Lower Rainy River Watershed

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Lower Rainy River Watershed Restoration and Protection Strategy Report

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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Key terms and abbreviations

Assessment Unit Identifier (AUID): The unique water body identifier for each river reach comprised of the U.S. Geological Survey (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 fecal bacteria standards are not met. Lakes are considered impaired for impacts to aquatic recreation if total phosphorus and either chlorophyll-*a* or Secchi disc depth standards are not met.

Hydrologic Unit Code (HUC): A HUC is assigned by the USGS for each watershed. HUCs are organized in a nested hierarchy by size. For example, the Minnesota River Basin is assigned a HUC-4 of 0702 and the Pomme de Terre River Watershed is assigned a HUC-8 of 07020002.

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 water body. 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 water bodies.

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 water bodies.

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 nonpollutant 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 Lower Rainy River Watershed (LRRW) is located in the Rainy River Basin on the Canadian border and has an eight-digit Hydrologic Unit Code (HUC) of 09030008. Unlike a typical nested watershed, LRRW is composed of a conglomeration of tributaries to the Rainy River from International Falls west to the Rainy River's pour point at the Lake of the Woods. The watershed drains 525,797 acres spanning Lake of the Woods and Koochiching counties, and 19,344 acres of land owned by the Red Lake Band of Chippewa Indians. Wetlands dominate the region at approximately 48% of total land area and the potential for agriculture is low. Development pressure is moderate and largely attributable to timber harvesting and recreation.

The LRRW contains 48 stream reaches defined by the state of Minnesota (i.e., have an Assessment Unit Identifier [AUID]) (Sigl et al. 2020). The primary streams include the middle and lower reaches of the Rainy River, the Baudette River, Winter Road River, Peppermint Creek, the Black River, and the West Fork Black River. Although 45% of the total LRRW stream lengths have been altered, mainly by ditching, water quality throughout the watershed is good overall.

In 2017, the Minnesota Pollution Control Agency (MPCA) led an intensive watershed monitoring (IWM) program and sampled 15 stream reaches for biological indicators. Six water chemistry stations were routinely monitored. Twelve reaches fully support aquatic life and one fully supports aquatic recreation. Several streams did not have enough data to evaluate for aquatic recreation use. Aquatic biological communities in all reaches meet the state standards. Although water quality remains relatively good, some water quality parameters could be improved, including reducing total suspended solids (TSS), and increasing dissolved oxygen (DO) for aquatic organisms, and reducing bacteria levels for recreation purposes. Likely causes of these issues include poor manure management, altered hydrology, channelization, and the natural low-gradient glacial wetland topography.

Three LRRW stream reaches failed to meet water quality standards and were placed on the federal CWA Section 303(d) impaired waters list. Placing a stream on this list requires a total maximum daily load (TMDL) study. The Black River (09030008-547) and West Fork Black River (09030008-547) are undergoing the TMDL process concurrently with the production of this report for *E. coli,* and the Rainy River is subject to phosphorus limits under the larger TMDL for Lake of the Woods. TMDL monitoring and source assessments identified watershed runoff, failing septic systems, and livestock stream access as nonpoint sources of pollution, and 12 municipal and industrial National Pollutant Discharge Elimination System (NPDES)-permitted facilities as point sources. Previously, the downstream reach of the Baudette River (09030008-536) experienced seasonally low DO and failed to meet the DO standard. Further analysis could not attribute the identified land uses to the impairment. After careful review of the data, it has been determined that the Baudette River DO issues are related to poor site selection for monitoring. The site receives backwaters from the nearby Rainy River as a result of backwater effects from Lake of the Woods. The impairment status in this reach of the Baudette River is in the process of re-categorization by the MPCA with the U.S. Environmental Protection Agency's (EPA); if approved, this impairment would be removed.

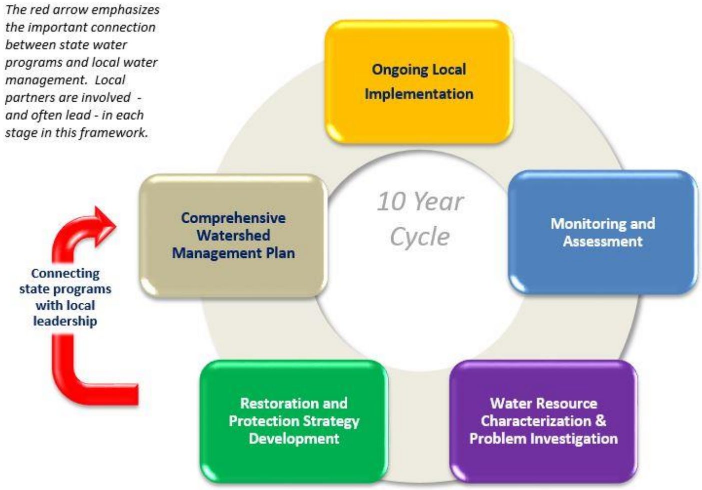
This Watershed Restoration and Protection Strategy (WRAPS) Report analyzes the LRRW's subwatersheds to identify field-scale opportunities for targeted implementation of best management practices (BMPs). Because the LRRW already possesses water resources of good quality, the WRAPS focuses on protection strategies for the watershed's primary streams. The analysis incorporated several inputs, including GIS tools, local knowledge, and a Hydrologic Simulation Program – FORTRAN (HSPF) model to evaluate different BMP scenarios. Key to successful BMP implementation is robust, continuous public engagement and education programming to promote adoption of BMPs and responsible management strategies across the watershed and its major industries like timber harvesting and agriculture. This report also details a monitoring and data collection approach to evaluate progress towards goals and desired outcomes.

Central to the purpose of the WRAPS process is the joint development of scientifically supported restoration and protection strategies that support water planning efforts by local working groups. These implementation strategies are intended to meet the TMDL goals outlined in this document. Following completion of the WRAPS process, the WRAPS report, as well as numerous other technical reports referenced in this document, will be publicly available on the MPCA's LRRW website located at: https://www.pca.state.mn.us/water/watersheds/lower-rainy-river.

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 cycle that addresses both restoration and protection.

As part of the watershed approach, the MPCA developed a process to identify and address threats to water quality in each of the state's major watersheds.



This process is called Watershed Restoration and Protection Strategy (WRAPS) development. The 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. The TMDLs are incorporated into the WRAPS reports. 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 use 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, the WRAPS report informs local planning efforts, but ultimately the local partners decide what work will be included in their local plans. The WRAPS report also serves as a building block for addressing the EPA Nine Minimum Elements of watershed plans, to help qualify applicants for eligibility for Clean Water Act (CWA) 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: •*Lower Rainy River and Rapid River Watershed Monitoring and Assessment Report* •*Lower Rainy River Watershed Total Maximum Daily Load Report*
Scope	•Impacts to aquatic recreation and impacts to aquatic life in streams •Impacts to aquatic recreation in lakes
Audience	•Local working groups (local governments, SWCDs, watershed management groups, etc.) •State agencies (MPCA, DNR, BWSR, etc.)

1. Watershed background and description

The LRRW is in the Rainy River Basin on the Canadian border and encompasses one 8-digit HUC watershed: Lower Rainy River (09030008). Unlike a typical nested watershed, LRRW is composed of a conglomeration of tributaries to the Rainy River from International Falls west to the Rainy River's pour point at the Lake of the Woods. LRRW resides entirely in the Laurentian Mixed Forest Ecological Province of northern Minnesota. It drains 525,797 acres, 37% of which lies in Lake of the Woods County and 63% in Koochiching County. Major towns in the watershed include Baudette, International Falls, and the western portions of Rainier. There are many small unincorporated communities also located in the watershed. Over 44% of the land in the LRRW is held by private landowners. The watershed also encompasses portions of the Lake of the Woods and Pine Island State Forests, and land owned by the Red Lake Band of Chippewa Indians. Principal industries include forest product harvesting, forest product manufacturing, farming, and tourism.

Streams and rivers in the LRRW largely drain wetland and peat bog terrain. West of the Rapid River, this watershed's major waterways include Wabanica Creek, Winter Road River, Baudette River, Silver Creek, and Miller Creek. The Black River and its tributaries comprise the bulk of the watershed's drainage area east of the Rapid River. The Rapid River is a separate watershed and has its own WRAPS report and associated TMDLs. Part of the Agassiz Lowlands region, the LRRW is characterized by extensive wetlands located on the Glacial Lake Agassiz lakebed (Figure 1). Soils are generally sandy loams, with considerable deposits of glacial till, clay, and outwash over a bedrock base.

Much of the land in the watershed is not suited or is poorly suited to agricultural uses. Wetlands predominate (48%), followed by forest (32%), grass/pasture/hay (9%), and row crops (7%). Development pressure is moderate throughout this watershed, with occasional lands being parceled out for timber production or recreational use. Additional information on the LRRW can be found on the MPCA website: https://www.pca.state.mn.us/water/watersheds/lower-rainyriver.

Additional Lower Rainy River Watershed resources

U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Rapid Watershed Assessment for the Lower Rainy River Watershed: https://www.nrcs.usda.gov/wps/portal/nrcs/mn/technical/dma/rwa/nrcs142p2_023649/

Minnesota Department of Natural Resources (DNR) Watershed Health Assessment Framework Watershed Report Card for the Lower Rainy River Watershed: Rainy River -Manitou found at: http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/ReportCard_Major_75.pdf

Minnesota Department of Natural Resources (DNR) Watershed Health Assessment Framework Watershed Report Card for the Lower Rainy River Watershed: Rainy River -Baudette found at: http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/ReportCard_Major_80.pdf

Minnesota Nutrient Planning Portal: Rainy River Black River: https://mrbdc.mnsu.edu/mnnutrients/watersheds/rainy-river-black-river

Minnesota Nutrient Planning Portal: Rainy River Baudette: https://mrbdc.mnsu.edu/mnnutrients/watersheds/rainy-river-baudette

Minnesota Nutrient Reduction Strategy: https://www.pca.state.mn.us/water/nutrient-reduction-strategy

Lower Rainy River and Rapid River Watersheds Monitoring and Assessment Report https://www.pca.state.mn.us/sites/default/files/wq-ws3-09030008b.pdf

International Joint Commission Canada and United States Water and Health in Lake of the Woods and Rainy River: https://www.ijc.org/sites/default/files/oblak-report.pdf

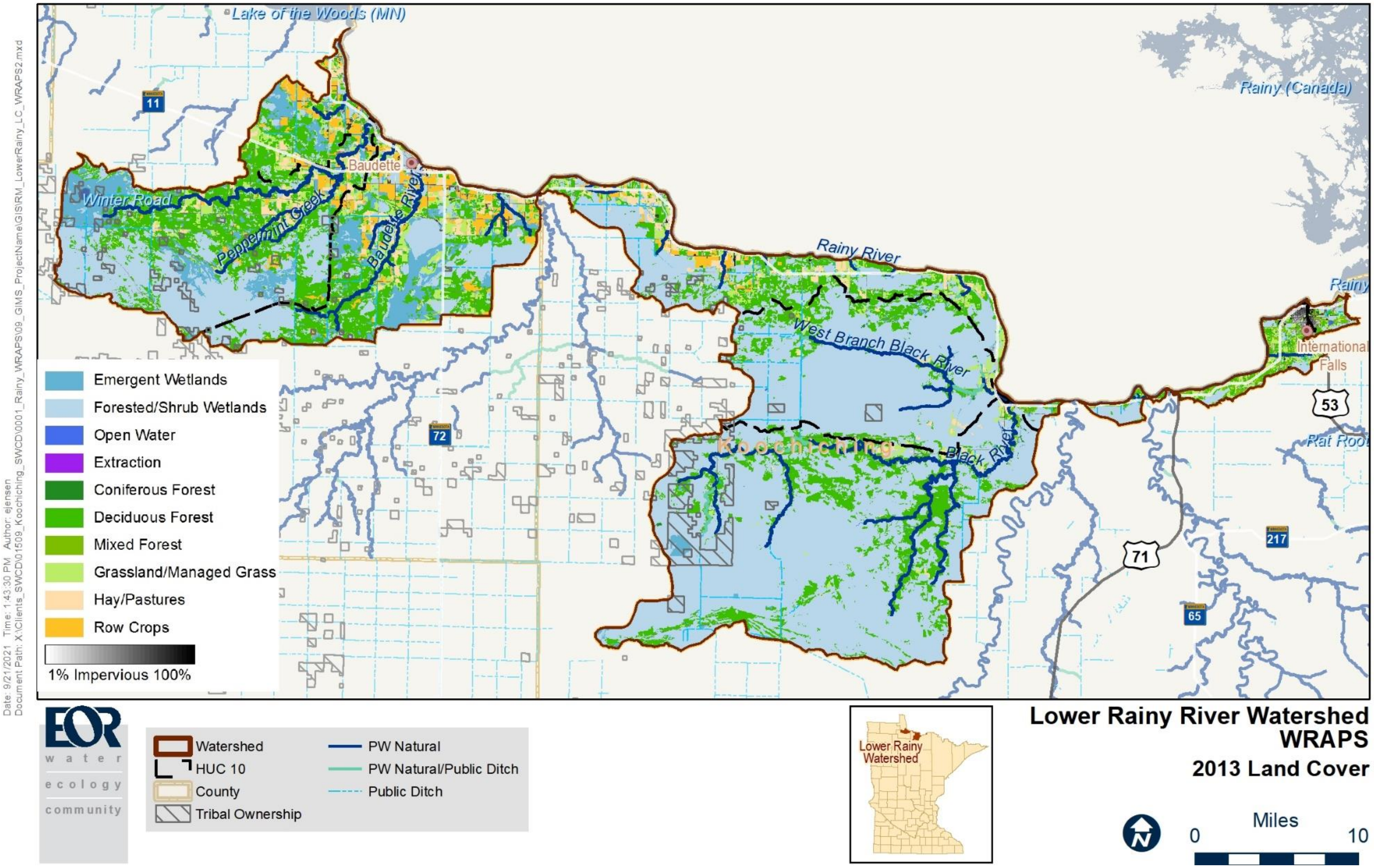


Figure 1. Land cover in the Lower Rainy River Watershed

2. Watershed conditions

In general, water quality conditions within the LRRW are good. The LRRW contains 48 stream reaches defined by the state of Minnesota (i.e., have an AUID) (Sigl et al. 2020). Central to the watershed is the middle and lower reaches of the Rainy River; other primary streams include the Baudette River, Winter Road River, Peppermint Creek, the Black River, and the West Fork Black River.

While much of the natural stream length remains unaltered, the LRRW's wetlands and peat bogs bear the legacy of significant ditching campaigns undertaken at the beginning of the 20th century. These ditches failed to drain land for farming and have left a fundamentally altered landscape and hydrology within this watershed. Today, 45% of the total stream length (including artificially created ditches) within the LRRW is altered. The Black River Subwatershed and its southern tributaries, including the South Fork of the Black River, have been particularly impacted by this ditching. The larger LRRW contains two dams, one located in the headwaters of the Winter Road River on Winter Road Lake, and the other in downtown International Falls.

In 2017, the MPCA initiated IWM efforts of LRRW rivers and streams. There are no lakes in the LRRW. This effort established 21 biological monitoring sites and 6 water chemistry sites; 2 subwatersheds (South Fork Black River – HUC 0903000803-03 and Tributary to Black River HUC 0903000803-02) were inaccessible due to their remote and wetland environment. Seven subwatersheds did not contain water chemistry sampling stations due to small drainage area and/or lack of sampling site that would adequately represent stream conditions. Low-flow conditions during the 2017-2018 IWM process further limited ability to sample. Fifteen of the planned 21 sampling sites we were able to sample. Of those, 12 stream reaches demonstrated water quality for aquatic life to thrive.

The other three sites identified *Escherichia coli* (*E. coli*) counts that exceeded the public health maximum for aquatic recreational activities in the Black River and West Fork Black River. Other water quality issues include high TSS, and low DO, although these factors did not appear to negatively affect aquatic communities. Altered hydrology, namely channelization and ditching, likely plays a causal role in these issues, in addition to the natural low-gradient glacial wetland topography which can contribute to elevated sediment levels and limit DO.

2.1 Condition status

This section describes the streams within the LRRW that are impaired or in need of protection. Impaired waters are targets for restoration efforts while waters currently supporting aquatic life and recreation are subject to protection efforts.

All water bodies with sufficient data (15 streams) were assessed in 2019 for aquatic life, aquatic recreation, and/or aquatic consumption use support. Results from the study found that most of the streams in the watershed are broadly in good condition. Again, sampling of some watershed stream reaches was limited due to low-flow conditions during the IWM period (2017-2018). The results of the monitoring and assessment are summarized in the following sections. Please refer to the Lower Rainy River and Rapid River Watersheds Monitoring and Assessment Report (Sigl et al. 2020) for full monitoring and assessment details.

Mercury and polychlorinated biphenyls (PCBs) were analyzed in fish tissue samples collected from the Rainy River from 1970 to 2016. According to MPCA, a water body triggers impairment status when over 10% of fish exceed concentrations of 0.2 milligram of mercury per kilogram fish fillet (parts per million). Furthermore, water bodies with average mercury concentrations in fish below 0.57 parts per million (ppm) fall under the Minnesota Statewide Mercury TMDL, while those rivers and lakes that sample concentrations above 0.57 ppm require additional reductions. All five stream reaches of the Rainy River are listed as impaired by mercury in fish tissue and covered under the Minnesota Statewide Mercury TMDL. Fish collected in 2016 from the Rainy River show mercury concentrations remain high: 10 Redhorse fish ranged from 0.113 ppm to 0.626 ppm and eight Smallmouth Bass ranged from 0.270 ppm to 0.440 ppm. For more information on mercury impairments, see the statewide mercury TMDL on the MPCA website 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.

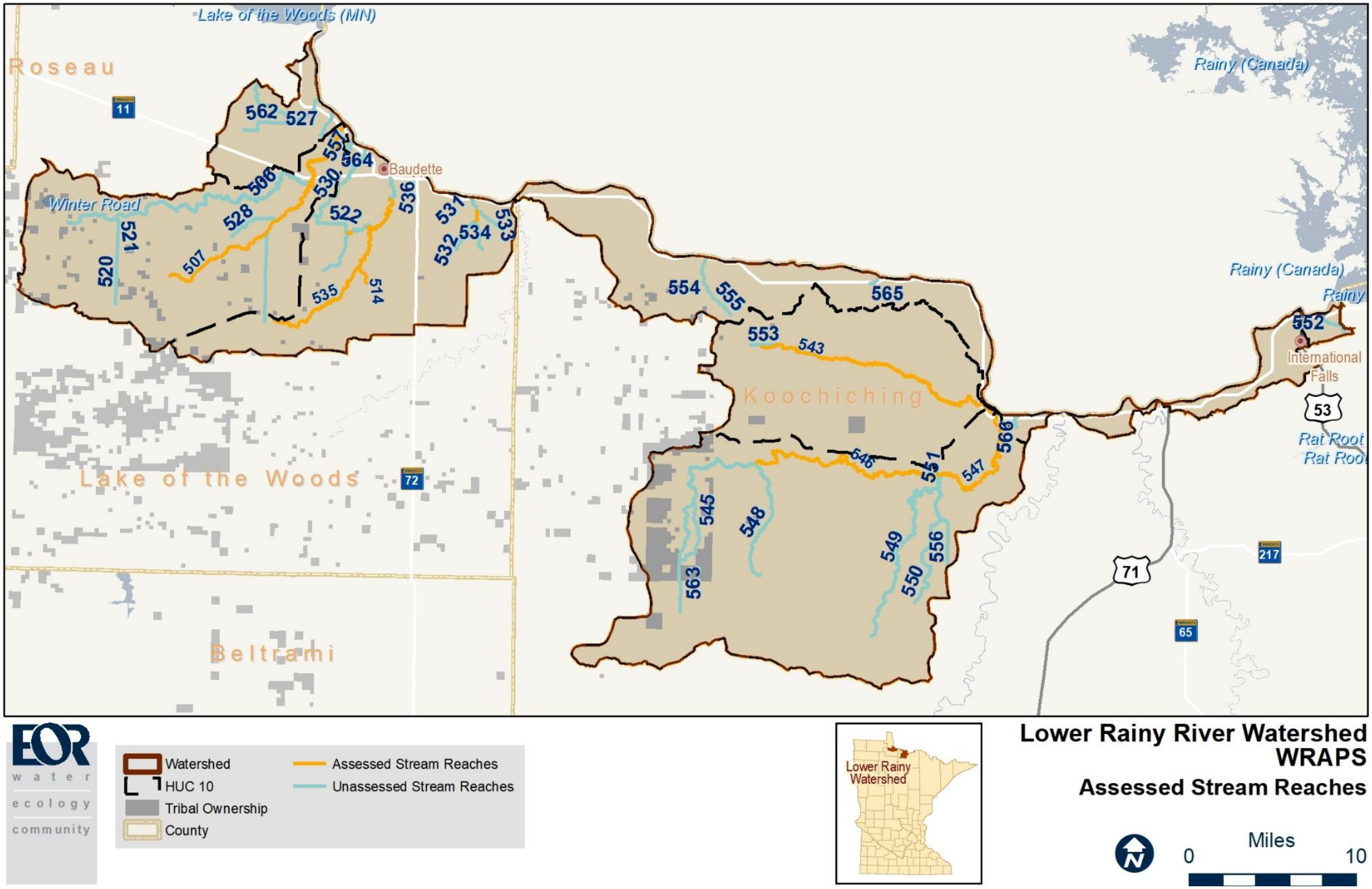


Figure 2. Assessed stream units in the LRRW

Streams

The primary streams within the LRRW were assessed against aquatic life and recreational use standards using a range of water chemistry and biological parameters, including DO, TSS, and bacteria concentrations and fish and macroinvertebrate index of biological integrity (IBI). Water quality measures were compared to both state standards and the normal range for each stream's ecoregion. The aquatic life standards incorporate IBI scores, DO, turbidity/TSS, chloride, pH, and ammonia; the recreational standard is based on *E. coli*.

Six water chemistry stations were sampled monthly within the LRRW from May through September in 2017, and again June through August of 2018, to provide sufficient data for analysis. These water chemistry stations were placed at the outlet of each aggregated HUC-12 subwatershed larger than 40 square miles. Lake of the Woods County Soil and Water Conservation District (SWCD) conducted water chemistry monitoring through Surface Water Assessment Grant (SWAG) funding.

In Table 1 below, LRRW stream segments are listed with their respective stream condition summaries. Fifteen of 48 stream reaches were assessed as part of the development of the LRRW and RRW Monitoring and Assessment Report (Sigl et al. 2020) to determine if individual reaches met applicable standards for one or more parameters. Based on the evaluation of standards met, it was determined that 12 stream reaches fully support aquatic life and 1 fully supported aquatic recreation—known as "use support" status. Two new recreational impairments exist due to high *E. coli* levels measured in the Black River (-547) and West Fork Black River (-543). Information used to create this table was summarized using the MPCA Watershed Monitoring and Assessment Report (Sigl et al. 2020).

Fish and aquatic macroinvertebrate communities were found to be very healthy and met standards for exceptional use (MPCA's highest use class designation). Of the subwatersheds examined, the Winter Road River produced the highest aggregate scores for the Minnesota stream habitat assessment (MSHA) and yielded consistently high fish, and aquatic macroinvertebrate IBI scores. Several streams demonstrated exceptional biological, chemical, and/or physical characteristics worthy of additional protection. Pitt Creek, a tributary to Peppermint Creek and popular local trout fishery, represents the only cold-water resource within the LRRW.

Table 1. Assessment status of river reaches in the Lower Rainy River Watershed.

Aggregated HUC-12 Subwatershed	AUID (Last 3 digits)	River	Reach description	Aquatic life				Aq. rec
				Fish Index of biotic integrity	Macroinvertebrate index of biotic integrity	Dissolved oxygen	Turbidity/TSS	Bacteria
Winter Road River	521	Unnamed Ditch	Unnamed Ditch to Winter Road River	MTS	NA	IF	IF	NA
	506	Winter Road River	Headwaters to Peppermint Creek	MTS	MTS	IF	IF	NA
	502	Winter Road River	Peppermint Creek to Rainy River	MTS	MTS	IF	IC	IC
Peppermint Creek	510	Unnamed Ditch (Pitt Creek)	T159 R32W S16, south line to Peppermint Cr	MTS	NA	IF	IF	NA
	528	Little Peppermint Creek	Unnamed Creek to Peppermint Creek	MTS	NA	NA	NA	NA
	507	Peppermint Creek	Headwaters to Winter Road River	MTS	NA	IF	MTS	IC
Baudette River	535	Baudette River	Headwaters to Unnamed Creek	MTS	NA	MTS	MTS	NA
	536	Baudette River	Unnamed Creek to Rainy River	NA	NA	EXS	MTS	SUP
Lower Rainy River	511	Silver Creek	West Branch Silver Creek to East Branch Silver Creek	MTS	NA	IF	IF	NA
Black River	563	Unnamed Creek	Unnamed Creek to Black River	IC	MTS	IF	IF	NA
	545	Black River	Headwaters to South Fork Black River	MTS	MTS	NA	NA	NA
	546	Black River	South Fork Black River to Unnamed Creek	MTS	MTS	IF	IF	NA
	547	Black River	Unnamed Creek to West Fork Black River	MTS	NA	IF	EXS	IMP
West Fork Black River	543	Black River, West Fork	Headwaters to Black River	MTS	NA	IC	IC	IMP
Middle Rainy River	552	Moonlight Creek	Headwaters to Rainy River	NA	NA	MTS	IC	NA
South Fork Black River	NA	NA	NA	NA	NA	NA	NA	NA
Trib to Black River	NA	NA	NA	NA	NA	NA	NA	NA

= found to support use case; = does not support use case and is impaired; no shading = inconclusive or insufficient to draw a conclusion

MTS = Meets Standard; EXS = Fails Standard; IF = the data collected was insufficient to make a finding; NA = not assessed; IC = Information was inconclusive to draw a conclusion

Lakes

There is one named lake within the LRRW, but it was not assessed during the IWM. Winter Road Lake is a small lake created by a dam on the Winter Road River

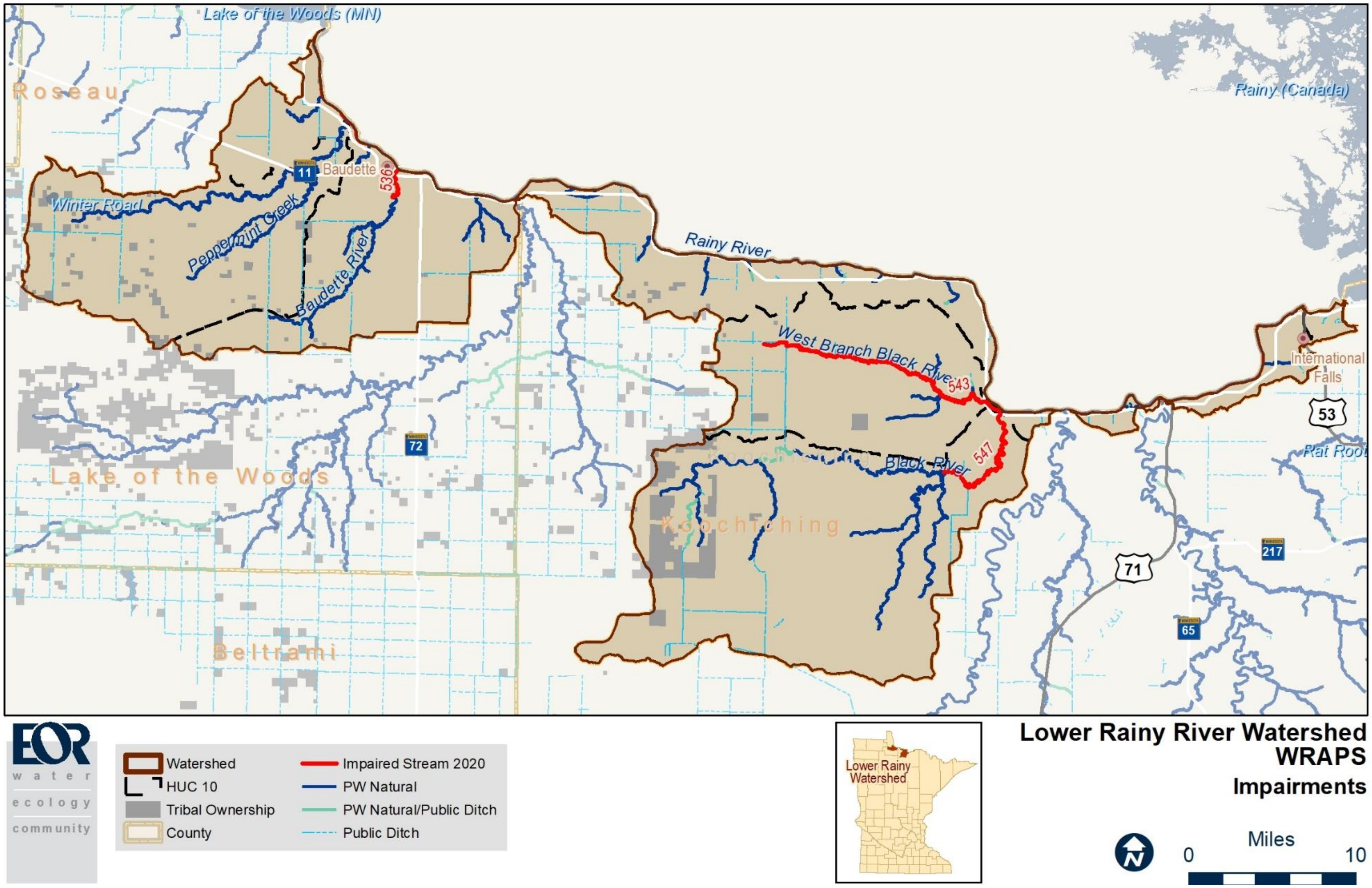


Figure 3. Impaired stream reaches in the LRRW

2.2 Water quality trends

Year-to-year weather variations affect water quality parameters; for this reason, interpreting long-term data trends minimizes year-to-year variation and provides insight into changes occurring in a water body over time. The MPCA completes annual trend analysis on lakes and streams across the state based on long-term transparency measurements. The data collection for this work relies heavily on volunteers across the state and their data is stored, along with MPCA and local government partner data, in the MPCA database called the Environmental Quality Information System (EQuIS).

Water clarity trends are calculated using a Seasonal Kendall statistical test for sites with a minimum of eight years of transparency data; Secchi disk measurements are used in lakes and Secchi tube measurements are used in streams. In this watershed, only one stream site displayed an improving transparency trend, the downstream reach of Moonlight Creek. Five other locations had sufficient data for trend analysis, none of which demonstrated a detectable trend in clarity (Table 2).

A Seasonal Kendall statistical test for water quality trends over the past 10 years was conducted using "R", a statistical software program that can be used to identify statistically significant trends in water quality (Table 3). This analysis was limited to data collected from June through September, and trends were only reported for constituents with at least eight years of data and 90% statistical confidence. The Rainy River at Manitou was the only stream that demonstrated significant trends. Both inorganic nitrogen (nitrate and nitrite) and TSS showed increasing concentrations over the past 10 years. However, the 10-year trend is used only as a potential indication of how water quality in water bodies may be changing and not of long-term conditions, as trends may be influenced by variations in hydrology and other minor changes in watershed characteristics. Despite this trend of increasing nitrogen and TSS, the Rainy River still represents a long-term success in recovery from wastewater pollution.

For long trends in the watershed, the MPCA published its trend analysis of statewide river monitoring data based on the historical Milestones Network in June 2014. The period of record spans over 30 years through 2010, with monitoring at some sites going back to the 1950s. For the Rainy River at Baudette there are decreasing trends in TSS, total phosphorus (TP), and biochemical oxygen demand as a result of significant improvements in wastewater treatment from municipal and industrial sources along the river (Christopherson 2014).

Table 2. Water clarity trends in the Lower Rainy River Watershed at citizen stream monitoring sites

Lower Rainy River HUC-8 09030008	Streams	Lakes
Number of sites w/increasing trend	1	--
Number of sites w/decreasing trend	0	--
Number of sites w/no trend	5	--

Table 3. Recent Water Quality Trends (2010-2019) in the Lower Rainy River Watershed

Water Body Name	AUID	Parameter	Trend
Baudette River	(09030008-536)	Chlorophyll-a	Decreasing slightly (not significantly)
Rainy River	(09030008-538)	Inorganic Nitrogen	Increasing Significantly (31%)
		Total Suspended Solids	Increasing Significantly (47%)

In 2017, the MPCA developed the Watershed Pollutant Load Monitoring Network (WPLMN) to track and store data across the state in each major watershed in the state. Users can access data via the WPLMN browser, which shows the location of long-term monitoring sites throughout the state. It includes links to the MPCA's Environmental Data Access (EDA) portal that contains all monitoring data for the entire period of record, including more recent data through 2019. More information on the monitoring data available in the watershed can be found in Section 4.

Pollutant sources

This section summarizes the sources of pollutants (e.g. phosphorus, bacteria, or sediment) to streams in the LRRW. According to IWM results, two stream reaches in LRRW displayed impairments for *E. coli*. Multiple reaches, including the two impaired segments, demonstrated high TSS and low DO at times, although none have impaired biotic communities. A breakdown of the relative contribution of nonpoint sources and point sources is shown in Figure 4. More information about the nonpoint sources and point sources in the LRRW is provided in the following sections.

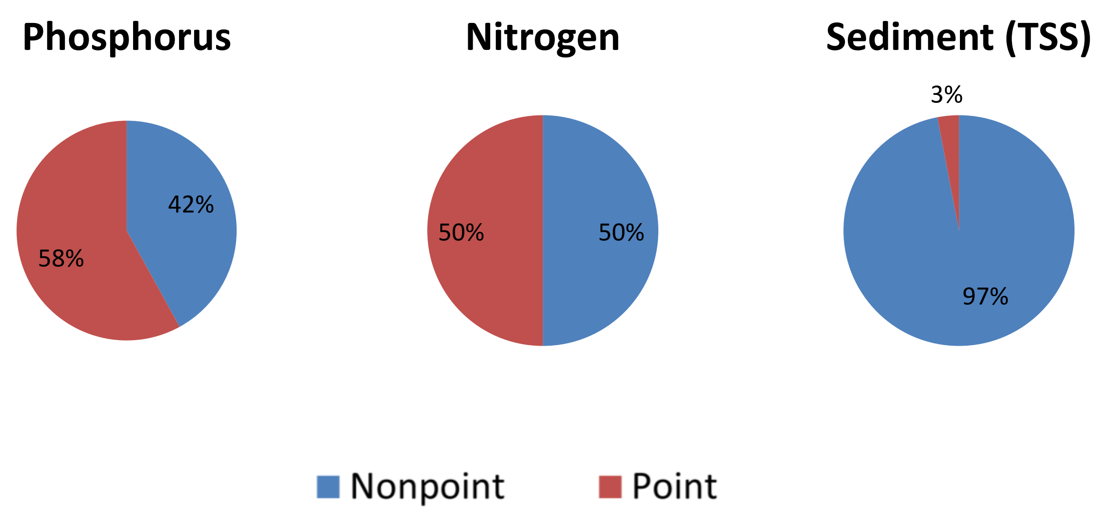


Figure 4. Relative contribution of phosphorus, nitrogen, and sediment by nonpoint sources and point sources in the Lower Rainy River Watershed predicted from HSPF (1996-2014)

Nonpoint Sources

Nonpoint pollution, unlike pollution from industrial and municipal wastewater treatment plants (WWTPs), enters the water system from a variety of sources. As rainfall or snowmelt moves over and through the ground, runoff picks up and carries away natural and anthropogenic pollutants and deposits them into lakes and streams. Significant nonpoint and natural pollutant sources identified in the LRRW include:

- **Watershed runoff:** The HSPF model was used to estimate watershed runoff volumes and TP loads for all 48 individual subwatersheds in the LRRW, based on land cover and soil type, and was calibrated using meteorological data from 2001 through 2015. The highest pollutant yields are predicted from agriculture and urban areas.
- **Wetland export:** Phosphorus export from wetlands is a well-known phenomenon in northern Minnesota wetlands. Wetlands make up a significant portion of the LRRW watersheds

- **Livestock:** Livestock grazing, watering, and feeding all can have impacts on local waterways from livestock manure entering waterways, and livestock in the water can also lead to erosion.
- **Artificial drainage and stream morphometry**: An increase in artificial drainage combined with stream channelization can lead to streambank instability, reduced base flow, and longer periods of intermittent flow.
- **Timber harvesting**: Forest harvest has been and currently is a major activity within the LRRW. While timber harvesting impacts today tend to be very localized, historical large-scale forest removal occurred in the watershed, which may have created legacy effects still being experienced by streams today.
- **Atmospheric deposition:** Atmospheric deposition represents the phosphorus that is bound to particulates in the atmosphere and is deposited directly onto surface waters.
- **Failing septic systems:** Septic systems that are not maintained or are failing near a lake or stream can contribute excess phosphorus, nitrogen, and bacteria.

Monitoring data and source assessment conducted for the TMDL suggest that the *E. coli* stream impairments stem from a mix of sources that occur primarily under low flow conditions but are sometimes also observed under high flows. Primary sources of concern differ by flow conditions: low flows typically struggle with septic systems and direct fecal deposition from cattle access to streams, while pasture runoff mostly occurs under high flows. Natural background sources contribute a relatively low magnitude to the overall bacterial load. (Table 4).

Table 4. Relative Magnitudes of Nonpoint sources in impaired streams in the LRRW

Stream Reach (AUID)	Pollutant	Likely Pollutant Sources				
		Pasture Runoff	Livestock Stream Access	Failing septic systems	Wildlife	Natural Background
West Fork Black River (09030008-543)	*E. coli*	M	M	M	H	L
Black River (09030008-547)	*E. coli*	M	M	M	H	L

Key: H = High; M = Moderate; L = Low

Point Sources

Point sources are defined as facilities that discharge stormwater or wastewater to a lake or stream and have a NPDES/State Disposal System (SDS) Permit (Permit). In the LRRW, there are two WWTPs and eight industrial facilities that require NPDES/SDS permits (Table 5). Figure 8 shows all permitted point sources in the LRRW; there are no active NPDES/SDS permitted feedlots located within the LRRW.

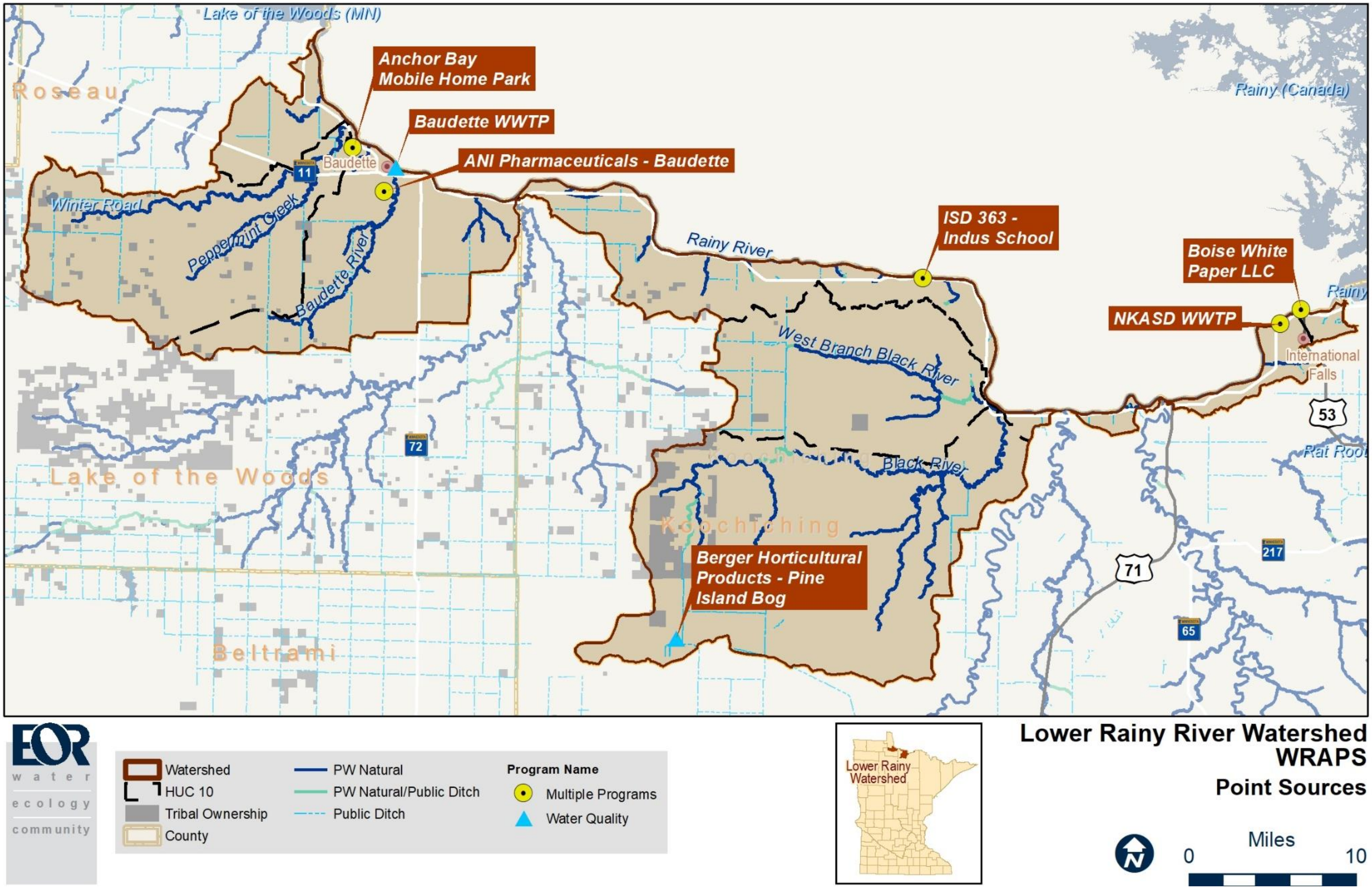


Figure 5. Point Sources in the Lower Rainy River Watershed

Table 5. Point sources in the Lower Rainy River Watershed.

HUC-12 Subwatershed	Point source			Pollutant reduction needed beyond current permit conditions/limits?
	Name	Permit #	Type	
Rainy River (0903000080708)	Anchor Bay Mobile Home Park	MNG585058	Domestic	No
Rainy River (0903000080708)	Baudette WWTP	MNG585174	Domestic	No
Baudette River (090300080705)	ANI Pharmaceuticals	MN0053104	Industrial	No
090300080702	Erickson Timber Products	MNR05386v	Industrial	No
Smooth Island – Rainy River (090300080504)	ISD 363 – Indus School	MN0049263	Domestic	No
Headwaters Black River (090300080301)	Berger Horticultural Products – Pine Island Bog	MN0066052	Industrial	No
City of International Falls - Rainy River (090300080501)	Boise White Paper LLC	MN0001643	Industrial	No
City of International Falls – Rainy River (090300080501)	NKASD WWTP	MN0020257	Domestic	No
City of International Falls – Rainy River (090300080501)	Minnesota Dakota & Western Railway	MNR0539BJ	Industrial	No

Altered Hydrology

In addition to traditional point and nonpoint sources of pollutants, human activities that modify drainage patterns within a watershed can play a significant role in determining the health of its water resources. Hydrologic alterations within the LRRW likely contribute to increased stream flow and modifications to groundwater surface water interactions. Many subwatersheds throughout the LRRW have extensive alterations to the natural drainage system, where it has been estimated that 45% of their watercourses have been altered. Modifications to drainage systems within wetlands can influence the nutrient balance within these areas and can lead to flushes of nutrients to downstream resources. Section 3.1 of the WRAPS provides further details on how altered hydrology analysis was used to target implementation areas in the LRRW.

2.3 Total Maximum Daily Load summary

A TMDL is a calculation of how much pollutant a lake or stream can receive before it does not support recreational or aquatic life uses. The federal CWA places all water bodies that do not meet water quality standards on the Impaired Waters List and requires TMDL studies to protect the most sensitive use of each water body. For each of these water bodies, a TMDL study determines allowable pollutant loads and reduction targets to all pollutant stressors contributing to the impairment. One TMDL study for *E. coli* was concurrently developed for two impaired stream reaches in the LRRW, in the Black River (-547) and West Fork Black River (-543) subwatersheds. Another stream reach, the Baudette River (-536), triggered a TMDL listing for low DO in 1994. The existing pollutant loading, the waste-load and load allocations, and the load reductions needed to meet the requirements of the TMDLs for the impaired reaches in the LRRW are shown in Table 6 and Table 7.

Dissolved Oxygen

The TMDL process began for the Baudette River (09030008-536) in 2008 and involved the river's main stem to its confluence with the Rainy River. While monitoring data confirmed that the river experienced seasonal low DO, the analysis could not attribute the identified land uses to the impairment. Anthropogenic influences are limited in this subwatershed but possible stressors identified include nutrient loading from the Baudette storm water system and storm water and wastewater from the Canadian community of Rainy River. The assessment determined that a complex hydrology including backflow from the Rainy River into Baudette Bay, the low-gradient, wetland nature of the watershed, and natural background loads of the Baudette and Rainy Rivers likely influence DO levels.

Escherichia coli

The Lower Rainy River TMDL addresses *E. coli* impairments for two stream reaches - West Fork Black River (09030008-543) and Black River (09030008-547). A summary of the TMDL for West Fork Black River is shown in Table 6 and for Black River in Table 7.

Table 6 West Fork Black River (09030008-543) *E. coli* TMDL summary

	E. coli **load (B org/day [a]) by flow zone**				
TMDL parameter	**Very High (249–2,877 cfs)**	**High (55–249 cfs)**	**Mid (21–55 cfs)**	**Low (3–21 cfs)**	**Very Low (0.2–3 cfs)**
Boundary condition	19	4.7	1.6	0.41	0.093
Load allocation	1,168	287	95	25	5.7
Margin of safety	132	32	11	2.8	0.64
TMDL	1,319	324	108	28	6.4
Maximum observed monthly geometric mean (org / 100 mL)	173				
Overall estimated percent reduction	27%				

Table 7. Black River (09030008-547) *E. coli* TMDL summary

	E. coli **load (B org/day [a]) by flow zone**				
TMDL parameter	**Very High (691–9805 cfs)**	**High (149–691 cfs)**	**Mid (56–149 cfs)**	**Low (10–56 cfs)**	**Very Low (0.7–10 cfs)**
Boundary condition	200	50	17	4.3	1.1
Load allocation	2,994	757	247	65	16
Margin of safety	355	90	29	7.7	1.9
TMDL	3,549	897	293	77	19
Maximum observed monthly geometric mean (org / 100 mL)	163				
Overall estimated percent reduction	23%				

Lake of the Woods Excess Nutrient TMDL

The Lake of the Woods Nutrient TMDL Study addresses the aquatic recreation impairment of Minnesota's portion of the Lake of the Woods caused by excess nutrients. Minnesota's portion does not meet water quality standards because of excessive TP and Chlorophyll-a concentrations and violation of the Secchi disk standard. The TMDL process for Lake of the Woods, an important internationally managed resource, was designed to help determine how to control algal blooms that limit recreational use. Excess phosphorus was identified as a key driver of a range of biological responses, and the Rainy River its largest contributing source (MPCA 2021). Under the Lake of the Woods TMDL, load reduction targets were created within the LRRW, with the overall goal of reducing phosphorus by 17.3%. As the LRRW drains directly into Lake of the Woods, the water quality goals set for the watershed were modeled to meet nondegradation standards. The analysis included determining delivery ratios for each pollutant source and reduction targets at both sources and the Lake. Sources with proposed wasteload allocations (WLAs) in the LRRW include four domestic and one industrial WWTP, listed below in Table 9 and Table 10. Each of these sources are currently acting under permits with TP effluent limits consistent with the TMDL WLAs. Below in Table 10, one can see all facilities are meeting their load allocations (LAs) for the TMDL.

Table 8. Annual TP loads for WWTP in the Lower Rainy River Watershed

Facility	2019	2020	2021	WLA
	TP (lbs/yr)	TP (lbs/yr)	TP (lbs/yr)	TP (lbs/yr)
Anchor Bay Mobile Home Park	2.2	6.5	5.6	97.0
Baudette WWTP	283.9	527.1	125.1	808.9
Boise White Paper LLC - Intl Falls[1]	61,294.0	41,656.4	59,562.8	72,952.4
ISD 363 - Indus School[2]	15.9	7.7	9.1	74.9
NKASD WWTP	2,061.5	1,504.7	1,415.4	7,312.9

[1]Boise White Paper LLC missing data for December 2021 estimated as 2019-2021 mean monthly load

[2]ISD 363 - Indus School missing data for November and December 2021 estimated as 2019-2021 mean monthly load

Table 9. Lake of the Woods Excess Nutrient TMDL summary of domestic WWTPs

Domestic WWTP	NPDES/SDS Permit Number	Effluent Type	Study Period Mean Annual TP Load (lb/yr)	Wasteload Allocation TP Load (lb/yr)
Anchor Bay Mobile Home Park	MN0046213	**Intermittent**	151.5	97.0
Baudette WWTP	MN0029599	**Controlled**	7,152.9	808.9
ISD 363 – Indus School	MN0049263	**Continuous**	30.0	74.9
NKASD WWTP	MN0020257	**Continuous**	8766.2	7,312.9
Total			16100.6	8293.7

Table 10. Lake of the Woods Excess Nutrient TMDL summary of industrial WWTPs

Industrial WWTP	NPDES/SDS Permit Number	Effluent Type	Study Period Mean Annual TP Load (lb/yr)	Wasteload Allocation TP Load (kg/yr)
Boise White Paper LLC – Intl Falls	MN0001643	Continuous	78,354.8	72,972.9

Table 11. Lake of the Woods Excess Nutrient TMDL Load Allocation Summary in the Lower Rainy River Watershed from US Sources

Stream	Existing Load at Source (lb/yr)	Proposed Load at Source (lb/yr)	Load Reduction at Source (lb/yr)
Black River	21,376	21,376	0
McCloud Creek	778	464	314
Whitefish Creek	1,171	674	497
Silver Creek	2,456	1,344	1,112
Unnamed (391)	1,008	769	239
Baudette River	3,553	2,816	736
Miller Creek	927	462	465
Winter Road River	7,233	6,913	320
Wabanica Creek	3,009	1,492	1,517
US Direct Drainage	12,888	12,888	0
Lower Rainy HUC-8	54,339	49,200	5,199

2.4 Protection considerations

Given the overall good quality of the water resources within the LRRW, protection strategies will be key to preventing future water quality degradation. Restoration and protection strategies should be developed to both improve the condition of degraded resources and ensure that unimpaired waters remain in good condition.

Protected areas

Large tracts of land within the LRRW are currently afforded some degree of protection, through either governmental management under a public lands designation or through enrollment in various land-management or conservation easements. These areas are protected due to certain restrictions placed on human activities which help preserve their natural conditions, thereby helping to preserve current water quality conditions (Figure 6). Currently, 64% of lands within the LRRW are in public ownership according to the 2008 Gap Analysis Project (GAP) (DNR 2008). Approximately 24% of the public land is School Trust Land, which is managed to provide a continual source of funding for public education. Although privately owned land constitutes a smaller percentage of the watershed than public lands, much of this land borders the Rainy River and other key waterways. As such, protection strategies may depend on the land use practices within those private lands and hinge on cooperation with the landowners.

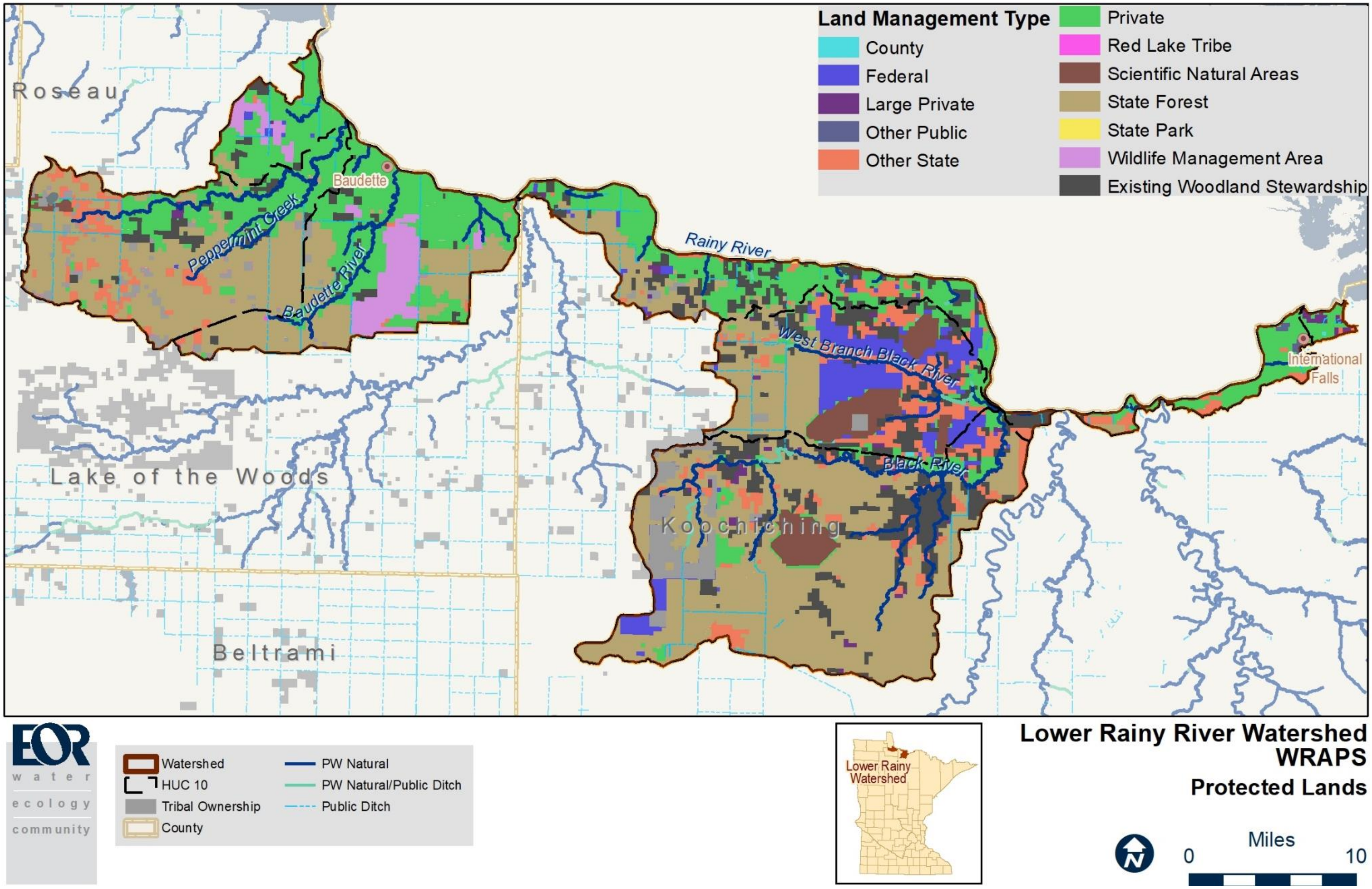


Figure 6. Protected lands in the LRRW

Prioritizing streams for protection

As summarized in the Monitoring and Assessment report, the MPCA, Minnesota Department of Natural Resources (DNR) and Board of Water and Soil Resources (BWSR) have worked together to prioritize the 12 streams in the LRRW that were found to be supportive of designated aquatic life uses (Sigl et al. 2020). The goal of this prioritization exercise was to identify and prioritize streams that are: 1) currently healthy but near the impairment threshold, or 2) currently healthy and are indicating good water quality. For those streams that are currently healthy, further prioritization exercises were performed to identify watersheds that are largely protected versus those that are at risk of degradation.

The stream protection and prioritization exercise identified two main landscape risks to biological condition, including: 1) percent disturbed land, and 2) density of roads. Each risk factor was assessed at two scales for each stream's riparian area, defined as 200 m on each side of the stream and for the whole drainage area.

The exercise then identified the amount of land in public ownership or permanent easement at both the riparian scale and watershed scale. Next, each stream was assessed to determine the number of communities (fish, macroinvertebrates, or both) that were near the impairment threshold (Figure 7). Each risk factor was then assessed relative to a statewide database for fully supporting streams. The final Protection Priority Rank was calculated as follows:

Protection Priority Rank = [(IBI Threshold Proximity) x (Riparian Risk + Watershed Risk + Current Protection)].

As an example, a stream with biological communities (fish and macroinvertebrates) that were near the IBI impairment threshold, with many roads in the stream's watershed, and a low percentage of land in protection (e.g., public lands) would be ranked a high risk or Priority A stream. No Priority A or B streams were identified near the threshold (Table 12; Figure 7); however, local efforts need to be vigilant in maintaining the excellent water quality in the area.

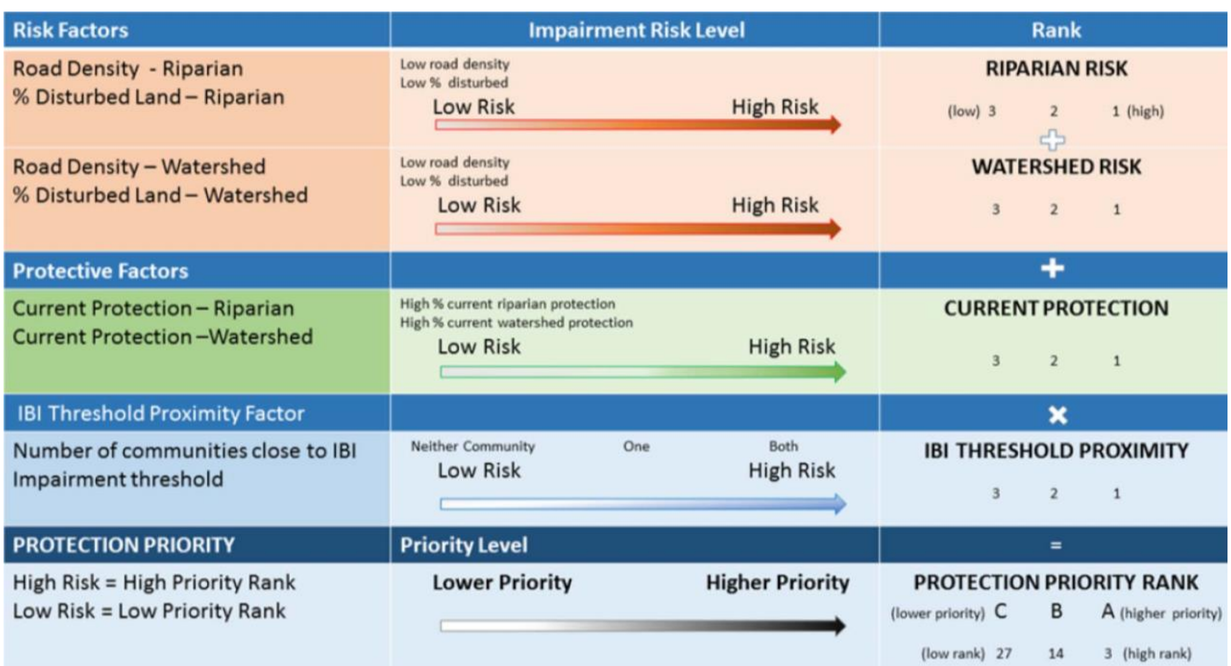


Figure 7. Stream protection and prioritization matrix.

Table 12. Stream protection and prioritization results in the Lower Rainy River Watershed

Water Body ID (AUID)	Stream Name	TALU	Cold/Warm	Riparian Risk	Watershed Risk	Current Protection Level	Protection Priority Class
09030008-506	Winter Road River	General	Warm	Med/Low	Med/Low	Med/High	C
09030008-507	Peppermint Creek	General	Warm	Medium	Med/Low	Med/High	C
09030008-521	Unnamed Ditch	General	Warm	Med/High	Low	High	C
09030008-535	Baudette River	General	Warm	Medium	Med/Low	Med/High	C
09030008-545	Black River	General	Warm	Medium	Low	High	C
09030008-546	Black River	General	Warm	Low	Low	Med/High	C

Prioritizing lakes for protection

There is one lake in the LRRW, an impounded portion of Winter Road River known as Winter Road Lake. It was not assessed as part of the monitoring and assessment process. No prioritization of lakes was performed for the LRRW.

Drinking water protection

Drinking water is important in any watershed in Minnesota. Most Minnesotans (75%) rely on groundwater for their drinking water source, and whether the source is a public or private well, that groundwater quality can be highly impacted by nearby surface water features. The remaining 25% of Minnesotans rely on surface water, primarily from the 23 city-owned and operated community public water suppliers active throughout the state. These surface water-using communities are highly dependent on the health of the watersheds in which they are located. Therefore, protection of drinking water should be a high priority for all watersheds in Minnesota.

The LRRW contributes to one community public water supply (PWS), International Falls, as a drinking water source. The city of International Falls relies on Rainy Lake and the Rainy River at the top of the watershed for their drinking water and benefits from restoration and protection of surface water in the watershed.

Many implementation activities conducted by the local governments, SWCDs, logging industries, private landowners, and local entities can collectively help address surface water quality. The main issue for International Falls' source water is naturally generated elevated organic carbon concentrations. This organic carbon can originate from a variety of sources, including plant and animal decomposition. However, when high concentrations of organic carbon combine with chlorine, the most common drinking water disinfectant, the resulting reaction can create carcinogenic chemicals known as disinfection byproducts. Figure 8 highlights the Source Water Assessment areas for International Falls. The areas were delineated using the following criteria:

- The Inner Emergency Response Area (ERA) is defined as the area in which the PWS utility would have little or no time to respond to a direct discharge of contamination, other than to close the intake. The area closest to the intake was designed to help the public water supplier address contaminant releases which present an immediate (acute) health concern to water users. The geographic area is defined by the amount of notification time the PWS would need to close the surface intake and a "buffer time" to accommodate unanticipated delays in notification and shut down. Three different sets of criteria were developed and used to delineate an ERA for different types of surface water bodies including: 1) rivers and streams, 2) lakes, and 3) mine pits. Information about the intake, water supply system, water storage capacity, and treatment methods were also considered.

- The Outer Source Water Management Area is defined as the area where the impacts to drinking water from point and nonpoint sources of contamination can be minimized by preventive management. This area was delineated to protect water users from long-term (chronic) health effects related to low levels of chemical contamination or the periodic presence of contaminants at low levels in the surface water used by the PWS.

Figure 8 shows the city of International Falls and the surface runoff and watershed area that contributes to the city's drinking water intake. Each of the streams and lakes inside the two Source Water Assessment areas are important places to focus on when planning implementation and restoration activities.

The International Falls Source Water Assessment will be updated using new guidance and definitions by 2025. The current document, which will be replaced by the new amended Assessment when it is completed, is available at the Minnesota Department of Health (MDH) Source Water Assessment webpage: https://www.health.state.mn.us/communities/environment/water/swp/swa.html.

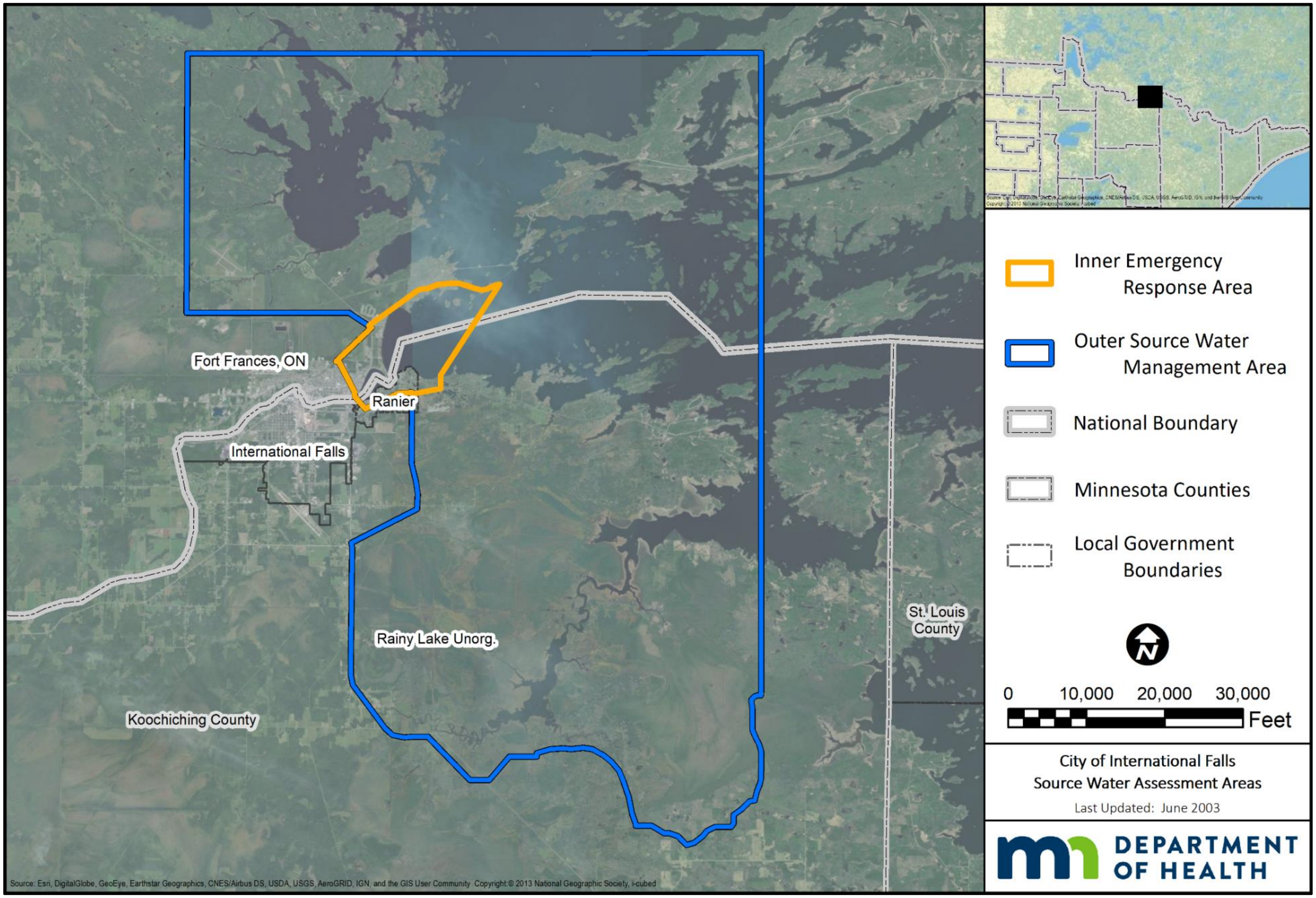


Figure 8. Source Water Assessment areas for the City of International Falls

3. Strategies for restoration and protection

The Clean Water Legacy Act (CWLA) requires that WRAPS contain strategies that are capable of cumulatively achieving needed pollution load reductions for point and nonpoint sources, including water quality goals, strategies, and targets by parameter of concern, and an example of the scales and timeline of adoption to meet water quality protection and restoration goals. This section of the WRAPS report provides the results of such strategy development. Because many 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 public participation is a part of the overall plan for moving forward.

The implementation strategies, including associated scales of adoption and timelines, provided in this section are the result of watershed modeling efforts and professional judgment based on what is known at this time and, thus, should be considered approximate. Furthermore, many strategies are predicated on 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 Targeting of geographic areas

The following section describes the specific tools that were used during the LRRW WRAPS process to help stakeholders identify, locate, and prioritize watershed restoration and protection strategies. The general approach began with a high-level overview of the issues and concerns facing the watershed and became increasingly more detailed as specific implementation actions were evaluated. An HSPF model was used to evaluate pollutant loading dynamics across the LRRW. A variety of geographic datasets were then reviewed by local resource managers and public stakeholders to understand watershed stresses and to prioritize subwatersheds. Through this process, reducing pollutant loading and improving altered hydrology were identified as key issues to address in the LRRW. Tools used to target geographic areas to further protect the resources include:

- Aggregated HUC-12 Subwatershed Priority Ranking
- HSPF Targeting Analysis
- Agricultural Parcel Prioritization
- Riparian Adjacency Quality (RAQ) and Agricultural Parcel Scoring
- Agricultural Conservation Planning Framework (ACPF)
- Small Grazing Operation Identification
- *E. coli* Source GIS Review
- Urban BMP Identification

Results from these tools are summarized in the following section and detailed maps of the potential BMP locations are found in Section 3.3. While the targeting exercise attempted to evaluate the feasibility of the potential projects, follow-up field reconnaissance is needed to provide further validation of locations, pollutant reductions, and cost estimates.

Aggregated HUC-12 Subwatershed Priority Ranking

During the early stages of the WRAPS planning process in 2020, a small working group of local resource professionals developed a ranking system to prioritize the aggregated HUC-12 subwatersheds within the LRRW. The aggregated HUC-12 subwatersheds are an intersection of HUC-12 subwatersheds, as defined by the United States Geologic Survey (USGS) hydrological system, along with the subwatershed areas defined by the HSPF model. Based on their contribution to the problems facing the watershed and their potential to achieve meaningful improvements, the subwatersheds were sorted into three categories—low, medium, and high—to indicate the priority level with which the subwatersheds would be targeted for improvements.

To begin the evaluation process, the working group considered and reviewed 56 data sets falling into 9 general categories. Reviewers first rated the effectiveness of each data set for prioritizing aggregated HUC-12 subwatersheds. The evaluation was completed specific to the unique characteristics of the watershed; other watershed may have been evaluated differently, because all watersheds are unique. Reviewers assigned ratings based on how useful each data set would be for prioritizing subwatersheds for focused efforts. The data set categories (altered hydrology, soil erosion, etc.) are presented below in order of the priority established by the local working group. Underlined data sets were selected by the working group as the most effective tools for prioritizing subwatersheds (Refer to Appendix A for further information on the geographic data sets and process that were used to prioritize subwatersheds). Following this rating exercise, the working group reviewed data from the underlined sets to evaluate specific characteristics of the aggregated HUC-12 subwatersheds and ranked subwatersheds by how great an impact improvement activity would contribute to the overall health of the watershed. The resulting prioritization of aggregated HUC-12 subwatersheds is shown in Table 13 and Figure 9. The following summarizes the data sets and their ranking:

Altered Hydrology

- <u>Aquatic Disruption</u>
- Connectivity Index
- <u>Altered Watercourses</u>
- Sandy Verry Channel Flow
- Sandy Verry Risk Model

Soil Erosion

- <u>Stream Power Index</u>
- <u>Geo Index – Soil Erosion Susceptibility</u>
- Geo Index – Steep Slopes Near Streams

Water Quality

- <u>HSPF Model – Sediment Yield</u>
- HSPF Model – Stream Bank Erosion
- HSPF Model – Cropland Erosion
- <u>HSPF Model – Phosphorus Yield</u>
- HSPF Model – Total Phosphorus – Cropland
- HSPF Model – Total Phosphorus – Septic load
- HSPF Model – Total Nitrogen
- HSPF Model – Flow Yield
- Monitored in-stream *E. coli* Concentration
- Monitored in-stream Total Phosphorus
- Monitored in-stream Dissolved Oxygen
- Monitored in-stream Total Suspended Solids

Land Use / Land Cover

- Wetlands & Open Water
- Developed Lands
- Agricultural Lands
- Forest and Other Natural Land
- Forest for the Future
- Potential Forest Protection Areas
- Sustainable Forest Incentive Act Lands
- Forest Stewardship Plan Parcels
- Total Protected Lands
- 2008 GAP Public Land
- 2008 GAP Tribal Land
- 2008 GAP Private Land
- 2010 Rural Housing Density.
- Road Distance

Wetlands

- National Wetland Inventory Total
- Surface Outflow Wetlands
- Wetland Water and Erosion Benefit
- Wetland Species Benefit
- <u>Wetland Habitat Stress</u>
- <u>Wetland Phosphorus Stress</u>
- <u>Wetland Nitrogen Stress</u>
- <u>Restorable Wetland Inventory</u>
- <u>Wetland Restoration Viability</u>

Previous Prioritizations

- Local Watershed Prioritization
- DNR Protection Status
- Combined Index – Geomorphology Triage Score

Groundwater

- Groundwater Sensitivity
- Geologic Index – Pollution Sensitivity of Near Surface Materials

Groundwater cont.

- Arsenic Concentration
- Nitrate Concentration

Biodiversity

- DNR Lake Phosphorus Sensitivity
- Wild Rice Lakes
- Minnesota Biological Survey (MBS) Biodiversity
- Wild Life Action Network
- Biological Index Terrestrial Habitat Quality

Improvements

- Number of Best Management Practice s (BMPs)

Table 13. Priority ratings of aggregated HUC-12 subwatersheds in the LRRW

Aggregated HUC-12	HUC-12	HSPF Catchment	Aggregated HUC-12 Subwatershed Rating
West Fork Black River (0903000802-01)	Upper West Fork Black River	A137	Medium
	Upper West Fork Black River	A139	Medium
	Middle West Fork Black River	A141	Low
	Middle West Fork Black River	A143	Low
	Lower West Fork Black River	A145	Low
	Lower West Fork Black River	A147	Medium
Black River (0903000803-01)	Headwaters Black River	A70R	Low
	Headwaters Black River	A81R	Medium
	Headwaters Black River	A90R	Low
	Upper Black River	A101	Low
	Upper Black River	A110	Low
	Middle Black River	A130	Medium
	Lower Black River	A150	Medium
Tributary to South Fork Black River (0903000803-02)	090300040205	A131	Low
	090300040205	A133	Low
	090300040206	A135	Medium
South Fork Black River (0903000803-03)	South Fork Black River	A121	Low
	South Fork Black River	A123	Low
	South Fork Black River	A125	Low
Middle Rainy River (0903000805-01)	City of International Falls-Rainy River	A10R	High
	Big Fork River-Rainy River	A30R	Medium
	Big Fork River-Rainy River	A50R	Medium
	Manitou Rapids-Rainy River	A170	High
	Manitou Rapids-Rainy River	A190	High
	McCloud Creek-Rainy River	A201	Medium
	McCloud Creek-Rainy River	A210	Medium
	Whitefish Creek-Rainy River	A221	Medium
	Whitefish Creek-Rainy River	A230	High
Winter Road River (0903000806-01)	Judicial Ditch No 23	A401	Medium
	Judicial Ditch No 23	A403	Medium
	Judicial Ditch No 23	A405	Medium
	Winter Road River	A407	Medium
	Winter Road River	A421	High
	Peppermint Creek	A411	Medium

Aggregated HUC-12	HUC-12	HSPF Catchment	Aggregated HUC-12 Subwatershed Rating
Peppermint Creek (0903080006-02)	Peppermint Creek	A413	Medium
	Peppermint Creek	A415	Medium
Lower Rainy River (0903000807-01)	Silver Creek	A381	High
	Silver Creek	A383	Medium
	Judicial Ditch No 13	A391	High
	Wabanica Creek	A423	High
	Rainy River	A390	High
	Rainy River	A399	High
	Rainy River	A430	High
Baudette River (0903000807-02)	Baudette River	A393	Medium
	Baudette River	A395	Medium
	Baudette River	A397	High

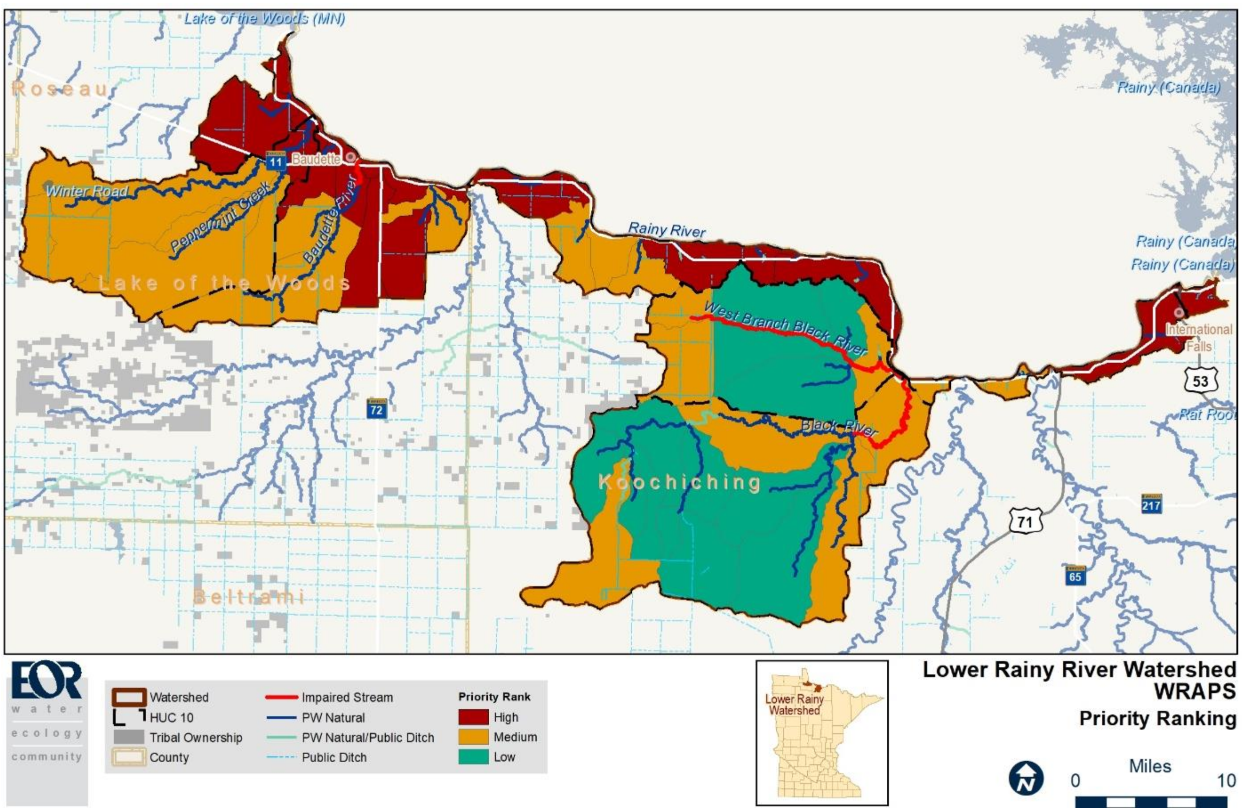


Figure 9. Priority ranking of aggregated HUC-12 Subwatersheds in the LRRW

Critical Area Identification

Hydrologic Simulation Program – FORTRAN

An HSPF model is a large-basin, watershed model that simulates nonpoint source runoff and water quality in urban and rural landscapes. Development of an HSPF model helps to improve understanding of existing water quality conditions and predict water quality changes under different land management practices and/or climatic changes at the subwatershed scale. The predictive capabilities of the HSPF model can be directed to evaluate the impact of alternative management strategies on load reduction goals and water quality conditions.

The Lower Rainy River HSPF model, which includes the LRRW, incorporates real-world meteorological data and is calibrated to real-world stream flow data. Point source data in the watershed, including both domestic and industrial WWTPs, is also added to flesh out the HSPF model. Through use of the model, the relative magnitude of TSS, TP, and total nitrogen (TN) pollution generated in each catchment of the LRRW was predicted. The HSPF model was also used to evaluate the extent of contributions from point, nonpoint, and atmospheric sources where necessary. The TSS, TP, and TN yields predicted from the HSPF model in the LRRW are mapped in Figure 10, Figure 11, and Figure 12.

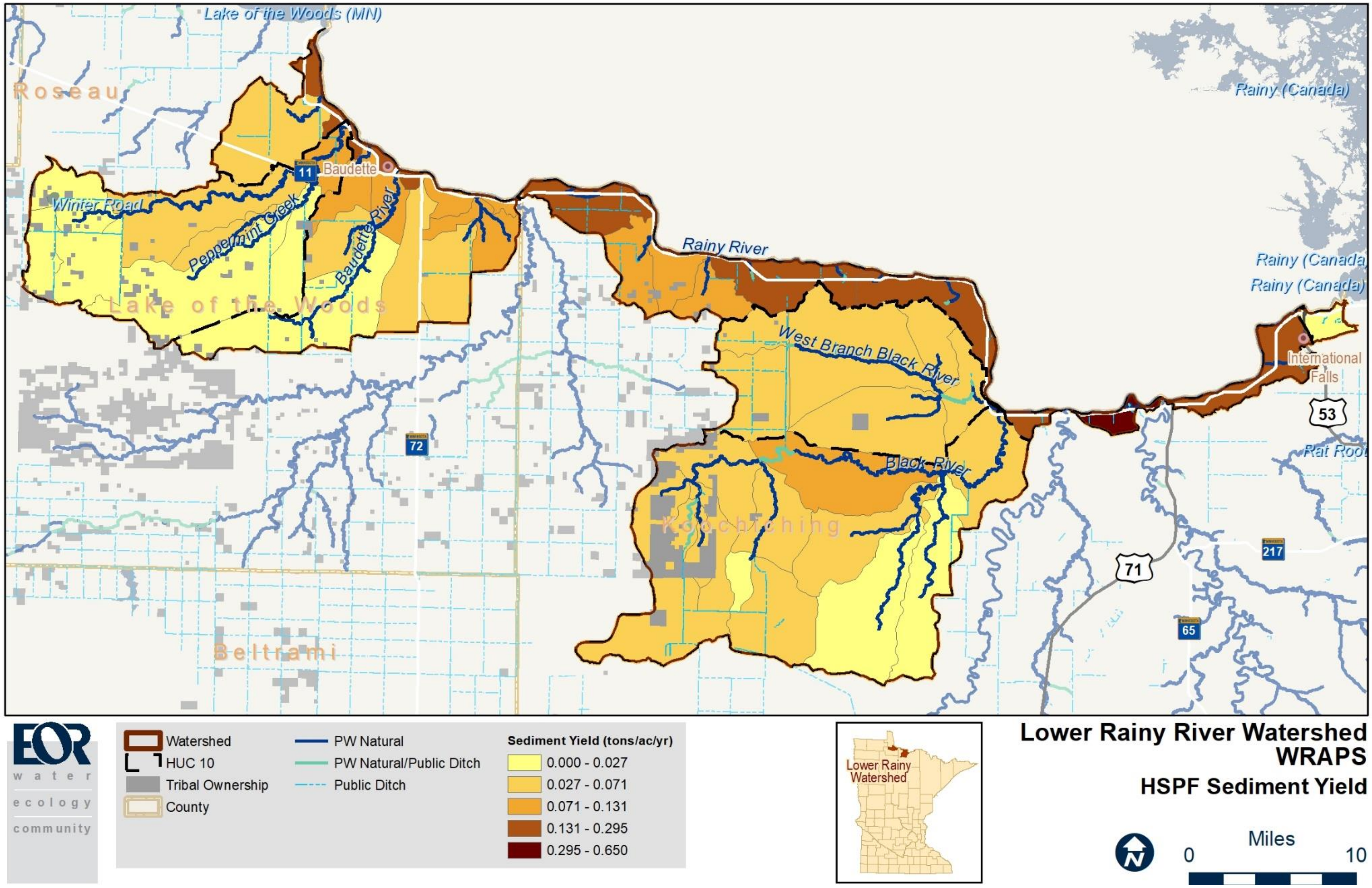


Figure 10. HSPF modeled sediment yields in the LRRW by aggregated HUC-12 subwatershed

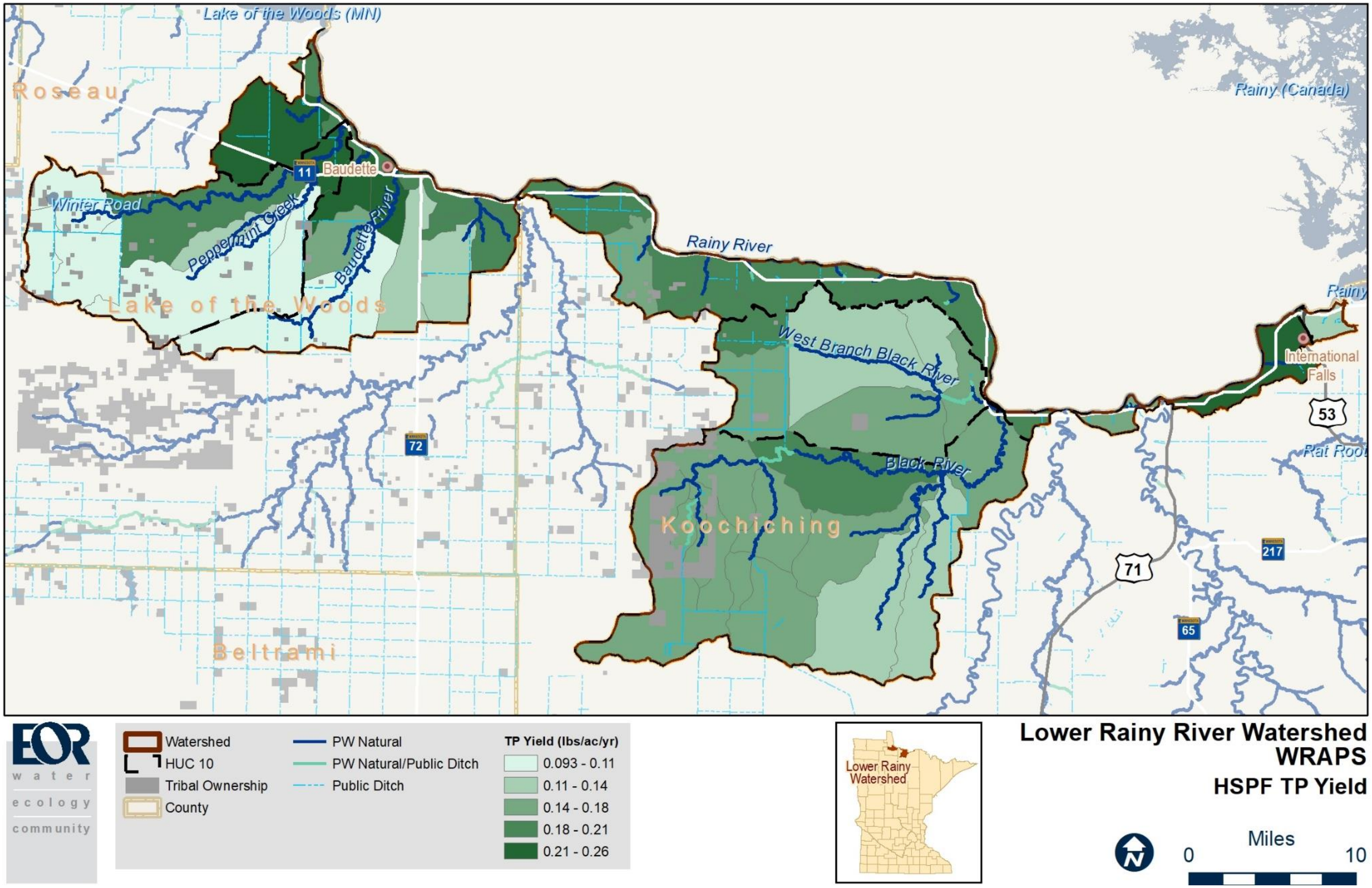


Figure 11. HSPF modeled total phosphorus yields in the LRRW by aggregated HUC-12 subwatershed

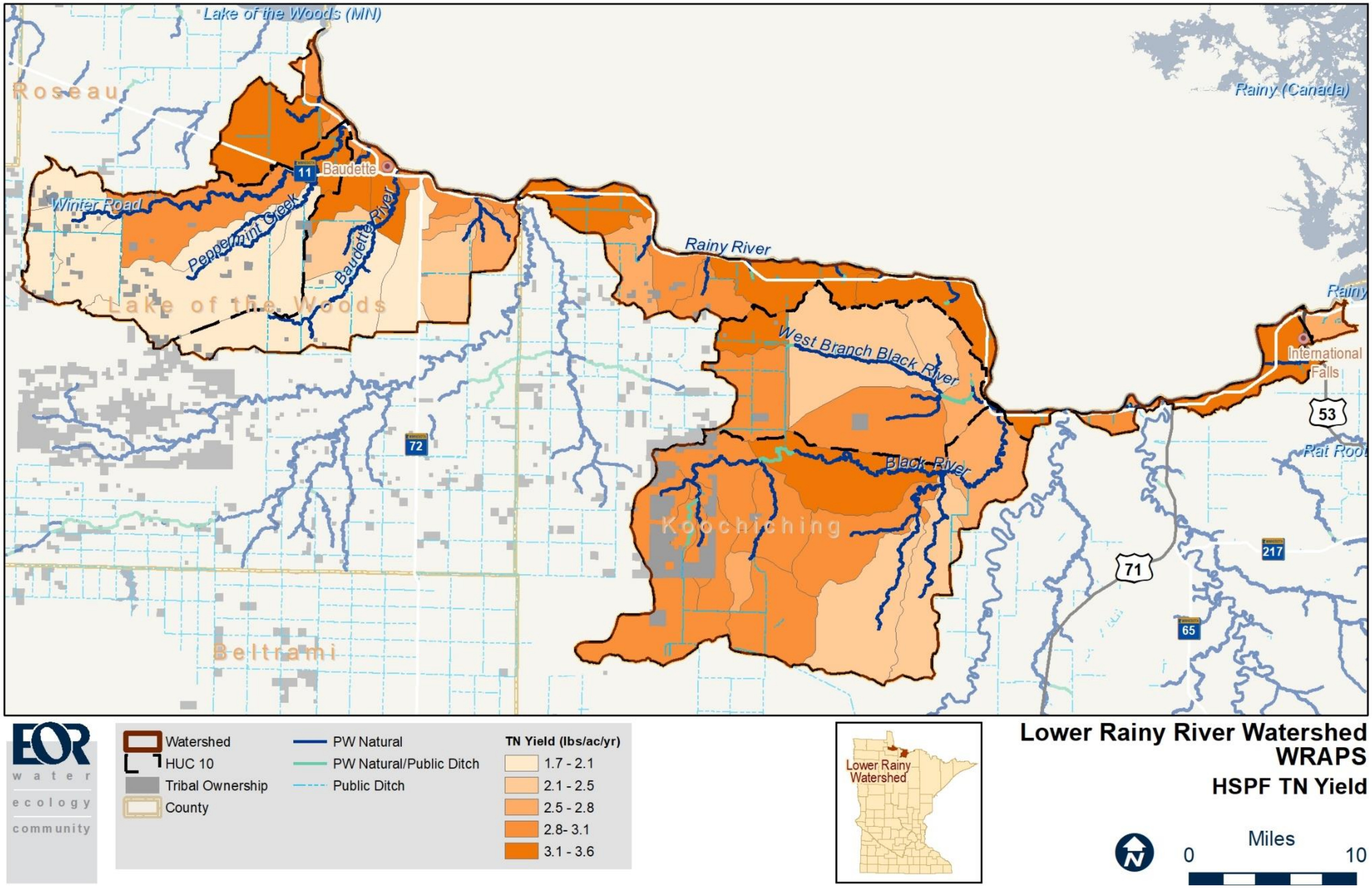


Figure 12. HSPF modeled total nitrogen yields in the LRRW by aggregated HUC-12 subwatershed

HSPF Targeting Analysis

In addition to identifying existing pollutant loads in the LRRW, the Lower Rainy River HSPF model can help target specific agricultural BMPs needed in the watershed to achieve a pollutant reduction goal. This goal for the LRRW is a TP reduction allocated to the watershed as part of the Lake of the Woods Excess Nutrient TMDL described in Section 2.3. Six types of agricultural BMPs were included in the targeting model scenarios including no-till, extending agricultural buffers to 100 ft, restoring tiled wetlands, water and sediment control basins (WASCOBs), conservation crop rotations, and nutrient management plans.

Numerous assumptions were used in the HSPF targeting analysis (Table 13). BMPs are ordered by their predicted cost effectiveness. No-till is the most cost-effective BMP and nutrient management plans are the least. For no-till and WASCOBs, the HSPF model assumes the applicable area is agricultural land with greater than 2% slope. The applicable areas of no-till and WASCOBs were increased to achieve the targeted load reduction. While these more-sloped areas should be targeted first, the BMPs may be applicable in other areas.

Table 14. HSPF Targeting Model Assumptions

BMP	Default Maximum Applicable Area (Acres)	Assumed Maximum Applicable Area (Acres)	Default Surface TP Load Reduction (%)	2021 Unit Cost ($/ac/yr)
Reduced Tillage (No-Till)	741	17,608	80%	$11.41
100 ft Riparian Buffers	4,547	4,547	80%	$26.62
Restore Tiled Wetlands	13,595	2,719	43%	$35.48
WASCOBs	741	3,522	85%	$58.09
Conservation Crop Rotation	17,422	17,422	50%	$44.40
Nutrient Management Plans	17,422	17,422	4%	$9.63

The results of the BMP targeting analysis with only LRRW HSPF subbasins had a total cost of $1,220,000 per year (Table 14). Load reductions were predicted at each HSPF subbasin (Figure 13). An additional analysis included the Rapid River Watershed. The Lake of the Woods Excess Nutrient TMDL did not allocate a load reduction to the Rapid River Watershed; however, including it will provide more options to achieve the targeted load reduction some of which may be more cost effective, indicated by the lower predicted cost of $380,000 per year (Table 16). HSPF model results for load reductions at each LRRW and RRW subbasin were categorized and mapped (Figure 14). Within the Rapid River Watershed, the largest benefit to the Lake of the Woods will be from BMPs implemented near the outlet of the watershed. The Lower Rainy model's predicted load reductions for each stream were calculated (Table 17). The largest TP load reductions can be achieved along the mainstem of the Rainy River, the Rapid River, Wabinica Creek, and Winter Road River. The actual implementation of agricultural BMPs will vary based on landowner participation, available funding, and practice feasibility based on local landscape characteristics.

Table 15. Estimated Implementation in the LRRW to meet the Lake of the Woods Excess Nutrient TMDL

BMP	Treated Area (ac)	Treated Area (% of Agricultural Land)	2021 Cost ($/yr)	TP Load Reduction (lbs/day)	TP Load Reduction (lbs/yr)
No-Till	17,608	100%	$200,000	7.9	2886
Riparian Buffers (100 ft)	4,547	26%	$120,000	1.4	511
Restore Tiled Wetlands	2,719	15%	$100,000	0.6	212
WASCOBs	3,522	20%	$200,000	1.0	353
Conservation Crop Rotation	11,599	66%	$490,000	1.1	394
Nutrient Management Plan	10,277	58%	$110,000	0.2	69
Total			**$1,220,000**	**12.2**	**4,425**

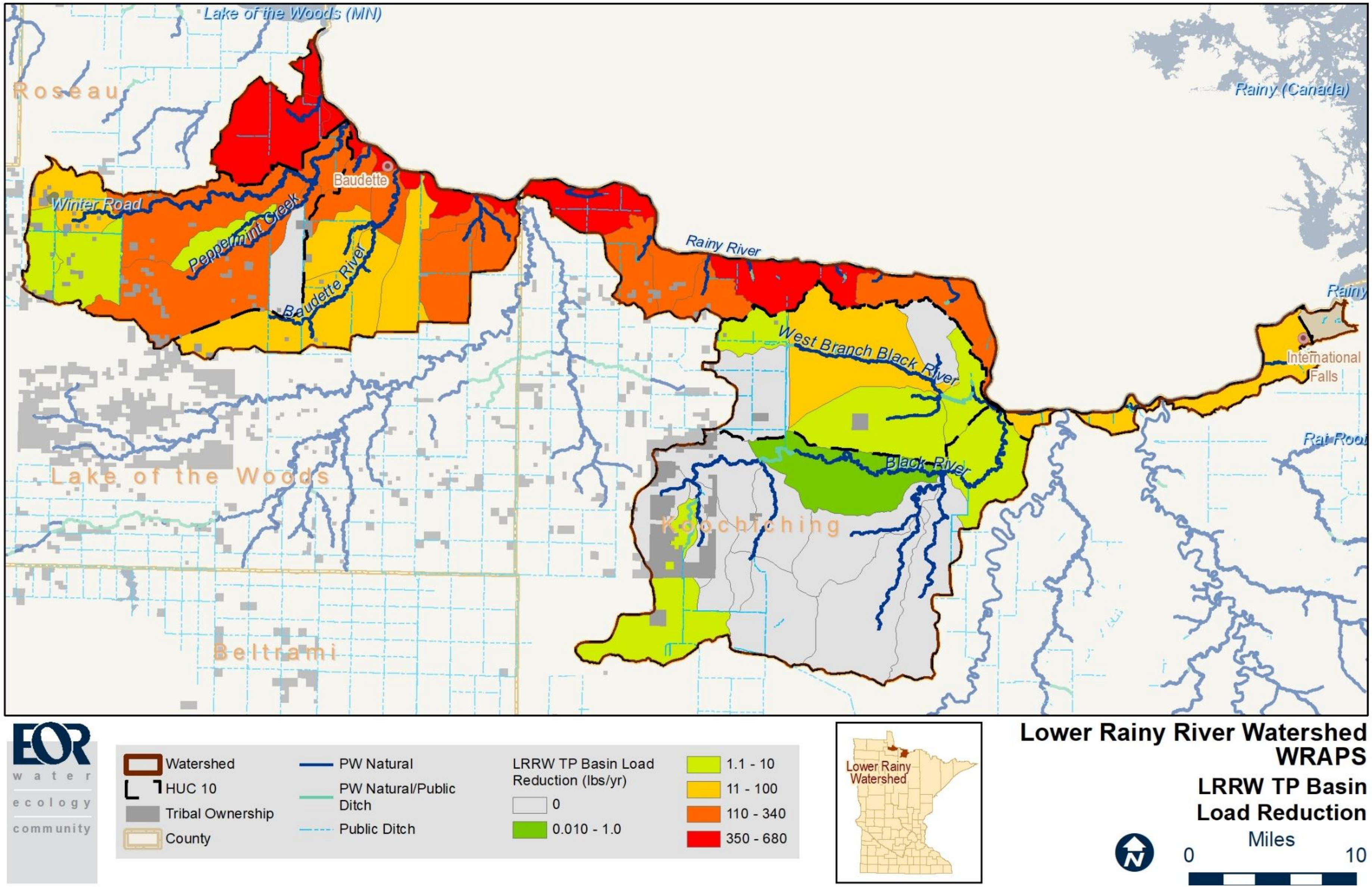


Figure 13. HSPF predicted total phosphorus basin load reduction in the Lower Rainy River Watershed.

Table 16. Estimated Implementation in the LRRW and Rapid River Watershed to meet the Lake of the Woods Excess Nutrient TMDL

BMP	Treated Area (ac)	Treated Area (% of Agricultural Land)	2021 Cost ($/yr)	TP Load Reduction (lbs/day)	TP Load Reduction (lbs/yr)
No-Till	20877	100%	$240,000	9.6	3509
Riparian Buffers (100 ft)	4244	20%	$140,000	2.5	916
Total			$380,000	12.2	4,425

Table 17. Predicted TP load reduction at each stream in the Lower Rainy HSPF Model

Stream	HSPF Subbasin	Load Reduction from LRRW Scenario (lb/yr)	Load Reduction from LRRW and RRW Scenario
Wabinica Creek	A423	681	509
Winter Road River	A421	514	378
Miller Creek	A399	155	112
Baudette River	A397	224	163
Silver Creek	A383	399	331
Rapid River	A370	NA	817
McCloud Creek	A201	105	77
Black River	A150	41	40
Rainy River Mainstem	-	2,305	1,998
Rainy River Outlet	A430	4,424	4425

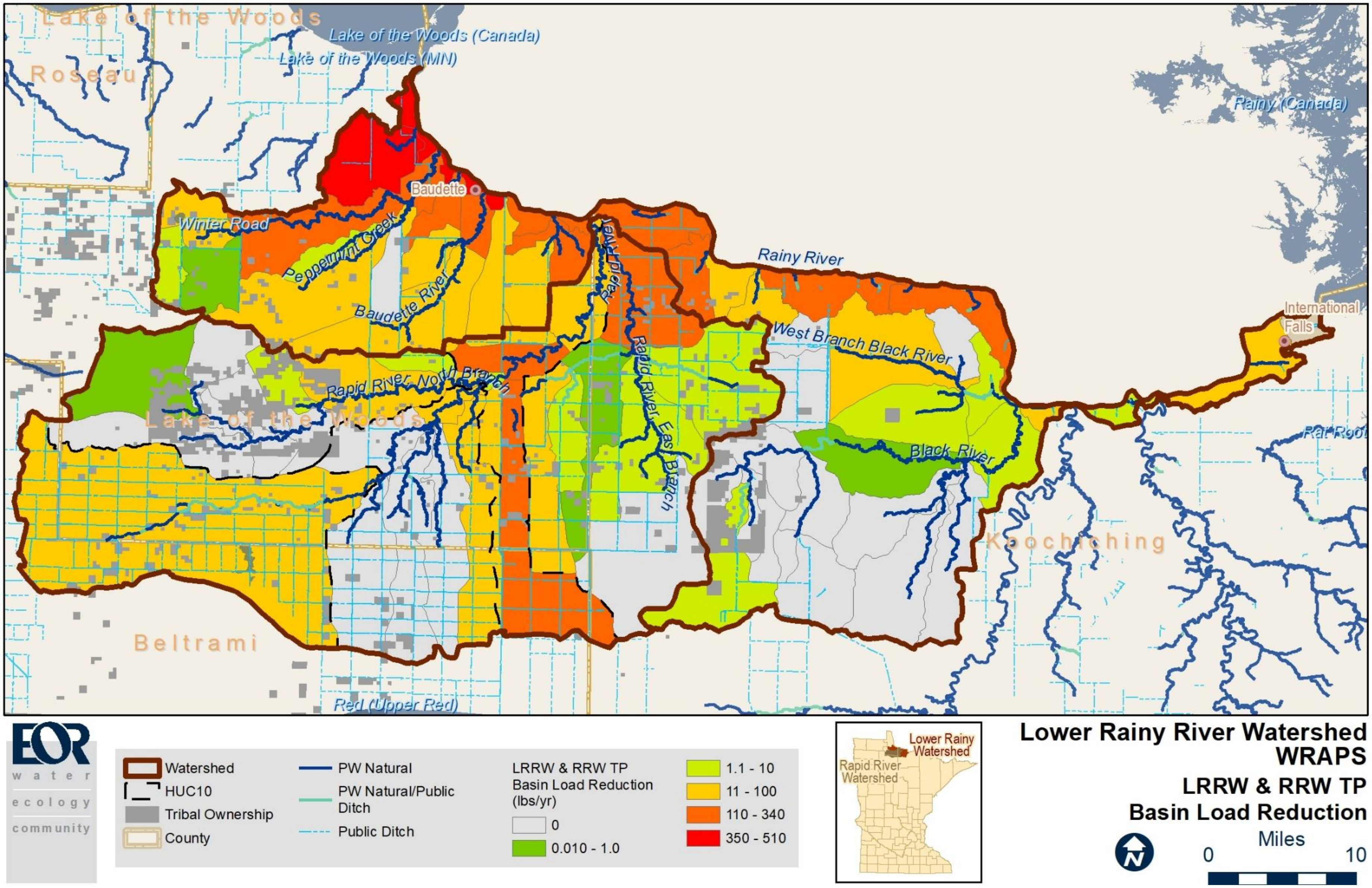


Figure 14. HSPF predicted total phosphorus basin load reduction in the Lower Rainy River Watershed and Rapid River Watershed.

Agricultural Parcel Scoring

To help target outreach efforts for siting agricultural BMPs in the LRRW, a process was developed using the parcels data for Lake of the Woods County and Koochiching County, a pollutant load layer derived from the Lower Rainy River HSPF model, and light detection and ranging (LiDAR)-derived digital elevation model (DEM). For more information on the pollutant load layer see Appendix 6.2. The process was derived to follow closely with the RAQ prioritization commonly performed to prioritize forest protection programs by public agencies concerned with water quality in Northern Minnesota. The first criterion was identification of the riparian areas next to lakes or streams, as these parcels can have a disproportionate impact on downstream water bodies. The second criterion was the parcel average pollutant yield derived from the predicted TP and sediment from the Lower Rainy River HSPF model. Urban and cropland parcels have higher estimated pollutant yields. The third criterion was the average slope in each parcel which was estimated from the LiDAR derived DEM. The total score is calculated by adding each of the criterion scores. The scoring values are listed in Table 18. The HUC-10 subwatersheds with the highest percentage of private land identified as having a priority of high and above are Sturgeon Creek-Rainy River Subwatershed and Winter Road River Subwatershed (Table 18).

Table 18. Riparian Pollutant Slope Scoring Criteria

Scoring Criteria:		
Riparian	3	Riparian
	2	Nonriparian: Shoreland (1 parcel back)
	1	2 parcels back
Pollutant	3	Parcels with predicted TP and Sediment yields in the top 25%
	2	Parcels with predicted TP and Sediment yields in the top 50%
	1	Parcels with predicted TP and Sediment yields in the top 75%
	0	Parcels with predicted TP and Sediment yields in the bottom 25%
Slope	3	The steepest 25% of parcels
	2	The steepest 50% of parcels
	1	The steepest 75% of parcels
	0	The flattest 25% of parcels

Table 19. Riparian Pollutant Slope Parcel Area Prioritization by HUC-10 Watershed in the LRRW

Agricultural Prioritization						
HUC-10 Name	HUC-10	Low Priority Area (ac)	Medium Priority Area (ac)	High Priority Area (ac)	Higher Priority Area (ac)	Highest Priority Area (ac)
West Fork Black River	0903000802	2,014	7,597	5,585	1,889	843
Black River	0903000803	3,852	13,441	4,814	5,006	2,666
Sturgeon Creek – Rainy River	0903000805	3,281	10,268	14,847	7,993	7,487
Winter Road River	0903000806	2,354	6,012	6,850	5,922	5,271
Rainy River	0903000807	6,818	15,850	13,308	8,905	6,372
Lower Rainy River	09030008	18,318	53,169	45,404	29,716	22,640

Agricultural Conservation Planning Framework GIS Toolset

The ACPF GIS toolset was used to identify potential locations for BMPs in the LRRW. The ACPF Toolbox includes tools to process high-resolution LiDAR-derived DEM. The processed DEM can then be used to prioritize agricultural fields, prioritize and classify riparian areas, and identify a suite of BMPs to address sediment and nutrient runoff.

The WASCOBs tool within the ACPF toolset was used to identify locations where potential grade stabilization structures could be built across drainageways in the watershed. Grade stabilization structures refer to a range of features, including earthen or cement dams and reinforced channels, and are typically sited within agricultural fields to reduce nutrient and pollutant loads, slow sheet flow runoff, and reduce the risk of gully formation. The WASCOBs tool was run for the entire LRRW. The tool was modified to identify locations for grade stabilization structures in nonagricultural areas as well because potential WASCOBs sited in these areas may be a result of streambed downcutting (incision) or other land changes. The specific targeted areas included gullies downstream of agricultural fields and gullies formed because of an incised stream channel. Modifications to the tool included:

- Expanding the siting analysis to nonagricultural lands; and
- Increasing the allowable drainage area to each grade stabilization structure to 50 to 640 acres instead of the default setting of 2 to 50 acres.

Three iterations of the modified WASCOBs tool were applied across the entire LRRW to identify potential grade stabilization structures. The first iteration used a standard WASCOB configuration of a 5-foot-high embankment to treat 2 to 50 acre drainage areas. In the second and third iterations, the drainage area parameter was increased to between 50 and 640 acres with either a 5-foot embankment (iteration 2) or a 10-foot embankment for iteration 3. The total number of grade stabilization structures, by configuration, identified for placement in the LRRW were determined (Table 19), as were the number of these practices within each HSPF catchment area (Figure 15).

Table 20. Grade Stabilization Structures Identified in the LRRW

Embankment Height	Drainage Area	Number of Structures
5	2-50	453
5	50-640	153
10	50-640	84
	Total	690

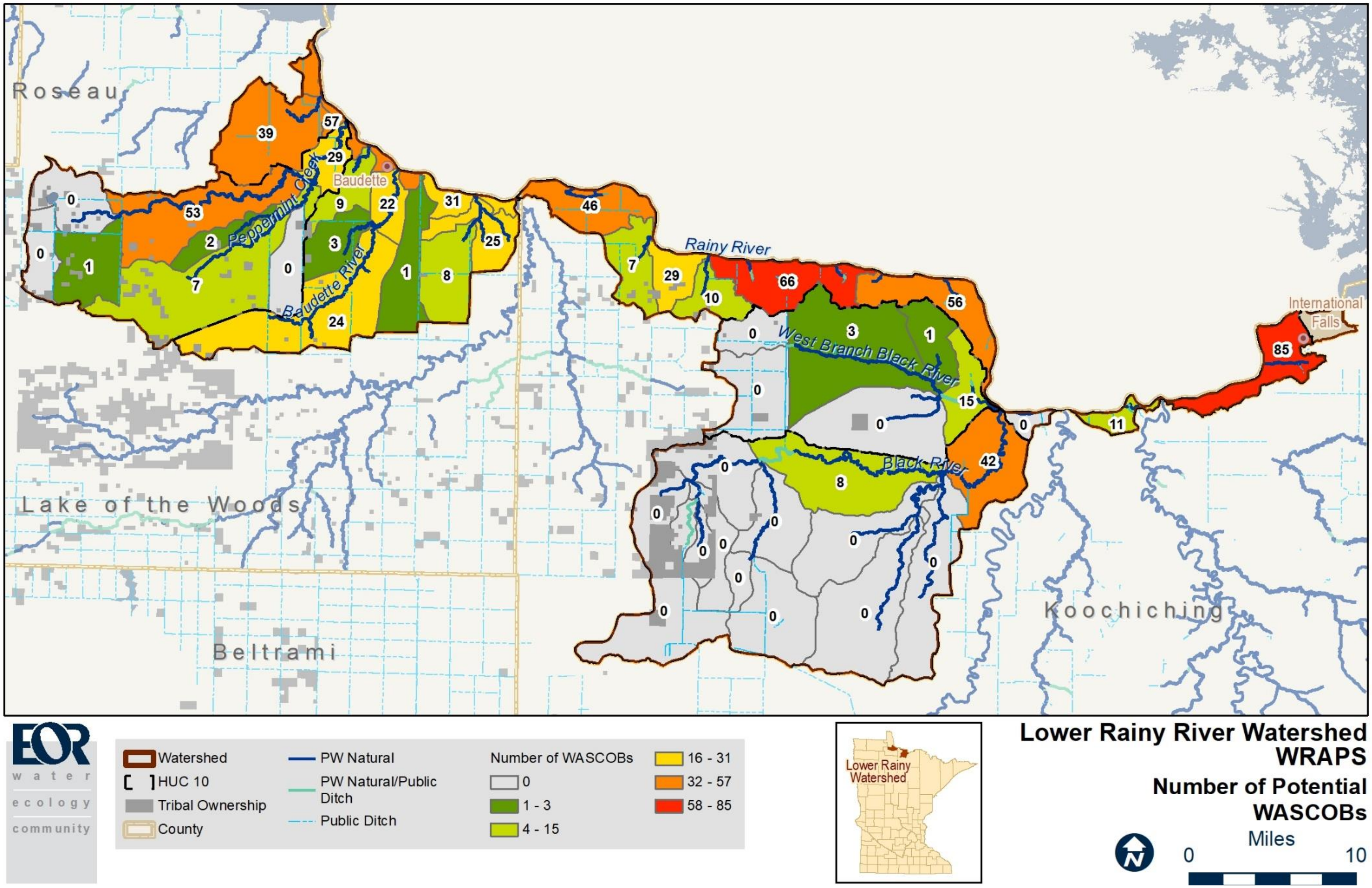


Figure 15. Predicted potential number of Water and Sediment Control Basins in the Lower Rainy River Watershed.

Small Grazing Operation Identification

Livestock operations in the LRRW are commonly small and graze animals on pastures. Typically, these types of livestock operations have less environmental impact than other types because most of the land is maintained in permanent vegetation. However, these operations can become sources of pollutants when livestock are allowed access to water bodies. Other areas such as exercise lots, over-wintering areas, and young stock lots where livestock have access to the same area for very long periods of time can also become problematic. Locations that have extended livestock access have been shown to contribute 10% to 60% of the total load from grazing operations (Vadas et al. 2012). In addition, small grazing operations were identified as having the potential to be a source of *E. coli* to the impaired stream reaches in the Black River. Small grazing operations often are not registered in Minnesota's Feedlot program. Therefore, a review of aerial imagery, including Farm Service Agency imagery from 2015, 2017, and 2019, along with Google Earth imagery, was used to identify areas in the watershed that showed evidence of extended livestock access. Evidence included pastures with large areas of exposed dirt, evidence of bail rings used to feed livestock, and piled manure near cattle barns. These areas were added to the registered feedlots in the LRRW. In total, 66 feedlots, including 27 registered feedlots and small grazing operations, were identified in the LRRW (Table 20). The potential TP load reduction from implementing improved pasture management practices was estimated to be between 750-4,500 lbs/yr and a cost of $650,000 per year (Table 22). Figure 16 shows the number of identified small feedlot operations identified in the LRRW.

Table 21. Feedlots and Small Grazing Operation summarized by HUC-10 in the LRRW

HUC-10 Name	HUC-10	Number of Feedlots
West Fork Black River	0903000802	3
Black River	0903000803	4
Sturgeon Creek – Rainy River	0903000805	26
Winter Road River	0903000806	11
Rainy River	0903000807	22
Lower Rainy (HUC-8 Total)	09030008	66

Table 22. Pollutant Load Reduction and Cost Estimates for Pasture Management Improvements

Description	Assumption	Total Phosphorus Load (lbs/yr)	Sediment Load (tons/yr)
Total Load from all activities	HSPF downscaled loads	9,000	4,000
Total Load from areas with extended livestock access	10%-60% of the Total Operation TP load (Vadas et al. 2012)	900-5,400	400-2,400
Load Reduction from improved pasture management and feedlot runoff control	83% TP Reduction and 79% TSS Reduction from Feedlot Runoff Control (Lenhart et al. 2017)	750-4,500	320-1,900
Grassland Area within land owned by feedlot operations (ac)	Lake of the Woods 2010 Land Cover	1,161	

Description	Assumption	Total Phosphorus Load (lbs/yr)	Sediment Load (tons/yr)
Cost	2017 Practice Average Annual Cost for Prescribed Grazing adjusted for Inflation to 2021 $335.80/ac/yr	$390,000	
	2017 Practice Average Annual Cost for Heavy Use Area Protection adjusted for Inflation to 2021 (Excluding Liquid Tight Reinforced Concrete Flatwork) $3,888.45/farm/yr	$260,000	

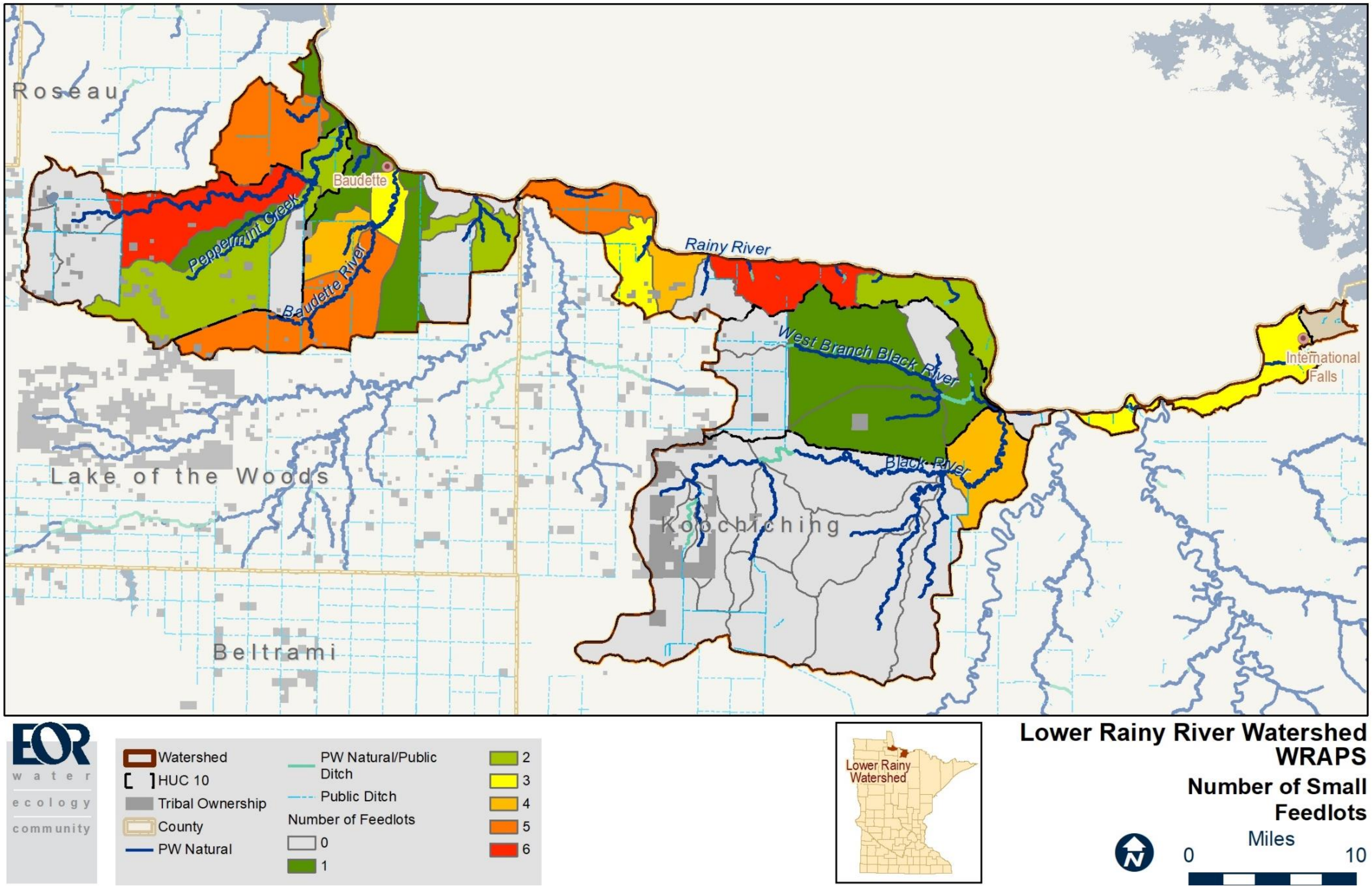


Figure 16. Number of small feedlots identified in the Lower Rainy River Watershed.

E. coli Source Geographic Information System Review

To identify potential sources of *E. coli* in the Black River Subwatershed, GIS was used to review aerial photography. The review identified households and feedlots in the watershed. The households were identified because the subsurface sewage treatment systems (SSTS) can contribute *E. coli* directly to surface waters. SSTS that contribute *E. coli* directly to surface waters are classified as imminent threat to public health and safety (ITPHS). In Koochiching County an estimated 10% of SSTS may be ITPHS. Feedlots were identified in the watershed because poor pasture management and livestock access to streams were identified as a likely source of *E. coli* in the Black River Subwatershed. The identified feedlots were intersected with the landowner layer for the watershed to identify the areas where cattle may have excess to the stream. Using the grassland classification in the 2010 Lake of the Woods Rainy River Basin Land Cover dataset the estimated pasture area in the watershed was estimated. The results of the GIS review are shown in Table 23. With 58 households and an estimated 10% of septic systems ITPHS, there are estimated to be 6 septic systems that might be contributing to *E. coli* to the Black River system. The actual number of ITPHS in the watershed will need to be verified with a compliance check conducted throughout the identified households in the watershed.

The average costs of a septic system in Minnesota is approximately $20,000 for a mound system, and approximately $15,000 for a trench system. These estimates are only estimates and each site will require different approaches. As an example, wetland conditions require different approaches to bedrock installed systems. If one were to estimate an average cost, inclusive of potential environmental conditions on-site, it may be approximately $30,000. The average cost of the 6 systems would be approximately $180,000.

The cost for reducing the *E. coli* loads from small feedlots and livestock was estimated using average annual cost estimates for prescribed grazing and feedlot runoff reduction in the Agricultural BMP Handbook for Minnesota 2017. Adjusted for inflation to 2021 the unit cost for pasture improvement was estimated to be $335.80/ac/yr and for feedlot runoff control $3,888.45/farm/yr. The total cost to improve all the identified small feedlot operations in the Black River Subwatershed was estimated to be $210,000/yr. The actual cost to improve the feedlots in the subwatershed will require a field visit to identify opportunities for improved management.

Table 23. Potential Sources of *E. coli* in the Black River Watershed

Stream (AUID)	Number of Households	Estimated Number of ITPHS	Number of Small Feedlots	Estimated Pasture Area (acres)
West Fork Black River (09030008-543)	11	1	3	299
Black River (09030008-547)	47	5	4	251
Total	58	6	7	550

Urban Best Management Practice Identification

Developed areas commonly have a high percentage of impervious surfaces, and runoff from these surfaces can contribute significantly to water quality issues. In the LRRW, such areas are predicted to contribute approximately 11% of the sediment load and 7% of the TP load. The largest developed areas in the watershed are the cities of International Falls and Baudette, followed by a developed area between Baudette and the Lake of the Woods along Highway 172. To combat higher pollutant loads and flooding in urban areas, a wide variety of urban-specific runoff BMPs can be installed as retrofits or as part of initial development. Stormwater BMPs built during new development can reduce the impact of that development on downstream water bodies. Information about these practices can be found in the Minnesota Stormwater Manual.

For the LRRW, the stormwater BMP treatment area needed in the urban areas to match the load reduction allocated to the LRRW was estimated from the Lower Rainy River HSPF model. The treatment area was estimated so that the predicted TP load from the developed area along Highway 172, Baudette, and International Falls was reduced by 4.6%, the reduction needed from LRRW to achieve the Lake of the Woods Excess Nutrient TMDL. The City of International Falls is expected to be subject to a municipal separate storm sewer system (MS4) permit in the future and was assigned a load reduction of 504 lbs per year in the Lake of the Woods Excess Nutrient TMDL. The wasteload allocated to International Falls corresponds directly to the percent area of the City within the TMDL Study Area. International Falls accounts for 0.026% of the Lake of the Woods TMDL Study Area, so the TMDL process assigned 0.026% of the Lake of the Woods loading capacity to the City.

To estimate loads more accurately from developed areas, analyses should include only areas directly connected to storm sewer systems. These areas likely contribute the greatest load because they do not receive treatment by flow through natural areas that remove some pollutants from runoff. For the developed areas in LRRW, the Sutherland equations were used to estimate the percentage of the developed areas that were directly connected to the storm sewer system (Sutherland 2000). These equations were developed to estimate the area of directly connected impervious surface in a range of development conditions as a function of total impervious surface. The load reductions and cost for green infrastructure BMPs were approximated using default values for bio-retention in the HSPF model which were a 61% TP reduction and a unit cost of $1263.12/ac/yr. The estimated cost includes design, permitting, construction, and maintenance cost.

The estimated treatment area, cost, and TP load reduction are shown in Table 24. The developed area along Highway 172 had the largest load reduction because it had the largest area. Most of the area along Highway 172 is still developing; however, most of the load comes from undeveloped areas. As the area along Highway 172 develops, there will be some load reduction from areas of cropland converted to urban land, assuming stormwater treatment is installed. In addition, BMPs can be built to treat the newly developed areas, which can be more cost effective than retrofits.

To start the process of identifying potential green infrastructure BMPs, potential retrofit locations were identified in GIS using LiDAR-derived DEM and aerial imagery. Locations were noted where water may already be flowing to or in areas of open space near large impervious areas, which generate large runoff volumes that should be treated to reduce their impact on downstream waters. In total, 316 retrofit locations were identified in the LRRW (Figure 17 for Baudette and Figure 18 for International Falls). These locations should be prioritized in future projects when more information about the city's infrastructure, planning priorities, and field level constraints are known. Several BMP types are feasible for runoff reduction (Figure 19 and Figure 20). Because infiltration effectively removes pollutants and reduces runoff volumes, areas where infiltration is feasible should be prioritized. Effectiveness largely depends on the presence of hydrologic soil groups A, B, and C, which refer to a classification of soils categorized by their runoff potential and sand content. However, most of the soils around Baudette and International Falls have low infiltration capacity with hydrologic soils of D, A/D, B/D, and C/D. More information about soil classification can be found at the USDA Web Soil Survey: https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm.

Table 24. Summary of the Green Infrastructure BMP Treatment Area, TP Load Reduction, and Cost for the Developed Area Along Highway 172, Baudette, International Falls, and Rainier

	Highway 172 Developed Area		Baudette		International Falls		Rainier	
Land Cover	Area (ac)	TP Load (lbs/yr)	Area (ac)	TP Load (lbs/yr)	Area (ac)	TP Load (lbs/yr)	Area (ac)	TP Load (lbs/yr)
Undeveloped	7,083	1,530	1,851	529	1,416	201	93	11
Developed	1,918	875	941	526	2,420	2366	298	349
Total	9,001	2,405	1,386	1,055	3,836	2567	391	360
Load Reduction (lbs/yr)		111		49		118		17
Treatment Area (ac)		397		142		332		36
2021 Cost ($/yr)		$500,000		$180,000		$420,000		$50,000
Estimated developed area directly connected to curb or storm sewer system (%)		21%		34%		50%		67%

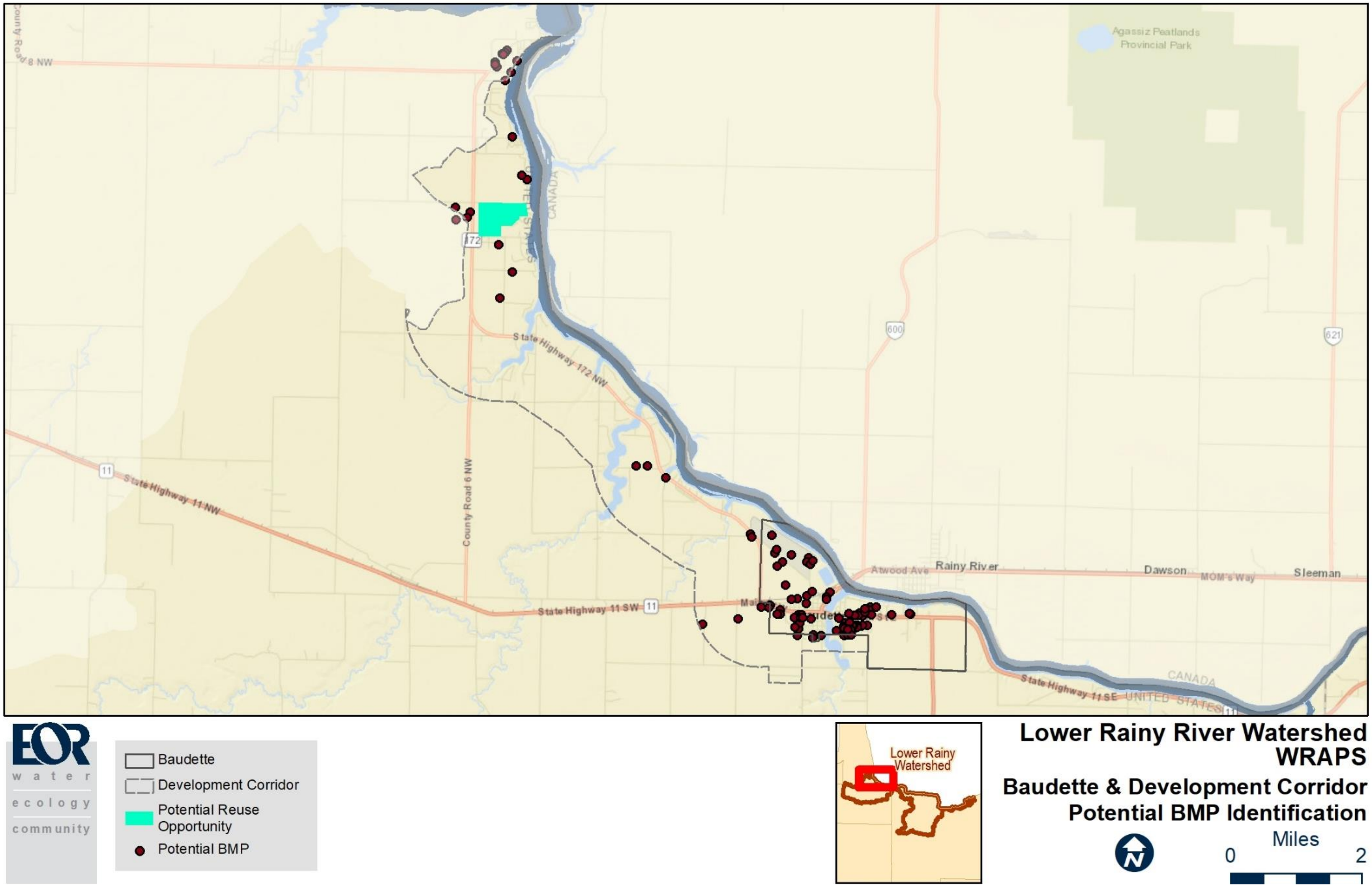


Figure 17. Potential green infrastructure BMPs in Baudette and the developed area along Highway 172 identified from aerial photography.

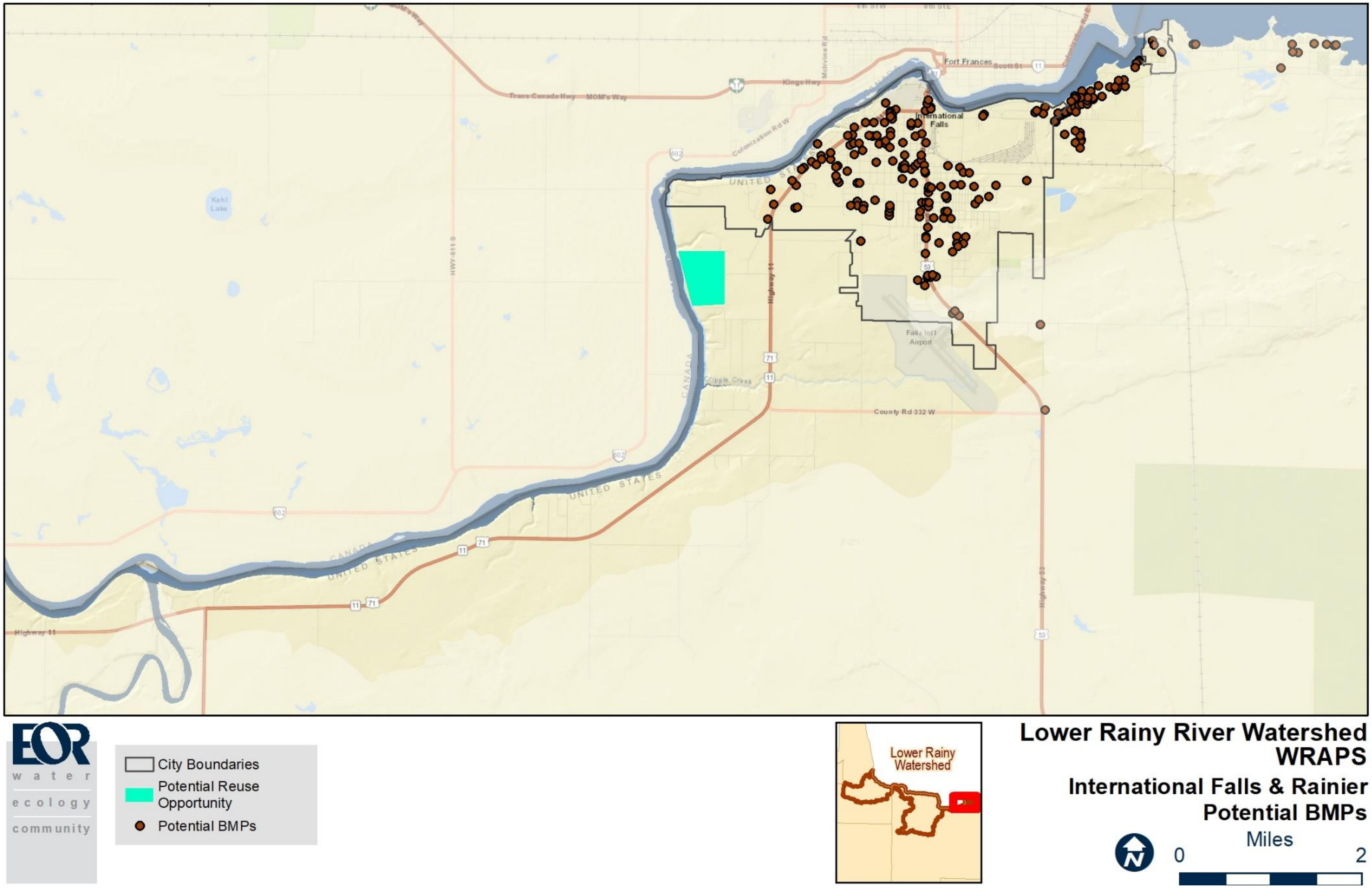


Figure 18. Potential green infrastructure BMPs identified in International Falls from aerial photography.

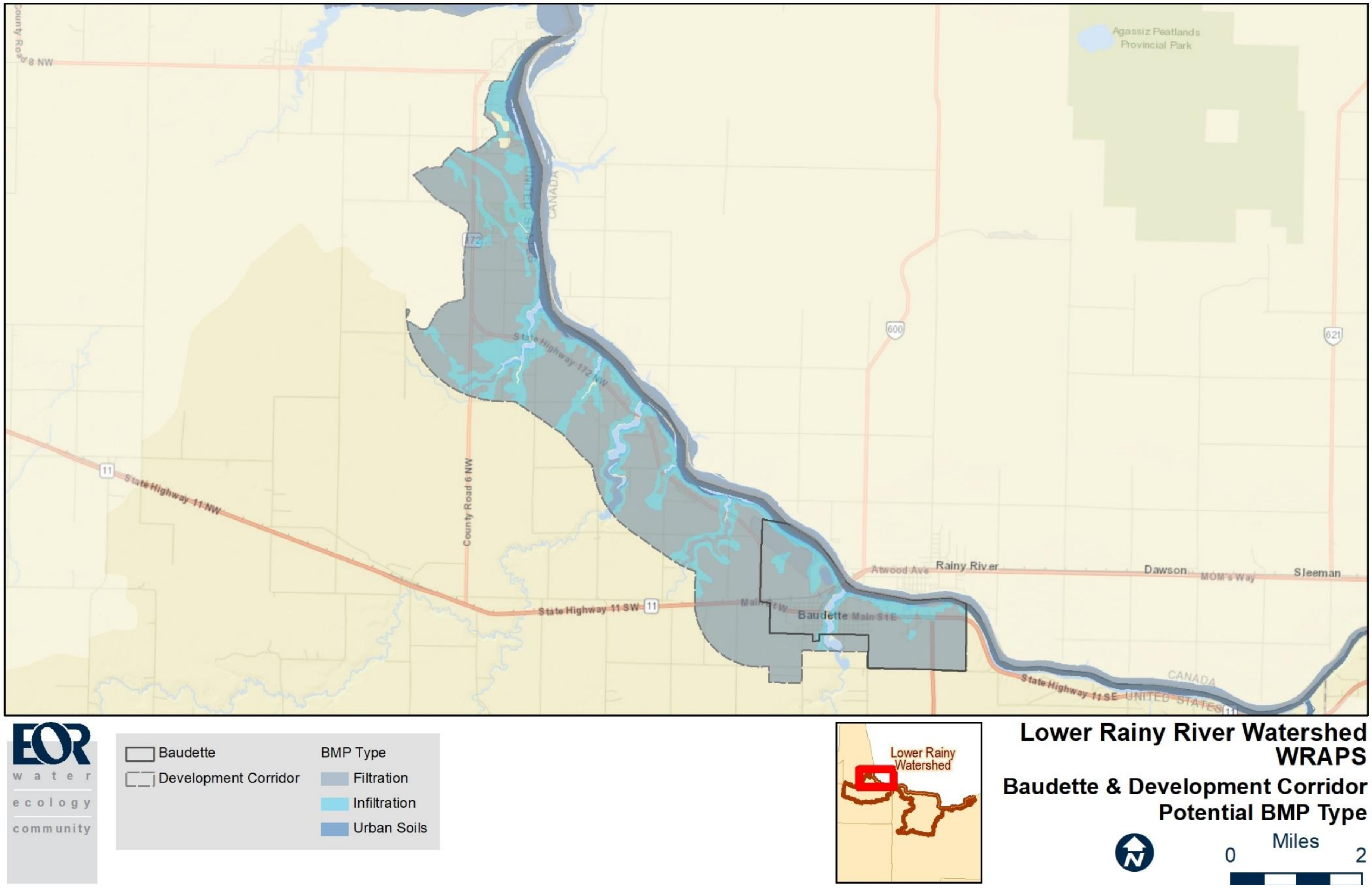


Figure 19. Potential green infrastructure BMP type in Baudette and the developed area along Highway 172 based on the NRCS soils data.

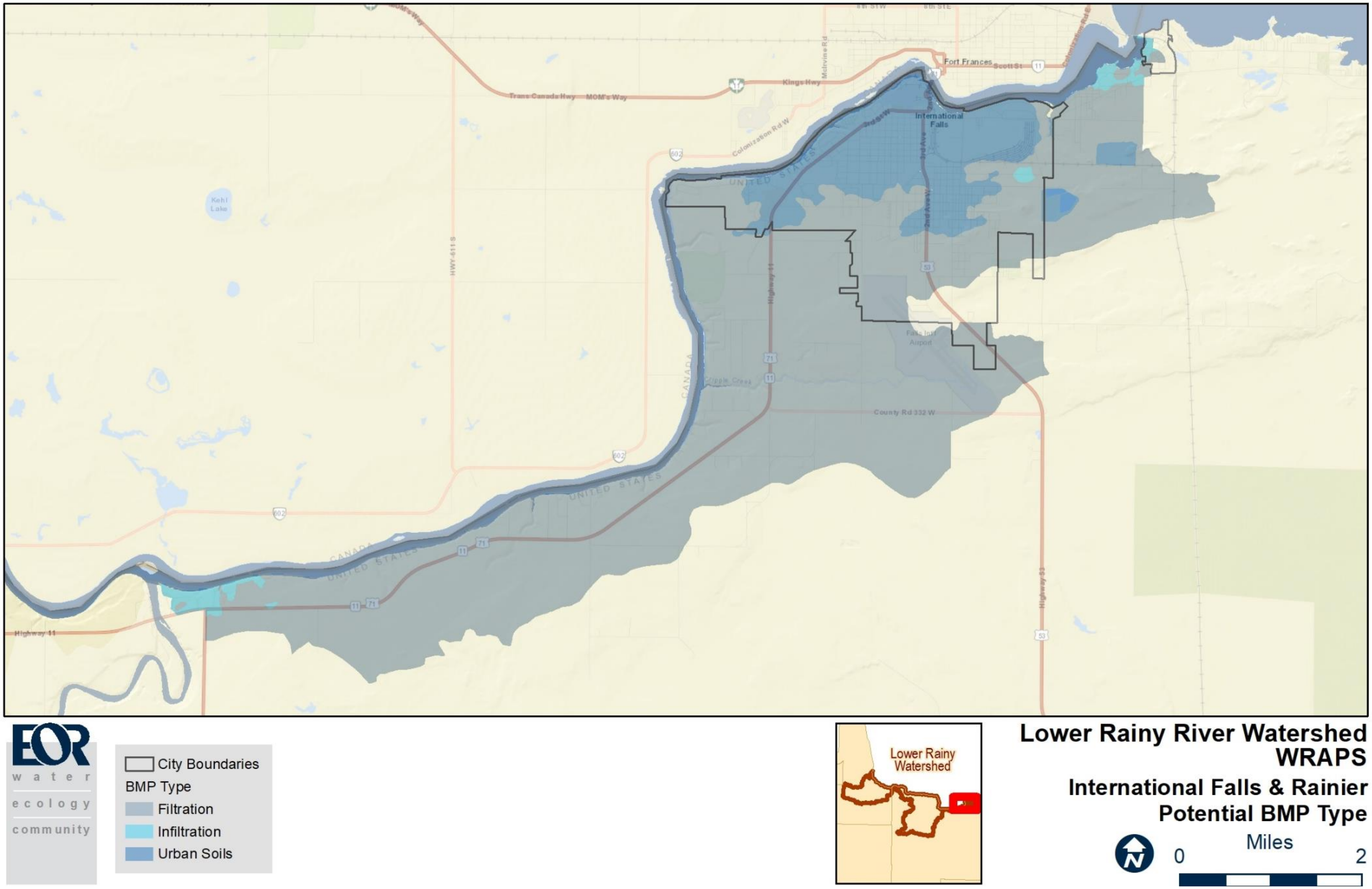


Figure 20. Potential green infrastructure BMP type in International Falls and Rainier based on the NRCS soils data.

Riparian Adjacency Quality Parcel Scoring

The RAQ process is a method developed by BWSR Technical Services Area 8 in northern Minnesota to help target outreach efforts about forest protection programs to landowners with large tracts of forested land (BWSR 2021). Protection programs aim to secure at least 75% of a watershed under a protected status. According to Jacobson et al. (2016), lakes surrounded by at least 75% forested land were found to be sufficiently protective of fish habitat by keeping phosphorus levels in check. The targeting focuses on three criteria and employs a simple GIS based scoring system. Each parcel receives a score between 0 and 10 with up to 3 points given for each RAQ criteria, except for quality (described below), which can achieve up to 4 points.

First, riparian ’R’ refers to parcels that are next to lakes or streams as these parcels can have a disproportionate impact on nearby water bodies. Second, adjacency ’A’ refers to parcels next to other parcels of land that are already protected in some way. Adjacency is important because large continuous tracts of forest are preferred over scattered parcels throughout the watershed. Lastly, quality ’Q’, the most subjective criteria, refers to protecting areas that have unique and important characteristics. Quality is used to include locally important characteristics into the prioritization. For the WRAPS, the following layers were included in the prioritization:

- Outstanding Resource Value Waters (MPCA)
- Old Growth Forests (DNR)
- Lakes with Exceptional IBI Scores (DNR)
- Drinking Water Supply Management Areas (MDH)
- Medium High or High Wildlife Action Network Score (WANS) (DNR)
- Priority Shallow/Waterfowl Lakes
- White Cedar Communities
- Audubon Important Bird Areas (IBAs)
- Rare Species (DNR)

The RAQ score is tabulated by adding the scores from each criterion. The scoring values are listed in Table 24. The highest priority parcels for protection have scores greater than eight and the max score is ten. The RAQ prioritization results are summarized by HUC-10 in Table 26. The results show that with the public land, which are assumed to be protected, and the existing percentage of land currently enrolled in a forest protection program, three of the five HUC-10 watersheds in the LRRW exceed the 75% goal developed for forested watersheds in northern Minnesota (BWSR 2021,Table 27). Approximately, 24% of the additional forest protection strategies prioritization will occur locally to address parcelization and resource needs.

Table 25. Riparian Adjacency Quality Scoring Criteria

Scoring Criteria:		
Riparian	3	Riparian
	2	Nonriparian: Shoreland (1 parcel back)
	1	2 parcels back
Adjacency	3	2 sides touching public land
	2	1 side touching public land
	1	1 parcel removed from public land or touching parcel with Sustainable Forest Incentive Act (SFIA) land or easement
Quality	4	1 point for each feature that the parcel touches. The max score is 4.
	3	
	2	
	1	

Note: Rare species data included in the RAQ scoring: Copyright 2020, State of Minnesota, Department of Natural Resources. Rare species data included here were provided by the Division of Ecological and Water Resources Division, Minnesota Department of Natural Resources (DNR), and were current as of May 2020. These data are not based on an exhaustive inventory of the state. The lack of data for any geographic area shall not be construed to mean that no significant features are present.

Table 26. RAQ Parcel Area Prioritization by HUC-10 Watershed in the LRRW

Forest Protection Program Prioritization											
		Low Priority		Medium Priority		High Priority		Higher Priority		Highest Priority	
		Enrolled (ac)		Enrolled (ac)		Enrolled (ac)		Enrolled (ac)		Enrolled (ac)	
HUC-10 Name	HUC-10	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
West Fork Black River	0903000802	193	663	1,316	1,849	2,717	6,835	1,226	1,557	475	1,097
Black River	0903000803	0	0	788	4,464	2,747	10,513	1,613	6,167	989	2,501
Sturgeon Creek – Rainy River	0903000805	6,849	1,669	13,326	4,302	8,024	3,782	3,296	2,003	681	0
Winter Road River	0903000806	2,981	439	`8,068	1,606	8,079	2,073	2,387	580	81	119
Rainy River	0903000807	11,006	672	19,616	2,547	13,020	1,099	3,091	160	0	46
Lower Rainy River	09030008	21,028	3,444	43,116	14,768	34,587	24,301	11,612	10,468	2,226	3,763

Hydrologic Unit Code (HUC-10)

Table 27. Forest Protection Area and Goals by HUC-10 in the LRRW.

HUC-10 Name	HUC-10	Total Area (ac)	Public Land (ac)	Forest Program Area (ac)	Protected Area (Percentage of Total Area)	Goal	Goal Met
West Fork Black River	0903000802	81,566	63,515	12,002	93%	75%	X
Black River	0903000803	173,522	143,360	26,646	98%	75%	X
Sturgeon Creek – Rainy River	0903000805	77,392	21,468	11,756	43%	75%	
Winter Road River	0903000806	94,778	67,039	4,818	76%	75%	X
Rainy River	0903000807	101,816	44,860	4,523	48%	75%	
Lower Rainy River	09030008	529,074	340,242	56,744	65%	75%	

Hydrologic Unit Code (HUC-10)

Summary

Prioritization and targeting of areas in the LRRW were accomplished at several different scales including by aggregated HUC-12 subwatersheds, by HSPF subbasins, by landowner property, and by individual parcels. Targeting of practices was mostly oriented towards meeting the Lake of the Woods Excess Nutrient TMDL. The predicted treatment areas, load reduction, and cost for each BMP considered as part of the WRAPS were determined (Table 27). The predicted TP load reduction is greater than the allocated TP load reduction in the LRRW, which is equal to 5,199 lb/yr. In addition, within the impaired stream reaches of the Black River and the West Fork Black River, potential sources of *E. coli* were identified to facilitate improvement in water quality (Table 23). The predicted results show one option for achieving the recreational water quality goals in the LRRW. Actual BMP implementation depends on landowner participation, funding, and local landscape characteristics.

Table 28. Summary of Predicted Adoption, Load Reduction, and Cost Estimate to achieve the Lake of the Woods Excess Nutrient TMDL for the LRRW.

BMP Type	Treated Area (ac)	TP Load Reduction (lb/yr)	Cost Estimate ($/yr)
Feedlot and Pasture Management	1,161	750	$650,000
Green Infrastructure Retrofits Baudette and the Development Corridor	541	157	$680,000
Green Infrastructure Retrofits International Falls and Rainier	368	135	$470,000
No Till	17,608	2,886	$200,000
Riparian Buffers Extended to 100 ft	4,547	511	$120,000
Restore Tiled Wetlands	2,719	212	$100,000
WASCOBs	3,522	353	$200,000
Conservation Crop Rotation	11,599	394	$490,000
Nutrient Management Plan	10,277	69	$110,000
Total		5,467	$2,990,000

3.2 Public participation

Public participation and engagement refer to education, outreach, conservation marketing, training, technical assistance, and other methods of working with stakeholders to achieve water resource management goals. Public participation efforts vary greatly depending on the water quality topic and location in the state. It is important in any public participation effort to clarify public participation goals, and all efforts should have some evaluative component to show progress towards reaching the identified goals. Each meeting held included informal evaluation to understand needs of participants and how to make the meeting logistics as best as possible for the participants.

Accomplishments and future plans

The SWCD and other local government units will continue conducting the public outreach efforts that were initiated before and during the WRAPS process. They will also continue to utilize existing established groups such as the Rainy/Rapid River Board (Lower Rainy Watershed) and Little Fork/Rat Root River Board (Rainy River-Rainy Lake Watershed). Measurable goals, and possible steps to reach these goals, for future public participation efforts in the Lower Rainy and Rainy River-Rainy Lake include:

- Increase the number of watershed residents participating in water quality discussions.
    - Meetings of the Rainy/Rapid River Board will continue, with a shared goal of increasing participation in coordination with all related local government units.
- Engage citizens in a meaningful way. Continuing to build relationships with and between citizens throughout the watershed will support implementation activities. Successful efforts will be continued, and new opportunities sought.
    - Participate in community events such as those put on by the local chapter of the Deer Hunter's Association and Voyageurs National Park, for example.
    - Seek additional outreach opportunities to existing community and natural resource management groups (sportsmen's clubs, civic groups, local governments, etc.).
    - Engage youth through educational opportunities such as, but not limited to:
        - Envirothon
        - Annual Outdoor Education Days event for 5th graders
        - Local classroom education as requested
- Increase education and communication of water quality activities within the watershed on a variety of natural resource management topics including forestry, aquatic invasive species, altered hydrology, agricultural BMPs, and more. There may be funding needs identified for technology or other resources to implement these strategies. Through the WRAPS process, the following education efforts have been completed and will continue:
    - Utilize successful communication strategies such as radio, newspapers, social media, and websites;
    - Participate in the annual Civic Engagement Workshop held March of each year in association with the Rainy-Lake of the Woods Water Quality Forum;
    - Online meetings and workshops that were recorded and available for later viewing;
    - Online survey developed and distributed;
    - Annual newsletters distributed to landowners in the watershed;
    - Updates on the Koochiching SWCD website and social media;
    - Public Participation Plan completed (January 25, 2020).
- Coordination of agencies through the core committee format established during the WRAPS process to bolster communication between all the partners. Relationships between government staff will be key to moving the WRAPS strategies forward and these should be fostered into the future. This core committee will make it easier to keep that connection and carry partnerships forward with a cohesive watershed identity.
- If the strategies in the WRAPS report are promoted with input from local land managers, the likelihood of implementation will increase. In addition, implementation activities will be streamlined due to the collaboration between landowners, local agencies, and funding sources.

- Strategies identified in the WRAPS will also assist the One Watershed, One Plan effort in this watershed and increase the likelihood of success through prioritization, targeting, and success will be measurable

The MPCA along with the local partners and agencies recognize the importance of public involvement in the watershed process. Table 29 summarizes the opportunities used to engage the public and targeted stakeholders in the watershed.

Table 29. Lower Rainy River Public Participation Meetings

Date	Location	Meeting Focus
5/18/2017	Baudette	SWAG Open House
5/22/2017	Ranier	SWAG Open House
10/23/2017	Ranier	WRAPS Open House
10/24/2017	Birchdale	WRAPS Kick-off
4/25/2019	Baudette	Professional Judgment Group Meeting – review proposed impairments
12/17/2019	WebEx in International Falls	Impairments Public Meeting
3/17/2020	Baudette (canceled due to COVID-19)	Forestry Management/WRAPS public meeting
3/18/2020	Ranier (canceled due to COVID-19)	Forestry Management/WRAPS public meeting
10/20/2020	WebEx	Public informational meeting
10/20 – 11/03 2020	Online	Public Survey
10/27/2020	WebEx	Public Input Meeting

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 April 4, 2022 through May 4, 2022. There was one comment received and responded to as a result of the public comment period.

3.3 Restoration and protection strategies

Agricultural BMPs

With 13,496 acres of the LRRW in cropland according to the Lake of the Woods 2010 Land Cover dataset, agricultural BMPs can help restore and protect downstream water bodies. Agricultural BMPs have been developed to fit a wide range of conditions that will reduce, control, and trap pollutants leaving agricultural areas, and several of these are suggested for the LRRW (Table 30). The actual BMPs used in the watershed will depend on landowner participation, funding, and local landscape characteristics. For a complete list of agricultural BMPs see the Natural Resources Conservation Service (NRCS) Field Office Technical Guide. Agricultural BMPs are also available for pasture areas and riparian areas. These practices are discussed in more detail in the following sections.

Table 30. Agricultural BMPs highlighted in the Lower Rainy River Watershed targeting analysis.

Strategy	Practice Type	Applicable standards (NRCS standard or Ag BMP reference)
Tillage/Residue Management	No-till or conservation tillage	329,329a
Buffers – Field Edge	Riparian Buffers 100+ ft wide	391
Agricultural Tile Drainage	Wetland Restoration	657/658
Designed Erosion Control and Trapping	Water And Sediment Control Basins	638
Changing crop rotation to less erosive crops	Conservation Crop Rotation (add more perennials)	328
Nutrient Management Plans	Nutrient Management (fertilizer, soil, manure)	590

Pasture/manure management

Pasture and manure management strategies tend to focus on manure containment strategies. In the LRRW there are approximately 26 registered feedlots and approximately 40 unregistered feedlots with fewer than 50 animals. Despite the relatively low numbers of facilities, feedlots can pose a risk to water resources, especially when they are in close proximity to waterways. As such, the primary focus in pasture management in the LRRW should be protecting and or limiting the extent of heavy use areas. Heavy use areas refer to areas where animals frequently congregate, limiting plant growth and creating areas of exposed, unprotected soil. These areas can border water, feed, shade, and exercise lots. The main strategy for limiting the extent of heavy use areas is rotational grazing where the animals are periodically rotated to different new pastures allowing grass to recover. This strategy may be difficult for the small feedlots in the LRRW, which may not have enough land. Protection strategies include building gravel or concrete pads below watering areas and feeding areas. For these types of strategies, it may be necessary to include wastewater filter strips or clean water diversions to clean and divert the runoff from the protected areas. Wastewater filter strips consist of a strip of permanent herbaceous vegetation that receives runoff from a feedlot or basin. Clean runoff diversions are any diversion that moves clean water around the lot to reduce the runoff volume from the feedlot. Diversions may consist of roof gutters, drip trenches, berms, or channels that divert clean runoff. For some facilities constructing a roof above the protected area may be necessary.

Urban BMPs

Urban areas can contribute to the degradation of downstream water bodies through the rapid transport of pollutants from impervious areas. To mitigate these negative impacts from urban areas, national, state, and local policies have been developed to manage stormwater from newly developed areas. In Minnesota the NPDES permit requires the treatment of stormwater up to the 1-inch storm and a TSS Removal of 80%. Additional benefits can be established through local ordinances that require further treatment of stormwater beyond that of the NPDES permit or through the construction of retrofit BMPs. Retrofit BMPs are BMPs built to capture and treat runoff from existing development. Retrofit BMPs are especially important in older neighborhoods built before permitting requirements where most of the runoff is untreated. Many potential retrofit BMP locations were identified in Section 3.1. Further analysis, including a field visit, should be completed to assess the feasibility of the identified locations through a stormwater retrofit analysis for each of the urban areas in the LRRW, including the developed area along Highway 172, Baudette, International Falls, and Rainier. With the verified list of potential

BMPs, an estimated pollutant reduction and cost associated for each BMP can be calculated and used to prioritize future work in the cities.

Forest Protection Program

Minnesotans tend to hold strong conservation values. Citizens of Minnesota have long recognized the value of forests for keeping waters clean, and thus supported the creation of various legislative conservation programs that help conserve working land forests. Because of this ethos, the well-managed forestlands and forested wetlands have helped maintain the excellent water quality of the LRRW.

Forestland and forested wetlands rank among the best land cover for providing clean water by absorbing rainfall and snow melt, slowing storm runoff, recharging aquifers, sustaining stream flows, filtering pollutants from the air and runoff before they enter waterways, and providing critical habitat for fish and wildlife. In addition, forested and wetland-rich watersheds provide abundant recreational opportunities, help support local economies, provide an inexpensive source of drinking water, and improve the quality of our lives.

Fortunately, many subwatersheds in the LRRW are already forested and protected by public ownership (federal, state, and county). Forest protection programs (Table 31) play a major role in ensuring private forest lands stay working forest lands to provide optimal ecosystem services such as wildlife habitat, enhanced water quality, carbon sequestration, and many other benefits, while providing landowners with a monetary incentive to keep the land forested. Table 31 applicable forest protection programs that will best allow the LRRW to continue to maintain its biological integrity and provide healthy waters by promoting forestland stewardship. See the DNR Forest Stewardship webpage for additional information: https://www.dnr.state.mn.us/foreststewardship/index.html. Lands in the LRRW that are protected through conservation easements, forest protection programs, or public ownership were mapped (Figure 6).

Table 31. Forest Protection Programs in the LRRW

Forest Protection Program	Applicability to the LRRW
Forest Stewardship Plan	An instrumental plan for family forest landowners who own 20 acres or more of forestland. This voluntary plan offers land management recommendations to landowners based on their goals for their property from a natural resource professional. Plans are updated every 10 years to stay current with landowner needs and woods. A Forest Stewardship Plan registered with the DNR qualifies the landowner for woodland tax and financial incentive programs.
Sustainable Forest Incentive Act (SFIA)	The SFIA is a tax incentive program available for landowners that have a registered Forest Stewardship Plan. This program offers an annual tax incentive payment per acre based on the amount of forest stewardship acres the landowner has. Payments per acre range from the $9-$16.50, based on the length of covenant the landowner decides to enroll into. The SFIA restricts land use conversion and subdivision of the parcel(s). A minimum of three acres must be excluded from the SFIA program if there is a residential structure present, landowners can exclude more acres if they plan to make future improvements on the land.
Conservation Easements	Most, but not all conservation easements are perpetual. Some landowners want to ensure their land will never be developed or converted to another use by selling or donating a conservation easement. Conservation easements serve a variety of conservation purposes and are generally intended to protect important features of the property. They are voluntary, legally binding agreements by the landowner to give up some of the rights associated with their property such as the right to develop, divide, mine, or farm the land to protect the conservation features such as wildlife habitat, water quality, and forest health, to name a few
Land Acquisition	Land acquisition is an option to permanently protect the land by selling the land to a conservation organization, agency, or other land trust. Once purchased land is restored or maintained to perpetually protect important natural resource values.

Timber Harvesting BMPs

Without timber harvesting BMPs, erosion during and after timber harvesting can be a source of sediment in forested areas. Studies have shown that fine sediment levels increased in streams after timber harvesting, with streambank instability increasing for several years and windthrow (toppled trees) occurring more frequently than in years prior to major timber harvesting (Edwards and Williard 2010). The same study found that higher sediment levels in nearby streams persisted for up to 10 years and only dissipated after a very large storm event flushed the sediment out of the system. Causes of erosion during and after timber harvesting include: the use of heavy equipment, which can create ruts and gullies; skid trails where logs are repeatedly dragged to the landing area; and the rapid change in vegetation cover. In Minnesota, timber harvesting is generally done over a small percentage of a watershed, thereby limiting, and localizing these effects.

Several BMPs have been found to be effective at reducing the erosion from timber harvesting. Studies have estimated that the use of BMPs can result in sediment reduction between 53% to 94% compared to timber harvesting without BMPs (Edwards and Williard 2010; Cristan et al. 2019). In the LRRW timber harvesting BMP implementation is monitored by the Minnesota Forest Resources Council (MFRC). Recommendations for the management area containing the LRRW are in Table 32 (Rossman et al. 2018). The MFRC determined that adoption of timber harvesting BMPs were not being followed as closely as envisioned. These BMPs include maintaining riparian management zones, avoiding wetland crossings, locating landings outside of wetlands and filter strips, retaining more leave trees, and limiting the extent of infrastructure in the timber harvesting area.

Table 32. Summary of Recommendations for the Lower Rainy River Watershed (Rossman et al. 2018)

Best Management Practice	Estimated Implementation	Description
Minimizing Soil Exposure on Filter Strips	80%	Filter strips are vegetated areas adjacent to water bodies that are used to trap and filter out suspended sediment and potential pollutants prior to reaching surface water resources.
Installation of erosion control on approaches where needed	99%*	Portions of forest roads and landings close to water bodies should use erosion control to minimize erosion.
Maintaining Riparian Management Zones (RMZ)	71%	RMZs are riparian areas adjacent to water bodies. They provide disproportionate benefits to aquatic ecosystems by providing direct shade to water bodies and adjacent land which cools and maintains water temperatures and vegetation cover which stabilizes the stream bank and filters out potential pollutants. Limited harvesting is recommended in RMZs.
Wetland Crossing Avoidance	72%	Crossings are sections of forest roads and skid trails where equipment crosses a water body. They are the forest management feature that has the highest potential for pollutant loading to water bodies and should be avoided whenever possible.
Landing Location	76%	Locate landings outside of wetlands and filter strips
Leave Tree Retention	65%	A percentage of leave trees should be left on clear-cut timber harvesting areas to maintain habitat for wildlife.
Infrastructure Management	52%	Equipment traffic contributes to compaction and rutting of forest soils that can cause erosion, damage vegetation, and limit future productivity of forest soils. Roads and Landing areas should be limited to minimize these impacts.

* Only two of the 205 approaches in the LRRW had slopes that needed erosion control. None of the approaches had erosion control installed.

**Red shading indicates BMP practices that can be improved in LRRW

Stream Restoration

Streams in the LRRW have extensive ditch systems in their watersheds, often through wetlands. These ditch systems were built to drain land for agriculture and in support of timber harvesting activities. Much of the original ditching failed to accomplish the goal of creating farm land, and they have contributed to degradation of surface waters. With downstream water bodies having to evolve to new hydrologic conditions (this can cause channel instability and aquatic habitat loss), streams could benefit from a combination of wetland hydrological restoration (ditch plugging/removal) and or stream restoration projects to mitigate channel instability. Several projects were identified during the study, including the Holte Road ditch near Silver Creek, Pitt Grade ditch, Highway 35 ditch, and the Highway 72 outlet. Additional stream restoration opportunities should be identified through a Bank Assessment for nonpoint Source Consequences of Sediment (BANCS) Study. A BANCS study evaluates the conditions of the stream channel and estimates whether segments in the stream are eroding faster than in undisturbed conditions. During the WRAPS process, a BANCS study of the Winter Road River was suggested. The locations of the potential stream restoration projects are shown in Figure 21.

Climate protection cost-benefit strategies

Impacts due to climate change are occurring in the LRRW. According to future climate projections, tree species ranges endemic to northern Minnesota forests such as paper birch, quaking aspen, balsam fir, and black spruce will migrate north, altering the current native forest communities and landscape. Reduced winter intensity has increased forest disturbance due to native insects like eastern larch beetle and spruce budworm. Decreased average winter temperatures across the northern U.S. and Canada have also allowed detrimental nonnative insects such as emerald ash borer, gypsy moth, and mountain pine beetle to increase their range, likely reaching forests in the Lower Rainy Watershed in the future and threatening ash, oak, and pine forest types. Loss of these tree species that dominated key forest types in the watershed will alter hydrology, decrease carbon capture, and impact regional rural economies. Widespread insect and disease tree mortality will also increase wildfire fuels in heavily forested watersheds like the LRRW. Adaptive forest management by landowners and natural resource managers will be necessary to address these changes to the landscape.

Climate change is also affecting weather patterns, specifically precipitation. In the past several years, local observation has shown the rainfalls come in large batches 1" to 3" at a time and in between these extreme events it gets very dry. This creates a "very wet, very dry boom and bust cycle" according to one local cattle farmer. This wet period often results in extreme run-off and erosion, while the extreme dry periods create habitat issues for aquatic organisms. In years past when locals have observed the precipitation was more spread out, the rivers were neither out of their banks, nor dry many times a year. In addition, the lake ice duration is also changing across Northern Minnesota, with ice forming a week later in many cases and melting a week earlier. This allows for longer degree heating days and has created temperature increases in some area lakes according to the DNR. Summers of 2018 and 2019 resulted in several smaller streams in the watershed dry most of the summer; when it did rain it all ran off and returned to nearly dry conditions a week or two after the event, resulting in very little groundwater recharge, an important component of the water cycle.

Many agricultural BMPs, which reduce the load of nutrients and sediment to receiving waters, also act to decrease emissions of greenhouse gases (GHGs) to the air. Agriculture is the third largest emitting sector of GHGs in Minnesota. Important sources of GHGs from crop production include the application of manure and nitrogen fertilizer to cropland, soil organic carbon oxidation resulting from cropland tillage, and carbon dioxide (CO2) emissions from fossil fuel used to power agricultural machinery or in the production of agricultural chemicals. Reduction in the application of nitrogen to cropland through optimized fertilizer application rates, timing, and placement is a source reduction strategy; while conservation cover, riparian buffers, vegetative filter strips, field borders, and cover crops reduce GHG emissions as compared to cropland with conventional tillage.

The NRCS has developed a ranking tool for cropland BMPs that can be used by local units of government to consider ancillary GHG effects when selecting BMPs for nutrient and sediment control. Practices with a high potential for GHG avoidance include conservation cover, forage and biomass planting, no-till and strip-till tillage, multi-story cropping, nutrient management, silvopasture establishment, tree and shrub establishment, and shelterbelt establishment. Practices with a medium-high potential to mitigate GHG emissions include contour buffer strips, riparian forest buffers, vegetative buffers, and shelterbelt renovation. A longer, more detailed assessment of cropland BMP effects on GHG emissions can be found at NRCS, et al., "COMET-Planner: Carbon and Greenhouse Gas Evaluation for Natural Resources

Defense Council, Inc." (NRDC) Conservation Practice Planning http://comet-planner.nrel.colostate.edu/COMET-Planner_Report_Final.pdf.

Beyond agricultural BMPs, wetland protection will play a critical role in reducing GHGs and promoting resilience to climate change throughout the watershed. As wetlands constitute almost half of the LRRW lands, this watershed serves as a major carbon and GHG sink. The WRAPS-identified protection programs that work to restore the hydrology of ditched peatlands and bring more lands under protection status will help preserve the natural function of wetland and peatland ecosystems as carbon storage habitats and prevent the release of carbon held in these stores. Furthermore, wetlands filter out pollutants that could otherwise impact downstream water bodies. Peatlands are also phosphorus sinks, as the plant life in peatlands decomposes very slowly. Combined with water quality BMPs, naturally-functioning wetlands help protect the LRRW from the threat of harmful algal blooms which increases with the warming climatic temperatures. Wetland hydrology restoration and protection strategies will encourage native revegetation, prevent dewatering, reduce loss of stored carbon to the atmosphere and phosphorus to lakes downstream, and reduce DOC in downstream waters that can be problematic in producing municipal drinking water (creates toxins).

Timber and forest BMPs can also promote climate benefits through protection of forests. The forest lands of the LRRW face the growing threat of invasive species as the climate shifts to tolerate pests. On the other hand, these forests also sequester large quantities of GHGs and their preservation already serves as a key carbon sink through carbon offset programs. Holistic protection programs that include reforestation and a variety of forest management and forest health practices will ensure the LRRW forests remain healthy, continue to sequester carbon, and promote soil health and ecological diversity.

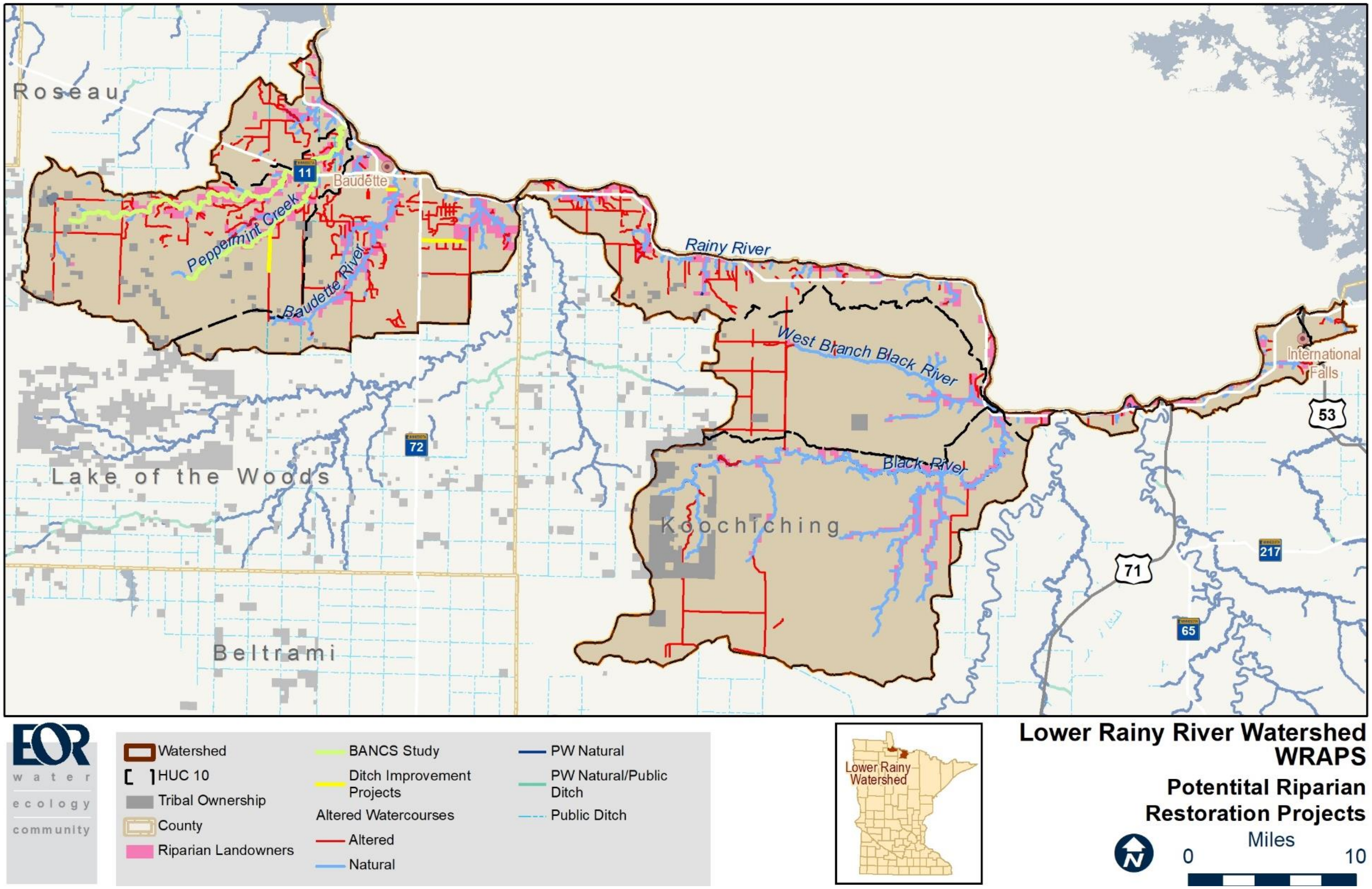


Figure 21. Potential riparian restoration projects in the Lower Rainy River Watershed.

Proposed Strategies and Actions by Subwatershed

Table 33. Strategies and actions proposed for the Lower Rainy River Watershed

Water body and location			Water quality (WQ)			Strategies to achieve final water quality goal				
							EXAMPLE Best Management Practice (BMP) Scenario			
HUC-12 Aggregated Watershed	Water body (ID)	Location and upstream influence counties	Pollutant/ Stressor	Current WQ conditions	WQ Goal (% and load to reduce)	Strategy type	BMP	Amount	Unit	Estimated reduction (lbs/yr) *as applicable*
All	All	Koochiching, Lake of the Woods	TP	115,000 lbs/yr	5,292 lbs/yr (4.6%)	Agricultural Management	Continue to provide education and outreach about Agricultural BMP assistance programs and opportunities			
						Designed erosion control and Trapping	Perform field review of ACPF identified Water and Sediment Control Basins to identify feasible projects.			
						Pasture Management	Perform field review of identified small feedlot operations to identify opportunities for improvements			
						Urban Stormwater Runoff Control	Perform and Pollutant Source Assessment Studies for the Development corridor along Highway 172, Baudette, and International Falls to identify and prioritize feasible projects in the towns.			
						Forestry Management	Continue to provide education and assistance in Forest protection programs and timber harvesting BMPs			
						Tillage/Residue Management	No-Till	17,608	Treated Area (acres)	2,886
						Buffers – Field Edge	Riparian Buffers, 100+ ft wide (perennials replace tilled)	4,547	Treated Area (acres)	511
						Agricultural tile drainage water treatment	Wetland restoration or construction for treatment	2,719	Treated Area (acres)	212
						Designed erosion control and Trapping	Water and Sediment Control Basins	3,522	Treated Area (acres)	353
						Changing rotation to less erosive crops	Conservation Crop Rotation add more perennials	11,599	Treated Area (acres)	394
						Nutrient Management	Nutrient Management -rate, form, placement, timing	10,277	Treated Area (acres)	69
						Pasture management	Pasture improvement Conventional pasture to prescribed rotational grazing	1,087	Treated Area (acres)	730

Water body and location			Water quality (WQ)			Strategies to achieve final water quality goal				
							EXAMPLE Best Management Practice (BMP) Scenario			
HUC-12 Aggregated Watershed	Water body (ID)	Location and upstream influence counties	Pollutant/ Stressor	Current WQ conditions	WQ Goal (% and load to reduce)	Strategy type	BMP	Amount	Unit	Estimated reduction (lbs/yr) *as applicable*
							Livestock Access Control			
						Feedlot runoff controls	Feedlot runoff reduction/treatment	65	Number of Farms	
						Urban Stormwater Runoff Control	Constructed Stormwater Pond	909	Treated Area (acres)	292
							Constructed Wetland			
							Infiltration Basin			
							Bioretention/Biofiltration/rain garden			
							Permeable surfaces and pavements			
			-	Maintain or Improve water quality		Natural Buffers	Provide education and outreach to landowners next to streams and rivers about the importance of natural vegetation in reducing streambank erosion			
			-	Maintain or Improve water quality		Monitoring	Monitor the effectiveness of restoration projects as well as BMPs on the landscape			
			-	Maintain or Improve water quality		Climate Mitigation	Explore and incorporate actions and conservation planning specific to climate change being developed by various agencies at the Federal, State, and Local Levels			
			-	Maintain or Improve water quality		Stream banks, bluffs & ravines protected/restored	Conduct a BANCS study to investigate stream bank erosion rates in the Winter Road River.			
			-	Maintain or Improve water quality		Stream banks, bluffs, & ravines protected/restored	Improve and maintain ditches to reduce erosion from near the streams and ditches in the watershed specifically the ditches on Holte Road, Highway 72 outlet, Highway 35, and Pitt Grade.			
Black River	Black River (-547)	Koochiching	*E. coli*	163 org/100 mL	23%	Microbial Source Tracking	Perform a Microbial Source Tracking study in the Black River and West Fork Black River to allocate portion of *E. coli* from human and livestock sources			
						Septic System Improvements	Perform a septic system compliance check in the watershed and continue to provide education about septic system maintenance in the watershed			

Water body and location			Water quality (WQ)			Strategies to achieve final water quality goal				
							EXAMPLE Best Management Practice (BMP) Scenario			
HUC-12 Aggregated Watershed	**Water body (ID)**	**Location and upstream influence counties**	**Pollutant/ Stressor**	**Current WQ conditions**	**WQ Goal** (% and load to reduce)	**Strategy type**	**BMP**	**Amount**	**Unit**	**Estimated reduction (lbs/yr)** *as applicable*
						Pasture Management	Perform a field review of small feedlot operations and pastures in the watershed to identify opportunities for improved pasture management			
						Pasture Management	Pasture Improvement	251	Treated Area (acres)	NA
							Conventional pasture to prescribed grazing			
							Livestock Access Control			
						Feedlot runoff controls	Feedlot runoff reduction	4	Treated Area (acres)	NA
							Rainwater diversions at feedlots			
						Septic System Improvements	Septic System Improvement	5	Number	NA
West Fork Black River	Black River, West Fork (-543)	Koochiching	*E. coli*	172 org/100 mL	27%	Microbial Source Tracking	Perform a Microbial Source Tracking study in the Black River and West Fork Black River to allocate portion of *E. coli* from human and livestock sources			
						Septic System Improvements	Perform a septic system compliance check in the watershed and continue to provide education about septic system maintenance in the watershed			

Water body and location			Water quality (WQ)			Strategies to achieve final water quality goal				
							EXAMPLE Best Management Practice (BMP) Scenario			
HUC-12 Aggregated Watershed	**Water body (ID)**	**Location and upstream influence counties**	**Pollutant/ Stressor**	**Current WQ conditions**	**WQ Goal** (% and load to reduce)	**Strategy type**	**BMP**	**Amount**	**Unit**	**Estimated reduction (lbs/yr)** *as applicable*
						Pasture Management	Perform a field review of small feedlot operations and pastures in the watershed to identify opportunities for improved pasture management			
						Pasture Management	Pasture Improvement	299	Treated Area (acres)	NA
							Conventional pasture to prescribed grazing			
							Livestock Access Control			
						Feedlot runoff controls	Feedlot runoff reduction	3	Treated Area (acres)	NA
							Rainwater diversions at feedlots			
						Septic System Improvements	Septic System Improvement	1	Number	NA

4. Monitoring plan

It is the intent of the implementing organizations in this watershed to make steady progress in terms of pollutant reduction. Accordingly, as a very general guideline, progress benchmarks established for this watershed assume that improvements will result in a water quality pollutant concentration decline each year.

This general guideline does not incorporate the range of variables that may influence the rate of progress. Factors that may slow progress include limits in funding or landowner acceptance, challenging fixes (e.g., unstable bluffs and ravines, invasive species), and unfavorable climatic factors. Conversely, there may be faster progress for some impaired waters, especially where high-impact fixes are slated to occur.

The collection of up-to-date land and water data is important in both assessing progress and informing management and decision-making. Because LRRW possesses water resources already in good quality, a robust monitoring program is crucial to the maintenance of current conditions and preemption of potential issues. The basic needs of a monitoring plan must include an understanding of variability, scale, confidence, and associated risk levels tailored to the specific needs of a particular resource. For example, the Black River needs mitigation strategies for *E. coli* issues to improve recreational safety, while other reaches in the LRRW contribute to excess nutrients in the Lake of the Woods. Monitoring data of both land and water components can be used to inform and calibrate watershed models, evaluate progress towards defined goals, and achieve desired outcomes.

The MPCA initiated a watershed-wide intensive monitoring program of the LRRW beginning in 2017. The effort assessed 15 stream reaches to obtain water chemistry and biological data to evaluate water quality and the effectiveness of past and future stream restoration, riparian enhancement, and other BMP implementation projects. Other recommendations anticipate future problems such as monitoring DO and water temperature to improve the understanding of climate change in the watershed, and examining the areas where aquatic communities are thriving despite high levels of TSS and low levels of DO, like the Black River Subwatershed.

Minnesota's state-led watershed approach consists of a 10-year rotation for monitoring and evaluation that creates the space for more complete and systematic assessment of water quality. An adaptive management strategy that responds to and corrects for ongoing monitoring results will ensure implementing organizations in LRRW are nimble enough to meet imminent issues like climate change. These monitoring programs, described in the following subsections, include those conducted by local, state, and federal entities and special projects.

These general guidelines do not necessarily account for factors that may slow progress include limits in funding or landowner acceptance, challenging fixes (e.g., restoring ditched peatlands, streambank stabilization) and unfavorable climatic factors.

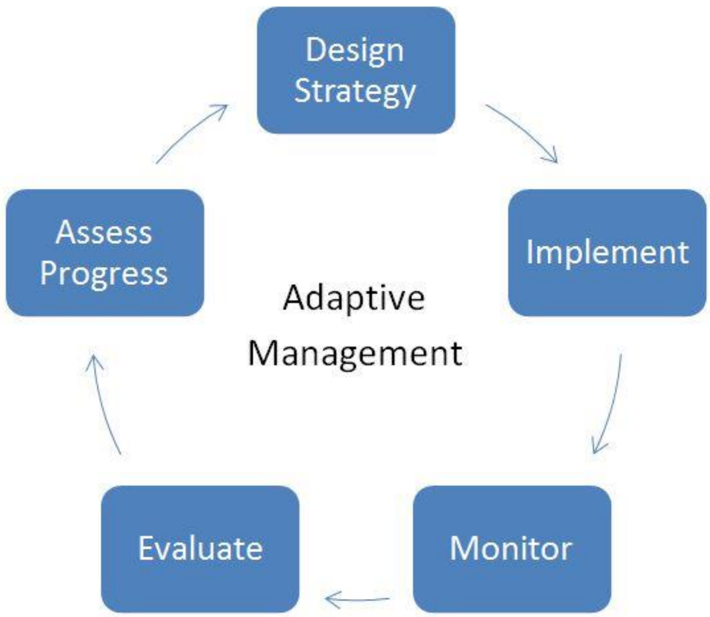


Figure 22. Components of Adaptive Management

Watershed Pollutant Load Monitoring Network

Pollutant loads refer to the amount of a pollutant discharged into a water body over a period. This parameter provides a useful indicator of water quality for a watershed. The WPLMN leverages partnerships with state and federal agencies, Metropolitan Council Environmental Services, state universities, and local entities to collect data on water quality and flow at 199 sites around Minnesota to calculate pollutant loads in rivers and streams. WPLMN data assist in watershed modeling, determining pollutant source contributions, developing reports, and measuring water quality restoration efforts. Stations monitor conditions on three different scales: basin, major watershed, and subwatershed.

One long term WPLMN station exists in the LRRW, the Rainy River at Manitou Rapids (Table 34). As a basin-scale site on the main stem Rainy River, this station does not characterize the average flow weighted mean concentration of pollutants generated within the LRRW. Approximately 35 water quality samples are collected annually at a basin-scale monitoring site.

Table 34. Long Term Watershed Pollutant Load Monitoring Network monitoring station in the Lower Rainy River Watershed

Site Type	Stream Name	Station ID
Basin	Rainy River at Manitou Rapids, MN (75005001)	S006-897

Water quality samples are collected near gaging stations, at or near the center of the channel. Samples are collected more frequently during periods of moderate to high water flow, when pollutant levels are typically elevated and most changeable. All major runoff events are sampled intensively to account for correlations between storm and seasonal differences that may exist in concentration and flow. Pollutant concentrations are generally more stable when water flows are low, and fewer samples are taken in those conditions. This staggered approach generally results in samples collected over the entire range of flows and an accurate estimate of the total pollutant load leaving the watershed.

Stream Monitoring

As part of the MPCA IWM strategy, 6 six sites were monitored for water chemistry from 2017 through 2018, and 15 stream sites were successfully sampled for biology (fish and macroinvertebrates) out of 21 total established (Table 35 and Table 36). Low-flow conditions during the sampling periods prevented several sites from sampling for biology, especially macroinvertebrates. The water chemistry stations were placed at the outlet of each aggregated HUC-12 subwatershed larger than 40 square miles in area. A portion of these sites will be sampled in the next 10-year IWM cycle, beginning in 2028. Details about the MPCA IWM strategy can be found in the Rainy River Rainy Lake Monitoring and Assessment Report (https://www.pca.state.mn.us/sites/default/files/wq-ws3-09030003b.pdf).

The MPCA and Koochiching SWCD will continue to monitor their long-term sites at the same frequencies. If data collected indicates issues at a particular site, additional monitoring or additional monitoring sites may be added to determine where issues may be arising.

Table 35. Intensive watershed monitoring water chemistry stations in the LRRW

Station ID	Biological Station ID	AUID	Water body Name	Location
S001-962	17RN053	09030008-547	Black River	At MN Hwy 11 at Loman
S005-707	17RN024	09030008-502	Winter Road River	At Co Hwy 167, 4.5 mi NW of Baudette
S009-445	05RN084	09030008-543	Black River, West Fork	At Co Hwy 82
S009-446	17RN082	09030008-535	Baudette River	Adjacent to Co Hwy 1, 2.6 mi SE of Baudette
S009-447	17RN026	09030008-507	Peppermint Creek	CSAH 177 (8th St SW), 5 mi W of Baudette
S014-234		09030008-536	Baudette River	At boat launch off International Dr., at Baudette

Environmental Quality Information System (EQuIS)

Table 36. Intensive watershed monitoring biological monitoring stations in the Rainy River – Rainy Lake Watershed

AUID	Biological Station ID	Water body Name	Biological Station Location
09030008-502	17RN024	Winter Road River	Upstream of Hwy 11, 3 mi NE of Pitt
09030008-506	17RN021	Winter Road River	Upstream of CR 2 SW, 6.5 mi S of Williams
09030008-506	17RN025	Winter Road River	Downstream of CSAH 6 (29TH Ave SW), 1 mi SE of Pitt
09030008-507	17RN026	Peppermint Creek	Upstream of CSAH 177 (8th St SW, 2 mi. SE of Pitt
09030008-507	17RN029	Peppermint Creek	Downstream of CR 173 (41st Ave SW), 5 mi SW of Pitt
09030008-510	17RN028	Pitt Creek	Adjacent to Pitt Grade Rd, 5 mi S of Pitt
09030008-511	17RN034	Silver Creek	0.5 mi E of CSAH 89, 2.5 mi SW of Clementson
09030008-517	17RN055	Baudette River, West Fork	Adjacent to CSAH 1, 3.25 mi SW of Baudette
09030008-521	17RN022	Unnamed Ditch	Adjacent to CR 2 SW, 7 mi S of Williams
09030008-528	17RN027	Little Peppermint Creek	Upstream of CSAH 19 (29th St SW), 4 mi S of Baudette

AUID	Biological Station ID	Water body Name	Biological Station Location
09030008-534	17RN033	Silver Creek, East Branch	Downstream of CSAH 19 (29th Ave SE), 2 mi SW of Clementson
09030008-535	17RN031	Baudette River	Upstream of CSAH 161 (19th St SW), 4 mi S of Baudette
09030008-535	17RN082	Baudette River	Adjacent to Hwy 1, 2.5 mi SE of Baudette
09030008-543	17RN040	Black River, West Fork	Downstream of CSAH 82 (W Fork Rd), 1.75 mi NW of Loman
09030008-545	17RN045	Black River	Adjacent to CSAH 101, 11 mi S of Birchdale
09030008-545	17RN054	Black River	Upstream of Fiero Truck Tr, 13 mi S of Birchdale
09030008-546	17RN100	Black River	Upstream of UT 100, 4.75 mi W of Loman
09030008-547	17RN053	Black River	Adjacent to Black River Rd, 1.5 mi SE of Loman
09030008-554	17RN050	McCloud Creek	Downstream of CSAH 4, 4 mi W of Birchdale
09030008-562	17RN023	Wabanica Creek	Downstream of CSAH 167, 3 mi S of Pitt
09030008-563	17RN047	Unnamed Ditch	Upstream of Fiero Truck Tr, 13.5 mi S of Birchdale

Lake Monitoring

In the LRRW there are no lakes currently monitored.

Citizen and Local Monitoring

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

The MPCA also coordinates two programs aimed at encouraging long term citizen surface water monitoring: the Citizen Lake Monitoring Program and the Citizen Stream Monitoring Program. Like the permanent load monitoring network, having citizen volunteers monitor a given lake or stream site monthly and from year to year can provide the long-term picture needed to help evaluate current status and trends. Citizen monitoring is especially effective at helping to track water quality changes that occur in the years between intensive monitoring years.

BMP Monitoring

On-site monitoring of implementation practices should also take place in order to better assess BMP effectiveness. All BMPs installed utilizing financial assistance from the state of Minnesota will follow the

Operation, Maintenance, and Inspection Procedures adopted by BWSR. Qualified technical staff prepare an Operation and Maintenance Plan specific to the BMP and site. All practices are to be inspected by the landowner on a regular basis. Technical staff confirm that the project is functioning as designed through completion of site inspections during the effective life of the project. For BMPs installed through other sources, a variety of criteria such as land use, soil type, and other watershed characteristics, as well as monitoring feasibility, will be used to determine which BMPs to monitor. Monitoring of a specific type of implementation practice can be accomplished at one site but can be applied to similar practices under similar criteria and scenarios. Effectiveness of other BMPs can be extrapolated based on monitoring results.

5. References and further information

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6. Appendix

6.1 Appendix A. Geospatial Prioritization Methodology

A small working group of local resource professionals and MPCA staff reviewed 56 data sets drawn from various watershed management tools and systems available for WRAPS projects in Minnesota (Table 37), and rated their usefulness in prioritizing subwatersheds in the LRRW. The evaluation was completed specific to the characteristics of the watershed. Reviewers rated each data set based on the how useful they would be for prioritizing subwatersheds in which to focus efforts.

The available data sets have utility in determining priorities from two perspectives: symptoms or cure. Some of the data sets are useful in identifying specific areas that are displaying the symptoms of water resource problems, whereas other data sets help target locations where improvements can be most beneficial.

Table 37. Tools available for WRAPS projects in Minnesota

Tools	Description	How can the tool be used?	Notes	Link to information and data
Board of Water and Soil Resources (BWSR) Landscape Resiliency Strategies	These webpages describe strategies for integrated water resources management to address soil and water resource issues at the watershed scale, and to increase landscape and hydrological resiliency in agricultural areas.	In addition to providing key strategies, the webpages provide links to planning programs and tools such as Stream Power Index, PTMApp, Nonpoint Priority Funding Plan, and local water management plans.	These data layers are available on the BWSR website. The MPCA download link offers spatial data that can be used with GIS software to make maps or perform other geography-based functions.	Landscape Resiliency - Water Planning Landscape Resiliency - Agricultural Landscapes MPCA download
Zonation	This tool serves as a framework and software for large-scale spatial conservation prioritization, and a decision support tool for conservation planning. The tool incorporates values-based priorities to help identify areas important for protection and restoration.	Zonation produces a hierarchical prioritization of the landscape based on the occurrence levels of features in sites (grid cells). It iteratively removes the least valuable remaining cell, accounting for connectivity and generalized complementarity, in the process. The output of Zonation can be imported into GIS software for further analysis. Zonation can be run on very large data sets (with up to ~50 million grid cells).	The software allows balancing of alternative land uses, landscape condition and retention, and feature-specific connectivity responses. (Paul Radomski, DNR, has expertise with this tool.)	Zonation software use and applications (syke.fi)
Restorable wetland inventory	A GIS data layer that shows potential wetland restoration sites across Minnesota. Created using a compound topographic index (CTI) (10-meter resolution) to identify areas of ponding, and U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO) soils with a soil drainage class of poorly drained or very poorly drained.	Identifies potential wetland restoration sites with an emphasis on wildlife habitat, surface and ground water quality, and reducing flood damage risk.	The GIS data layer is available for viewing and download on the Minnesota 'Restorable Wetland Prioritization Tool' website.	Restorable Wetlands

Tools	Description	How can the tool be used?	Notes	Link to information and data
National Hydrography Dataset (NHD) and Watershed Boundary Dataset (WBD)	The NHD is a vector GIS layer that contains features such as lakes, ponds, streams, rivers, canals, dams, and stream gages, including flow paths. The WBD is a companion vector GIS layer that contains watershed delineations.	General mapping and analysis of surface-water systems. These data have been used for fisheries management, hydrologic modeling, environmental protection, and resource management. A specific application of this data set is to identify riparian buffers around rivers.	The layers are available on the USGS website.	USGS
Light Detection and Ranging (LiDAR)	Elevation data in a digital elevation model (DEM) GIS layer. Created from remote sensing technology that uses laser light to detect and measure surface features on the earth.	General mapping and analysis of elevation/terrain. These data have been used for erosion analysis, water storage and flow analysis, siting and design of best management practices (BMPs), wetland mapping, and flood control mapping. A specific application of the data set is to delineate small catchments.	The layers are available on the Minnesota Geospatial Information Office (MGIO) website.	MGIO
Hydrological Simulation Program – FORTRAN (HSPF) Model	Simulation of watershed hydrology and water quality for both conventional and toxic organic pollutants from pervious and impervious land. Typically used in large watersheds (greater than 100 square miles).	Incorporates watershed-scale and nonpoint source models into a basin-scale analysis framework. 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.	Local or other partners can work with MPCA HSPF modelers to evaluate at the watershed scale: 1) the efficacy of different kinds or adoption rates of BMPs, and 2) effects of proposed or hypothetical land use changes.	EPA Models USGS

Data Sets Reviewed

The following data sets were reviewed by a small work group made up of local SWCD professionals familiar with the watersheds. The work group was asked to rate the data sets as High, Medium, Low, or not-applicable for their ability to prioritize subwatersheds. The data sets are generally organized by water resource issue. The information contained in each data set was mapped to the subwatershed level for relative comparisons. For example, if the data set was a mapping of lakes, the proportion of lakes within each subwatershed (as a % of the total subwatershed) would be presented. This would allow for comparison of subwatersheds based on their proportion of lakes.

Altered Hydrology

- Aquatic Disruption: Connectivity component index based on a density of aquatic disruptions per mile of stream length within each watershed (DNR 2020).
- Connectivity Index: - Riparian Connectivity: Connectivity component index based on the amount of development or cropland within riparian zones (DNR 2020).
- Altered Watercourses: Based on altered watercourse data layer created by MPCA and Minnesota Geospatial Commons (Minnesota Geospatial Information Office 2020).
- Sandy Verry Channel Flow: From Sandy Verry's research on Land fragmentation and impacts to streams - Identifies subbasins with higher amount of land cover change near streams that cause increased bankfull flow and streambank erosion (Brinks 2019).
- Sandy Verry Risk Model: Sandy Verry research compiled into a decision tree (Jeff Reinhart (DNR Forestry and Minnesota Forest Resources Council (MFRC)), adapted by M. Brinks) - The model assesses stream stability at peak flows in relation to the amount of forest cover in the watershed (Brinks 2019).

Soil Erosion

- Stream Power Index (SPI): Estimate of the erosive power of flowing water calculated from LiDAR aggregated to a 15 m resolution. Area represents areas with values greater than the 99th percentile (EOR).
- SPI - The 99th Percentile value used for the Lower Rainy Lake Watershed differed from the value used for the Lower Rainy River and Rapid River watersheds because of a difference in landforms and surface geomorphology (EOR).
- Geo Index - Soil Erosion Susceptibility: Based on the soil k-factor and 4 slope classes (providing scoring weights: 0-1% slope = 1x weight factor, 1-2% slope = 2x weight factor, 2-3% slope = 3x weight factor, >3% slope = 4x weight factor) (DNR 2020).
- Geo Index - Steep Slopes Near Streams: Based on the density of steep slopes that are located within a threshold distance of streams, normalized to total stream length (DNR 2020).

Water Quality

- Sediment Yield: The HSPF model predicted sediment yield in tons/ac/yr by subwatersheds from 1996-2014 (Lupo 2016).

- Stream Bank Erosion: The HSPF model predicted sediment yield from bed and bank erosion in tons/ac/yr by subwatersheds from 1996-2014 (Lupo 2016).
- Cropland Erosion: The HSPF model predicted sediment yield from high till cropland in tons/ac/yr by subwatersheds from 1996-2014 (Lupo 2016).
- Phosphorus Yield: The HSPF model predicted TP yield in lbs/ac/yr by subwatersheds from 1996-2014 (Lupo 2016).
- TP – Cropland: The HSPF model predicted TP yield from high till cropland in lbs/ac/yr by subwatersheds from 1996-2014 (Lupo 2016).
- TP – Septics: The HSPF model predicted TP yield from septic systems in lbs/ac/yr by subwatersheds from 1996-2014 (Lupo 2016).
- Total Nitrogen: The HSPF model predicted total nitrogen yields in lbs/ac/yr by subwatersheds from 1996-2014 (Lupo 2016).
- Flow Yield: The HSPF model predicted flow yield in ft/yr by subwatersheds from 1996-2014 (Lupo 2016).
- *E. coli* Concentration: Estimate of the monthly geometric mean *E. coli* concentrations available in the MPCA EDA Surface water Database.
- TP: Estimate of the stream summer average phosphorus concentration from the MPCA EDA Surface Water Database related to the water quality standard of 50 ug/L for northern streams.
- DO: Estimate of the relative percentage of DO measurements in the MPCA EDA Surface water Database below 5 mg/L in the streams.
- TSS: Estimate of the 90th percentile TSS concentration and the number of samples exceeding the water quality standard of 15 mg/L for water samples in the MPCA EDA Surface Water Database.

Land Use/Land Cover

- Wetlands and Open Water: The sum of areas classified as open water, woody wetlands, and emergent herbaceous wetlands divided by the area of the subwatershed (MLRC 2016).
- Developed: The sum of areas classified developed, open space; developed, low-density; developed, medium density; and developed, high density divided by the total area of the subwatershed (MLRC 2016).
- Agriculture: The sum or areas classified as pasture/hay and cultivated crops divided by the area of the subwatershed (MLRC 2016).
- Forest and Other Natural Land: The sum of the areas classified as deciduous forest, evergreen forest, mixed forest, shrubland, grassland, and barren land divided by the area of the subwatershed (MLRC 2016).
- Forest for the Future: Priority Forests for the Minnesota Forests for the Future Program that looked at recreational, economic, and ecological values. Source: DNR (2010) (Brinks 2019).

- Potential Protection: 20+ acre, private parcels that intersect a forested tract of land > 20 acres minus National Wetland Inventory (NWI) wetlands (Brinks 2019).
- Sustainable Forest Incentive Act (SFIA): 20+ acre parcel enrolled in the SFIA program (Minnesota Department of Revenue (MDOR) and DNR) minus NWI wetlands and divided by the subwatershed area (Brinks 2019).
- Forest Stewardship Plan: Parcels with a DNR registered woodland/forest stewardship plan on file that is current (written within the last 10 years) minus wetlands and divided by the subbasin area. Source: DNR Forestry (Brinks 2019).
- Protected Lands: Sum of the Public Lands and waters, easements, SFIA, NWI on private land and other conservation land as a proportion of the subwatershed (Brinks 2019).
- 2008 GAP Public Land: Amount of land owned by a private entity in the 2008 GAP stewardship data layer divided by the subwatershed area (DNR 2008).
- 2008 GAP Tribal Land: Amount of land owned by a tribe in the 2008 GAP stewardship data layer divided by the subwatershed area (DNR 2008).
- 2008 GAP Private Land: Amount of land owned by a private entity in the 2008 GAP stewardship data layer divided by the subwatershed area (DNR 2008).
- 2010 Rural Housing Density: The amount of houses in each subwatershed from the 2010 United States Census outside of city boundaries divided by the subwatershed area (Brinks 2019).
- Road Distance: The average distance from a federal, state, county or local road in each subwatershed. Projects farther than 1-2 mi from a roadway may have higher costs. (Does not include minimum maintenance roads) (MnDOT 2018).

Wetlands

- NWI Total: The total area of wetlands in the NWI in each subwatershed divided by the subwatershed area (DNR 2019).
- Surface Outflow Wetlands: The area of wetlands classified with a dominant flow path of outflow, bi-directional, and throughflow in the hydrogeomorphic classification divided by the subwatershed area (DNR 2019).
- Water and Erosion Benefit: Subwatershed average predicted benefit in terms of reductions in terms of water flow and erosion from wetland restoration. Higher values indicate higher benefit from wetland restoration (University of Minnesota Duluth 2014).
- Species Benefit: Subwatershed average predicted benefit in terms of reductions in terms of improving habitat for species from wetland restoration. Higher values indicate higher benefit from wetland restoration (University of Minnesota Duluth 2014).
- Habitat Stress: Subwatershed average predicted wetland habitat stress. Higher values indicate higher wetland stress (University of Minnesota Duluth 2014).
- Phosphorus Stress: Subwatershed average predicted wetland phosphorus stress. Higher values indicate higher wetland stress (University of Minnesota Duluth 2014).

- Nitrogen Stress: Subwatershed average predicted wetland nitrogen stress. Higher values indicate higher wetland stress (University of Minnesota Duluth 2014).
- Restorable Wetland Inventory: Estimate of the area of potential restorable wetlands in each subwatershed divided by the subwatershed area (University of Minnesota Duluth 2014).
- Restoration Viability: Estimate of predicted viability of wetland restoration projects lasting long into the future (University of Minnesota Duluth 2014).

Previous Prioritizations

- Local Watershed Prioritization: Risk Classification as identified in a local County Water Plan (limited extent) (Brinks 2019).
- DNR Protection Status: DNR Lake Protection Framework developed by M. Duval, P. Jacobson, T. Cross (Brinks 2019).
- Combined Index - Geomorphology Triage Score: This score is used within a targeted decision process for selecting sites for more detailed fluvial geomorphic assessments. This score is calculated by taking the average of 8 input index scores: Stream Species Quality, Fish IBI; Con Index - Aquatic Connectivity; Con Index - Riparian Index; Geo Index - Steep Slopes Near Streams; Hyd Index - Impervious Cover; Hyd Metric - Loss of Hydrologic Storage; and WQ Index - Localized Pollution Sources (DNR 2020).

Groundwater

- Groundwater Sensitivity: Areas mapped as "High" in the Pollution Sensitivity of Near-Surface Materials layer from DNR/County Geologic Atlas (Brinks 2019).
- Geologic Index - Pollution Sensitivity of Near Surface Materials: Based on the watershed mean of pollution sensitivity of near-surface materials data, valued on an ordinal basis (DNR County Geologic Atlas, 2016) (DNR 2020).
- Arsenic Concentration: New well points from MDH. Arsenic only goes back to 2008. - The average arsenic concentration in groundwater wells in the subwatershed (Brinks 2019).
- Nitrate Concentration: New well points from MDH. The average nitrate concentration in groundwater wells in the subwatershed (Brinks 2019).

Biodiversity

- DNR Lake Phosphorus Sensitivity: Lakes with phosphorus sensitivity “higher" and "highest" classifications only (count and acres) (Brinks 2019).
- Wild Rice Lakes: Prioritized list of DNR's top 350 wild rice lakes across Minnesota (Brinks 2019).
- Minnesota Biological Survey (MBS) Biodiversity: Sites of native biodiversity that may contain high quality native plant communities, rare plants, rare animals, and/or animal aggregations. Source: DNR Natural Heritage Program/County Biological Survey (Brinks 2019).
- Wildlife Action Network (WAN): The WAN was developed as part of the 2015-2025 Minnesota Wildlife Action Plan revision. The WAN is made up of 10 GIS layers representing quality aquatic and terrestrial habitats across the state of Minnesota. - The subwatersheds are prioritized based

on the area of land classified as High and Medium High as a percentage of the total subwatershed area (Brinks 2019).

- Biological Index Terrestrial Habitat Quality: Biology component index that ranks the quality of terrestrial habitats within each subwatershed (DNR 2020).

Improvements

- Number of BMPs: The number of BMPs according to the BWSR eLink system (BWSR 2020).

Reviewers were asked to rate each data set on a not applicable (NA), low, medium, high scale. These adjective ratings were converted to a numerical score, aggregated and averaged to determine the priority data sets to be used. The following are the top 10 rated data sets prioritized by the working group for the LRRW.

- Forest Stewardship Plan
- 2008 GAP Public Land
- Sediment Yield
- Stream Bank Erosion
- Cropland Erosion
- Phosphorus Yield
- TP - Cropland
- Flow Yield
- Wetland: Water and Erosion Benefit
- Potential Protection

Based on the ratings of general resource issue categories and specific data sets, an overall scoring system was developed to compare and prioritize subwatersheds. In the case of some data sets, there were only slight differences in values from one subwatershed to the next. In other cases, groups of data sets were redundant. A scoring system was developed using the following 10 geographic data sets:

- Altered Hydrology
    - Aquatic Disruption
    - Altered Watercourses
- Soil Erosion
    - Stream Power Index
    - Geo Index - Soil Erosion Susceptibility
- Water Quality
    - Sediment Yield
    - Phosphorus Yield
- Wetlands
    - Habitat Stress
    - Phosphorus Stress
    - Nitrogen Stress
    - Restorable Wetland Inventory and Viability

The raw data value for each subwatershed was normalized to 1 to 100 scale, where the lowest subwatershed value was set to 0, while the highest value was set to 100. This normalization interpreted the original data set (i.e., whether a high or low value was indicative of a high priority rating). These values were then summed and averaged for each of the subwatersheds within the LRRW. Resultant values were assigned an adjective rating of high, medium, low to reflect the upper 25th percentile, middle 50th percentile, and lower 25th percentile respectively as shown in Table 38.

Table 38. Rainy River Rainy Lake Watershed Subwatershed Prioritization Rating

HUC-10 Name	HUC-12 Name	HSPF Catchment	Aquatic Disruption	Altered Watercourse	Stream Power Index	Soil Erosion Susceptibility	Habitat Stress	Phosphorus Stress	Nitrogen Stress	Sediment Yield	Phosphorus Yield	Restorable Wetlands & Viability	Total Score	Subwatershed Rating
West Fork Black River	Upper West Fork Black River	A137	0.0	73.0	18.2	58.6	2.8	3.4	5.2	3.7	0.9	4.8	17	Medium
	Upper West Fork Black River	A139	6.1	96.5	8.4	10.3	1.7	2.4	2.9	1.9	0.8	1.0	13	Medium
	Middle West Fork Black River	A141	0.0	0.0	10.1	27.6	1.4	2.0	3.0	1.8	0.6	13.9	6	Low
	Middle West Fork Black River	A143	0.0	7.9	55.4	17.2	3.1	4.0	5.6	2.0	0.6	5.8	10	Low
	Lower West Fork Black River	A145	0.0	0.0	10.0	3.4	2.7	2.5	3.6	2.2	0.8	11.3	4	Low
	Lower West Fork Black River	A147	28.6	29.3	13.5	34.5	16.6	15.9	19.8	2.9	0.7	25.1	19	Medium
Black River	Headwaters Black River	A70R	0.0	0.0	1.6	27.6	1.5	2.3	3.8	2.3	0.8	0.0	4	Low
	Headwaters Black River	A81R	6.1	100.0	6.6	13.8	4.0	5.9	7.2	2.2	0.8	0.4	15	Medium
	Headwaters Black River	A90R	8.2	23.3	0.6	10.3	0.6	1.0	1.2	2.6	0.8	1.7	5	Low
	Upper Black River	A101	0.0	0.0	1.1	0.0	0.0	0.0	0.1	1.9	0.8	1.0	0	Low
	Upper Black River	A110	16.3	25.5	11.2	34.5	5.3	7.4	9.0	3.1	0.8	1.2	11	Low
	Middle Black River	A130	8.2	3.6	47.8	62.1	7.3	8.3	11.5	4.4	0.9	21.2	18	Medium
	Lower Black River	A150	8.2	16.2	36.5	37.9	10.2	6.7	10.0	3.8	0.7	30.3	16	Medium
South Fork Black River	South Fork Black River	A121	0.0	100.0	2.1	3.4	2.7	3.6	4.5	1.6	0.7	0.0	12	Low
	South Fork Black River	A123	0.0	0.0	0.0	3.4	0.0	0.0	0.0	1.0	0.7	0.0	1	Low
	South Fork Black River	A125	0.0	0.4	7.0	27.6	0.7	0.9	1.5	2.6	0.8	0.9	4	Low
Tributary to South Fork Black River	090300040205	A131	0.0	0.0	12.9	13.8	3.3	2.9	3.8	0.1	0.5	15.8	5	Low
	090300040205	A133	0.0	0.0	11.8	17.2	0.5	0.6	0.8	2.9	0.8	19.8	5	Low
	090300040206	A135	0.0	20.0	12.4	44.8	5.9	4.9	7.0	0.4	0.6	25.0	12	Medium
Middle Rainy River	City of International Falls-Rainy River	A10R	0.0	11.4	95.2	89.7	91.4	45.0	57.5	36.8	100.0	44.8	57	High
	Big Fork River-Rainy River	A30R	0.0	20.8	5.9	6.9	23.2	14.4	21.0	100.0	2.4	22.8	22	Medium
	Big Fork River-Rainy River	A50R	0.0	13.4	2.6	48.3	26.4	15.3	20.9	38.6	4.2	29.0	20	Medium
	Manitou Rapids-Rainy River	A170	0.0	10.0	88.4	100.0	26.6	26.2	32.7	50.5	5.4	44.1	38	High
	Manitou Rapids-Rainy River	A190	16.3	32.3	100.0	89.7	32.5	34.2	41.4	42.8	2.8	25.0	42	High
	McCloud Creek-Rainy River	A201	14.3	60.2	23.3	69.0	20.5	26.9	31.1	5.2	0.9	27.5	28	Medium
	McCloud Creek-Rainy River	A210	0.0	40.6	18.7	75.9	29.2	36.4	40.9	6.9	1.3	54.3	30	Medium
	Whitefish Creek-Rainy River	A221	0.0	72.1	10.1	55.2	19.8	25.0	29.0	4.5	0.9	36.2	25	Medium
	Whitefish Creek-Rainy River	A230	26.5	51.4	40.4	62.1	32.0	36.1	42.3	42.5	3.8	51.5	39	High
Winter Road River	Judicial Ditch No 23	A401	10.2	29.5	29.6	41.4	33.8	35.4	32.6	12.7	11.0	13.1	25	Medium
	Judicial Ditch No 23	A403	0.0	97.2	3.4	10.3	29.8	27.6	19.8	2.8	1.6	0.2	19	Medium
	Judicial Ditch No 23	A405	0.0	47.0	18.0	17.2	41.4	39.9	30.7	4.5	1.8	1.1	20	Medium
	Winter Road River	A407	100.0	32.7	18.0	13.8	33.6	32.7	26.9	2.4	0.2	10.0	27	Medium
	Winter Road River	A421	57.1	36.8	54.6	44.8	65.8	64.0	59.0	3.7	3.3	29.8	42	High
Peppermint Creek	Peppermint Creek	A411	34.7	28.0	2.4	10.3	31.7	29.5	21.7	9.6	3.4	0.1	17	Medium
	Peppermint Creek	A413	0.0	30.1	5.4	27.6	54.8	52.8	46.5	11.3	3.1	23.3	25	Medium

HUC-10 Name	HUC-12 Name	HSPF Catchment	Aquatic Disruption	Altered Watercourse	Stream Power Index	Soil Erosion Susceptibility	Habitat Stress	Phosphorus Stress	Nitrogen Stress	Sediment Yield	Phosphorus Yield	Restorable Wetlands & Viability	Total Score	Subwatershed Rating
	Peppermint Creek	A415	61.2	95.9	0.9	3.4	30.0	29.5	24.9	1.0	0.2	2.4	25	Medium
Baudette River	Baudette River	A393	71.4	89.2	3.9	13.8	42.4	36.4	34.4	0.0	0.0	28.8	32	Medium
	Baudette River	A395	59.2	43.7	21.4	24.1	41.6	39.9	34.5	0.6	0.6	28.8	29	Medium
	Baudette River	A397	18.4	56.3	5.5	27.6	60.3	61.1	58.3	3.3	1.0	63.7	36	High
Lower Rainy River	Silver Creek	A381	10.2	27.2	12.2	62.1	100.0	100.0	98.7	1.0	0.6	83.7	50	High
	Silver Creek	A383	40.8	58.9	10.2	20.7	44.3	42.6	37.2	0.6	0.2	44.1	30	Medium
	Judicial Ditch No 13	A391	0.0	25.0	16.3	41.4	72.2	77.0	75.3	1.4	1.1	60.1	37	High
	Wabanica Creek	A423	49.0	15.6	17.2	58.6	98.6	86.5	86.5	1.1	0.2	83.4	50	High
	Rainy River	A390	0.0	49.8	29.1	37.9	75.2	75.6	74.8	4.8	1.0	53.4	40	High
	Rainy River	A399	38.8	36.2	11.9	65.5	93.0	95.5	100.0	19.3	3.8	64.9	53	High
	Rainy River	A430	10.2	63.4	7.5	48.3	94.8	95.5	97.7	10.4	5.3	100.0	53	High

6.2 Downscaled HSPF Pollutant Yields

The HSPF model is a lumped parameter model where characteristics of a watershed are spatially averaged into simplified categories that can be used to approximate the flow and pollutant loads from the area. Therefore, the model can be used to predict generalized changes over a subbasin (e.g., implementing 1,000 acres of No Till somewhere in the watershed) but can be limited in providing predicted benefits from specific projects. To provide a tool to quickly estimate the benefit from specific projects and prioritize areas within the HSPF subbasins, the HSPF predicted yields from the different land cover and soil categories were downscaled using the GIS layers used to create the model (Table 39). The resulting downscaled yields layer can then be used like any other export coefficient method where the estimated load from a watershed is estimated by summing the product of the land use specific pollutant yields by the area of each land use. However, with this method the pollutant yields are from a calibrated model instead of literature values. The predicted TP yield in the HSPF model range from 0 to 1.6 lbs/ac/yr (Figure 23). The predicted sediment yield in the HSPF model range from 0 to 0.9 tons/ac/yr (Figure 24). The downscaled yields are representative of the average conditions for that land cover category in that subbasin. Therefore, they do not incorporate local characteristics such as local soils, topography, or existing management conditions of the land.

Table 39. HSPF Downscaled Approach

<table>
<tr><th>2010 Lake of the Woods Land Cover</th><th>HSPF Land Cover Category</th><th>NRCS Hydrologic Soil Group Layer</th><th>HSPF Soils Category</th><th>HSPF Subbasins</th><th>Predicted TP and Sediment Yields</th></tr>
<tr><td>Developed High Density</td><td rowspan="3">Developed Effective Impervious Area</td><td rowspan="6">NA</td><td rowspan="6">NA</td><td rowspan="19">Intersected with the land cover and soils layer</td><td rowspan="19">Joined by HSPF Subbasin ID, HSPF Land Cover Category, and HSPF Soil Category</td></tr>
<tr><td>Developed Medium Density</td></tr>
<tr><td>Developed Roads</td></tr>
<tr><td>Developed Low Density</td><td rowspan="3">Developed</td></tr>
<tr><td>Developed Managed Grass</td></tr>
<tr><td>Extraction</td></tr>
<tr><td rowspan="2">Deciduous Forest</td><td rowspan="2">Mature Deciduous Forest</td><td>A, B</td><td>AB</td></tr>
<tr><td>C, D, A/D, B/D, C/D</td><td>CD</td></tr>
<tr><td>Regenerating Forest</td><td rowspan="2">Young Forest</td><td>A, B</td><td>AB</td></tr>
<tr><td>Regenerating Forested Wetland</td><td>C, D, A/D, B/D, C/D</td><td>CD</td></tr>
<tr><td>Coniferous Forest</td><td rowspan="3">Mature Coniferous Forest</td><td>A, B</td><td>AB</td></tr>
<tr><td>Mixed Forest</td><td rowspan="2">C, D, A/D, B/D, C/D</td><td rowspan="2">CD</td></tr>
<tr><td>Sparse Forest</td></tr>
<tr><td>Row Crops & Small Grains</td><td>Cropland High Till</td><td rowspan="6">NA</td><td rowspan="6">NA</td></tr>
<tr><td>Hay & Pasture</td><td>Grassland</td></tr>
<tr><td>Lakes and Ponds</td><td rowspan="4">Wetlands</td></tr>
<tr><td>Herbaceous Wetlands</td></tr>
<tr><td>Woody Wetlands</td></tr>
<tr><td>Wetland/Sandbar</td></tr>
</table>

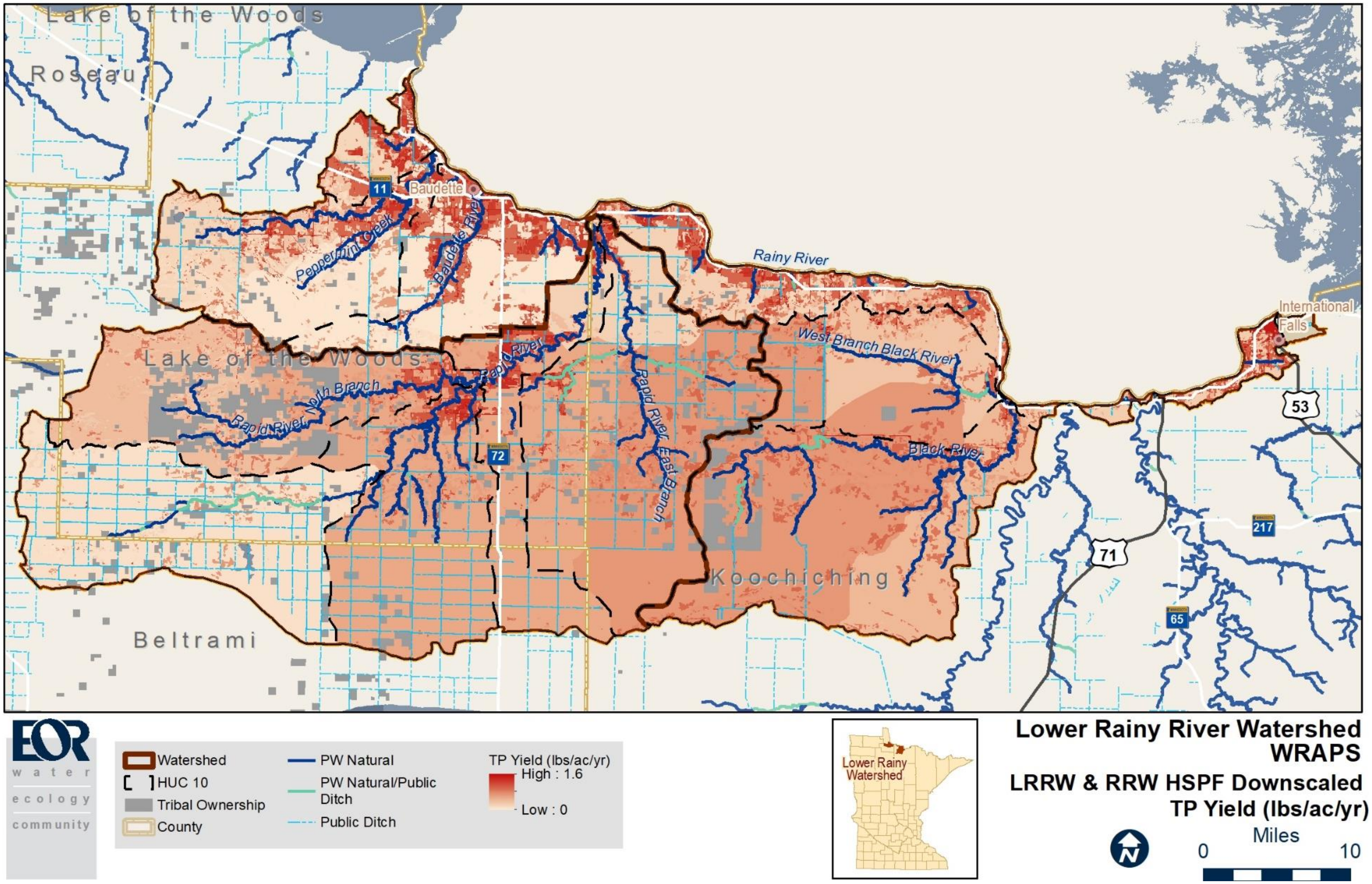

Figure 23. HSPF downscaled TP yield (lbs/ac/yr) for the Lower Rainy HSPF model.

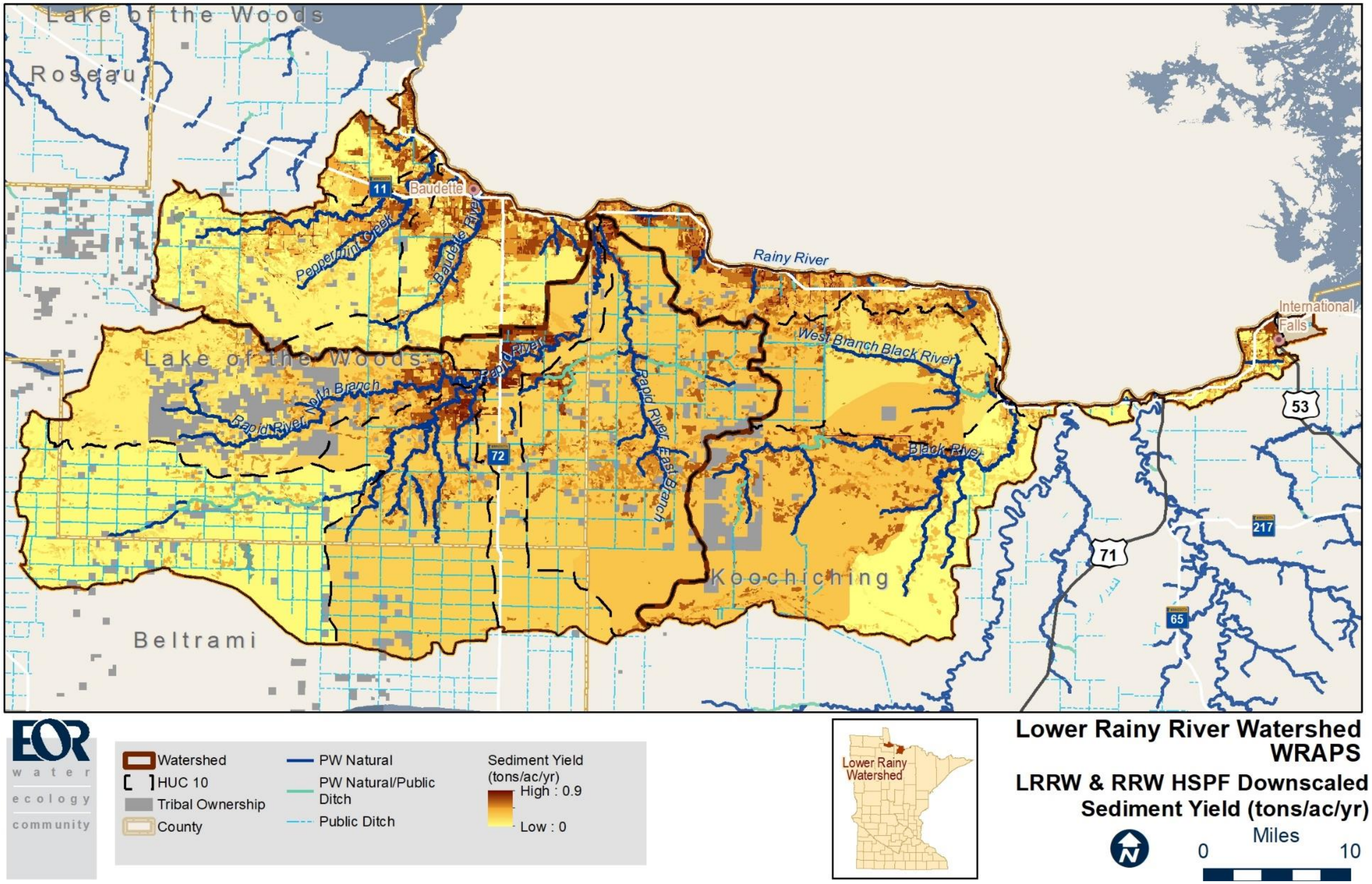

Figure 24. HSPF downscaled sediment yield (tons/ac/yr) for the Lower Rainy HSPF model.