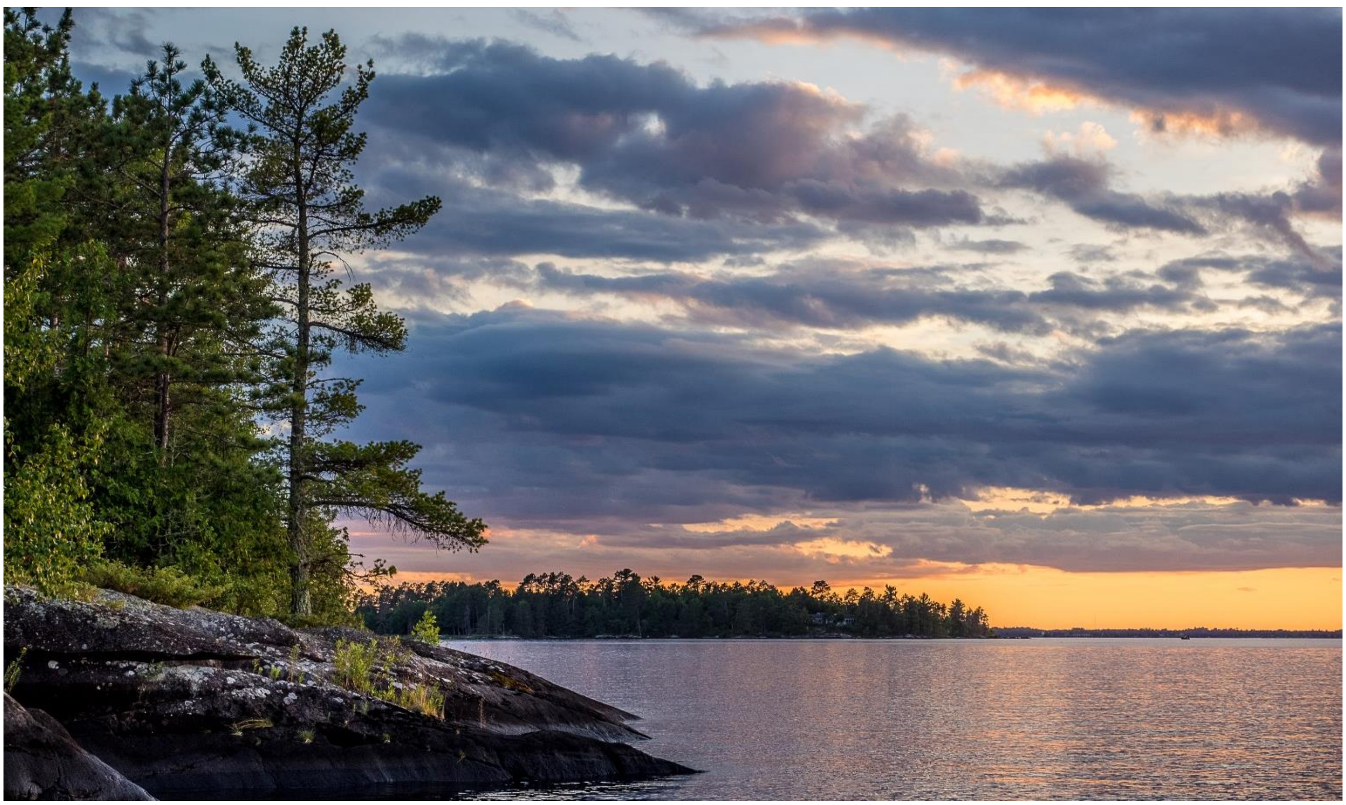
Rainy River – Rainy Lake Watershed

July 2022

Rainy River-Rainy Lake Watershed Restoration and Protection Strategy Report



MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

Authors

Pat Conrad
Trevor Rundhaug
Ally Mark
Meghan Funke, PhD.
Section 1.1.1, Drinking Water Protection, provided by MDH

Contributors/acknowledgements

Koochiching SWCD
Jolén Simon
Pam Tomevi
Sam Soderman
Eric Olson
James Aasen

North St. Louis SWCD
Phil Norvitch
Becca Reiss
Anita Provinzino

MPCA
Amy Mustonen
Jenny Jasperson
Angus Vaughn
Jesse Anderson
Nate Mielke
Ben Lundeen

DNR
Ben Nicklay
Kevin Peterson
Kristen Patterson
Tom Burri
Jeff Tillma
Rian Reed
Richard Biemiller
Karl Koller

BWSR
Erin Loeffler
Jeff Hrubes

MDH
Chris Parthun
Tracy Lund

USFS
Marty Rye
Jason Butcher
Emily Creighton

Voyageurs National Park
Ryan Maki

Editing and graphic design

PIO staff
Graphic design staff
Administrative Staff

Cover photo: Rainy Lake, Jeff Kantor

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Key terms

Assessment Unit Identifier (AUID): The unique waterbody 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.

Best Management Practice (BMP): Control measure employed to address changes to the quantity and quality of stormwater that result from land use change.

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

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

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

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

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

Stressor (or biological stressor): This is a broad term that includes both pollutant sources and 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.

Abbreviations

ACPF	Agricultural Conservation Planning Framework
BANCS	Bank Assessment of Nonpoint source Consequences of Sediment
BMP	Best Management Practice
BWSR	Minnesota Board of Water and Soil Resources
CWLA	Clean Water Legacy Act
DNR	Minnesota Department of Natural Resources
DO	Dissolved Oxygen
EDA	Environmental Data Access
EPA	United States Environmental Protection Agency
EQuIS	Environmental Quality Information System
ERA	Emergency Response Area
F-IBI	Fish index of biological integrity
GAP	Gap Analysis Project
GHG	Greenhouse Gas
GIS	Geographic Information System
HSPF	Hydrologic Simulation Program FORTRAN
HUC	Hydrologic Unit Code
IJC	International Joint Commission
IWM	Intensive Watershed Monitoring
MDH	Minnesota Department of Health
MFRC	Minnesota Forest Resources Council
M-IBI	macroinvertebrate index of biological integrity
MPCA	Minnesota Pollution Control Agency
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRCS	Natural Resources Conservation Services
NWI	National Wetland Inventory
ORVW	Outstanding Resource Value Waters
PWS	Public Water Supply Utility

RAQ	Riparian Adjacency Quality
RRRLW	Rainy River-Rainy Lake Watershed
SDS	State Disposal System
SFIA	Sustainable Forest Incentive Act
SID	Stressor Identification
SPI	Stream Power Index
SWAG	Surface Water Assessment Grant
SWCD	Soil and Water Conservation District
TALU	Tiered Aquatic Life Uses
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
USFS	United States Forest Service
USGS	United States Geologic Survey
VNP	Voyageurs National Park
WAN	Wildlife Action Network
WASCOB	Water and Sediment Control Basin
WPLMN	Watershed Pollutant Load Monitoring Network
WRAPS	Watershed Restoration and Protection Strategy
WWTF	Wastewater Treatment Facilities
WWTP	Wastewater Treatment Plant

Executive summary

This Watershed Restoration and Protection Strategy (WRAPS) report for the Rainy River-Rainy Lake Watershed (RRRLW) is a well-researched 10-year roadmap for maintaining healthy lakes and streams within the watershed. It walks through the characteristics and trends of important water resources in the watershed and lays out the strategies for restoration and protection. These strategies will assist in sustaining a healthy and prosperous environment for Minnesota. It should be used to guide local water planning, the allocation of funds, and efforts toward conservation practices.

Located in the Laurentian Mixed Forest Ecological Province of northern Minnesota (Cleland et al. 1997), the RRRLW covers 296,624 acres of land. The RRRLW is characterized by lakes and stream reaches that drain extensive wetlands located on the Glacial Lake Agassiz lakebed in Koochiching County. Many of these stream reaches drain into the watershed's principal resource, Rainy Lake, the state's third largest lake.

The RRRLW contains three key waterbodies including Rainy Lake, the Rat Root River, and the Rat Root River, East Branch. In total, there are 27 lakes (each >10 acres) and 16 stream reaches in the Minnesota portion of the watershed. These surface and groundwater resources represent key drivers of the region's economy, supplying drinking water and recreational opportunity. In 2017, the Minnesota Pollution Control Agency (MPCA) initiated monitoring efforts of rivers and lakes in the watershed and in 2019, four stream reaches and one lake were assessed for aquatic life, aquatic recreation, and/or aquatic consumption use support. Results from the study found that most of the stream miles in the watershed are in good condition due to the relatively undisturbed forest and wetlands that make up much of the watershed's land cover. However, in parts of this watershed, total suspended solids (TSS) and dissolved oxygen (DO) occasionally fail to meet the state standards. The region's geologic past left behind flat topography and fine sediment, a legacy that likely plays a significant role in the occasional poor TSS and DO water quality metrics. Increases in anthropogenic stressors, such as historical and recent forest cover changes, backwater effects from a downstream dam, and the draining of wetlands, may locally affect aquatic life health. Where standards are being met, protection strategies to maintain good water quality are important.

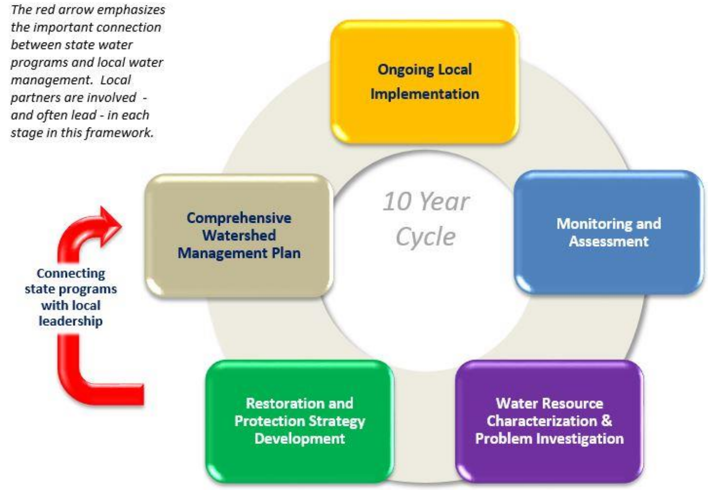
Several targeting and prioritization processes were conducted to help RRRLW stakeholders identify, locate, and prioritize restoration and protection strategies. The general approach began with providing a high-level overview of the issues and concerns facing the watershed, and became increasingly more detailed as specific implementation actions were evaluated. Through this process, sediment and DO were identified as key issues to be addressed in the RRRLW. Hydrologic Simulation Program – FORTRAN (HSPF) modeling was used to evaluate pollutant loading dynamics across the RRRLW. A variety of geographic datasets were then reviewed by local resource managers and public stakeholders to understand watershed stresses and to prioritize subwatersheds.

Once priority subwatersheds were identified, additional geographic information system (GIS) and other tools were utilized to identify and prioritize specific protection and restoration strategies. Land cover was analyzed through the Riparian Adjacency Quality (RAQ) tool and Riparian Forest Buffer tool to target protection efforts and riparian improvements. The Agricultural Conservation Planning Framework (ACPF) toolset was used to identify potential grade and ravine stabilization structures that could be built across drainageways in the watershed. These potential structures were further prioritized using two indicators of potential feasibility, including the distance from the structure to the nearest road and an estimated runoff curve number for the structure's drainage area.

Channel conditions, including erosion and bank height, were assessed using the Bank Assessment for Nonpoint source Consequences of Sediment model by the DNR, MPCA, and Koochiching County SWCD. Efforts focused on the Rat Root River and Rat Root River, East Branch and identified three segments of concern for erosion and incision. Generally, both rivers experience low erosion rates. Banks with higher erosion rates were mostly scattered throughout the surveyed section, indicating more localized issues rather than systemic risk.

The collection of current land and water data is key to both assessing progress and informing management and decision-making. Improved watershed management in the RRRLW requires reliable data to generate the information that underpins targeting and prioritization. Data from numerous monitoring programs will continue to be collected and analyzed for the RRRLW.

What is the WRAPS report?



Minnesota has adopted a watershed approach to address the state's 80 major watersheds. The Minnesota watershed approach incorporates **water quality assessment, watershed analysis, public participation, planning, implementation, and measurement of results** into a 10-year monitoring and evaluation 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 these 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 total maximum daily load (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 waterbodies and overall watershed health, including both protection and restoration efforts. A key aspect of this effort is to develop and utilize watershed-scale models and other tools to identify strategies for addressing point and nonpoint source pollution that will cumulatively achieve water quality targets. For nonpoint source pollution, 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 the basis for addressing the U.S. Environmental Protection Agency's (EPA) Nine Minimum Elements of watershed plans, to help qualify applicants for eligibility for Clean Water Act Section 319 implementation funds.

Purpose	•Support local working groups and jointly develop scientifically-supported restoration and protection strategies to be used for subsequent implementation planning •Summarize watershed approach work done to date including the following reports: •*Rainy River-Rainy Lake Watershed Monitoring and Assessment* •*Rainy River-Rainy Lake Watershed Biotic Stressor Identification*
Scope	•Impacts to aquatic recreation and impacts to aquatic life in streams •Impacts to aquatic recreation in lakes
Audience	•Local working groups (local governments, Soil and Water Conservation Districts (SWCDs), watershed management groups, etc.) •State agencies (MPCA, DNR, BWSR, etc.)

This report focuses on conventional pollutants and stressors, including fecal bacteria, nutrients, and eutrophication indicators, DO, pH, temperature, and TSS. This report also addresses fish and macroinvertebrate bioassessments. Minnesota's TMDL Priorities for 2016 through 2022 document focuses on TMDL completion for conventional pollutants and states: “For the other nonconventional pollutants, Minnesota is using (or is in the process of developing) other strategies. The MPCA will continue to develop TMDLs for nonconventional pollutants, such as mercury and chloride, during this time period, but those impairments are not included in Minnesota TMDL Completion Priority List.” Also, when appropriate, other processes (e.g., permitting) are used to address nonconventional pollutants.

1. Watershed background and description

The RRRLW (09030003) is located in the Rainy Lake Basin, east of International Falls, Minnesota. The watershed in Minnesota is 33% in St. Louis County and 67% in Koochiching County. Based on data from the American Community Survey, the MPCA classifies the portion of the RRRLW within St. Louis County as an environmental justice area of concern. The MPCA defines these environmental justice areas of concern by census tract data wherein the percentage of people of color exceeds 50% or over 40% of households report an income less than 185% of the federal poverty level. The St. Louis County portion of the watershed meets the second criterion, which points out the need for additional considerations to prevent disproportionate environmental harm and cycles of injustice (MPCA 2022).

The northern boundary is part of the international border waters with Ontario, Canada. There are no large cities in this remote watershed. The small communities of Island View, Ericsburg, Ray, and Ranier, Minnesota are the only towns in the watershed. The Minnesota portion of this international watershed covers 296,624 acres and is located in the Laurentian Mixed Forest Ecological Province (Cleland et al. 1997). Lakes and wetland areas make up 54% of the Minnesota portion of the watershed.

In 2008, the International Joint Commission’s (IJC’s) Transboundary Hydrographic Data Harmonization Task Force was convened to improve the alignment of geospatial hydrographic datasets along the United States–Canada border. The results of the data harmonization shifted the eastern HUC-8 Major watershed boundary, reassigning a portion of the RRRLW (09030003) to the Rainy River – Headwaters Watershed (09030001). The MPCA uses the Natural Resources Conservation Service’s (NRCS) Watershed Boundary Set, which reflects the data harmonization results. However, note that the HUC-8 boundary dataset used by the Minnesota Department of Natural Resources (DNR) does not reflect the data harmonization results.

This area is primarily boreal forest on shallow soils over bedrock or peat bog. The eastern portion is in the Border Lakes ecological sub-region; the western portion is in the Little Fork/Vermilion Uplands, interlaced with extensive wetland bogs. Wilderness recreation/tourism is the prime economic driver due to the scenic beauty, resorts, camping, fishing, and hunting opportunities (MPCA 2011). While a small portion of the watershed is urban, most of the watershed is wilderness, and a portion is protected by U.S. National Park status. Precipitation in the watershed averages 23 inches annually. Additional information on the RRRLW can be found on the watershed page on the MPCA website (https://www.pca.state.mn.us/water/watersheds/rainy-river-rainy-lake).

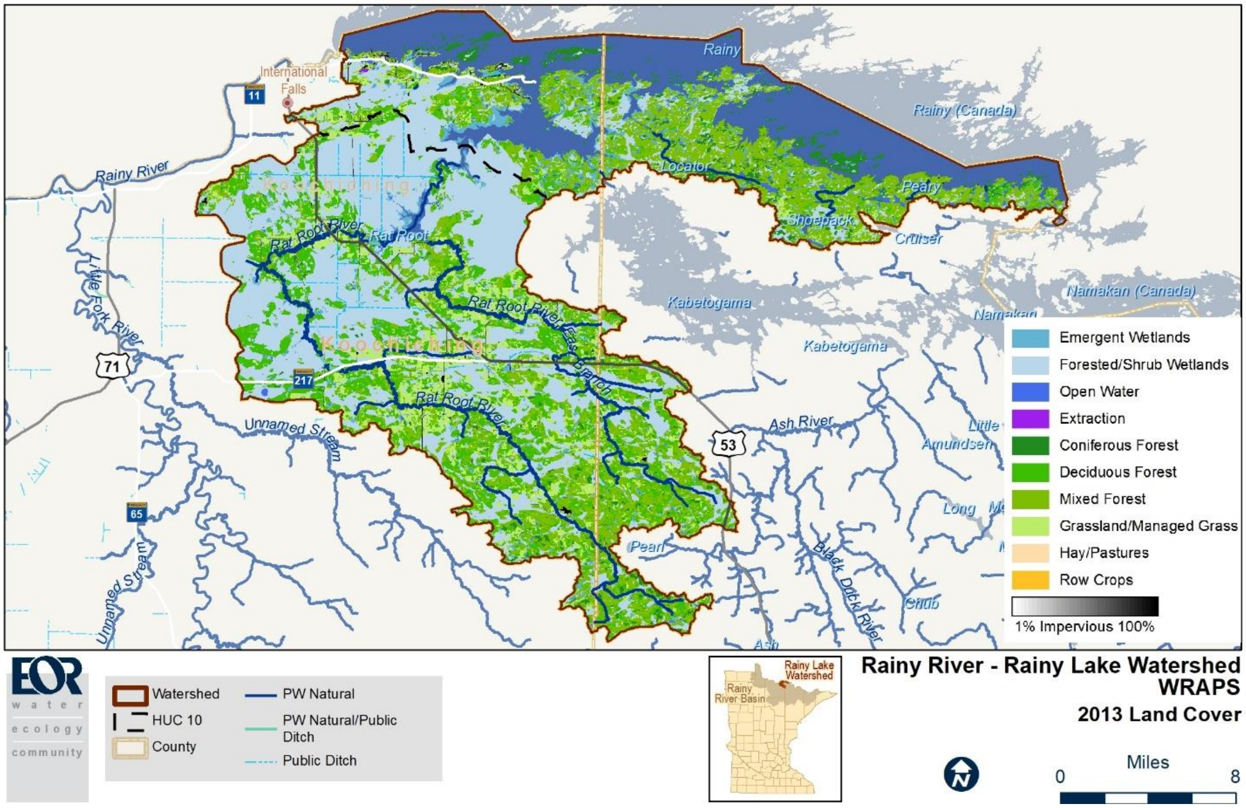


Figure 1. Land cover in the Rainy River – Rainy Lake Watershed

Additional Rainy River – Rainy Lake watershed resources

U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Rapid Watershed Assessment for the Rainy River-Rainy Lake Watershed: https://www.nrcs.usda.gov/wps/portal/nrcs/mn/technical/dma/rwa/nrcs142p2_023644/

Minnesota Department of Natural Resources (DNR) Watershed Context Report for the Rainy River-Rainy Lake Watershed: http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/context_report_major_74.pdf

Minnesota Department of Natural Resources (DNR) Watershed Health Assessment Framework Watershed Report Card for the for the Rainy River-Rainy Lake Watershed:

http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/ReportCard_Major_74.pdf

Minnesota Nutrient Planning Portal for the Rainy River – Rainy Lake Watershed: https://mrbdc.mnsu.edu/mnnutrients/watersheds/rainy-river-rainy-lake

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

Rainy River – Rainy Lake Watershed Monitoring and Assessment Report: https://www.pca.state.mn.us/sites/default/files/wq-ws3-09030003b.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

Rainy River – Rainy Lake Watershed Stressor Identification Report: https://www.pca.state.mn.us/sites/default/files/wq-ws5-09030003.pdf

2. Watershed conditions

Overall, water quality conditions are good and can be attributed to the forest and wetlands that dominate land cover within the RRRLW. However, in parts of this watershed, TSS and DO at times fail to meet the state standards. The underlying fine sediments and generally flat topography of the region, a function of the geologic past, contribute to the occasional poor TSS and DO metrics. Increases in anthropogenic stressors, such as historical and recent forest cover changes, backwater effects from a downstream dam, and the draining of wetlands, may locally and further affect water quality and overall aquatic life health. Careful planning around waterbodies with poorer water quality can support efforts towards meeting standards. Where standards are being met, protection strategies to maintain good water quality are important.

2.1 Condition status

In 2017, the MPCA initiated intensive watershed monitoring (IWM) efforts of surface waters within the RRRLW. Five stream stations were sampled for biology at the outlets of variable sized drainages. These locations included both the mainstem Rat Root River and the Rat Root River, East Branch. The monitoring stations in the RRRLW are shown in Figure 2. As part of this effort, the MPCA staff joined with Koochiching County Soil and Water Conservation District (SWCD) to conduct stream water chemistry sampling at the outlets of the Rat Root River and the Rat Root River, East Branch. In 2019, rivers, streams, and lakes with sufficient data were assessed to determine if they supported aquatic life, recreation, and consumption. In addition to the data collected by the MPCA, the assessors considered data from other state and federal agencies, local units of government, lake associations, and/or individuals. In all, four stream segments, out of 16 total, and one lake, out of 27 total, were assessed for aquatic life and recreation.

Mercury was analyzed in fish tissue samples collected from 14 lakes in the watershed. Only one lake, Rod Smith Pond, is not on the Impaired Waters List due to mercury in fish tissue. It was sampled in 2005 and had a single northern pike, which was above the 0.2 mg/kg water quality standard but did not meet the minimum of five fish for assessment. Rainy Lake has a strong record of fish collections between 1971 and 2015. During that time, the mean mercury concentrations in Northern Pike and Walleye remained surprisingly steady throughout the period: long-term means were 0.555 mg/kg and 0.472 mg/kg respectively. Rainy Lake and 12 other waterbodies in the RRRLW are impaired by mercury as summarized in Table 1. Of these impairments, three mercury TMDLs were approved as part of the 2020 Statewide Mercury TMDL Appendix A. Revisions to Appendix A of the Minnesota Statewide Mercury TMDL are submitted to the EPA every two years with the impaired waters list (MPCA 2007). Water resources with mercury concentrations greater than 0.572 mg/kg are not part of Appendix A. These waterbodies have a TMDL target completion year of 2033. For more information on mercury impairments, including the statewide mercury TMDL, see the TMDL special projects webpage on the MPCA website at: https://www.pca.state.mn.us/water/tmdl-special-projects.

Table 1. Summary of mercury impairments in the Rainy River-Rainy Lake Watershed

Waterbody Name	Waterbody Type	AUID	Year Added to 303(d) List	Approved TMDL
Boot	Lake	69-0868-00	2002	No
Brown	Lake	69-0839-00	2002	No
Fishmouth	Lake	69-0834-00	2002	Yes (2007)
Locator	Lake	69-0936-00	1998	No
Loiten	Lake	69-0872-00	2004	No
Moose	Lake	36-0008-00	1998	No
Oslo	Lake	69-0838-00	2002	No
Peary	Lake	69-0833-00	1998	Yes (2007)
Quill	Lake	69-0871-00	2006	Yes (2007)
Rainy	Lake	69-0694-00	1998	No
Shoepack	Lake	69-0870-00	1998	No
Unnamed	Lake	69-0835-00	2002	No
War Club	Lake	69-0937-00	1998	No

Source: Draft Minnesota 2022 303(d) list
Assessment Unit Identifier (AUID)

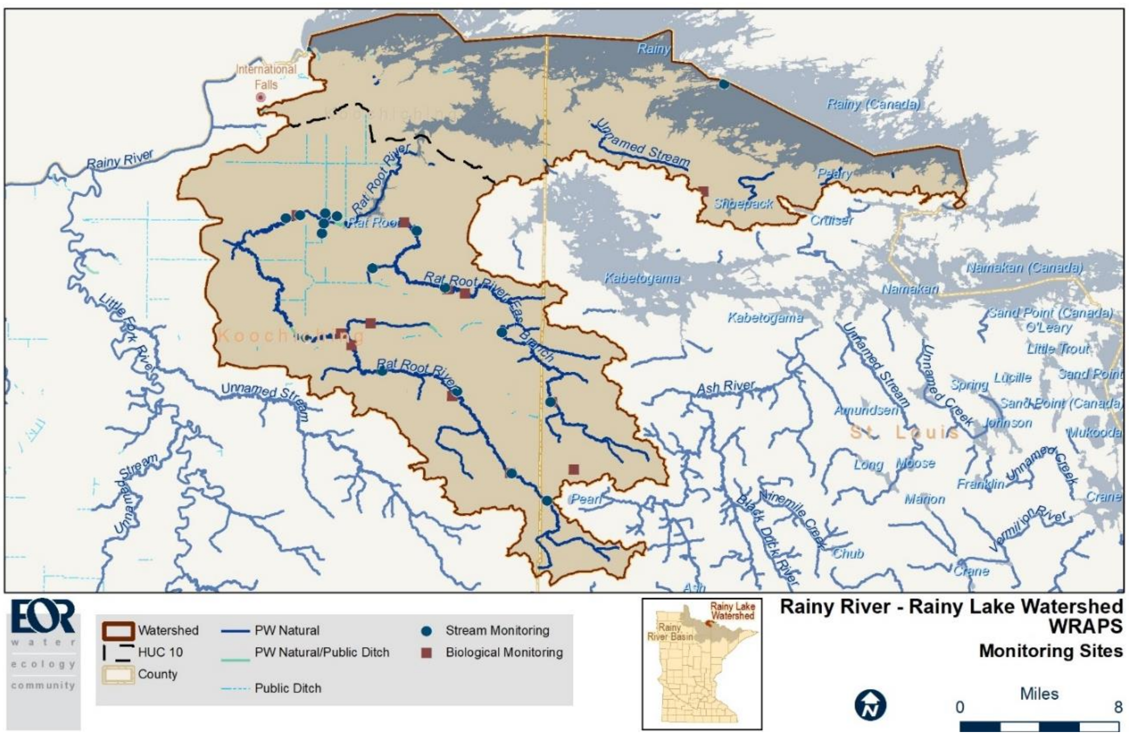


Figure 2. Monitoring sites in the Rainy River – Rainy Lake Watershed.

Streams

Assessable streams, those with sufficient information available to make assessments, in the RRRLW are limited to the Rat Root River and the Rat Root River, East Branch. Three of the four assessed stream reaches in the RRRLW fully supported aquatic life and/or recreation. The fourth stream reach, the Rat Root River (from Unnamed Creek to Rat Root River, East Branch) had inconclusive information to make a determination of aquatic life use but was determined to be supporting of aquatic recreation. (Table 2).

No reaches in the RRRLW are designated as impaired for aquatic life use. Fish index of biological integrity (F-IBI) and macroinvertebrate index of biological integrity (M-IBI) scores are poorer than expected thresholds in the middle section of the Rat Root River. TSS and DO at times do not meet respective state water quality standards in the downstream to mid-river reaches of the Rat Root River. This is likely a function of the fine, glacially derived sediments that are found in this area in the case of TSS. Low DO is likely due to natural wetland environments, low gradient nonaerating reaches, and the "backwater" effect from downstream damming. TSS is frequently elevated in the downstream to mid-river reaches of the East Rat Root River. Despite elevated TSS in the East Rat Root River, biological index scores are good, with F-IBI and M-IBI scores meeting their expected thresholds at the sampled locations.

Stream habitat, as indicated by the Minnesota Stream Habitat Assessment scores, ranged from poor to fair. Land use and riparian area scores were generally high due to the lack of watershed development, but in-stream habitat did not fare as well. Most scores for substrate, fish cover, and channel morphology were below the 50th percentile. Fish cover tended to be higher in the low gradient headwater reaches where there was usually more diverse habitat available. In some cases, high quality in-stream habitat may mitigate the negative consequences of other stressors.

Stream instability and mass wasting of streambanks is likely the result of soil types found within the middle and downstream reaches of the Rat Root River corridor, where Glacial Lake Agassiz deposited clay and clayey silts (MPCA 2021a). Sources of the sediment and turbidity are numerous, and are a function of the watershed's geological setting, the river's geomorphology, and current/historical land use practices. Water quality is impacted by the high sediment load in the form of excessive turbidity. The fine sediments are ultimately deposited into the slower, low gradient portions of streams in the Rat Root River drainage, Rat Root Lake, and Rainy Lake.

Table 2. Assessment status of river reaches in the Rainy River-Rainy Lake Watershed

Aggregated HUC-12 Subwatershed	AUID (Last 3 digits)	River	Reach description	Aquatic life Indicators: Fish Index of biotic integrity	Aquatic life Indicators: Macroinvertebrate index of biotic integrity	Aquatic life Indicators: Dissolved oxygen	Aquatic life Indicators: Turbidity/TSS	Aquatic life Indicators: Eutrophication	Aquatic life	Aquatic rec. (Bacteria)
Rat Root River	634	Rat Root River	Headwaters to Unnamed Creek	MTS	MTS	IF	IF		SUP	- -
	635	Rat Root River	Unnamed Creek to Rat Root River, East Branch	MTS	- -	NA*	EXS	IC	IC	SUP
Rat Root River, East Branch	632	Rat Root River, East Branch	Headwaters to Unnamed Creek	MTS	- -	IF	IF		SUP	- -
	633	Rat Root River, East Branch	Unnamed Creek to Rat Root River	MTS	MTS	IF	EXS		SUP	SUP

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

Assessment Unit Identifier (AUID); Hydrologic Unit Code (HUC)

Lakes

Although all lakes were impaired for aquatic consumption (i.e., mercury in fish), Rainy Lake clearly met recreational use goals. The high recreational lake quality reflects the undisturbed nature of their contributing watersheds. In the remote northeastern region of the watershed where obtaining water quality samples may be difficult, lake clarity data suggests that these lakes are suitable for recreation.

The DNR confirmed the presence of zebra mussel veligers (i.e., larval stage of zebra mussels) in Black Bay of Rainy Lake in 2021. Zebra mussels, an aquatic invasive species, have multiple effects on lakes they invade. They alter ecosystems by changing the flow of energy through a system, reducing food available to some fish, and causing extirpation of some native mollusks. Zebra mussels also have economic impacts often caused by clogging water intakes and possibly by reducing waterfront property values. The sharp shells of zebra mussels can be a nuisance to swimmers who may cut their feet when stepping on the shells.

Federal, Provincial, State, and County partners are collaborating on Aquatic Invasive Species prevention efforts in this watershed. The International Rainy-Lake of the Woods Watershed Board is developing an aquatic invasive species risk assessment for the Rainy-Lake of the Woods Basin to support the development of aquatic invasive species prevention across multiple jurisdictions. This will result in identification of knowledge gaps, priority focus areas, and a binational list of aquatic invasive species of concern. County inspection and decontamination efforts are also underway to prevent or slow the spread of invasive species in Minnesota waters. Delaying infestation of waterbodies as long as possible provides important time for advances in control and prevention technologies for aquatic invasive species. The public should be encouraged to clean, drain, and dry boats and equipment between lakes and to follow all aquatic invasive species regulations and recommendations. They should also be encouraged to make use of the decontamination stations near Rainy, Kabetogama, Ash River, or Crane lakes when available.

Table 3. Assessment status of lakes in the Rainy River-Rainy Lake Watershed.

Aggregated HUC-12 Subwatershed	Lake ID	Lake	Aquatic life indicator: Chloride	Aquatic recreation indictor			Aquatic recreation use
				Total Phosphorus	Chlorophyll-a	Secchi Disk Depth	
Rainy Lake	69-0694	Rainy	IF	MTS	MTS	MTS	SUP
	69-0833	Peary	MTS	IF		MTS	IF
	69-0834	Fishmouth	--	IF		IF	IF
	69-0835	Unnamed	MTS	IF		MTS	IF
	69-0838	Oslo	--	IF		IF	IF
	69-0868	Boot	--	IF		IF	IF
	69-0870	Shoepack	MTS	IF		EXS	IF
	69-0871	Quill	--	IF		IF	IF
	69-0872	Loiten	--	IF		IF	IF
	69-0936	Locator	MTS	IF		IF	IF
	69-0937	War Club	--	IF		IF	IF

Imp = impaired for impacts to aquatic recreation, Sup = fully supporting aquatic recreation, IF = insufficient data to make an assessment, IC = inconclusive

Hydrologic Unity Code (HUC)

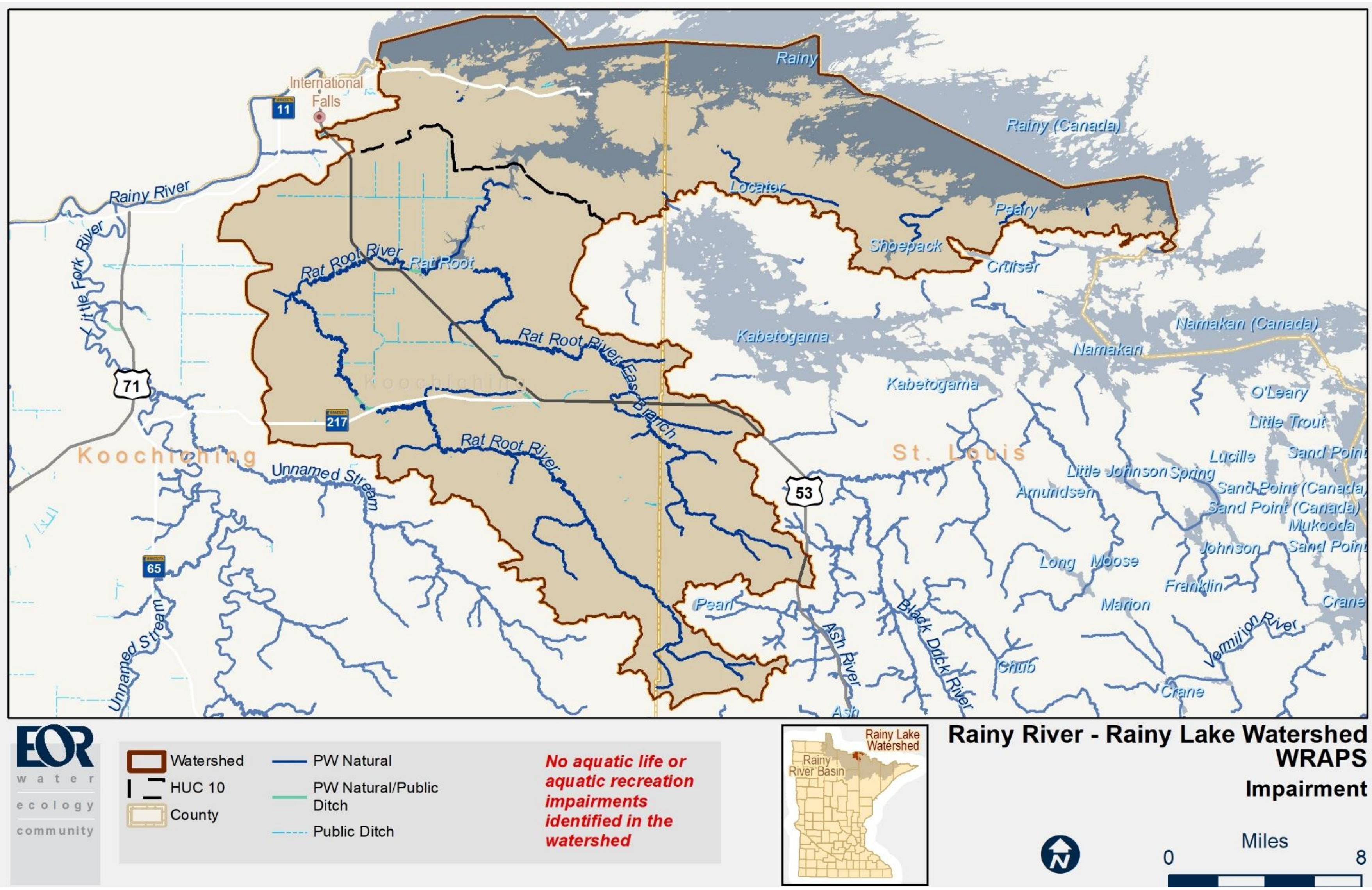


Figure 3. Impairments in the Rainy River-Rainy Lake Watershed

Drinking Water

Drinking water is important in every 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 sources should be a high priority for all watersheds in Minnesota.

The RRRLW contributes to one downstream community public water supply—International Falls—and six noncommunity public water suppliers that use surface water or groundwater under the direct influence of surface water as a drinking water source.

Many of the implementation activities conducted by the MPCA, SWCDs, logging industries, private landowners, and local entities can help address surface water quality. The main issues for these public water suppliers include:

- Naturally generated elevated organic carbon concentrations in many waterbodies. Chlorine used for drinking water disinfection can react with natural organic matter in surface waters and generate carcinogenic disinfection byproducts including trihalomethanes and haloacetic acids (MDH 2022).
- Some waterbodies have elevated nutrient concentrations.
- Black Bay of Rainy Lake has a history of high turbidity flows that have required complex filtration treatment systems for some public water suppliers.

Noncommunity Public Water Supplies

The noncommunity public water supplies in the watershed rely on surface water from the many lakes and rivers present in the watershed for drinking water. Noncommunity public water supplies include bars, restaurants, camps, and resorts that serve customers for shorter periods of time. The following surface water bodies serve as drinking water sources:

- Rainy Lake
- Rainy River

Community Public Water Supplies

The city of International Falls, while not in the watershed, relies on the Rainy River immediately downstream from the RRRLW outlet for drinking water, and thereby benefits from restoration and protection of surface water in the RRRLW. The Source Water Assessment area for International Falls includes portions of the RRRLW.

The figure below highlights the Source Water Assessment area 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 public water supply utility (PWS) 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 (i.e., 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 waterbodies 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 (i.e., 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 4 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.

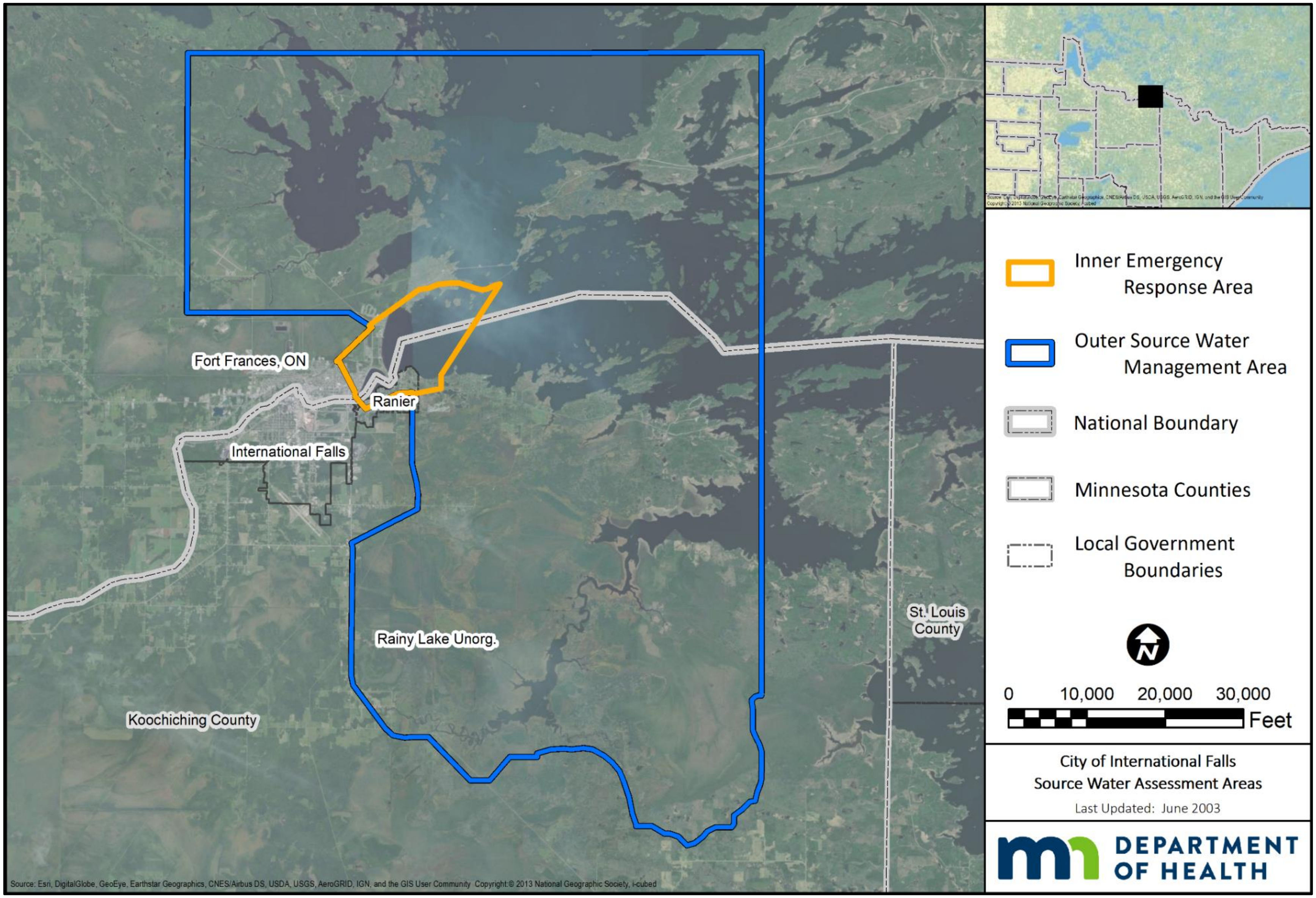


Figure 4. Source Water Assessment areas for the city of International Falls

2.2 Water quality trends

Water Clarity

Year-to-year weather variations affect water quality observation data; for this reason, interpreting long-term data trends minimizes year-to-year variation and provides insight into changes occurring in a waterbody 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 incorporates any relevant agency and partner data submitted to the MPCA Environmental Quality Information System (EQuIS). The water clarity trends are calculated using a Seasonal Kendall statistical test for sites with a minimum of eight years of transparency data, using Secchi disk measurements in lakes and Secchi tube measurements in streams. Citizen volunteer monitoring and monitoring conducted by Voyageurs National Park (VNP) occurs at Rainy Lake in this watershed. Water clarity shows no trend (i.e., no change) based on this historical dataset. Larger transparency datasets available for the Rat Root River and Rat Root River, East Branch show no trend in water clarity change over time (Table 4).

Table 4. Water Clarity Trends in the Rainy River – Rainy Lake Watershed at Citizen Monitoring Sites

Rainy River – Rainy Lake Watershed (09030003)	Streams	Lakes
Number of sites w/increasing trend	0	0
Number of sites w/decreasing trend	0	0
Number of sites w/no trend	2	1

Water Quality

A Seasonal Mann Kendall statistical test for water quality trends was conducted on Rainy Lake using "R", a statistical software program that can be used to identify statistically significant trends in the water quality. This statistical test detects changes in water clarity over time by comparing months across years (e.g., May is compared to May, June to June, etc.). Although monitoring efforts track many pollutants, trend reports were generated only for pollutants with enough data across enough years to give at least 90% statistical confidence. For years 1977 to 2020 there is evidence of no change in water clarity for Rainy Lake. For the most recent year of the analysis, median water clarity was the same as the watershed median.

Starting in 2017, the MPCA switched to the Watershed Pollutant Load Monitoring Network (WPLMN). There is one long-term monitoring location in the RRRLW, on the Rat Root River near International Falls, M. Users can access this 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. As shown in Figure 5, Figure 6, and Figure 7, average flow weighted mean total phosphorus (TP), total nitrogen (TN), and TSS concentrations from 2007 through 2017 in the RRRLW were low relative to other areas in the state.

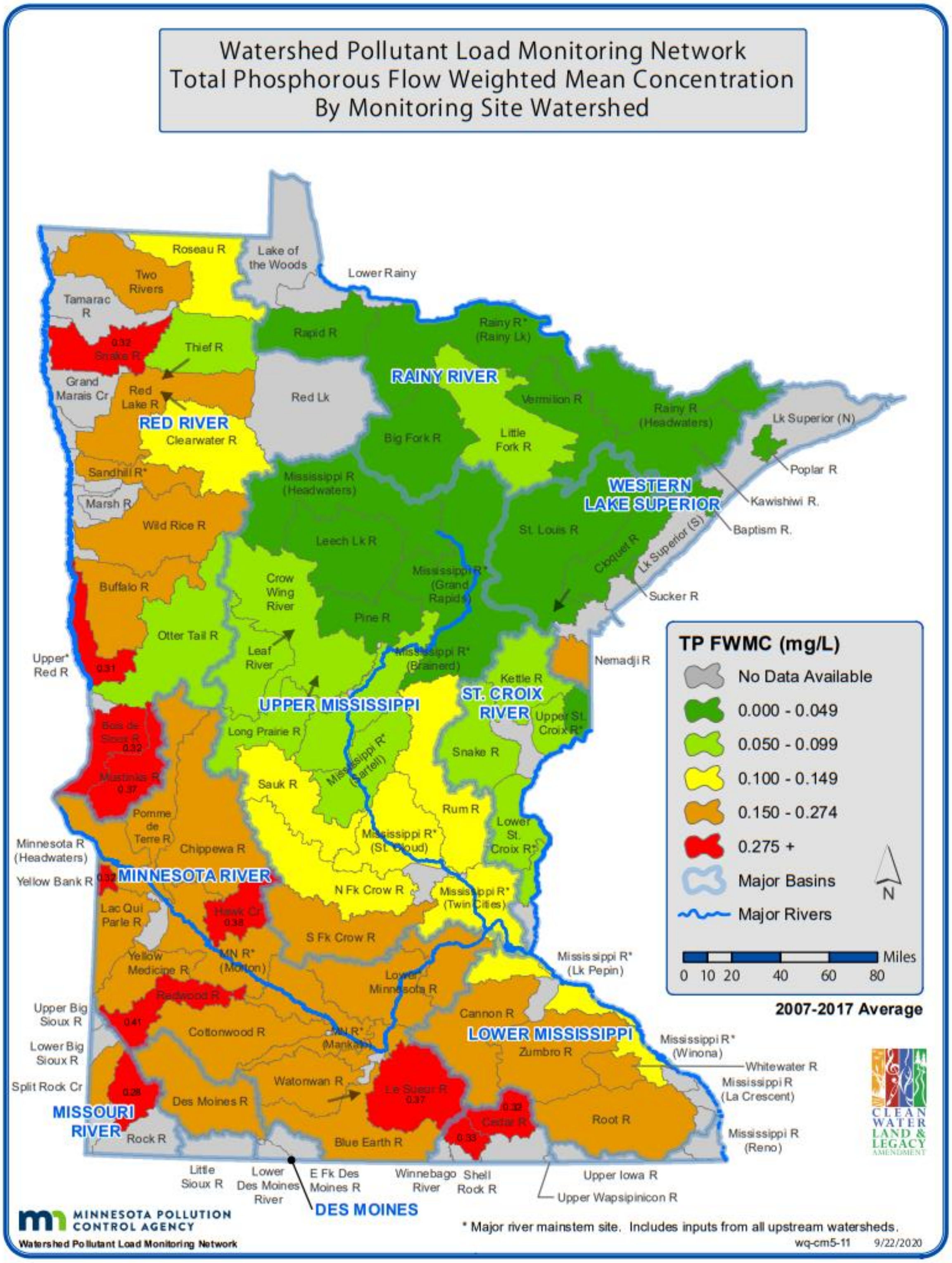


Figure 5. Watershed Pollutant Load Monitoring Network – Average Total Phosphorus Flow Weighted Mean Concentration from 2007-2017

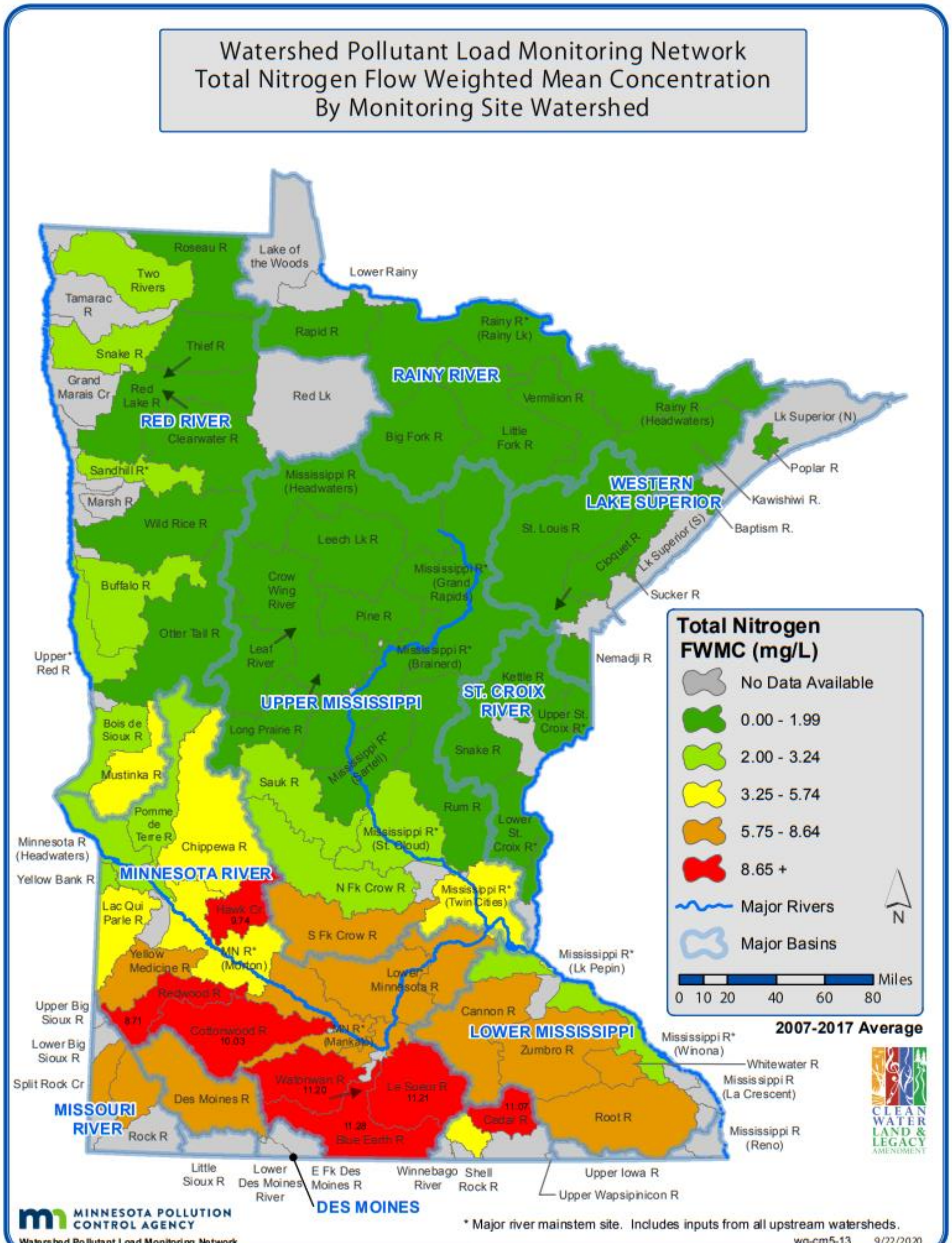


Figure 6. Watershed Pollutant Load Monitoring Network – Average Total Nitrogen Flow Weighted Mean Concentration from 2007-2017

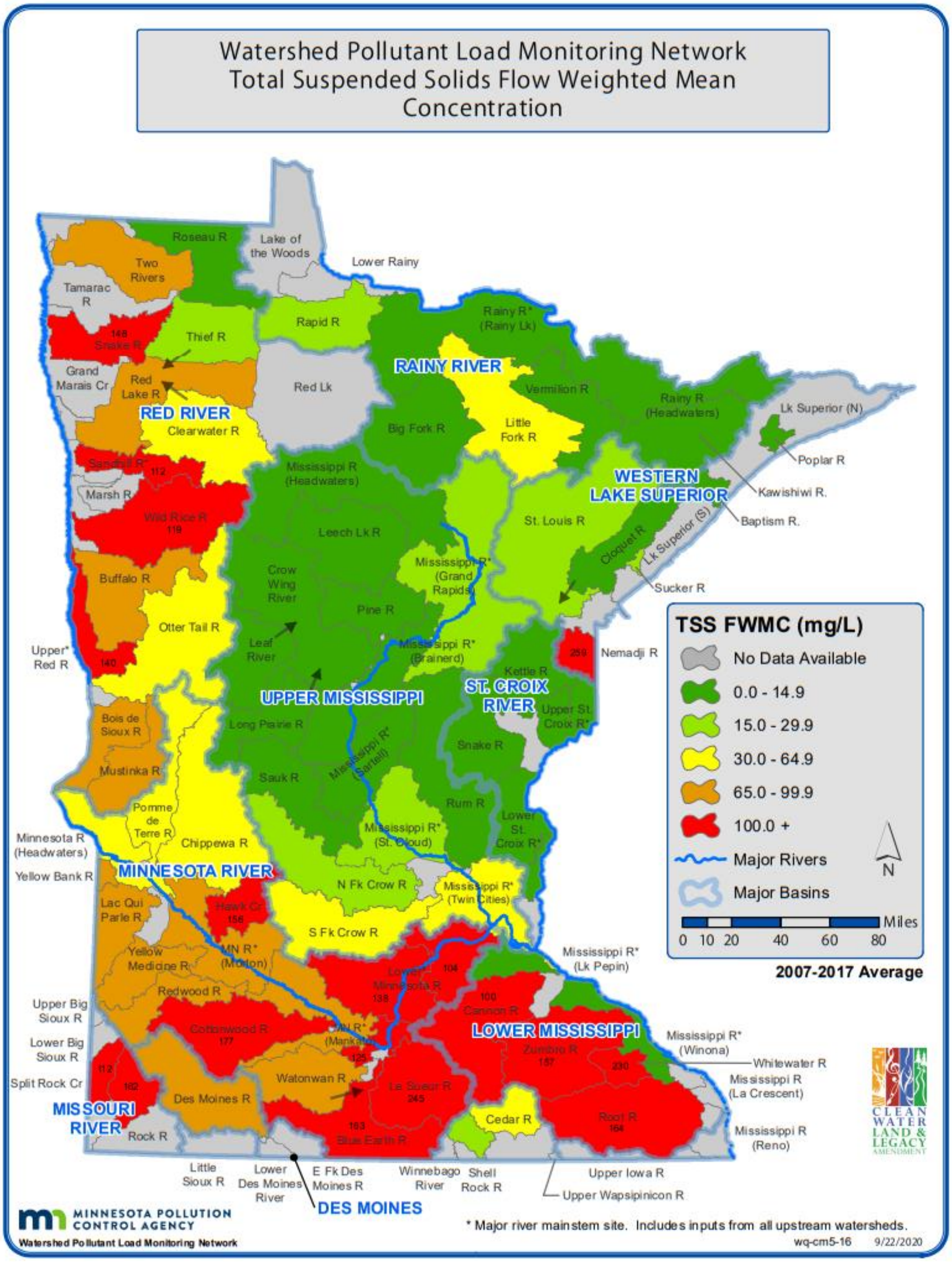


Figure 7. Watershed Pollutant Load Monitoring Network – Average Total Suspended Solids Flow Weighted Mean Concentration from 2007-2017

2.3 Stressors and sources

In order to develop appropriate strategies for restoring or protecting waterbodies and their aquatic communities, the stressors and sources impacting or threatening them must be identified and evaluated. Biological stressor identification (SID) is typically conducted for river reaches with either fish or macroinvertebrate biota impairments and encompasses the evaluation of both pollutant and nonpollutant-related (e.g., altered hydrology, fish passage, habitat) factors as potential stressors. Section 3 provides further detail on stressors and pollutant sources.

A **stressor** is something that adversely impacts or causes fish and/or macroinvertebrate communities in streams to become unhealthy. A SID is conducted for streams with either fish or macroinvertebrate biota impairments, and encompasses the evaluation of both pollutants (such as nitrate-N, phosphorus, and/or sediment) and nonpollutant-related (such as altered hydrology, fish passage, or habitat) factors as potential stressors.

Pollutant source assessments are completed where a biological SID process identifies a pollutant as a stressor, as well as for the typical pollutant impairment listings such as TSS. Pollutants to lakes and streams include point sources (such as wastewater treatment plants) or nonpoint sources (such as agricultural runoff).

Stressors of biologically-impaired river reaches

A SID study was conducted in the RRRLW and was finalized in 2021. The study examined fish and macroinvertebrate communities and related habitat to identify stressors to the aquatic community. Due to the relatively undisturbed nature of the RRRLW, the emphasis of the SID effort shifted from identifying stressors of biologically impaired waters to providing data to guide watershed planning, protection, and restoration efforts on locally important streams. The SID focused primarily on the Rat Root River based on monitoring and assessment findings and local watershed priorities, and emphasized hydrology, TSS, DO and physical habitat. According to the SID results, low DO, sedimentation, slow flow velocities, mediocre habitat, and to a lesser degree TSS, negatively influence biological communities in the Rat Root River. Natural conditions such as low gradient stream channels and glacially-derived clay soils are significant factors in water quality and habitat conditions. Although development is low in the watershed, human impacts over the past century or more have altered watershed and stream health. Conclusions from the SID report are summarized in Figure 8.

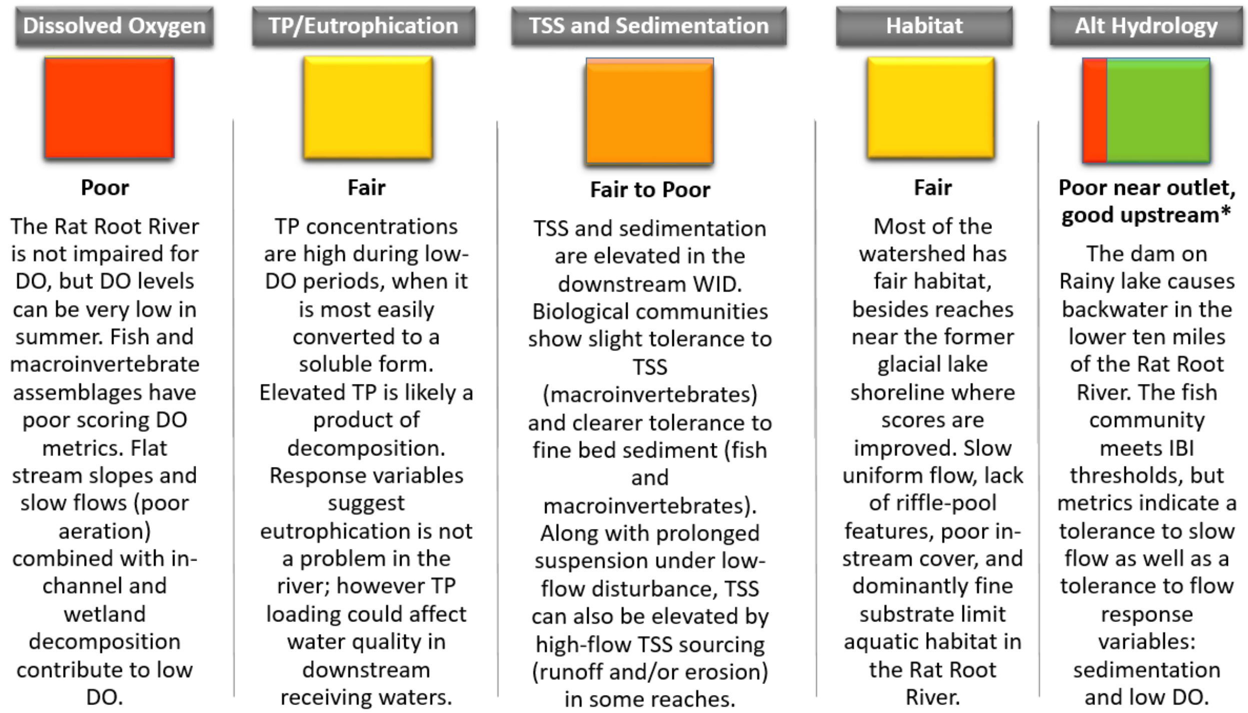


Figure 8. Summary of evaluated stressors for the Rat Root River (MPCA 2021a).

It should be noted that in 2021, the DNR confirmed the presence of zebra mussel larvae in Rainy Lake. Like other dominant invasive species, zebra mussels can out-compete native filter-feeder species, disrupting the preexisting flow of energy through an ecosystem. These mussels negatively impact the survival of native biological communities by filtering out algae that some fish species rely on for food, and causing extirpation of some native mollusks by attaching to and incapacitating them.

Pollutant sources

This section summarizes the sources of pollutants (such as phosphorus, bacteria, or sediment) to streams in the RRRLW. The HSPF model is a large-basin, watershed model that simulates nonpoint source runoff and water quality in urban and rural landscapes. The Rainy Lake HSPF model, which includes the RRRLW, incorporates real-world meteorological data. The HSPF model development included the addition of point source data in the watershed, including both domestic and industrial WWTFs. The Rainy Lake HSPF model is part of a larger group of HSPF models covering the entire Rainy River basin. These models were updated and calibrated several times (RESPEC 2014; RESPEC 2015a; RESPEC 2015b; RESPEC 2016). However, for the Rainy Lake HSPF model limited monitoring data was available to calibrate the model well within the RRRLW. Justification for the accuracy of the model instead includes a comparison of the land use pollutant yields within the RRRLW with the rest of the Rainy Lake Basin HSPF models (RESPEC 2016), and a visual comparison of the predicted and observed flow from the HSPF model extended to 2018 and 2019 when flow was first measured in the Rat Root River (MPCA 2021a).

A detailed breakdown of TSS and TP loading from the Rat Root River Subwatershed (HSPF Reach 210) and the overall RRRLW (HSPF Reach 380) is provided in Table 5 (RESPEC 2016). The location of HSPF Reach 210 and HSPF Reach 380 with respect to the overall HSPF model for the Rainy River Watershed are shown in Figure 9. The model incorporates into its pollutant load estimates load inputs from upstream watersheds including the Vermilion Watershed in Minnesota, Rainy River Headwaters Watershed in Minnesota and Canada, and Big and Little Turtle River Watershed in Canada.

The predicted pollutant loads in the RRRLW reflect the relatively healthy and unaltered conditions in the watershed, with the largest predicted loads from forestry and wetland land covers. However, as with any model further refinement is needed to improve the accuracy of the model as more data is collected in the watershed. The largest potential discrepancy with the model and the observed conditions is perceived to be the portion of the load from stream bed and bank erosion. Due to the geology of the watershed and historic logging, the contribution of bed and bank erosion is thought to be greater than shown in the modeling results. A thorough summary with detailed conclusions about the watershed using monitoring data collected in the watershed from 2017 through 2019 is provided in the monitoring and assessment report and the SID study (MPCA 2020; MPCA 2021a). Further updates to the model incorporating the data collected for these studies will improve the accuracy of the model. In addition, model accuracy may be improved by conducting a sediment fingerprinting study within the RRRLW. Sediment fingerprinting uses chemical differences in sediment known as isotopes to differentiate the portion of the sediment coming from in-stream sources with watershed runoff sources. Sediment fingerprinting was recommended in other watersheds in the Rainy Lake Basin to improve the accuracy of the predicted stream bed and bank erosion loads (MPCA 2021b).

Table 5. Predicted total load and percent contribution for sediment and total phosphorus from the Rat Root River Watershed and the overall Rainy River – Rainy Lake Watershed from HSPF (1996-2014)

	Rat Root River				Rainy River – Rainy Lake Watershed			
Source	TSS Load (tons/year)	%	TP Load (lbs/year)	%	TSS Load (tons/year)	%	TP Load (lbs/year)	%
Wetland	862	11%	6,299	29%	721	2%	16,168	5%
Young Forest	1,907	24%	3,144	14%	2,086	5%	10,275	3%
Mature Forest	3,550	44%	8,978	42%	5,219	14%	38,389	12%
Cropland	48	0.6%	81	0.4%	28	<0.1%	79	<0.1%
Grassland	654	8%	1,367	6%	349	0.9%	1,477	0.5%
Developed	899	11%	1,544	7%	1,173	3%	4,691	1%
Feedlot	0.2	<0.1%	0	<0.1%	0	0%	0	0%
Septics	0	0%	242	1%	0	0%	1,529	0.5%
Atmospheric Deposition	0	0%	29	0.1%	0	0%	29,330	9%
Stream Bed and Bank*	84	1%	0	0%	934	2%	23	<0.1%
Groundwater to Lakes	0	0%	0	0%	4	<0.1%	235	<0.1%
Boundary Condition	0	0%	0	0%	27,900	73%	218,184	68%
Total	8,004	-	21,684	-	38,414	-	320,378	-

Loads represent basin source fate loads for reach A210 for the Rat Root River and reach A380 for the Rainy River-Rainy Lake Watershed in the HSPF model for the Rainy River-Rainy Lake Watershed.

*The portion of load from stream bed and bank erosion is thought to be larger than shown by local agencies

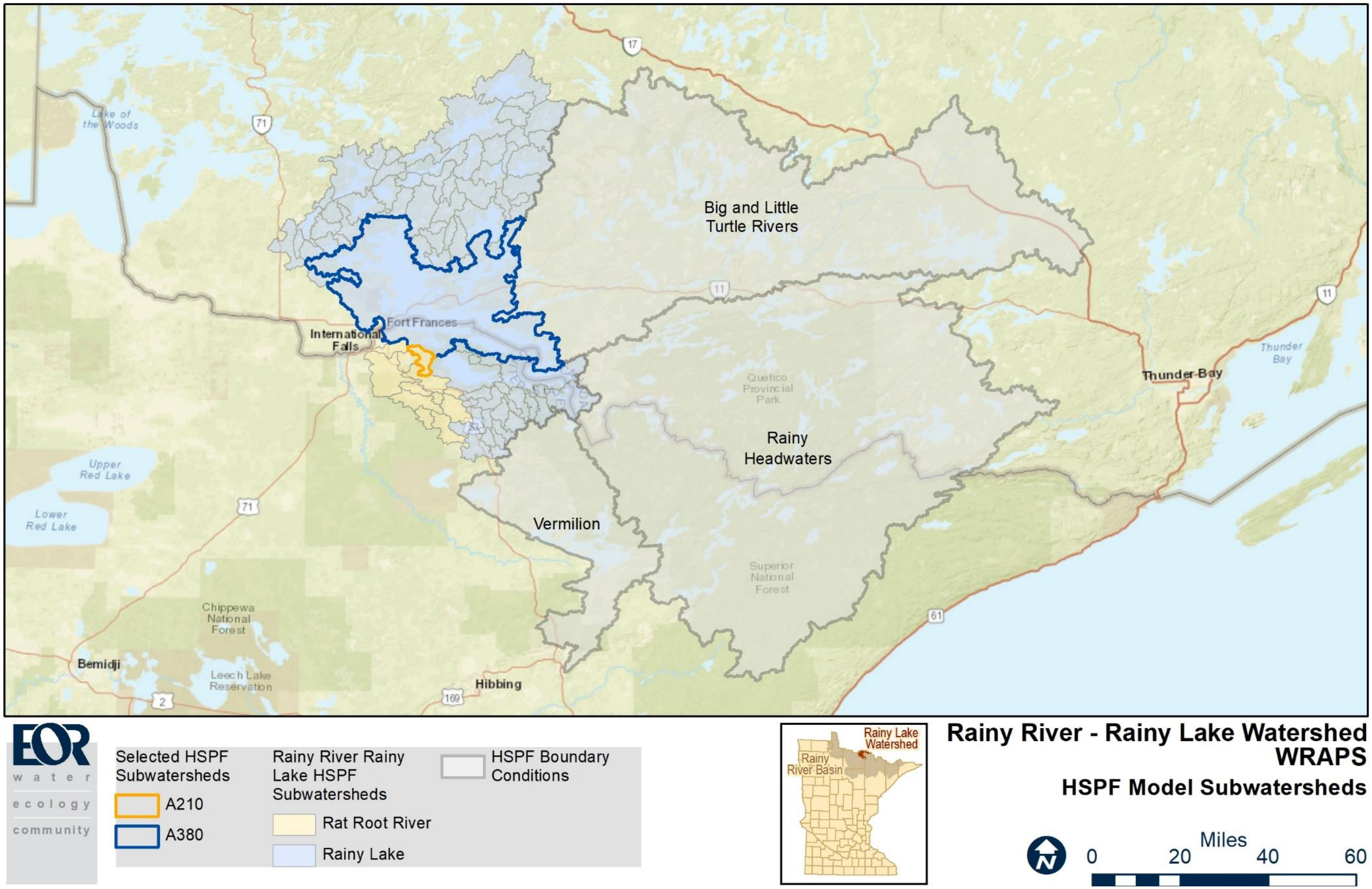


Figure 9. Rainy River-Rainy Lake HSPF model subwatersheds.

Point Sources

Point sources are defined as facilities that discharge stormwater or wastewater to a lake or stream and have a National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit (Permit). There are six NPDES/SDS permits with 10 wastewater outfalls located in the RRRLW (Table 6). There are no active NPDES/SDS permitted feedlots located within the RRRLW. Due to low population density, there are no Municipal Separate Storm Sewer System (MS4) permits within the watershed.

Table 6. Point sources in the Rainy River-Rainy Lake Watershed.

Aggregated HUC-12 Subwatershed	Name	MPCA Site ID	Station Type	Station	Station Description
Rainy Lake (0903000319-01)	Kettle Falls Hotel & Guest Villas	MN0057410	Waste Stream	WS 006	Intermediate: WW to Land
Rainy Lake (0903000319-01)	Kettle Falls Hotel & Guest Villas	MN0057410	Wastewater Treatment	MN0057410	
Rat Root River, East Branch (0903000318-02)	Mark Sand & Gravel Acquisition Co	MNG490125	Surface Discharge	SD 043	MNG49 Stormwater, Nonspecific
Rat Root River (0903000318-01)	MnDOT SP 3608-48 International Falls	MNG790265	Surface Discharge	SD 002	Effluent To Surface Water
Rat Root River (0903000318-01)	NKASD WWTP	MN0020257	Land Application	LA 347	Application Site, Biosolids
Rat Root River (0903000318-01)	Pucks Point Sanitary Sewer District	MN0070530	Waste Stream	WS005	Intermediate: WW to Land
Rat Root River (0903000318-01)	Pucks Point Sanitary Sewer District	MN0070530	Waste Stream	WS006	Intermediate: WW to Land
Rat Root River (0903000318-01)	Pucks Point Sanitary Sewer District	MN0070530	Waste Stream	WS007	Intermediate: WW to Land
Rainy Lake (0903000319-01)	Ulland Brothers Inc	MNG490069	Surface Discharge	SD 012	MNG49 Stormwater, Nonspecific
Rainy Lake (0903000319-01)	Ulland Brothers Inc	MNG490069	Land Application	LA 027	MNG49 Wastewater

Hydrologic Unit Code (HUC)

Nonpoint Sources

Nonpoint pollution, unlike pollution directly discharged from industrial and municipal wastewater treatment facilities (WWTFs), refers to pollutants collected from many diffuse sources, often transported by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-caused pollutants and deposits them into lakes and streams. Significant nonpoint and natural pollutant sources identified in the RRRLW include:

- **Watershed runoff:** The HSPF model was used to estimate watershed runoff volumes and TP loads for all 13 individual subwatersheds in the RRRLW based on land cover and soil type, and was calibrated using meteorological data from 1996 through 2014**.**
- **Wetland export:** Phosphorus export from wetlands is a well-known phenomenon in northern Minnesota wetlands (MPCA 2014; MPCA 2016; MPCA 2017; MPCA 2019; MPCA 2019; MPCA 2020; MPCA 2021a). Wetlands make up a significant portion of the RRRLW.

- **Altered Hydrology**: Human-induced changes to the natural flow regime, including downstream Rainy Lake water level management, can further reduce stream velocities in naturally low gradient streams. Low stream velocities often contribute to increased sedimentation and low DO conditions.
- **Streambank Erosion**: Areas of streambank erosion were observed in the Rat Root River. The likely causes of observed moderate erosion may include disturbances near the stream from limited agricultural lands near surface waters, timber harvesting, and changes in the stream channel in response to legacy impacts, including that of historic large-scale timber harvesting.
- **Geology and soils**: The fine silty clay soils in the RRRLW were formed in the former glacial Lake Agassiz. Watersheds containing glacial clays are more vulnerable to elevated TSS concentrations because glacial clays are easily suspended and are slow to settle out of the water column.
- **Timber harvesting**: Forest harvest has been and currently is a major activity within the RRRLW. Historical large-scale forest removal occurred in the watershed, which may have created legacy effects still being experienced by streams today. These impacts may include stream instability and adjustment (see Streambank Erosion section above).

Altered Hydrology

Human activities that modify drainage patterns within a watershed can also play a significant role in determining the health and quality of its water resources. Hydrologic alterations within the RRRLW can cause disruptions to aquatic life, changes in stream flow, and modifications to groundwater surface water interactions. In the Rat Root River Subwatershed most of these alterations, such as ditched wetlands or backwater effects from the downstream dam, are in the lower reaches near Rat Root Lake. Modifications to drainage systems within wetlands can influence the nutrient balance within these areas and can lead to flushes of nutrients to downstream resources. Backwater effects from the downstream dam slow stream velocities, resulting in an accumulation of sediment in the stream. Section 3.1 of the WRAPS provides furthers details on how altered hydrology was used to target implementation areas in the RRRLW.

Rainy Lake Water Level Management

Spanning the international border with Canada, Rainy Lake's hydrology is managed by the IJC, an entity established by a binational treaty to protect the transnational environment. The Commission developed the Rainy Lake Rule Curve, a type of water level regulation procedure, to maintain Rainy Lake's water levels. The Rule Curve established upper and lower lake level limits to help avoid extreme conditions and maintain a wide variety of uses and interests for both nations, such as fishing and recreation.

The 2000 Rule Curve change was instituted in response to adverse impacts of the original rule curves to aquatic and biological communities. In 2018, the IJC updated the 2000 Rule Curve with an alternative curve for use in high flood risk years to reduce flood peaks. The 2018 Rule Curve also dictated a faster drawdown period in the fall to encourage the survival of muskrat and vital fish species (Figure 10). Although backwater effects remain present, the faster drawdown may benefit the Rat Root River by reducing backwater effects created from high water levels in the lake as compared to the 2000 Rule Curve. Backwater effects from the dam are estimated to extend 10 miles upstream of Black Bay on the Rat Root River (MPCA 2021a). Backwater effects slow velocity within the stream and can lead to increased sedimentation rates and, in some cases, lowered DO levels. The Rule Curves incorporate extensive public engagement work and research on hydrologic, hydraulic, cultural, economic, and environmental risk factors.

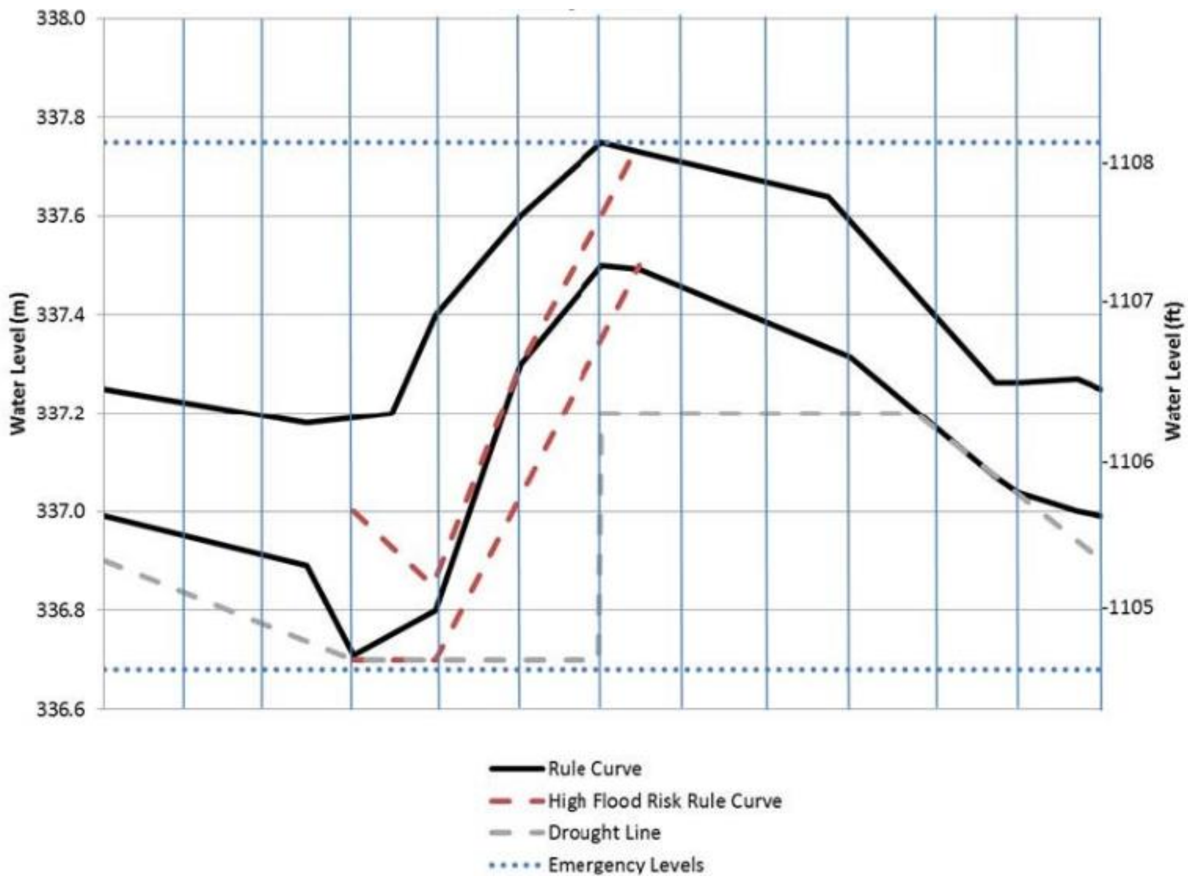


Figure 10. Rainy Lake Rule Curve changes in 2018 were designed to incorporate more ecological considerations, including the survival of vital fish species and muskrats (Bunch 2018 Aug 21).

The Rainy Lake Rule Curve is enforced with the cooperation of three dams. Under the 2018 Rule Curve change, the water levels committee are allowed greater flexibility to promote various activities as conditions allow, such as maintaining water levels for wild rice growth. Ongoing data collection efforts will analyze the impacts of the Rule Curves and inform future Rule Curve adjustments, particularly as climate and rainfall patterns shift (Kaczke 2018).

Low Gradient Streams

Slow stream velocities are observed upstream of the area impacted by the dam because of the naturally low gradient streams in the RRRLW. A stream geomorphology survey report identified several segments of the Rat Root River and East Rat Root River as stable low gradient reaches (DNR 2020a). Generally, these reaches maintain adequate access to the river floodplain and well-vegetated banks, resulting in low average erosion rates. The survey found no significant upland sources of sediment.

The scattered locations of banks with higher erosion rates suggests that erosion issues that cause TSS inputs are localized. However, the sediment input from erosion is still significant and may contribute a significant TSS load to the Rat Root River. A few extended reaches demonstrate increased erosion and stability issues. Issues with erosion due to gullying can be compounded when gullies lie downstream of agricultural fields, which are often sources of excess nutrients. These reaches require ongoing streambank monitoring, as streambank erosion may continue or worsen in response to a range of factors from forest disturbances to adjustments from legacy impacts. Because fine sediment remains suspended in the water column, the cumulative impact of bank erosion represents a significant threat. For more information, see the subsection Stream Restoration Opportunities in Section 3.3.

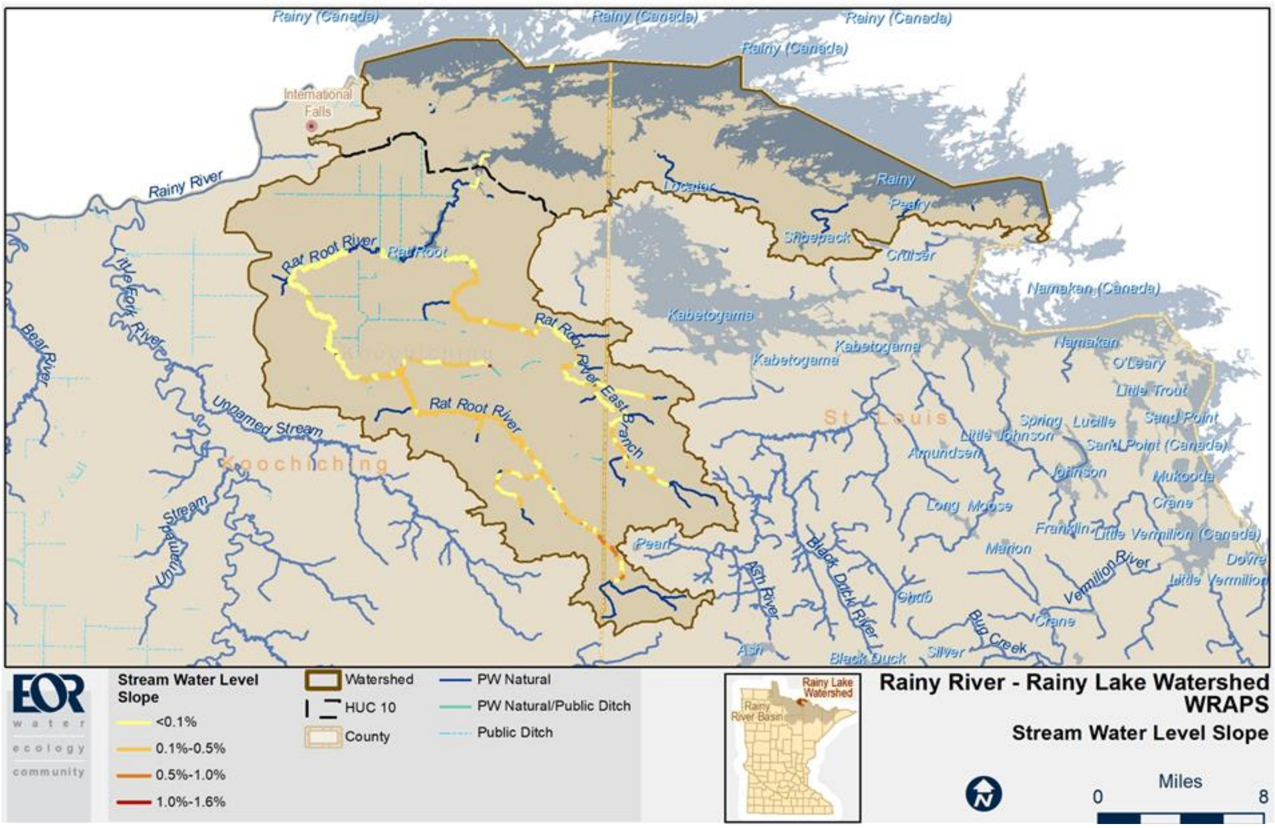


Figure 11. Stream water level slope in the Rainy River-Rainy Lake Watershed.

Geology

Geology plays a major role in determining the natural water quality of a resource, especially the sediment and dissolved solids content. The RRRLW runs through a flat landscape heavily shaped by glacial activity -- namely former Glacial Lake Agassiz. Glacial parent material in the RRRLW includes glacial lake sediment, lake modified till, ground moraines, and peat soils. Glacial till and peatland (saturated, peat-forming wetlands) soils are dominant in the vicinity of Rat Root Lake and extend south to the southern boundary of the historic shoreline of Glacial Lake Agassiz/Koochiching Lobe and the Rainy Lobe (Figure 14). The clay and silty soils from the Glacial Lake Agassiz and Koochiching Lobe are easily suspended and persist for a long time in the water column. Along the downstream reaches of the East Rat Root River and Rat Root River, these fine silty clay soils drive most of the elevated TSS. Soils texture is overall coarser upstream (south) of the historic glacial lake shoreline, which is reflected in clearer water and lower TSS levels in the upstream reaches of both streams.

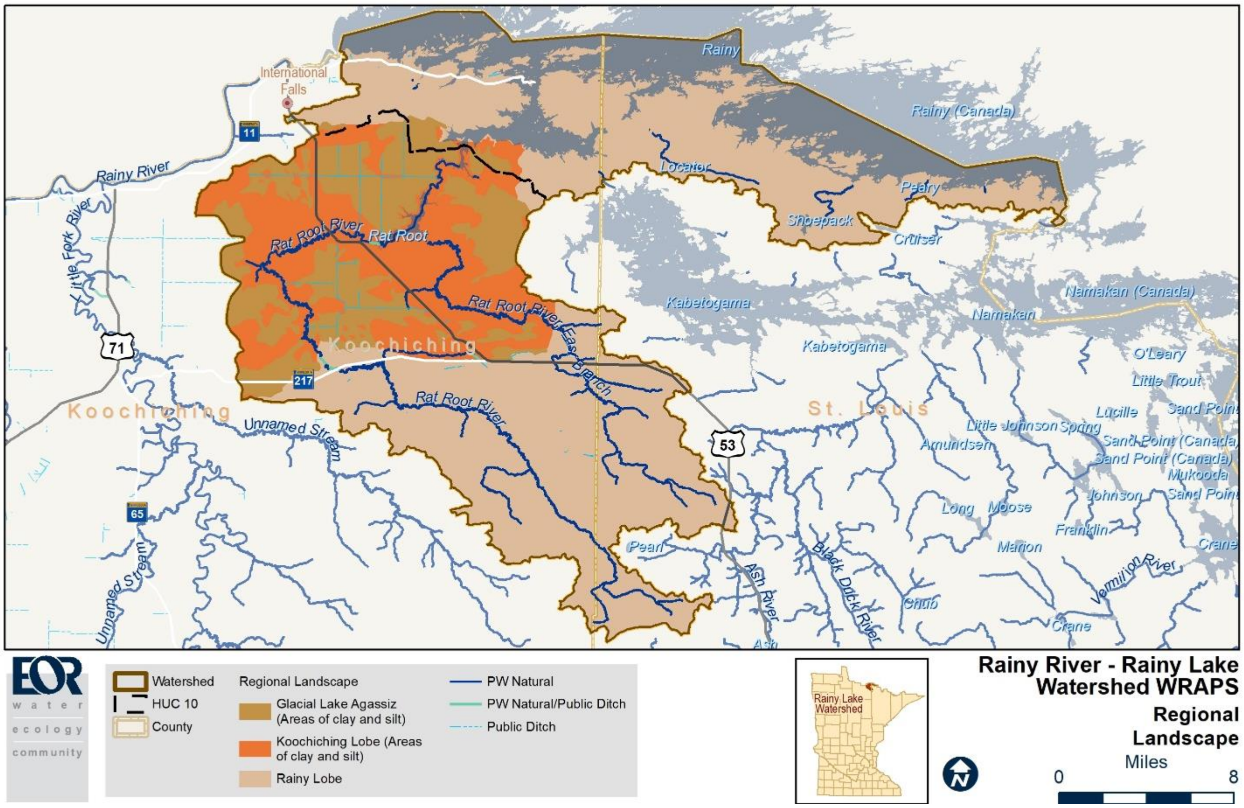


Figure 12. Regional landscapes in the Rainy River-Rainy Lake Watershed.

2.4 TMDL summary

Besides the statewide Mercury TMDL, there are no TMDLs developed for water resources within the RRRLW. Thirteen lakes within the RRRLW are impaired by mercury in fish tissue as of the 2022 Draft Impaired Waters Inventory, 10 of which are categorized as EPA Category 5 for impaired waters needing a TMDL, and three EPA Category 4a for impaired waters with an approved TMDL. More information about the mercury impairments is provided in Section 2.1

2.5 Protection considerations

Currently, the RRRLW contains a relatively large percentage of protected resources as compared to other watersheds in Minnesota. The high quality of water resources within this watershed represents the combined protection efforts of VNP and state and county agencies. Given the watershed's conditions, protection strategies will be key to preventing future water quality degradation. Restoration and protection strategies will both improve the condition of degraded resources and ensure that unimpaired waters remain in good condition. Section 3 will address the development of these strategies.

Protection Streams

The MPCA, DNR, and Board of Water and Soil Resources (BWSR) have worked together to prioritize the stream reaches in the RRRLW 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 for each stream's riparian area, defined as 200 m on each side of the stream and 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. Each risk factor was 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 streams were identified in the RRRLW.

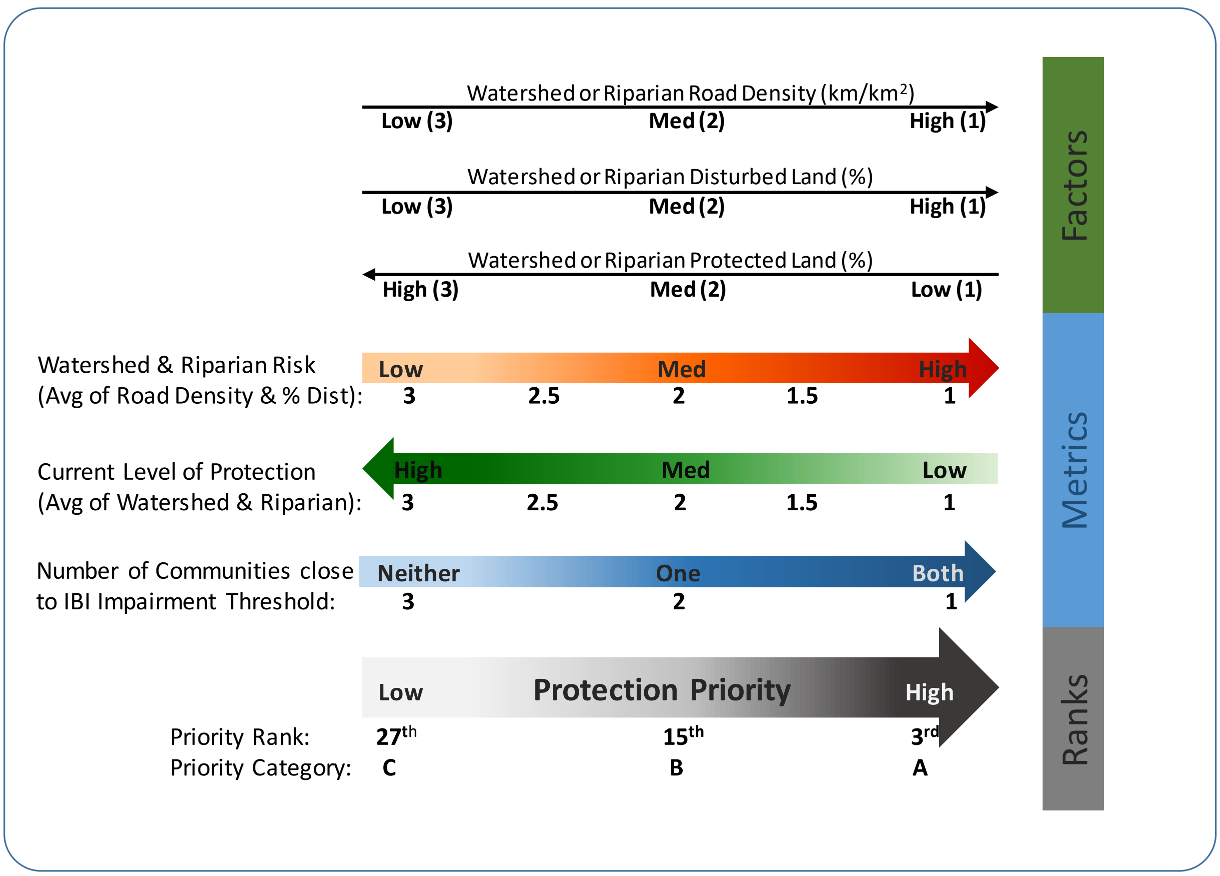


Figure 13. Stream protection and prioritization matrix (MPCA 2018).

Table 7. Stream protection and prioritization results for the RRRLW

AUID	Stream Name	Reach Length (miles)	Drainage Area (mi^2)	TALU	Cold/Warm	Fish or Macroinvertebrate Community Nearly Impaired	Riparian Risk	Watershed Risk	Current Protection Level	Protection Prioritization Class
09030003-633	Rat Root River, East Branch	22.39	76.0	General	Warm	one	low	low	medium	B
09030003-634	Rat Root River	30.44	73.3	General	Warm	one	low	low	high	B
09030003-632	Rat Root River, East Branch	20.37	51.2	General	Warm	neither	low	low	med/high	C

Assessment Unit Identifier (AUID); Tiered Aquatic Life Uses (TALU)

Protection Lakes

As summarized in the Monitoring and Assessment Report, the MPCA and DNR developed methods to help identify waters that are high priority for protection and restoration activities. The results of the analysis are provided to watershed project teams for use during WRAPS development and represent a preliminary sorting of protection priorities. The prioritization methodology developed for lakes is based on water quality assessment results, the amount of clarity lost if phosphorus is added, the amount of land use disturbance, lake size, and what is known about current trends in water (MPCA 2018). A schematic of the MPCA protection and prioritization methodology is shown in Figure 14.

The first step considers how much lake clarity would be lost with an increase of 100 pounds of phosphorus to the lake. This is also known as the lake's phosphorus sensitivity. The second step considers the significance of this sensitivity – i.e., the likelihood that this increase in phosphorus would occur given the nature of the lakeshed, and the proximity of the lake to the impairment threshold. Finally, the third step results in a prioritized list of lakes, each with a load reduction goal that is calculated as a 5% reduction in predicted phosphorus loading (pounds/year) for any given lake. The prioritized list of lakes for the RRRLW is shown in Table 8.

Rainy Lake has been identified as an Outstanding Resource Value Water (ORVW) in Minnesota State Statute, Minn. R. 7050.0335, and is classified as a prohibited ORVW. Prohibited ORVWs have extra levels of protection above other waters to protect their unique natures. These include high-quality waters and waters that have exceptional recreation, cultural, aesthetic, or scientific value. All proposed projects in Minnesota waters designated as Prohibited ORVWs must apply for an Individual 401 Water Quality Certification review.

Figure 14. MPCA lake protection and restoration methodology schematic (MPCA 2018)

Table 8. Prioritized Lakes within the RRRLW (MPCA 2020)

Lake ID	Lake Name	Mean TP (ug/L)	Trend	% Disturbed Land Use	5% TP load reduction goal (lbs./year)	Lake Phosphorus Sensitivity Significance Priority	Lake Benefit Cost Assessment Priority Class	Lake of Biological Significance
69-0694-00	Rainy	19.2	No evidence of trend	1%	20,852	C	Higher	Outstanding
69-0833-00	Peary	16.3		0%	7	C	High	
69-0834-00	Fishmouth	5.0		0%	0	C	High	
69-0835-00	Unnamed (Ryan)	8.0		0%	0	C	High	
69-0838-00	Oslo	5.0		0%	1	C	High	
69-0839-00	Brown	5.0		0%	2	C	High	
69-0868-00	Boot	12.7		0%	1	C	High	Outstanding
69-0870-00	Shoepack	23.3		0%	22	C	High	Outstanding
69-0871-00	Quill	5.0		0%	2	C	High	
69-0872-00	Loiten	5.0		0%	1	C	High	
69-0936-00	Locator	8.8		0%	6	C	High	
69-0937-00	War Club	5.0		0%	2	C	High	

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.

For a watershed with so many high-quality lakes, protection actions will dominate this plan's strategic approach. The overall goal of protection programs is to get over 75% of a watershed into a protected status. According to Jacobson, et al., lakes surrounded by at least 75% protected areas were found to likely be sufficiently protected enough to promote fish habitat (Jacobson et al. 2016). In the following subsections of the WRAPS report, the three main components of the restoration and protection strategy are discussed: the methods and techniques for identifying and prioritizing target areas; the securing of public participation to promote trust and build networks; and finally, the actions and schedule to implement the strategy. Subsection 3.1 provides the results of such prioritization and 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 best management practices (BMPs). Thus, effective ongoing public participation is a critical part of the overall plan for moving forward, as demonstrated in Subsection 3.2.

The implementation strategies, including associated scales of adoption and timelines, provided in Subsection 3.3 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 depend on the availability of funding. As such, the proposed actions outlined are subject to adaptive management—an iterative approach of implementation, evaluation, and course correction.

Estimates for the financial costs and technical assistance needed will be completed in conjunction with specific local or project plans and are not presented in this report. However, the work done in the RRRLW will continue to lean on partnerships with Koochiching and St. Louis counties and their associated SWCDs, MPCA, DNR, VNP, lake and river associations, and others. This includes technical assistance as well as funding through a combination of cost shares, grants, and loan programs.

3.1 Targeting of geographic areas

The following section describes the specific tools that were used during the RRRLW WRAPS process to help stakeholders identify, locate, and prioritize restoration and protection strategies. The general approach began with considering 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 RRRLW. A variety of geographic datasets were then reviewed by local resource managers and public stakeholders to understand watershed characteristics and to prioritize subwatersheds. Through this process, reducing pollutant loading and improving altered hydrology were identified as key issues to address in the RRRLW. Tools used to target critical geographic areas to further protect the resources in the RRRLW include:

- RAQ Parcel Scoring

- ACPF
- Riparian Forest Buffer Identification
- Evaluation of Altered Hydrology
- Hydrogeologic Risk Assessment
- Stream Restoration Opportunities 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.

Critical Area Identification

Hydrologic Simulation Program – FORTRAN

The HSPF model discussed in more detail in Section 2.3 was used to predict the relative magnitude of TSS, TP, and TN pollution generated in each catchment of the RRRLW. The HSPF model was also used to evaluate the extent of contributions from point, nonpoint, and atmospheric sources where necessary. The HSPF model helps to better understand existing water quality conditions, and predict how water quality might change under different land management practices and/or climatic changes at the subwatershed scale. An HSPF model also provides a means to evaluate the impacts of alternative management strategies to reduce these loads and improve water quality conditions. The TSS, TP, and TN yields predicted from the HSPF model in the RRRLW are mapped in Figure 15, Figure 16, and Figure 17. The subwatershed pollutant yields are directly related to the land use pollutant yields shown to be consistent throughout the Rainy River Basin (RESPEC 2016). The highest predicted pollutant yields in the RRRLW are in the lower reach of the Rat Root River, East Branch and the middle reaches of the Rat Root River. The larger pollutant loads from the Rat Root River, East Branch are consistent with the SID study of the watershed of the river that attributed legacy impacts of historic clear-cutting altering the channel (MPCA 2021a).

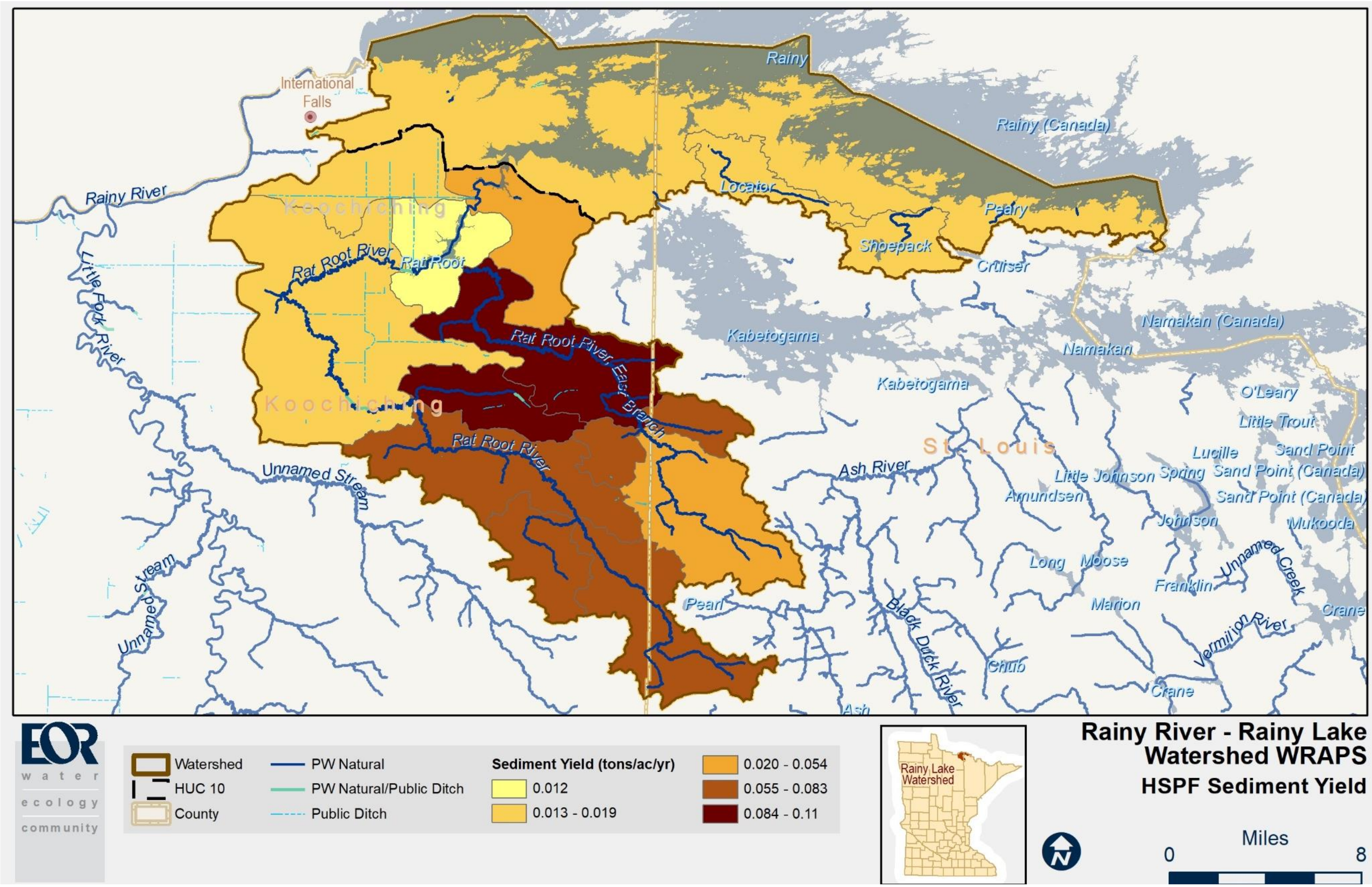


Figure 15. HSPF predicted sediment yield without boundary conditions, 1996-2014 (tons/acre/year)

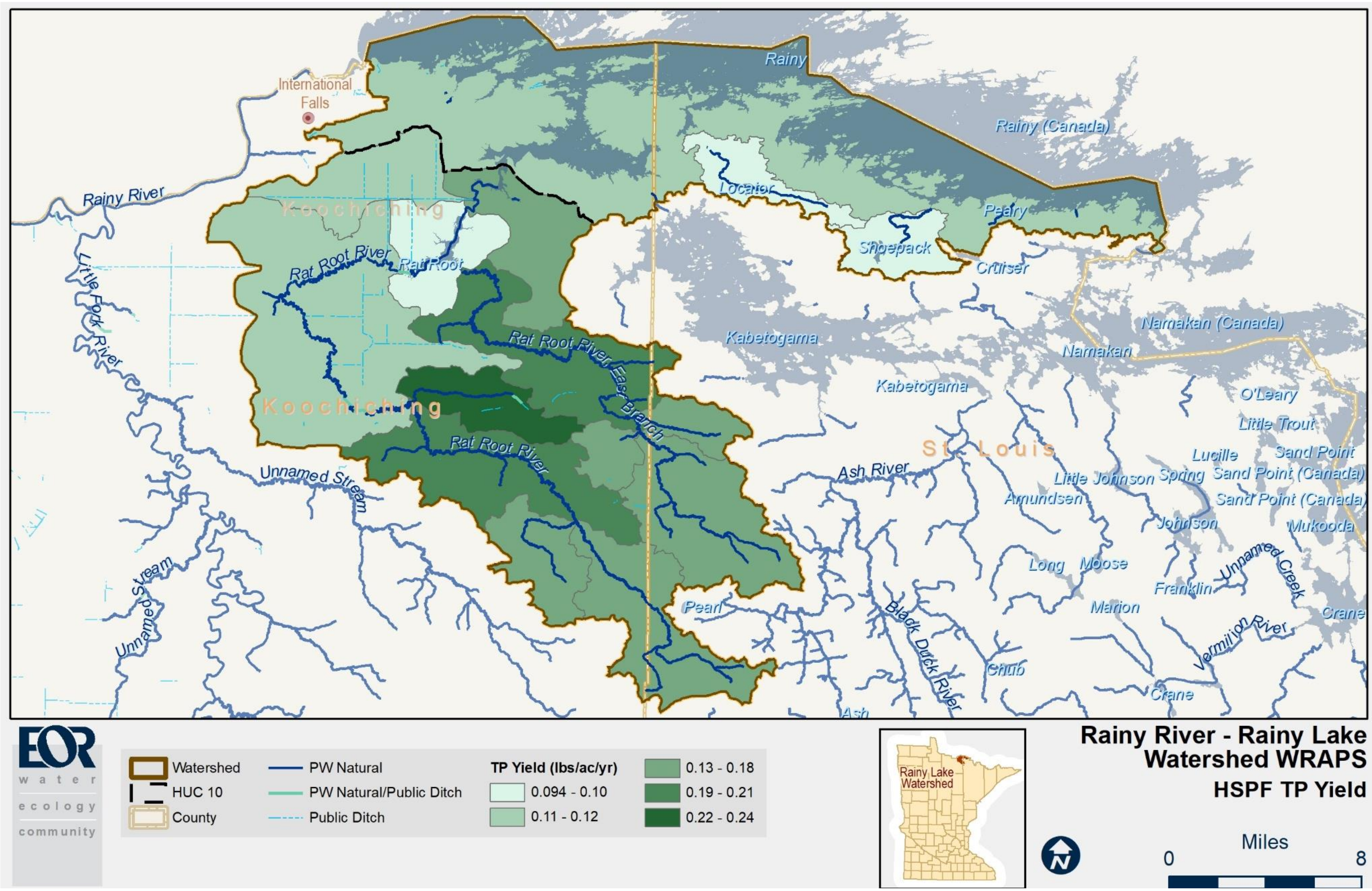


Figure 16. HSPF predicted total phosphorus (TP) yield without boundary conditions, 1996-2014 (tons/acre/year)

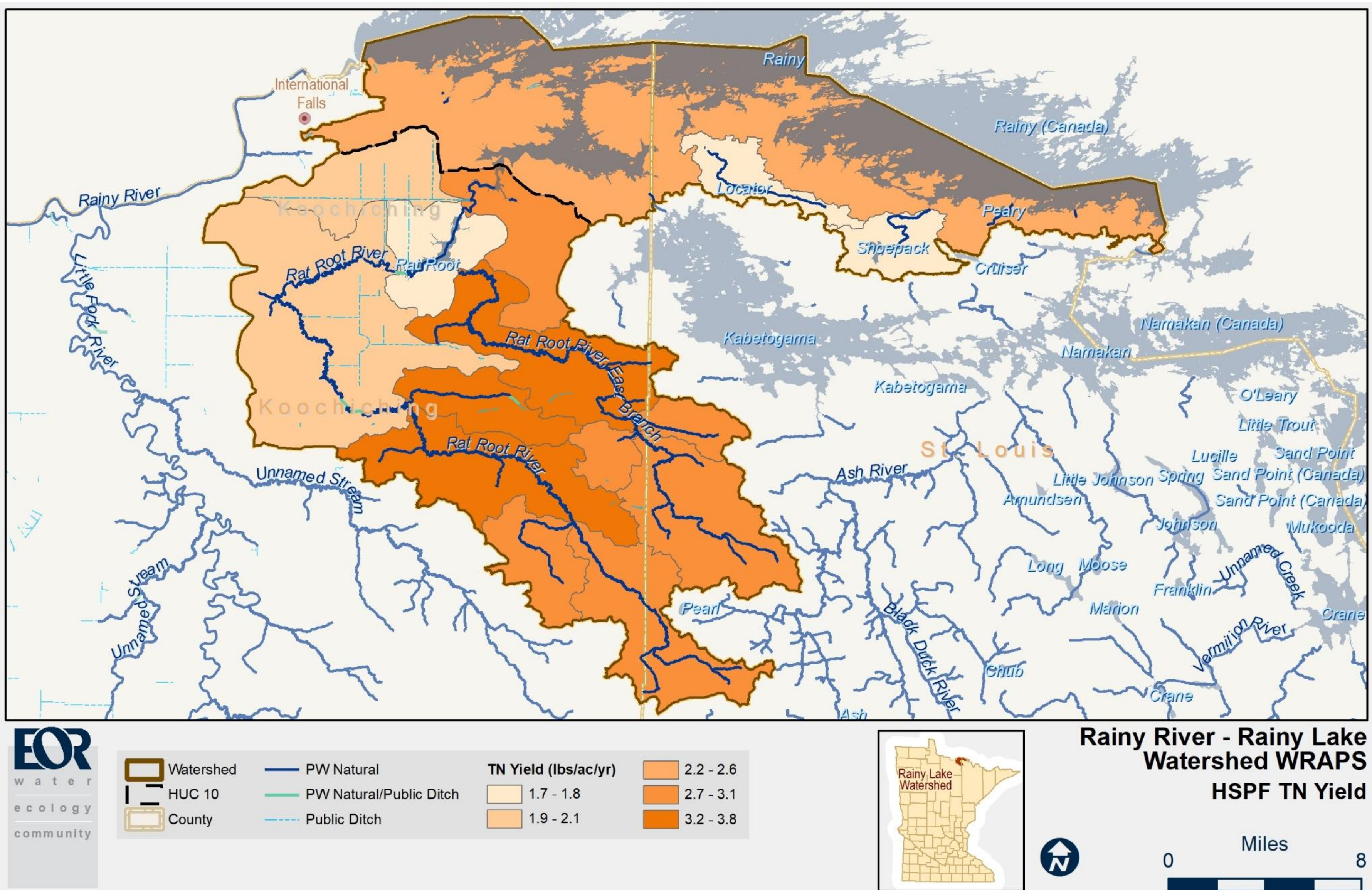


Figure 17. HSPF predicted total nitrogen (TN) yield without boundary conditions, 1996-2014 (tons/acre/year)

Hydrologic Unit Code-14 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 hydrologic unit code (HUC) 14 subwatersheds within the RRRLW, based on their contribution to the problems facing the watershed and their potential to achieve meaningful improvements. The HUC-14 subwatersheds are defined by the United States Geologic Survey (USGS) hydrological system and are used as subwatershed areas defined by the HSPF model. The working group reviewed 56 data sets falling into nine general categories. Reviewers rated the effectiveness of each data set for prioritizing HUC-14 subwatersheds. The evaluation was completed specific to the characteristics of the watershed. Reviewers rated each data set based on how useful it would be for prioritizing subwatersheds for focused efforts. The data set categories (altered hydrology, soil erosion, etc.) are presented 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 a labeled map of the subwatersheds and for further information on the geographic data sets and process that were used to prioritize subwatersheds). The resulting prioritization of HUC-14 subwatersheds is shown in Table 9 and Figure 18. 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
- Arsenic Concentration
- Nitrate Concentration

Biodiversity

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

Improvements

- Number of BMPs installed

Table 9. Priority ratings of HUC-14 subwatersheds in the Rainy River-Rainy Lake Watershed

HUC-12 Watershed	HSPF Subwatershed Name	HSPF Subwatershed ID	Subwatershed Rating
Rat Root River	Headwaters Rat Root River	A130	High
	Town of Ray-Rat Root River	A141	Low
	Town of Ray-Rat Root River	A150	High
	Town of Ray-Rat Root River	A161	High
	Town of Ericsburg-Rat Root River	A170	High
	Rat Root Lake	A190	High
	Rat Root Lake	A201	High
	Rat Root Lake	A210	Low
Rat Root River, East Branch	Upper East Branch Rat Root River	A171	High
	Lower East Branch Rat Root River	A173	High
	Lower East Branch Rat Root River	A175	High
	Lower East Branch Rat Root River	A177	High
Rainy Lake	Rainy Lake	A215	Low
	Rainy Lake	A217	Low
	Rainy Lake	A380	High

Hydrologic Unit Code (HUC); Hydrologic Simulation Program FORTRAN (HSPF)

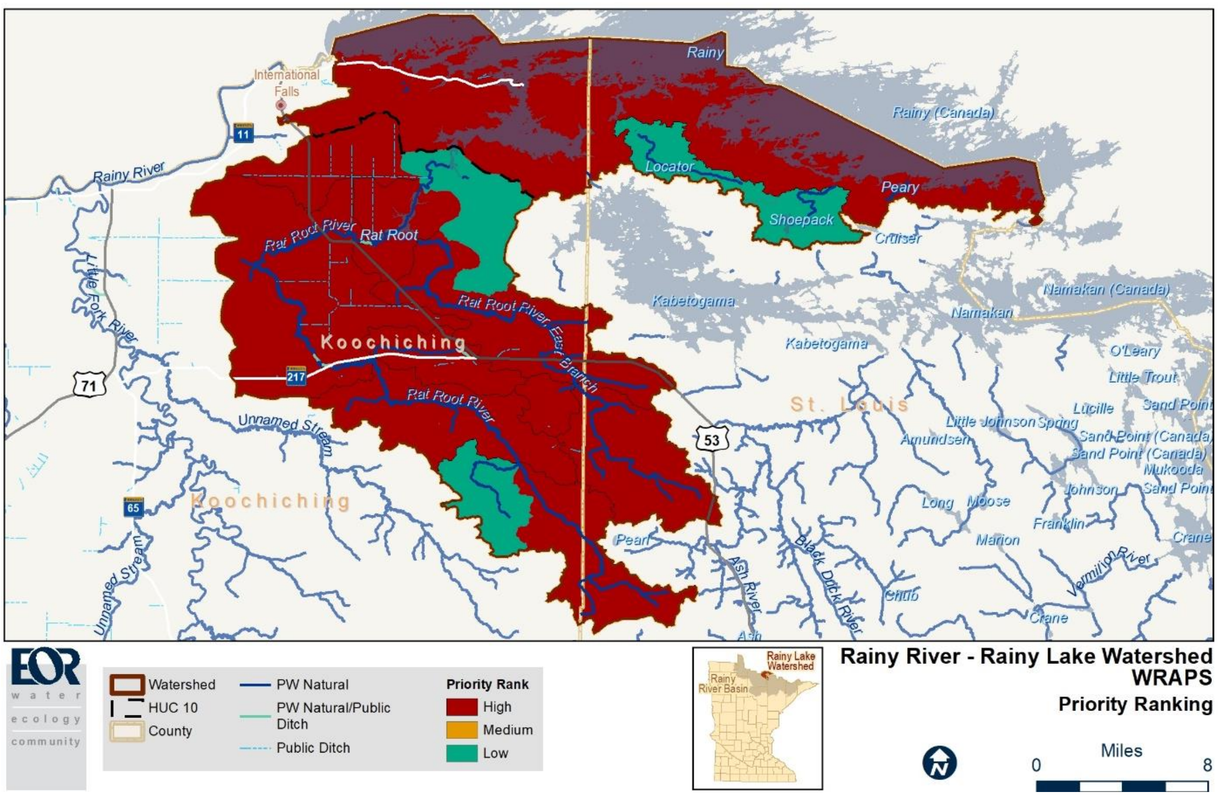


Figure 18. Priority ranking of HUC-14 subwatersheds in the Rainy River-Rainy Lake Watershed

Riparian Adjacency Quality Parcel Scoring

The RAQ scoring system is a method developed by BWSR Technical Services Area 8 in northern Minnesota to help target protection work and landowner outreach efforts about forest protection programs for large tracts of forested land. 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 component, except for quality, which can achieve up to 4 points.

First, riparian 'R' refers to shoreline parcels next to lakes or streams, as these parcels can disproportionately impact downstream waterbodies. Second, adjacency 'A' scores parcels based on their proximity to public or otherwise protected lands. Large continuous tracts of forest are preferred over scattered parcels throughout the watershed, so parcels touching other protected lands score highest. Lastly, quality 'Q', the most subjective criteria, refers to protecting areas with 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:

- Minnesota Biological Survey - Sites of Biodiversity Significance
- Lakes of Biological Significance
- Wild Rice Lakes Identified by DNR Wildlife
- Cisco Refuge Lakes, Minnesota
- DNR Hydrography – Trout Lake Designation
- State Designated Trout Streams, Minnesota

The RAQ score is tabulated by adding the score from each criterion. The scoring values are listed in Table 10. The highest priority parcels for protection have scores greater than eight. The RAQ prioritization results are summarized by HUC-10 in Table 11. The results show that with public lands, which are assumed to be protected, and the existing percentage of land currently enrolled in a forest protection program, all HUC-10 watersheds in the RRRLW exceed the 75% goal developed for forested watersheds in northern Minnesota (Table 12). However, there are still pockets of forest land within the RRRLW that are not well protected, and approximately 33% of the public land in the watershed are school trust lands. School trust lands are managed to provide a continuous source of revenue for education in Minnesota through timber harvesting and mining, and therefore maybe harvested more frequently than other public lands. Further protection strategies prioritization will occur locally to address parcellation and resource needs.

Table 10. RAQ Scoring Criteria

Scoring Criteria:		
Riparian	3	Within 100 ft of a stream or lake
	2	Within 100 ft of a Riparian "3" Parcel
	1	Within 100 ft of a Riparian "2" Parcel
Adjacency	3	Within 100 ft of public land or protected private land in the Woodland Stewardship Layer
	2	Within 100 ft of an Adjacency "3" parcel
	1	Within 100 ft of an Adjacency "2" parcel
Quality	4	

Scoring Criteria:		
	3	1 point for each feature that the parcel touches. The max score is 4.
	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 11. RAQ Parcel Area Prioritization by HUC-10 Watershed in the Rainy River - Rainy Lake Watershed

Forest Protection Program Prioritization											
		Low Priority (0-1)		Medium Priority (2-3)		High Priority (4-5)		Higher Priority (6-7)		Highest Priority (8-10)	
		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
Rat Root River	0903000304	748	0	3,290	1671	13,559	18,128	8,012	12,729	824	156
Rainy Lake	0903000305	424	0	936	39	1,635	676	1,012	1,201	1,853	519
Rainy River Rainy Lake	090300003	1,172	0	4,226	1,710	15,194	18,804	9,024	13,930	2,677	675

Hydrologic Unit Code (HUC-10)

Table 12. Forest Protection Area and Goals by HUC-10 in the Rainy River – Rainy Lake Watershed

HUC-10 Name	HUC-10	Total Area (ac)	Public Land (ac)	Forest Program Area (ac)	Protected Area (ac) (Percentage of Total Area)	Goal	Goal Met
Rat Root River	0903000304	181,687	121,663	32,684	85%	75%	X
Rainy Lake	0903000305	115,122	85,516	2,435	76%	75%	X
Rainy River Rainy Lake	09030003	296,809	207,179	35,119	82%	75%	X

Hydrologic Unit Code (HUC-10)

Agricultural Conservation Planning Framework GIS Toolset

The ACPF GIS toolset was used to identify potential locations for BMPs in the RRRLW. The ACPF Toolbox includes tools to process high-resolution Light Detection and Ranging (LiDAR) based digital elevation models (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 Water and Sediment Control Basins (WASCOB) tool within the ACPF toolset was used to identify potential grade stabilization structures that 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 nutrients and pollutant loads, slow runoff, and reduce the risk of gully formation. The WASCOBs tool was run for the entire RRRLW. Since opportunities for agricultural BMPs are limited due to small amounts of row crop agriculture within the watershed, the tool was modified to identify locations for grade stabilization structures in nonagricultural areas as well. Potential grade stabilization structures identified in nonagricultural areas may not be appropriate for a typical WASCOB-like structure. However, potential structures identified by the tool may be in areas where active erosion is occurring for reasons beyond agriculture. In these instances, site characteristics should be used to identify the appropriate BMP to remediate the issue. The specific targeted areas included gullies downstream of agricultural fields and gullies formed because of an incised stream channel. These findings confirm previous work done by a stream survey for the SID report and the general understanding of the water quality risk posed by low gradient streams, as discussed in Section 2.3. 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 WASCOB tool were applied across the entire RRRLW 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. Table 13 shows the number of grade stabilization structures, by configuration, identified in the RRRLW. Figure 19 shows the total number of grade stabilization practices sited within each HSPF subwatershed area.

Table 13. Potential Grade Stabilization Structures Identified in the Rainy River - Rainy Lake Watershed

Embankment Height	Drainage Area	Number of Structures
5	2-50	310
5	50-640	54
10	50-640	14
	Total	**378**

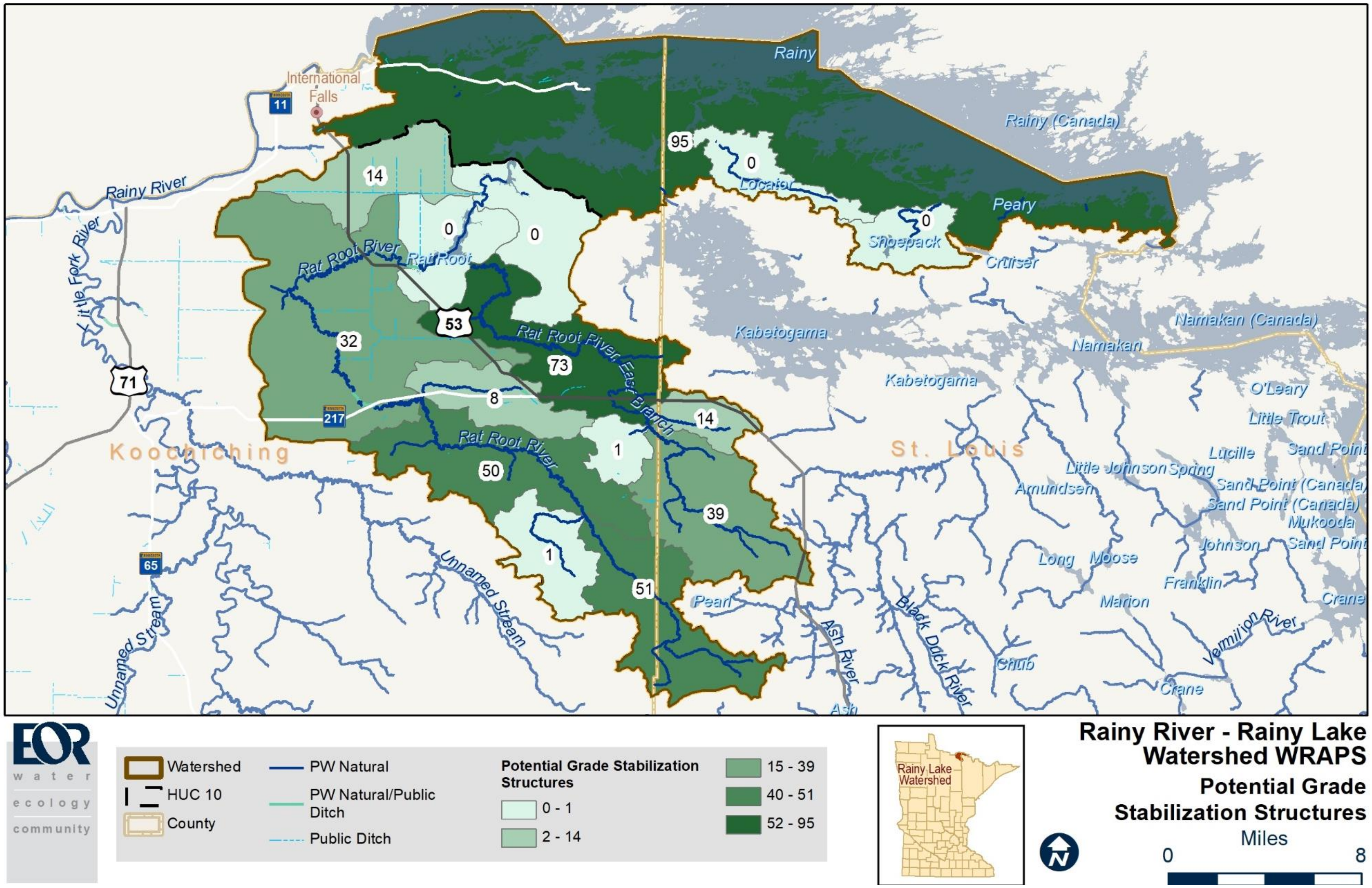


Figure 19. Potential grade stabilization structures in the Rainy River - Rainy Lake Watershed.

Riparian Forest Buffers

The Minnesota Buffer Law requires perennial vegetative buffers of up to 50 feet along lakes, rivers, and stream and buffers of 16.5 feet along ditches. As of March 2021, 94% to 100% of Koochiching County was compliant with the Buffer Law. Planting and widening forest buffers in the RRRLW may provide additional protection benefits for water quality in downstream rivers and improve water chemistry indicators, habitat conditions, and other stream characteristic. As Sweeney and Newbold summarized, forest buffers greater than 100 ft (about 30m) provide the optimal level of protection for a range of stressors including sediment, nitrogen, water temperature, and habitat for macroinvertebrate and fish communities (2014). These streamside forest buffers effectively slow, and can even block, mobilized nutrients and sediment from entering the watercourse.

To identify the critical areas in the RRRLW where riparian forest buffers might be needed, the GIS solar radiation toolbox was used to estimate the solar radiation in RRRLW based on topography. Areas facing the south receive more sunlight and are likely therefore warmer. Warmer water temperatures can contribute to lower DO concentrations, a stressor in the RRRLW. To include existing tree cover, the solar radiation was multiplied by the percentage of open land. The percentage of open land was estimated using the national land cover dataset 2016 tree canopy cover dataset (MRLC 2016). Then the results were summarized using 150 m buffers surrounding the streams. Larger values are less likely to have riparian forest buffers and contribute more to warming water. The areas in the RRRLW that are more likely to not have riparian forest buffers are shown in red in Figure 20. Future steps towards protection should include a review of these areas to define at a finer scale where lack of cover is a result of altered land use, such as agriculture or recent timber harvesting versus natural landscape features such as a wetland. The two primary areas identified with this approach were the portion of the Rat Root River near Rat Root Lake and the town of Ericsburg and a tributary to the Rat Root River near County Road 217.

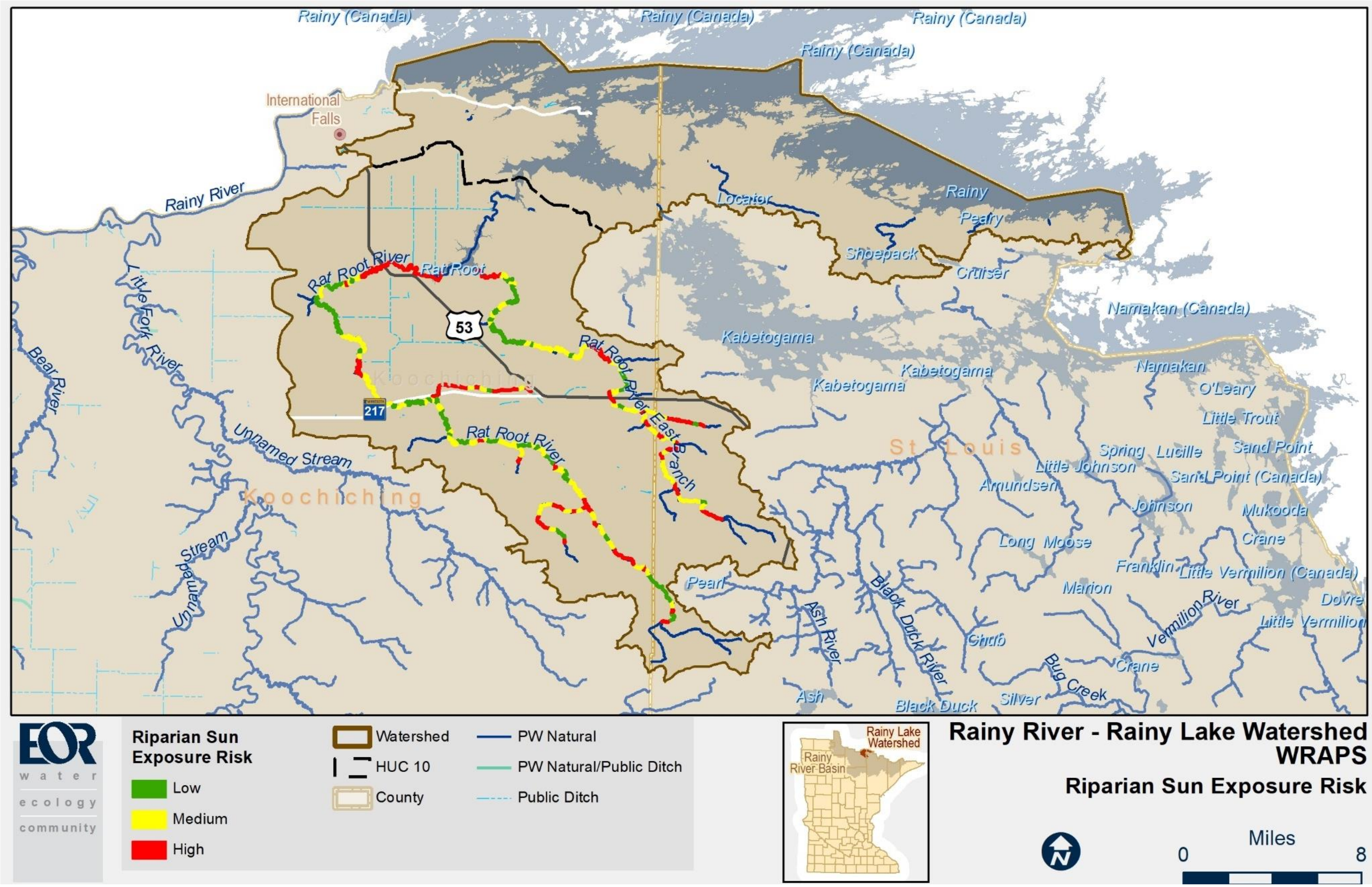


Figure 20. **Riparian sun exposure risk for prioritizing riparian forest buffers in the Rainy River-Rainy Lake Watershed.**

Evaluation of Altered Hydrology

Approximately 12% of streams in the RRRLW are altered and channelization, overall, is relatively low. Most of the headwaters of the Rat Root River remain unaltered. The watershed's altered hydrology includes dams at the inlet and outlet of Rainy Lake and two extensive ditch networks made in peatlands along the Rat Root River, created in attempt to drain wetlands for agricultural development. The networks are comprised of 48.9 miles of ditches, 29.2 miles of which are within one mile of a road. Ditches located farther than one mile from a road are considered inaccessible and have most likely not been maintained since installation. These ditches have essentially been abandoned. The county could investigate the option of legally abandoning these ditches as a means of preventing future ditch manipulation. Figure 21 shows the most accessible ditches where improvements could be made.

Specific improvements are dependent on a site visit to the ditch but could include two-stage ditching, inline or off-channel sediment basins, or any structure to make the ditch function more like a natural channel. Grade stabilization may be needed at the outlets of these ditches.

Additional assessment of legacy ditch removal should be conducted using ditch plugs or legal ditch abandonment. Assessment of this strategy should consider the water quality benefits of restoring hydrology and reducing nutrient and sediment mobilization, as ditches can accumulate pollutants and act as pathways for their exportation into waterways.

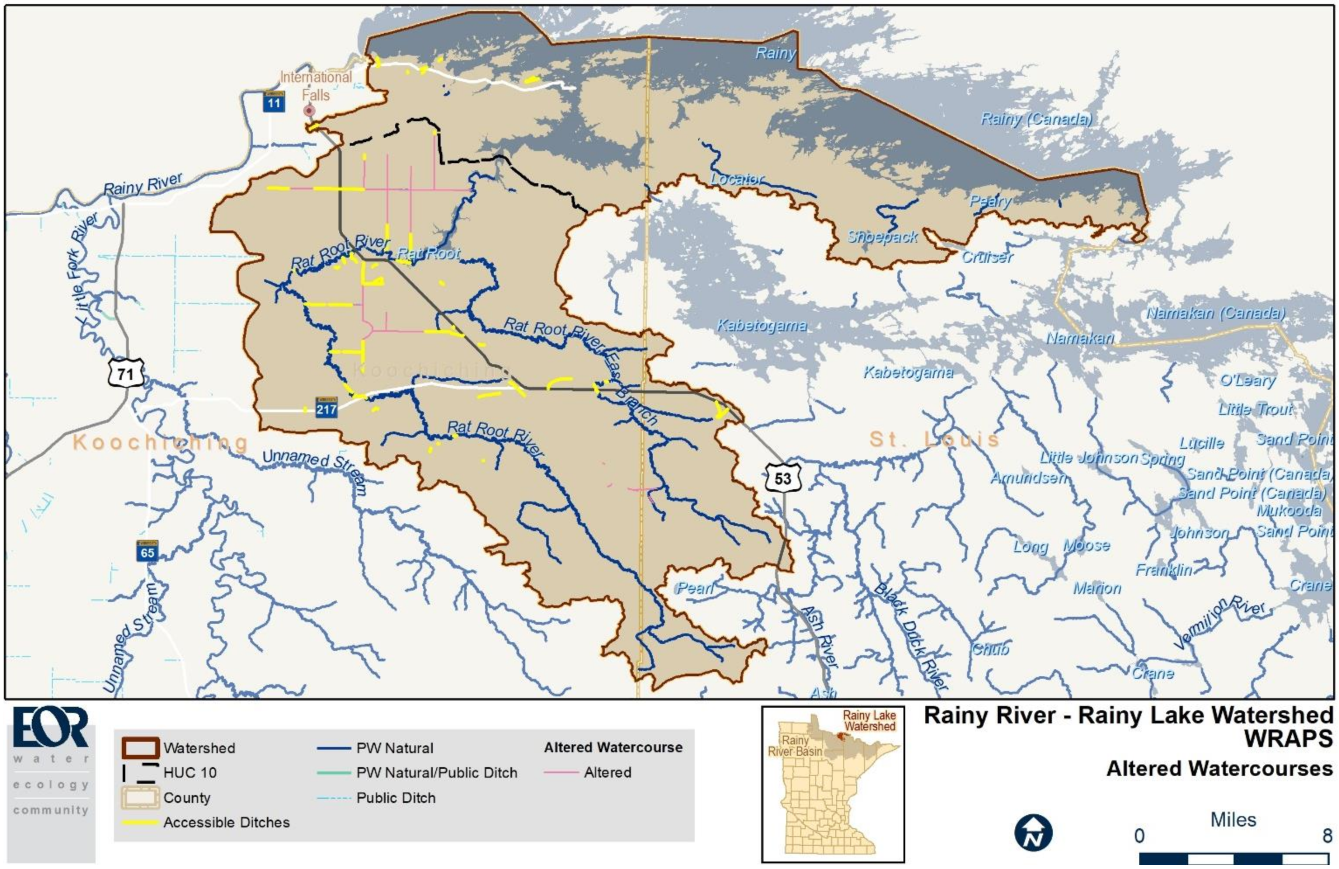


Figure 21. Altered watercourses for prioritizing potential ditch improvements in the Rainy River - Rainy Lake Watershed.

Hydrogeologic Risk Assessment

Timber harvesting, the region’s predominant industry, can contribute to increased stream flow and pollutant loads in local areas in a watershed. Tree removal can increase streamflow through the reduction of water intercepted by leaves and taken up by roots, and the possibility of erosion and pollution from the lack of large root systems holding down the soil.

Assessment of hydrogeologic risk for the RRRLW was based on a DNR and Minnesota Forest Resources Council (MFRC) study and incorporated several factors, including slope, soil erosivity, drainage area (referred to as flow accumulating area in the report), distance to hydrology, and forest canopy (Figure 22) (Wilson et al. 2021). These factors were derived from map layers at a 3-meter LiDAR-derived depth elevation model. Researchers developed a model for estimating risk that describes the tendency for higher slopes and more erosive soils to contribute to greater bank erosion, while greater distance to hydrology and higher percent of intact forest canopy both decrease that risk (Wilson et al. 2021). Areas in the RRRLW with higher geologic risk are in the headwaters and riparian areas of the Rat Root River and the East Root River.

$$Risk = \ln\left(1 + \frac{SWK * SPI}{(1 + (\ln(1 + \%\,Canopy) + \ln(1 + DistanceHydro)))}\right)$$

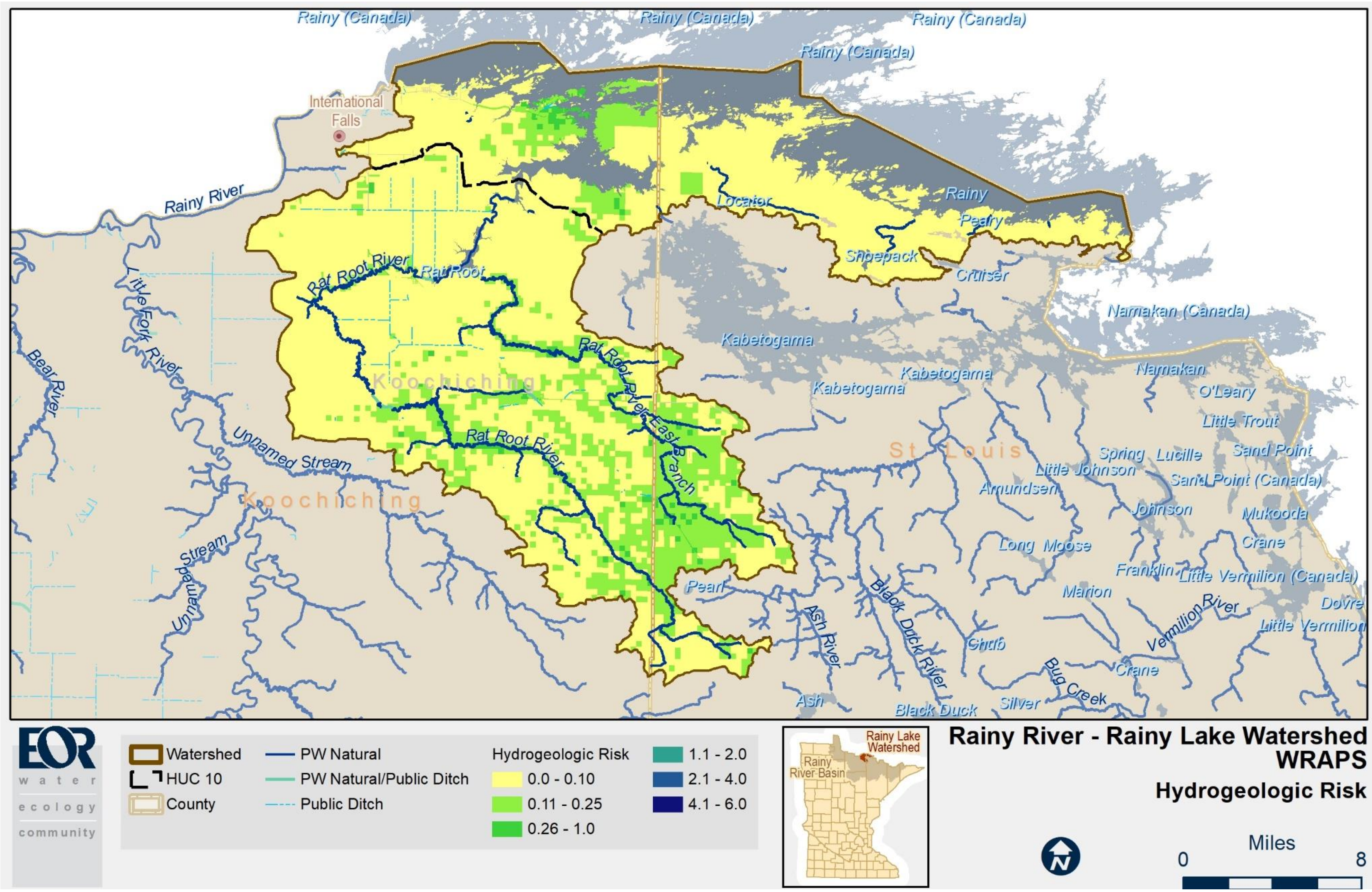


Figure 22. Hydrogeologic risk in the Rainy River-Rainy Lake Watershed.

Stream Restoration Opportunities

Survey efforts associated with the SID process and the Bank Assessment for nonpoint source Consequences of Sediment (BANCS) tool summarized the surveyed stream conditions in the RRRLW as mostly having stable low gradient reaches with adequate access to the river flood plain. As noted in the previous subsection on low gradient streams (Section 2.3), the survey identified several areas with higher erosion rate in Figure 23, including a 3,500-foot reach of bank instability in the Rat Root River, East Branch, and potential gullying in the upper Rat Root River. The middle reach of the Rat Root River, East Branch was identified as the largest contributor of TSS due to its high bank heights and erosion rates. Other problem areas include stretches of higher bank heights along middle and lower reaches of the main stem of the Rat Root River. Surveyors noted some gullies and channel incisions in these sections of the river as potential ravine stabilization opportunities, although further investigation is needed to assess TSS impacts of these features.

In addition to identifying portions of the streams with higher erosion rates, the survey identified that the stream bed and flow were very uniform throughout the reaches, which contributes to lower DO concentrations. Possible improvements to the stream to change these characteristics include removing the obstructions in the stream from an old trail one mile downstream of MN State Highway 217, and leaving alone large wood features and beaver dams that are shown to vary the flow and create turbulence in the stream. Furthermore, stream restoration in areas identified in the field with enough stream power should be considered for adding riffles capable of producing aeration to increase DO.

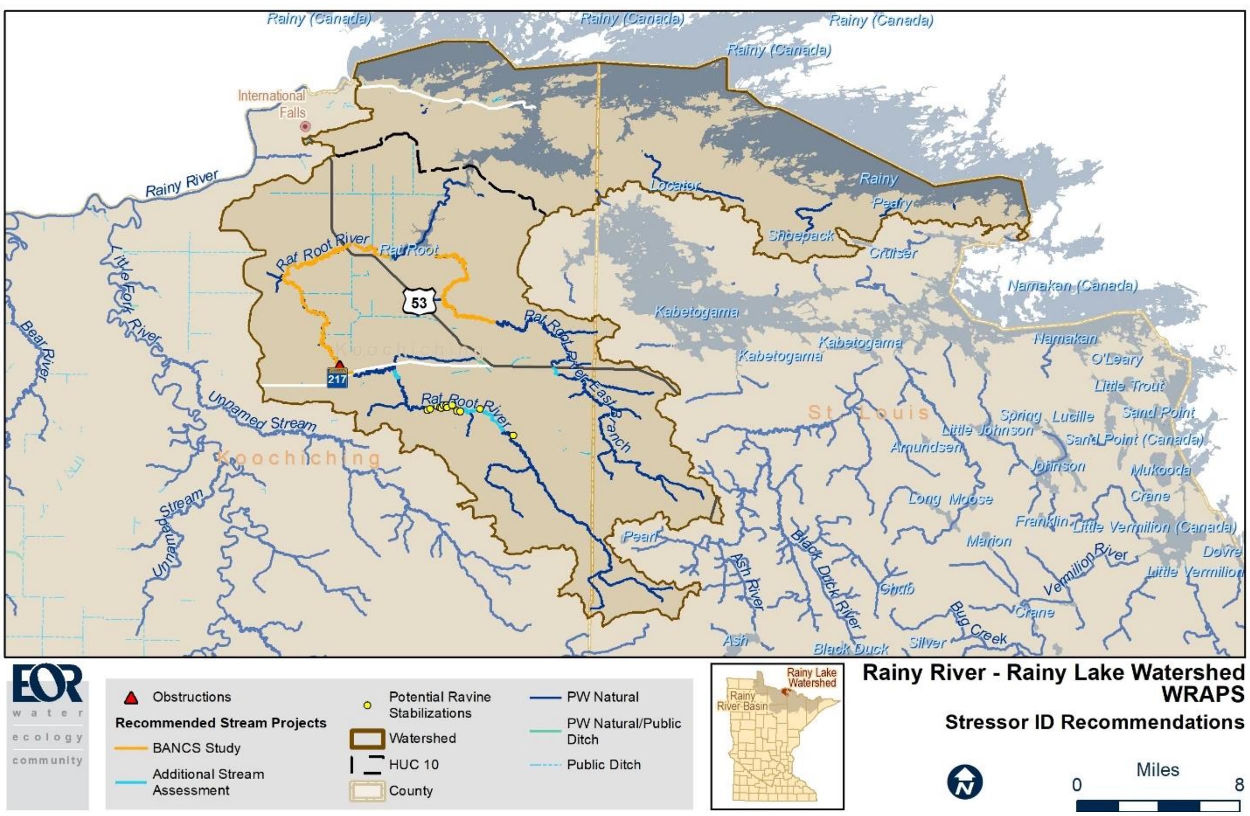


Figure 23. Stream projects recommended in the Rainy River-Rainy Lake Watershed Stressor ID Report.

3.2 Public Participation

A key prerequisite for successful strategy development and on-the-ground implementation is meaningful public participation. Public participation refers 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 public participation goals.

Public Meetings and Outreach

The WRAPS process for the RRRLW included a range of opportunities for public participation and targeted stakeholder engagement between 2017 and 2022, summarized in Table 14.

Table 14. Rainy River-Rainy Lake Watershed Public Participation Meetings

Date	Location	Meeting Focus
5/18/2017	Baudette	Surface Water Assessment Open House
5/22/2017	Ranier	Surface Water Assessment Open House
10/23/2017	Ranier	WRAPS Open House
10/24/2017	Birchdale	WRAPS Open House
12/17/2019	WebEx, Duluth &International Falls	Impaired Waters List 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
XX		WRAPS Public Notice Meeting

The October 2020, public survey listed in Table 14 above was conducted to obtain input on the watershed's resources from the public. The results of this survey confirmed the importance and familiarity of Rainy River to the local community and the widespread recreational use of the resource. The Rat Root River and Rat Root River, East Branch both received high or medium ratings for importance but appear to be less utilized than Rainy River and Rainy Lake. Residents of the watershed identified streambank erosion and sedimentation as common issues plaguing the resources.

Beyond the formal public meetings listed above, the Koochiching SWCD developed creative outreach programs to engage residents of the RRRLW. During the summers of 2017, 2018, and 2019, the SWCD collaborated with Crowd Hydrology to host a citizen monitoring station, creating personal connections between residents and local water quality issues and data. The station allowed citizens to measure water levels and text their readings to the SWCD database. Another successful outreach effort includes four drain stencil painting events in which participants painted between 60 and 70 drain covers in each of these events. The events took place at the following:

- 5/30/17: City of Fort Frances
- 6/14/18: City of Fort Frances

- 5/21/19: City of Ranier
- 5/29/19: City of Ranier

Core Team Meetings:

A Core Team of regional resource professionals met five times throughout the process to provide their professional judgment on water quality issues within the watershed and provide guidance to water quality monitoring, assessment, problem investigation and WRAPS development. This core team included representatives from various entities listed below:

- Koochiching SWCD
- North St. Louis SWCD
- DNR
- MPCA
- BWSR
- MDH
- United States Forest Service (USFS)
- National Park Service (NPS)

Additionally, subsets of the Core Team met several times to further guide coordination of state agencies and the development of the WRAPS Report. Table 15 outlines the date, location and meeting focus of Core Team meetings and meetings of subsets of the Core Team held during watershed condition assessment, problem investigation, SID, and WRAPS development.

Table 15. Rainy River – Rainy Lake Watershed WRAPS Development Core Team Meetings

Date	Location	Meeting Focus
9/12/2016	Baudette	Core Team IWM kickoff meeting
2/9/2017	Grand Rapids	State interagency coordination
4/23/2018	International Falls & WebEx	Core team meeting on IWM updates, SID planning, watershed boundary discussion, DNR standard deliverables, local waters of interest
4/25/2019	Ranier	Core Team Professional judgement meeting of proposed assessments
5/20/2019	WebEx	Core Team meeting on assessment overview, 2019 problem investigation workplan, partner updates
3/30/2020	WebEx	Project planning meeting of EOR and Koochiching SWCD
4/16/2020	WebEx	Project Planning Meeting of EOR and Koochiching SWCD
5/15/2020	WebEx	Project Planning Meeting of EOR, Koochiching SWCD, and MPCA
7/30/2020	WebEx	Project Planning Meeting of EOR and Koochiching SWCD
9/1/2020	WebEx	Core Team WRAPS development meeting
9/17/2020	WebEx	Project planning meeting of EOR, MPCA and Koochiching SWCD
9/24/2020	WebEx	Public meeting planning with EOR, MPCA and Koochiching SWCD
10/8/2021	WebEx	Public Meeting Planning with EOR and Koochiching SWCD

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) and Little Fork/Rat Root River Board (Rainy River-Rainy Lake). Measurable goals, and possible steps to reach these goals for future public participation efforts in the Lower Rainy and Rainy River-Rainy Lake watersheds were developed in a Civic Engagement Plan, completed January 25, 2020. The plan includes:

1. Increase the number of watershed residents participating in water quality discussions.
   - Meetings of the Rainy/Rapid River Board and Little Fork/Rat Root River Board (Rainy River-Rainy Lake Watershed) will continue, with a shared goal of increasing participation in coordination with all related local government units.
2. Effectively engage citizens in a meaningful way. Continuing to build relationships with and between citizens throughout the watershed will support implementation activities. Successful opportunities 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 VNP, 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;
     - Drain Stencil projects in the U.S. and Fort Frances (if budget allows);
     - Annual Outdoor Education Days event for 5th graders; and
     - Local classroom education as requested.
3. 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 resource 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; and
   - Updates on the Koochiching SWCD website.

4. Coordination of agencies through the core committee established during the WRAPS process to bolster communication between all the partners. Relationships between government staff will be key to moving the watershed protection and restoration 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 increase the benefit to the watershed through prioritization and targeting, and success will be measurable.
5. Strategies identified in the WRAPS will also assist the 1W1P effort in this watershed and increase the likelihood of success through prioritization, targeting, and setting measurable goals. 1W1P efforts also provide watershed-based implementation funding.

Future updates of WRAPS documents

Revisions and updates of WRAPS documents can also include components of public participation; however, the public participation efforts will be limited in scope to address the focused efforts detailed in the Cycle 1 WRAPS Report. Based on the partners' input, additional public participation activities may be included as part of the WRAPS update. Funds for public participation and engagement activities are also included in some BWSR grants.

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. One comment letter was received and responded to as a result of the public comment period. Comments focused on mining issues in the Rainy River – Headwaters, Little Fork River, and Saint Louis River major watersheds. These watersheds also have WRAPS reports developed. Also included in these comments was a concern for the protection and restoration of waters from excess mercury and mercury methylation. As indicated in the Rainy River - Rainy Lake WRAPS, there are waters in this watershed, including Rainy Lake, that are not covered by the statewide TMDL and TMDLs will need to be developed for these waters. As TMDLs are developed for waters impaired by mercury, a holistic approach that considers the sources that contribute to the impairment will be used to determine appropriate reductions and implementation strategies. As indicated in the Rainy River – Rainy Lake WRAPS Report, mercury TMDLs for waters not included in the Statewide TMDL within the RRHW watershed are anticipated to be completed between 2025 and 2033.

3.3 Restoration and protection strategies

The RRRLW is a relatively natural watershed and has few impaired waterbodies in need of restoration. As a result, protecting the tremendous natural resources will be extremely important in the RRRLW. This section outlines existing BMPs in the watershed, restoration strategies, and protection strategies.

Existing BMPs

Watershed partners have completed many projects to protect and improve the water quality in the RRRLW. A list of existing BMPs that have been implemented or installed within the RRRLW is available on the MPCA's Healthier Watersheds webpage and is shown in Table 16. All BMPs were implemented to reduce nonpoint source pollution within the watershed.

Table 16. Best management practices installed in the Rainy River-Rainy Lake Watershed

Strategy type	BMP	NRCS BMP code	Number of BMPs installed	Installed amount (by unit)	Units
Stream banks, bluffs, and ravines	Streambank and Shoreline Protection	580	12	2,623	Feet
Pasture management	Prescribed Grazing	528	6	155	Acres
Habitat and stream connectivity	Tree/Shrub Establishment	612	3	72	Acres
Converting land to perennials	Critical Area Planting	342	1	0	Acres
Other	Livestock Pipeline	516	5	13,665	Feet
	Windbreak/Shelterbelt Establishment	380	1	3,576	Feet
	Fence	382	2	3,275	Feet
	Seasonal High Tunnel System for Crops	325	2	2,678	Sq Ft
	Integrated Pest Management	595	8	104	Acres
	Watering Facility	614	4	4	Count
	Forage and Biomass Planting	550	4	4	Acres
	Forest Management Plan – Written	106	1	3	Count
	Pumping Plant	533	2	2	Count
	Water Well	642	1	1	Count
	Tree/Shrub Site Preparation	490	1	0	Acres
	Heavy Use Area Protection	561F	2	0	Acres
	Mulching	484	1	0	Acres

Walleye Spawning Enhancement

Recreational walleye fishing represents a major economic driver within the Rainy Lake regional tourism industry. As a result, local interest in improving walleye spawning has spurred several recent monitoring and implementation programs in the Rat Root River. Historically, the river has maintained a sizable spawning run, but the DNR has observed a large decrease over the last century in female walleyes using the river for spawning. Further study identified sedimentation in the Rat Root Lake and Rat Root River and channel-spanning log jams as key contributors to the walleye decline (Ellen River Partners 2008). Both issues are related to human activity, including effects of early-century logging, and the downstream impoundment of Rainy Lake compounded with several large floods that caused sedimentation in the downstream reaches of the river. Furthermore, a monoculture of aspen that replaced logged forests is aging at the same time Dutch Elm Disease is spreading through stands of elm trees, leading to an increase in fallen trees.

In the last decade, a coordinated effort between public and private entities arose to spearhead several spawning improvement projects. The main targets of this ongoing cooperation include removal of channel blocking log jams, sediment load reduction, and walleye spawning habitat restoration through tree plantings, stream stabilizations, and stream riffle habitat installations. Restoration projects were mostly focused on the downstream reaches of the Rat Root River between Rat Root Lake and the Arrowhead State Trail crossing, as were log jam removal projects (see subsection on Large In-Stream Wood Protection and Management below for more information), which extended from Rat Root Lake to the MN State Highway 217 crossing.

Large In-Stream Wood Protection and Management

The streamside forests along the Rat Root River have historically supplied the riparian ecosystem with large wood, which has shaped the river's geomorphology and fostered stream complexity and biodiversity. However, as the local economy has developed, large wood has often been removed for navigational, aesthetic, and recreational purposes, as well as potentially to reduce localized flooding. Although the public typically perceives large wood features in waterways negatively, large in-stream wood provides critical habitat for fish and many other organisms, stabilizes streambanks, decreases in-stream temperatures, and improves floodplain connectivity. Large wood creates flow velocity variation and riffle pools, promoting habitat diversity and fish spawning environments. The same mechanisms can trap sediment, potentially reducing TSS downstream, and help prevent channel incision and bank erosion (Abbe et al. 2018). During precipitation events, large wood can slow the erosive force of high flows and direct them onto surrounding floodplains, which then deposit sediment and nutrients critical to the floodplain ecosystem (Department of Fisheries and Wildlife, Oregon State University Corvallis, Oregon 97331, USA et al. 2003). In this WRAPS report, large wood refers to all large wood in streams while log jams indicate complete blockages of the channel that may require human intervention to remove. Other terms that may be used include: channel-spanning wood, which refers to a minor log jam that span the entire river channel; and bank or side-channel wood, which keeps the wood features along the banks to achieve benefits of large wood while allowing navigation.

The downstream to middle reaches of the Rat Root River have been the target of several log jam removal projects in the last decade, often as part of efforts to improve walleye spawning. These projects were undertaken in response to the Ellen River Partners study, which concluded that fallen trees obstructing the Rat Root River's flow may result in sediment buildup preventing walleye movement upstream, alter fish and macroinvertebrate habitat, and contribute to streambank erosion. The study attributed the recent increase in fallen trees and log jams to the region's history as a major timber producer; heavy early-century logging reduced pine forests, which were replaced by a monocultures of elms and now-aging aspen (MPCA 2021a). The reduced biodiversity rendered the elm forests susceptible to Dutch Elm Disease. Stream surveys in 2017 and 2019 indicate that large wood in the mainstem currently provides good habitat and downstream scouring of fines, while not appearing to cause any increase in bank erosion rates. Habitat and channel development in stream reaches with select or no wood removal appeared healthier than areas in which extensive wood removal had occurred. More data is needed to determine the full impact of the wood in the channel, but no strong evidence emerged of systemic slowdowns in flow for either the Rat Root River or Rat Root River, East Branch (MPCA 2021a).

Therefore, large wood removal projects must carefully evaluate and balance the needs of the local community with a full suite of stream health and riverine ecosystem benefits. For example, reasons for log jam removal include reducing sedimentation to promote walleye spawning, but research suggests large wood can improve downstream TSS, slow incision and bank erosion, and vary streamflow velocities and direction (Abbe et al. 2018). While log jams may need to be removed to promote recreation and walleye movement, projects may instead consider partial removal or leaving side-channel wood in the lower reaches, where navigation is a higher priority. Complete removal of large wood appears to damage biodiversity and habitat health. The SID report identified no large wood features for removal and suggests allowing large wood to re-establish in channels. Although log jams have traditionally been perceived as, and can be problems, understanding of river ecosystems has shifted to acknowledge the broader ecological benefits of large in-stream wood features. Monitoring programs should accompany large wood re-establishment efforts to track the projects' ecological impacts and to ensure restoration actions do not impede recreation activities.

Wild Rice Management

Wild rice production in the RRRLW occurs along the floodplain of Rat Root River and throughout Rat Root Lake and Rainy Lake. The operation of dams in Rainy Lake poses major challenges to the growth of wild rice, which in turn threatens indigenous communities who rely on the resource. Tribal nations successfully advocated and worked with the IJC on the 2018 Rainy Lake Rule Curve Change to promote wild rice survivability and harvest, and the growth of muskrat populations, which control competitive species of cattails. These changes accounted for new research, which identified optimal water levels and conditions for wild rice growth and harvest, and shorter winter drawdown periods for improved muskrat survival. One study discovered that invasive cattail populations could be controlled by cutting the roots beneath the water surface (Dysievick et al. 2016). However, climate change still presents ongoing threats to wild rice harvests as heavy storms can damage plants and warming winters may favor more competitive species.

Forest Protection Programs

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

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 the 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 RRRLW are already forested and protected by public ownership (federal, state, and county) (Figure 24). Forest protection programs 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. Figure 24 displays the lands in the RRRLW that are protected through conservation easements, forest protection programs, or public ownership.

Table 17 outlines applicable forest protection programs that will best allow the RRRLW 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.

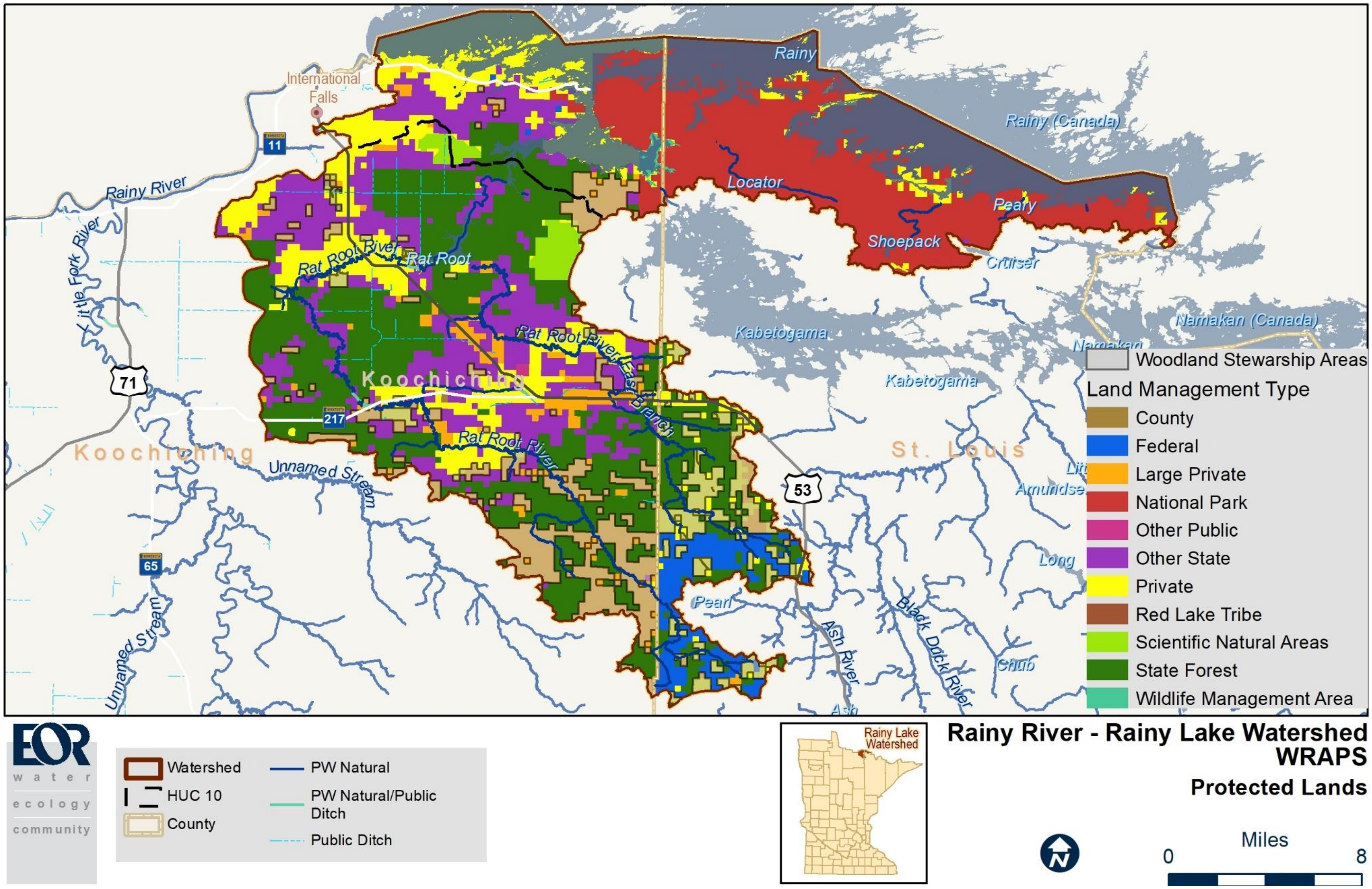


Figure 24. Lands protected by conservation easements, forest protection programs, or public ownership including school trust lands in Rainy River – Rainy Lake Watershed.

Table 17. Forest Protection Programs used within the Rainy River-Rainy Lake Watershed

Forest Protection Program	Applicability to the RRRLW
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 off the amount of forest stewardship acres the landowner has. Payments per acre range from the $9-$16.50, based off 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 major source of sediment in forested areas. Studies have shown that fine sediment levels increased throughout the watershed after timber harvesting, with unstable banks increasing for several years and windthrow occurring more frequently than prior to 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.

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 RRRLW timber harvesting BMPs implementation is monitored by the MFRC. Recommendations for the management area containing the RRRLW are in Table 18 (Wilson and Slesak 2020). Generally, there is good adoption of timber harvesting BMPs in the watershed.

Table 18. Summary of Recommendations for the Rainy River-Rainy Lake Watershed (Wilson and Slesak 2020)

Best Management Practice	Estimated Implementation	Description
Minimizing Soil Exposure on Filter Strips	99%	Filter strips are vegetated areas adjacent to waterbodies that are used to trap and filter out suspended sediment and potential pollutants prior to reaching surface water resources.
Maintaining Riparian Management Zones (RMZ) on lakes and open water wetlands	100%	RMZs are riparian areas adjacent to waterbodies. They provide disproportionate benefits to aquatic ecosystems by providing direct shade to waterbodies 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	90%	Crossings are sections of forest roads and skid trails where equipment crosses a waterbody. They are the forest management feature that has the highest potential for pollutant loading to waterbodies and should be avoided whenever possible.
Leave Tree Retention	94%	A percentage of leave trees should be left on clear-cut timber harvesting areas to maintain habitat for wildlife.
Coarse Woody debris retention	92%	A portion of bark on down logs should be left in the harvest area to maintain habitat for wildlife.
Installation of erosion control on approaches where needed	83%	Portions of forest roads and landings close to waterbodies should use erosion control to minimize erosion.
Infrastructure Management	56%	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.
Maintaining RMZs along streams	50%	RMZs are riparian areas adjacent to waterbodies. They provide disproportionate benefits to aquatic ecosystems by providing direct shade to waterbodies 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.
Avoidance of dense debris accumulation on landings	37%	Dense debris accumulation on landings can inhibit regeneration of woody vegetation.

Best Management Practices with high compliance; Opportunities for Improvement

Streambank Restoration

The following discussion provides strategies to restore altered stream channels in the watershed. However, development of site-specific restoration plans will require further assessment to determine the optimal extent, methods, and locations for restorations. In addition, the length of ditched and incised reaches, local constraints, and project costs may restrict the restoration options available.

As a result of extensive timber harvesting in the early 1900s, ditching in the downstream reaches, and several large floods, the streams in the watershed are still recovering through channel evolution (Figure 25). Evolving streams often undergo predictable changes in form involving periods of accelerated erosion, deposition, and lateral migration. Each stream adjusts differently depending on watershed characteristics such as valley shape and slope, substrate, and vegetation composition and density. Specific stream segments were identified as being impacted from legacy changes in the watershed. They include an incised segment downstream of Ericsburg, of the Rat Root River, East Branch and two potentially incised segments of the mainstem Rat Root River that require further examination (MPCA 2021a). Incised segments, seen in the “G” stream type in Figure 25 below, risk lowering the local water table and rendering the area's floodplain inaccessible at bankfull flows. Without floodplain access, higher flows stay concentrated within the channel, increasing sheer stress on the bed and banks, and accelerating bank erosion. The resulting instability creates excess sediment, a lack of variable bed form, and minimal quality habitat for all life stages of biota. Restoring these streams would promote channel stability, prevent future erosion issues, and provide better habitat.

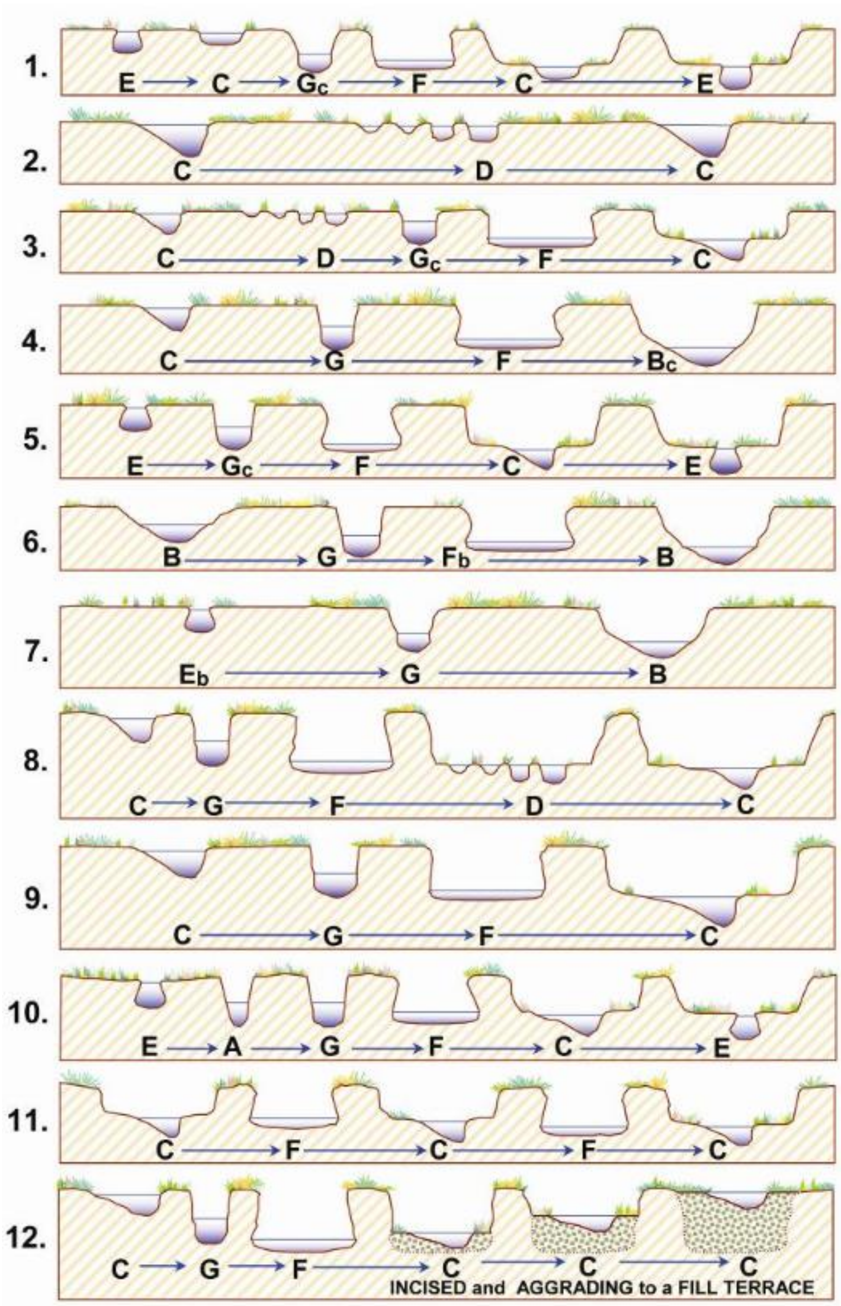


Figure 25. Some of the stream evolution scenarios documented in actual rivers (Rosgen 2011)

The DNR recommends a holistic approach for stream restoration planning and implementation to best address the five components of stream health. Rather than fixing isolated symptoms, a holistic approach seeks to alleviate the drivers of instability while shoring up a stable channel to improve functions within the five components. This holistic approach includes understanding how the different stream and watershed characteristics may influence stream evolution so the restoration plan can be adapted the current evolutionary stage of a stream (Figure 25).

Specific stream restoration activities identified in the SID Report include removing a bridge and its pilings just downstream of where the Rat Root River crosses MN State Highway 217. In this reach, monitoring data from the report identified high TSS and extremely low DO relative to the rest of the river system. This action seeks to address these issues by aiming to increase stream velocity, reduce sedimentation, and prevent further warming of stream temperature, which impacts DO concentrations and rate of microbial respiration.

Another opportunity, discussed in the subsection “Large In-Stream Wood Protection and Management,” is to promote the natural establishment of large wood features in stream channels throughout the watershed. The SID report notes that this action would, among other ecological benefits, provide a diversity of healthy aquatic habitat and streamflow velocities, stabilize streambanks, and encourage the scouring of gravels and riffle-pool development. Buildup of wood in stream channels occurs naturally as part of a healthy ecological system and its associated impacts and benefits should be considered holistically and in conjunction with locally-driven reasons for wood removal, such as promotion of recreational activities. Removal of large channel spanning wood, that becomes excessive and limits sediment transport and degrades water quality and aquatic habitat, should be considered under the guidance of water quality and stream geomorphology data.

Climate protection co-benefit of strategies and adaptation BMPs

Although agricultural use is minimal in this watershed, there are locations where agriculture related BMPs, such as riparian buffers and conversion of open lands to forest, can reduce GHG emissions in addition to providing water quality benefits. 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 (CO_2) 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, other 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 emission can be found at NRCS, et al., “COMET-Planner: Carbon and Greenhouse Gas Evaluation for Natural Resources Defense Council Conservation Practice Planning http://www.comet-planner.com/.

Beyond agricultural BMPs, wetland protection will play a critical role in sequestering carbon and reducing atmospheric carbon dioxide, a major GHG. As wetlands constitute almost half of the RRRLW lands, this watershed serves as a major carbon sink. Wetland degradation and hydrologic change could negatively impact carbon sequestration. While wetlands sequester carbon, they are also a source of the GHG methane. However, the degree that methane production offsets the benefits of carbon sequestration is poorly understood. Wetlands also provide resilience to impacts from climate change by providing water storage during extreme precipitation events. They do this by holding water and releasing it slowly over time, reducing extreme runoff events. The WRAPS protection programs that work to restore ditched peatlands and bring more lands under protection status will help preserve wetland and peatland ecosystems and prevent the release of carbon held in these stores. Furthermore, wetlands filter out pollutants that could otherwise impact downstream waterbodies. Combined with water quality BMPs, wetlands can help protect the RRRLW from the threat of harmful algal blooms, which increases with the warming water and climatic temperatures. Protection strategies will encourage native revegetation, water management practices to prevent dewatering, peatland restoration, and fire controls during drought periods.

Timber and forest BMPs can also promote climate benefits through protection of forests. The forest lands of the RRRLW face the growing threat of invasive species as the climate shifts to welcome 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 RRRLW forests remain healthy, continue to sequester carbon, and promote soil health and ecological diversity.

Proposed Strategies and Actions by Subwatershed

Watershed-wide and HUC-10 level protection strategies are detailed in Table 19. The objective for the RRRLW is to maintain or improve water quality because there are no impaired waterbodies in the RRRLW. The strategies reflect the various land uses in the watershed.

Table 19. Strategies and actions proposed for the Rainy River-Rainy Lake Watershed

Waterbody and location			Water quality (WQ)			Strategies to achieve final water quality goal				
							Example Best Management Practice (BMP) Scenario			
HUC-10 Subwatershed	Waterbody (AUID)	Location and upstream influence counties	Pollutant/ Stressor	Current WQ conditions	Final WQ Goal	Strategy Type	BMP	Amount	Unit	Estimated reduction (lbs/yr) as applicable
All	All	Koochiching, Saint Louis	Total Suspended Solids, Habitat	Table 2, Table 3, Table 7, Table 8	Maintain or Improve Existing Water Quality	Habitat and stream connectivity management	**Modify/replace dams culverts & fish passage barriers** – Continue to work with County Engineering department to identify culverts contributing to erosion or reducing stream connectivity for aquatic life.	-	-	-
			Total Suspended Solids, Total Phosphorus, Dissolved Oxygen, Habitat				**Riparian tree planting to improve shading [390, 612]** - Establish and maintain permanent vegetation along the stream corridor that includes a variety of grass, trees, and shrubs preferably greater than 100 ft and downstream of roads, agricultural areas, and recently harvested timber.[1]	-	-	-
			Total suspended solids, Dissolved Oxygen, Habitat				**Stream Restoration using Natural Channel Design principles** - Assess and allow for a healthy amount of wood to establish naturally in the stream channel.[1]	-	-	-
			Total suspended solids, Total Phosphorus			Stream banks, bluffs & ravines protected/restored	**Ravine Stabilization [410]** - Perform field review of very high priority potential grade stabilization structures predicted from the ACPF tool to identify and fix gully erosion in the watershed.	-	-	-
			Total suspended solids, Total Phosphorus			Agricultural Strategies	Continue to work with agricultural landowners to encourage BMP s such as, nutrient management plans, residue and tillage management, and edge of field BMPs	-	-	-
			Total suspended solids, Dissolved Oxygen, Total Phosphorus, Habitat			Forestry Management	**Forest erosion control on harvested lands** - Encourage forestry practices that are protective of the stream riparian and water and adhere to MFRC Guidelines[1] especially in areas with low implementation rates including **Roads and trails improvement [655]** -infrastructure management, **Riparian zone forestry management** - riparian management along streams, and avoidance of dense debris accumulation on landings and retaining more preferred tree species.[2]	-	-	-
			Habitat, Temperature				**Reforestation on nonforested land and after cutting** - Diversify tree species, emphasizing longer-lived conifers and climate change resiliency in species selection.[1]	-	-	-
			Total suspended solids, Total Phosphorus, Habitat				**Forestry management and improvement [147M, 490, 666]** - Work with private landowners to develop Forest Stewardship Plans using RAQ scoring and hydrogeologic risk assessment.[1]	-	-	-
			Total suspended solids, Dissolved Oxygen, Total Phosphorus			Monitoring	Monitor the effectiveness of past and future stream restoration and riparian area enhancement projects as well as the effects of BMPs implemented on the landscape.[1]	-	-	-
			Dissolved Oxygen				Consider on-going monitoring of DO and water temperature and how climate change may impact these parameters.[1]	-	-	-
			TSS, Dissolved Oxygen, Total Phosphorus, Habitat			Climate Mitigation and Adaption	Explore and incorporate actions and conservation planning specific to climate change being developed by various agencies at the Federal, State and Local levels.[1]	-	-	-

			Total suspended solids			Education and Outreach	Provide education to private landowners of streambanks and shorelines on the importance of maintaining natural buffers near waterbodies.[1]	-	-	-
			Total Suspended Solids, Dissolved Oxygen, Total Phosphorus, Habitat				Educate and/or assist private landowners in forest, pasture, cropland, and overall healthy riparian area and watershed management.[1]	-	-	-
			Total Suspended Solids, Dissolved Oxygen, Total Phosphorus, Habitat				Educate landowners and stakeholders about the current state of the watershed, identified stressors, future threats (e.g. climate) to stream health, and the importance of watershed protection.[1]	-	-	-
Rat Root River (09030000311)	Rat Root River (513, 634), Rat Root River, East Branch (632, 633), Rat Root River (Rainy Lake) (514), Unnamed Creek (531, 560, 626, 627, 630), Unnamed ditch (631)	Koochiching, St. Louis	Total Suspended Solids, Dissolved Oxygen, Habitat	Table 2, Table 3, Table 7, Table 8	Maintain or Improve Existing Water Quality	Habitat and stream connectivity management	**Stream restoration using Natural Channel Design principles** - Remove bridge and pilings 1 mi south of MN State Highway 217 at former trail crossing with consideration of removal methods that will not negatively impact stream stability.[1]	-	-	-
			Total Suspended Solids, Dissolved Oxygen, Total Phosphorus, Habitat, Altered Hydrology				**Wetland Restoration for habitat [658]** - Consider legally abandoning inaccessible legacy ditches that currently provide little to no benefit to landowners	-	-	-
			Total Suspended Solids, Dissolved Oxygen, Total Phosphorus, Habitat, Altered Hydrology				**Restore floodplains and reconnect with channel** - Consider improving ditches that are accessible and continue to benefit landowners with practices that make them more natural such as two-stage ditches	-	-	-
			Total Suspended Solids, Dissolved Oxygen, Habitat				**Stream restoration using Natural Channel Design principles** - Using DNR-approved methods, determine stream bank stability and potential degree of aggregation or sedimentation at locations of interest.[1]	-	-	-
			Total Suspended Solids, Dissolved Oxygen, Habitat				**Stream restoration using Natural Channel Design principles** - Using DNR-approved methods, continue the BANCS survey in areas with potentially high bank erosion inputs.[1]	-	-	-
			Dissolved Oxygen			Monitoring	Consider investigating the role of sediment-oxygen-demand in low DO reaches	-	-	-
Lower Rainy Lake (09030000318)	Rainy River (Rainy Lake) (505, 506), Rat Rt Root River (Rainy Lake) (514), Unnamed Creek (620, 622, 624), Unnamed Creek (Shoepack Lake) (621), Unnamed creek (Unnamed Lake) (623), Artificial Path (625), Tilson Creek (629)	Koochiching, St. Louis	Habitat, Total Phosphorus, Total suspended solids	Table 2, Table 3, Table 7, Table 8	Maintain or Improve Existing Water Quality	Lake Internal Load Management	**Lake Level Management** -Continue to monitor rule curve and collaborate with IJC to make sure wild rice and environmental concerns on the lake are a priority	-	-	-
			Total Phosphorus	Table 2, Table 3, Table 7, Table 8	Maintain or Improve Existing Water Quality	Education and Outreach	Educate Rainy Lake houseboat owners and rental companies to reduce discharge of greywater	-	-	-

[1] (MPCA 2021a); [2](Wilson and Slesak 2020)

4. Monitoring plan

It is the intent of the implementing organizations in this watershed to make steady progress in terms of pollutant reduction. The collection of current land and water data is an important component to the assessment of that progress and to inform management and decision-making. Because RRRLW possesses water resources already high in quality, continued monitoring will produce reliable data necessary to maintain current conditions and preempt potential issues. The basic needs of a monitoring plan must include an understanding of variability, scale, confidence, and associated risk levels, as well as specific knowledge of characteristics of each target subwatershed, which can inform the plan's design. For example, the middle reaches of the Rat Root River face challenges with TSS and low DO and requires monitoring for the effects of climate change and streambank erosion, while Rainy Lake is highly regulated and monitored for water levels due to its recreational use and wild rice habitats. Monitoring of both land and water components is needed and data is then used to inform and calibrate watershed models, evaluate progress towards defined goals, and desired outcomes.

Following MPCA and CWLA strategy, a watershed-wide monitoring approach was implemented in the RRRLW beginning in the summer of 2017. The SID Report identified several opportunities for possible expanded monitoring aimed at supporting water quality improvements to the Rat Root River and Rat Root River, East Branch subwatersheds:

- Evaluating the effectiveness of past and future stream restoration, riparian enhancement, and other BMP implementation projects;
- Continuing the geomorphic assessments of the middle reaches of both branches of the Rat Root River (previously identified in Section 3.1);
- Building on current BANCS survey data in areas with potentially high bank erosion inputs, such as the Rat Root River, East Branch between County State Aid Highway (CSAH) 3 and Rainy Lake, and gullies and tributaries that appear unstable or at-risk;
- Anticipating future issues, such as monitoring DO and water temperature to improve the understanding of climate change in the watershed;
- Examining the role of sediment-oxygen-demand in low DO reaches, with a particular focus on the middle reach of the Rat Root River; and
- Monitor the water quality and geomorphology impacts of future large wood formations to document benefits and to guide future decisions surrounding potential removal if a large wood formation is found to be detrimental.

The 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 (Figure 26) that responds to and corrects for ongoing monitoring results will ensure implementing organizations in RRRLW 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. Conversely, there may be faster progress for some impaired waters, especially where high-impact fixes are slated to occur.

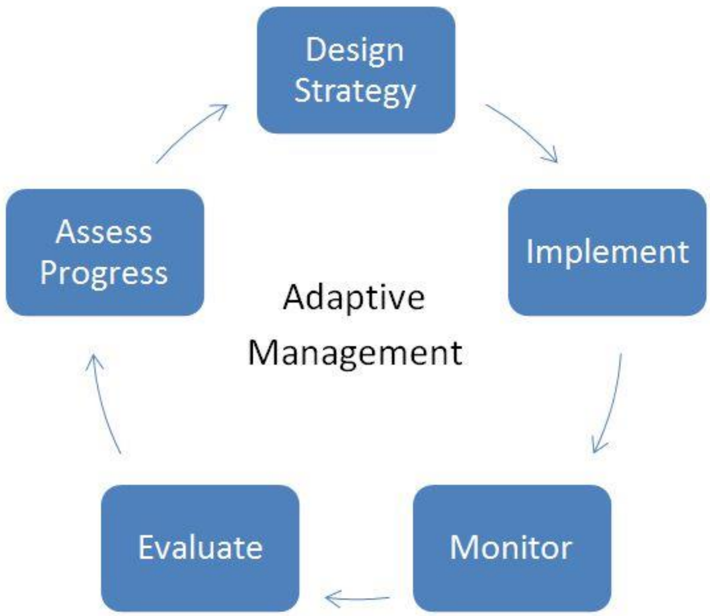


Figure 26. Adaptive Management

Watershed Pollutant Load Monitoring Network

Pollutant loads refer to the amount of a pollutant discharged into a waterbody over a period of time. 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 in Minnesota to calculate pollutant loads in rivers and streams. Data are collected at 199 sites around the state, including one subwatershed monitoring site at the Rat Root River (Table 20).

Table 20. WPLMN stream monitoring sites in the Rainy River-Rainy Lake Watershed.

Site Type	Stream Name	EQuIS ID
Subwatershed	Rat Root River near International Falls, CR145(H74033011)	S007-612

Environmental Quality Information System (EQuIS)

WPLMN data assist in watershed modeling, determining pollutant source contributions, developing reports, and measuring water quality restoration efforts. Each year, approximately 20 to 25 water quality samples are collected seasonally at a subwatershed monitoring site. Water quality samples are collected near gaging stations, at or near the center of the channel. Samples are collected more frequently when water flow is moderate to high, 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 stream flow is low, and fewer samples are taken in those conditions. This staggered approach generally results in samples collected over the entire range of flows and provides an accurate estimate of the total pollutant load leaving the watershed.

Stream Monitoring

As part of the MPCA IWM strategy, five stream sites were monitored for biology (fish and macroinvertebrates) and two sites were monitored for water chemistry from 2017 through 2018 (Table 21, Table 22). 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. Additional monitoring around large wood features should occur to evaluate the results of large wood re-establishment and log jam removal projects, for parameters both upstream and downstream such as habitat health, flow variability, erosion, substrate, and TSS. This monitoring effort should aim to identify a balance between the local community's recreational and navigational needs with the ecological and stream health benefits.

Table 21. Intensive watershed monitoring water chemistry stations in the Rainy River-Rainy Lake Watershed

EQuIS ID	Biological Station ID	WID	Waterbody Name	Location
S009-293	17RN001	09030003-635	Rat Root River	Upstream of Hwy 53, 1.5 mi. NW of Ericsburg
S009-450	17RN006	09030003-633	Rat Root River, East Branch	Upstream of CSAH 3, 2 mi. N of Ray

Environmental Quality Information System (EQuIS)

Table 22. Intensive watershed monitoring biological monitoring stations in the Rainy River-Rainy Lake Watershed

WID	Biological Station ID	Waterbody Name	Biological Station Location
09030003-635	17RN001	Rat Root River	Upstream of Hwy 53, 1.5 mi. NW of Ericsburg
09030003-634	17RN003	Rat Root River	End of FR 174 (Old Hwy 217), 4.5 mi. W of Ray
09030003-634	17RN004	Rat Root River	Upstream of FR 161, 3.5 mi. S of Ray
09030003-633	17RN006	Rat Root River, East Branch	Upstream of CSAH 3, 2 mi. N of Ray
09030003-632	17RN007	Rat Root River, East Branch	Upstream of unnamed FR, 4.5 mi. NW of Arbutus

Lake Monitoring

Lakes most heavily used for recreation (all those greater than 500 acres and at least 25% of lakes 100 to 499 acres) are monitored for water chemistry to determine if recreational uses, such as swimming and wading, are being supported and where applicable, where fish community health can be determined. Lakes are prioritized by size, accessibility (i.e., can the public access the lakes), and presence of recreational use. In the RRRLW there are 12 lakes that meet these criteria with the most prominent being Rainy, Shoepack, Locator, and Peary Lake. Eleven of these lakes are within VNP, are difficult to access, and did not have enough water quality data to fully assess support of aquatic recreation use. However, these lakes are well protected from degradation due to the remote, forested nature of the surrounding landscape, and VNP clarity datasets indicate good recreational water quality. These lakes are monitored regularly by VNP. Although some VNP monitoring results were included in 2019 assessments, several years of monitoring data, particularly from small lakes, were not included. Therefore, they were not assessed. Incorporating this data and future monitoring results into the MPCA water quality database would better support future assessments. MPCA and VNP are partnering to incorporate VNP water quality data into the MPCA's water quality database.

Rainy Lake is monitored by numerous organizations including the USGS, VNP, MPCA, Koochiching SWCD, and others. Details about the MPCA IWM strategy for lakes 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). Lake monitoring in the RRRLW will continue in the future.

With the recent identification of zebra mussel larvae in Rainy Lake, additional monitoring is now underway to advance AIS prevention efforts in partnerships across federal, state, and county agencies. This includes county inspection and decontamination efforts to prevent or slow the spread of invasive species in Minnesota waters. Monitoring and delaying the advance of AIS will provide the opportunity for improved control and prevention technologies and strategies.

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 the 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 and can be applied to similar practices under similar criteria and scenarios. Effectiveness of other BMPs can be extrapolated based on monitoring results.

Local and Citizen Monitoring

Local and citizen monitoring is an important component of the watershed approach. The MPCA and its local partners jointly select the stream sites and lakes to be included in the IWM process. Funding passes from MPCA through Surface Water Assessment Grants (SWAGs) to local groups such as counties, 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. Volunteers to the Citizen Lake Monitoring Program are collecting water quality data on Rainy Lake. There are two high priority stream sites in the watershed in need of volunteer monitoring, one on the Rat Root River at the County Road 97 crossing, and the other on the Rat Root River, East Branch at the County State Aid Highway 3 crossing near the community of Ray. For more information or to volunteer to monitor a water in the Rainy – River Rainy Lake watershed, visit the MPCA's Volunteer Water Monitoring webpage.

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6. Appendix

Appendix A. Geospatial Prioritization Methodology

A small working group of local resource professionals and the MPCA staff reviewed 56 data sets drawn from various watershed management tools and systems available for WRAPS projects in Minnesota, and rated their usefulness in prioritizing subwatersheds in the RRRLW (Figure 27). The evaluation was completed specific to the characteristics 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.

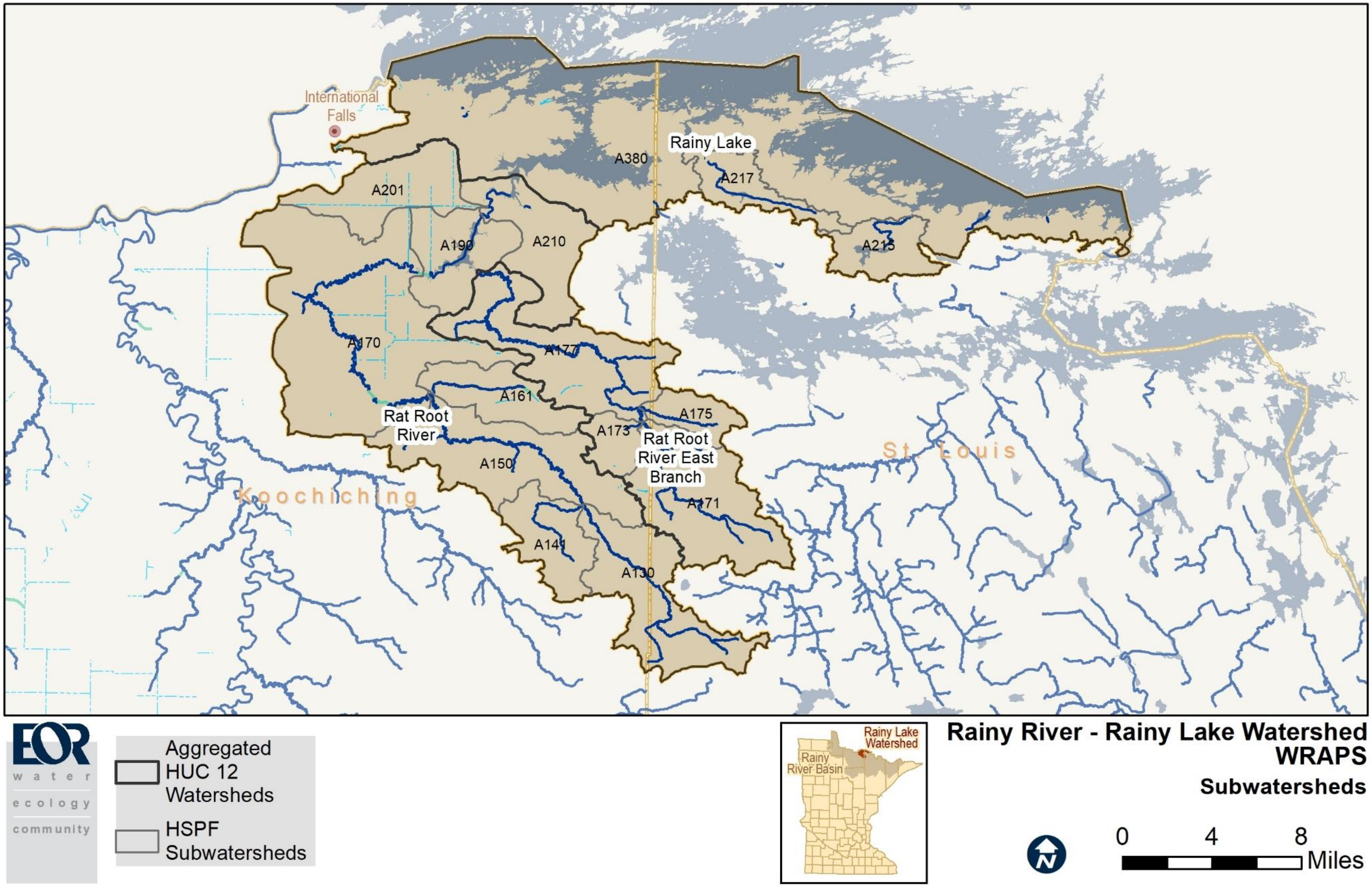

Figure 27. Rainy River – Rainy Lake Watershed priority ranking subwatersheds.

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 2020b).
- Connectivity Index - Riparian Connectivity: Connectivity component index based on the amount of development or cropland within riparian zones (DNR 2020b).
- Altered Watercourses: Based on altered watercourse data layer created by the MPCA and Minnesota Geospatial Commons, the quantity of altered watercourses from ditching and straightening estimated as a percentage of total watercourse length (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 (DNR 2020b).
- Sandy Verry Risk Model: Sandy Verry research compiled into a decision tree (Jeff Reinhart [DNR Forestry and MFRC], adapted by M. Brinks) - The model assesses stream stability at peak flows in relation to the amount of forest cover in the watershed (DNR 2020b).

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 99^{th}percentile (created as part of this study).
- SPI - The 99^{th} Percentile value used for the Rainy Lake Watershed differed from the value used for the Lower Rainy River and Rapid River because of a difference in landforms and surface geomorphology (created as part of this study).
- Geo Index - Soil Erosion Susceptibility: Based on the soil k-factor and 4 slope classes (providing scoring weights: 0% to 1% slope = 1x weight factor, 1% to 2% slope = 2x weight factor, 2% to 3% slope = 3x weight factor, >3% slope = 4x weight factor) (DNR 2020b).
- 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 2020b).

Water Quality

- Sediment Yield: The HSPF model predicted sediment yield in tons/ac/yr by subwatersheds from 1996 through 2014 (RESPEC 2016).
- Stream Bank Erosion: The HSPF model predicted sediment yield from bed and bank erosion in tons/ac/yr by subwatersheds from 1996 through 2014 (RESPEC 2016).
- Cropland Erosion: The HSPF model predicted sediment yield from high till cropland in tons/ac/yr by subwatersheds from 1996 through 2014 (RESPEC 2016).
- Phosphorus Yield: The HSPF model predicted TP yield in lbs/ac/yr by subwatersheds from 1996 through 2014 (RESPEC 2016).
- TP – Cropland: The HSPF model predicted TP yield from high till cropland in lbs/ac/yr by subwatersheds from 1996 through 2014 (RESPEC 2016).
- TP – Septics: The HSPF model predicted TP yield from septic systems in lbs/ac/yr by subwatersheds from 1996 through 2014 (RESPEC 2016).
- TN: The HSPF model predicted TN yields in lbs/ac/yr by subwatersheds from 1996 through 2014 (RESPEC 2016).
- Flow Yield: The HSPF model predicted flow yield in ft/yr by subwatersheds from 1996 through 2014 (RESPEC 2016).
- *E. coli* Concentration: Estimate of the monthly geometric mean *E. coli* concentrations available in the MPCA EDA Surface water Database (created as part of this study).
- 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 (created as part of this study).
- DO: Estimate of the relative percentage of DO measurements in the MPCA EDA Surface water Database below 5 mg/L in the streams (created as part of this study).
- TSS: Estimate of the 90^{th} 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 (created as part of this study).

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 (Brinks 2019).
- Potential Protection: 20+ acre, private parcels that intersect a forested tract of land > 20 acres minus National Wetland Inventory (NWI) wetlands (DNR 2019).
- SFIA: 20+ acre parcel enrolled in the SFIA program (Minnesota Department of Revenue 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 (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 (Gap Analysis Project) 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 number 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) (Brinks 2019).

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, F-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 2020b).

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 2020b).
- 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 - 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 (Brinks 2019).

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 RRRLW.

- 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
    - SPI
    - Geo Index - Soil Erosion Susceptibility
- Water Quality
    - Sediment Yield
    - Phosphorus Yield
- Wetlands

- Habitat Stress
- Phosphorus Stress
- Nitrogen Stress
- Restorable Wetland Inventory & 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 RRRLW. 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 23.

Table 23. 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
Rat Root River	Headwaters Rat Root River	A130	0	0.0	56.5	71.8	3.0	7.2	6.1	17.4	4.9	26.9	19.4	High
	Town of Ray-Rat Root River	A141	0	0.0	13.1	38.5	6.6	9.9	9.7	15.1	5.3	24.3	12.2	Low
	Town of Ray-Rat Root River	A150	40	1.8	26.2	66.7	26.8	37.1	36.4	18.7	6.5	38.9	29.9	High
	Town of Ray-Rat Root River	A161	13	15.7	3.4	79.5	100.0	100.0	100.0	24.7	9.1	53.9	50.0	High
	Town of Ericsburg-Rat Root River	A170	100	30.0	7.7	25.6	39.6	39.1	40.1	1.4	1.5	87.2	37.2	High
	Rat Root Lake	A190	0	15.9	0.0	5.1	27.8	21.9	27.3	0.0	0.5	100.0	19.9	High
	Rat Root Lake	A201	0	96.8	0.5	7.7	53.4	40.4	43.1	1.7	1.8	55.9	30.1	High
	Rat Root Lake	A210	0	1.2	3.2	0.0	0.8	1.2	1.8	9.1	4.5	26.9	4.9	Low
Rat Root River, East Branch	Upper East Branch Rat Root River	A171	13	5.8	54.7	100.0	6.2	5.4	6.2	11.2	4.4	25.2	23.2	High
	Lower East Branch Rat Root River	A173	0	2.9	3.2	76.9	5.9	10.7	13.6	15.1	5.4	14.9	14.9	High
	Lower East Branch Rat Root River	A175	0	20.5	4.4	33.3	66.1	31.6	40.6	13.9	5.1	40.4	25.6	High
	Lower East Branch Rat Root River	A177	100	4.0	17.1	89.7	55.5	48.0	54.0	20.0	7.1	72.8	46.8	High
Rainy Lake	Rainy Lake	A215	0	0.0	19.5	53.8	1.1	1.9	2.4	1.9	0.3	0.0	8.1	Low
	Rainy Lake	A217	0	0.0	24.4	56.4	0.0	0.0	0.0	1.8	0.0	0.0	8.3	Low
	Rainy Lake	A380	0	2.3	100.0	48.7	35.4	23.0	24.0	100.0	100.0	9.0	44.2	High