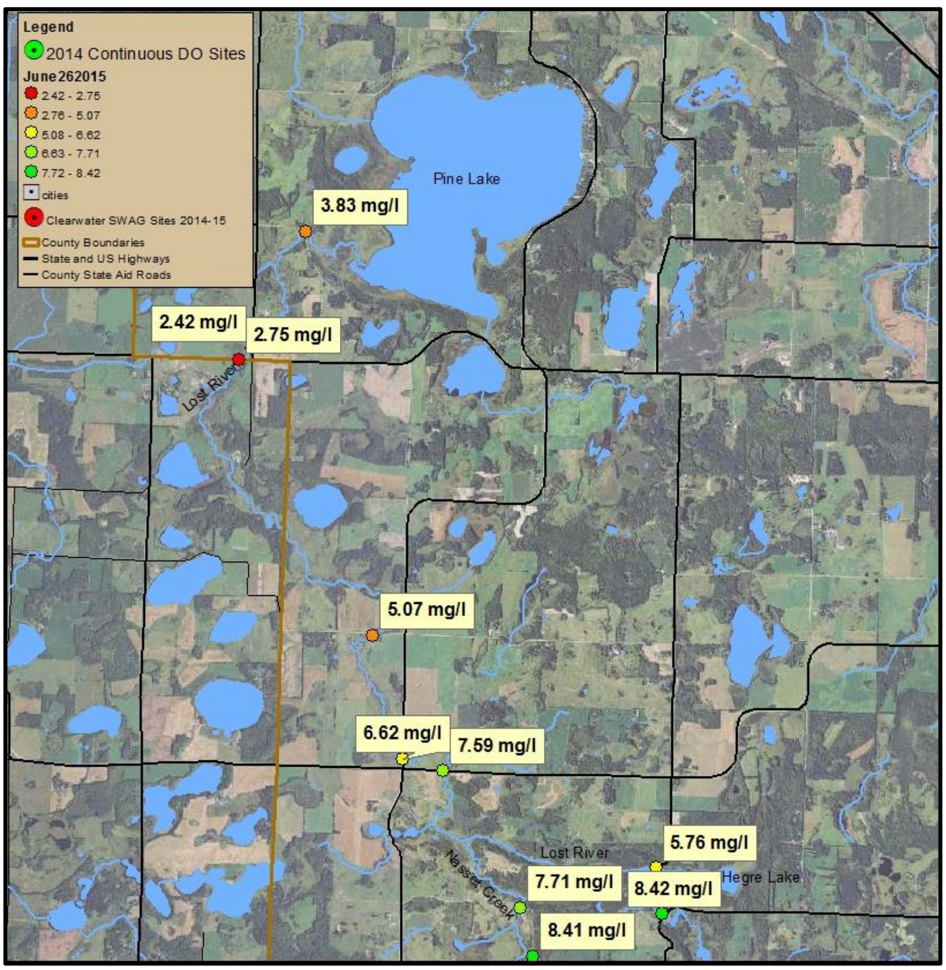


Figure 3-19. Longitudinal DO measurements along AUIDs 529, 530, and 545 on June 26, 2015

Low DO and high *E. coli* are concerns along the Lost River (AUIDs 529 and 530) and Nassett Creek (AUID 545) upstream of Pine Lake. Longitudinal sampling and DO measurements show that DO concentrations are low throughout the Lost River upstream of Pine Lake (Figures 3-19 and 3-20).

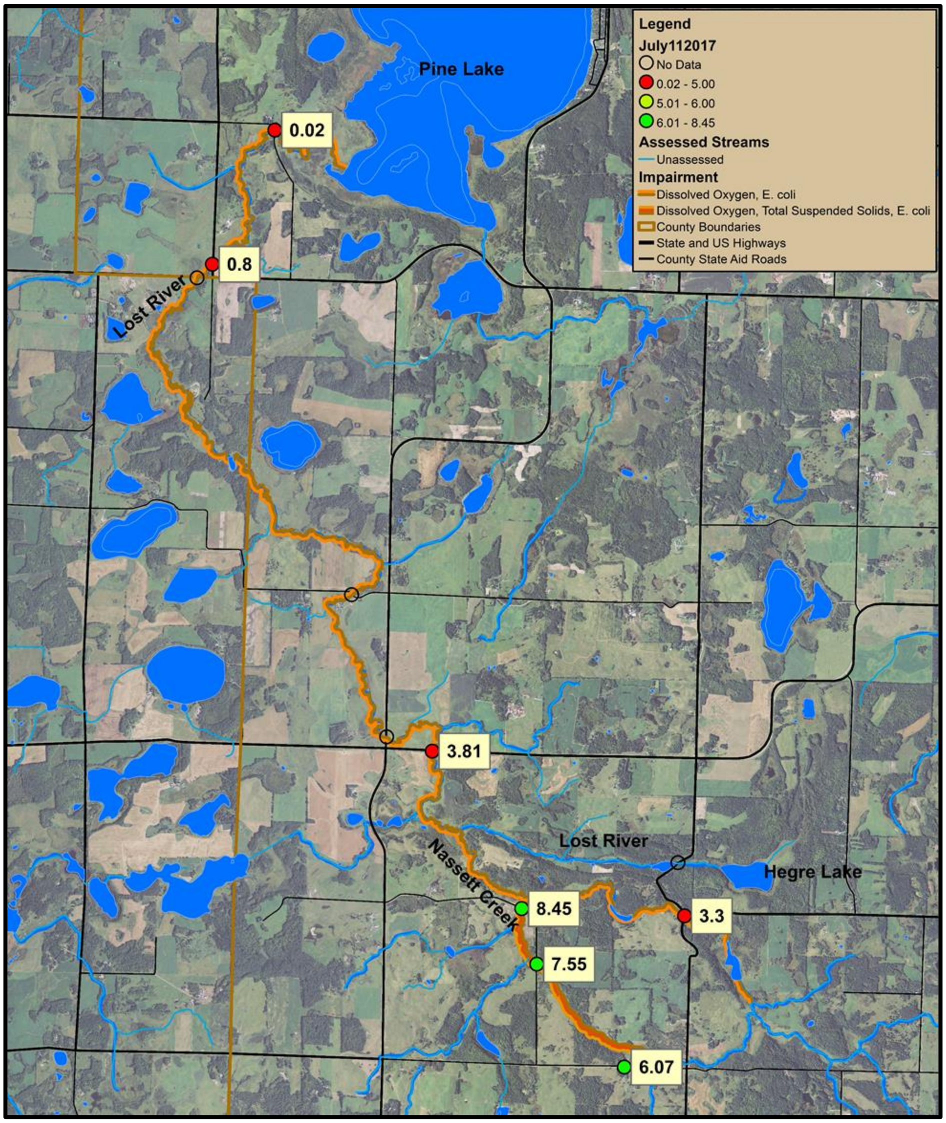


Figure 3-20. Longitudinal DO measurements along AUIDs 529, 530, and 545 on July 11, 2017

E. coli concentrations increase as streams flow through areas where livestock have access to the streams but can also be high where only natural sources are contributing (Figure 3-21).

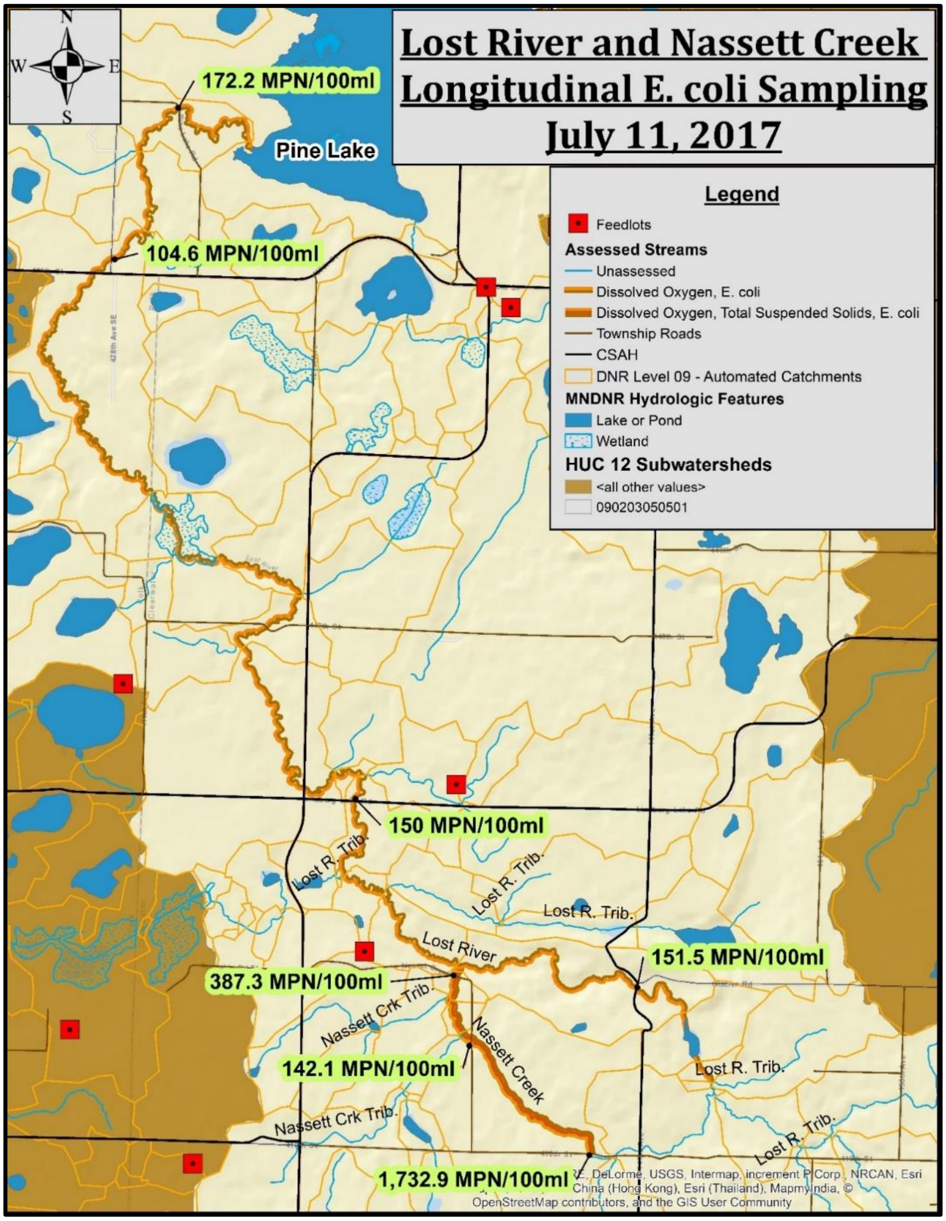


Figure 3-21. Longitudinal *E. coli* sample collection along AUIDs 529, 530, and 545 on July 11, 2017

Ruffy Brook (09020305-513)

Longitudinal samples were collected on August 4, 2016 along Ruffy Brook to identify the locations in which pollutants, particularly *E. coli* bacteria, increase along the stream. *E. coli* concentrations were greater than the maximum reporting limit of 2,419.6 MPN/100ml throughout much of the watershed – from CSAH 4 to the confluence with the Clearwater River (Figure 3-22). The lab performed a 10X dilution for the sample that was collected at CSAH 11 and the concentration still exceeded the post-dilution maximum reporting limit of 24,196 MPN/100ml. The livestock operation along 199th Avenue may have contributed to a measurable increase in *E. coli* between 209th Avenue and CSAH 4. A significant increase in *E. coli* concentrations also occurred between CSAH 3 and 209th Avenue. There were livestock operations along that portion of the stream. Livestock operations and other sources caused an increase in *E. coli* bacteria between CSAH 223 and CSAH 3. There were sources of *E. coli* upstream of CSAH 223 that caused the concentration to exceed the chronic standard at that location (178.9 MPN/100ml).

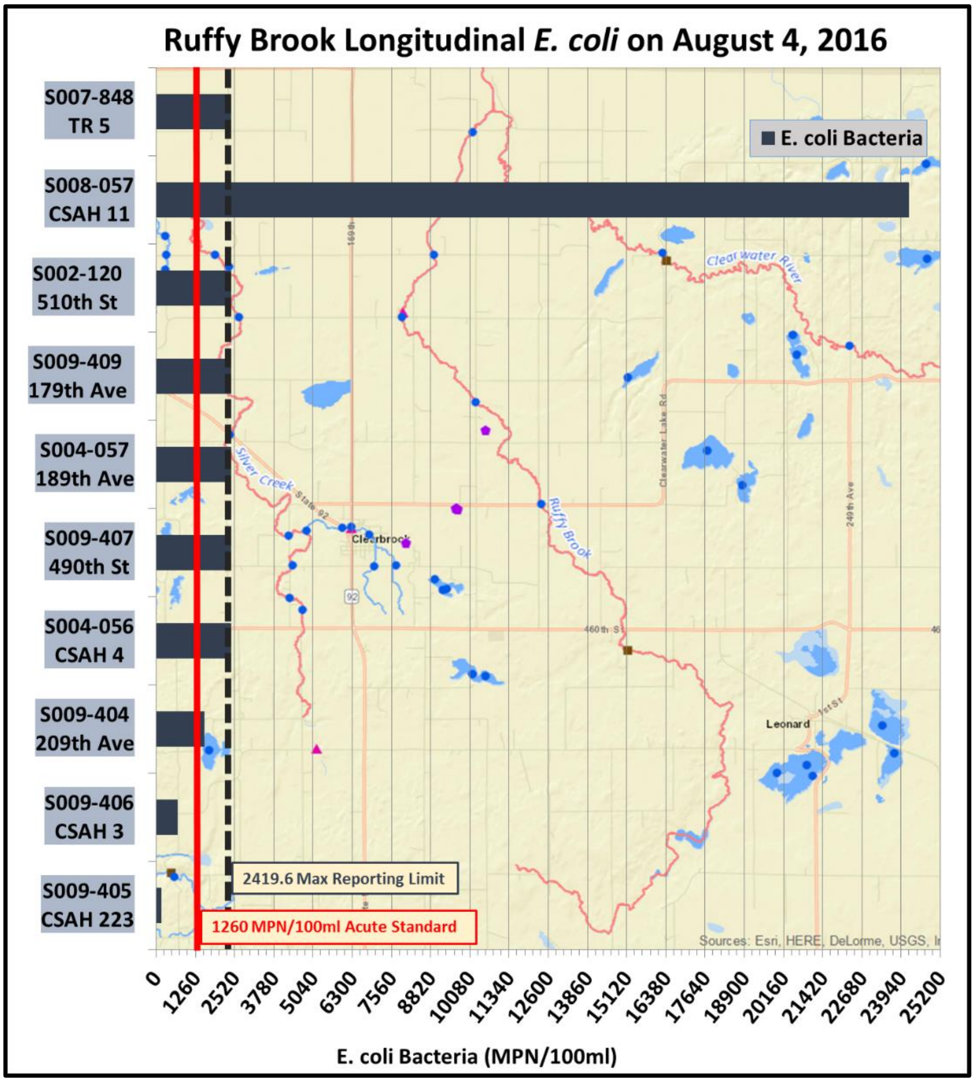


Figure 3-22. Longitudinal *E. coli* sampling along Ruffy Brook (AUID 513) on August 4, 2016

Low DO levels were found in the headwaters of Ruffy Brook at CSAH 3 and CSAH 223 during the August 4, 2016 sampling effort. There was a significant increase in TSS concentrations in the lower reaches of Ruffy Brook (Figure 3-23).

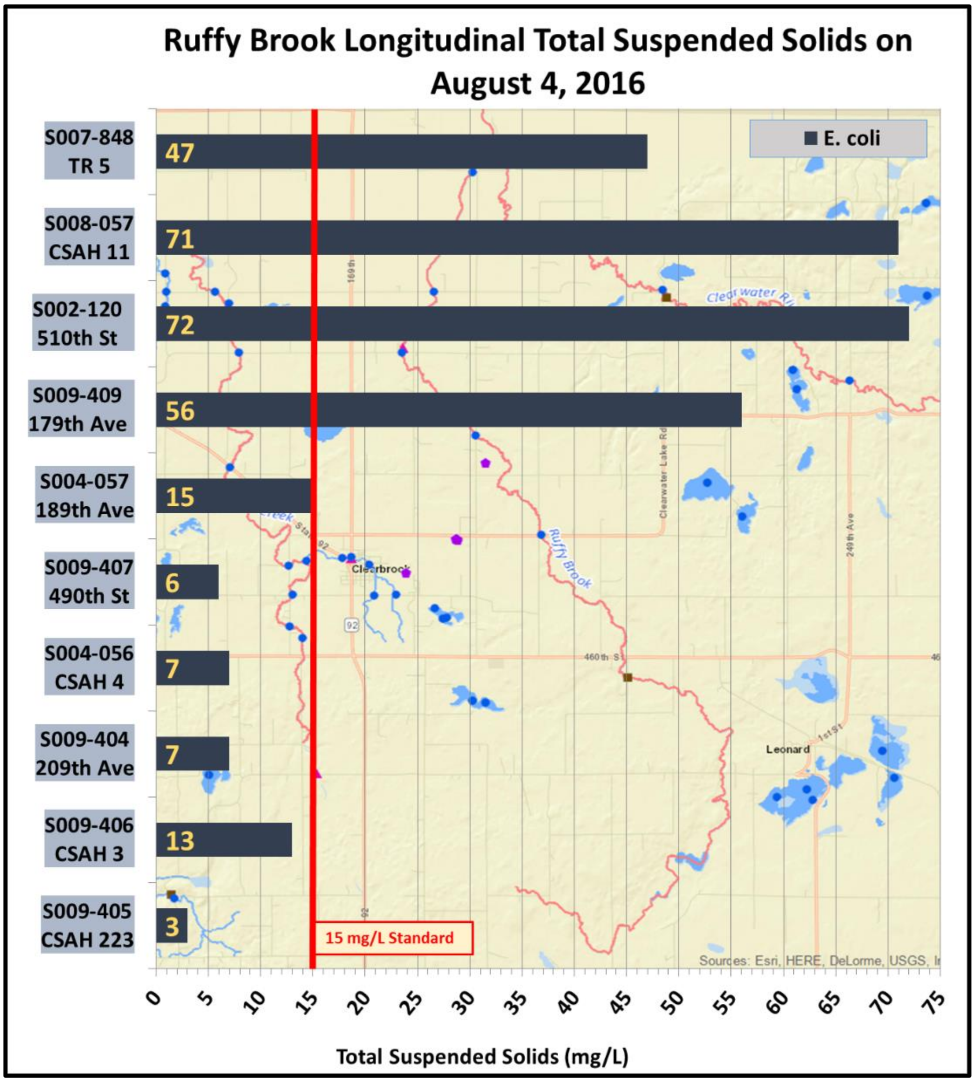


Figure 3-23. Longitudinal TSS sampling along Ruffy Brook (AUID 513) on August 4, 2016

Clear Brook (09020305-526)

Longitudinal water quality measurements and samples were collected at all crossings of Clear Brook on July 6, 2017. DO levels were low in the upstream crossings along CSAH 49 but met the 5 mg/L standard at all the downstream crossings. *E. coli* concentrations exceeded the 126 MPN/100mL chronic standard at most of the crossings. The most significant increase in *E. coli* concentrations occurred between the CSAH 5 and CSAH 92 crossings (Figure 3-24). This is the reason behind the recommendation for septic system inspections of unsewered homes on the west side of the city of Clearbrook. The increase at CSAH 5 could be from sources within a park. Dog fecal DNA markers were found in MST samples of water downstream of the Clear Brook and Silver Creek confluence likely came from pet waste that was not cleaned-up.

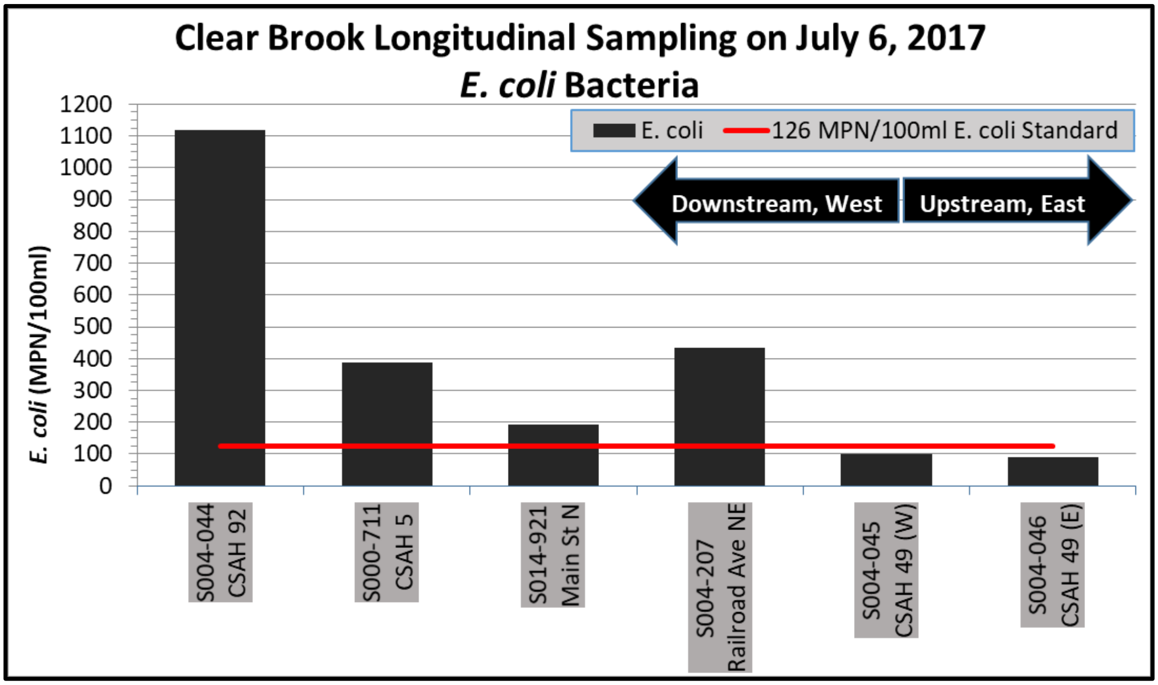


Figure 3-24. Longitudinal *E. coli* samples from Clear Brook (AUID 526) that were collected on July 6, 2017

Silver Creek (09020305-527)

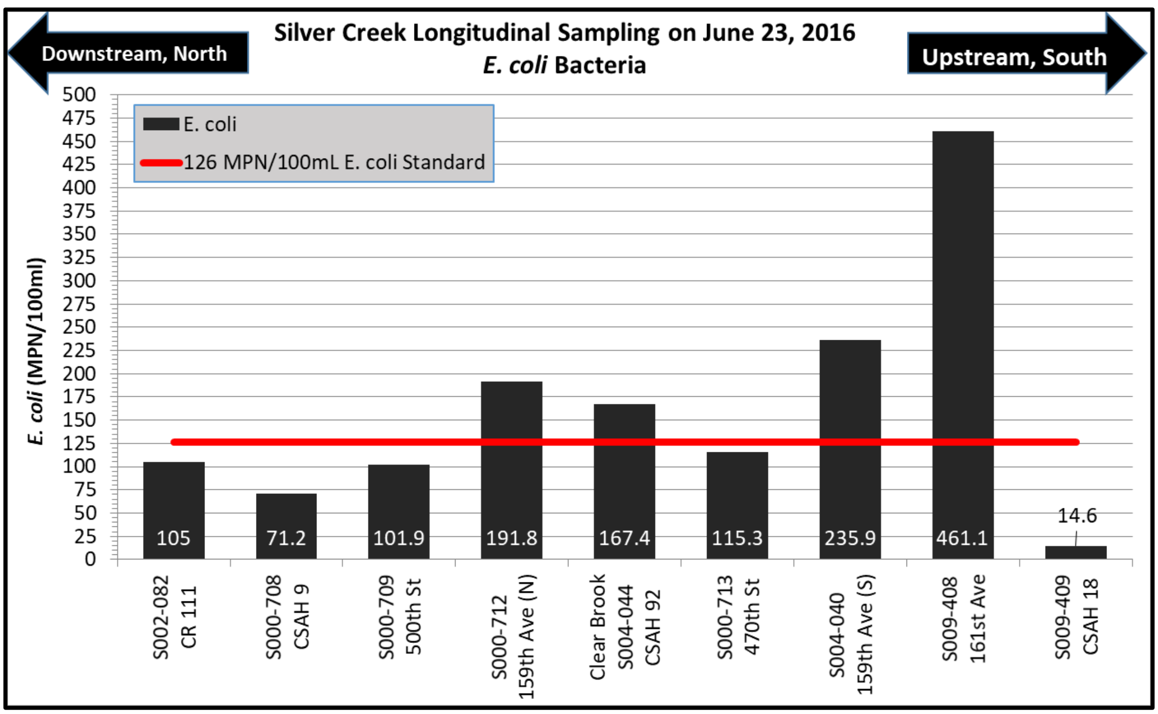


Figure 3-25. Longitudinal *E. coli* samples collected along Silver Creek (AUID 527) on June 23, 2016

Longitudinal water quality measurements and samples were collected along Silver Creek on June 23, 2016 (Figure 3-25). DO levels were low at the furthest upstream crossing (CSAH 18) due to stagnant conditions. There were low flow conditions throughout Silver Creek on that day. Flow at S002-082 was <1 cfs. DO levels were greater than 6 mg/L throughout the rest of the stream. *E. coli* concentrations increased dramatically between CSAH 18 and 161st Avenue. *E. coli* concentrations decreased at crossings near the downstream end of the stream. A high concentration of *E. coli* was coming from Clear Brook and there was an increase in *E. coli* as Silver Creek flowed through the pasture upstream of S000-712.

Another set of longitudinal samples were collected on July 24, 2017 (Figure3-26) during low-flow conditions (approximately 1 cfs at S002-082). Low DO levels were found again at CSAH 18 and DO was also low at 161st Avenue and in Clear Brook. A high concentration of *E. coli* was found again in Clear Brook and a high concentration was found at S000-712. *E. coli* concentrations decreased downstream of S000-712, which indicated that the most significant sources of *E. coli* were upstream of 159th Avenue.

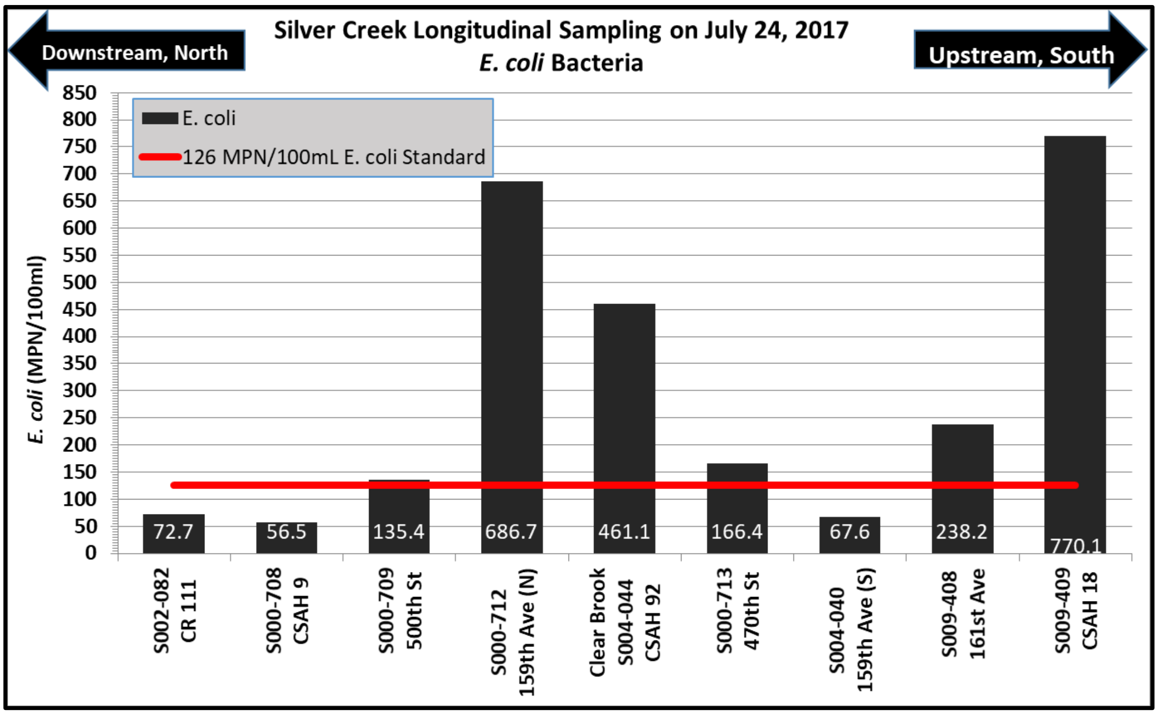


Figure 3-26. Longitudinal *E. coli* samples collected along Silver Creek (AUID 527) on July 24, 2017

<u>Hill River (09020305-539, 655, and 656)</u>

An informative set of longitudinal DO measurements was collected along the Hill River on June 30 and July 5 of 2017 (Figure 3-27). Flow at S002-082 was approximately 28 cfs on June 30, 2017. Decreases in DO along AUID 655 downstream of Cross Lake and downstream of Hill River Lake were found. There were gradual increases in DO as the river flowed downstream through AUID 656 from 380th Avenue Southeast to 335th Avenue Southeast. Similar results for DO (Figure 3-28) were found downstream of Hill River Lake on July 12, 2017 and upstream of Hill River Lake on July 13, 2017. The DO levels again "bottomed-out" upstream of Hill River lake near Olga (380th Avenue Southeast) and downstream of the lake at 320th Avenue Southeast. *E. coli* samples were also collected on July 12, 2017. Large increases in *E. coli* concentrations were found near Brooks. The large increase at CR 129, shown in Figure 3-29, was likely caused by a livestock operation along the river, near the CSAH 92 crossing, where the livestock have also increased erosion rates along the streambank.

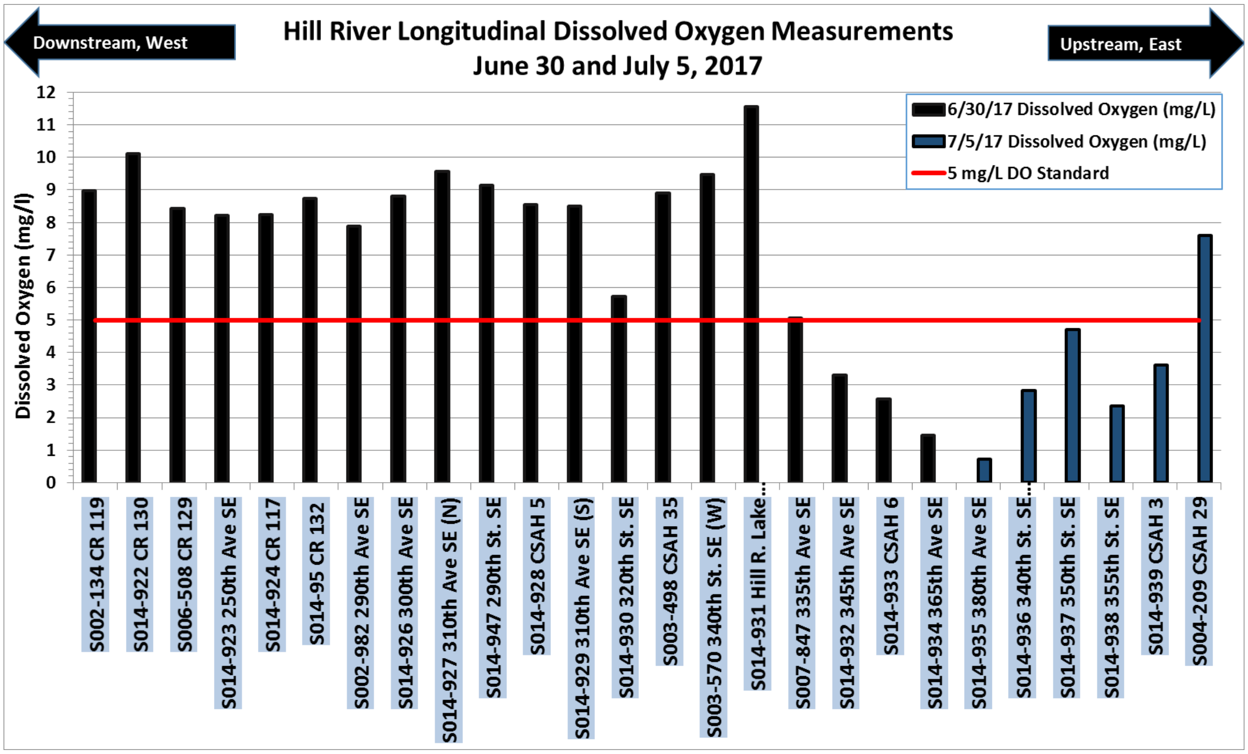


Figure 3-27. Longitudinal DO measurements along the Hill River AUIDs 539, 656, and 655 on June 30, and July 5, 2017

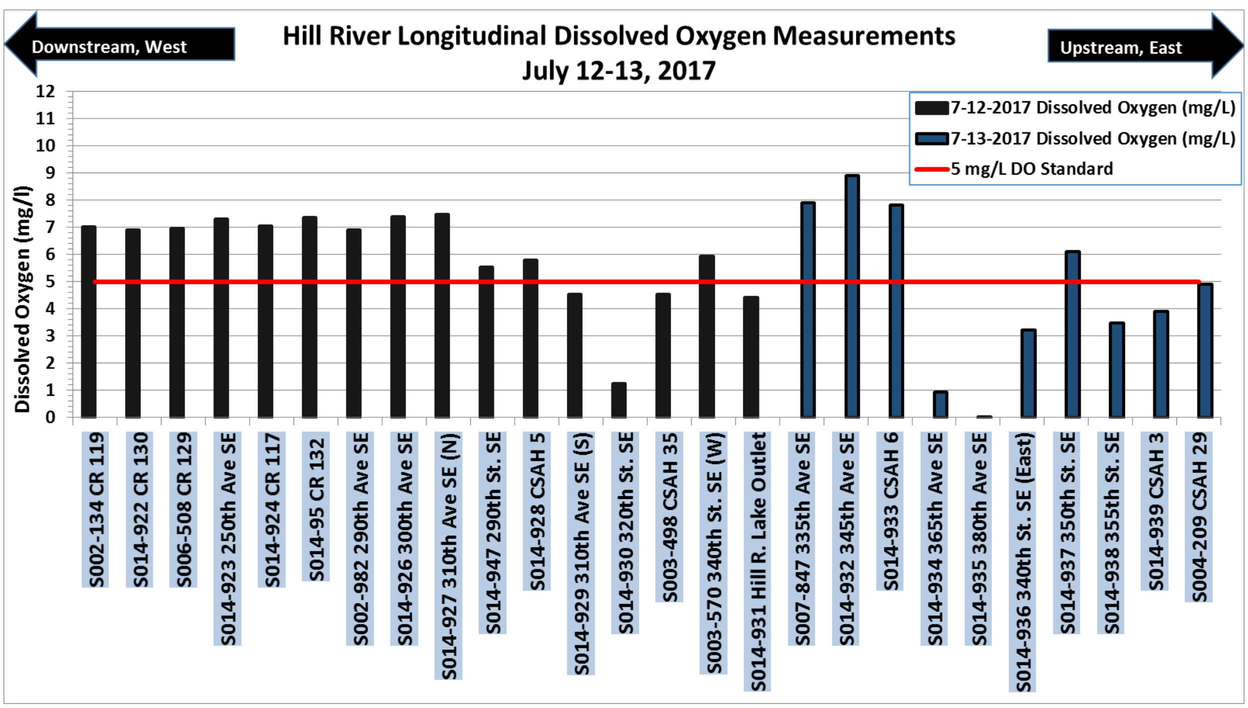


Figure 3-28. Longitudinal DO measurements along the Hill River AUIDs 539, 656, and 655 on July 12-13, 2017

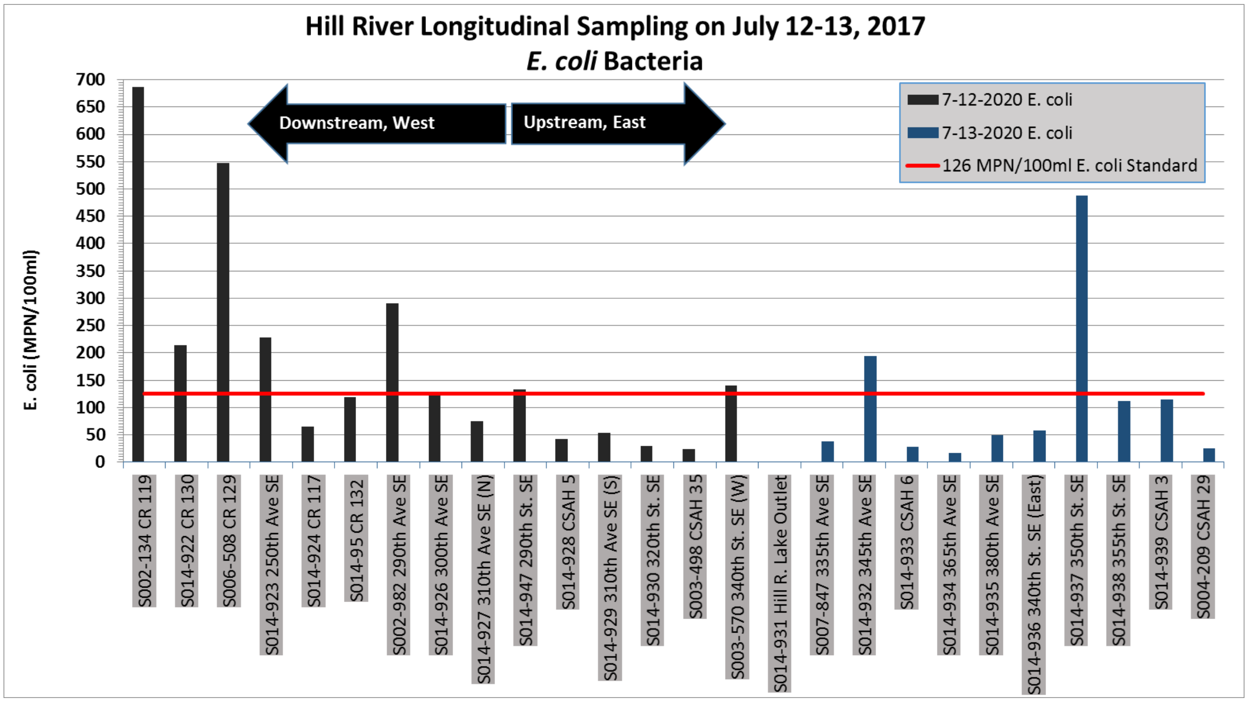


Figure 3-29. Longitudinal *E. coli* samples from the Hill River AUID 539 on July 12-13, 2017

<u>Judicial Ditch 73 and Poplar River Diversion (09020305-549, 550, 552, 542, and 543)</u>

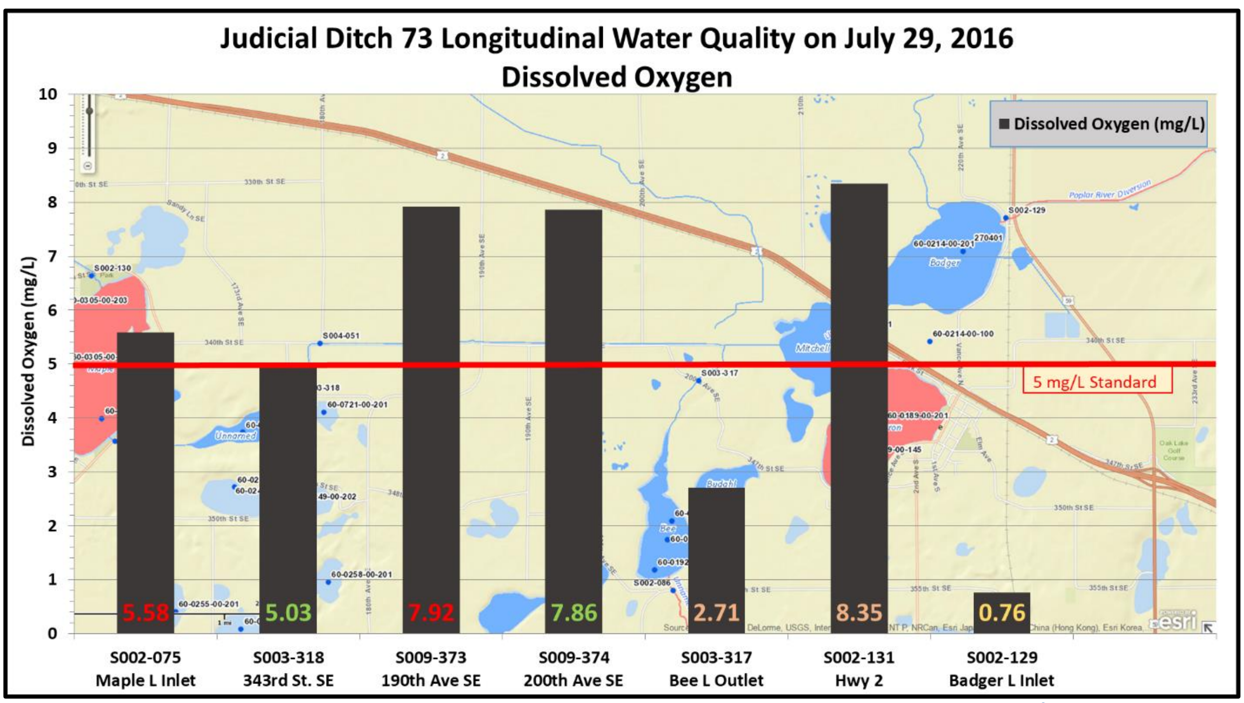


Figure 3-30. Longitudinal DO measurements along JD 73 and the Poplar River Diversion on July 29, 2016 (AUIDs 543, 542, 551, 552, 550, and 549)

Longitudinal DO measurements were conducted along the JD 73 channel and the Poplar River Diversion on July 29, 2016 (Figure 3-30). An impairment was found at the 343rd Street Southeast crossing. Other locations along upstream AUIDs also failed to meet DO standards but were either not formally assessed or recategorized. DO levels met standards at crossings upstream of 343rd Street Southeast but decreased at that crossing. A tributary of JD 73, the outlet of Bee Lake, had very low DO levels.

Assessment of Fluvial Geomorphology

The stability of the Clearwater River and some of its tributaries was assessed during the WRAPS process. The effort was completed by DNR staff with the help of RLWD staff. DNR staff provided a draft version of the Clearwater River Watershed Fluvial Geomorphology report for use in writing the Clearwater River WRAPS and TMDL reports. Kayak reconnaissance was completed in 2014. Detailed Bank Erosion Hazard Index (BEHI) ratings, photos, and notes were collected along those routes. Pfankuch stability ratings (Figure 3-32) were conducted during the kayak reconnaissance and at the channel survey stations. Data were collected for the Bank Assessment for Nonpoint source Consequences of Sediment (BANCS) model at channel survey locations.

The Clearwater River was mostly stable within the Upper Clearwater River HUC-10 Subwatershed. There was very little or no evidence of erosion within the headwaters of the Clearwater River as the banks were bordered with wetland vegetation and the gradient is low. Upland sources of sediment and sedimentation within the channel are greater problems within the headwaters of the Clearwater River than streambank erosion. The gradient of the Clearwater River channel significantly increases as it transitions into the trout stream portion that lies within Beltrami County. The geomorphology work found that the river and its banks are stable throughout the trout stream reach, though there were some room for improvement and some erosion problems. There were some streambank stability problems that occurred where deep-rooted vegetation had been removed by livestock grazing or by homeowners who have maintained a lawn near the river's edge. Streambanks were relatively unstable within the basin of a historical pool that was used to stage logs behind a splash dam. The sediment that accumulated within that pool is relatively erodible. A meander cut-off occurred upstream the CSAH 22 crossing. Some areas of bank erosion and excess sedimentation were found downstream of CSAH 22. Between CSAH 24 and the Clearwater Lake inlet, the channel was stable, and the riparian cover was excellent.

The Clearwater River was found to be stable for most of the portion between Clearwater Lake and the beginning of the channelized reach. The channel of the Clearwater River abruptly degrades from a stable "C" channel to an unstable, incised, and entrenched "F" channel due to head-cutting that was caused by channelization. This abrupt change can be seen in Figure 3-32, near the downstream end of AUID 650. A large grade stabilization project had been completed in that area (Figure 3-31) and has been successful at maintaining stability and reducing erosion upstream of the project (green dot near the AUID 650 label in Figure 3-32). However, the reconnaissance and channel survey for the geomorphology study found that the stability of the channel rapidly degrades downstream of the last grade stabilization structure (red dot near the AUID 650 label in Figure 3-32). The grade stabilization work needs to be extended downstream. The geomorphology report found that the unstable portion has a higher gradient than downstream reaches. The slope needs to be stepped-down with additional grade stabilization structures between the existing structures and the lower-gradient portion of the channel.

Figure 3-31. Grade stabilization structure on the Clearwater River (near the downstream end of AUID 650)

Although stability slightly improves in downstream reaches of the channelized portion of the Clearwater River, it is still moderately unstable, confined by spoil piles, and lacks access to an adequate floodplain. It lacks the riffle-pool pattern that would be found in a meandering river. The river returns to being relatively stable, natural, and meandering within the Lower Clearwater River HUC-10 Subwatershed (downstream of the channelized reach). There were still some problem areas within that portion of the river. Streambank erosion problems were identified. Mass wasting is a problem along the Clearwater River and the outlets of waterways that flow into the lower portions of the river as it nears the Red Lake River confluence. Removal of trees and deep-rooted vegetation appeared to have exacerbated some of the mass wasting problems.

Four reaches along the Lost River were examined. Two of the reaches were in the downstream, natural portion of the river. One reach was located within the channelized portion of the river, between CSAH 28 and CSAH 6, north of the village of Trail. The other reach was the portion of the Lost River between Anderson Lake and the upstream end of the channelized reach. The portion of the Lost River downstream of Anderson Lake provided an example of what the Lost River could have been like had it not been channelized. The channel was generally stable along that reach. However, erosion was observed within that reach along portions of the channel that lacked deep-rooted vegetation.

The channelized portion of the Lost River was rated as moderately unstable to stable (depending on the stream type) by the Pfankuch assessment, but the banks were relatively stable and not contributing much sediment. The drainage area along this reach was heavily cropped, so sediment contributions from the drainage area were more of a concern than channel erosion. The channel is confined between spoil piles and unable to dissipate energy to a floodplain. Therefore, the trees and shrubs that line the banks are very important for erosion prevention along this reach and need to be left in place. Some erosion problems can be seen in the upstream portions of the Lost River in aerial photos. The effects of the rock structures at CSAH 28 were noted during the geomorphology study. Upstream of the bridge, the channel was too deep to wade and nearly lentic. The downstream end of the channelized portion of the Lost River was partially assessed (via kayak) and was determined to be stable due to the impoundment of water behind a road crossing (Texas crossing).

Between CR 129 and Highway 59, the Lost River was moderately unstable due to incision and entrenchment. The riparian area was in excellent condition and primarily forested. However, a meander cut-off was found 0.65 miles downstream of CR 129. The meander cut-off should be stabilized soon before it abandons 650 feet of channel, increases the upstream gradient, and increases upstream erosion. The portion of the Lost River downstream of CR 118 was the most unstable reach of the Lost River that was examined. Streambank erosion and sedimentation are problems along that reach and appear to extend upstream of CR 118. The sediment bars that were visible in aerial photos gave an indication of the amount of sediment, particularly sand, that was being moved through that portion of the river. Logs in the river looked as if they had been sandblasted because they were white, smooth, and stripped of their bark.

A portion of the Hill River was explored downstream of the CSAH 92 crossing. Bank slumping and erosion were occurring within a heavily pastured area downstream of that road crossing. That pastured area was also a likely source of excess *E. coli* bacteria and should be targeted for BMPs. The stream was relatively stable downstream of that pastured area due to the robust riparian vegetation and despite slight incision.

Beau Gerlot Creek, Red Lake County Ditch 23 (CD 23), Silver Creek, and the Poplar River were examined from a geomorphic perspective to aid the SID process. Beau Gerlot Creek, upstream of CR 114, was heavily forested but incised. The bank erosion from the incision had caused trees to fall into the river and cause additional erosion problems.

The biological and geomorphic assessment of CD 23 occurred upstream of the CSAH 1 crossing. The channel was stable upstream of that crossing and somewhat ponded. The culvert at CSAH 1 seemed to be controlling the gradient and helping to maintain stability in the channel upstream of CSAH 1. The channel downstream of CSAH 1, however, needs to be surveyed for the planning of grade stabilization and fish passage improvement projects. An examination of aerial photos and LiDAR data shows that the gradient steepens downstream of CSAH 1. That steep gradient may be causing erosion problems and may be restricting fish passage.

The stability of Silver Creek was assessed in three locations: upstream of the Clear Brook confluence, downstream of the Clear Brook confluence, and upstream of 520th Street. The channel was moderately unstable at the furthest upstream site, upstream of CR 74. Sediment deposition in the channel was notable and indicated that there was an excess supply of sediment, too little stream power, or both. The channel was stable downstream of the Clear Brook confluence (near S000-712). At the downstream end of Silver Creek, at 520th Street, the channel was moderately unstable due to significant erosion on lower banks and incision. The channel bottom at that location, however, was in good condition with stable materials and only minor amounts of scour and deposition.

The condition of the Poplar River channel was examined at three locations. Upstream of the CSAH 27 crossing, east of Fosston, the channel was stable. No barriers to fish passage were found. The Poplar River channel was also stable upstream of CSAH 30, north of Fosston. Some straightening of the channel has occurred near the road crossing. The channel was also stable downstream of 315th Street Southeast (near the Poplar River Diversion structure). Almost all Pfankuch categories ranked as either good or excellent.

A disturbed portion of Ruffy Brook was evaluated by MNDNR and RLWD staff in November of 2005. The site had been pastured. Due to the disturbed banks, the stream had become wider and shallower. The geomorphology assessment determined that the stream was slightly entrenched with a moderate to high width to depth ratio. It received a poor Pfankuch stability rating.

Generally, stream channels within the Clearwater River were stable if they were not experiencing incision or entrenchment. Those channels with some degree of incision also had, generally, some degree of instability. Access to a floodplain during at bank-full elevations should be created or maintained to reduce streambank erosion and improve/preserve healthy riverine habitat. Grade stabilization would also be beneficial on the two unstable reaches on the Lost River and Clearwater River. Recommendations from the geomorphology report have been incorporated into the WRAPS in Section 3.3.

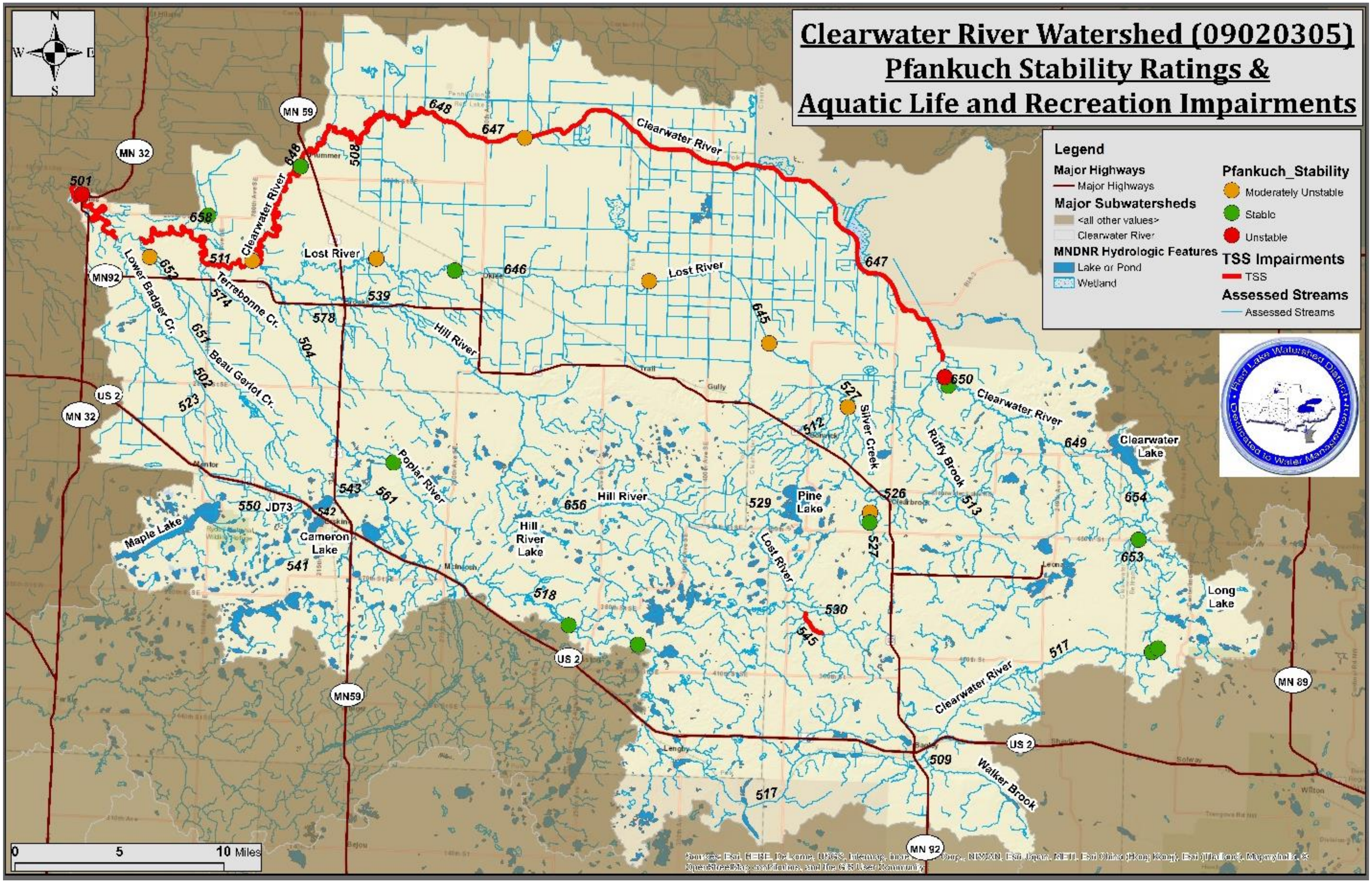


Figure 3-32. Pfankuch stream channel stability ratings throughout the Clearwater River Watershed

Restorable Wetland Inventory

Wetland restoration can provide multiple benefits including mitigation of flows, habitat improvement, and providing water for livestock. To identify potential wetland restorations, local, state, and federal staff can use a GIS data layer that shows potential wetland restoration sites across Minnesota. The layer was created using a compound topographic index (CTI) (10-meter resolution) to identify areas of ponding, and USDA NRCS SSURGO soils with a soil drainage class of poorly drained or very poorly drained. The layer identifies potential wetland restoration sites with an emphasis on wildlife habitat, surface and ground water quality, and reducing flood damage risk.

The restorable wetland inventory GIS data layer (Figure 3-33) is available for viewing and download on the Minnesota 'Restorable Wetland Prioritization Tool' web site.

http://www.mnwetlandrestore.org/links-contact/data-download/

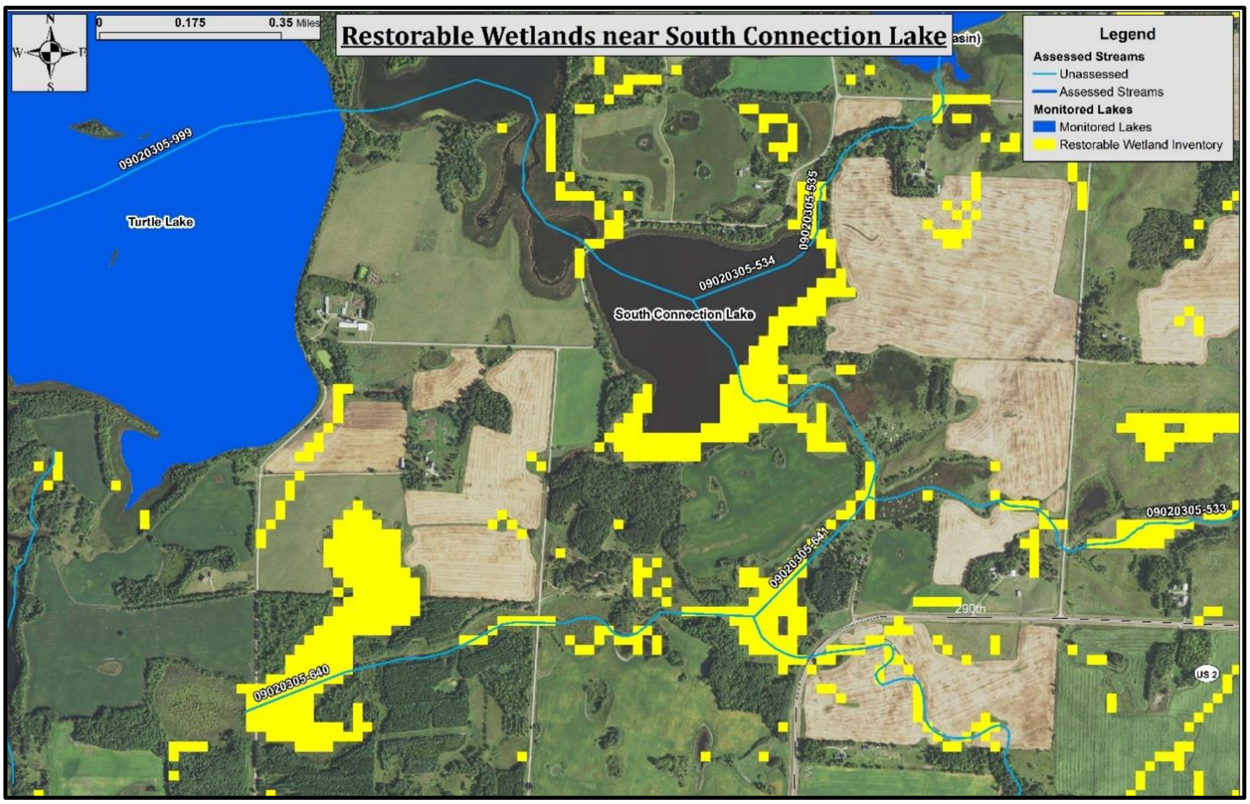


Figure 3-33. Restorable wetlands and drained wetlands upstream of South Connection Lake

3.3 Civic Engagement and Public Participation

The WRAPS process provided an opportunity to improve civic engagement with the Clearwater River Watershed through public meetings and other methods of engaging with the public. At the beginning of the WRAPS project, RMB Environmental Laboratories, Inc. was hired to help with the civic engagement aspect of the Clearwater River WRAPS. At the onset of the Clearwater River WRAPS project in 2011, a list of potential stakeholders was compiled. RMB, MPCA, and RLWD staff collaborated to organize public open house events. Tabletop displays and posters were used during public events for the Clearwater

River WRAPS. Table 3-9 lists the public and technical advisory committee (TAC) meetings that were held throughout the WRAPS project.

The Clearwater River WRAPS Kick-off Open House Event was held on December 2nd, 2014 in Clearbrook, Minnesota (Figure 3-34). The meeting had great attendance (more than 40 total people and more than 34 non-agency attendees). The format of the meeting was an open house with posters of information about the WRAPS. The evaluation surveys showed that people liked the open house format. They were able to ask questions of the poster presenters and discuss problems and ideas. The event was publicized through email, social media, and press releases in local newspapers. Photos, posters, and a more detailed summary of the event can be found on the Clearwater River blog at https://clearwaterriver.wordpress.com/2014/12/18/kick-off/.

Figure 3-34. Clearwater River WRAPS Kick-Off Open House Event in Clearbrook

An open house event for the Clearwater River WRAPS project was held in Red Lake Falls on September 25, 2017 (Figure 3-35). The meeting was promoted through press releases, direct mailing (newsletters), a mass email to a list of Clearwater WRAPS contacts, flyer postings, and social media. Short presentations were prepared for the event and were conducted at 30-minute intervals during the event. A limit of 10 minutes was planned for each presentation, but some went longer due to the amount of interest and questions during those presentations. There was opportunity for small group or one-on-one discussion at informational booths. The attendance was relatively low, but those in attendance participated in many conversations at the booths and asked questions during the presentations. The newsletter that was mailed prior to the event was a 4-page newsletter that included a fold-out insert.

The inserted page had a map of the watershed with its impaired waters on one side and a list of impaired waters (or anticipated impairments, at the time).

Figure 3-35. Presentation during the September 2017 Clearwater River Public Open House Event in Red Lake Falls

TAC, or Core Team meetings were also held to seek more in-depth input on the direction of the project. The November 2018 meeting was particularly important for reviewing and making recommendations for the restoration and protection strategies that will be an important part of the WRAPS as well as Section 9 of this TMDL.

RLWD staff met with lake associations on multiple occasions to discuss water quality issues in the lakes and potential projects, activities, and opportunities for collaboration. RLWD staff also met with East Polk County staff and board members to discuss future projects to address water quality issues in the Clearwater River Watershed.

Table 3-9. List of public and technical advisory meetings

Meeting	Meeting Date	Meeting Location	Number of Participants
Kick-off Meeting	December 2, 2014	Clearbrook, MN	34 (non-agency)
Technical Advisory (Core Team) Mtg	August 27, 2014	Thief River Falls, MN	12
East Polk Annual Planning Meeting	February 15, 2017	McIntosh, MN	>10
Clearwater Lake Area Association	May 28, 2017	Clearwater Lake	>10
Open House	September 25, 2017	Red Lake Falls, MN	16
Maple Lake Improvement District Meeting	September 14, 2017	Mentor, MN	10
Maple Lake Improvement District Annual Meeting	July 14, 2018	Mentor, MN	>30
Technical Advisory (Core Team) Mtg	November 28, 2018	Thief River Falls, MN	12
Maple Lake Improvement District Meeting	January 10, 2019	Mentor, MN	>10

These meetings provided opportunities to gain insight, gain historical knowledge, discuss sources of problems, and discuss future projects with participants. Directly visiting with existing organizations (SWCD boards and lake associations) was very productive way of promoting and facilitating actions to improve water quality. The format of the second public open house meeting, with short presentations separated by periods of time for discussion, worked very well. It resulted in constant engagement with attendees throughout the event. Keeping the presentations short helped keep people's attention. Future meetings should allow more time (at least 30 minutes) between presentations to allow more time for questions during presentations and to avoid having to cut conversations short to start the next presentation. Some of the notable comments and observations from the meetings that are pertinent to impaired waters in this watershed included:

- Attendees of open house meetings suggested that rice farmers could install holding ponds to reduce sediment before releasing into the Clearwater River. Some farmers have already implemented that practice by installing water control structures that allow for settling within ditch channels that outlet to the Clearwater River.
- According to surveys completed by attendees, press releases in newspapers and direct mailings were the most effective way of promoting the public meetings.
- There was interest in how the Buffer Law was being enforced.
- The RLWD entered agreements to help fund sample collection by the MLID and the East Polk SWCD as a result of meeting with those boards. The SWCD will be sampling nine lakes within the watershed (including Cameron and some potentially impaired lakes like Oak Lake and Hill River Lake) and the MLID will be sampling Maple Lake.
- The East Polk SWCD is interested in focusing on Cameron Lake to identify solutions to the water quality problems and implement projects to improve water quality in the lake (erosion control).
- Wind erosion of peat soils in the area of potato and wild rice farms was brought up as a concern.
- The East Polk SWCD would like to install more water and sediment control basins (WASCOBs) in the Clearwater River Watershed and pursued grant funding for that work.
- An attendee of the Red Lake Falls open house remembered the Clearwater River before it was dredged. It would flood frequently, but there were a lot more fish. The fields would be filled with fish after floods. She talked about how the bridge on CR 134 was one of the last iron bridges in the area until it was replaced.
- Another attendee of the Red Lake Falls open house said that when they moved to the Clearwater River in the early 1960s, it was a great walleye fishing river. Now, however, it is not a good fishery. He tied the wild rice production and the lack of fishing together since the wild rice production was taking off at that time.
- There were questions about why streams can still be unstable in wooded areas. The discussion regarding the appearance of stream channel condition upstream/downstream of pasture land was brought up because several landowners feared they will have to fence off cattle access to streams in the future. From their perspective, streams appear to be just as unstable before pastures as they are within it.

- A landowner talked about channel degradation in Silver Creek at the Red Lake Falls open house, and fortuitously, the MPCA Monitoring and Assessment staff had a slide in his presentation that showed channel degradation/incision in Silver Creek.
- One attendee mentioned that Badger Creek was illegally ditched, and some farmers got in trouble for it.
- The Clearwater River has clean substrate in Red Lake Falls, which provides great habitat.
- Some species will move out of an area during very low flows or very high flows w/poor water quality.
- Beau Gerlot Creek looks great in some places but has a lot of erosion and sedimentation in others.
- Ruffy Brook had the best MSHA scores and had rare cold-water caddisfly larvae.
- Beaver dams are a problem in the Poplar River, but there isn't direct funding available for cleaning them out.
- Scouring in the Poplar River from increased runoff
- Overspray has killed apple trees and other vegetation in the Poplar River near the CSAH 49 crossing.
- Cattle upstream of CSAH 49 were mentioned as a possible source of *E. coli* in the Poplar River.
- The Poplar River looks muddy by CSAH 49 this week after rainfall events.
- There were questions and comments about WWTFs, particularly the Bagley WWTF that overflowed in the mid-nineties.
- A couple of people at the Red Lake Falls open house expressed concern about the wild rice operations and wondered about what the farmers are doing to prevent sediment/peat/silt and fertilizers from getting into the river when they release their pond water.
- The Clearwater SWCD samples 5 lakes in the county, including Stony Lake.
- Retrofit analysis was recommended for streams that are impaired by low F-IBI scores to assess culverts for fish passage.
- No-till drill farming practices and residue management were recommended as good practices for keeping sediment and nutrients on fields and out of waterways.
- Low velocities, lack of cover, and low DO could be limiting fish passage in the channelized reach.
- Liver flukes have been found in wet areas downstream of Hill River Lake.
- The Clearwater SWCD is working on a cattle exclusion project along Silver Creek.
- Sedimentation within the channelized reach is likely having a negative effect on aquatic life. There is nice gravel present, but it is buried by silt.
- Residents reported experiencing swimmer's itch after coming in contact with water (while kayaking and swimming) in the Clearwater River during wild rice paddy discharge.

Multiple forms of digital communication were explored as ways to expand the audience and interest in water quality issues in the Clearwater River:

- The RLWD, with help from Emmons and Olivier Resources, Inc., has launched a new set of web pages to make it easier for anyone to learn more about a watershed. Each of the five major watersheds within the RLWD District (including the Clearwater River) will have has its own set of pages with general information, links to reports, a photo gallery, WRAPS project information, maps, contacts, and 1W1P information in some cases. Organizing information by watershed should make it easier for people to find information that is pertinent to the area in which they live/farm/hunt/fish. Follow this link to begin exploring the Clearwater River Watershed: http://www.rlwdwatersheds.org/cw-watershed.
- Information was shared with the public through social media to promote public events.
- Articles were written about the Clearwater River and Cameron Lake for the Polk County Lake Leader Newsletter.
- "Water Minutes" radio public service announcement scripts were written by staff from the RLWD, MPCA, and RMB Environmental Labs. They were read by radio personality Joel Heitkamp and broadcast on local radio stations. Topics included the Clearwater River WRAPS, *E. coli* bacteria, DO, the WRAPS process. MP3 audio files were obtained for the WRAPS ("10-Year Cycle"), "Fish Habitat," and "Bacteria in Water" Water Minutes.
- RLWD staff provided information to the MPCA for a newsletter article entitled "2018 Impaired Waters List: Success stories surfacing for Minnesota lakes, streams."
- RMB Environmental labs completed a document that summarized civic engagement activities, survey results, and recommendations for future efforts: "Clearwater River Watershed Restoration and Protection Plan: An Evaluation of Civic Engagement."
- RLWD staff created a Flickr account for sharing georeferenced photos of erosion problems and georeferenced scenic photos. Other local government staff can use this as a tool for finding areas where erosion control projects can be implemented. A map-based search for photos can be conducted at this site: https://www.flickr.com/map. The RLWD photos can be found at this site: https://www.flickr.com/photos/131072259@N04/. Other means of sharing georeferenced photos will be explored in the future.
- Environmental Laboratories, RLWD, and MPCA staff created short videos to help local citizens understand DO, turbidity, and *E. coli* bacteria. Combined, the videos have accumulated over 10,500 views on YouTube as of February 1st, 2019.
  - DO: http://youtu.be/qUq7jFdVo3g
  - Turbidity: http://youtu.be/EkH3jZvADTk
  - *E. coli* bacteria: http://youtu.be/vkYUiJXyqLI
- In 2018, information about the Clearwater Watershed was available from RLWD booths that were set up at the Polk County and Clearwater County Fairs.

Measurable goals for future civic engagement and public participation efforts in the Clearwater River Watershed include:

1. Increase volunteer participation in natural resource monitoring.
2. Increase the number of watershed residents participating in water quality discussions.
3. Find effective ways to engage citizens in a meaningful way.
4. Increase the resources utilized to communicate water quality activities within the watershed.
5. Compile contact information for local resources, specific to certain quality concerns or funding.

The public can be kept informed of water related news, water quality problems, solutions to water issues, and opportunities for involvement in water-related programs through several different means. The RLWD and other LGUs need to continue conducting the public outreach efforts that were initiated during the WRAPS process. LGUs may continue to host open house style events that will facilitate one-on-one discussions with residents and other stakeholders. Booths at county fairs and community events (Thief River Falls Expo, Clearwater County Fair) are another way to connect with the public.

- Websites of LGUs
    - RLWD
        - www.redlakewatershed.org or www.rlwdwatersheds.org
    - East Polk SWCD
        - https://eastpolkswcd.org/
    - Red Lake County SWCD
        - http://www.redlakecountyswcd.org/index.html
    - Clearwater County SWCD
        - https://clearwaterswcd.com/
    - Beltrami County SWCD
        - http://www.co.beltrami.mn.us/index.html
- MPCA
    - http://www.pca.state.mn.us/ or https://www.pca.state.mn.us/water/watersheds/clearwater-river
- Mailings to individual landowners
- Radio interviews
- Informational brochures and displays
- Press releases and advertisements with local media contacts
- SWCD newsletters
- Organization of events to bring attention to the resource

- Presentations for local civic groups

The RLWD Water Quality Coordinator writes monthly water quality reports that originated as reports to the RLWD Board of Managers and represent a means of documenting project progress throughout the year (making annual report writing easier). The reports are available on the RLWD website (http://www.redlakewatershed.org/monthwq.html).

Local government can gain insight on water issues by consulting the public. The public can provide feedback on analysis, alternatives, and/or decisions. Working directly with the public throughout the process helps ensure that public concerns and aspirations are consistently understood and considered.

- Public meetings and open houses (including 1W1P meetings)
- Social Media
- RLWD Facebook page: https://www.facebook.com/Red-Lake-Watershed-District-266521753412008/
- East Polk SWCD Facebook page: https://www.facebook.com/EastPolkSoilandWater/
- Clearwater SWCD Facebook page: https://www.facebook.com/ClearwaterSWCDMN/?ref=br_rs
- Public Comment period on final draft reports

If the solutions in the TMDL, WRAPS, and 1W1P documents are developed with input from local land managers, the likelihood of implementation may increase. In addition, implementation activities will be streamlined due to the collaboration between landowners, local agencies, and funding sources.

Public Notice for Comments

An opportunity for public comment on the draft WRAPS report was provided via a public notice in the State Register from November 16, 2020 through December 16, 2020. There was one comment received and responded to as a result of the public notice.

3.4 Restoration and Protection Strategies

To better understand what strategies are needed to accomplish water quality goals in the Clearwater River Watershed, a review of work already completed should be considered. BMP locations are tracked to the HUC-12 level. Figure 3-36 shows where the most BMP implementation projects, from all funding sources, are as documented by the MPCA's Healthy Watersheds website. The map also shows where state-funded BMPs have been implemented (State Funded BMPs – BWSR GIS data from the Minnesota Geospatial Commons). Since 2004, 1,721 BMPs have been installed in the watershed at a cost of $69,083,000. This number could be significantly higher as these are only the BMPs documented through governmental agencies. The impact from a single BMP project varies because it could be a single grade stabilization structure or could be a multi-acre cropland BMP project. An unknown number of BMPs have been installed by local landowners without government assistance. Most of that spending has been Conservation Reserve Program (CRP) payments. Examples of the watershed's most successfully implemented BMPs include:

- 7,797 acres of prescribed grazing

- 7,284 acres of cover crop
- 11,255 acres (42,660 feet) of windbreak/shelterbelt establishment
- 67,711 acres of residue/tillage management
- 5,677 feet of streambank and shoreline protection
- 70 grade stabilization structures
- 55 acres (15,782 feet) of riparian forest buffer

Specific projects/strategies have been identified throughout the WRAPS project and other studies of the Clearwater River Watershed. Members of the Clearwater River WRAPS TAC worked together to create a list of strategies that can be used to restore impaired waters and provide protection where water quality is meeting standards. A November 2018 technical advisory meeting was held to discuss the strategies. Staff from the DNR, MPCA, BWSR, Clearwater SWCD, Red Lake SWCD, East Polk SWCD, Beltrami SWCD, and the RLWD reviewed the list of strategies and suggested changes. The strategies are presented in a table for practices that can be applied to the entire watershed and separate tables for practices more specifically applicable to each 10-digit HUC subwatershed. Figures 3-37 through 3-43 provide a reminder and quick reference for where the subwatersheds are located. This is done in accordance with Minn. Stat. 114D.26, subd. 1, which states that WRAPS shall "contain strategies that are capable of cumulatively achieving needed pollution load reductions for point and nonpoint sources, including identifying:

1. Water quality parameters of concern
2. Current water quality conditions
3. Water quality goals, strategies, and targets by parameter of concern
4. Strategies and an example of the scale of adoptions with a timeline to meet water quality restoration or protection goals

Additional explanation of specific columns in the table:

HUC-10 Sub-watershed: The strategies are organized by area. There are strategies that can be applied watershed-wide (Table 3-10). Separate lists of strategies were assembled for each HUC-10 subwatershed (Tables 3-11 through 3-17). Subwatershed maps precede each subwatershed's restoration and protection strategy table. It is particularly helpful to provide a reference for the locations of AUIDs.

Waterbody ID: This column identifies the waterbodies in which the strategies, actions, and goals will be applied. All the full AUIDs (09020305-XXX) for the streams in the Clearwater River Watershed begin with the 8-digit major watershed HUC for the Clearwater River: 09020305. Therefore, it is only necessary to use the final three digits of a stream AUID to identify a specific reach. Where possible, the name of the stream is also included to improve clarity and make the table more understandable.

Parameter (including non-pollutant stressors): Strategies were compiled to reduce the pollutants like TSS, TP, and *E. coli* that have caused impairments in the watershed. Strategies were also compiled to address non-pollutant stressors contributing to impairments like low DO and a lack of habitat and connectivity.

Water Quality – Current Conditions: "Current" condition is interpreted as the baseline condition over some evaluation period for the pollutant or non-pollutant stressor identified in the previous column. This is a numeric descriptor and unit of measurement. This can be a current load (from TMDL or from the load monitoring program if pursuing a downstream goal and not a local goal), a pollutant concentration (e.g., *E. coli* geometric mean) or a score (e.g., IBI or MSHA score). Watershed-wide current conditions are less specific and list the number of impairments that exist in the watershed for each parameter. Strategies for specific waters are color-coded based on the current conditions:

Red Rows: Impaired waters requiring restoration

Purple Rows: Impaired waters that are nearly restored (close to meeting standards)

Orange Rows: Unimpaired waters that are approaching impairment thresholds (nearly impaired)

Green Rows: High quality, unimpaired waters requiring protection

Water Quality – Goals/Targets: This column expresses goals related to the previous column (Current Conditions) and will generally be a load target (could be percent reduction or a load value) or a water quality concentration target. For some parameters (e.g. phosphorus reduction in a lake watershed) it may be best to use a load target. For others (e.g., *E. coli*) a concentration may be easier to both express (avoiding strings of scientific notation) and understand. Watershed-wide goals in this WRAPS are broad in scope and refer to the quantity of AUIDs or lakes that can be restored or protected.

Strategies: This column is intended to provide the high-level strategies to be used. 'High-level' generally means a category-type of action rather than a specific BMP or a specific project (e.g., 'Improve upland/field surface runoff controls' rather than 'Vegetated buffers').

Proposed Actions: This column more-specifically lists actions to be taken to apply a strategy to the waters listed in the Waterbody ID column.

Current Strategy Adoption Level: If known, this column describes current adoption rates of practices or the amount of work already completed.

Interim 10-year Milestones: This column ties to the Estimated Scale of Adoption column and should describe progress to be made toward implementing the strategy in the first 10 years. This may be provided in the form of a percentage, amount, or narrative descriptor.

Suggested Goal and Units: Where possible, numerical goals were estimated using the restoration plans of the TMDL, HSPF-SAM BMP implementation scenarios, calculations, observations, information in the SID report, past achievements, and reasonable estimations of achievable actions. The effects of some projects like BMPs and erosion control projects can be measured in load reductions. The benefits of other strategies may be less tangible and express other means of interpreting success (number of projects, number of restored waters, participation rates, acres of plantings, etc.).

Estimated Year to Achieve Water Quality Targets: This applies to the waterbody, specifically the year it is reasonably estimated that applicable water quality targets will be achieved. Explanatory information may be added either as a footnote or in the preceding narrative providing any assumptions or caveats used in the estimate. Unless a project is "shovel-ready" or anticipated in the near future, one of several key dates was used as an estimated year to achieve the water quality target:

- 2022 = Earliest estimated completion of the Clearwater River 1W1P

- 2025-2026 = Next round of intensive watershed monitoring that will involve biological monitoring, intensive sampling for Surface Water Assessment Grants, and fluvial geomorphology assessments
- 2026 = Next formal assessment of water quality in the Clearwater River Watershed
- 2028 = Draft List of Impaired Waters that will include the results of the 2026 assessment
- 2030 = 10 years after the completion of the Draft Clearwater River Watershed TMDL and WRAPS
- 2033 = Year by which the 10-year goals of the first 1W1P should be accomplished
- 2036 = Formal assessment of water quality in the Clearwater River Watershed
- 2040 = 20 years after the completion of the Draft Clearwater River Watershed TMDL and WRAPS

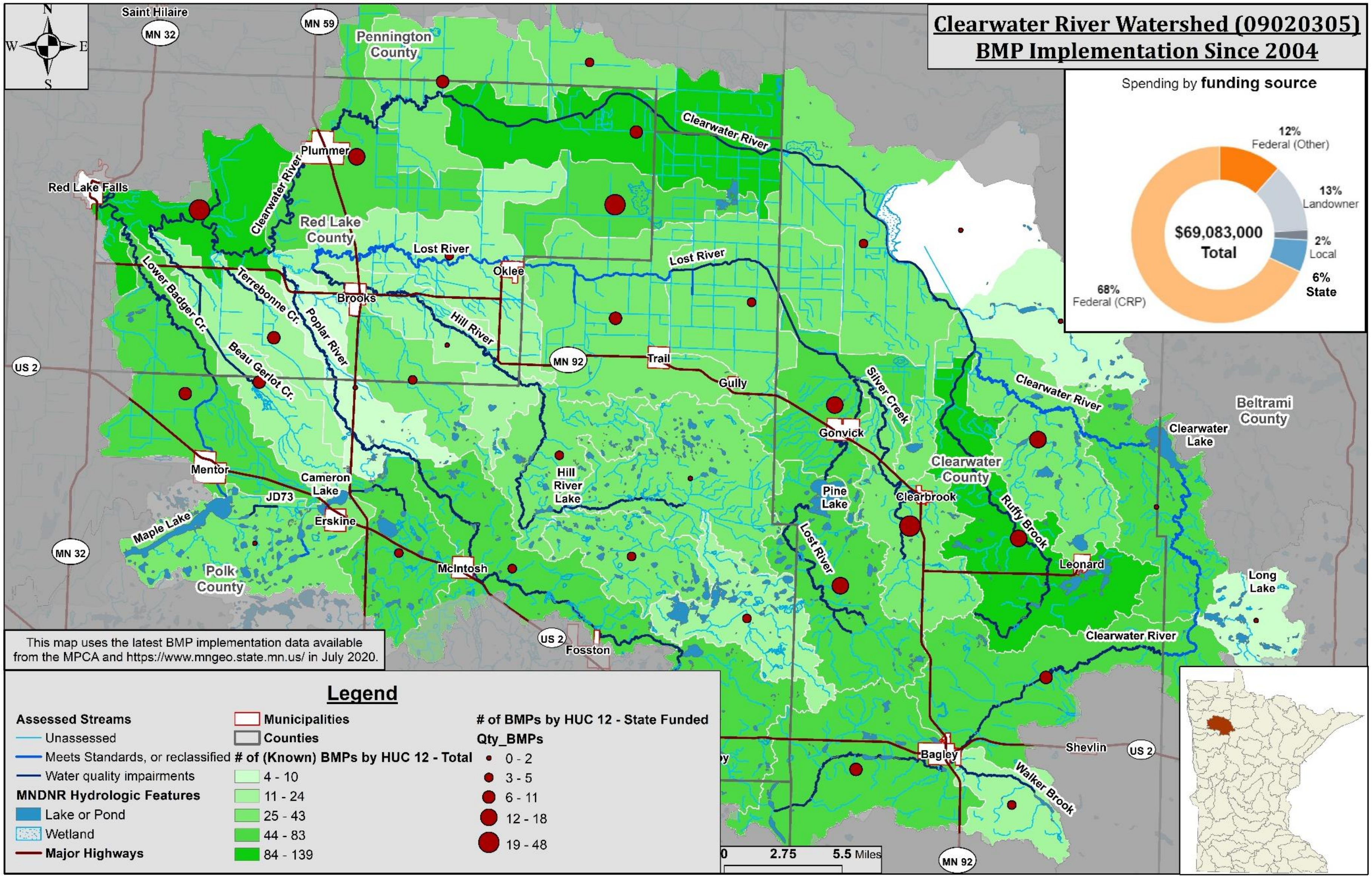


Figure 3-36. Numbers of BMPs implemented, by HUC-12 subwatershed and total sediment loading reductions from those BMPs.

Watershed-wide Strategies

Table 3-10. Watershed-wide strategies and actions proposed for the Clearwater River Watershed.

HUC-10 Sub-watershed	Parameter (incl. non-pollutant stressors)	Water Quality		Waterbody and Location	Strategies	Strategy scenario showing estimated scale of adoption to meet 10-year milestone and final water quality targets.					Estimated Year to Achieve Water Quality Target
		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction	Waterbody (ID)		Proposed Actions	Estimated Adoption Rate: Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	
All	All	n/a	n/a	All	Engage local experts and decision-makers in the assessment process, local input for Use Attainment analysis	Meetings to discuss use attainment with local and state staff	MPCA has begun meeting with local staff for round 2 of IWM	Meeting prior to 2024 biological sampling	1	meeting	2023
						Local staff participation in Professional Judgement Group meetings	Local staff were at the 2016 PJG meeting	SWCDs also attend, in addition to the RLWD	4	LGU staff	2026
						Solicit comments from local staff and stakeholders on Draft List of Impaired Waters	RLWD submitted comments on 2018 List of Impaired Waters	Keep all LGUs informed before, during, and after the assessment process	4	Sets of local comments	2028
	TSS	5 impaired reaches 3 nearly impaired reaches	0 impaired reaches	Nassett Creek (545); Clearwater River (511, 647, 648, 501)	Restore impaired waters that are close to meeting water quality standards.	Prioritize these reaches for projects and practices	Ongoing voluntary BMP implementation	* AUID 647 has been restored *AUID 648 has been restored *AUID 545 has been restored	352.96 +628.9 +1,842.72 2,824.58 total	tons/year TSS	2032
				Lost River (646), Lower Badger Creek (502) Silver Creek (527)	Protect unimpaired waters that are at risk of exceeding impairment thresholds	Prioritize these reaches for projects and practices	Nearly impaired waters identified in WRAPS	During the 2026 assessment, no new impairments are found on waters that were assessed during the 2016 assessment.	14.7 +17.3 +31.5 63.5	tons/year TSS	2026
				All	Establish buffers or alternative practices along channels	*Updated education and outreach programs *Plantings that add trees, shrubs, and native vegetation	Compliance required by November 2017 on public waters & November 2018 on public ditches	*Compliance checks are performed at regular intervals. *GIS data is used to assess buffer quality	100	% Compliance	2020
				Concentrate upon cultivated land throughout the watershed	Utilize models, tools, inventories, and site visits to implement targeted BMPs like side water inlets, alternative side water inlets, cover crops, and crop residue management to control upland erosion.	PTMApp and zonation are completed for the watershed	HSPF-SAM	*Grant funds are acquired for the accelerated implementation *Prioritize small watersheds for intensive inventories *Work with DNR staff to analyze the Clearwater River watershed using the process of zonation. Provide DNR staff with data that can assist the process	2	Completed desktop tools	2022
				Clearwater River Corridor	Stabilize the outlets of Clearwater River tributaries and ditches.	*Use LiDAR-equipped drones to evaluate eroding outlets *Design and construct grade stabilization structures	Projects have been completed along the Red Lake River that can be used as examples	*Ditch outlets are prioritized by the severity of the erosion *5 projects have been completed (one every two years)	1,025	tons/ year TSS	2032
				All	Use conservation programs like CRP, EQIP, and RIM to encourage CPs in critical areas	*Outreach to landowners with expiring contracts *Offset CRP loss with perennial plants or alternative crops *Grant funding acquired to expedite implementation *Work with landowners to implement rotational grazing systems on expiring acres.	Ongoing voluntary BMP implementation	*A net increase in the percentage of tilled acres that utilize on-field BMPs to reduce soil loss *Minimized CRP loss	432	Tons/year TSS	2032
									500	tons/year TSS	2032
						Install/replace windbreaks to reduce wind erosion	Many windbreaks are not being replaced after removal	There is a net gain in shelterbelts by the end of the 10-year period.	Net increase	acres	2032

HUC-10 Sub-watershed	Parameter (incl. non-pollutant stressors)	Water Quality		Waterbody and Location	Strategies	Strategy scenario showing estimated scale of adoption to meet 10-year milestone and final water quality targets.					Estimated Year to Achieve Water Quality Target
							Estimated Adoption Rate				
		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction	Waterbody (ID)		Proposed Actions	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	
All	TSS	5 impaired reaches 3 nearly impaired reaches	0 impaired reaches	Focus on areas where a need is identified in the geomorphology report	Floodplain access maintenance and improvement along ditches.	*Pursue opportunities to provide/acquire the additional funding needed to incorporate two-stage ditch design into ditch improvement projects. *Review ditches to see that they are not deepened or still have access to the floodplain through as-built surveys.	Lost River between CSAH 28 and CSAH 6 was an example of a channelized stream that has access to the floodplain and riparian vegetation along much of the reach to protect streambank stability	*Maintenance of floodplain access is considered when ditches are cleaned or improved. *Improved floodplain access on portions of ditches that are severely incised	1	2-stage ditch created	2032
				All	Revegetation of disturbed areas (e.g. ditch cleanouts).	*Revegetation of ditch cleanouts becomes a requirement during the permitting process.	Public ditches are usually seeded to reestablish vegetation, but private and township ditch revegetation efforts are inconsistent	*The most recently updated guidance on ditch cleanouts is utilized.	10	Miles of re-vegetated ditch	2032
					Education and outreach	*Water festivals *Newsletters *Annual/monthly reports *Open house events *1W1P Advisory Committee meetings *Newspaper articles *Social media *River Watch *Educational workshops *Envirothon Competitions	*Annual water festivals *County newsletters *RLWD annual report *RLWD monthly water quality reports *Facebook pages *Clearwater River blog *River Watch *County fair booths * MN Ag Water Quality Certification Program *Annual Envirothon competitions *Rain barrel workshops (East Polk SWCD)	*Distribution of annual reports monthly reports, and newsletters *Regular newspaper articles are written *Personalized landowner contacts and information to promote BMPs in critical areas *Continue existing educational programs *Plan semi-annual informational open house events	5 10 10 2 2	Public meetings Water Festivals Envirothons Rain barrel workshops Lake-scaping workshops	2029
					Education for developers, realtors, planners, mayors, county boards and other decision makers about the effects that development and land use have upon water quality and the effect that flooding and erosion hazards can have upon development	*Develop easy-to-understand brochures and newsletters *Include these people in the 1W1P process	Other than RLWD, SWCD, and county board members, there is little direct contact with developers and planners to discuss water resource issues	*Informational materials are distributed *Workshop for professionals involved with land management, regulation, and sales is held. *Incentives for attendance	1	Workshop	2032
					Compile and share inventories of erosion problems	*Evaluate other online tools for sharing georeferenced photos and information *GIS Layer based on windshield surveys and in-stream reconnaissance	*Flickr account *Direct discussion about specific erosion problems	*Inventories are used as a resource for prioritizing, planning, and acquiring funding for erosion control projects.	300	Shared photos	2022
				Red Lake Falls, Bagley, Fosston, Erskine	Promote infiltration, retention, and extended detention practices in new and existing urban developments based on current stormwater BMPs	*Stormwater assessment of Red Lake Falls *Rain barrel workshops	*Stormwater ponds in Bagley and Clearbrook. *Stormwater assessment completed for Clearbrook	*One stormwater retention/infiltration project has been completed within each of the targeted cities *Stormwater sampling has been conducted in each city *The effectiveness of the Bagley stormwater ponds has been evaluated	5	New stormwater ponds or other stormwater BMP install-ations	2029
		33 AUIDs with >20 TSS samples or transparency readings	37 AUIDs with >20 TSS samples or transparency readings	All	Continued Monitoring	*Increase in the amount of assessment that is made possible by monitoring efforts compared to previous assessments	Several ongoing long-term monitoring programs, volunteer monitoring, and intensive sampling for IWM	*Sufficient data for the 2024 water quality assessment. *Sufficient data to verify borderline assessment results	>10%	increase in AUIDs assessed	2025

HUC-10 Sub-watershed	Parameter (incl. non-pollutant stressors)	Water Quality		Waterbody and Location	Strategies	Strategy scenario showing estimated scale of adoption to meet 10-year milestone and final water quality targets.					Estimated Year to Achieve Water Quality Target
							Estimated Adoption Rate				
		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction	Waterbody (ID)		Proposed Actions	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	
All	*E. coli*	15 impaired AUIDs 7 nearly impaired AUIDs	0 impaired AUIDs	Lost River (512) Clear Brook (526) Brooks Creek (578)	Restore impaired waters that are closest to meeting state water quality standards.	Prioritize these reaches for targeted projects and practices	Ongoing, scattered voluntary practices and projects	*AUID 526 has been restored *AUID 578 has been restored *AUID 512 has been restored	210.2 +7,680.3 +2,294.4 = 10,184.9	Billion orgs. /year	2032
				CD 57 (508), Clearwater River (511 & 517), Poplar River (518), Lost River (645 & 646), Hill River (656)	Protect unimpaired waters that are closest to becoming impaired.	Prioritize these reaches for projects and practices	Ongoing, scattered voluntary practices and projects	*No new impairments are found on waters that were assessed during the 2016 assessment *Maximum monthly geometric means for AUIDs 652, 508, 511, 646, 656, and 517 have dropped below 100 MPN/100ml.	0	New impair-ments	2026
				All	Septic system compliance	*Conduct septic system inventories to identify non-compliant septic systems *Target areas where human fecal DNA markers were found in MST samples *Update county ordinances to include point of sale septic inspections. *Help homeowners get low interest loans for septic system updates	Unknown	*Out-of-compliance systems are brought into compliance in a timely manner.	5	Improved septic systems	2029
					Grazing management to limit or exclude the access of livestock to waterways	*Ensure that all feedlots are up to date and comply with regulations, ones that do not meet the regulations, work with the landowner to get compliance	Ongoing, scattered voluntary practices and projects	*Existing *E. coli* impairments are delisted. *Delisted *E. coli* impairments continue to meet standards	10	Livestock exclusion projects	2029
		30 AUIDs with at least 1 month with >5 samples	33 AUIDs with at least 1 month with >5 samples	All	Continued sampling	*Increase in the completeness of the State water quality assessment compared to previous assessments.	Ongoing long-term monitoring programs – See Section 4	*Enough data for the 2026 water quality assessment *Sufficient data to verify borderline assessment results	10%	Increase in assessed AUIDs	2026
	Habitat/ connectivity	4 nearly restored F-IBI Impairments, 2 nearly restored M-IBI impairments	0 impaired AUIDs	Poplar River (518), Silver Creek (527), Hill River (539), AUID 561, Lost River (645), Beau Gerlot Creek (652)	Restore impaired waters that are closest to meeting expectations	*Remove or retrofit fish passage barriers *habitat improvement projects *Rock riffles for mechanical aeration *Storage and infiltration to improve base flows	*Stressor ID report completed, and restoration needs have been identified *LGUs applied for 1W1P development funding. This list of nearly restored waters can be prioritized in the 1W1P.	*AUIDs 539, 518, and 645 have been restored *Competitive or watershed-based funding acquired, and projects completed to improve nearly restored waters	8	AUIDs are delisted for aquatic life impair-ment	2029
		9 nearly F-IBI-impaired AUIDs 13 nearly M-IBI-impaired AUIDs	0 newly-impaired AUIDs	Lower Badger Creek (502), Poplar River (504), Lost River (512), Ruffy Brook (513), CD 14 (523), Silver Creek (527), Hill River (539), JD 73 (550), SD 61 (590), JD 72 outlet (643)	Protect unimpaired waters that are closest to becoming impaired.	*Storage and infiltration to improve base flows *Improve the quality of riparian habitat through buffer compliance and riparian planting of deep-rooted and woody vegetation	*Riparian buffers planted along Ruffy Brook and Silver Creek. *LGUs applied for 1W1P development funding. This list of nearly impaired waters can be prioritized in the 1W1P.	*During the 2026 assessment, no new impairments are found on waters that were assessed during the 2016 assessment. *Competitive or watershed-based funding acquired, and projects completed to improve nearly impaired waters	0	New IBI impair-ments	2026
		7 F-IBI Impairments 3 M-IBI Impairments	0 impaired AUIDs	All	Evaluate IBI expectations, sampling locations, and impairment thresholds with local stakeholder input.	*Hold local/regional workshops to better explain the classification and decision-making process. *Make sure expectations are appropriate.	A need for more local input was identified after the 1st round of IWM. Local input is being sought and meetings have been held prior to the 2nd round.	*Complete this review and make agreed-upon changes prior to the 2022 biological sampling and intensive watershed monitoring.	1 or more	Meeting	2023-2024
					Assessment of road crossings for fish passage and stream stability	*Length, width, and height measurements of culverts, along with elevations and culvert type	Culvert inventory in progress for the purpose of hydro-conditioning the LiDAR DEM	Watershed-wide, prioritize impaired (F-IBI and TSS) streams	20	12-digit HUCs inventoried	2024

HUC-10 Sub-watershed	Parameter (incl. non-pollutant stressors)	Water Quality		Waterbody and Location	Strategies	Strategy scenario showing estimated scale of adoption to meet 10-year milestone and final water quality targets.					Estimated Year to Achieve Water Quality Target
							Estimated Adoption Rate				
		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction	Waterbody (ID)		Proposed Actions	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	
All	Habitat / connectivity	7 F-IBI Impairments 3 M-IBI Impairments	0 impaired AUIDs	All	Improve connectivity with properly sized and placed culverts on road crossings	*At the very least, check on specific culverts that have been identified in through stressor ID process and other means (Buzzle Lake outlet, Hill River AUIDs 655 and 656, CD 23) *Ensure that proper culvert size and placement are being used when road work and repairs are being completed. Follow MESBOAC designs	DNR permitting takes fish passage into consideration	*Completed culvert inventory that also assesses crossings for potential fish passage barriers. *Problem culverts have been replaced with new culverts that are properly sized for the effective movement of sediment, water, and fish. *Fish passage has been maintained or improved	5	Culvert replace-ments	2024
				Watershed-wide with focus on Ruffy Brook and Clearwater River upstream of Clearwater Lake	Reduce sedimentation within channels and pools by addressing overland and streambank erosion.	Utilize BANCS erosion estimates from the geomorphology study and other tools to ID locations for effective projects	Ongoing voluntary BMP implementation and competitive-grant-funded erosion control projects	*No new TSS impairments *Improved trends in TSS concentrations. *Improved substrate habitat	10%	Reduction in average TSS concen-trations	2032
		16 AUIDs with fair MSHA ratings (55.6-point average) 7 poor MSHA ratings (37.9-point average)	Average MSHA score on fair scoring AUIDs increases to >66 points Average MSHA score on poorly scoring AUIDs increases to >45 points	All	Improve MSHA scores along reaches that were given fair and poor ratings during the 2016 assessment.	*Improve the quality of riparian habitat through buffer compliance and riparian planting of deep-rooted and woody vegetation *improve in-stream habitat by reducing sedimentation, restoring meanders, and installing rock riffles structures	Some projects were completed through competitive grants and through Phase II of the Clearwater River Nonpoint Study	*Confirm the MSHA rating for Reach *Multiple projects have been completed. *5 MSHA scores have improved from poor to fair/good) *MSHA metrics are considered during the planning of projects *5 MSHA scores have improved from fair to good	>19%	Improve-ment in average scores	2026
		Unknown	No excess pesticides in surface or groundwater	All	Reduce runoff and leaching of pesticides	*Work with MDA to collect pesticide samples in the Clearwater River Watershed *Educational programs to prevent leaching and runoff of pesticides	No known sample collection in the Clearwater River water	The Minnesota Department of Agriculture doesn't find violations of pesticides during its pesticide monitoring program.	5	Pesticide sampling sites	2032
		25 assessed AUIDs	25 assessed AUIDs	All	Continued sampling	*Sample Nassett Creek, Clear Brook, AUID 530 of the Lost River, and the Clearwater River Headwaters (517) *Do not sample biology in artificial watercourses (590, 643) and streams that were not assessed for aquatic life in 2016 (592, 641) *Utilize volunteers (River Watch) and local staff to collect additional M-IBI or MSHA data that can be used to inform future assessments.	Local and MPCA staff have met to discuss the TALU process. The RRWMB has expressed concern about biological expectations for artificial watercourses that were only created to move/divert water and do not qualify as altered watercourses because they do not follow the path of a pre-existing channel. MPCA has started meeting with local experts for the se Attainment Analysis and Intensive Watershed Monitoring site selection.	*Sufficient data for the 2026 water quality assessment *Consult local staff/stakeholders when choosing reaches and sites for monitoring *Expectations for ditches are realistic. Designated impairment thresholds make sense. *Man-made, limited value, intermittent road ditches are not sampled. *Knowledge and capabilities for biological monitoring are shared with willing and capable entities so that the MPCA is not the sole provider of data and so that larger data sets improve understanding of temporal and spatial variability in the IBI scores	4	Newly assessed streams	2025
		Degraded habitat and a lack of base flow	Improved habitat and base flow	All	Ag drainage system design training	*Education on practices that minimize nitrogen (nitrate) losses and reduce downstream nitrogen loads *Testing of water quality from tile drainage	*Local SWCDs have occasionally organized informational workshops for farmers	*Multiple workshops have been organized	5	workshops	2032

HUC-10 Sub-watershed	Parameter (incl. non-pollutant stressors)	Water Quality		Waterbody and Location	Strategies	Strategy scenario showing estimated scale of adoption to meet 10-year milestone and final water quality targets.					Estimated Year to Achieve Water Quality Target
		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction	Waterbody (ID)		Proposed Actions	Estimated Adoption Rate: Current strategy adoption level, if known	Estimated Adoption Rate: Interim 10-year Milestone	Estimated Adoption Rate: Suggested Goal	Estimated Adoption Rate: Units	
All	Habitat / connectivity	1 completed FDR project	5 completed FDR projects	All	Attenuate peak flows and augment base flows in streams throughout the watershed.	*Prevent or mitigate activities that will further alter the hydrology of the watershed. *Wetland restorations *Evaluate alternatives for ditch systems that aren't beneficial *Drainage water management *Incorporate natural resource enhancement into impoundment projects	RLWD Peak Flow Reduction Study identifies potential impoundment sites to achieve a 20% peak flow reduction at Crookston. *1 FDR project completed at Little Pine Lake WMA. *USFWS has completed many wetland restorations	*There is more focus upon water storage and controlled drainage. *Water storage projects are limited to areas that will not destroy aquatic habitat. *Improved relationships and cooperation between agencies and landowners *LGUs assist USFWS with locating potential wetland restorations	6,421	Acre-feet of storage	2042
	Low Dissolved Oxygen	1 nearly restored AUID	1 restored AUID	Lost River (645)	Restore impaired waters that are closest to meeting state standards.	*Improve shading of streams *Improve base flows *Improve mechanical aeration (rock riffles)	Ditch maintenance and agricultural activities have removed deep-rooted and woody vegetation	*The frequencies of low DO levels have decreased in impaired reaches. *IBI scores have improved	1	Restored AUID	
		4 nearly-impaired AUIDs	2 Nearly impaired AUIDs	Poplar River (504), Ruffy Brook (513), Lost River (530), Terrebonne Creek (574), Clearwater River (647), Hill R (655)	Protect unimpaired waters that are closest to becoming impaired.	*Improve shading of streams *Improve base flows *Improve mechanical aeration (rock riffles)	Grazing management and tree plantings on properties along Ruffy Brook, buffer strip and tree plantings on properties along Silver Creek	*During the 2026 assessment, no new impairments are found on waters that were assessed during the 2016 assessment. *Stream restoration projects are completed or planned.	0	New DO impair-ments	2025
		20 assessed AUIDs	31 assessed AUIDs	All	Continued Monitoring	*See Section 4 *Identify and addressed data gaps that were found during the 2016 assessment *Continuous DO monitoring	*DO logger deployments in 2016-2018, 10-year DO logger deployment plan for the RLWD *New long-term monitoring station on AUID 655	*Sufficient data for the 2024 water quality assessment. *Sufficient data to verify borderline assessment results	31	Assessed AUIDs	2025
	Phosphorus and Eutroph-ication	49,934 lbs/yr at S002-916	21,696 lbs/yr at S002-916	All	Nutrient and soil health management	*Build relationships between agency staff and crop advisors *Switch from fall to spring fertilizer *Application of P & N using precision fertilizing and manure application techniques *Cover crops on fallow cropland and short season crops *Perennials in riparian zones & marginal cropland *Research and development of marketable cover crops *Tillage practices that leave >30% crop residue cover or alternative practices *Grassed waterways and structural practices *Tile drainage water quality treatment and storage through wetland restoration, controlled drainage, water control structures, two-stage ditches, saturated buffers, and bioreactors *Develop strong private-public partnerships to support implementation of voluntary BMPs	Ongoing, voluntary BMP implementation	*10% reduction in TP loads from 2003 conditions *13% reduction of N loads from 2003 conditions *Increased education and adoption of mutually beneficial nutrient loss reduction strategies *Increased education about water quality issues *Increased use of demonstration projects to increase adoption of practices *reduction of nitrogen losses on corn following soybeans	28,238	Lbs./yr. reduction in TP loads	2042
		32 assessed lakes	34 assessed lakes	All	Continued monitoring of lake water quality	*Maintain and build a network of volunteer samplers *Maintain and build partnerships with local organizations to collect lake samples	Volunteer and SWCD monitoring of lakes See Section 4	Increase the number of assessed lakes during the 2026 assessment. Sufficient, new (2016-2025) data from 34 lakes	34	Assessed lakes	2025

Upper Clearwater River 0902030501 Strategies

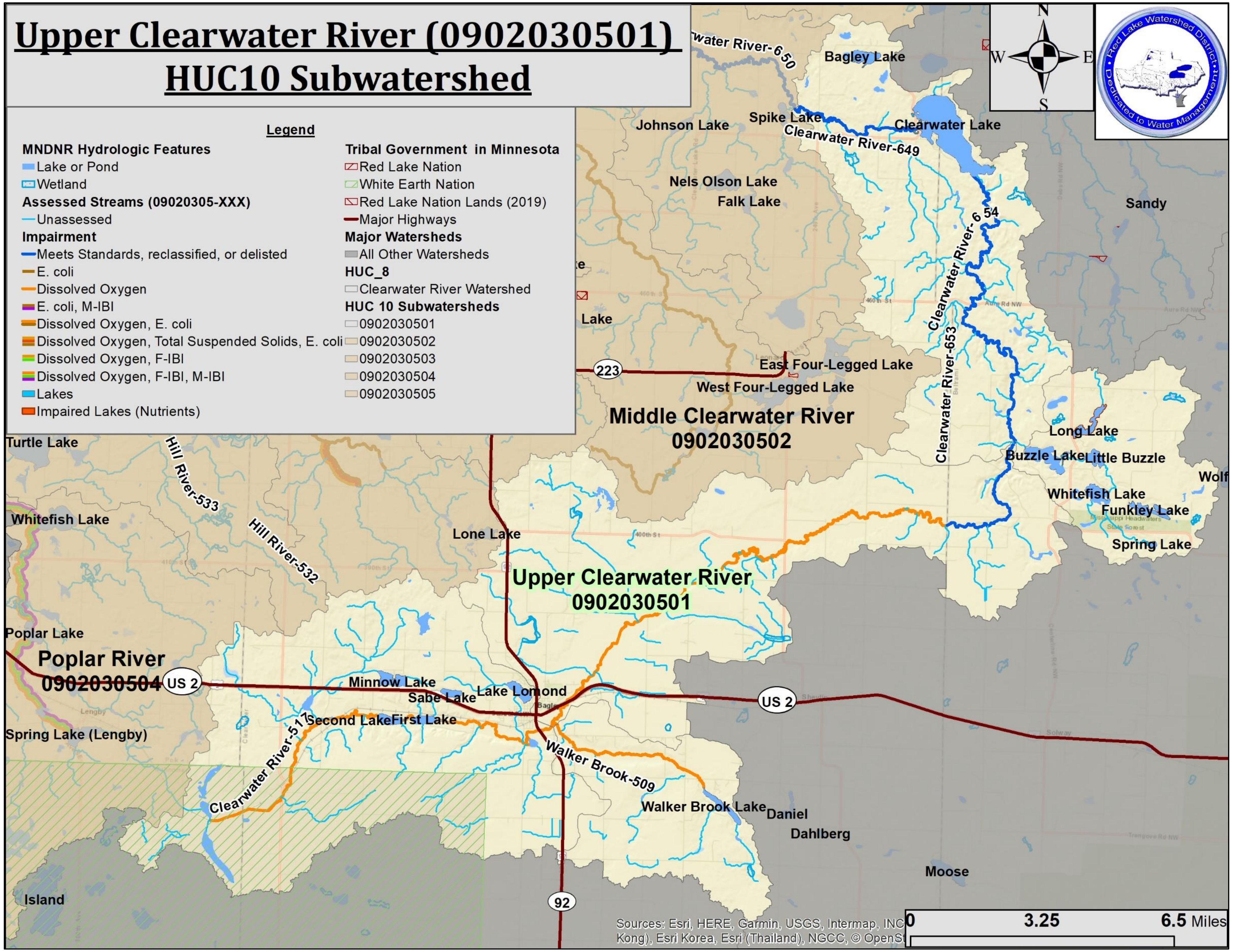


Figure 3-37. Upper Clearwater River Subwatershed (0902030501)

Table 3-11. Strategies and actions proposed for the Upper Clearwater River Subwatershed (0902030501)

HUC-10 Sub-watershed	Parameter (incl. non-pollutant stressors)	Water Quality		Waterbody and Location	Strategies	Strategy scenario showing estimated scale of adoption to meet 10-year milestone and final water quality targets.					Estimated Year to Achieve Water Quality Target
							Estimated Adoption Rate				
		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction	Waterbody (ID)		Proposed Actions	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	
Upper Clearwater River 0902030501	Sediment /TSS	8.3% of TSS >10 mg/L	<7.5% of TSS >10 mg/L	Clearwater River (653)	Streambank stabilization	Stabilize eroding banks through bioengineering and re-vegetation.	Recently stabilized bank downstream of CSAH 22	LGUs and landowners have collaborated to stabilize eroding streambanks	4	projects completed	2032
	Habitat / connectivity	Nearly impaired 41.7 F-IBI and 35.3 M-IBI in AUID 653 High quality IBI scores in AUIDs 650 and 654	>45.9 F-IBI and >44.9 M-IBI in AUID 653 Maintain high quality habitat in AUIDs 650 and 654 Assess AUID 517	Clearwater River (517, 653, 649, 650)	Improve riparian conditions and floodplain connectivity	*Enforcement of Buffer Law requirements along with compliance inspections *Preemptive BMP establishment on new/changing livestock operations near the river	Much of the riparian area is undisturbed within state land. There is a landowner along AUID 517 that stated plans to start grazing along the river.	*Buffers are inspected regularly *Landowners have been contacted *Deep-rotted and woody vegetation has been re-planted	100	% known compliance with the buffer law	2032
				Clearwater River (653, 654)	Re-evaluate habitat scores	*Follow standard methods *Re-evaluate conditions at biological sampling sites and at other representative sites	*Possible issues with the habitat assessments were brought up in discussion of the 2014-15 results	*Primary deficiencies in stream habitat (that led to poor scores) are verified (14RD302 & 10EM085)	12	MSHA ratings	2025
				Clearwater River (653)	Improve fish habitat and riparian vegetation	*Improve riparian cover along the trout stream reach *Improve refuge for over-wintering of trout	*Documented issues with natural reproduction *Marginal temperatures for trout	*One project has been completed *Improved MSHA score along the reach is recorded prior to the 2026 assessment *Improved size of trout in the Clearwater River *Improved natural reproduction of trout in the Clearwater River	20%	Increase in MSHA ratings at 14RD302 and 10EM085	2025
				Clearwater River (517, 653, 654)	Reduce sedimentation in the Clearwater River upstream of Clearwater Lake & the Clearwater Lake inlet	*Erosion control projects *BMPs on private lands	*River currently meets 10 mg/L standard, but exceedance rate is relatively close to the 10% threshold *Some sites had relatively low MSHA substrate scores	*Multiple projects have been completed *Improvement is shown in MSHA and fluvial geomorphology assessments *Native plantings	20	Minimum substrate scores in 2024-2025 MSHA results	2025
		Zebra mussel veligers in Lake Lomond	No new infestations	Clearwater River (517) Pine Lake Clearwater Lake	Early detection zebra mussel sampling	*Sample collection along outlet of Lake Lomond and the Bagley stormwater pond between Lake Lomond and the Clearwater River *Continued early detection sampling in Clearwater and Pine Lakes *Continued deployment of stationary samplers on docks	*Early detection sampling in Lake Lomond, Clearwater Lake, and Pine Lake through 2019 *PVC pipe samplers deployed at lakes with docks	*No new infestations *If there are new infestation, they are discovered to prevent spread	10	Years of sampling	2029
					Prevent spread of zebra mussels	*Continue or increase county AIS prevention efforts	County AIS prevention and education efforts	*No new infestations *Structures or other measures to prevent downstream drift from Lake Lomond	0	New infestations	2029
	Phosphorus and Eutrophication	0.052 mg/L summer average TP	<0.050 mg/L summer average TP	Clearwater River (653)	Improve the quality of riparian vegetation with deep rooted native and woody plants	*Target projects in areas with high TP yields	Ongoing, voluntary BMP implementation	*Cattle exclusion fencing installed *Vegetation plantings have been established *BEHI ratings improved *Maintenance of Bagley stormwater ponds	10%	Reduction in TP loads	2032
		Clearwater L: 0.019 mg/L First Lake: 0.023 mg/L Long Lake: 0.044 mg/L Second Lake: 0.028 mg/L Walker Brook Lake: 0.024	Clearwater L: <.02 mg/L First Lake: <0.02 mg/L Long Lake: <.02 mg/L Second Lake: <0.02 mg/L Walker Brook L: <0.02 mg/L	Clearwater Lake (04-0343) First Lake (15-0139) Long Lake (04-0295) Second Lake (15-0140) Walker Brook (15-0060)	Monitor changes in water quality in impaired or nearly impaired lakes	*Fund sampling by volunteers *Communicate with landowners to get approval for lake access to sample Long Lake	*CLAA samples Clearwater Lake *Renewed sampling effort is needed for Long Lake *First and Second Lake could be conveniently sampled by the Clearwater SWCD (close to their office)	*Sufficient data for trend analysis *2016-2025 data quantity is greater than the minimum amount needed for an assessment	>8	2016-2025 samples from each lake	2025
				Clearwater Lake (04-0343)	Shoreline erosion control	*Continue progress from the grant-funded work that was recently completed *Stabilize gullies	*Beltrami SWCD and CLAA were awarded a grant for shoreline stabilization	*LGUs have worked with the Clearwater Lake Area Association to address all of the areas where erosion is a concern	300	Meters of shoreline stabilized	2032

Middle Clearwater River 0902030502 Strategies

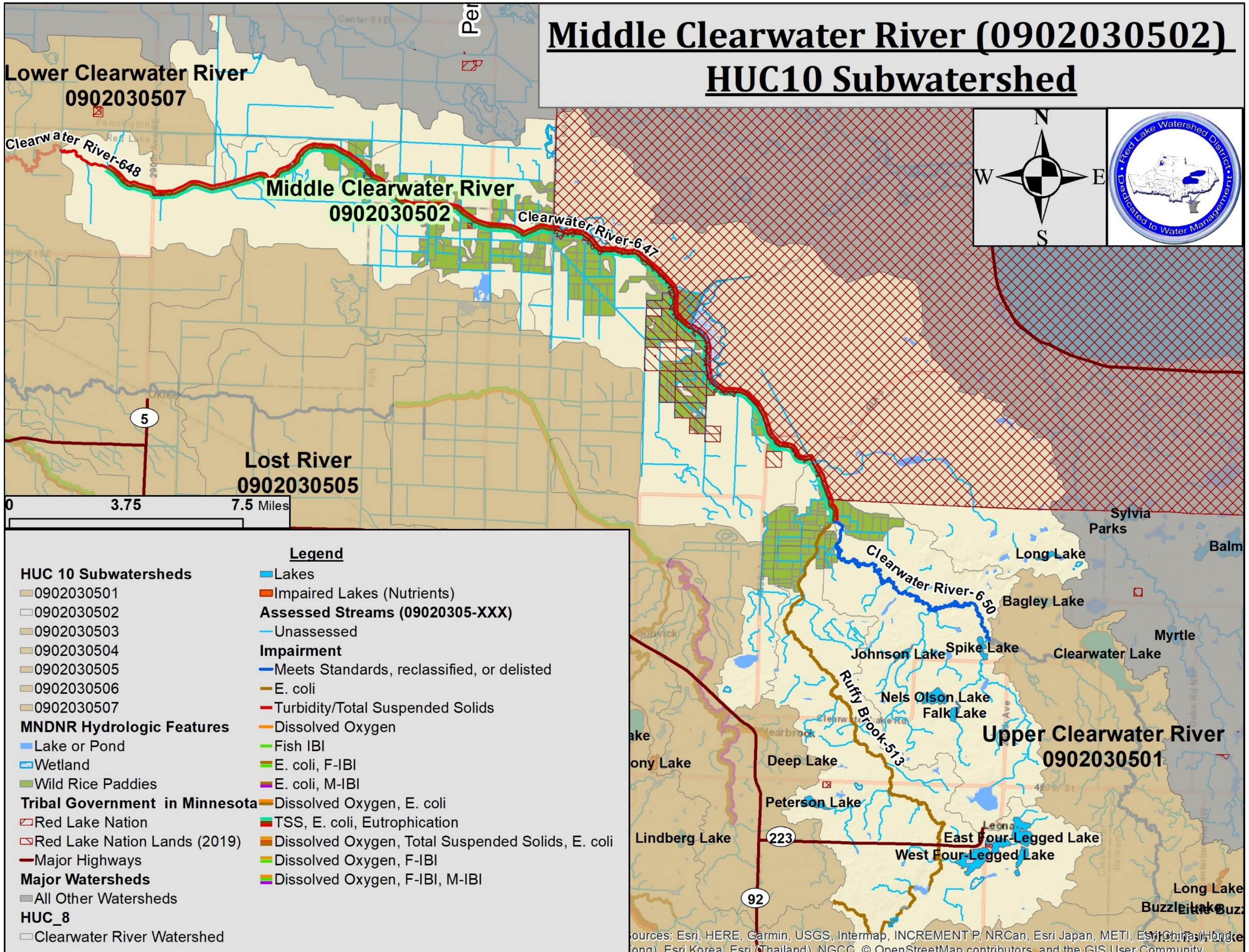


Figure 3-38. Middle Clearwater River Subwatershed (0902030502)

Table 3-12. Strategies and actions proposed for the Middle Clearwater River Subwatershed (0902030502)

HUC-10 Sub-watershed	Parameter (incl. non-pollutant stressors)	Water Quality		Waterbody and Location	Strategies	Strategy scenario showing estimated scale of adoption to meet 10-year milestone and final water quality targets.					Estimated Year to Achieve Water Quality Target
							Estimated Adoption Rate				
		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction	Waterbody (ID)		Proposed Actions	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	
Middle Clearwater River 0902030502	Sediment /TSS	11.6% of TSS >30 mg/L	<10% of TSS >30 mg/L	Clearwater River (647)	Grade Stabilization	*Stabilize the upstream end of the channelized reach, near Ruffy Brook confluence *Pre-project surveying *Landowner contacts	Surveying and detailed BEHI ratings were completed during the fluvial geomorphology study	A grade stabilization project has been funded and completed between the lower end of the existing project and the Ruffy Brook confluence	1.3	Miles of stabilized channel	2029
					Improve floodplain access.	*Identify potential projects in the confined, channelized portion of the Clearwater River *Evaluate project ideas and alternative solutions like re-meandering channels, setback levees, two-stage ditch design, and other alternatives *Post-project monitoring	*Representative reaches were assessed during the fluvial geomorphology study *Mixed opinions on restoring the Clearwater River have been shared at public meetings	*Incorporated into 1W1P*Project location(s) have been identified	2	Miles of restored channel	2026
					Main line tile drainage installation on wild rice paddies	Target wild rice operations that are still drained by internal drainage ditches	*Approximately 11,279 acres of paddies had main line tile in 2009	*Updated inventory of wild rice paddy drainage infrastructure *Tile drainage in wild rice paddies is recognized as a BMP and promoted with cost-share funds	6000	Tons/yr. reduction in TSS	2032
		4.3% of TSS >30 mg/L 17% of TSS >10 mg/L	3.9% of TSS >30 mg/L <10% of TSS >10 mg/L	Ruffy Brook (513)	Grade Stabilization	Stabilize the outlet of Ruffy Brook	*Identified as a potential project, but the landowner does not support the project	*Landowner Support *Preliminary engineering	4,500	Feet of stabilized channel	2029
					Conduct a geomorphology assessment of Ruffy Brook	*Focus on representative reaches (disturbed and undisturbed) and the outlet to the Clearwater River *Stabilize the lower portion of Ruffy Brook near the Clearwater confluence *Determine the extent to which the stability of the lower portion of Ruffy Brook is dependent upon the stability of the Clearwater R. *Compare forested and pastured riparian conditions	*1 reach has been assessed with an intensive survey	*Locations have been identified *Access permission from landowners *Recommendations are developed from the results of the assessment, incorporated into the revised WRAPS after the 2026 assessment, and incorporated into the 1W1P *Recommendations help develop a targeted project that improves stream bank/channel stability, reduces sedimentation, and/or improves habitat.	>3	Fluvial geomorph-ology stations assessed	2032
	E. coli	230 maximum monthly geomean *E. coli*	<126 maximum monthly geomean *E. coli*	Ruffy Brook (513)	Reduce cattle access to the stream banks	*Landowner contacts *Cattle exclusion *Riparian tree plantings *Off-channel water sources	*SWCD has had past success in the area.	*Revegetation of damaged stream banks	2.5	Miles of protected channel	2032
	Habitat / connectivity	Moderately unstable Pfankuch stability rating, poor MSHA	Stable Pfankuch stability rating, fair MSHA	Clearwater River (647)	Improve the width and quality of riparian cover along the channelized reach of the Clearwater River	*One mile of plantings	*Buffer Law compliance	*Improved MSHA scores at 14RD205 near the Polk/Clearwater Co boundary, 14RD203 near CSAH 10, 07RD017 near CSAH 5	4	Miles of plantings	2032
		41.9-point minimum F-IBI	51.9-point minimum F-IBI		Improve fish habitat	*In-stream habitat improvements	*Areas of concern identified by MSAH ratings, IBI scores, and geomorphology study	A location has been identified for a channel restoration project	24%	Improvement in F-IBI scores	2025
	Habitat / connectivity	*60% of daily minimum DO <7 mg/L; *90th percentile summer temperature = 22.7° C	*10% of daily minimum DO <7 mg/L; *90th percentile summer temperature = 18.3° C	Ruffy Brook (513)	Work toward restoring Ruffy Brook's ability to support trout	*Riparian tree, shrub and native veg planting *Livestock exclusion	*Some grazing management has been completed, but long-stretches of the stream are damaged by livestock *Local goal – MPCA standards will not change until stream can support cold water species	*Low DO levels are less frequent *Decreasing trend in water temperature *Decreasing trend in TSS	20	% decrease in 90th percentile summer temp-eratures	2042
	Phosphorus and Eutroph-ication	49,934 lbs./year TP at S002-916	21,696 lbs./yr TP at S002-916	Clearwater River (647)	Support research that informs variable rate fertilizer application	*Provide wild rice growers with data on nutrient concentrations in the Clearwater River	*Grant applications submitted for research on nutrient management on wild rice farms	*Improvements in practices and technology lead to reduced TP loads in the river	7,910	Lbs/yr reduction in TP	2032

Hill River 0902030503 Strategies

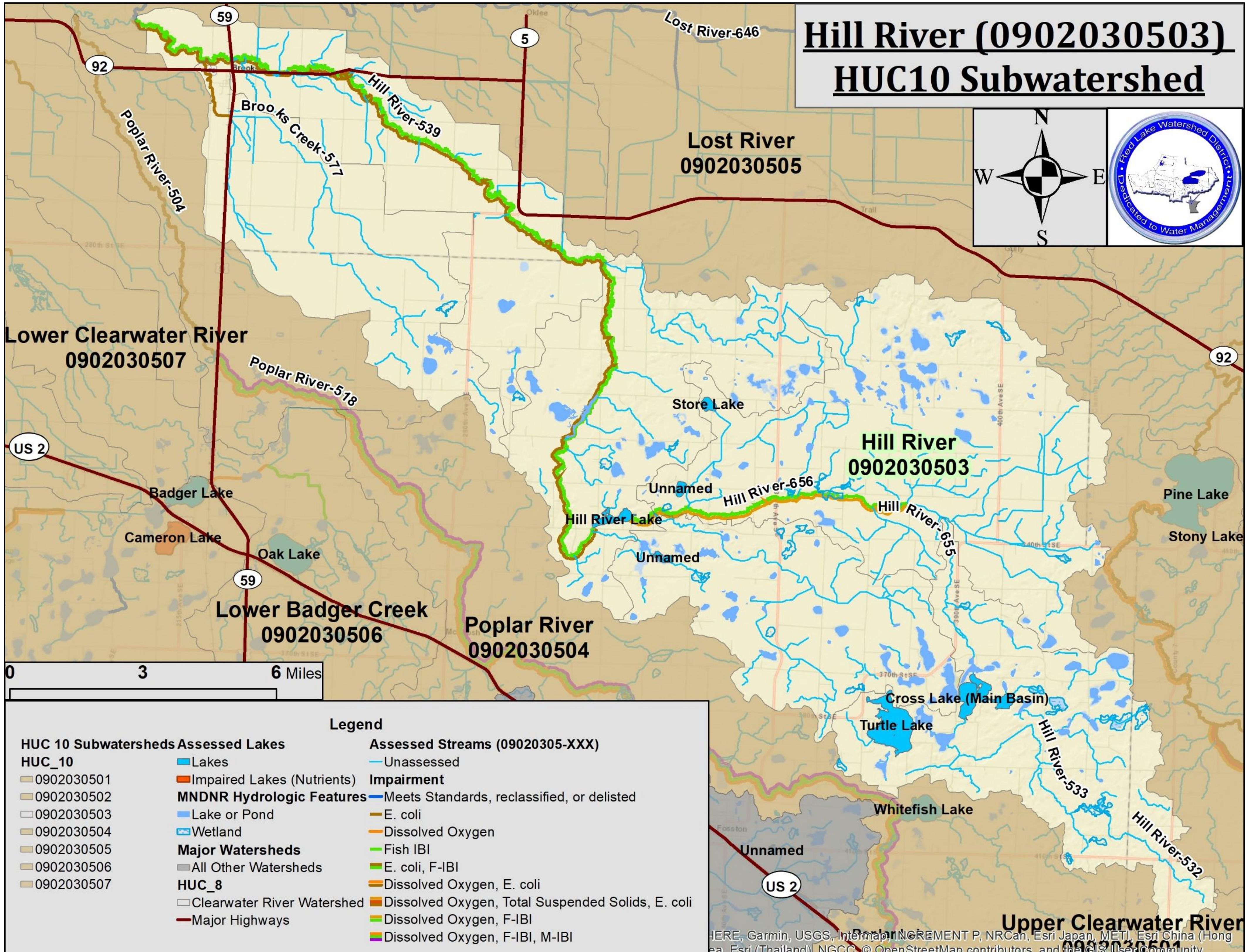


Figure 3-39. Hill River Subwatershed (0902030503)

Table 3-13. Strategies and actions proposed for the Hill River Subwatershed (0902030503)

HUC-10 Sub-watershed	Parameter (incl. non-pollutant stressors)	Water Quality		Waterbody and Location	Strategies	Strategy scenario showing estimated scale of adoption to meet 10-year milestone and final water quality targets.					Estimated Year to Achieve Water Quality Target
		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction	Waterbody (ID)		Proposed Actions	Estimated Adoption Rate: Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	
Hill River 0902030503	Phosphorus and Eutroph-ication	Nearly impaired for aquatic life	Improved IBIs	Hill River Lake (60-0142), Cross Lake (60-0027)	Improve the quality of fish communities	*Aerate where needed *Assess the quality of habitat *Reduce sediment /nutrient runoff *BioBase Mapping	Unknown	*At least one F-IBI-limiting factor has been identified and there is a plan for addressing that problem.	10%	F-IBI increase	2025
		*0.140 mg/L summer average TP in AUID 656 *High TP concentrations found in Hill River Lake	<0.40 mg/L summer average TP in AUID 656 (based on standard for Hill River Lake)	Hill River (655, 656)	WASCOB Sediment Basins	Target the southern portion of the subwatershed where topography is conducive to this BMP and drainage areas of nearly impaired waters	*East Polk SWCD is working on projects to reduce pollution in the stream	*Funding acquired for targeted implementation *Funding for WASCOBs *Improved Cross Lake F-IBI score *Cross Lake meets water quality standards *Improvement in water quality conditions in Hill River Lake.	3,721	acres	2032
	Sediment /TSS	3.2% of TSS >30 mg/L in AUID 539 0 TSS >30 mg/L in AUID 656	<2.9% of TSS >30mg/L in AUID 539 0 TSS >30 mg/L in AUID 656	Hill River (655, 656, 539)	Conduct a more extensive geomorphology assessment	*Revisit sites from last study *Additional reconnaissance *Additional intensive survey station	*1 reconnaissance reach in previous study – no Pfankuch rating	*At least one additional station has been assessed between Hill R L. and the Lost R	1	Additional geomorph-ology station	2032
				Hill River (539)	Re-meander channelized reach	Restore the channelized portion along CSAH 92	*Reach was assessed during the reconnaissance for the fluvial geomorphology study	*Incorporated into 1W1P *Preliminary survey conducted *Landowners contacted *Evaluation of feasibility *Structural stabilization practices	600	Feet of channel restored	2042
	Sediment/ TSS and Bacteria /*E. coli*	Unstable reaches identified	Stabilized reaches	Hill River (539)	Improve riparian vegetation	Target the Pastured area downstream of CSAH 92	*Critical areas identified during geomorphology reconnaissance	*Adequate buffer*Grazing management plan has been implemented *Deep-rooted vegetation has been planted.	2	Miles of riparian plantings	2032
	Bacteria /*E. coli*	354.5 MPN/100mL maximum monthly geomean *E. coli*	<126 MPN/100mL maximum monthly geomean *E. coli*	Hill River (539, 655)	Grazing Management	Implement projects to eliminate cattle access points along the Hill River in: *Sect 16, Queen Twp. *Sect 8 (NE ¼), Queen Twp. *Sect 9 (E ½), Queen Twp.	*SWCDs have good working relationships with landowners	*Violations of regulations have been fixed	12	Eliminated cattle access points	2024
				Hill River (539)	Septic inspections	Target the Hill River Subwatershed upstream of S002-134, to CSAH 5 (S014-928)	County staff are aware of the *E. coli* problem and the presence of human fecal DNA	*A septic inventory has been completed *Failing septic systems are brought into compliance	2	Septic systems upgraded	2032
	Habitat / connectivity	Unassessed, affects impairments in AUID 656	Assessed	Hill River (655) Section 5, Queen Twp.	*Improve connectivity by removing or retrofitting barriers to fish passage	*Work with landowners to find options that allow field access and fish passage at private crossings. *Remove unpermitted earthen dams from the Hill River and its riparian wetlands in Section 5 of Queen Township	* Potential fish passage barriers have been identified in the stressor ID and TMDL reports *SWCD is working with the landowner to fix the problem in Section 5 of Queen Township	* The feasibility of adding fish passage or modifying structures has been explored. If changes are not feasible, evidence is provided to explain why that is the case. The history and plans for the dams are documented. *Unlawful practices have ceased. *Landowner has not committed additional environmental transgressions.	2	Fish passage barriers removed	2024
				Hill River (655)	Stream restoration along Polk CD 68 portion of the Hill River	*Pre-project surveying * Landowners contacts to gauge support for the project *Evaluate alternative strategies	Unknown	*Stream restoration along the Hill River is incorporated into the Clearwater River 1W1P	0.5	Miles of restored channel	2042

HUC-10 Sub-watershed	Parameter (incl. non-pollutant stressors)	Water Quality		Waterbody and Location	Strategies	Strategy scenario showing estimated scale of adoption to meet 10-year milestone and final water quality targets.					Estimated Year to Achieve Water Quality Target
							Estimated Adoption Rate				
		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction	Waterbody (ID)		Proposed Actions	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	
Hill River 0902030503	Habitat / connectivity	33.4-point minimum F-IBI in AUID 539 15.7-point minimum F-IBI in AUID 656 26.5-point minimum M-IBI in AUID 539	47-point minimum F-IBI in AUID 539 47-point minimum F-IBI in AUID 656 41-point minimum M-IBI in AUID 539	Hill River (539, 655, 656)	Restore drained wetlands to provide storage that could contribute to base flows. Restore 3.5-10.5 acres of wetlands along the Hill River between CSAH 29 and CSAH 3	Restore 3.5-10.5 acres of wetlands along the Hill River between CSAH 29 and CSAH 3	USFWS has restored many wetlands on private lands and are looking for additional projects that may provide additional benefits like grazing management (water sources), FDR, and improvement of upland habitat	*Completed restoration	10.5	Acres of wetland	2032
						Hill River corridor in Section 16, Queen Twp. The final 0.15 miles of the CD 68 portion of the Hill River looks like it was dug to drain a 7-acre wetland. That would be an on-channel restoration, though.		*Completed restoration	7	Acres of wetland	2032
						Hill River corridor in Section 8 (SE ¼), Queen Twp. 1.8-acre restorable basin on the west side of the river. Should be coupled with BMPs on the agricultural drainage ditch that flows into it to minimize sedimentation within the restored basin (side water inlet, grassed waterway).		*Completed restoration	1.8	Acres of wetland	2032
						>9-acre wetland, drained by a ditch, in the NW ¼ of Section 9, Queen Township		*Completed restoration	9	Acres of wetland	2032
						Multiple drained wetlands along Polk County Ditch 23 between Sawmill Lake and the Hill River.		*Completed restoration	10	Acres of wetland	2032
						3-acre wetland on the north side of the Hill River (CD81) in the NW ¼ of Section 33 of Eden Township		*Completed restoration	3	Acres of wetland	2032
						*Small wetlands in the N ½ of Sect 32, Eden Township, Polk Co.		*Completed restoration	1	Acres of wetland	2032
						*Several large wetlands, along with some smaller ones, that are drained by ditches on the north side of CSAH 35 in the SW ¼ of Section 30 in Eden Township and the SE ¼ of Section 25 of Hill River Township in Polk Co.		*Completed restoration	10	Acres of wetland	2032
						*23-acre drained (by a ditch) wetland (or small lake) in the NW ¼ of Sect 35 and the NE ¼ of Sect 34 in Hill R Township in Polk Co.		*Completed restoration	23	Acres of wetland	2032
					Increase the amount of woody and native vegetation along the Hill River	Enforcement of Buffer Law requirements along with compliance inspections	*Buffers are being inspected regularly *Some landowners have planted trees near the river	*Buffer law compliance *Riparian plantings of natives, shrubs, and trees	15	Acres of riparian tree plantings	2042

Poplar River 0902030504 Strategies

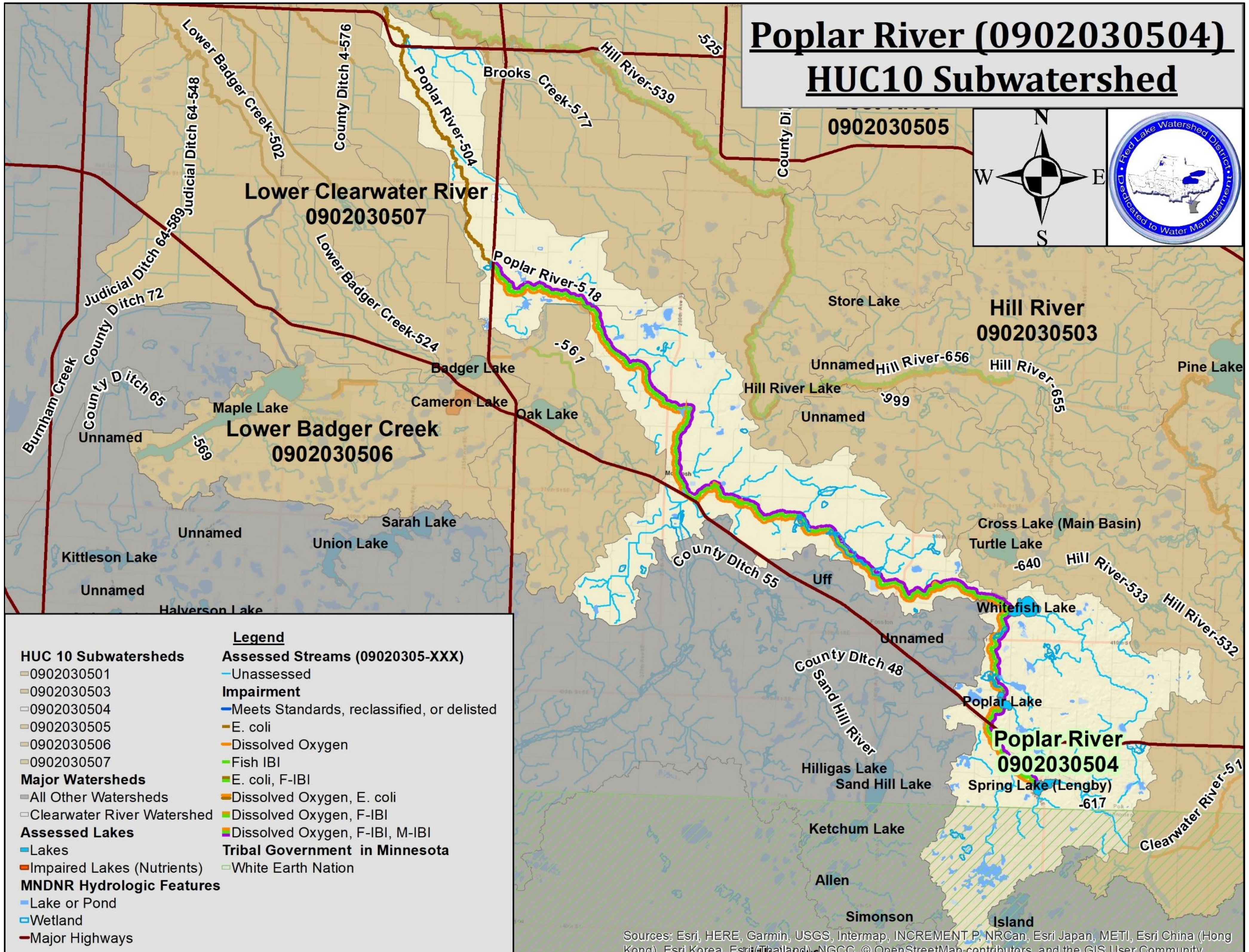


Figure 3-40. Poplar River Subwatershed (0902030504)

Table 3-14. Strategies and actions proposed for the Poplar River Subwatershed (0902030504)

HUC-10 Sub-watershed	Parameter (incl. non-pollutant stressors)	Water Quality		Waterbody and Location	Strategies	Strategy scenario showing estimated scale of adoption to meet 10-year milestone and final water quality targets.					Estimated Year to Achieve Water Quality Target
							Estimated Adoption Rate				
		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction	Waterbody (ID)		Proposed Actions	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	
Poplar River 0902030504	Bacteria / *E. coli*	226.3 MPN/100mL maximum monthly geomean (504) 102 MPN/100mL maximum monthly geomean (518)	<126 MPN/100mL maximum monthly geomean (504) <94.5 MPN/100mL maximum monthly geomean (518)	Poplar River (518, 504)	Grazing management	*Restrict cattle access to the stream channel *Preemptive BMP establishment on new/changing livestock operations near the river *Prevent runoff from feedlots along waterways, lakes and wetlands	Ongoing, voluntary BMP implementation	*Project completed downstream of CSAH 6 *Project completed near 47.6080, -95.7642 *Incorporated into the 1W1P	45%	Decrease in maximum monthly geomean *E. coli*	2032
	Habitat / Connectivity and Low Dissolved Oxygen	May-Sept. discrete DO: 17.2% <5 mg/L in AUID 518 3.2% <5 mg/L in AUID 504 F-IBI: 23.2-point min. in AUID 518 73.6-point min. in AUID 504 M-IBI: 25.7-point min. in AUID 518 38.1-point min. in AUID 504	May-Sept. discrete DO: <7.5% <5 mg/L in AUID 518 <3.2% <5 mg/L in AUID 504 F-IBI: 47-point min. in AUID 518 Maintain good habitat in AUID 504 M-IBI: 43-point min. in AUID 518 49.9-point min. in AUID 504	Poplar River (518)	Wetland restoration	Restore large wetlands that have been drained with ditches that flow to the Poplar River. Create deeper, open water zones to minimize hypoxic/anaerobic conditions in the water/sediment.	USWFS has been active in restoring wetlands in Polk and Clearwater Counties.	*Improved base flow (decreased % of year with low or zero flow) *Improved storage	500	Acres of wetland and upland habitat restored	2029
					Identify and address barriers to fish passage and flow	*Recommendations from DNR or MPCA staff *Work with county/township and permitting authorities to coordinate the replacement and facilitate proper sizing	*Potential barriers identified in the stressor ID report *1 potential barrier confirmed (360th Ave SE)	*Replace culverts at 310th Ave SE *Inspect private crossing upstream of CSAH 6, east of Fosston and replace if necessary*Identify root cause of flow impediments and remove man-made blockages.	1	Road crossing replace-ment	2025
					Restore channelized portions	*Upstream of 360th Ave SE *Along Hwy 2, E of McIntosh	Channelized reaches identified in WRAPS	*Surveying complete *Evaluate designs and alternatives	>1,400	Feet of restored channel	2042
				Poplar River (518)	Riparian plantings of native and woody vegetation	Target the reaches between CSAH 6 and CSAH 30 and between CSAH 1 and CSAH 27	Some landowners have planted groves of trees, shrubs, and/or native vegetation near the river.	*Tree planting projects have been completed	50	Acres of riparian plantings	2032
				Poplar River (518 and 504)	Identify areas where riffles can feasibly be constructed to protect grade stability and proved aeration	*Examination of the channel with LiDAR data *Longitudinal surveys of the channel	Longitudinal sampling and site-specific assessment have identified portions of the channel where DO has been depleted and areas where DO levels are gradually improving	*One project has been completed and there is monitoring data available to assess the effectiveness of the project.	6	In-channel grade stab-ilization structures	2029
	Phosphorus and Eutroph-ication	*0.065 mg/L summer average TP *35.2 µg/L summer average Chl-a	<0.060 mg/L summer average TP <20 µg/L summer average Chl-a	Whitefish Lake (60-0015)	Improve the water quality for fish communities	*Aerate where needed *Assess the quality of habitat *Reduce sediment and nutrient runoff *BioBase mapping of lake vegetation	*Data did not meet quantity requirements for the 2016 assessment but exceeded standards. *East Polk SWCD will be collecting monthly samples in 2018-2020 *East Polk SWCD has general cost estimates for BioBase mapping of lake vegetation	*At least one F-IBI-limiting factor has been identified and there is a plan for addressing that problem.	10%	F-IBI increase	2025
Poplar River	Sediment /TSS	*0 TSS samples >30 mg/L *3.3 mg/L average in AUID 518 *6.3 mg/L average in AUID 504	*0 TSS samples >30 mg/L *<3.1 mg/L average (518) *<6.0 mg/L average (504)	Poplar River (518, 504)	Maintain riparian conditions and floodplain connectivity	*Enforcement of Buffer Law requirements along with compliance inspections *Education about the benefits of buffers, limitations of buffers, and alternative practices	Due dates for compliance have passed. Buffers are being regularly inspected.	*Buffers are regularly inspected. *Accurately summarize buffer research in blog, newsletters, or monthly water quality reports	5%	Decrease in average concentrati ons	2026
					WASCOB Sediment Basins	*Focus on areas where topography is conducive. *Focus on the drainage areas of nearly impaired and impaired lakes *Identify ideal locations for WASCOBs using PTMApp modeling and ground-truthing.	Grant applications submitted in 2018 and 2019	A targeted WASCOB implementation project has been funded and implemented to address at least 50% of those locations.	3,721	Acres	2029

Lost River 0902030505 Strategies

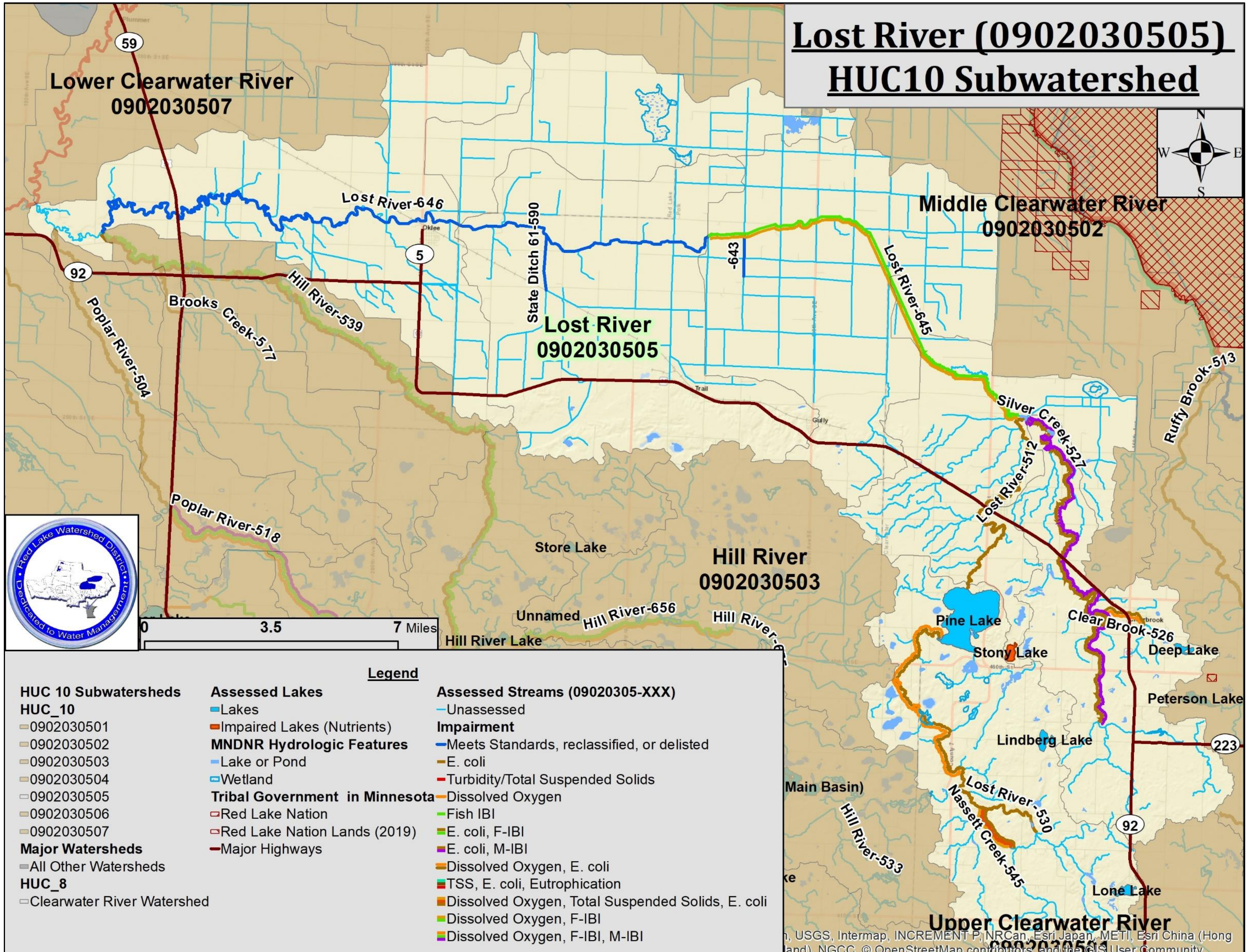


Figure 3-41. Lost River Subwatershed (0902030505)

Table 3-15. Strategies and actions proposed for the Lost River Subwatershed (0902030505)

HUC-10 Sub-watershed	Parameter (incl. non-pollutant stressors)	Water Quality		Waterbody and Location	Strategies	Strategy scenario showing estimated scale of adoption to meet 10-year milestone and final water quality targets.					Estimated Year to Achieve Water Quality Target
							Estimated Adoption Rate				
		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction	Waterbody (ID)		Proposed Actions	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	
Lost River 0902030505	Sediment /TSS	>10% of samples are > 10 mg/L in AUID 545	<10% of samples are > 10 mg/L in AUID 545	Nassett Creek (545, 630, 631, 632, 635)	Tillage/residue management	No-till/ridge till (329, 329A)	Unknown	50% of suggested goal	202	acres	2032
					Buffers and filters - field edge	Riparian Buffers, 50+ ft wide (replacing **pasture**) [390, 391, 327] *Native and woody vegetation	Cattle have access to >2,200 ft of channel	50% of suggested goal	5	acres	2032
					Buffers and filters - field edge	Riparian Buffers, 50+ ft (perennials replace **tilled**) [390, 391, 327	*Compliance with the buffer law was required by Nov. 2018. 50-ft buffers are required for Nassett Creek and its tributaries	*Buffers are regularly inspected and in compliance *Buffers are enhanced with higher quality vegetation like native plants, shrubs, and trees	8	acres	2032
		8.4% of samples are > 10 mg/L in AUID 646	>10% of samples are > 10 mg/L in AUID 545	Lost River (646)	Erosion control projects	*Additional geomorphic survey has been conducted to determine the upstream extent of the incision problem near the Clearwater River confluence *Survey and design for stabilization of meander cut-off downstream of CR 129	*Incision and excess sediment problem noted during the geomorphology study reconnaissance *Meander cutoff found downstream of CR 129	*BEHI rating between CR 119 and CR 118 *One channel restoration project has been funded *Stabilize the meander cut-off downstream of CR 129	3	Completed projects	2032
		0% of samples are > 10 mg/L in AUID 645	0% of samples are > 10 mg/L in AUID 645	Lost River (645)	Channel restoration and grade stabilization	*Focus on sections 20 & 21 of Winsor Twp. In Clearwater Co.	*Some re-sloping and revegetation of banks has been completed to protect roads	*Locations have been identified where the restoration of proper dimension, pattern, and profile can be restored	3	Completed projects	2032
	Bacteria /*E. coli*	141.4 MPN/100mL max. monthly geomean	<126 MPN/100mL max. monthly geomean	Lost River (512)	Address feedlots and livestock operations	*Riparian Buffers, 50+ ft wide (replacing pasture) [390, 391, 327] *Deep rooted native and woody vegetation	Cattle have access to >12,000 feet of channel	*grazing management practices have been implemented *50% of suggested goal	13	Riparian protected from cattle	2032
	Habitat / connectivity	33-point min. F-IBI	47-point min. F-IBI	Lost River (645)	Structural practices to improve mechanical aeration	*Re-arrange rocks at CSAH 28 to reduce upstream stagnation *Grade stabilization + riffles in channelized reach *riffles at ditch outlets *Examine Anderson Lake and potential for restoration, storage potential, and potential outlet modifications to reduce eutrophication and downstream DO flux.	*Grade and bank stabilization at CSAH 28 *Beaver dam removal from tributary ditches	*Grade stabilization at ditch outlets *Longitudinal survey to identify potential number of grade stabilization structures that could be installed along the channelized portion of the Lost River *Anderson Lake landowner contacts *Anderson Lake water quality and sediment sampling *Anderson bathymetric profile *Examine Anderson Lake for characteristics that could affect project permitting	1	Project completed	2029
		54.7-point min. M-IBI	>55-point min. M-IBI	Lost River (645)	Improve fish habitat in streams	Focus on channelized reach of the Lost River	*Channelized reach begins upstream of CSAH 7 and ends at 270th Ave SE	*Location identified for a channel restoration project *Improve buffer compliance and quality of vegetation	5,000	Feet to restored channel	2032
		Buffer Law Compliance required by November 2018	Continued compliance and improved quality of vegetation	Lost River (529, 512, 645, 646); Nassett Creek (545); Silver Creek (527)	Improve the compliance and quality of buffers	*In addition to minimum requirements of the Buffer Law, promote the establishment of high quality, deep-rooted native and woody vegetation in riparian areas	*Buffers are regularly inspected *Some portions of the channel are not buffered or have poor quality vegetation	*Buffers meet requirements of the Buffer Law *At least tree/shrub planting or native plant seeding project along the riparian corridor	100%	Buffer Compliance	2032
	Habitat/ Connectivity And Low Dissolved Oxygen	15-point lake F-IBI score	>24-point lake F-IBI score	Pine Lake (15-0149)	Improve the quality of fish communities in lakes	**Keep a record of DO levels *Assist local volunteers with permitting and operation of an aerator and supply volunteers with monitoring equipment *Assess the quality of habitat (BioBase) *Reduce sediment and nutrient runoff	Annual aeration and under-ice DO monitoring	*At least one F-IBI-limiting factor s been identified and there is a plan for addressing that problem. *Winterkill is prevented *No accidents (safety procedures are followed)	10%	F-IBI increase	2025
Lost River	Low Dissolved Oxygen	1 nearly restored AUID	Improved DO in Lost River	Lost River (645)	Improve water quality and DO levels within Anderson Lake	*Evaluate current conditions in the lake and at the outlet	*Some discussion of Anderson Lake as a potential site for an FDR project due to its location in the Red River Basin	*Evaluation of options, permittable changes, and landowner views	70	Acre-feet. of storage	2029

HUC-10 Sub-watershed	Parameter (incl. non-pollutant stressors)	Water Quality		Waterbody and Location	Strategies	Strategy scenario showing estimated scale of adoption to meet 10-year milestone and final water quality targets.					Estimated Year to Achieve Water Quality Target
							Estimated Adoption Rate				
		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction	Waterbody (ID)		Proposed Actions	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	
		High DO flux in Lost River AUID 645	Reduced DO Flux	Anderson Lake (15-0159)	and downstream portion of the Lost River Restore impaired waters that are closest to meeting state standards.	*Evaluate strategies for increasing storage (in coordination with FDR goals), aeration, and possible dredging/deepening *Improve shading of streams *Improve base flows *Improve mechanical aeration (rock riffles)	*Rock grade and streambank stabilization structures at CSAH 28 *Ditch maintenance and agricultural activities have removed deep-rooted and woody vegetation	*The frequencies of low DO levels have decreased in impaired reaches. *IBI scores have improved *Grade stabilization at ditch outlets *Longitudinal survey to identify quantity and spacing for grade stabilization riffles along the channelized portion *Critical area plantings to improve shading of the channel			
	Phosphorus and Eutroph-ication	Pine Lake 15-0149-00 met standards Stony Lake Stony Lake 15-0156-00 was impaired No other lakes were assessed	Increased Lake Monitoring	Assessable Lakes	Continued sampling in assessed lakes, plus additional monitoring in previously unassessed lakes	*Prioritize on-channel lakes for sampling because they may influence TP and DO *Contact landowners for access to lakes without public access	*Pine Lake sampling *Lost Lake 15-0146-00 sampling in 2019	*Landowner permission for additional sampling *Increase number of assessed lakes in the watershed	4	Assessed Lakes within the Lost River Sub-watershed	2025
			Reduce Nutrient Loading	Stony Lake 15-0156-00	Address upland sources Evaluate in-lake management alternatives	*Agricultural BMPs *Sediment sample collection *Vegetation mapping	Buffer along south shore of the lake	*BMPs implemented to reduce loading from agricultural drainage *Study to evaluate in-lake management alternatives	65	Lbs/year nonpoint TP reduction	2031

Lower Badger Creek 0902030506 Strategies

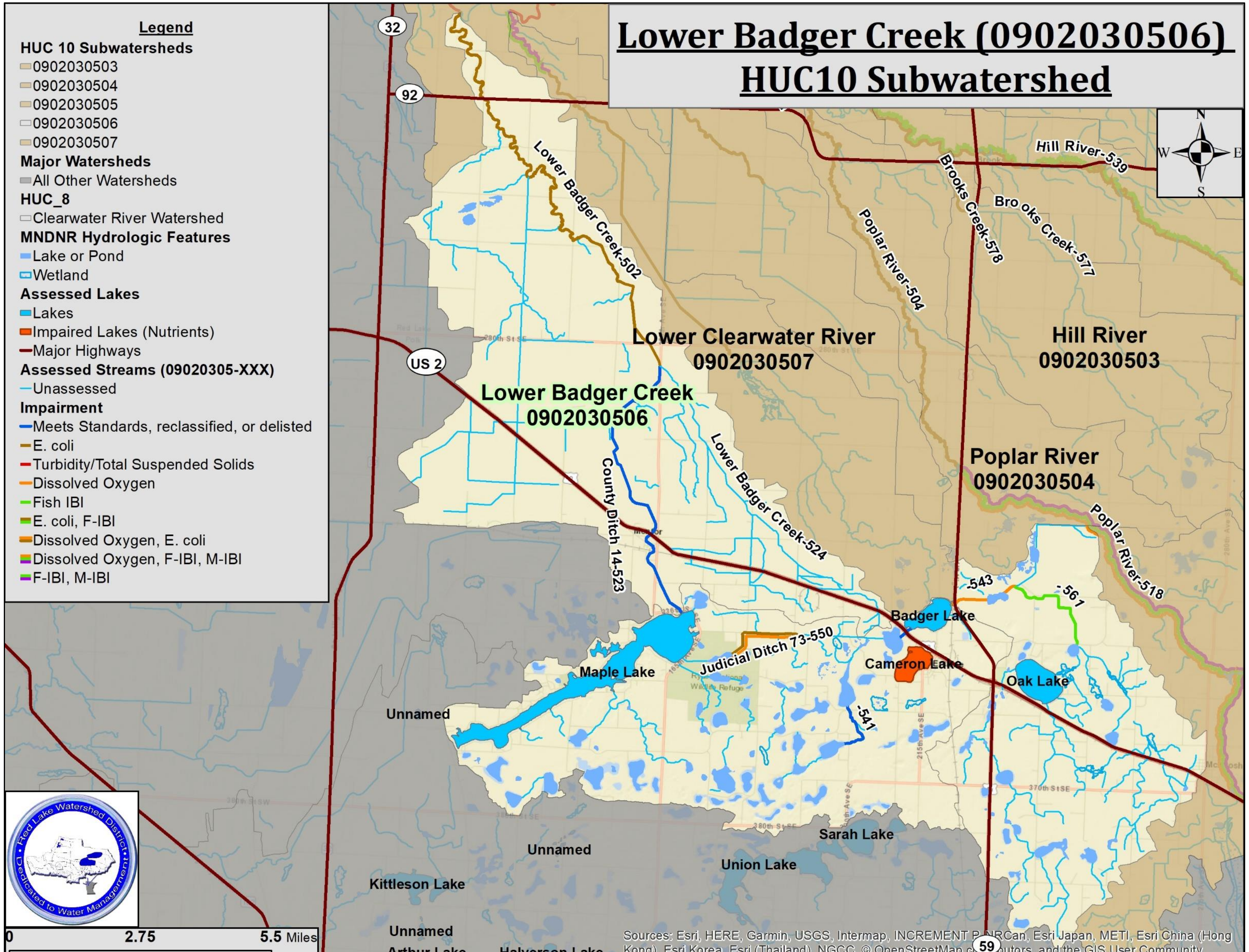


Figure 3-42. Lower Badger Creek Subwatershed (0902030506)

Table 3-16. Strategies and actions proposed for the Lower Badger Creek Subwatershed (0902030506)

HUC-10 Sub-watershed	Parameter (incl. non-pollutant stressors)	Water Quality: Current Conditions (load or concentration)	Water Quality: Goals / Targets and Estimated % Reduction	Waterbody and Location: Waterbody (ID)	Strategies	Strategy scenario showing estimated scale of adoption to meet 10-year milestone and final water quality targets: Proposed Actions	Estimated Adoption Rate: Current strategy adoption level, if known	Estimated Adoption Rate: Interim 10-year Milestone	Estimated Adoption Rate: Suggested Goal	Estimated Adoption Rate: Units	Estimated Year to Achieve Water Quality Target
Lower Badger Creek 0902030506	Phosphorus	0.094 mg/L summer average in Cameron Lake 0.039 mg/L summer average in Maple Lake High TP in limited Oak Lake Data	<0.06 mg/L summer average in Cameron Lake Sufficient Oak Lake data for assessment	Cameron Lake (60-0189) Oak Lake (60-0185)	Reduce nonpoint runoff to lakes	*Focus on the portion of the watershed where topography is conducive to this BMP. *Focus on the drainage areas of nearly impaired and impaired lakes *Identify ideal locations for WASCOBs with PTMApp modeling and ground-truthing. *Shoreline erosion control	Grant application submitted in 2018 was unsuccessful but will likely be re-submitted in 2019	*A targeted WASCOB implementation project has been funded and implemented to address at least 50% of those locations. *Use Oak Lake data to complete interim assessment and establish 1W1P pollutant reduction goals *Shoreline erosion control in Cameron Lake	400	Acres of cropland treated	2029
			<0.06 mg/L summer average in Cameron Lake	Cameron Lake (60-0189)	Stormwater treatment in Erskine	*Stormwater study of drainage, alternative BMPs, and projects *Acquire funding *Project designs	*Identified as a source of nonpoint nutrient runoff in a past study and the TMDL	Problematic stormwater drainage systems have been treated with projects and practices to reduce runoff to the lake	2	projects	2029
			<0.06 mg/L summer average in Cameron Lake <.0.039 mg/L summer average in Maple Lake	Cameron Lake (60-0189 Maple Lake (60-0305)	Public education and/or signage to reduce watercraft speeds in shallow waters	*Focus on areas that are less than 10 feet deep *Attempt to quantify contribution to internal loading from boating	*Some interest from the Maple Lake Association *Actual contribution from boating has not been quantified *High levels of internal loading identified in Cameron Lake TMDL	*Educational article in a newsletter or website *Educational or restrictive signage	>100	Lbs./year from internal loading	2029
					Lakescaping and rain barrels	*Educational workshops in the Erskine/Mentor area *Work with lake associations to provide cost-share for multiple lakescaping projects *Distribution of information	*Some interest from the Maple Lake Association *2018 East Polk SWCD rain barrel workshops *Rain gardens and shoreland restorations have been completed along Maple Lake	*East Polk SWCD continues to hold rain barrel workshops *Hold similar workshops for lakescaping *Demonstration project near a beach or boat landing	>10 >10	Workshops Projects	2029
			<.0.039 mg/L summer average in Maple Lake	Maple Lake (60-0305)	Reduce upland runoff to Maple Lake	*Identify areas that can be targeted for projects and practices Work with the MLID to provide cost-share funding for projects *Septic compliance inspections and upgrades	*Communication and cooperation between local staff and the MLID increased during the WRAPS and MLID has increased interest in taking steps toward improved water quality	*MLID and LGUs have worked together to provide cost-share funding for targeted BMPs *Incorporated into the 1W1P *Financial incentive for septic system inspections	300	Lbs./year TP runoff reduction	2022
	Habitat / connectivity	32.7-point minimum F-IBI	>47-point minimum F-IBI	Lower Badger Creek (502)	Evaluate and address potential fish passage barriers	Examine Section 1 of Lake Pleasant Township in Red Lake Co.	*Specific potential problems identified during the WRAPS and stressor ID studies	All potential barriers have been examined and either ruled-out or modified.	1	Barrier removed	2024
	Habitat / connectivity and Low Dissolved Oxygen	Low DO in AUID 543 0-point F-IBI in AUID 561	AUID 543 not assessed (reclassified) >15-point F-IBI in AUID 561, or reclassified and not assessed	Poplar River Diversion (543, 542, 550, 561) Trib. To Poplar R. Div. (561)	Restore drained wetlands to improve waterfowl habitat, water retention, and base flows	Restore Tamarack Lake and abandon the Poplar River Diversion channel Ditch abandonment & plugging for restoration of drained wetlands	*Historical attempt at creating an impoundment *Formal reclassification of AUID 543	*Public outreach *Interagency discussion about the feasibility of these projects has taken place. If there is agreement about the project's feasibility, a survey of the project area has been completed and preliminary design alternatives have been developed.	46	Acres of restored wetlands	2042

Lower Clearwater River 0902030507 Strategies

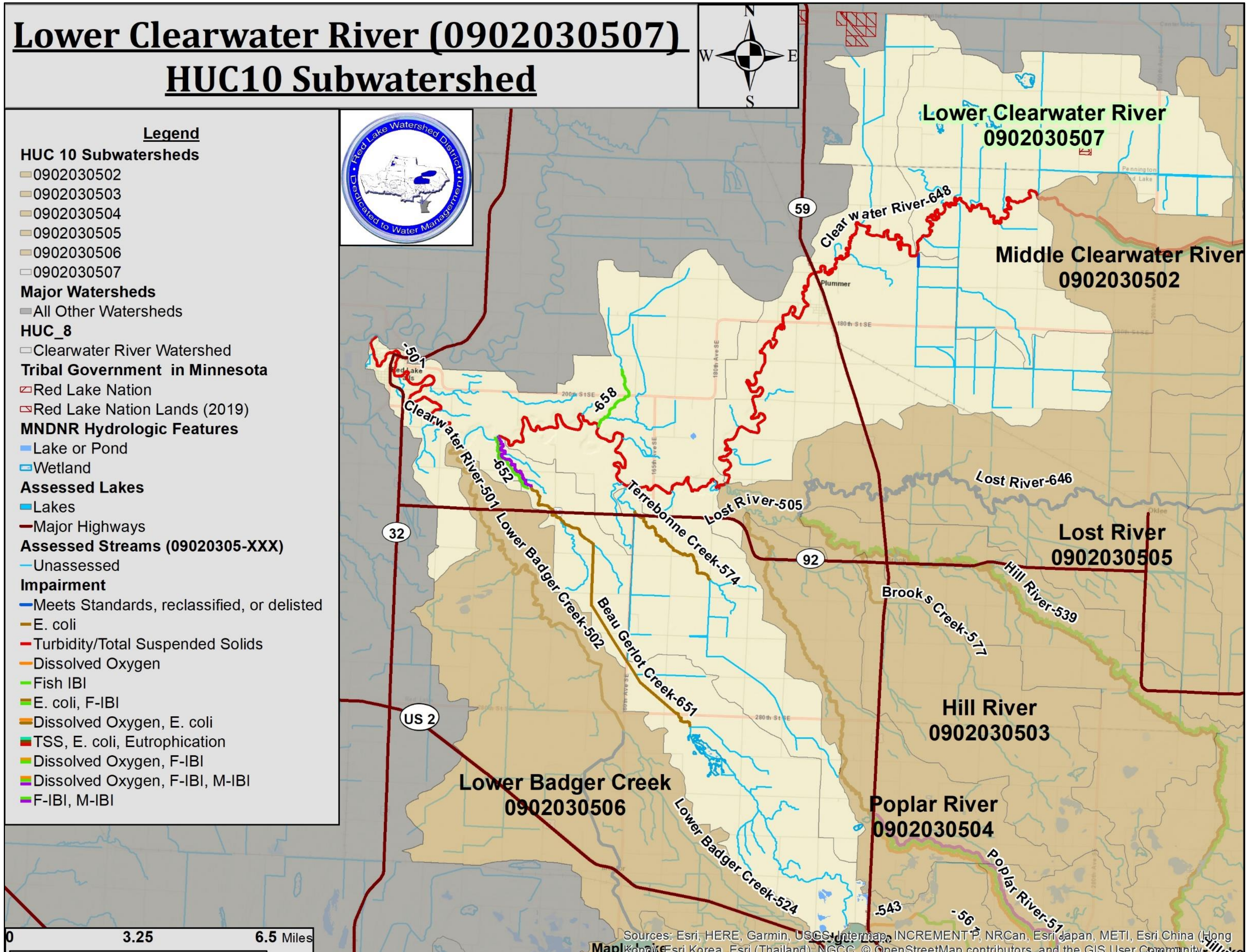


Figure 3-43. Lower Clearwater River Subwatershed (0902030507)

Table 3-17. Strategies and actions proposed for the Lower Clearwater River Subwatershed (0902030507)

HUC-10 Sub-watershed	Parameter (incl. non-pollutant stressors)	Water Quality: Current Conditions (load or concentration)	Water Quality: Goals / Targets and Estimated % Reduction	Waterbody and Location: Waterbody (ID)	Strategies	Proposed Actions	Estimated Adoption Rate: Current strategy adoption level, if known	Estimated Adoption Rate: Interim 10-year Milestone	Suggested Goal	Units	Estimated Year to Achieve Water Quality Target
Lower Clearwater River 0902030507	Sediment /TSS	7,328 tons/yr. TSS load at S002-118	4,802 tons/yr. TSS load at S002-118	Clearwater River (501, 519, 511)	Streambank stabilization	Prioritize portions of the river or specific bank failures for projects	Occasional, competitive grant-funded projects	At least 5 projects have been designed, funded, and constructed	1000	Tons/year TSS reduction	2029
				Clearwater River (501, 519, 511), CD 23 (653), Terrebonne Creek (574), Beau Gerlot Creek (652)	Stabilize the lower reaches of tributary streams and ditches	*Plan stabilization projects between the last crossings of channels and confluences with the Clearwater River *Plantings of trees, shrubs, and/or native grasses along all mass-wasting cut banks	Projects have been completed along the Red Lake River near Red Lake Falls that can serve as examples.	*Incorporated into the 1W1P *At least 2 grade stabilization projects have been completed along Clearwater R Tributaries	1025	Tons/year TSS reduction	2032
					Grazing management	Target streambanks that were damaged by livestock	Ongoing, voluntary BMP implementation	Removed or replaced with properly sized culverts	5	Projects	2032
					WASCOB Sediment Basins	Target the Clearwater River corridor where topography is conducive to this practice	Ongoing, voluntary BMP implementation	*A project has been funded and completed *50% of suggested goal	3,721	Acres	2032
	Habitat / connectivity	AUID 651 not assessed; 6.95-point minimum F-IBI score in AUID 652	>AUID 651 assessed; 42-point minimum F-IBI score in AUID 652	Beau Gerlot Creek (651, 652)	Channel and/or meander restoration along Beau Gerlot Creek	*Landowner contacts *Permitting *Surveying *Design and cost estimates *Funding acquisition	*Channelization in AUID 651 identified as a stressor in AUID 652	*Identified in Clearwater River 1W1P *Surveying and design completed	2.5	Miles of restored channel	2032
	Habitat / connectivity	0-point minimum F-IBI	>35-point minimum F-IBI	CD 23 (658)	Survey the outlet of CD 23	*Landowner contacts *Survey *Survey and GIS data sharing *Grade or bank stabilization project planning	Stressor ID report and TMDL identified potential fish passage barriers and concern about the unknown condition of the channel	*Landowner contacted *Survey completed *Survey and GIS data shared and evaluated *Grade or bank stabilization project planned	>35	Average F-IBI score	2032

Strategy scenario showing estimated scale of adoption to meet 10-year milestone and final water quality targets.

4. Monitoring Plan

Local, state, and federal agencies combine efforts to collect a large amount of environmental data within the Clearwater River Watershed. Water quality in rivers and streams is monitored using specialized equipment and certified laboratory analysis. Stage and flow levels are monitored along the Clearwater River and its tributaries. SWCDs monitor groundwater levels. The state conducts biological monitoring. Compliance monitoring is also important for the protection of natural resources.

Water quality monitoring can be conducted for multiple purposes. Much of the data is collected to monitor the condition of waterways over time (Table 4-1), assessing current water quality conditions, and calculating pollutant loads. The number of parameters and the frequency at which they are measured depends upon the project goals, the budget of the monitoring project, available equipment, and available staff time. Official water quality assessments require a minimum number of water quality measurements to determine whether a waterway is meeting or violating water quality standards. Monitoring programs may be short-term or long-term. Short-term monitoring efforts may aim to achieve a minimal snapshot of water quality conditions (SWAG Grants), diagnose the source of a water quality problem, or measure the effectiveness of a project. Long-term monitoring should be sufficient to measure trends over time and to compile sufficient data for the assessment of a waterway's ability to support aquatic life and recreation. All data that is collected following proper procedures needs to be submitted to the MPCA for entry and storage in the state's EQuIS water quality database. The state uses data stored in EQuIS during the official water quality assessments. Data compiled in EQuIS is also used for many other purposes, like writing TMDLs.

The parameters that are measured for long-term monitoring projects may vary slightly among organizations and monitoring sites. Basic parameters that can be measured on-site while monitoring (field parameters) include water temperature, DO, pH, specific conductivity, stage, transparency, turbidity, and observations/comments. Water samples are shipped overnight or delivered on the same day to a lab that is certified by the Minnesota Department of Health for analysis. Typically, samples are analyzed for a basic set of parameters that includes TP, OP, TSS, ammonia nitrogen, total Kjeldahl nitrogen, nitrates and nitrites, and *E. coli*. Additional parameters like chemical oxygen demand, BOD, sulfates, total organic carbon, and/or chl-a may be collected, dependent upon project needs. Oxygen demand data is collected at sites on reaches that are impaired by low DO levels (either officially or suspected). Chl-*a* has been collected for the MPCA from the lower end of major subwatersheds to measure eutrophication levels.

The RLWD began monitoring water quality in the Clearwater River Watershed in 1980 and now monitors 33 sites in the watershed (Figure 4-1). Newer sites that were monitored for the Clearwater River WRAPS Project were added to the RLWD long-term monitoring program. The monitoring program collects data from the significant waterways within the watershed, including multiple reaches of the Clearwater River and its significant tributaries. Field measurements of DO, temperature, turbidity, specific conductivity, pH, and stage are collected during each site visit (if there is water). Four rounds of samples are also collected at and analyzed for TP, OP, TSS, total dissolved solids, TKN, ammonia nitrogen, nitrates + nitrites, and *E. coli* at most of the sites. For the past few years, BOD analysis has been added for the sites that are located on reaches that have had low DO levels or potential eutrophication impairments. Sampling months are alternated each year with the goal of collecting at least five samples per calendar month within a 10-year period. A long-term monitoring site has been added to AUID 647, channelized reach of the Clearwater River for the 2018 monitoring season. Three SWCDs in the Clearwater River Watershed have the ability to collect water quality data. The Red Lake County SWCD samples sites in Red Lake County, once a month, during the months of May through September. Staff from the East Polk SWCD had been monitoring several streams for the MPCA Citizen Stream Monitoring Network, but is now equipped for the collection of additional water quality parameters. The Clearwater County SWCD is equipped for monitoring and sampling. They have conducted monitoring for SWAG projects and are planning to start monitoring select sites on a long-term basis. The MPCA WPLMN monitors a selection of stations that are equipped with real-time flow gauges. Lake associations have been responsible for the collection of the most reliable, long-term water quality data from lakes in the Clearwater River Watershed. Monitoring efforts for other lakes has been less organized and shorter in duration.

River Watch is a volunteer monitoring program that gives high school students the opportunity to collect water quality data. This data is collected using the same methods that are used by professionals and is stored in the EQuIS database along with all other data that is collected within the watershed. Schools that have participated in the program within this watershed include Win-E-Mac (Winger, Erskine, and McIntosh), Fosston, Red Lake Falls, Red Lake County Central (Oklee), Clearbrook-Gonvick, and Bagley. Bagley and Fosston schools are currently inactive in the monitoring program. Restarting those programs should be a priority. Some River Watch groups have sampled macroinvertebrates for educational purposes. The calculation of index of biotic integrity scores using MPCA methods/training could be an advanced goal of this sampling. Intermediate goals of sampling efforts could focus on specific metrics where numbers were found to be deficient during the MPCA sampling. For example, Trichoptera numbers could be compared among sites.

Robust collection of water chemistry data at long-term stream gaging sites improves the quality of water quality models (HSPF) by providing a record of measured water quality that can be compared to the simulated conditions during the model calibration process. Key monitoring sites where more frequent data collection would aid future model calibration efforts include:

- S002-916 – Clearwater River at County Road 127
- S004-816 – Beau Gerlot Creek at CSAH 92
- S006-506 – Brooks Creek at CSAH 92
- S005-501 – Lost River at Lindberg Lake Road

Additional data collection efforts and adjustments could be considered for future monitoring efforts. LGUs could establish Regional Assessment Location monitoring sites on the Clearwater River and its most significant tributaries. Additional intensive sampling during runoff events will help shed light upon the causes of water quality problems in the watershed. Bolstered data collection efforts at key sites would aid with pre/post project evaluation. Long-term monitoring programs can evolve to include different or additional sites that have a strategic value that is equal to or greater than existing long-term monitoring sites.

Table 4-1. Clearwater River Watershed long-term monitoring activity, organized by assessment unit

Long-Term Monitoring Activity in the Clearwater River Watershed - 2018 Monitoring Season								
Assessment Unit ID	Waterbody Name	Station ID	Station Description	RLWD	SWCD	WPLMN	River Watch	Volunteers and Lake Associations
09020305-501	Clearwater River	S002-118	Bottineau Avenue in Red Lake Falls	X	X	X	X	
09020305-502	Lower Badger Creek	S004-837	CR 114	X			X	
		S009-377	150th Avenue SE	X				
09020305-504	Poplar River	S007-608	CR 118	X				
09020305-509	Walker Brook	S002-122	CSAH 19	X				
09020305-511	Clearwater River	S002-914	CSAH 12	X	X		X	
09020305-512	Lost River	S001-007	486th Street	X				
		S007-607	CSAH 8	X				
09020305-513	Ruffy Brook	S008-057	CSAH 11	X				
09020305-517	Clearwater River	S004-986	CSAH 25, near Bagley	X				
		S001-908	CSAH 2	X				
09020305-518	Poplar River	S003-127	CSAH 30	X				
		S005-320	330th Street SE		X			
		S009-392	310th Street SE	X				
09020305-523	Polk CD 14	S002-130	CSAH 10	X				
09020305-526	Clear Brook	S004-044	CSAH 92	X				
09020305-527	Silver Creek	S000-712	159th Avenue	X				
		S002-082	CR 111	X				
09020305-529	Lost River	S005-283	109th Avenue	X				
09020305-539	Hill River	S003-498	CSAH 35	X	X			
		S002-134	CR 119	X			X	
09020305-541	Bee Lake Inlet	S002-086	CSAH 37				X	
09020305-542	Poplar River Diversion	S002-131	U.S. Highway 2				X	
09020305-543	Poplar River Diversion	S002-129	Badger Lake inlet @ 220th Avenue SE	X			X	
09020305-545	Nassett Creek	S004-205	Nessett Creek Road	X				
09020305-549	JD73	S002-075	CSAH 10, Maple Lake inlet	X			X	
09020305-550	JD 73	S003-318	343rd Street SE	X			X	
09020305-551	Bee Lake Outlet	S003-317	340th Street SE				X	
09020305-574	Terrebonne Creek	S004-819	CSAH 92	X				
0920305-645	Lost River	S007-849	CSAH 28	X				
09020305-646	Lost River	S003-500	330th Avenue SE		X			
		S001-131	CSAH 5 in Oklee	X				
		S002-133	CR 119	X		X		
09020305-647	Clearwater River	S003-174	CSAH 10		X			
		S002-121	370th Avenue SE		X			

Long-Term Monitoring Activity in the Clearwater River Watershed - 2018 Monitoring Season								
Assessment Unit ID	**Waterbody Name**	**Station ID**	**Station Description**	**RLWD**	**SWCD**	**WPLMN**	**River Watch**	**Volunteers and Lake Associations**
09020305-648	Clearwater River	S002-124	Minnesota Street (Plummer Gage)	X	X	X		
09020305-649	Clearwater River	S001-461	CSAH 14	X				
09020305-652	Beau Gerlot Creek	S008-058	CR 114	X				
09020305-653	Clearwater River	S001-460	CSAH 24	X				
09020305-655	Hill River	S014-935	380th Avenue SE		X			
09020305-656	Hill River	S007-847	335th Avenue SE	X				
04-0343-00	Clearwater Lake	04-0343-00-204	47.742662,-95.196518					X
15-0040-00	Bagley Lake	15-0040-00-201	47.759886,-95.231919					X
15-0060-00	Walker Brook Lake	15-0060-00-101	47.487093,-95.291485					X
15-0104-00	Lone Lake	15-0104-00-201	47.586315,-95.426007					X
60-0006-00	Poplar Lake	60-0006-00-201	47.544138,-95.664122		X			
60-0012-00	Spring Lake	60-0012-00-201	47.508523,-95.639581		X			
60-0015-00	Whitefish Lake	60-0015-00-101	47.586745,-95.653952		X			X
60-0027-02	Cross Lake	60-0027-02-202	47.626311,-95.633302		X			
60-0032-00	Turtle Lake	60-0032-00-201	47.61764 -95.669525		X			
60-0142-00	Hill River Lake	60-0142-00-201	47.677826 -95.80251		X			
60-0185-00	Oak Lake	60-0185-00-201			X			
60-0189-00	Cameron Lake	60-0189-00-201	47.665911,-96.019496		X			
60-214-00	Badger Lake	60-0214-00	47.681351,-96.008927		X			
60-0305-00	Maple Lake	60-0305-00-204	47.671185, -96.129124					X

Figure 4-1. Water quality stations that are monitored by the RLWD long-term monitoring program

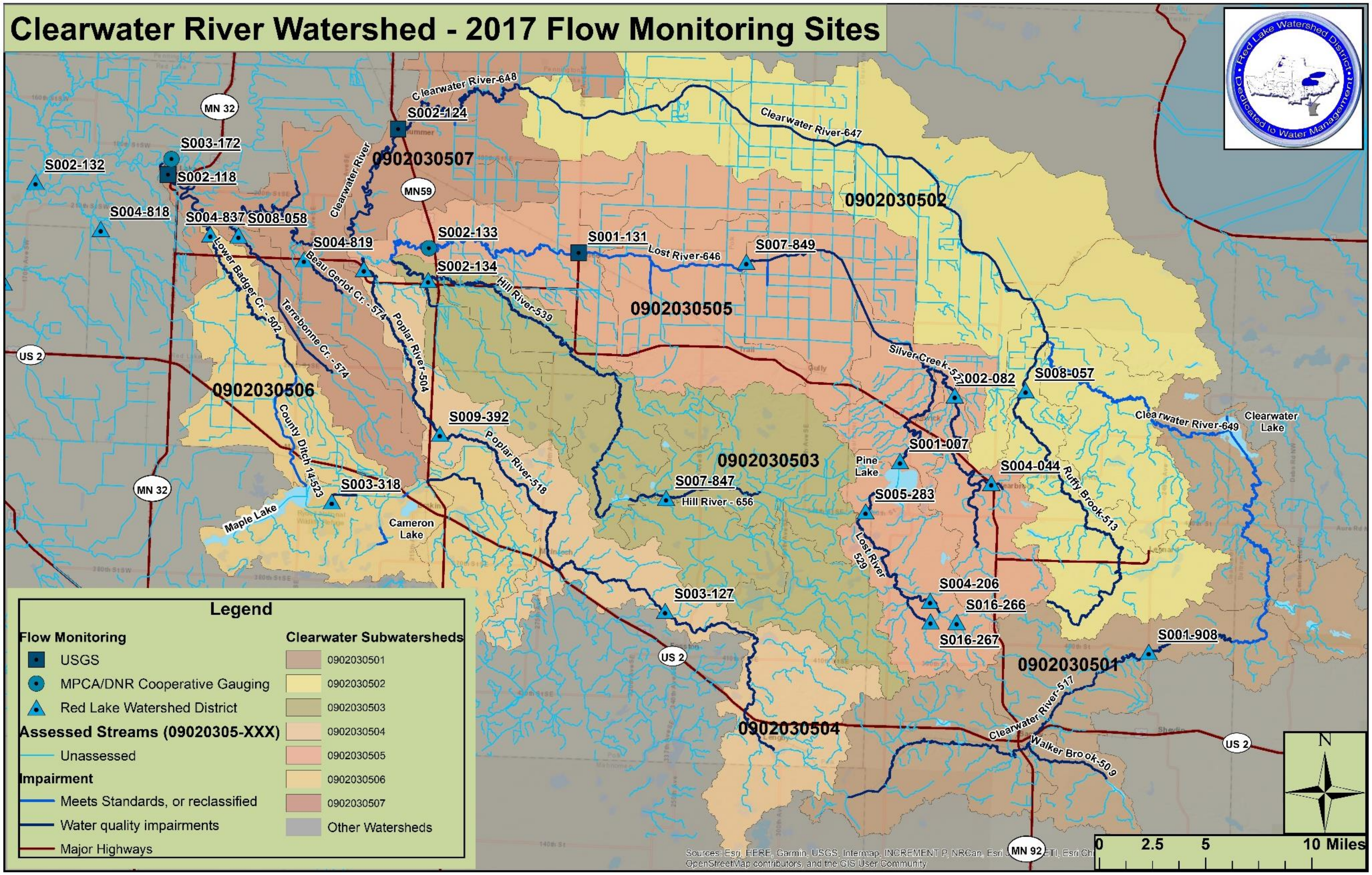


Figure 4-2. Flow and stage monitoring stations in the Clearwater River Watershed, as of the 2017 monitoring season

The MPCA plans to assess the Clearwater River Watershed once every 10 years. The RLWD water quality staff will use the latest MPCA assessment methods to assess conditions once every two years, at a minimum. Tracking water quality conditions is important for finding reaches that can be recommended for delisting (post-restoration removal from the 303(d) List of Impaired Waters), tracking progress toward delisting, identifying new problems so they can be addressed sooner, and identifying areas that need additional data.

The collection of continuous DO data is essential, at most sites, to capture DO measurements prior to 9:00 a.m. The MPCA requires a record of pre-9 a.m. DO readings to declare that the waterway contains enough DO to fully support aquatic life. DO logging equipment can collect regular DO measurements (e.g. every 30 minutes) while deployed in a waterway. Equipment is deployed for a maximum of two weeks at a time before it is retrieved for data retrieval, cleaning, and re-calibration. Prior to the next state water quality assessment of the Clearwater River, continuous DO monitoring should be conducted to fully assess the capacity of key reaches in the watershed to support aquatic life. Data collected during the monitoring seasons of 2016 through 2025 can be used for the 2026 state water quality assessment. Priority should be given to reaches and sites that are too remotely located from LGU offices for pre-9 a.m. measurements. Continuous DO data may also be used for the assessment of river eutrophication. The MPCA assessment methods require that data is collected from at least two separate years. A 10-year monitoring plan has been compiled by the RLWD for the collection of additional continuous DO data prior to the next assessment. The effort will attempt to complete multiple deployments at most of the significant, accessible stream reaches in the watershed. Deployments will be made in two separate years at sites that have high concentrations of TP, to meet the minimum requirements of the DO flux river eutrophication standard.

The map in Figure 4-2 shows that flow monitoring stations are located near the downstream end of most pollutant-impaired streams in the watershed. However, there are at least three impaired AUIDs that could use additional flow monitoring on the Clearwater River (AUID 647), Clear Brook, and the Lost River (AUID 512). Real-time stage and discharge monitoring stations have been installed in several locations along the Clearwater River and its tributaries. The DNR/MPCA Cooperative Gauging Program also monitors several sites without the use of telemetry. Other significant reaches of the watershed are monitored with HOBO water level loggers by the RLWD (without telemetry).

1. USGS Gauge on the Clearwater River in Red Lake Falls
    - USGS gaging station
    - USGS# 05078500
    - EQuIS ID# S002-118
    - https://waterdata.usgs.gov/mn/nwis/uv?05078500
2. Lost River near Brooks, at CR 119
    - DNR/MPCA Cooperative Stream Gaging station
    - EQuIS ID# S002-133
    - https://www.dnr.state.mn.us/waters/csg/site_report.html?mode=get_site_report&site=66048001

3. USGS Gauge on the Clearwater River near Plummer
    - USGS gaging station
    - USGS# 05078000
    - EQuIS ID# S002-124
    - https://waterdata.usgs.gov/mn/nwis/uv?05078000
4. USGS Gauge on the Lost River at Oklee
    - USGS gaging station
    - USGS# 05078230
    - EQuIS ID# S001-131
    - https://waterdata.usgs.gov/mn/nwis/uv?05078230
5. Silver Creek at CR 111 (S002-082)
    - RLWD HOBO Water Level- Logger station
6. Beau Gerlot Creek at CR 114 (S008-058)
    - RLWD HOBO Water Level- Logger station
7. Clearwater River at CSAH 2 (S001-908)
    - RLWD HOBO Water Level- Logger station
8. Hill River at 335th Ave SE (S007-847)
    - RLWD HOBO Water Level- Logger station
9. Judicial Ditch 73 at 343rd St. SE (S003-318)
    - RLWD HOBO Water Level- Logger station
10. Lost River at 109th Ave (S005-283)
    - RLWD HOBO Water Level- Logger station
11. Lost River at CSAH 28 (S007-849)
    - RLWD HOBO Water Level- Logger station
12. Lower Badger Creek at CR 114 (S004-837)
    - RLWD HOBO Water Level- Logger station
13. Hill River at CR 119 (S002-134)
    - MPCA gauging station (during the WRAPS, now removed)
    - RLWD HOBO Water Level- Logger station
14. Poplar River at CSAH 30 (S003-127)
    - RLWD HOBO Water Level- Logger station

15. Poplar River at CR 118 (S007-608)
    - RLWD HOBO Water Level- Logger station
16. Ruffy Brook at CSAH 11 (S008-057)
    - RLWD HOBO Water Level- Logger station
17. Terrebonne Creek at CSAH 92 (S004-819)
    - RLWD HOBO Water Level- Logger station
18. Clearwater River at CSAH 24 (S001-460)
    - MPCA gauging station (during the WRAPS, now removed)

Follow-up fish sampling is beyond the scope of local agencies due to the requirements of specialized, expensive equipment and permitting requirements. The sampling of macroinvertebrates, however, is more feasible. River Watch volunteers have been sampling macroinvertebrates for educational purposes. The RLWD is equipped for macroinvertebrate sampling. If proper methods are used, targeted volunteer sampling and/or LGU sampling could provide useful data. The samples could be sent to a qualified laboratory, or even the same laboratory that is used by the state, for identification and quantification. That data could be used to, at least, calculate some of the key metrics (e.g. those related to Trichoptera) and provide an indication as to whether conditions have changed in a reach (particularly those that are impaired, nearly restored, and nearly impaired) or not.

Other forms of monitoring are also important for the protection of natural resources in the Red Lake River Watershed.

- An intensive geomorphological study of the watershed was completed in conjunction with the Clearwater River WRAPS. The process can be repeated at least once every 10 years to measure erosion rates and assess the accuracy of BEHI ratings.
- The findings of drainage ditch inventories can be used to identify areas that need to be addressed with BMPs to reduce erosion and sedimentation within ditches.
- Traveling along navigable streams in a kayak or canoe and documenting conditions is one of the best ways to find erosion problems, finding other sources of water quality problems, and assessing the quality of habitat along a waterway.
- The Northland Community and Technical College Aerospace Program inspecting ditch systems and identifying the sources of water quality problems. Drones are now capable of collecting high resolution three-dimensional images that can be used to find and measure erosion problems along rivers and streams.
- Early detection sampling for zebra mussels has been initiated by the Clearwater SWCD with sampling in three lakes (Lake Lomond, Pine Lake, and Clearwater Lake) and stationary PVC pipe sampler deployments at lakes with docks. That effort should continue and other agencies like the DNR and the RLWD may assist with supplemental sampling where needed. Early detection sampling will be important along the channel and within the stormwater pond between Lake Lomond and the Clearwater River.

5. References and Further Information

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Clearwater River Watershed Reports

All Clearwater River Watershed reports referenced in this watershed report are available at the Clearwater River Watershed webpage: https://www.pca.state.mn.us/water/watersheds/clearwater-river