Watershed

May 2022

Final Wild Rice River Watershed Total Maximum Daily Load Report

A watershed-wide compilation of TMDL studies for the Minnesota Pollution Control Agency.

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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Abbreviations

1W1P	One Watershed, One Plan
AQC	aquatic consumption
AU	animal unit
AUID	assessment unit identifier
BMP	best management practice
BWSR	Board of Water and Soil Resources
CAFO(s)	concentrated animal feeding operation(s)
cfs	cubic feet per second
Chl-*a*	chlorophyll-*a*
CREP	Conservation Reserve Enhancement Program
CRP	Conservation Reserve Program
CRNR	Central River Nutrient Region
CWA	Clean Water Act
CWLA	Clean Water Legacy Act
DO	dissolved oxygen
DNR	Minnesota Department of Natural Resources
E. coli	*Escherichia coli*
EDA	Environmental Data Access
EPA	U.S. Environmental Protection Agency
EQuIS	Environmental Quality Information System
HSPF	Hydrological Simulation Program-Fortran
HUC	hydrologic unit code
IBI	indices of biotic integrity
ITPHS	imminent threat to public health and safety
IWM	intensive watershed monitoring
kg	kilogram
km^2	square kilometer
LA	load allocation
lbs	pounds
lbs/day	pounds per day

LAP	Lake Agassiz Plain
LC	loading capacity
LDC	load duration curve
LGU	local government unit
MAWQCP	Minnesota Agricultural Water Quality Certification Program
mgd	million gallons per day
mg/L	milligrams per liter
mL	milliliter
MOS	margin of safety
MPCA	Minnesota Pollution Control Agency
MS4	municipal separate storm sewer systems
NCHF	North Central Hardwood Forests
NLCD	National Land Cover Dataset
NLF	Northern Lakes and Forest
NPDES	National Pollutant Discharge Elimination System
NPS	nonpoint source
OLA	Open Lot Agreement
PWP	Permanent Wetland Preserve
RIM	Reinvest in Minnesota
SDS	state disposal system
SSM	single sample maximum
SSTS	subsurface sewage treatment system
SRNR	South River Nutrient Region
SWCD	soil and water conservation district
TALU	tiered aquatic life use
TMDL	total maximum daily load
TP	total phosphorus
TSS	total suspended solids
µg/L	micrograms per liter
WLA	wasteload allocation
WQBEL	water quality-based effluent limit

WRAPS	Watershed Restoration and Protection Strategy
WRP	Wetland Reserve Program
WRRW	Wild Rice River Watershed
WWTP	wastewater treatment plant

Executive summary

Section 303(d) of the Clean Water Act (CWA) provides authority for completing total maximum daily loads (TMDLs) to achieve state water quality standards and/or designated uses. A TMDL establishes the maximum amount of a pollutant a waterbody can receive on a daily basis and still meet water quality standards. The TMDL is divided into wasteload allocations (WLAs) for point or permitted sources, load allocations (LAs) for nonpoint sources (NPS) and natural background, plus a margin of safety (MOS).

The Wild Rice River Watershed (WRRW), which is identified by the 8-digit hydrologic unit code (HUC-8) 09020108, is located in northwestern Minnesota and covers an area of 1,636 square miles in portions of six Minnesota counties (listed in order of the percentage of watershed area)—Mahnomen (32%), Norman (28%), Becker (13%), Clay (13%), Clearwater (13%), and Polk (<1%). The Wild Rice River's flow direction is generally east to west, originating in the Northern Lakes and Forest (NLF) Ecoregion in the east. From there the Wild Rice River flows west through the North Central Hardwood Forests (NCHF) Ecoregion into the Lake Agassiz Plain (LAP) Ecoregion where the river enters the Red River of the North. Land use within the watershed is predominantly agricultural in the west, abruptly transitioning to lakes and forests in the east. The vast majority of the eastern half of the WRRW overlaps with the boundary of the White Earth Nation and off-reservation tribal trust land; 47.5% of the drainage area of the WRRW is tribal land.

This TMDL report addresses the following impairments in the WRRW:

- 10 aquatic recreation use impairments caused by high *Escherichia coli* (*E. coli*) concentrations in streams (**10 *E. coli* TMDLs**);
- 5 aquatic life use impairments caused by high turbidity or TSS concentrations in streams (**5 TSS TMDLs**); and
- 1 aquatic recreation use impairment caused by excessive nutrients in a lake (**1 total phosphorus [TP] TMDL**).

This report contains a total of 16 TMDLs to address 16 impairments in 13 stream reaches and 1 lake. Fifteen of these TMDLs address impairments that are listed on Minnesota's approved 2020 303(d) list (MPCA, 2021) of impaired waterbodies that require a TMDL. The remaining TMDL addresses an impairment that is no longer on the 303(d) list, as it is a replacement for the *Lower Wild Rice River Turbidity Final Total Maximum Daily Load Report*, which was approved by the U. S. Environmental Protection Agency (EPA) in 2009 (MPCA, 2009). Turbidity standards have changed to TSS standards since the TMDL was approved in 2009, which necessitates the replacement.

Addressing multiple impairments in one TMDL report is consistent with Minnesota's Water Quality Framework, which seeks to develop watershed-wide protection and restoration strategies rather than focus on individual reach impairments. However, not all impairments on the 303(d) list are being addressed with TMDLs in this report. There are eight aquatic life use impairments on six stream reaches identified by poor biological communities that are not addressed in this report due to the stressors being nonpollutants, not having enough data to develop TMDLs, or pollutant stressors meeting standards. Two aquatic consumption (AQC) use impairments on one stream reach caused by high mercury levels are not addressed in this report and are part of Minnesota's *Statewide mercury TMDL* approach, which can be found on Minnesota Pollution Control Agency's (MPCA) website (MPCA, 2022).

This TMDL report uses a variety of methods to evaluate current loading contributions by the various pollutant sources as well as the allowable pollutant loading capacity (LC) of the impaired waterbodies. These methods include the Hydrological Simulation Program–Fortran (HSPF) model, the load duration curve (LDC) approach, and BATHTUB lake modeling. Estimated primary pollutant sources for: *E. coli* are crop runoff (46%), pastures (17%), wildlife (17%), environmental propagation (10%), feedlots (7%), and humans (3%); TSS are cropland (71%) and bed/bank (21%); and phosphorus are all NPS such as sediment-bound phosphorus from upland erosion, fertilizer and manure runoff from fields, subsurface sewage treatment systems (SSTSs), internal load, and atmospheric deposition. An overall estimated reduction was calculated for each *E*. *coli* TMDL ranging from 8% to 86% per TMDL and for each TSS TMDL ranging from 71% to 91% per TMDL. TP in Rockstad Lake needs to be reduced by 48% to meet standards.

Strategies and a general cost estimate for implementation to address the impairments are included in this report. NPS will be the focus of implementation efforts. NPS contributions are not regulated and will need to be addressed on a voluntary basis. More information on the implementation strategies can be found in the *Final Wild Rice River Watershed Restoration and Protection Strategy Report* (MPCA, 2022).

1. Project overview

1.1 Purpose

Section 303(d) of the federal CWA requires that TMDLs be developed for waters that do not support their designated uses. These waters are referred to as "impaired" and are included in Minnesota's list of impaired waterbodies. The term "TMDL" refers to the maximum amount of a given pollutant a waterbody can receive on a daily basis and still achieve water quality standards. A TMDL study determines what is needed to attain and maintain water quality standards in waters that are not currently meeting them. A TMDL study identifies pollutant sources and allocates pollutant loads among those sources. The total of all allocations, including WLAs for permitted sources, LAs for nonpermitted sources (including natural background), and the MOS, which is implicitly or explicitly defined, cannot exceed the maximum allowable pollutant load.

The passage of Minnesota's Clean Water Legacy Act (CWLA) in 2006 provided a policy framework and resources to state and local governments to accelerate efforts to monitor, assess, and restore impaired waters and to protect unimpaired waters. The result has been a comprehensive "watershed approach" that integrates water resource management efforts, local governments, and stakeholders to develop watershed-scale TMDL reports, restoration and protection strategies, and plans for each of Minnesota's 80 major watersheds. The information gained and strategies developed in the watershed approach are presented in major watershed-scale WRAPS reports, which guide restoration and protection of streams, lakes, and wetlands across the watershed, including those for which TMDL calculations are not made.

The WRRW, which is identified by the 8-digit HUC-8 09020108, is located in northwestern Minnesota (**Figure 1**), and covers an area of 1,636 square miles in portions of six Minnesota counties, listed in order of the percentage of watershed area—Mahnomen (32%), Norman (28%), Becker (13%), Clay (13%), Clearwater (13%), and Polk (<1%). The Wild Rice River's flow direction is generally east to west, originating in the NLF Ecoregion in the east, flowing west through the NCHF Ecoregion into the LAP Ecoregion where the river enters the Red River of the North. Land use within the watershed is predominantly agricultural in the west, abruptly transitioning to lakes and forests in the east. The majority of the eastern half of the watershed overlaps with the boundary of White Earth Nation (a reservation containing tribal land).

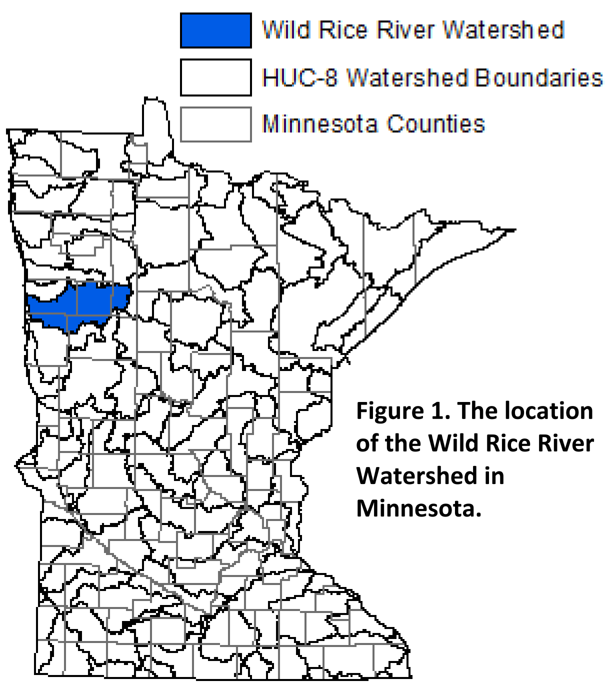


Figure 1. The location of the Wild Rice River Watershed in Minnesota.

This TMDL report presents 16 TMDLs (10 *E. coli*, 5 TSS, and 1 TP) to address 16 impairments in 13 stream reaches and 1 lake in the WRRW (none of these waterbodies are located wholly within tribal lands, but three stream reaches are partially located in White Earth Nation). Fifteen of the TMDLs address impairments that are listed on Minnesota's approved 2020 303(d) list (MPCA, 2021) of waterbodies that are impaired and require TMDLs. The remaining TMDL addresses an aquatic life use impairment caused by high turbidity in assessment unit identifier (AUID) 09020108-501 (hereafter each AUID will be referred to by its unique 3-digit number such as -501) that is no longer on the 303(d) list as the *Lower Wild Rice River Turbidity Final Total Maximum Daily Load Report* was approved for the AUID by the EPA in 2009 (MPCA, 2009). The approved TMDL is being replaced with a new TMDL in this report, because turbidity standards have changed to TSS standards since the TMDL was approved in 2009.

The goal of this TMDL report is to quantify the pollutant reductions needed to meet state water quality standards for *E. coli*, TSS, and TP for the impairments in **Table 1** and **Table 2**. This TMDL report is developed and established in accordance with Section 303(d) of the CWA and provides WLAs and LAs for the watershed as appropriate.

Addressing multiple impairments in one TMDL report is consistent with Minnesota's Water Quality Framework, which seeks to develop watershed-wide protection and restoration strategies rather than focus on individual reach impairments.

Not all impairments in the WRRW on the 303(d) list are being addressed with TMDLs in this report. There are eight aquatic life use impairments on six stream reaches caused by poor biological communities that are not addressed in this report due to the stressors being nonpollutants, not having enough data to develop TMDLs, or pollutant stressors meeting standards. Two AQC use impairments on one stream reach (-501) caused by high mercury levels are not addressed in this report and will be part of Minnesota's *Statewide mercury TMDL,* which can be found on MPCA's website (MPCA, 2022). Other than the previously mentioned impairment that has a replacement TMDL in this report, only one other impairment has been addressed previously. An AQC use impairment caused by elevated mercury in the water column in Minerva Lake (Lake ID # 15-0079-00) was approved as part of Minnesota's *Statewide mercury TMDL* in 2008, information about which can be found on MPCA's website (MPCA, 2022).

1.2 Identification of waterbodies

There are currently 25 aquatic life use, aquatic recreation use, and AQC use impairments in 17 stream reaches and 1 lake in the WRRW listed on Minnesota's approved 2020 303(d) list (MPCA, 2021) of waterbodies that need TMDLs developed to address impairments (**Table 1**, **Table 2**, and **Figure 2**).

This TMDL report presents 16 TMDLs to address 16 impairments in 13 stream reaches (some reaches have multiple impairments) and 1 lake in the WRRW:

- 10 aquatic recreation use impairments caused by high *E. coli* concentrations in streams (**10 *E. coli* TMDLs**);
- 5 aquatic life use impairments caused by high turbidity or TSS concentrations in streams (**5 TSS TMDLs**); and
- 1 aquatic recreation use impairment caused by excessive nutrients in a lake (**1 TP TMDL**).

Of the 16 addressed impairments, 15 of them are listed on Minnesota's approved 2020 303(d) list (MPCA, 2021) of waterbodies that are impaired and require TMDLs. The remaining impairment affects aquatic life use due to high turbidity in AUID -501 and is no longer on the 303(d) list as the *Lower Wild Rice River Turbidity Final Total Maximum Daily Load Report* was approved for the AUID by EPA in 2009

(MPCA, 2009). The approved TMDL is being replaced with a new TMDL in this report, because state standards have changed from turbidity to TSS.

There are eight aquatic life use and two AQC use impairments on Minnesota’s approved 2020 303(d) list (MPCA, 2021) that are not addressed with TMDLs in this report. All eight of the aquatic life use impairments were identified by poor biological communities (fish and macroinvertebrates), which were investigated in the *Wild Rice River Watershed Stressor Identification Report* (MPCA, 2018), a summary of which is shown in **Table 3**. Two unaddressed aquatic life use impairments (in -579 and -646) were found to be caused by nonpollutant stressors (MPCA, 2018), which are not subject to load quantification and therefore do not require TMDLs. However, while it is not the case for these impairments, in situations where a nonpollutant stressor is linked to a pollutant (e.g. habitat issues driven by TSS or low dissolved oxygen [DO] caused by excess TP), a TMDL is required. Three unaddressed aquatic life use impairments (in -654 and -661) did have high suspended sediment identified as a stressor to the biological communities, but TSS data were too limited to develop TMDLs, and were too limited to assess TSS against standards in 2016 (MPCA, 2017). Two additional unaddressed aquatic life use impairments (in -650) had high suspended sediment identified as a stressor, but TSS meets standards (MPCA, 2017). The two AQC use impairments are caused by excessive mercury in AUID -501 and are addressed as part of Minnesota’s *Statewide mercury TMDL* approach, which can be found on MPCA’s website (MPCA, 2022).

Table 1. WRRW stream impairments on Minnesota's approved 2020 303(d) list (MPCA, 2021) or with a replacement TMDL in this report. [a]

AUID (09020108 -###)	Waterbody name (description)	Designated use class [a]	Pollutant	Affected use [b]	Listing year	TMDL target completion year	Addressed in this TMDL report?
-501	Wild Rice River (S Br Wild Rice R to Red R)	2Bg	Turbidity	AQL	2006	NA, Category 4A [c]	Yes: Replacement of MPCA's 2009 TSS TMDL (PRJ07750-001)
			Mercury in fish tissue	AQC	2016	2029	No, to be addressed with the mercury TMDL (MPCA, 2022)
			Mercury in water column	AQC	2018	2031	No, to be addressed with the mercury TMDL (MPCA, 2022)
-504 [d]	Wild Rice River (White Earth R to Marsh Cr)	2Bg	TSS	AQL	2018	2028	Yes: TSS TMDL
-544	Coon Creek (Unnamed cr to Wild Rice R)	2Bg	*E. coli*	AQR	2018	2028	Yes: *E. coli* TMDL
-546	Unnamed creek (Unnamed cr to Wild Rice R)	2Bg	*E. coli*	AQR	2018	2028	Yes: *E. coli* TMDL
-553	County Ditch 45 (Unnamed ditch to Unnamed ditch)	2Bg	*E. coli*	AQR	2018	2028	Yes: *E. coli* TMDL
-577	Coon Creek (Unnamed cr to Unnamed cr)	2Bg	*E. coli*	AQR	2018	2028	Yes: *E. coli* TMDL
-579	Garden Slough (Headwaters to Mashaug Cr)	2Bg	Fish bioassessments	AQL	2018	2028	No: Nonpollutant stressors
-643	Wild Rice River (Marsh Cr to Unnamed cr)	2Bg	Turbidity	AQL	2010	2028	Yes: TSS TMDL
			E. coli	AQR	2018	2028	Yes: *E. coli* TMDL
-644	Wild Rice River (Unnamed cr to S Br Wild Rice R)	2Bg	Turbidity	AQL	2010	2028	Yes: TSS TMDL
			E. coli	AQR	2018	2028	Yes: *E. coli* TMDL
-646 [d]	Wild Rice River (Unnamed cr to Lower Rice Lk)	2Bg	Fish bioassessments	AQL	2018	2028	No: Nonpollutant stressors
-648 [d]	Spring Creek (140th Ave to Wild Rice R)	2Bg	*E. coli*	AQR	2018	2028	Yes: *E. coli* TMDL
-650	Mashaug Creek (T-92 to Wild Rice R)	2Bg	Benthic macroinvertebrates bioassessments	AQL	2018	2028	No: Data "somewhat supports" TSS as a stressor (MPCA 2018), but TSS meets standards
			Fish bioassessments	AQL	2018	2028	
			E. coli	AQR	2018	2028	Yes: *E. coli* TMDL
-652 [d]	Marsh Creek (-95.9973 47.4054 to Wild Rice R)	2Bg	Turbidity	AQL	2008	2028	Yes: TSS TMDL

AUID (09020108 -###)	Waterbody name (description)	Designated use class [a]	Pollutant	Affected use [b]	Listing year	TMDL target completion year	Addressed in this TMDL report?
-654	Felton Creek/County Ditch 45 (200th St to T141 R46W S14, west line)	1B, 2Ag	Benthic macroinvertebrates bioassessments	AQL	2018	2028	No: Data “strongly supports” TSS as a stressor (MPCA 2018) but data are limited
			Fish bioassessments	AQL	2018	2028	No: Data “somewhat supports” TSS as a stressor (MPCA 2018) but data are limited
-659	South Branch Wild Rice River (T-246 to Wild Rice R)	2Bg	*E. coli*	AQR	2018	2028	Yes: *E. coli* TMDL
-661	South Branch Wild Rice River (-96.1406 47.0658 to Unnamed cr)	2Bg	Fish bioassessments	AQL	2018	2028	No: Data “somewhat supports” TSS as a stressor (MPCA 2018), but data are limited
-662	South Branch Wild Rice River (Unnamed cr to Unnamed cr)	2Bg	Benthic macroinvertebrates bioassessments	AQL	2018	2028	No: Data “somewhat supports” TSS as a stressor (MPCA 2018), but data are limited
			E. coli	AQR	2018	2028	Yes: *E. coli* TMDL

[a] g = general tiered aquatic life use (TALU) designation. The other possible TALU designations are m (modified) and e (exceptional).

[b] AQL = aquatic life, AQR = aquatic recreation, AQC -= aquatic consumption

[c] NA = not applicable, impairment is categorized as 4A. A TMDL study was approved for this impairment (MPCA, 2009), but a replacement TMDL study is provided in this report.

[d] AUID is located partially within White Earth Nation.

Table 2. WRRW lake impairments on Minnesota’s approved 2020 303(d) list (MPCA, 2021).

AUID/DNR Lake ID #	Waterbody name	Pollutant	Designated use class (ecoregion) [a]	Affected use [b]	Listing year	TMDL target completion year	Addressed in this report?
15-0075-00	Rockstad	Nutrients	2B (NLF)	AQR	2018	2028	Yes: TP TMDL

[a] NLF = Northern Lakes and Forests Ecoregion

[b] AQR = Aquatic Recreation

Figure 2. Waterbodies in the WRRW with aquatic life use and/or aquatic recreation use impairments on Minnesota's approved 2020 303(d) list (MPCA, 2021) and those addressed in this report.

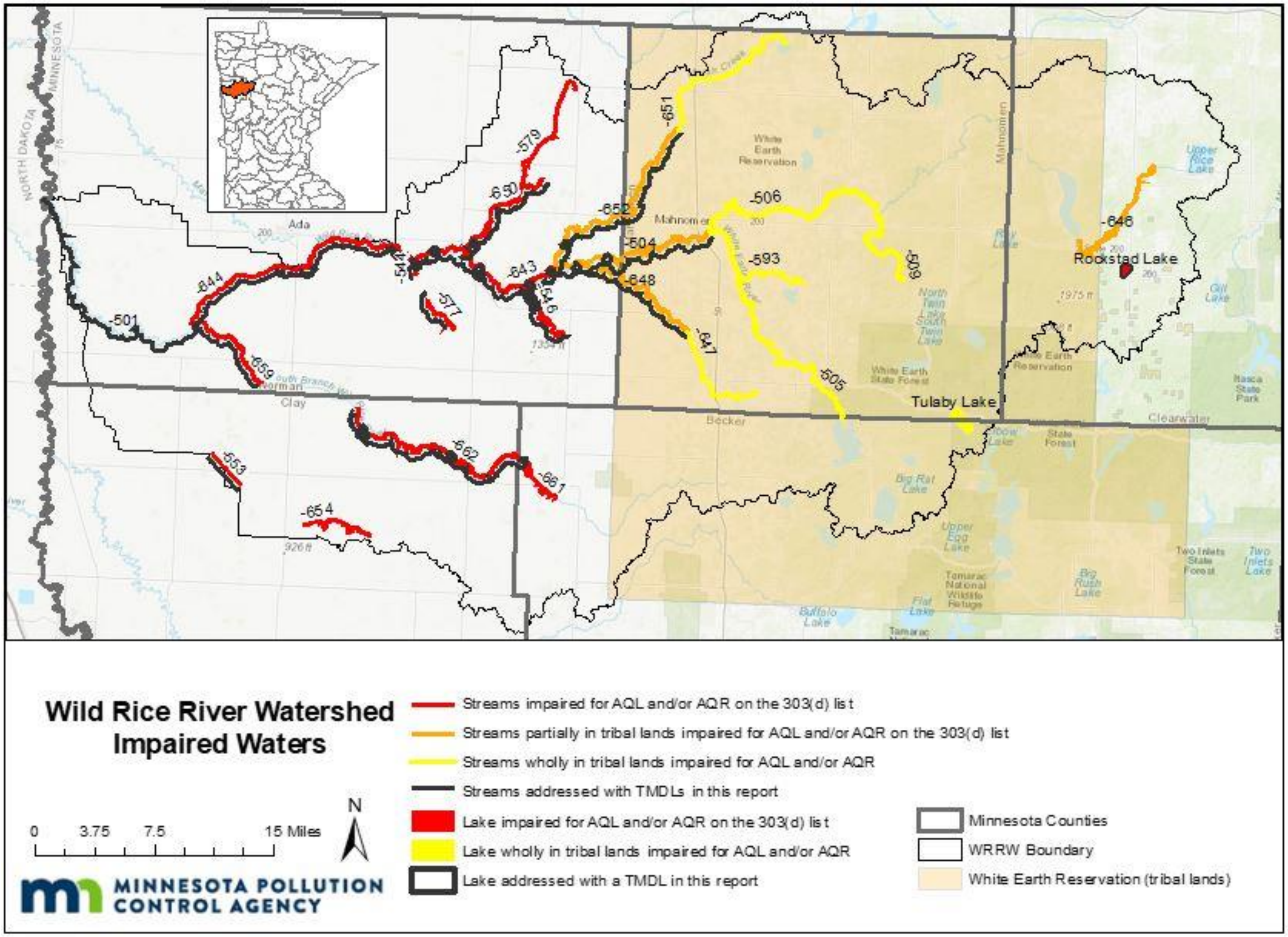


Table 3. Summary of candidate causes as stressors contributing to biological impairments in the WRRW (MPCA, 2018).

AUID (09020108-###) [b]	Waterbody name (description)	Biological impairment	Candidate causes [a]					
			Loss of longitudinal	Flow regime instability	Insufficient physical habitat	High suspended sediment	Low dissolved oxygen	High temperature
-579	Garden Slough (Headwaters to Mashaug Cr)	Fish bioassessments	+++	++	++	0	++ [c]	NA
-646	Wild Rice River (Unnamed cr to Lower Rice Lk)	Fish bioassessments	++	0	0	NE	+ [c]	NA
-650	Mashaug Creek (T-92 to Wild Rice R)	Fish bioassessments	0	++	+	+	+ [d]	NA
		Benthic macroinvertebrates bioassessments	NE	+	+	+	+ [d]	NA
-654	Felton Creek/County Ditch 45 (200th St to T141 R46W S14, west line)	Fish bioassessments	++	+	++	+	++ [c]	+++
		Benthic macroinvertebrates bioassessments	NE	+	++	++	+ [c]	++
-661	South Branch Wild Rice River (-96.1406 47.0658 to Unnamed cr)	Fish bioassessments	0	++	++	+	+ [c]	NA
-662	South Branch Wild Rice River (Unnamed cr to Unnamed cr)	Benthic macroinvertebrates bioassessments	NE	+	+	+	+ [c]	NA

[a] Key: **+++** the available evidence *convincingly supports* the case for the candidate cause as a stressor, **++** the available evidence *strongly supports* the case for the candidate cause as a stressor, **+** the available evidence *somewhat supports* the case for the candidate cause as a stressor, **0** *neither supports nor weakens* the case for the candidate cause as a stressor, **NE** *no evidence* is available to support the case for the candidate cause as a stressor, and **NA** *not applicable.*

[b] Biological impairments in streams that are located wholly within White Earth Nation are not listed in the table.

[c] Data on eutrophication (which includes TP [a pollutant for which a TMDL can be developed] and its response variables) was determined to be insufficient to determine if it is adversely affecting the DO regime.

[d] Data on eutrophication (which includes TP [a pollutant for which a TMDL can be developed] and its response variables) do not suggest that it is adversely affecting the DO regime.

1.3 Priority ranking

The MPCA's schedule for TMDL completions, as indicated on Minnesota's Section 303(d) impaired waters list, reflects Minnesota's priority ranking of TMDLs. The MPCA has aligned TMDL priorities with the watershed approach. The schedule for TMDL completion corresponds to the WRAPS report completion following the 2-year intensive watershed monitoring (IWM) cycle. The MPCA developed a state plan, *Minnesota's TMDL Priority Framework Report* (MPCA, 2022), to meet the needs of EPA's national measure (WQ-27) under *EPA's Long-Term Vision for Assessment, Restoration and Protection under the CWA Section 303(d) Program* (EPA, 2013). As part of these efforts, the MPCA identified water quality-impaired segments to be addressed by TMDLs through the watershed approach.

2. Applicable water quality standards and numeric water quality targets

The federal CWA requires states to designate beneficial uses for all waters and develop water quality standards to protect each use. Water quality standards consist of several parts:

- Beneficial uses—Identify how people, aquatic communities, and wildlife use our waters;
- Numeric criteria—Amounts of specific pollutants allowed in a body of water that still protect it for the beneficial uses;
- Narrative criteria—Statements of unacceptable conditions in and on the water; and
- Antidegradation protections—Extra protection for high-quality or unique waters and existing uses.

Together, the beneficial uses, numeric and narrative criteria, and antidegradation protections provide the framework for achieving CWA goals. Minnesota's water quality standards are in Minn. R. chs. 7050 and 7052.

2.1 Beneficial uses

The beneficial uses for waters in Minnesota are grouped into one or more classes as defined in Minn. R. 7050.0140. The classes and associated beneficial uses are:

- Class 1 – domestic consumption;
- Class 2 – aquatic life and recreation;
- Class 3 – industrial consumption;
- Class 4 – agriculture and wildlife;
- Class 5 – aesthetic enjoyment and navigation;
- Class 6 – other uses and protection of border waters; and
- Class 7 – limited resource value waters.

The Class 2 aquatic life beneficial use includes a tiered aquatic life use (TALU) framework for rivers and streams. The framework contains three tiers—exceptional, general, and modified uses.

All surface waters are protected for multiple beneficial uses, and numeric and narrative water quality criteria are adopted into rule to protect each beneficial use. TMDLs are developed to protect the most sensitive use of a waterbody.

2.2 Narrative and numeric criteria and state standards

Narrative and numeric water quality criteria for all uses are listed for four common categories of surface waters in Minn. R. 7050.0220. The four categories are:

- Protected for cold water aquatic life and their habitat, aquatic recreation, and drinking water: Classes 1B; 2A, 2Ae, or 2Ag; 3; 4A and 4B; and 5;
- Protected for cool and warm water aquatic life and their habitat, aquatic recreation, and drinking water: Classes 1B or 1C; 2Bd, 2Bde, 2Bdg, or 2Bdm; 3; 4A and 4B; and 5;
- Protected for cool and warm water aquatic life and their habitat, aquatic recreation, and wetlands: Classes 2B, 2Be, 2Bg, 2Bm, or 2D; 3; 4A and 4B; and 5; and
- Limited resource value waters: Classes 3; 4A and 4B; 5; and 7.

The narrative and numeric water quality criteria for the individual use classes are listed in Minn. R. 7050.0221 through 7050.0227. The procedures for evaluating the narrative criteria are presented in Minn. R. 7050.0150.

The MPCA assesses individual waterbodies for impairment for Class 2 uses— aquatic life and recreation. Class 2A waters are protected for the propagation and maintenance of a healthy community of cold water aquatic life and their habitats. Class 2B waters are protected for the propagation and maintenance of a healthy community of cool or warm water aquatic life and their habitats. Protection of aquatic life entails the maintenance of a healthy aquatic community as measured by fish and macroinvertebrate indices of biotic integrity (IBIs). Fish and invertebrate IBI scores are evaluated against criteria established for individual monitoring sites by waterbody type and use subclass (exceptional, general, and modified; identified as e, g, and m in the first three bullet points above).These three use subclasses are also known as TALU designations, and while they are used to determine biological (fish and macroinvertebrate) criteria, they are not used to determine criteria for other aquatic life use parameters (e.g., DO, TSS) or aquatic recreation use parameters.

Classes 2A, 2Bd, and 2B waters are also protected for aquatic recreation activities including bathing and swimming, and the consumption of fish and other aquatic organisms. In streams, aquatic recreation is assessed by measuring the concentration of *E. coli* in the water, which is used as an indicator species of potential waterborne pathogens. To determine if a lake supports aquatic recreation activities, its trophic status is evaluated using TP, Secchi depth, and chlorophyll-*a* (Chl-*a*) as indicators. The ecoregion standards for aquatic recreation protect lake users from nuisance algal bloom conditions fueled by elevated phosphorus concentrations that degrade recreational use potential.

All of the streams and the lake with at least one TMDL in this report are Class 2Bg and Class 2B, respectively. They are all protected for cool and warm water aquatic life and their habitat, aquatic recreation, and wetlands. The use subclass (i.e., TALU designation) for all of the streams is general, which, along with waterbody type, determines the criteria that are used to directly assess the health of the biological communities.

2.3 Antidegradation policies and procedures

The purpose of the antidegradation provisions in Minn. R. 7050.0250 through 7050.0335 is to achieve and maintain the highest possible quality in surface waters of the state. To accomplish this purpose:

- Existing uses and the level of water quality necessary to protect existing uses are maintained and protected;

- Degradation of high water quality is minimized and allowed only to the extent necessary to accommodate important economic or social development;
- Water quality necessary to preserve the exceptional characteristics of outstanding resource value waters is maintained and protected; and
- Proposed activities with the potential for water quality impairments associated with thermal discharges are consistent with section 316 of the CWA, United States Code, title 33, section 1326.

2.4 Wild Rice River Watershed water quality standards

The impaired waters with TMDLs in this report are classified as Class 2B. Relative to aquatic life and aquatic recreation, the designated beneficial uses for 2B waters are described in Minn. R. 7050.0222, subp. 4:

> **Class 2B waters** – *The quality of Class 2B surface waters shall be such as to permit the propagation and maintenance of a healthy community of cool or warm water aquatic biota, and their habitats... These waters shall be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable. This class of surface water is not protected as a source of drinking water.*

While Minn. R. 7050.0222 lists the narrative and numeric water quality standards, further criteria on how the standards were used to determine stream and lake impairments are outlined in *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment: 305(b) Report and 303(d) List* (MPCA, 2016). Details from aforementioned resources and others found on MPCA's TMDL policy and guidance webpage (MPCA, 2019) were used to develop **Sections 2.4.1** and **2.4.2**.

2.4.1 Streams

Applicable numeric water quality standards and criteria for impaired streams with TMDLs in this report are summarized in **Table 4** and described in further details in **Sections 2.4.1.1** and **2.4.1.2**.

Table 4. Surface water quality standards for stream reach impairments addressed in this TMDL report.

Pollutant	Water quality standard	Units	Criteria	Period of time standard applies	Applicable AUIDs addressed in this report
E. coli	Not to exceed 126	org/100 mL	Monthly geometric mean	April 1–October 31	-544, -546, -553, -577, -643, -644, -648, -650, -659, -662
	Not to exceed 1,260	org/100 mL	Upper 10th percentile		
Total suspended solids (TSS), Central River Nutrient Region	Not to exceed 30 (Class 2B)	mg/L	Upper 10th percentile	April 1–September 30	-504, -643, -644, -652
Total suspended solids (TSS), South River Nutrient Region	Not to exceed 65 (Class 2B)	mg/L	Upper 10th percentile	April 1–September 30	-501

2.4.1.1 *Escherichia coli*

Minnesota's water quality standard for *E. coli* has two parts, both of which must be met for a stream to be attaining the standard, but if one or both parts are not met, a stream does not attain standards and is impaired. According to Minn. R. 7050.0222 (2018), the water quality standard for *E. coli* states:

> Escherichia (E.) coli - *Not to exceed 126 organisms per 100 milliliters as a geometric mean of not less than five samples representative of conditions within any calendar month, nor shall more than ten percent of all samples taken during any calendar month individually exceed 1,260 organisms per 100 milliliters. The standard applies only between April 1 and October 31.*

The MPCA adopted the 126 org/100 mL part of the *E. coli* water quality standard based on EPA's recommendation (EPA, 1986). The geometric mean of water quality observations in a month (April through October) over the past 10 years is compared to this value and often best determines the long-term status of a waterbody. The geometric mean of *E. coli* data is used in place of arithmetic mean, because it better describes the central tendency of the data, normalizes data collected from different flow zones, as may occur during periods of low flow or high flow storm events, and allows a percentage change to be made equally to the geometric mean across watersheds. The geometric mean can be calculated using the following function:

$$\textbf{Geometric mean} = \sqrt[n]{\boldsymbol{x_1 * x_2 * \ldots x_n}}$$

Where $\boldsymbol{x_1, x_2, \ldots, x_n}$ are *E. coli* concentrations for each sample in a month.

The second part of the standard is no more than 10% of all samples collected from April through October over the past 10 years can exceed the single sample maximum (SSM) of 1,260 org/100 mL. This part of the standard was calculated based on EPA's recommended equation (EPA, 1986):

$$\textbf{\textit{E. coli} SSM = antilog}_{10}\ \textbf{[(log}_{10}\ \textbf{GM) + (CLF) x (log}_{10}\ \textbf{SD)}$$

Where **GM** is the geometric mean of 126, **CLF** is the confidence level factor of 1.25, which is the one-sided z-value determined by the area under the normal probability curve, and **SD** is the standard deviation of 0.8. The CLF and SD were both based on *E. coli* data collected in Minnesota. The result of the equation is actually 1,259 but was rounded to 1,260.

The MPCA's *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 305(b) Report and 303(d) List* (MPCA, 2016) provides more details regarding how waters are assessed for conformance to the *E. coli* standard.

2.4.1.2 Total Suspended Solids

In January of 2015, the EPA issued an approval of the adopted amendments to the state water quality standards, replacing the turbidity standard with TSS standards. In the WRRW, the aquatic life use impairments caused by high turbidity were listed in 2008 and will remain listed as turbidity. However, this TMDL report addresses the turbidity impairments with TSS TMDLs to be consistent with the current water quality standards.

TSS is a measurement of the weight of suspended mineral (e.g., soil particles) or organic (e.g., algae) sediment per volume of water. Minnesota's TSS standards are based on nutrient regions, which are loosely based on ecoregions. The WRRW is located within all three of the nutrient regions: south river in the western portion of the WRRW, central river in the middle of the WRRW, and north river in the eastern portion of the WRRW. Of the five stream reaches addressed with TSS TMDLs in this report, one (AUID -501) has South River Nutrient Region (SRNR) TSS standards and four (AUIDs -504, -643, -644, and -652) have Central River Nutrient Region (CRNR) TSS standards. The TSS standards for the SRNR and CRNR are 65 and 30 milligrams per liter (mg/L), respectively.

2.4.2 Lakes

Lake eutrophication standards protect lakes as a function of their designated beneficial use. In addition to meeting the TP part of the standard, the Chl-*a* and Secchi transparency parts of the standard must be met for a lake to be considered unimpaired for nutrients. In developing the lake eutrophication standards for Minnesota lakes (Minn. R. 7050.0222), the MPCA evaluated data from a large cross-section of lakes within each of the state's ecoregions (MPCA, 2005). Clear relationships were established between the causal factor, TP, and the response variables Chl-*a* and Secchi transparency. Based on these relationships it is expected that by meeting the phosphorus target in each lake, the Chl-*a* and Secchi parts of the standard will likewise be met.

The MPCA considers a lake impaired when TP and a least one of the response variables (Chl-*a* or Secchi depth) fail to demonstrate compliance with the standard (MPCA, 2016). The impaired lake addressed in this report, Rockstad Lake, is a shallow, Class 2B waterbody. Minnesota's lake water quality standards vary by ecoregion and depth classification in certain ecoregions. Rockstad Lake is in the NLF Ecoregion, which does not have separate standards depending on depth classification. **Table 5** displays the eutrophication standard for the NLF Ecoregion that applies to Rockstad Lake.

Table 5. Eutrophication standard for Rockstad Lake (15-0075-00) which is addressed in this TMDL report.

Ecoregion	Applicable waterbody types	Eutrophication/Nutrients standard			Criteria	Period of time standard applies
		Total Phosphorus (µg/L)	Chl-*a* (µg/L)	Secchi Disk Depth (m) [a]		
Northern Lakes and Forests	Lakes, shallow lakes, and reservoirs	Not to exceed 30	Not to exceed 9	Not below 2.0	Summer avg of all samples	June 1-Sept. 30

[a] The standard for Secchi disk depth is the minimum transparency value (i.e., values must be greater than the standard).

3. Watershed and waterbody characterization

The WRRW is located in the northwestern portion of Minnesota and consists of lakes, wetlands, and rich soils. The watershed has a total drainage of 1,636 square miles, spanning portions of six counties (listed in order of the percentage of watershed area): Mahnomen (32%), Norman (28%), Becker (13%), Clay (13%), Clearwater (13%), and Polk (<1%). The WRRW contains 882 miles of intermittent stream, 643 miles of intermittent drainage ditch, 477 miles of perennial stream and river, and 50 miles of perennial drainage ditch (DNR, 2020).

The Wild Rice River starts at Upper Rice Lake in the White Earth State Forest in Clearwater County, about 32 miles northeast of Mahnomen. It flows westward for 168 miles until it reaches its confluence with the Red River of the North, approximately three miles south of Halstad. Approximately 19 major tributaries flow into the Wild Rice River. Identified from upstream to downstream, some of the major tributaries to the Wild Rice River include the following: Mosquito Creek (5 miles W of Minerva), Twin Lake Creek (7 miles NW of Naytahwaush), White Earth River (1.5 miles E of Mahnomen), Spring Creek (6.9 miles ENE of Twin Valley), Marsh Creek (5 miles ENE of Twin Valley), Mashaug Creek (2.2 miles NW of Twin Valley), Coon Creek (4 miles WNW of Twin Valley), Unnamed Creek (Trib. to Coon Creek, 3 miles W of Twin Valley), South Branch Wild Rice River (8 miles NE of Perley), and Felton Creek (3.7 miles NE of Perley).

According to the *Statewide Altered Watercourse Project* (MPCA, 2013), 47% of the watercourses in the WRRW have been physically altered (i.e., channelized, ditched), 1% are impounded, 29% are natural, and 23% have no discernable channel. The headwaters of the Wild Rice River have not been historically channelized; however, as the river flows west and enters the LAP Ecoregion, approximately 17 stream miles of the mainstem near the outlet have been channelized to aid drainage. The tributaries follow the same pattern. In the headwaters, most of the tributaries are natural, but the central to western portions of the watershed have been channelized (**Figure 3**). Flood management is an issue that has impacted this region since European settlement, so the channelization was done to aid drainage and aid flood management practices. However, these alterations, coupled with historical changes in land cover (i.e., native vegetation to cropland), have altered the natural flow regime of many watercourses, causing them to be prone to high and quick peak flows, along with prolonged periods of low discharge (Van Offelen, Evarts, Johnson, Groshens, & Berg, 2002) (WRWD, 2003).

Figure 3. Results of the *Statewide Altered Watercourse Project* (MPCA, 2013) for the Wild Rice River Watershed.

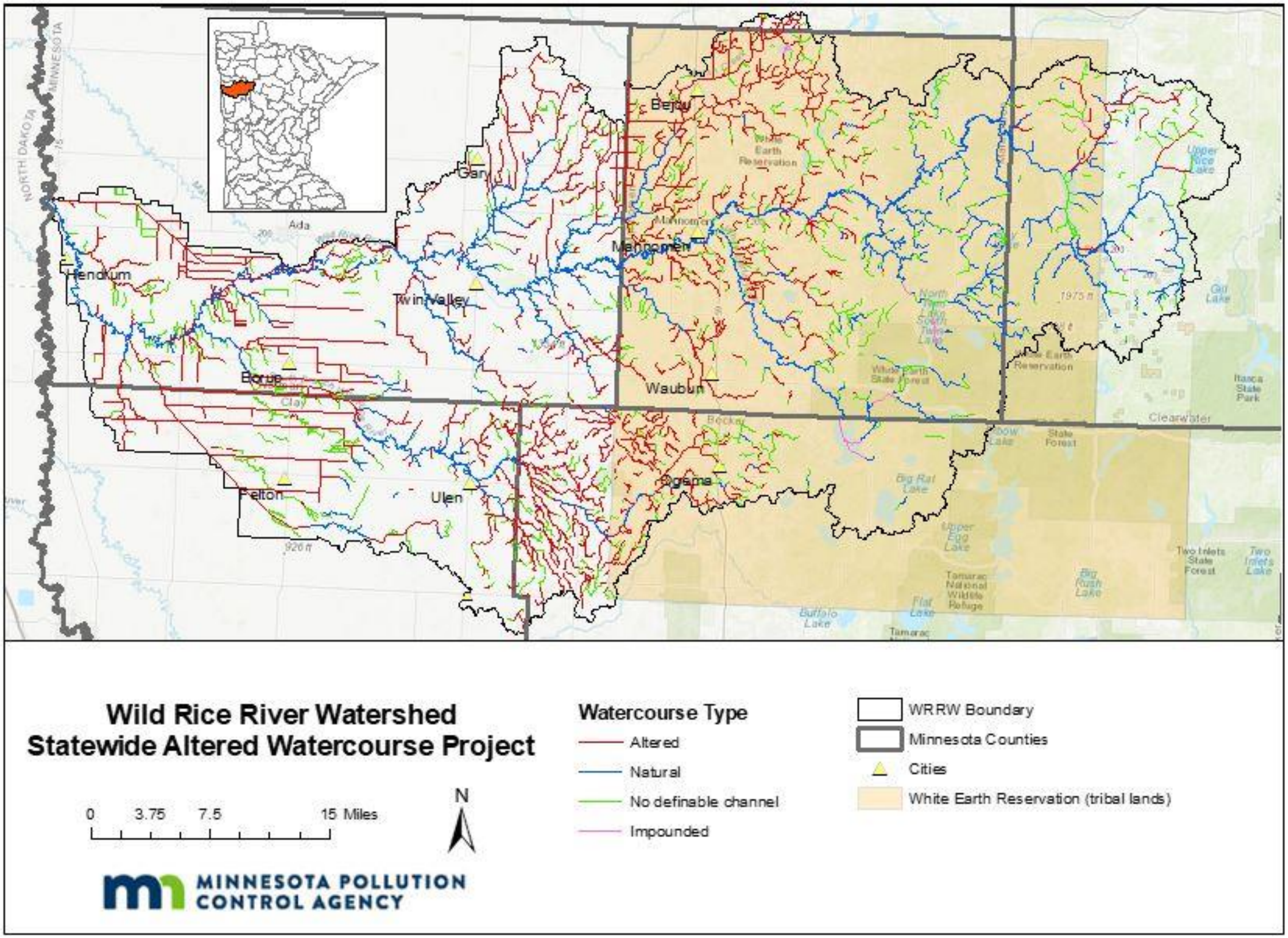
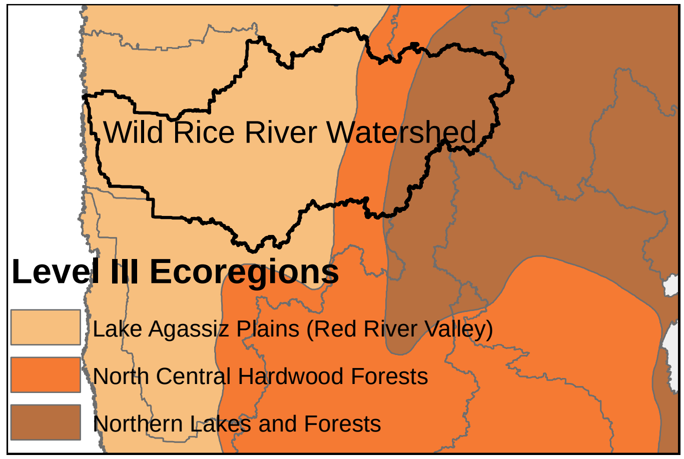


Figure 4. Level III ecoregions in the Wild Rice River Watershed.



The watershed lies within three EPA Level III ecoregions. The largest portion of the watershed lies within the LAP Ecoregion, covering most of the western half of the watershed. This area is largely used for agriculture, as it features rich soils that originated from historic, glacial Lake Agassiz. The next ecoregion, NCHF, in the central portion of the watershed, is dominated by hardwood and coniferous forests. The soils within this ecoregion have generally poor fertility compared to the LAP Ecoregion. The NLF Ecoregion is located in the eastern portion of the watershed. This ecoregion is heavily forested, with a variety of lakes and wetlands. Agricultural activities are slightly hindered within this ecoregion due to the nature of the hilly topography and the generally poor soils.

Historically, the downstream portion (western side) of the watershed was inundated by a portion of glacial Lake Agassiz, with smaller lakes and forests in the headwaters portion. Although 8,500 years have passed since Lake Agassiz receded, the effects of the massive lake are still evident today. The presence of the lake contributed to the formation of rich soils within the ancient lake bottom that have given rise to modern agricultural opportunities.

Most of the eastern portion of the watershed is located in White Earth Nation. The reservation boundary of White Earth Nation consists of all of Mahnomen County and parts of Becker and Clearwater Counties (**Figure 5**). Note that in the WRRW east of White Earth Nation, there are also parcels of off-reservation tribal trust lands in Clearwater County (the majority of these tribal lands are located south of Rockstad Lake as can be seen in **Figure 5**). Of the WRRW's total 1,636 square miles, 776.1 square miles are part of White Earth Nation and 1.8 square miles are tribal trust lands for a total of 777.9 square miles of tribal land (47.5% of the 1,636 square mile drainage area of the WRRW). Waterbodies that are designated as partially and wholly tribal are explained below:

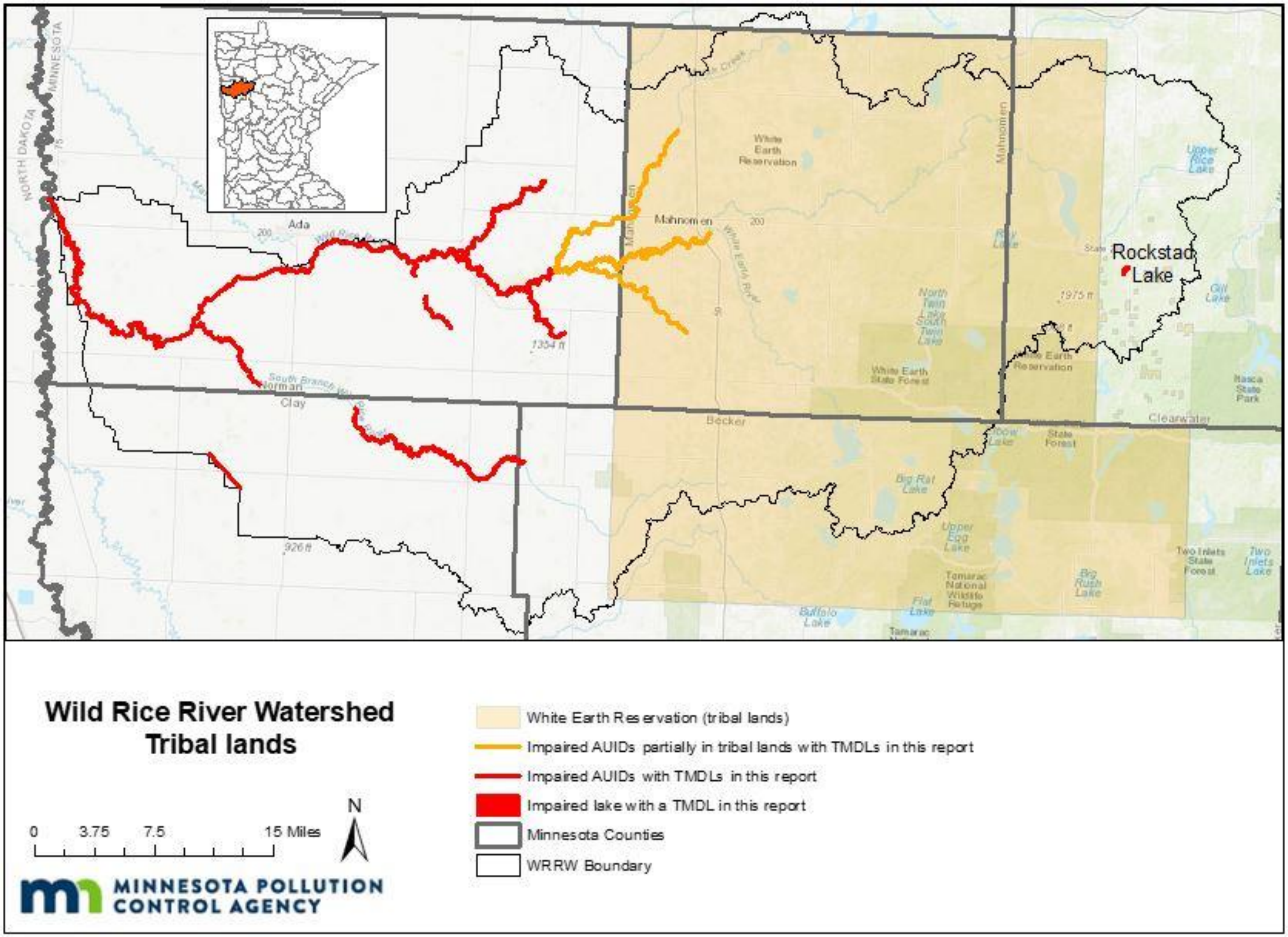
- Partial: A waterbody with a partial tribal designation is partially within a federally recognized Indian reservation and does not serve as a border between a federally recognized Indian reservation and Minnesota land. The state and tribe have worked cooperatively on this water quality assessment and agree that the water should be included on the state's impaired waters list. For the purposes of the 303(d) list, the impaired portion of the waterbody within the reservation is advisory to the EPA only, because the EPA has stated that it does not approve the state's impaired waters listings for waters within the boundaries of an Indian reservation. Note that the MPCA includes parcels held in trust (tribal trust lands) in the definition of Indian reservation.
- Wholly: A waterbody with a wholly tribal designation is completely within a federally recognized Indian reservation and are not on the 303(d) list. A separate list for these impaired waters was prepared under authority in state law. The list is located in the "Wholly Tribal Designation" tab of the impaired waters list (MPCA, 2021). This list of impairments is advisory to EPA only,

because these waterbodies are located wholly within a federally recognized Indian reservation, and EPA has stated that it does not approve the state's impaired waters listings for waters that are within the boundaries of an Indian reservation. Note that the MPCA includes parcels held in trust (tribal trust lands) in the definition of Indian reservation.

Four waterbodies (all of which are stream reaches) that are on Minnesota's approved 2020 303(d) list are partially located within White Earth Nation (see **Table 1**). Three of these 4 stream reaches each have a TMDL in this report, but each TMDL is only calculated for the portion of the stream reach and its drainage area that is not on tribal land.

There are 14 additional impaired waterbodies (6 stream reaches and 8 lakes) that are listed on the "Wholly Tribal Designation" tab of the approved 2020 impaired waters list as they are located wholly within White Earth Nation. Since the list of impaired waterbodies that are designated as wholly tribal is separate from the 303(d) list, it is only advisory to EPA. The EPA also does not approve TMDLs developed by the state for these waterbodies. Therefore, the 14 impaired waterbodies that are wholly tribal are not addressed in this TMDL report, nor are they listed in tables or figures.

Figure 5. Tribal lands in the WRRW.



3.1 Lakes

There is one impaired lake, Rockstad Lake, requiring a TMDL. Rockstad Lake is a shallow lake located in the NLF Ecoregion. Lake morphometry and watershed information for Rockstad Lake is presented in **Table 6**.

Table 6. Morphometry and watershed area of Rockstad Lake, which has a TP TMDL in this report.

HUC-10 subwatershed	Lake name	AUID/DNR Lake ID #	Surface area (acres)	Maximum depth (feet)	Watershed area, direct drainage (acres)	Watershed area, total drainage (acres)	Watershed area: Surface area ratio
Headwaters Wild Rice River (0902010801)	Rockstad	15-0075-00	136	15	3,214	3,214	23.6

3.2 Streams

Drainage areas and length for each impaired AUID with at least one TMDL in this report is presented in **Table 7**. The direct drainage area in the table is the area of land where runoff and tributaries flow directly into the AUID. Since upstream conditions can affect conditions downstream, the table also shows the entire drainage area of each AUID from both direct and upstream runoff (i.e., the subwatershed of each AUID). **Table 7** also shows how many square miles (and percentage) of an AUID's drainage area are tribal land.

Table 7. Approximate drainage areas of impaired stream reaches addressed in this TMDL report.

HUC-10 subwatershed name (number)	Waterbody name (description)	AUID (09020108-###)	Direct drainage area (sq mi)	Direct and upstream drainage area (sq mi) [a]	AUID length (miles)	Tribal lands in drainage area (sq mi [percent of entire drainage area]) [c]
Spring Creek (0902010805)	Spring Creek (140th Ave to Wild Rice R)	-648	68.9	68.9	11.72 [b]	67.4 (97.7%)
Middle Wild Rice River (0902010806)	Wild Rice River (White Earth R to Marsh Cr)	-504	38.8	676.6	27.17 [b]	560.4 (82.8%)
Marsh Creek (0902010807)	Marsh Creek (-95.9973 47.4054 to Wild Rice R)	-652	40.6	166.3	21.27 [b]	140.6 (84.5%)
Mashaug Creek (0902010808)	Mashaug Creek (T-92 to Wild Rice R)	-650	34.6	74.8	12.38	N/A
Lower Wild Rice River (0902010809)	Coon Creek (Unnamed cr to Wild Rice R)	-544	45.7	45.7	1.44	N/A
	Unnamed creek (Unnamed cr to Wild Rice R)	-546	60.6	60.6	7.4	29.0 (47.9%)
	Coon Creek (Unnamed cr to Unnamed cr)	-577	45.7	45.7	3.99	N/A
	Wild Rice River (Marsh Cr to Unnamed cr)	-643	35.2	1,084	28.2	730.0 (67.3%)
South Branch Wild Rice River (0902010810)	South Branch Wild Rice River (T-246 to Wild Rice R)	-659	8.9	258.2	8.27	47.8 (18.5%)
	South Branch Wild Rice River (Unnamed cr to Unnamed cr)	-662	23.0	192.5	23.79	47.8 (24.8%)

HUC-10 subwatershed name (number)	Waterbody name (description)	AUID (09020108-###)	Direct drainage area (sq mi)	Direct and upstream drainage area (sq mi) [a]	AUID length (miles)	Tribal lands in drainage area (sq mi [percent of entire drainage area]) [c]
Felton Creek (0902010811)	County Ditch 45 (Unnamed ditch to Unnamed ditch)	-553	4.9	57.7	2.85	N/A
Outlet Wild Rice River (0902010812)	Wild Rice River (Unnamed cr to S Br Wild Rice R)	-644	30.4	1,135	16.19	730.0 (64.3%)
	Wild Rice River (S Br Wild Rice R to Red R)	-501	38.7	1,636.0	30.53	777.9 (47.5%)

[a] Entire drainage area of each AUID.

[b] While these are the entire lengths of AUIDs -648, -504, and -652, 66% (7.75 miles), 61% (16.50 miles), and 46% (9.84 miles), respectively, are located within White Earth Nation and 34% (3.97 miles), 39% (10.67 miles), and 54% (11.43 miles), respectively, are the state portions.

[c] Tribal lands includes both White Earth Nation and off-reservation tribal trust lands.

The entire WRRW.

3.3 Subwatersheds

The WRRW is comprised of 12, 10-digit HUC subwatersheds, 9 of which have impaired reaches or lakes within them. Those include the Headwaters Wild Rice River (0902010801), Spring Creek (0902010805), Middle Wild Rice River (0902010806), Marsh Creek (0902010807), Mashaug Creek (0902010808), Lower Wild Rice River (0902010809), South Branch Wild Rice River (0902010810), Felton Creek (0902010811), and Outlet Wild Rice River (0902010812). The three remaining HUC-10s are located entirely in the White Earth Nation. **Figure 6** shows the HUC-10 subwatershed boundaries in the WRRW.

Another important subwatershed type is that of an AUID or lake. The maps in **Figure 7** through **Figure 19** show the drainage area (watershed) of each AUID with TMDLs in this report, the square miles of which were listed in **Table 7**. The map in **Figure 20** shows the drainage area (watershed) of Rockstad Lake, the acres of which was listed in **Table 6**. Also shown in each map are relevant water quality stations, flow stations (if applicable), and wastewater treatment plants (WWTPs) (if present).

Figure 6. 10-digit HUC subwatersheds in the WRRW.

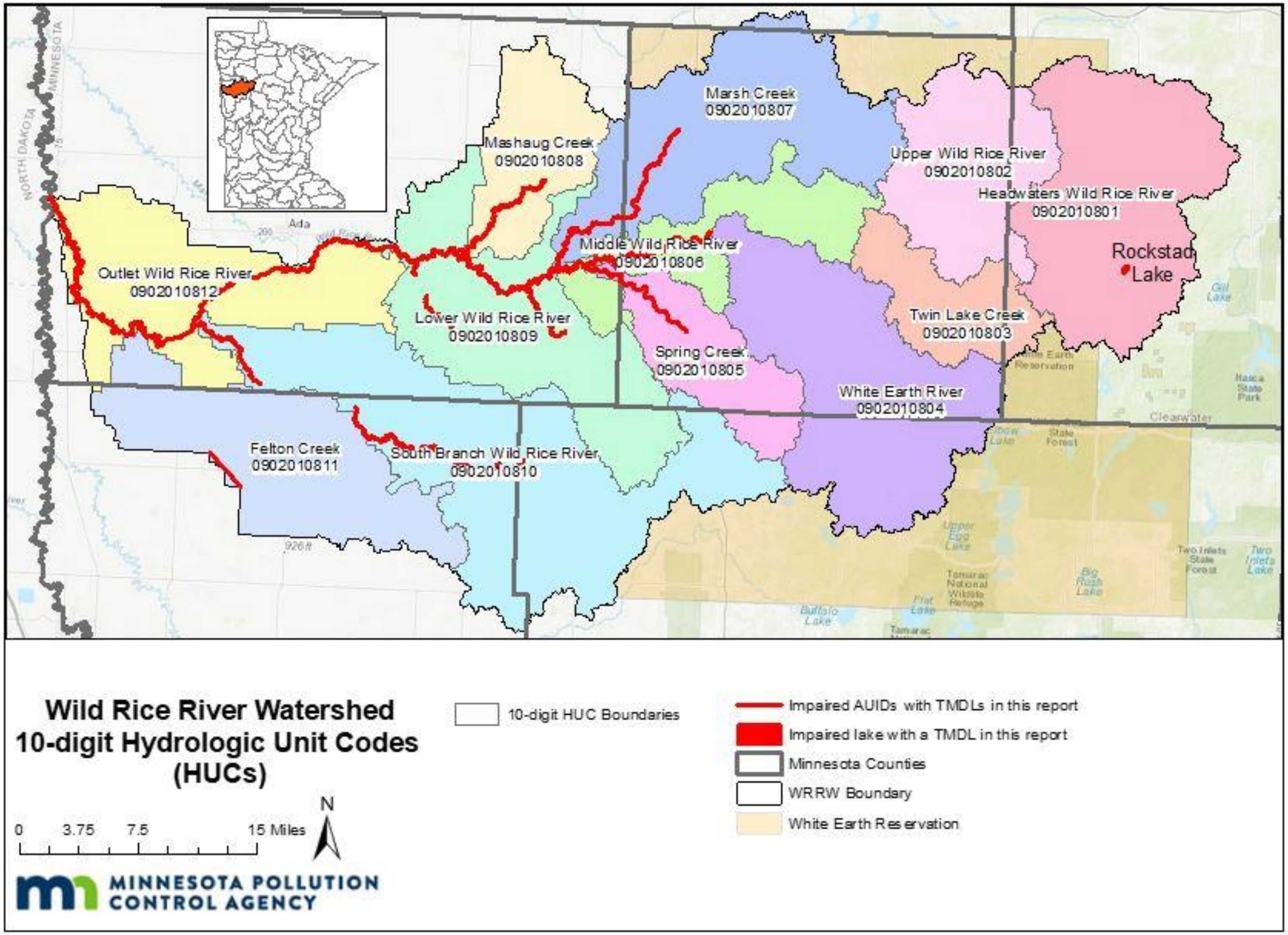


Figure 7. Drainage area (watershed) of the Wild Rice River (AUID -501).

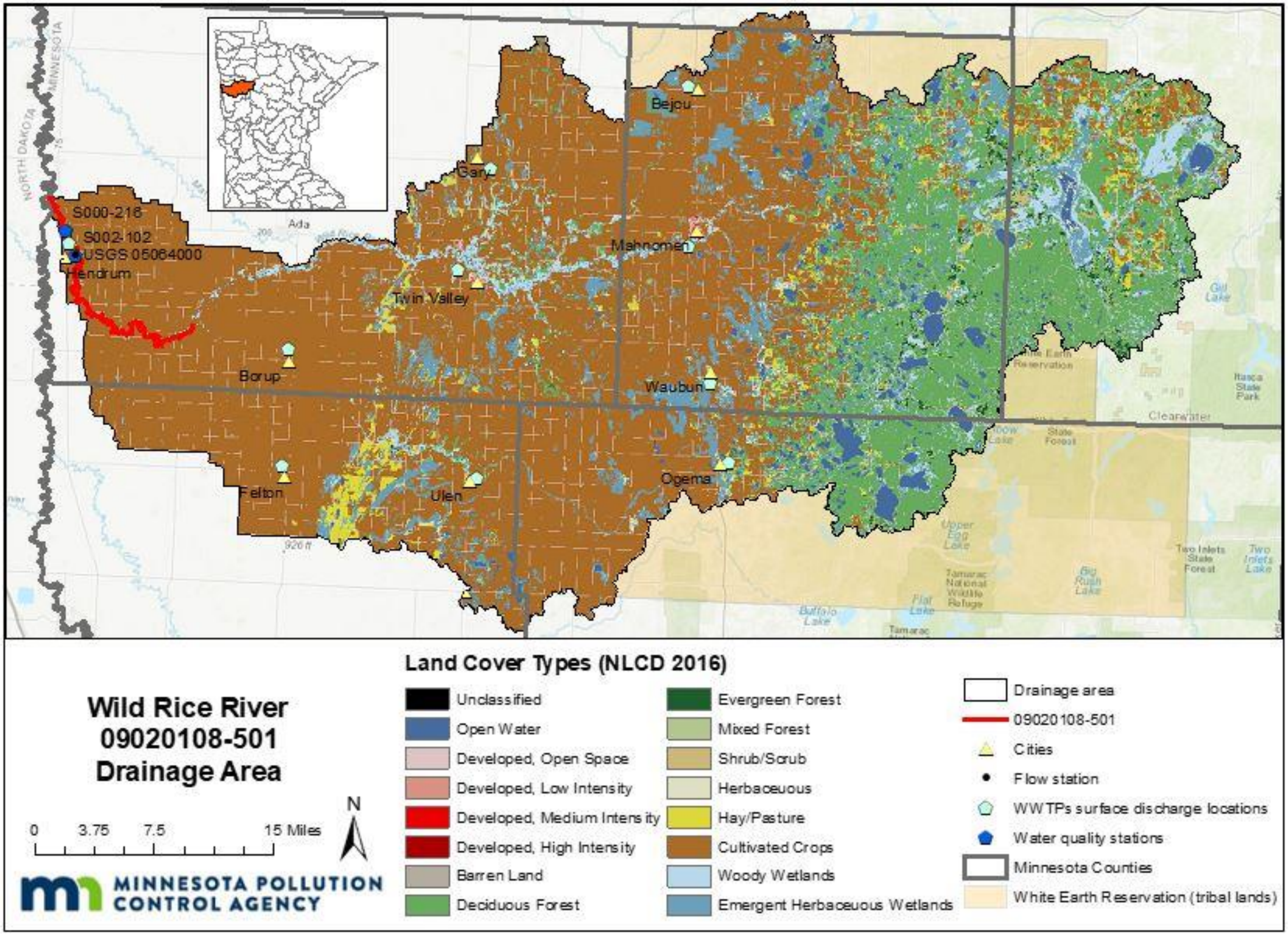


Figure 8. Drainage area (watershed) of the Wild Rice River (AUID -504).

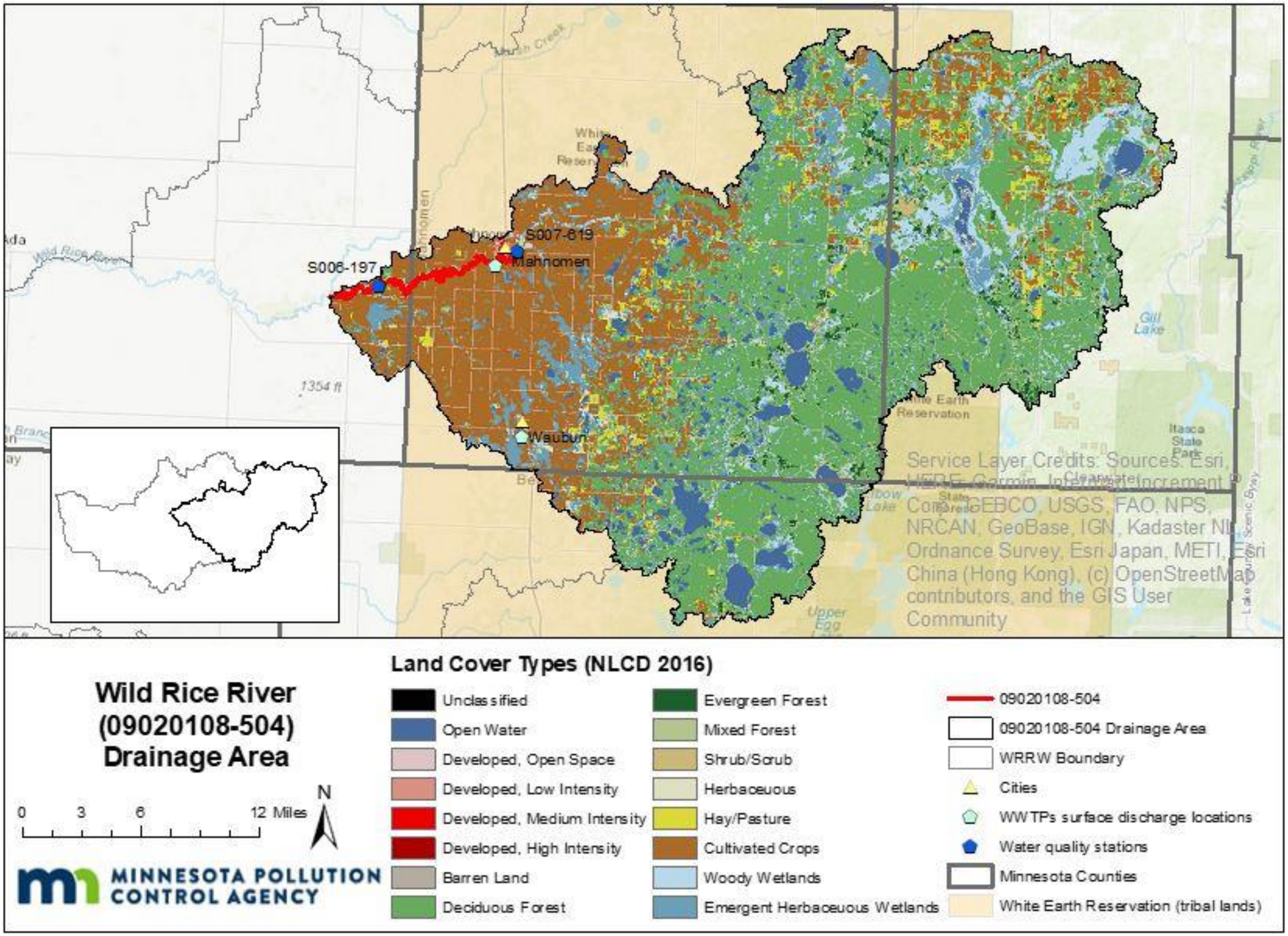


Figure 9. Drainage area (watershed) of Coon Creek (AUID -544).

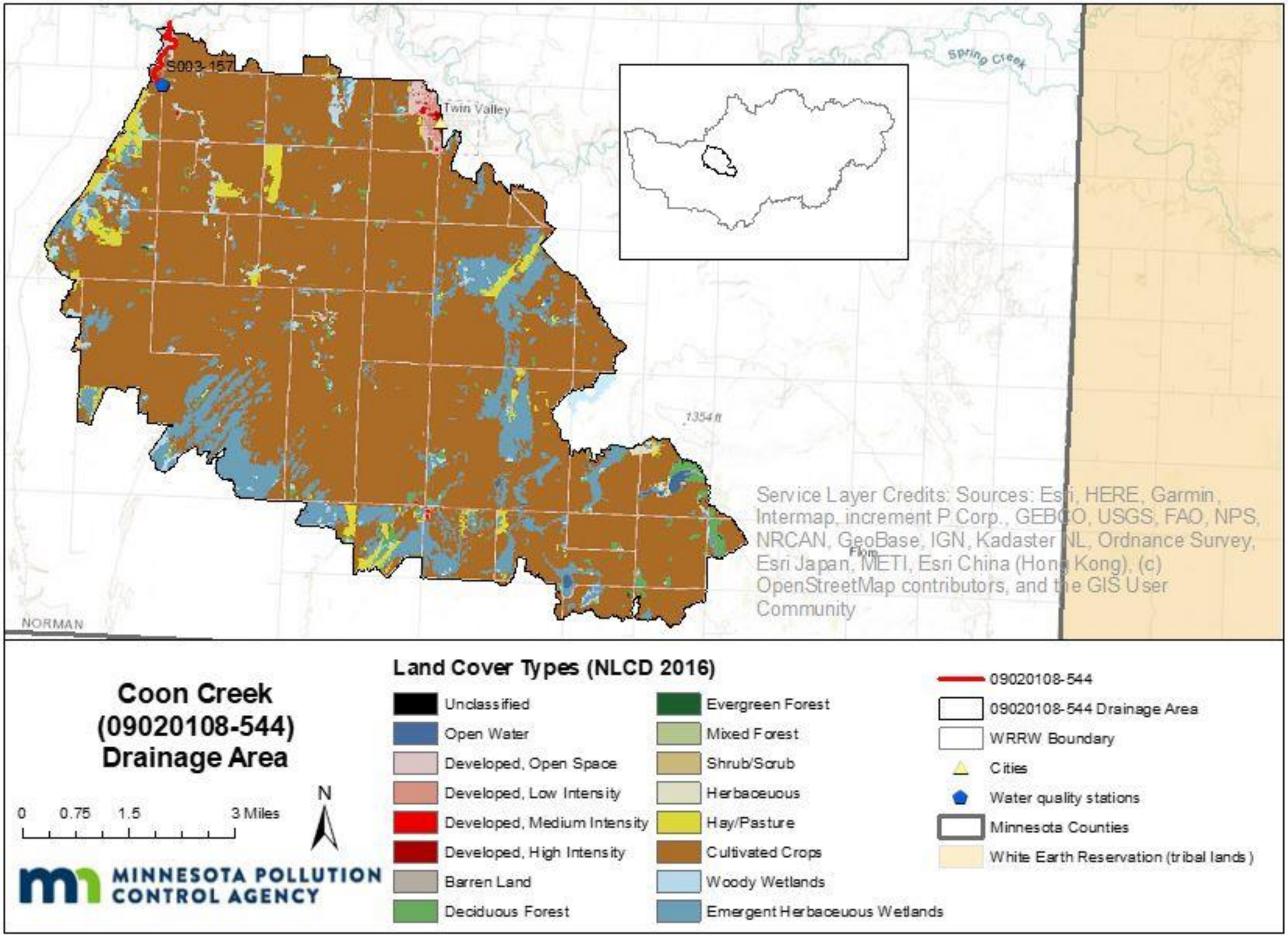


Figure 10. Drainage area (watershed) of an unnamed creek (AUID -546).

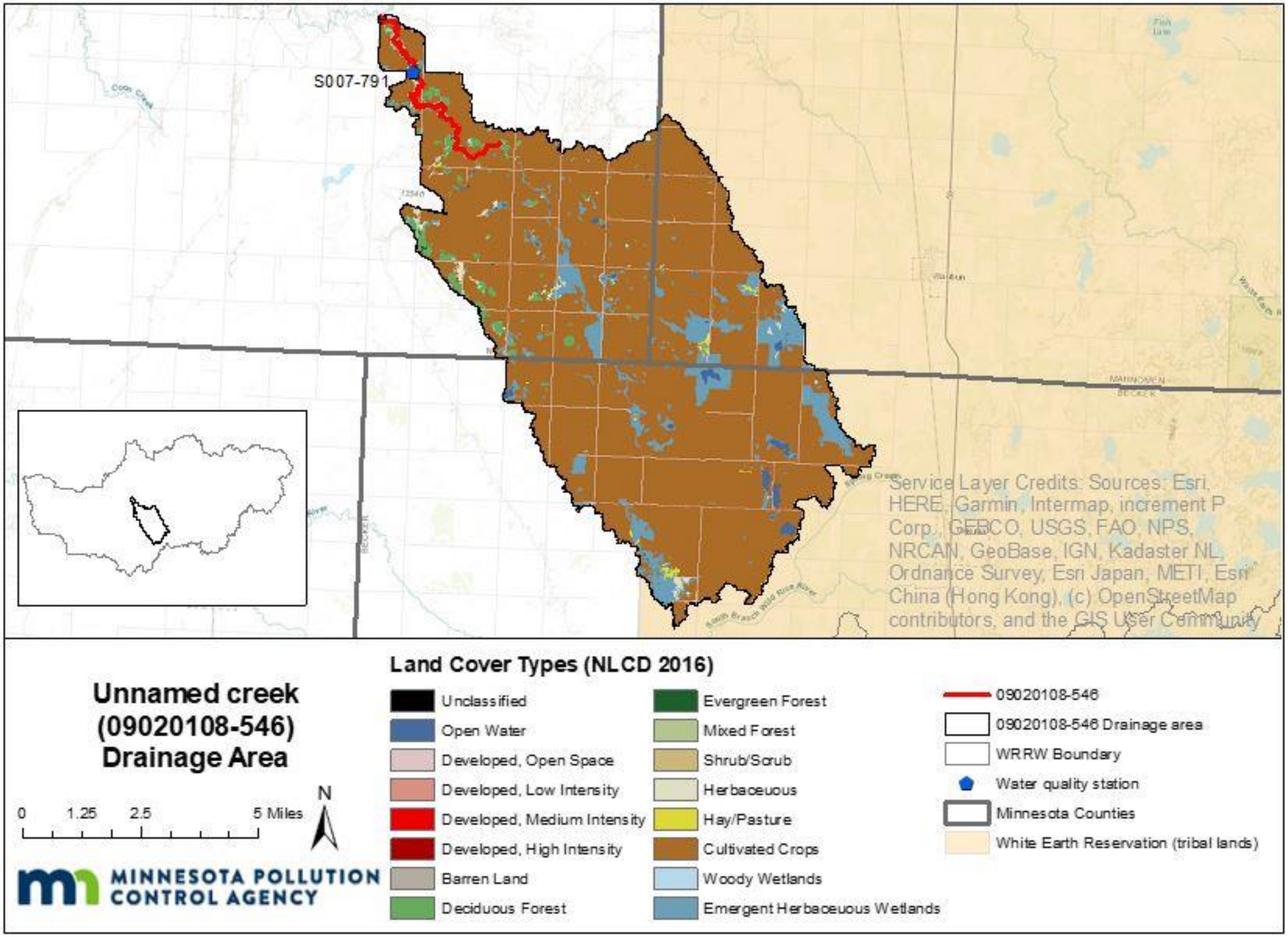


Figure 11. Drainage area (watershed) of County Ditch 45 (AUID -553).

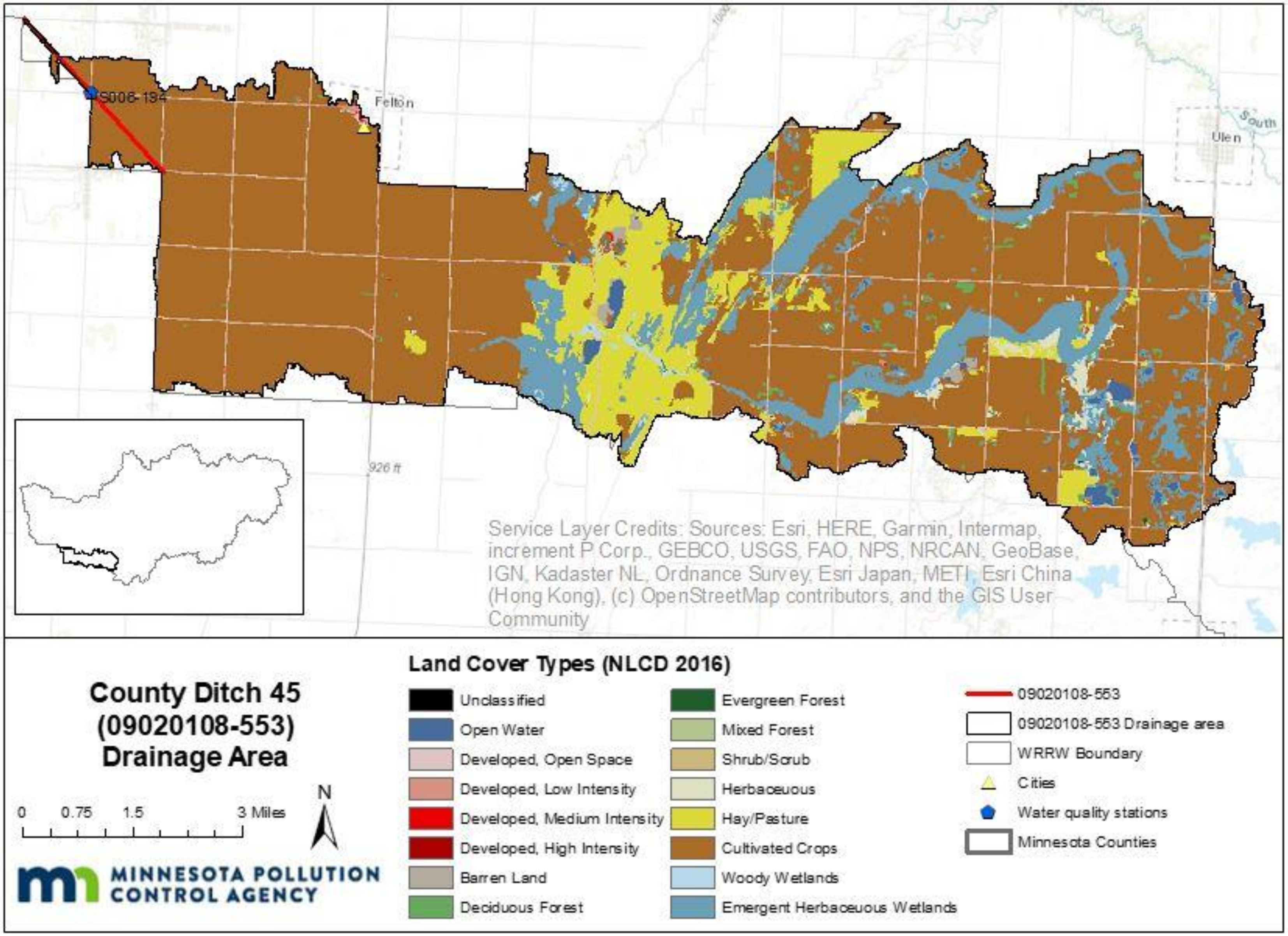


Figure 12. Drainage area (watershed) of Coon Creek (AUID -577).

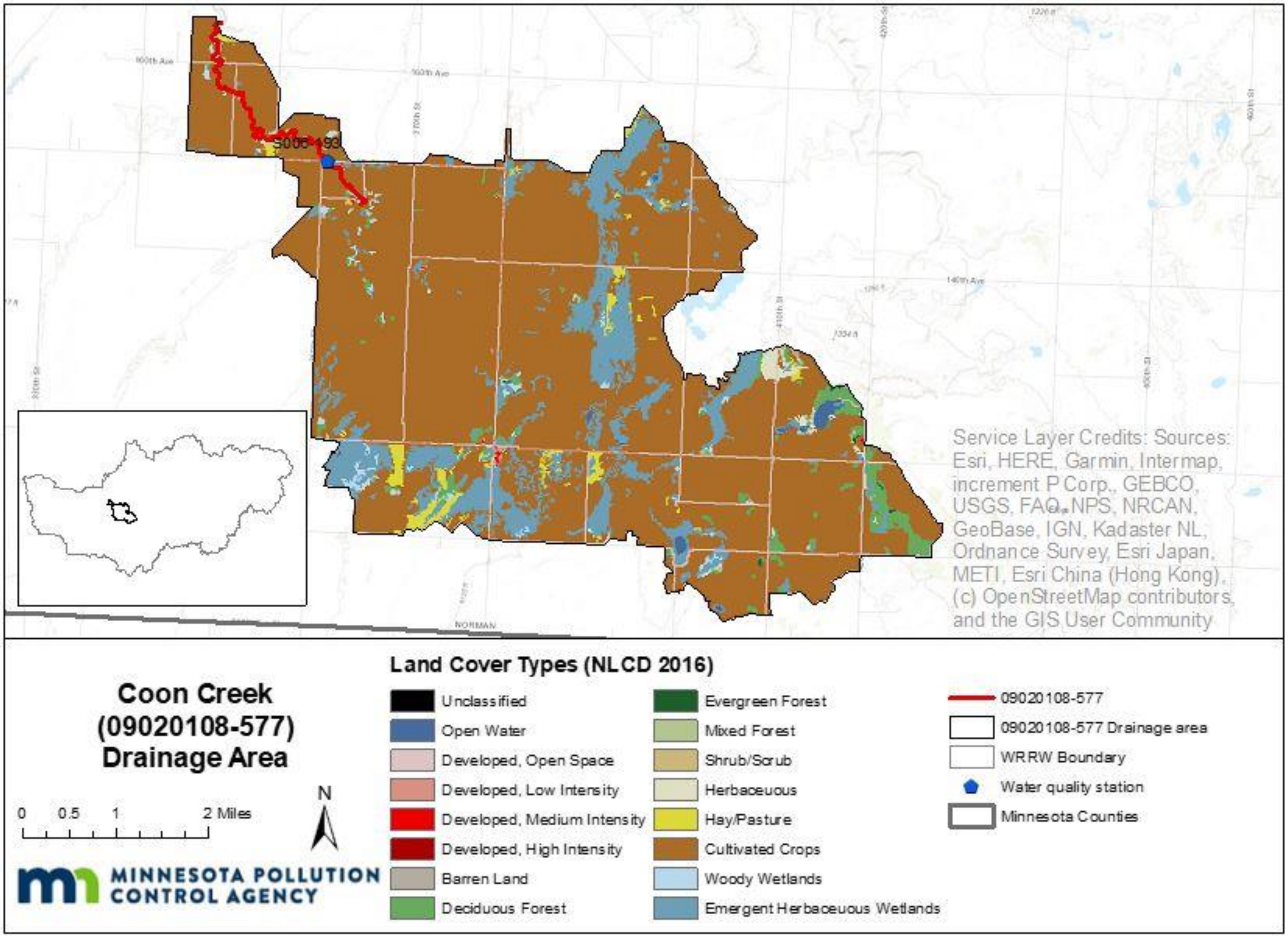


Figure 13. Drainage area (watershed) of the Wild Rice River (AUID -643).

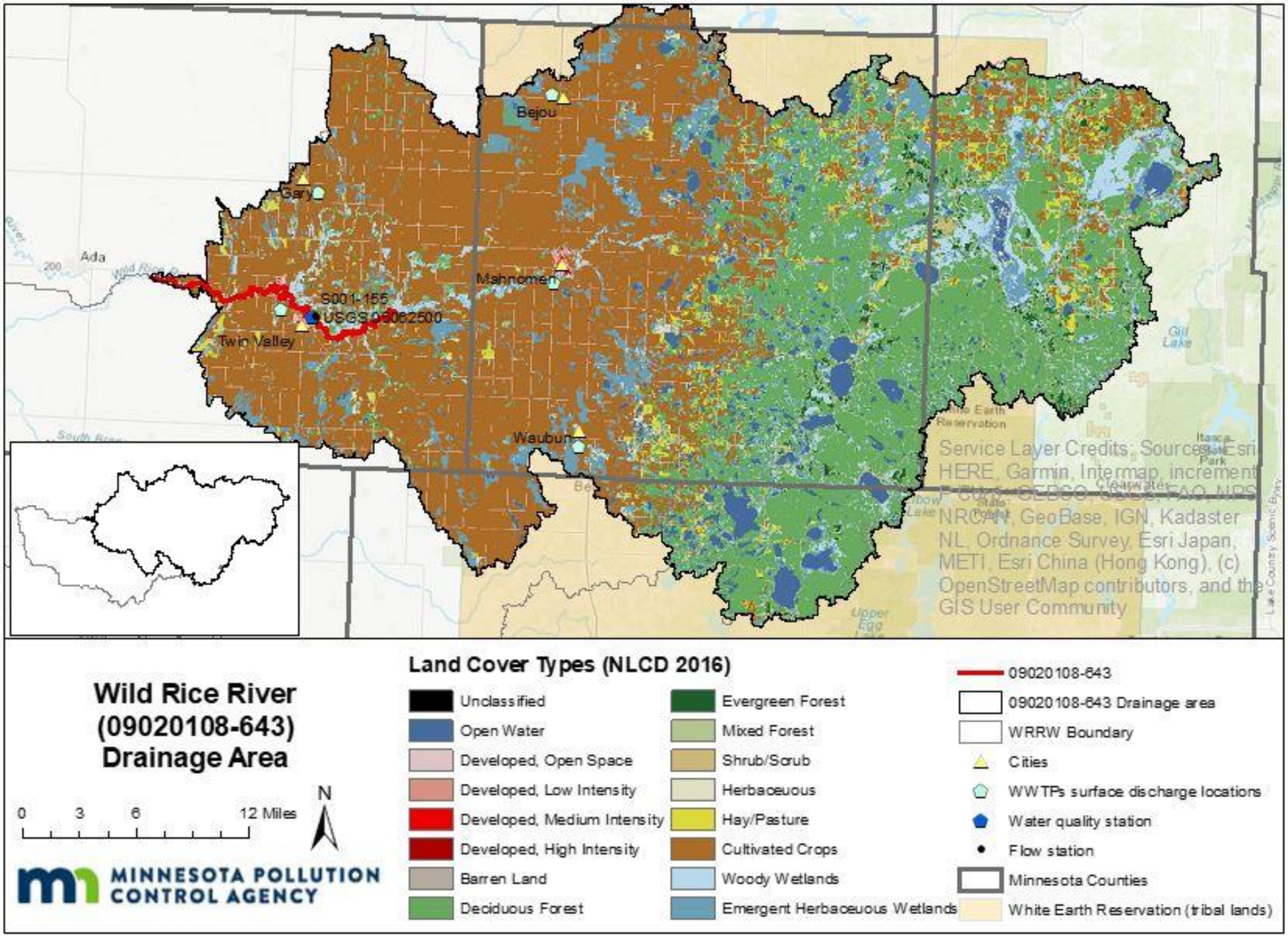


Figure 14. Drainage area (watershed) of the Wild Rice River (AUID -644).

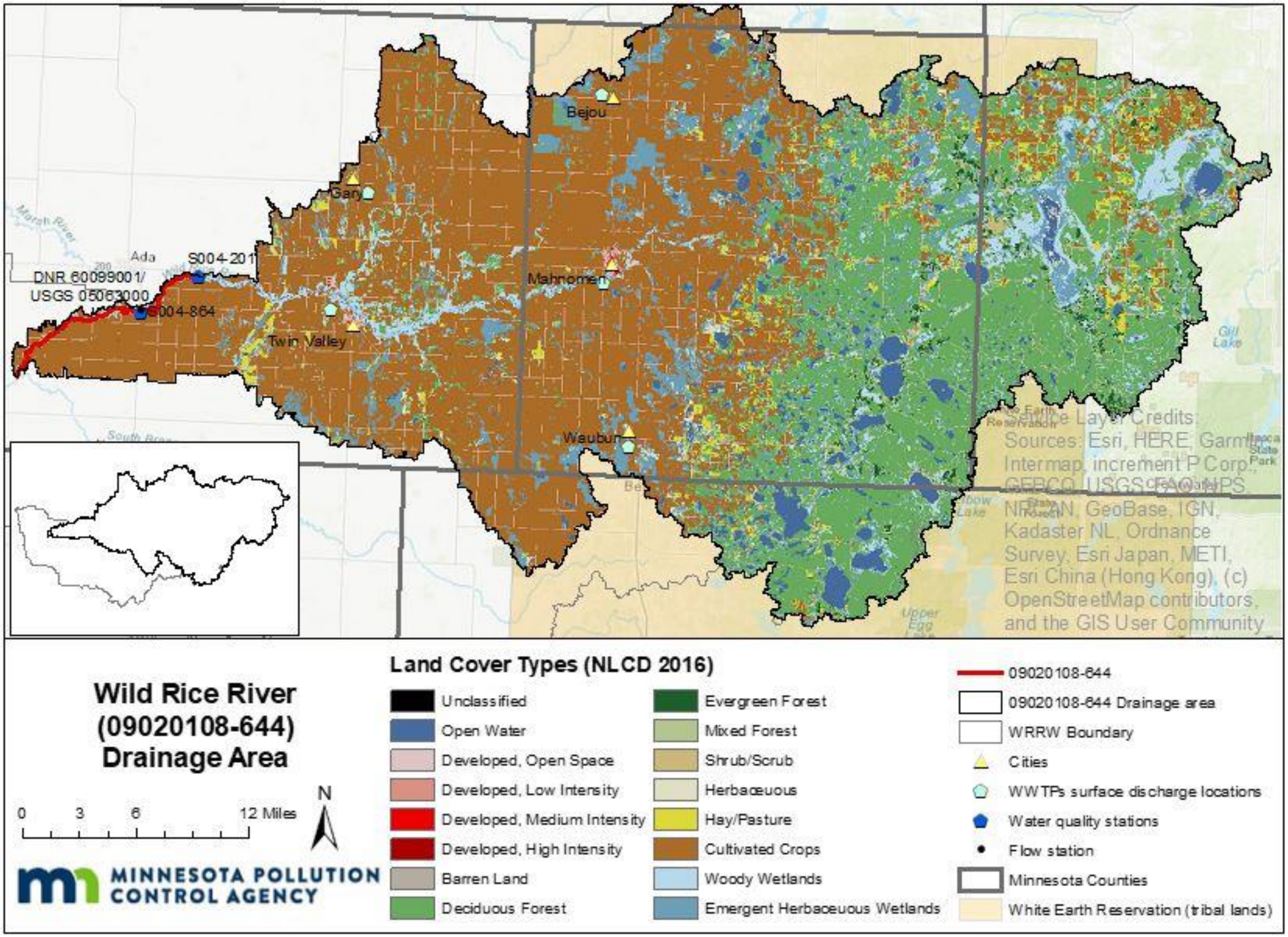


Figure 15. Drainage area (watershed) of Spring Creek (AUID -648).

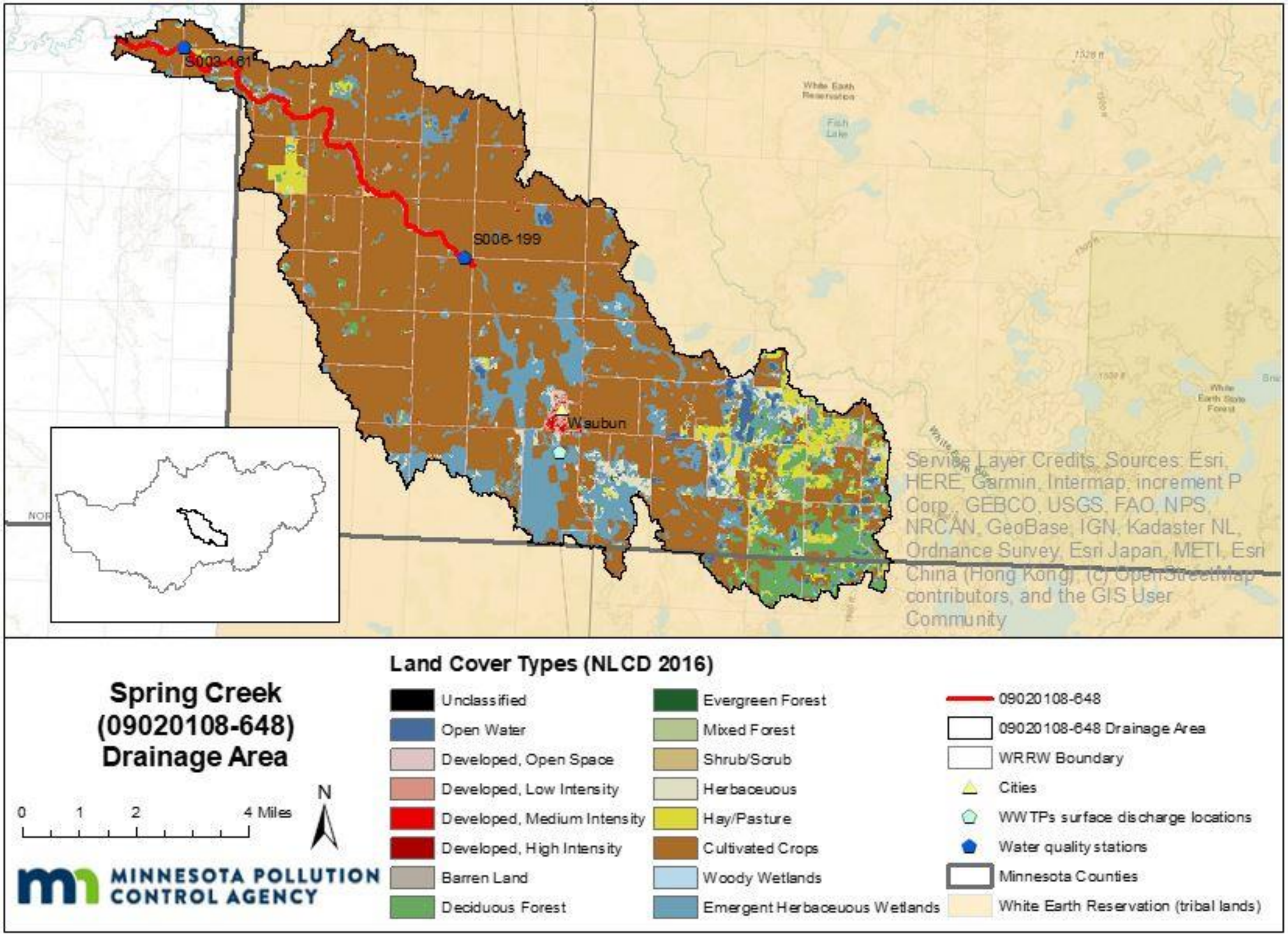


Figure 16. Drainage area (watershed) of Mashaug Creek (AUID -650).

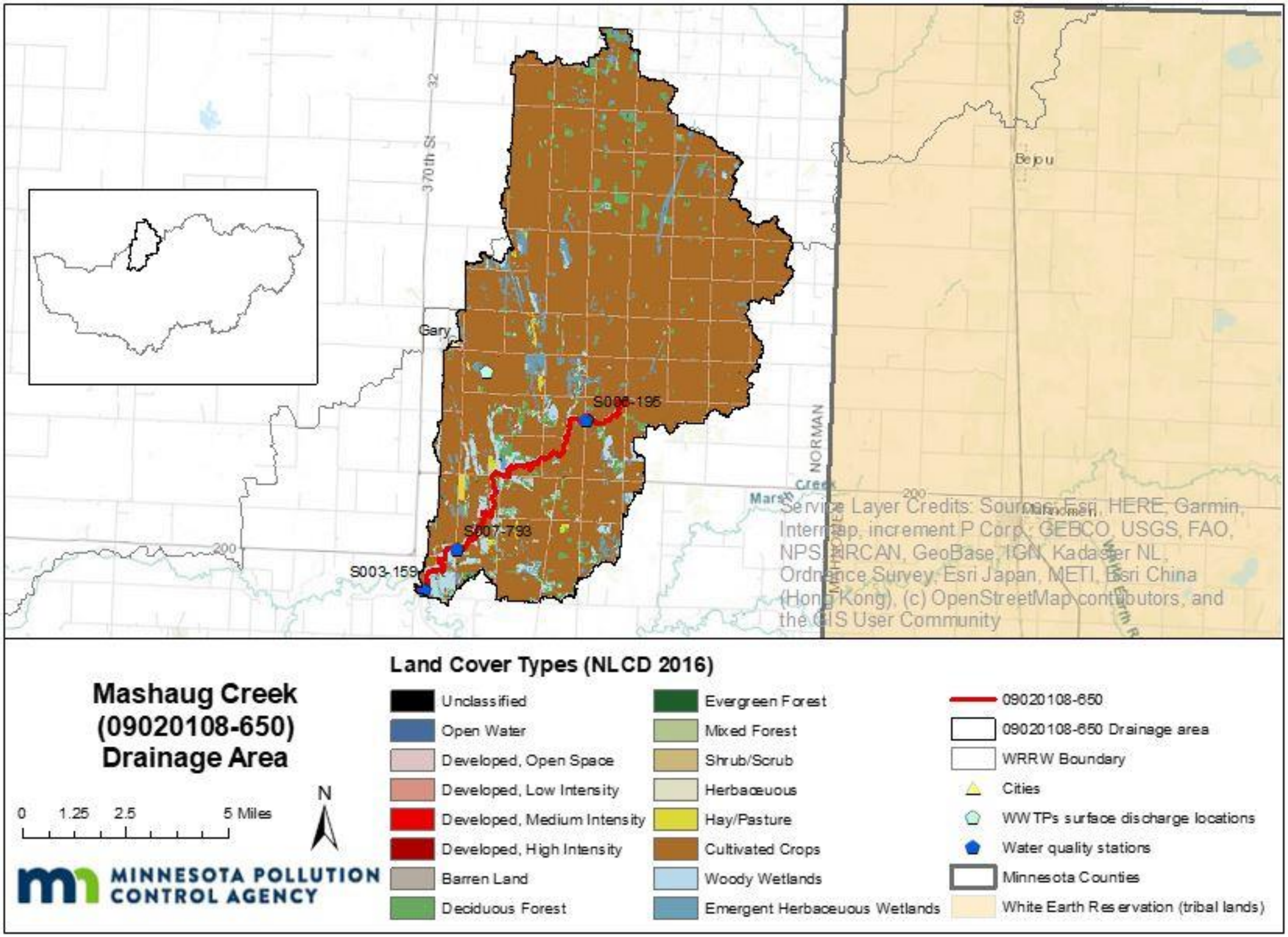


Figure 17. Drainage area (watershed) of Marsh Creek (AUID -652).

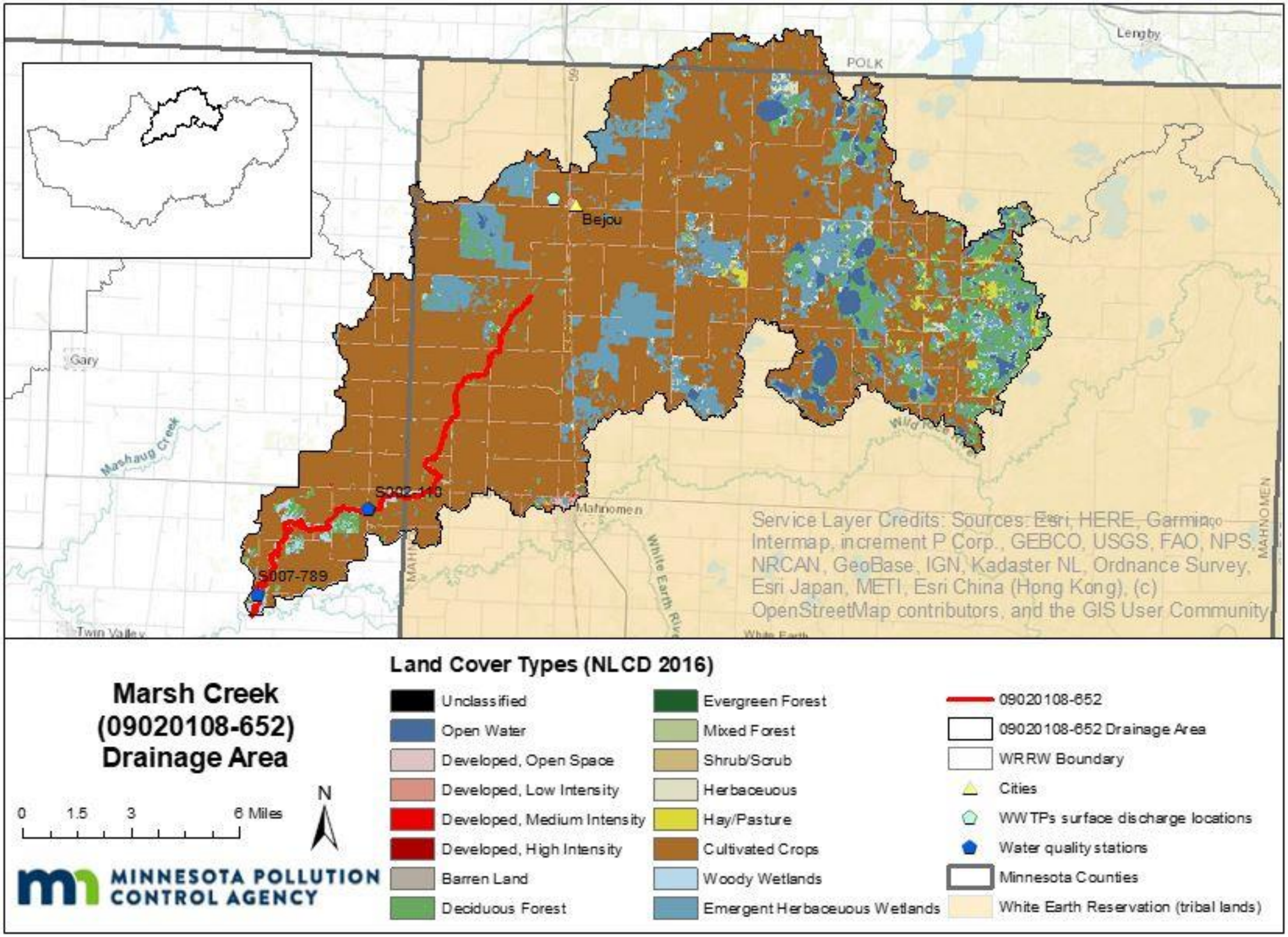


Figure 18. Drainage area (watershed) of the South Branch Wild Rice River (AUID -659).

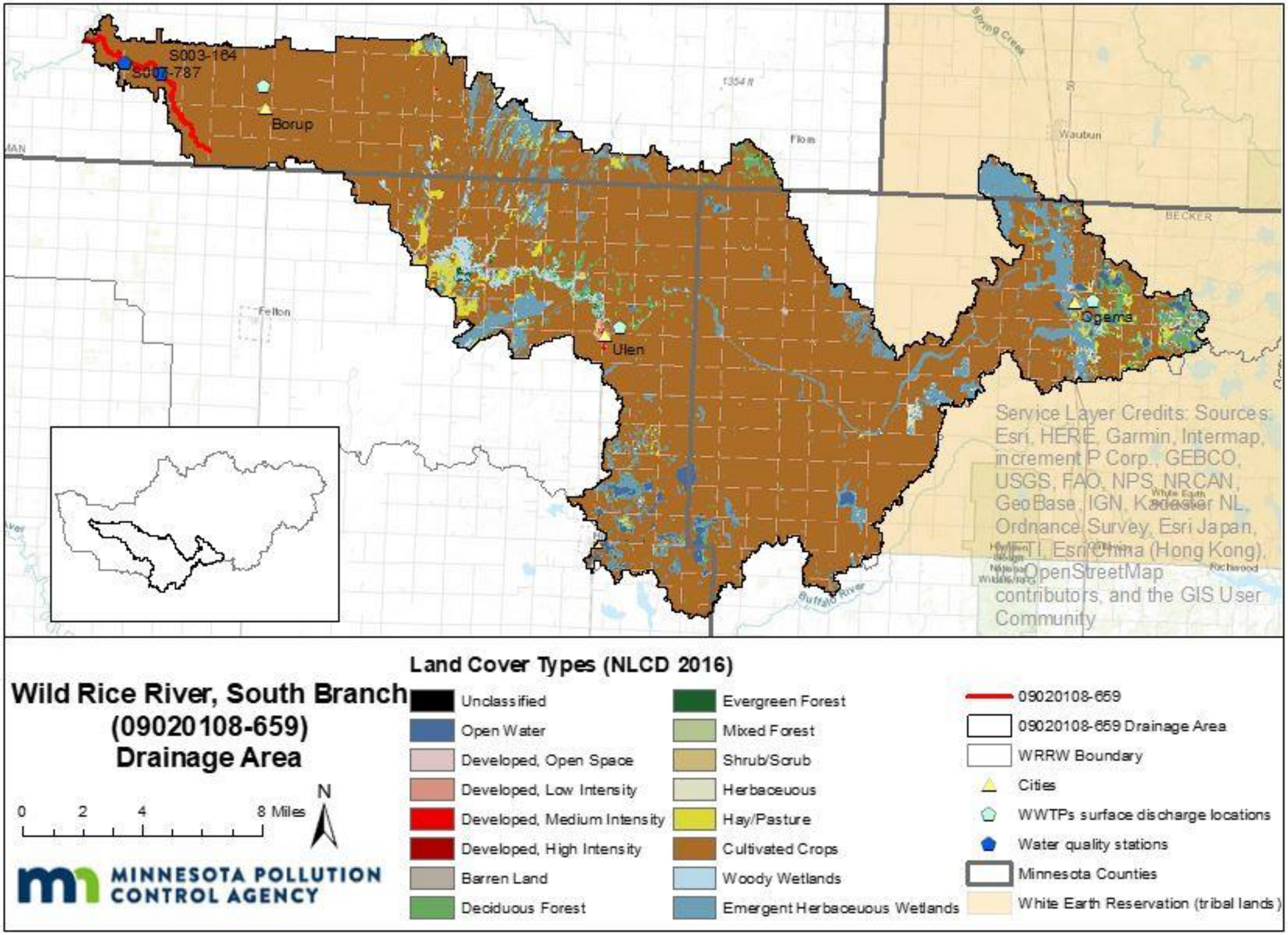


Figure 19. Drainage area (watershed) of the South Branch Wild Rice River (AUID -662).

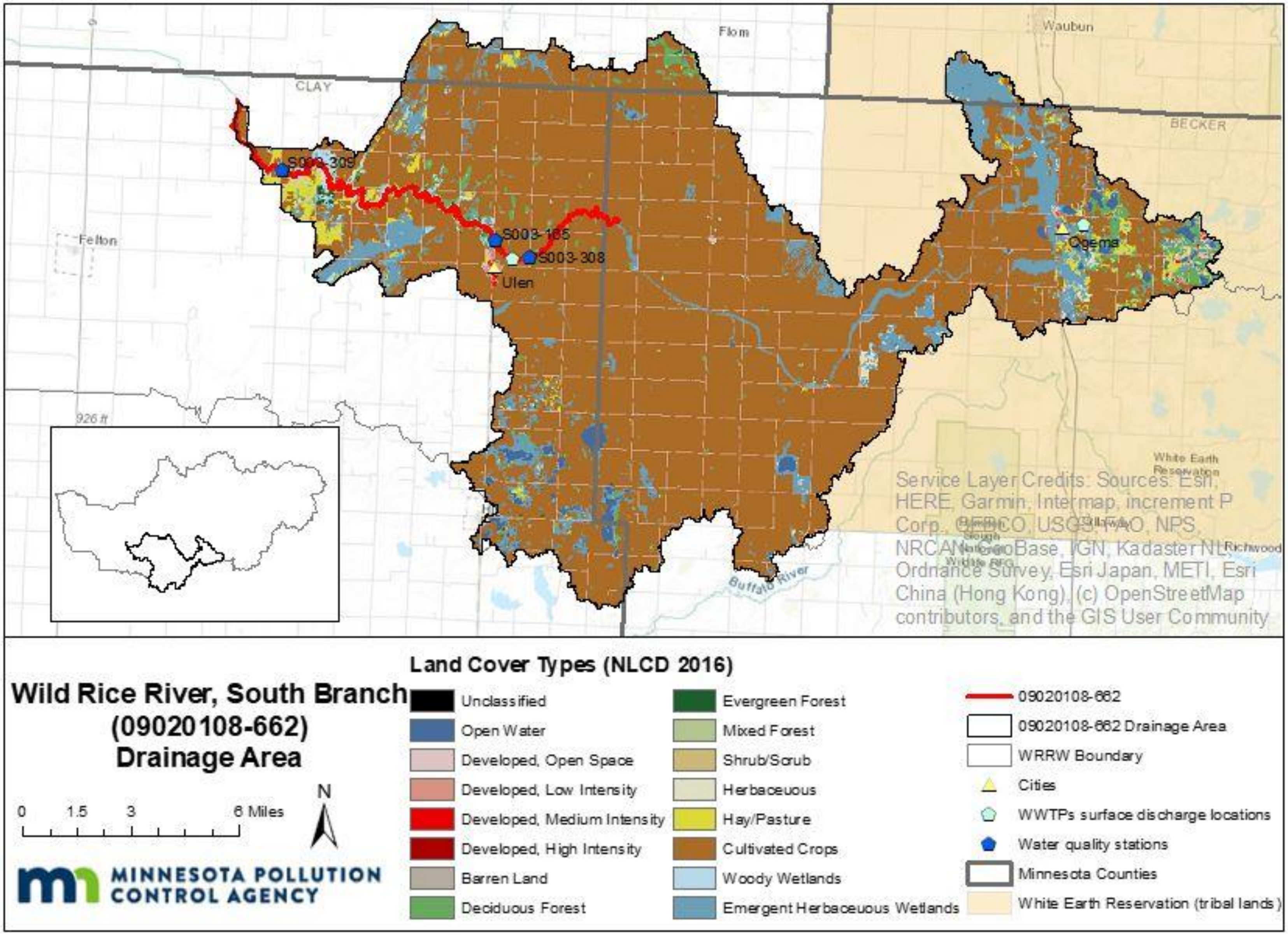
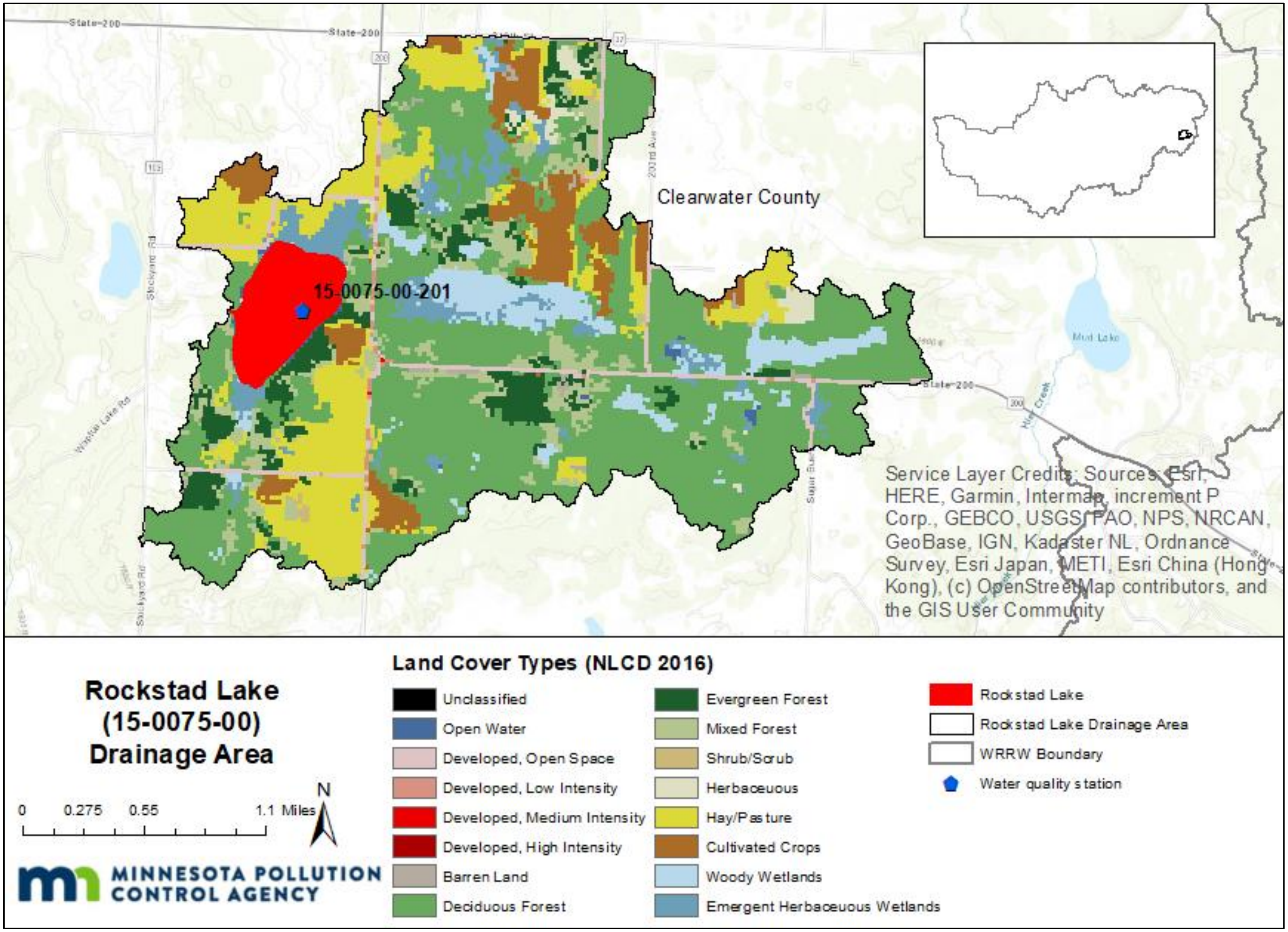


Figure 20. Drainage area (watershed) of Rockstad Lake (15-0075-00).



3.4 Land cover

Pre-European settlement land cover in what is now the WRRW was primarily emergent herbaceous wetland and grassland/herbaceous in the western portion, and various forested conditions in the eastern portion (**Figure 21**).

Currently, cropland is the largest land cover in the western portions of the WRRW, and forest/shrub lands are the predominant land covers in the eastern portion where the headwaters of the Wild Rice River is located (**Table 8**, **Figure 22**).

Starting in the early 1900s, the WRRW was managed for optimal agricultural production (Van Offelen, Evarts, Johnson, Groshens, & Berg, 2002). During European settlement in the area, flood management had been a concern. Early flood management practices included modifying natural stream channels to develop vast drainage systems. This watershed-wide alteration changed the natural hydrology of the entire watershed, causing an abrupt change in the whole ecosystem (Van Offelen, Evarts, Johnson, Groshens, & Berg, 2002). According to the *Rapid Watershed Assessment* (NRCS, 2007) there were 1,168 farms in the WRRW as of 2007. A total of 572,374 acres within the watershed were used for farming activities (**Figure 22**), with each farm averaging 195 acres.

Historically, logging practices also dominated the landscape. Part of the alteration in the WRRW included the connection of the Marsh River with the Wild Rice River. This connection allowed logs to be floated down the Wild Rice River and then shifted to flow down the Marsh River, meeting up with a sawmill just east of Ada. This connection is now used for flood management purposes; during high flow events, when the Wild Rice River reaches 95% flow, water runs over the dike at the connection, allowing the excess water to flow down the Marsh River before reaching its confluence with the Red River of the North.

The WRRW is sparsely populated with 13,564 people living within the watershed. Land ownership is dominated by private ownership—76% of the watershed is privately owned, 18% publicly owned, and 6% is tribal (NRCS, 2007).

Table 8. Land cover based on the NLCD 2016 (Yang, et al., 2018) percentages in the WRRW.

HUC-8 watershed/HUC-10 subwatershed name (number)	Cropland	Rangeland	Developed	Wetland	Open Water	Forest/ Shrub	Barren/ Mining
Wild Rice River Watershed (09020108)	57.6%	3.5%	2.9%	13.0%	3.1%	19.8%	0.15%
Headwaters Wild Rice River (0902010801)	11.6%	6.2%	2.3%	21.4%	3.6%	54.6%	0.29%
Upper Wild Rice River (0902010802)	10.2%	6.5%	2.1%	20.7%	4.0%	56.0%	0.57%
Twin Lake Creek (0902010803)	3.3%	1.8%	2.4%	11.2%	11.1%	70.0%	0.17%
White Earth River (0902010804)	21.0%	4.2%	2.4%	13.7%	10.5%	48.0%	0.26%
Spring Creek (0902010805)	66.3%	6.0%	3.5%	15.2%	2.0%	6.8%	0.26%
Middle Wild Rice River (0902010806)	69.3%	2.5%	4.3%	13.4%	2.7%	7.8%	0.05%
Marsh Creek (0902010807)	70.9%	1.8%	2.5%	15.7%	2.5%	6.6%	0.01%
Mashaug Creek (0902010808)	83.0%	0.7%	3.2%	8.8%	0.0%	4.2%	0.001%

HUC-8 watershed/HUC-10 subwatershed name (number)	Cropland	Rangeland	Developed	Wetland	Open Water	Forest/ Shrub	Barren/ Mining
Lower Wild Rice River (0902010809)	75.4%	2.5%	3.3%	14.9%	0.8%	3.0%	0.04%
South Branch Wild Rice River (0902010810)	80.7%	2.3%	3.1%	10.3%	1.2%	2.3%	0.03%
Felton Creek (0902010811)	82.8%	6.4%	3.2%	6.4%	0.4%	0.5%	0.20%
Outlet Wild Rice River (0902010812)	90.7%	0.6%	3.5%	4.1%	0.8%	0.2%	0.02%

Represents land cover in all 1,636 square miles of the WRRW HUC-8.

Figure 21. Pre-European settlement vegetation (land cover) in the WRRW based on the original “Marschner’s Map”.

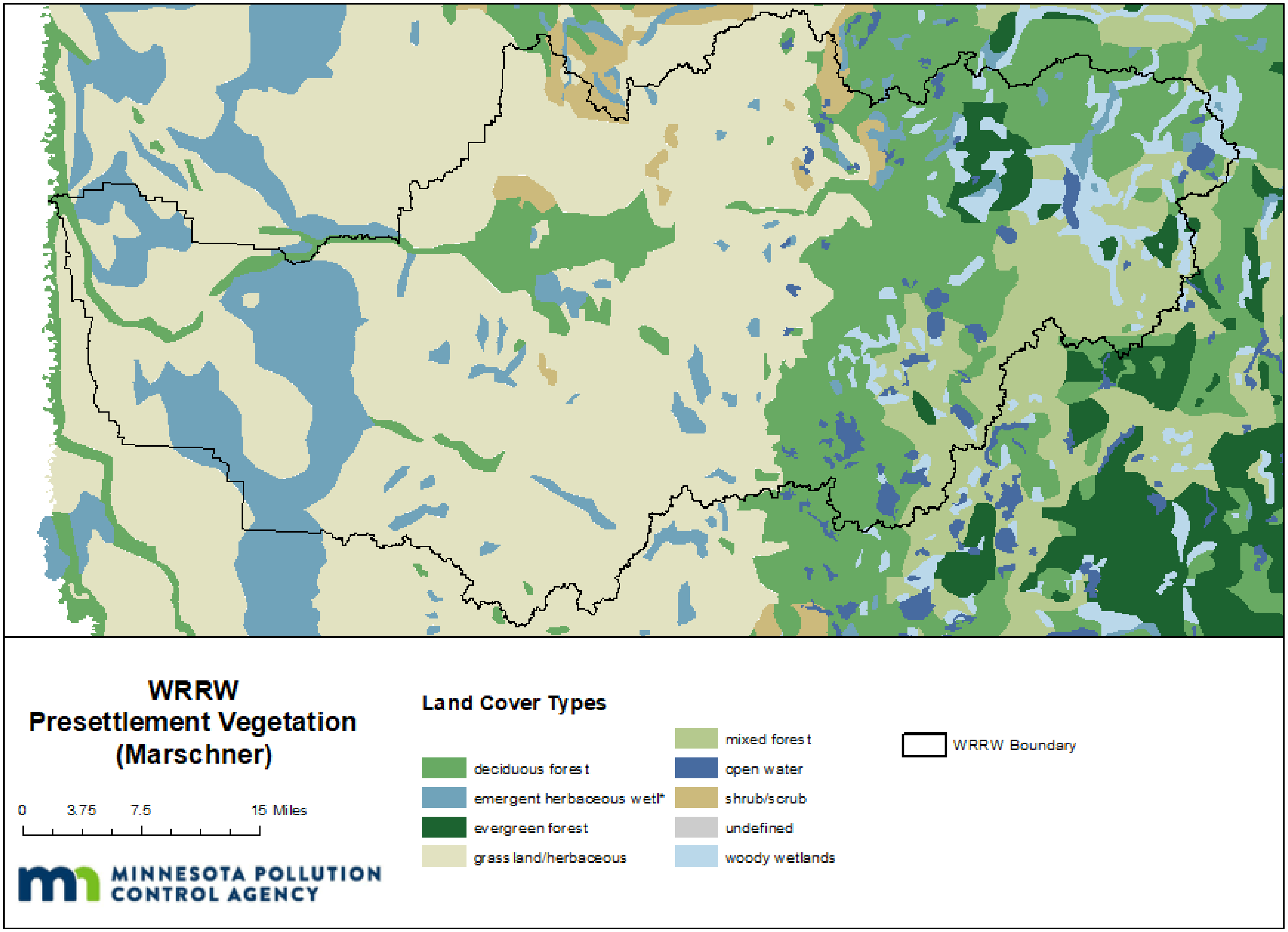
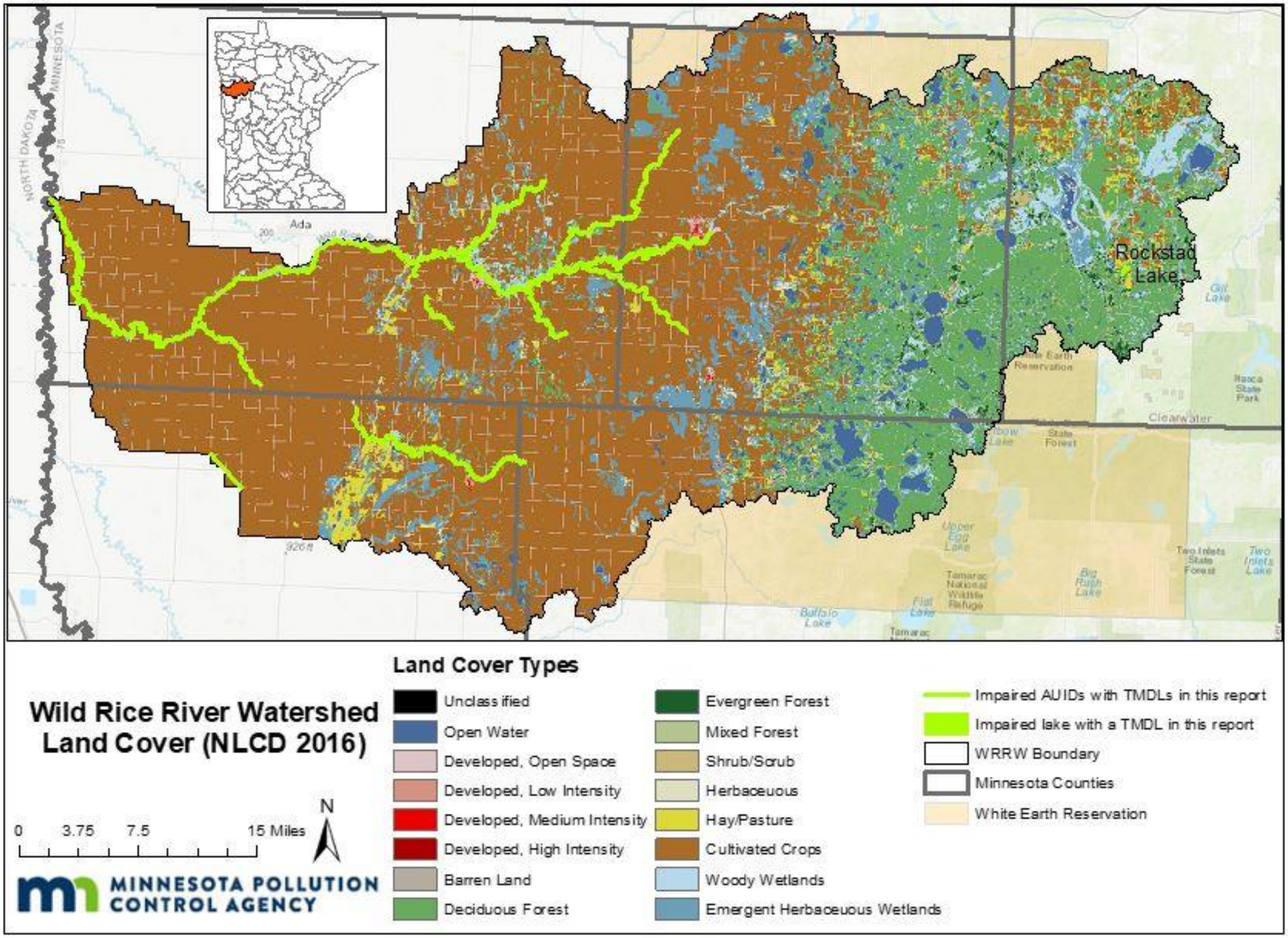


Figure 22. Land cover based on the NLCD 2016 (Yang, et al., 2018) in the WRRW.



3.5 Water quality data

Observed water quality conditions were described using data downloaded from the MPCA's *Environmental Quality Information System (EQuIS)* database (MPCA, 2022). EQuIS stores water quality data from more than 17,000 sampling locations across the state, containing information from Minnesota streams and lakes dating back to 1926. Data are collected by the MPCA, tribes, partner agencies (soil and water conservation districts [SWCDs], watershed districts, etc.), grantees, and citizen volunteers. Monitoring locations used for this TMDL report are shown in **Figure 7** through **Figure 20**. *E. coli*, TSS, and TP data are summarized in **Table 9** through **Table 11**, respectively. All water quality sampling data used for assessments, modeling, and data analysis, for this report and reference reports are stored in EQuIS and are accessible through the MPCA's Environmental Data Access (EDA) webpage (MPCA, 2020).

The MPCA conducts two years of IWM in all 80 watersheds in Minnesota on a 10-year cycle, beginning monitoring in an average of 8 watersheds per year (i.e., every major watershed is sampled for 2 years, once every 10 years). The WRRW IWM occurred in 2014 and 2015.

Data from the 10-year assessment period (2007 through 2016) were used for development of the *E. coli* and TSS TMDLs in this report. For *E. coli*, data collected during the months of April through October were used. For TSS, data collected from April through September were used. Data collected in June through September in the years 2009 through 2020 were used for development of the TP TMDL in this report and was used to describe current TP, Chl-*a*, and Secchi depth conditions.

3.5.1 *Escherichia coli*

Table 9 shows monthly *E. coli* summary statistics for each sampling station on each AUID with TMDLs in this report. To better compare *E. coli* data to the standards in **Section 2.4.1**, the summary statistics are reported as the monthly number of samples (n), geometric mean, and percent exceedances of the SSM of 1,260 org/100mL. The majority of exceedances of the standards occurred in June, July, and August and are identified by red text in the table.

Table 9. *E. coli* summary statistics (2007–2016) of AUIDs addressed with *E. coli* TMDLs in this report. [a]

AUID (09020108-###)		-544	-546	-553	-577	-643	-644			-648			-650				-659			-662		
Station(s)/ Site(s)		S003-157	S007-791	S006-194	S006-193	S001-155	S004-201	S004-864	AUID (both sites)	S003-161	S006-199	AUID (both sites)	S003-159	S006-195	S007-793	AUID (all 3 sites)	S003-164	S007-787	AUID (both sites)	S003-165	S003-308	AUID (both sites)
Years		2008-2015	2014-2015	2010-2011	2010-2011	2008-2015	2008-2015	2008-2009	2008-2015	2008-2015	2010-2011	2008-2015	2008-2009	2010-2011	2014-2015	2008-2015	2008-2009	2014-2015	2008-2015	2010-2011	2014-2015	2010-2015
Apr	n	2					2		2	2		2	2			2	2		2			
	Geo [b]	8					79		79	12		12	2			2	18		18			
	% n>1260	0%					0%		0%	0%		0%	0%			0%	0%		0%			
May	n	2				2	2	2	4	2		2	2			2	2		2			
	Geo [b]	90				22	19	30	24	48		48	10			10	45		45			
	% n>1260	0%				0%	0%	0%	0%	0%		0%	0%			0%	0%		0%			
Jun	n	9	5	6	6	10	7	5	11 [c]	7	6	13	2	6	5	13	2	5	7	6	5	11
	Geo [b]	262	281	548	629	137	164	194	176	385	380	383	111	185	251	192	596	224	296	255	138	193
	% n>1260	11%	0%	17%	33%	0%	0%	0%	0%	14%	0%	8%	0%	17%	0%	8%	0%	0%	0%	0%	0%	0%
Jul	n	7	5	4	4	10	7	5	11 [c]	7	4	11	2	4	5	11	2	5	7	4	5	9
	Geo [b]	129	699	1,103	683	126	61	379	125	457	312.1	378	107	128	531	236	563	94	157	328	93	163
	% n>1260	0%	40%	50%	0%	0%	0%	20%	8%	14%	0%	9%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Aug	n	6	5	5	5	10	7	5	12	7	5	12	2	5	5	12	2	5	7	5	5	10
	Geo [b]	172	891	600	652	43	26	89	43	269	446	332	45	159	186	137	34	43	40	204	119	156
	% n>1260	17%	60%	0%	20%	0%	0%	0%	0%	0%	20%	8%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sept	n	1				3	2	3	5	2		2	2			2	2		2			
	Geo [b]	93				241	41	435	169	286		286	27			27	107		107			
	% n>1260	0%				33%	0%	33%	20%	0%		0%	0%			0%	0%		0%			
Oct	n	2					2		2	2		2	2			2	2		2			
	Geo [b]	333					109		109	55		55	41			41	50		50			
	% n>1260	50%					0%		0%	0%		0%	0%			0%	0%		0%			
Apr-Oct	# (%) n>1260	3/29 (10%)	5/15 (33%)	3/15 (20%)	3/15 (20%)	1/35 (3%)	0/29 (0%)	2/20 (10%)	2/47 (4%)	2/29 (7%)	1/15 (7%)	3/44 (7%)	0/14 (0%)	1/15 (7%)	0/15 (0%)	1/44 (2%)	0/14 (0%)	0/15 (0%)	0/29 (0%)	0/15 (0%)	0/15 (0%)	0/30 (0%)

[a] The data used in this table are the same data used to assess the waterbodies for impairments (MPCA, 2017). Values in red indicate exceedance of the standard (either monthly geometric means with n ≥ 5 that exceed 126 org/100 mL, or AUIDs for which ≥ 10% of samples exceed 1,260 org/mL [bottom row of the table]). As additional information, the geometric mean per month by station and the % of samples exceeding 1,260 org/mL by station and by month have also been calculated.

[b] Geometric mean, all concentration units are org/100 mL.

[c] Two samples were collected on the same day, so the geometric mean of those two samples was calculated and counted as one sample.

3.5.2 Total Suspended Solids

TSS data were summarized by AUID and station for each stream for which a TSS TMDL was developed in this report (**Table 10**). Variation in TSS concentrations as they relate to flow can be seen in the TSS LDCs (see **Section 4.1.4.9**).

Table 10. Current TSS conditions (2007-2016) at each water quality site for AUIDs with TSS TMDLs in this report.

AUID (09020108-###)	TSS standard (mg/L)	Stream station	Period	Number of samples	90th percentile (mg/L)	Number of exceedances of applicable TSS standard
-501	65	S002-102	2007-2016	233	328	171
		S000-216	2014	10	200	8
-504	30	S006-197	2010-2014	31	76.0	7
		S007-619	2014-2016	62	130.0	22
-643	30	S001-155	2008-2016	90	334.0	38
-644	30	S004-200	2007	5	43.0	0
		S004-201	2007-2015	27	76.0	5
		S004-864	2008-2009	23	237.0	11
-652	30	S002-110	2008-2010	17	39.2	5
		S007-789	2014-2015	11	130.0	2

3.5.3 Lake Nutrients

In-lake water quality data collected from 2009 through 2020 were reviewed and summarized for use in developing the TMDL for Rockstad Lake. **Table 11** provides the number of samples and average (mean) during the summer (June through September) for TP, Chl-*a*, and Secchi disk depth.

Table 11. Water quality data associated with the lake impairment addressed in this TMDL report.

Lake Name	AUID/DNR Lake ID #	TP			Chl-*a*			Secchi Disk Depth		
		Years of data	n	Mean (µg/L)	Years of data	n	Mean (µg/L)	Years of data	n	Mean (m)
Rockstad	15-0075-00	2009, 2012, 2016, 2019, 2020	23	57.9	2009, 2012, 2016, 2019, 2020	23	34.0	2009, 2010, 2012, 2016, 2019, 2020	27	1.07

3.6 Pollutant source summary

Sources of pollutants in the WRRW include permitted and nonpermitted sources. The permitted sources discussed here are pollutant sources that require a NPDES permit. Nonpermitted sources are pollutant sources that do not require an NPDES permit. All NPDES permits that are issued by Minnesota are also SDS permits, so they are hereafter referred to as NPDES/SDS permits, but some pollutant sources require SDS permit coverage alone without NPDES permit coverage (e.g., spray irrigation, large septic systems, land application of biosolids, and small feedlots).

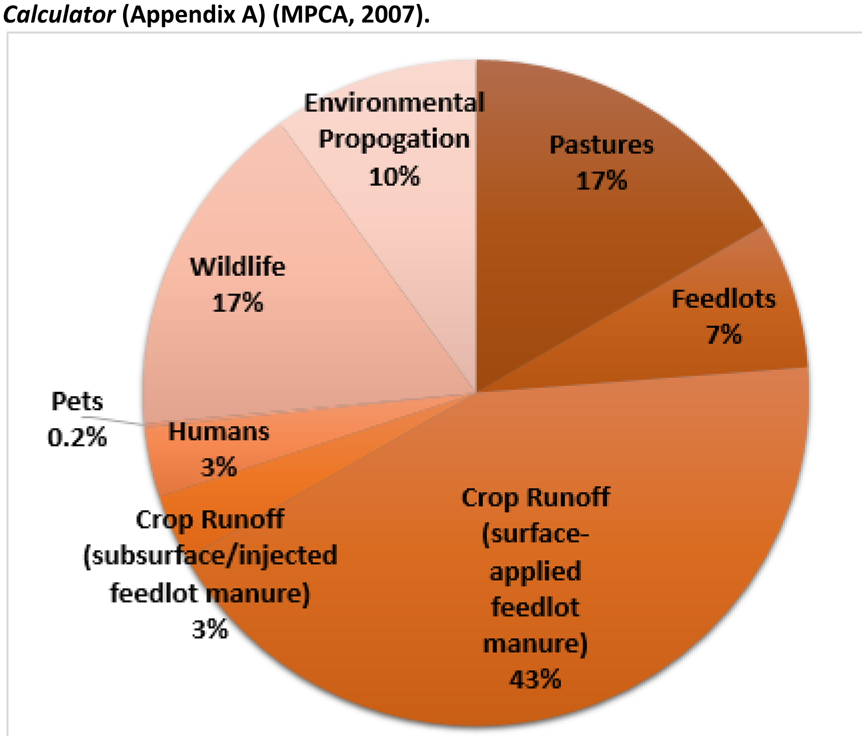
The phrase “nonpermitted” does not indicate that the pollutants are illegal, but rather that they do not require an NPDES/SDS permit. Some nonpermitted sources are unregulated, and some nonpermitted sources are regulated through non-NPDES programs and permits such as state and local regulations.

3.6.1 *Escherichia coli*

Assessing the amount of *E. coli* generated by major sources in the watershed can aid in identifying conservation activities to reduce *E. coli* loading to surface waters. *E. coli* delivered to waterbodies in the WRRW was estimated using available data on livestock (MPCA, 2020), manure application, pasture (Homer, et al., 2015), human populations (MN Dept of Administration, 2019), SSTSs (MPCA, 2019), pets, and wildlife populations (based on literature rates from previous studies on sources to estimate production). These data were used to input values into MPCA's Bacteria Source Estimates Calculator to estimate the percentage of *E. coli* being delivered to waterbodies by various sources. See Appendix A for an image of the completed calculator for the WRRW and further details about how the values were determined.

The greatest source of *E. coli* loading in the WRRW is manure from livestock (**Figure 23**; **Figure A-1**). It accounts for 70% of *E. coli* loading in the WRRW and is inclusive of surface (43%) and subsurface (3%) applied manure, manure from pasture grazing livestock (17%), and manure from livestock in feedlots (7%). Wildlife account for 17% of *E. coli* loading and the remaining 20% is estimated to come from humans (3%), pets (0.2%), and environmental propagation of *E. coli* (default of 10% was used). A general summary of the permitted and nonpermitted sources of *E. coli* is given below.

Figure 23. Watershed-wide *E. coli* sources in the WRRW as determined by the MPCA's *Bacteria Source Estimates Calculator* (Appendix A) (MPCA, 2007).



3.6.1.1 Permitted and/or point sources

NPDES/SDS-permitted animal feedlots — Of the 116 animal feedlots in the WRRW that are registered, active, and have greater than 0 animal units (AUs), there are 5 concentrated animal feeding operations (CAFOs), 4 of which have greater than 999 AUs and an NPDES/SDS permit (the 5th is considered a "gap" site, because it is a CAFO, has less than 1,000 AUs, and does not require/have an NPDES/SDS permit). The "gap" site CAFO has swine (960 AUs) and of the 4 NPDES/SDS-permitted CAFOs, 1 has birds (4,251

AUs), and 3 have bovines (1,840, 4,540, and 3,546 AUs) totaling 15,137 AUs, nearly half of the 32,218 total AUs in the WRRW (MPCA, 2020). See **Table 12** and **Figure 24**, both of which show information about all animal feedlots (those with and without NPDES/SDS permits) in the WRRW, but NPDES/SDS-permitted CAFOs are specified. CAFOs are defined by the EPA based on the number and type of animals. The MPCA uses the federal definition of a CAFO in its permit requirements of animal feedlots along with the definition of an AU. In Minnesota, the following types of livestock facilities are required to operate under an NPDES/SDS permit or a state issued SDS permit: a) all federally defined CAFOs that discharge or intend to discharge, some of which are under 1,000 AUs in size; and b) all CAFOs and non-CAFOs that have 1,000 or more AUs. CAFOs with fewer than 1,000 AUs and that do not discharge may choose to operate without an NPDES/SDS permit.

CAFOs and animal feedlots with 1,000 or more AUs must be designed to contain all manure and manure contaminated runoff from precipitation events of equal to or less than a 25-year, 24-hour storm event. Having and complying with an NPDES/SDS permit allows some enforcement protection if a facility discharges due to a 25-year, 24-hour precipitation event (approximately 4.85 inches in the WRRW) (NOAA, 2017), and the discharge does not contribute to a water quality impairment. Large CAFOs permitted with an SDS permit or those with fewer than 1,000 AUs that have chosen to forego NPDES/SDS permit coverage must contain all runoff, regardless of the precipitation event. Therefore, many large CAFOs in Minnesota have chosen to have an NPDES/SDS permit, even if discharges have not occurred at the facility. A current manure management plan that complies with Minn. R. 7020.2225 and the respective permit is required for all CAFOs and animal feedlots with 1,000 or more AUs.

All CAFOs are inspected by the MPCA in accordance with the MPCA NPDES Compliance Monitoring Strategy approved by the EPA. All CAFOs (NPDES/SDS-permitted, SDS-permitted, and not required to be permitted) are inspected by the MPCA on a routine basis with an appropriate mix of field inspections, offsite monitoring, and compliance assistance.

For the WRRW TMDLs, all NPDES/SDS- and SDS-permitted feedlots are designed to have zero discharge, and as such they are not considered a significant source of *E. coli*. All other feedlots are accounted for as nonpermitted sources. The land application of all manure in agronomic amounts, regardless of whether the source of the manure originated from permitted (e.g., CAFOs) or nonpermitted animal feedlots, is also accounted for as a nonpermitted source.

Table 12. Summary of animal feedlots in the WRRW (HUC-8: 09020108) and within the drainage areas (includes both direct and upstream) of AUIDs addressed with *E. coli* TMDLs in this report (MPCA, 2020). [a]

HUC-8 / AUID	Feedlots within each HUC-8 or AUID drainage area							
	General				Sensitive areas			
	Total feedlots	NPDES/SDS-permitted CAFOs	Total AUs	Primary animal types	Open lot feedlots	Feedlots near water [c]	Open lot feedlots near water	Open lot agreements
09020108	116	4 [b]	32,218	Bovine 78% Bird 15%	101	26	26	7
-544	3	0	502	Bovine 64% Pig 36%	2	2	2	0
-546	7	0	706	Bovine 99.6% Horse 0.4%	7	1	1	0
-553	8	0	909	Bovine 100%	7	3	3	0
-577	2	0	216	Pig 83% Bovine 17%	1	1	1	0
-643	77	2	17,953	Bovine 67% Bird 27%	67	15	15	7
-644	78	2	18,172	Bovine 67% Bird 26%	68	15	15	7
-648	10	0	1,873	Bovine 95% Other 5%	8	4	4	0
-650	6	0	619	Bovine 99.998% Bird 0.002%	6	2	2	0
-659	26	2	12,839	Bovine 92% Pig 8%	22	4	4	0
-662	21	1	8,337	Bovine 88% Pig 12%	18	4	4	0

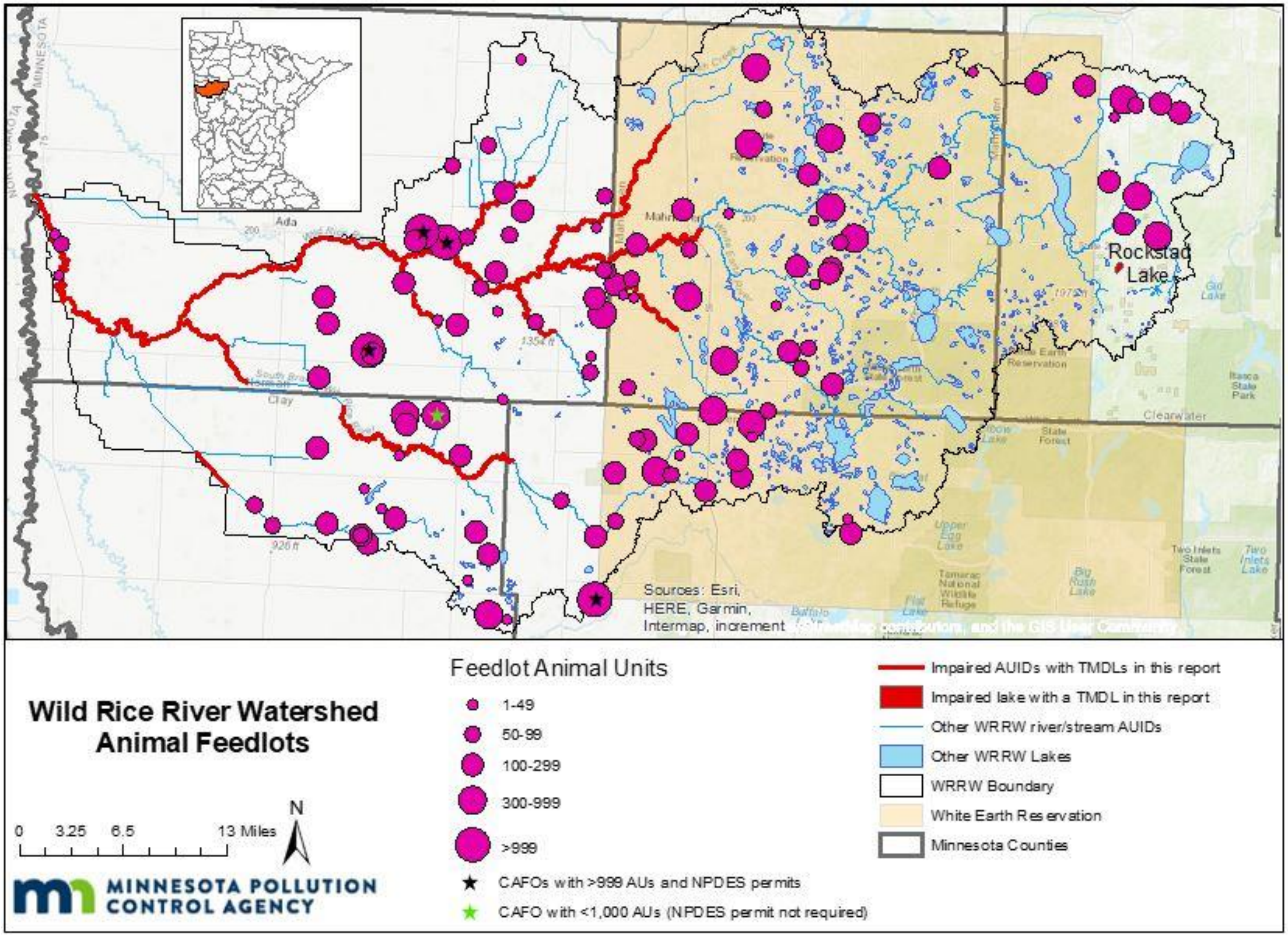
[a] Only animal feedlots that are active, registered, and have more than 0 AUs as of October 20, 2020 are included in this table.

[b] These 4 NPDES/SDS-permitted CAFOs are comprised of 14,177 AUs.

[c] These are the animal feedlots that are listed as being near a river, stream, or shoreland (MPCA, 2020).

Represents animal feedlot data in all 1,636 square miles of the WRRW HUC-8.

Figure 24. Animal unit counts for animal feedlots and CAFOs in the WRRW as of October 22, 2020.



Wastewater Treatment Plants – While human waste can be a source of *E. coli* during any flow condition, it can be a more substantial source during low flow periods. There are eight WWTPs with NPDES/SDS permits in the WRRW that discharge within the drainage area of at least one AUID addressed with an *E. coli* TMDL in this report. Four of these WWTPs are located within tribal lands, and the remaining four are located outside tribal lands. All eight WWTPs are controlled discharge facilities (pond systems) and are unlikely to contribute to *E. coli* during periods of low flow as discharge coincides with windows of higher flows. However, if low flow conditions do occur during discharge, a WWTP can become a greater source of *E. coli*. The discharge windows in the WWTP permits are from March 1 to June 30 and September 1 to December 31 with no discharge to ice covered waters. These windows prohibit discharge during the months of January and February when ice is most likely and July and August when low flows are most likely. Rarely, during extreme high flow conditions, WWTPs may also be a source if they become overloaded and have an emergency discharge of partially or untreated sewage, known as a release or sanitary system overflow (SSO). From January 1, 2006 to December 31, 2020, there have been 11 incidents categorized as a spill or release. None of these incidents are recent; all of them occurred in 2007, 2008, 2009, 2010, 2011, and 2012. The most common reasons for the 11 spills or releases were too much rain, equipment failure, and electrical issues.

There are an additional four tribal WWTPs in the WRRW that have been issued NPDES permits by EPA that do not have Minnesota SDS permits. All four discharge within the drainage area of at least one AUID addressed with an *E. coli* TMDL. Similarly to the NPDES/SDS-permitted WWTPs, these four NPDES-permitted are controlled discharge facilities (pond systems). The discharge windows are from March 1 to June 30 and September 16 to December 31 with no discharge to ice covered waters.

WLAs are only calculated for the four NPDES/SDS-permitted WWTPs that are not located within tribal lands. WLAs are not calculated for the four NPDES/SDS-permitted WWTPs that are located within tribal lands, nor are they calculated for the four NPDES-permitted tribal WWTPs that are within tribal lands. The permitted loads for these eight WWTPs are included in boundary condition (BC) loads (see **Section 4.1.3.1**).

Straight pipe systems – These are defined as sewage disposal systems that transport raw or partially treated sewage directly to a lake, drainage system, or ground surface (Minn. Stat. 2019, 115.55, subd. 1). The sewage contains *E. coli* and other organisms, some of which can be pathogenic to humans. While straight pipe systems are not NPDES/SDS-permitted, they are point sources.

3.6.1.2 Nonpermitted and/or nonpoint sources

SSTS – Examples of SSTSs that are noncompliant and imminent threats to public health and safety (ITPHS) are those that have unsecured or damaged maintenance hole covers, discharge sewage to the surface, cause sewage backup into connected dwellings, etc. These are NPS with the exception of those identified as straight pipe systems, which are point sources as discussed above. Systems that are ITPHS near waterways can be a source of fecal contamination to waterbodies especially during low flow. While not a source of fecal contamination to surface water, another category of noncompliant SSTSs are those that have a functioning, intact tank and soil absorption system, but fail to have an adequate amount of unsaturated soil between sewage discharge and groundwater or bedrock (termed “failing” as they fail to protect groundwater). Educating the public as to what constitutes a noncompliant (ITPHS and/or failing) SSTS is crucial.

Counties are required to submit annual reports to the MPCA regarding SSTS compliance within their respective county. Data reported is aggregated by each county so the location of SSTSs are not known to the State of Minnesota. Raw data used to develop the *2018 SSTS Annual Report* (MPCA, 2019) show that the six counties that have contributing areas in the WRRW have indicated the percentages of SSTSs that present an IPHT range from 0% in Mahnomen County to 5% in Norman County. While the estimates are for the entire counties, the WRRW does not encompass any one county completely. These counties continue to invest in the education of landowners on the maintenance and impact that noncompliant systems can have on humans and wildlife. Additionally, counties continue to develop county-wide GIS databases for SSTS to facilitate outreach and inspection of noncompliant systems.

Table 13. 2018 estimates of compliant and noncompliant (failing and IPHT) SSTSs in the counties partially encompassed by the WRRW. Numbers are based on raw data used to develop the *2018 SSTS Annual Report* (MPCA, 2019).

	Mahnomen	Norman	Becker	Clay	Clearwater	Polk
# (%) potentially failing SSTSs	124 (10%)	187 (20%)	1,293 (10%)	261 (7%)	529 (15%)	1,174 (23%)
# (%) potential IPHT SSTSs	0 (0%)	47 (5%)	129 (1%)	74 (2%)	35 (1%)	102 (2%)
# (%) compliant SSTSs	1,112 (90%)	701 (75%)	11,509 (89%)	3,387 (91%)	2,962 (84%)	3,829 (75%)
Total # of SSTSs	**1,236**	**935**	**12,932**	**3,722**	**3,526**	**5,105**

Non-NPDES/SDS-permitted animal feedlots – Animal feedlots under 1,000 AUs and those that are not federally defined as CAFOs do not operate with permits. In Minnesota, feedlots with greater than 50 AUs, or greater than 10 AUs in shoreland areas, are required to register with the county feedlot officer if the county is delegated, or with the MPCA if the county is non-delegated. Facilities with fewer AUs are not required to register. Shoreland is defined by Minn. R. 7020.0300 as land within 1,000 feet from the normal high water mark of a lake, pond, or flowage, and land within 300 feet of a river or stream.

All non-CAFOs are inspected in delegated counties by the county feedlot officer on a routine basis in accordance with the delegated county's Delegation Agreement and Work Plan, which is prepared with and approved by the MPCA every other year. Non-CAFOs in non-delegated counties are inspected by MPCA on an as-needed or complaint-driven basis.

The animals raised in animal feedlots produce manure that is stockpiled on site or on crop fields or stored in pits, lagoons, tanks, and other storage devices. The manure is then applied or injected to area fields as fertilizer. When stored and applied properly, this beneficial re-use of manure provides a natural source for crop nutrition. It also lessens the need for fuel and other natural resources that are used in the production of fertilizer. Animal feedlots, however, can pose environmental concerns. Inadequately managed manure runoff from open lot feedlot facilities and improper application of manure can contaminate surface or groundwater. The 116 registered feedlots in the WRRW that are active and have greater than 0 AUs are mapped in **Figure 24** and summarized in **Table 12**. Of the 116 registered animal feedlots, 112 do not have an NPDES/SDS permit and they contain a total of 18,041 AUs, over half of the 32,218 total AUs in the WRRW (the rest of the AUs [14,177] are in the 4 NPDES/SDS-permitted CAFOs).

Livestock are potential sources of fecal bacteria and nutrients to streams in the WRRW, particularly when direct access is not restricted and/or where feeding structures are located adjacent to riparian areas (especially if this area is an open lot). Because open lots and shoreland are such sensitive areas with a greater potential for manure to be delivered to surface waters, they are specified in **Table 12**.

Animal waste from nonpermitted animal feedlots can be delivered to surface waters from failure of manure containment, runoff from the feedlot itself, or runoff from nearby fields where the manure is applied. While a full accounting of the fate and transport of manure was not conducted for this project, a large portion of it is ultimately applied to the land surface and, therefore, this source is of possible concern. Minn. R. 7020.2225 contains several requirements for land application of manure; however, there are no explicit requirements for *E. coli* treatment prior to land application. Manure practices that inject or incorporate manure pose lower risk to surface waters than surface application with little or no incorporation. In addition, manure application on frozen/snow covered ground in late winter months presents a high risk for runoff.

Pasture – According to Minn. R. 7020.0300, subp. 3 (2019), pastures shall not be considered animal feedlots, thus they are considered to be a separate source. Of the 116 registered and active animal feedlots with greater than 0 AUs (totaling 32,218 AUs) in the WRRW, 98 (17,133 AUs) are listed as having associated pasture land, and of those 98, 25 (2,723 AUs) are listed as being near shoreland (MPCA, 2020). Livestock can contribute fecal contamination to waterbodies (as indicated by the presence of elevated *E*. *coli* levels) from poorly managed pasture lands that are overgrazed, or through the direct access of livestock to surface waters. Poorly maintained pasture can have significant overland surface flow during heavy precipitation events resulting in manure transport from the pasture. Livestock with direct access to streams and lakes can defecate directly into the waterbody resulting in direct contamination.

Wildlife and Pets – Similar to livestock and humans, *E. coli* is present in the digestive tracts of all warm blooded wildlife. In the WRRW, land cover that could potentially attract wildlife includes: wetlands and row crops adjacent to streams and lakes, wildlife management areas (WMA), and open water. Areas such as WMAs, state parks, national parks, national wildlife refuges, golf courses, state forest, and other conservation areas provide habitat for wildlife and are potential sources of fecal contamination due to high densities of animals. Additionally, private land managed for wildlife with practices such as food-plotting or supplemental feeding can concentrate wildlife and have the potential to be a source of fecal contamination and *E. coli* from wildlife sources.

Birds such as swallows nesting under bridges and in culverts, ducks, geese, and shorebirds and other warm blooded wildlife such as beavers and muskrats that spend a significant amount of time in surface water contribute fecal contamination (and *E. coli*) directly into surface water. The aforementioned wildlife when not directly in, on, or above surface water and others (e.g., deer, raccoons, coyote, foxes, squirrels) also contribute to fecal contamination of surface water through runoff.

Pets such as dogs and cats, can contribute fecal contamination to a watershed when their waste is not disposed of properly, especially at a local level when in the immediate vicinity of a waterbody. A portion of the waste from domestic cats is collected by owners in the form of litter boxes and a portion of waste from dogs are collected by owners and are not sources of fecal contamination when this collected waste is disposed of properly. Pets are a small contributor with loading approximately continuous over the course of a year.

Naturalized *E. coli* – The relationship between *E. coli* sources and *E. coli* concentrations found in streams is complex, involving precipitation and flow, temperature, sunlight and shading, livestock management practices, wildlife contributions, *E. coli* survival rates, land use practices, and other environmental factors. Research in the last 15 years has found the persistence of *E. coli* in soil, beach sand, and sediments throughout the year in the north central United States without the continuous presence of sewage or mammalian sources. This *E. coli* that persists in the environment outside of a warm-blooded host is referred to as naturalized *E. coli* (Jang, et al., 2017). Naturalized *E. coli* can originate from different types of *E. coli* sources, including natural background sources such as wildlife and human attributed sources such as pets, livestock, and human wastewater. Therefore, whereas naturalized *E. coli* can be related to natural background sources, naturalized *E. coli* is not always from a natural background source.

An Alaskan study (Adhikari, Barnes, Schiewer, & White, 2007) found that total coliform bacteria in soil were able to survive for six months in subfreezing conditions. Two studies near Duluth, Minnesota, found that *E. coli* were able to grow in agricultural field soil (Ishii, et al., 2010) and temperate soils (Ishii, Ksoll, Hicks, & Sadowsky, 2006). A study of ditch sediment in the Seven Mile Creek Watershed in southern Minnesota found that strains of *E. coli* had become naturalized to the water−sediment ecosystem (Chandrasekaran, et al., 2015). Survival and growth of fecal coliform has been documented in storm sewer sediment in Michigan (Marino & Gannon, 1991), and *E. coli* regrowth was documented on concrete and stone habitat within an urban Minnesota watershed (Burns & McDonnell Engineering Company, 2017). This ability of *E. coli* to survive and persist naturally in watercourse sediment can increase *E. coli* counts in the water column, especially after resuspension of sediment (Jamieson, Joy, Lee, Kostaschuk, & Gordon, 2005).

The MPCA does not currently use any methods as standard practice to estimate (using an equation or model) or measure (using a laboratory analysis) what proportion of *E*. *coli* is naturalized. While a measurement would be preferable over an estimate, it is also more expensive, because it involves a laboratory component. The adaptation and evolution of naturalized *E*. *coli* that allows it to survive and reproduce in the environment makes it physically and genetically distinct from *E*. *coli* that cannot survive outside of a warm-blooded host. Laboratory methods target those physical and genetic differences and quantify their presence to provide a measurement. The MPCA is developing a protocol for the use of laboratory analyses to track *E*. *coli* to their source(s) (i.e., microbial source tracking); these approaches may shed light on naturalized *E. coli*.

Natural background sources - “Natural background” is defined in both Minnesota statute and rule. The CWLA (Minn. Stat. § 114D.15, subd. 10) defines natural background as “characteristics of the waterbody resulting from the multiplicity of factors in nature, including climate and ecosystem dynamics, that affect the physical, chemical, or biological conditions in a waterbody, but does not include measurable and distinguishable pollution that is attributable to human activity or influence.” Minn. R. 7050.0150, subp. 4 states, “‘Natural causes’ means the multiplicity of factors that determine the physical, chemical, or biological conditions that would exist in a waterbody in the absence of measurable impacts from human activity or influence.”

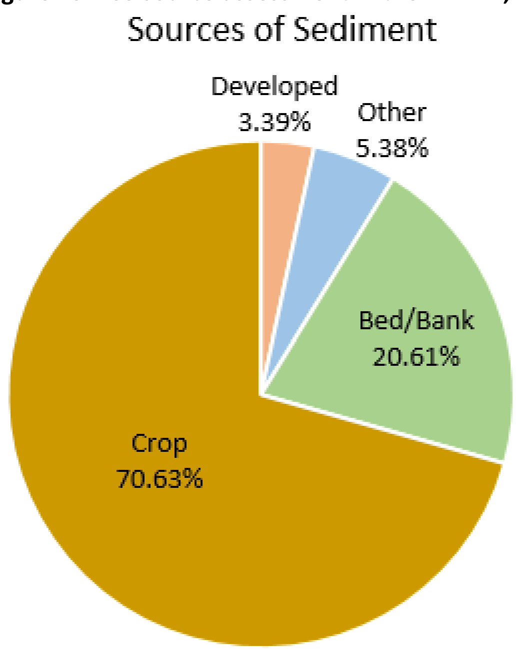
Natural background sources are inputs that would be expected under natural, undisturbed conditions. Natural background of *E. coli* can include inputs from sources such as wildlife. However, for each impairment, natural background levels are implicitly incorporated in the water quality standards used by the MPCA to determine/assess impairment status, and therefore natural background is accounted for and addressed through the MPCA’s waterbody assessment process. Natural background conditions have been evaluated within the pollutant source summaries above. These source summaries indicate that natural background inputs are generally low compared to livestock, WWTPs, noncompliant SSTSs, and other anthropogenic sources.

Based on the MPCA's waterbody assessment process and the *E. coli* source assessment exercises, there is no evidence at this time to suggest that natural background sources are a major driver of any of the impairments and/or affect the waterbodies' ability to meet state water quality standards.

3.6.2 Total Suspended Solids

External sources of TSS to streams include sediment loading from permitted sources such as construction stormwater runoff, industrial stormwater runoff, and wastewater effluent as well as nonpermitted sources such as overland erosion and windblown sediment. Sources of TSS that occur internally within a stream include sediment from bank erosion, scouring, and in-channel algal production. Sources of TSS are variable seasonally as the majority of sediment loading to waterbodies occurs during precipitation events. Heavy precipitation during which soil is exposed is when erosion and sediment loss is most likely. The external and internal TSS sources are presented in **Figure 25**.

Figure 25. TSS source assessment in the WRRW, based on HSPF modeling.



3.6.2.1 Permitted and/or point sources

Wastewater Effluent - Wastewater from NPDES/SDS-permitted sites can be a source of TSS. Ten NPDES/SDS-permitted sites discharge within the drainage areas of streams addressed with TSS TMDLs in this report. The 10 WWTPs are located in the cities of Bejou, Borup, Felton, Gary, Hendrum, Mahnomen, Ogema, Twin Valley, Ulen, and Waubun. Four of these WWTPs are located within tribal lands (in Bejou, Mahnomen, Ogema, and Waubun), and the remaining six are located outside tribal lands. The permit limits for TSS that are already assigned to these WWTPs are already consistent with the WLAs assigned in this report's TSS TMDLs. More discussion on the WLAs is provided in **Section 4.1.4.3**.

There are also four tribal WWTPs in the WRRW that have been issued NPDES permits by EPA, but do not have Minnesota SDS permits. All four discharge within the drainage area of at least one AUID addressed with a TSS TMDL. Similarly to the NPDES/SDS-permitted WWTPs, these four NPDES-permitted are controlled discharge facilities (pond systems). The discharge windows are from March 1 to June 30 and September 16 to December 31, with no discharge to ice covered waters.

WLAs are only calculated for the six NPDES/SDS-permitted WWTPs that are not located within tribal lands. WLAs are not calculated for the four NPDES/SDS-permitted WWTPs that are located within tribal lands, nor are they calculated for the four NPDES-permitted tribal WWTPs that are within tribal lands. The permitted loads for these eight WWTPs are included in BC loads (see **Section 4.1.4.1**).

Construction Stormwater – The annual average area under construction in the five of the six counties that make up >99% of the WRRW is 0.014% in Becker County, 0.063% in Clay County, 0.004% in Clearwater County, 0.035% in Mahnomen County, and 0.014% in Norman County based on construction activity covered under the Construction Stormwater General Permit (MNR100001) from 2015 through 2019 (MPCA, 2020). With the addition of an implicit MOS, 0.05% of the watershed is assumed to be under construction at any given time. TSS from permitted construction stormwater is not considered a significant source of TSS load to the impaired stream reach.

Industrial Stormwater – Stormwater from industrial activities can contribute to the TSS load of waterbodies, but there is very little industrial activity within the WRRW. The annual average area under industrial activities from 2015 through 2019 in the five of the six counties that make up >99% of the WRRW is assumed to be the same as what has undergone construction activities (0.05%).

Municipal Stormwater Runoff – There are no municipalities with a municipal separate storm sewer systems (MS4) permit, nor any development with a storm sewer system within the WRRW.

3.6.2.2 Nonpermitted and/or nonpoint sources

Overland Erosion – Overland runoff of sediment was assessed to be the greatest contributor of TSS to waterbodies in the WRRW, with approximately 70.63% determined to come from crop surfaces (**Figure 25**). That is equivalent to an average of 184 lbs of sediment per acre per year. High TSS can occur when heavy rains fall on unprotected soils, dislodging particles that are then transported with surface runoff to adjacent waterbodies. Losses are greatest during the spring, April through June, when vegetation is not yet actively growing, and rainfall is elevated. Ephemeral systems, streams, and gullies are highly susceptible to intermittent flows and have high erosion potential in agricultural systems. Farming practices can exacerbate erosion in sensitive areas if soil is unprotected from rain and there is insufficient buffering of stream channels. Other overland erosion sources include sheet and rill runoff from upland fields and livestock pastures in riparian zones.

Streambank Erosion – Unstable stream banks are common in the WRRW. Altered hydrology has increased stream flows due to lower water storage from tiling, altered evapotranspiration cycles, and decreased water residence time in the stream channel due to straightening. Managing water on and below fields, in addition to deep-rooted vegetation in the riparian zone, can stabilize soil and decrease sediment loading, lowering TSS in adjacent waterbodies. Approximately 20.61% of total sediment reaching the outlet is from streambed and streambank erosion (**Figure 25**) and is approximately 28,000 tons of sediment per year.

Windblown Sediment – Average wind speeds in the WRRW are greater than five miles per hour and strong seasonal winds are capable of transporting sediment from fields. Windblown sediment is a likely source of TSS within the watershed but is likely a small percentage of total TSS in impaired streams.

Natural background sources – "Natural background" is defined in both Minnesota statute and rule. The CWLA (Minn. Stat. § 114D.15, subd. 10) defines natural background as "characteristics of the waterbody resulting from the multiplicity of factors in nature, including climate and ecosystem dynamics, that affect the physical, chemical, or biological conditions in a waterbody, but does not include measurable and distinguishable pollution that is attributable to human activity or influence." Minn. R. 7050.0150, subp. 4 states, "'Natural causes' means the multiplicity of factors that determine the physical, chemical, or biological conditions that would exist in a waterbody in the absence of measurable impacts from human activity or influence."

Natural background sources are inputs that would be expected under natural, undisturbed conditions. Natural background sources of sediment can include inputs from natural geologic processes such as soil loss from upland erosion and stream development. However, for each impairment, natural background levels are implicitly incorporated in the water quality standards used by the MPCA to determine/assess impairment, and therefore natural background is accounted for and addressed through the MPCA's waterbody assessment process. Natural background conditions have been evaluated within the pollutant source summaries above. These source summaries indicate that natural background inputs are generally low compared to cropland, animal feedlots (especially open lots with exposed sediment), streambank erosion, WWTPs, and other anthropogenic sources.

Based on the MPCA's waterbody assessment process and the TSS source assessment exercises, there is no evidence at this time to suggest that natural background sources are a major driver of any of the impairments caused by high TSS and/or affect the waterbodies' ability to meet state water quality standards.

3.6.3 Phosphorus

Nutrient availability for lakes is largely assessed by phosphorus loads in freshwater lakes, as nitrogen availability is rarely the limiting nutrient controlling primary production. External sources of phosphorus to Rockstad Lake include upland erosion, stream bank erosion, fertilizer application, manure runoff from agricultural fields, open tile intakes, and SSTSs. Upland sources of sediment-bound phosphorus are the primary source of nutrient loading to Rockstad Lake. Internal phosphorus cycling plays a large seasonal role in phosphorus concentration in lakes as well. Phosphorus can become re-suspended throughout the water column as the water in a lake turns over and phosphorus-rich water from the lake bottom mixes with surface waters, or through the disturbance of phosphorus-rich sediment by bottom-feeding fish. In shallow lakes that mix intermittently throughout the growing season, phosphorus from sediment is available to drive primary production. Phosphorus sources vary annually depending on environmental conditions. These sources are described in more detail below by permitted and nonpermitted sources.

3.6.3.1 Permitted sources

Wastewater Effluent – There are no WWTPs that discharge within the drainage area of Rockstad Lake.

Construction Stormwater – The annual average area under construction in Clearwater County, which encompasses the entirety of Rockstad Lake's drainage area, is 0.004% based on construction activity covered under the Construction Stormwater General Permit (MNR100001) from 2015 through 2019 (MPCA, 2020). Additionally, a review of all construction stormwater sites showed no sites within the drainage area of Rockstad Lake. However, with a small drainage area of 3,214 acres, even a small construction site of an acre is a bigger proportion of Rockstad Lake's drainage area than it would be for a lake with a large drainage area. To account for the small drainage area and the possibility of there being a construction site within the drainage area in the future, it is assumed that 0.05% of the lakeshed is under construction at any given time. Phosphorus from permitted construction stormwater is not considered to a significant source of phosphorus load to Rockstad Lake.

Industrial Stormwater – Stormwater from industrial activities can contribute to the phosphorus load of waterbodies, but there is very little industrial activity within Clearwater County. The annual average area under industrial activities within the drainage area of Rockstad Lake is assumed to be the same as construction activities (0.05%).

Municipal Stormwater Runoff – There are no municipalities with an MS4 permit, nor any development with a storm sewer system within the drainage area of Rockstad Lake.

3.6.3.2 Nonpermitted sources

Upland Erosion (Overland Erosion/ Open Tile Intakes/ Tile Lines) – Overland erosion can occur by sheet, rill, or gully modes of sediment transport that can convey phosphorus bound to sediment to waterbodies. Upon the formation of a gully, these areas are sensitive and highly susceptible to continued disturbance.

Phosphorus, once mobilized, can be transported by surface or tile drains to surface waters. Loss by tiles can be attributed to open tile intakes that convey surface water runoff to a tile system with little to no impoundment period, preventing sediment and phosphorus settling prior to conveyance to the tile system.

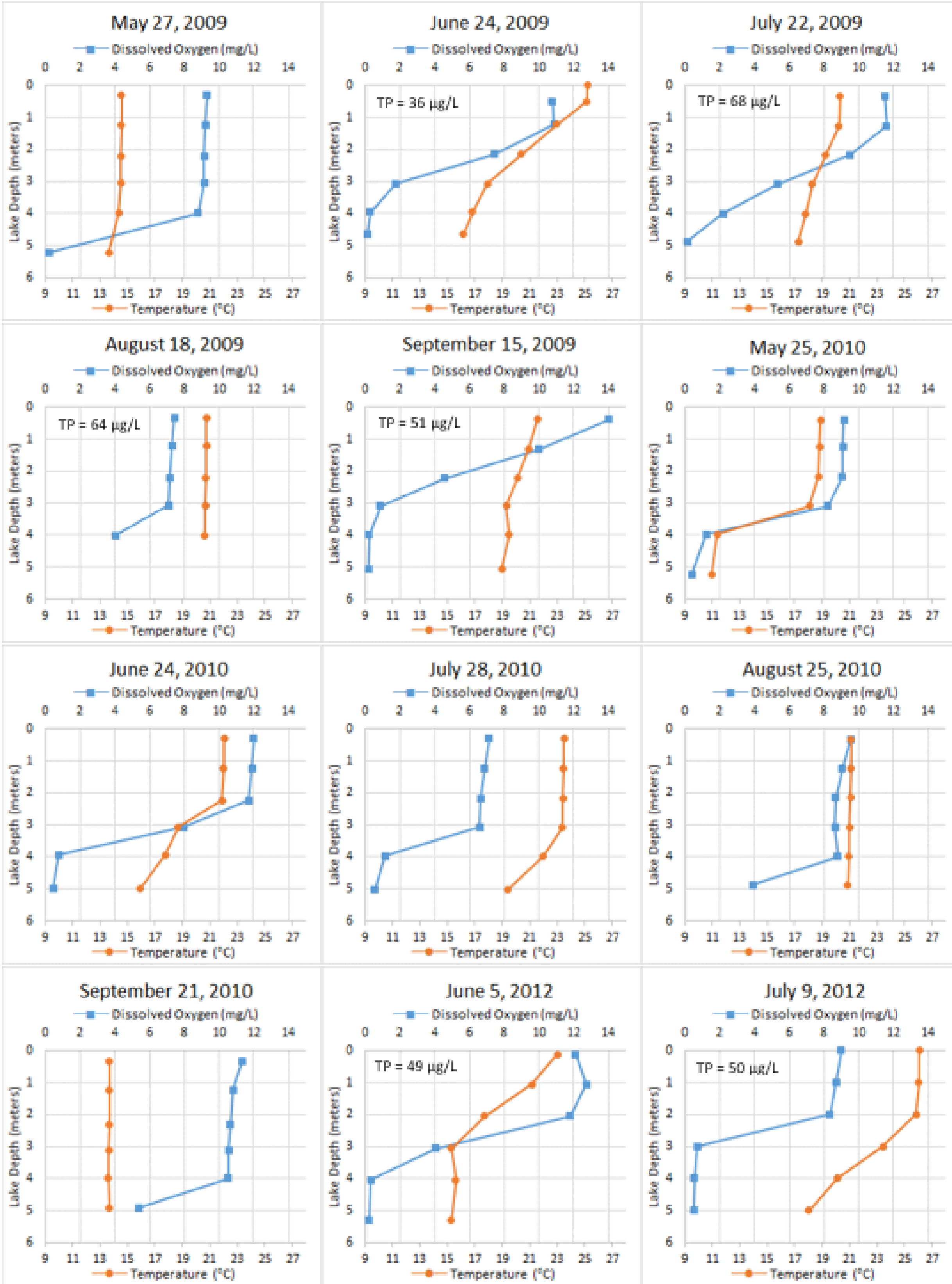
Overland runoff coupled with the high percentage of straightened stream channels, agricultural land use, loss of wetlands, and tiling – jointly indicating an altered hydrology – increases the conveyance of phosphorus from the landscape to waterbodies after it is mobilized from soils.

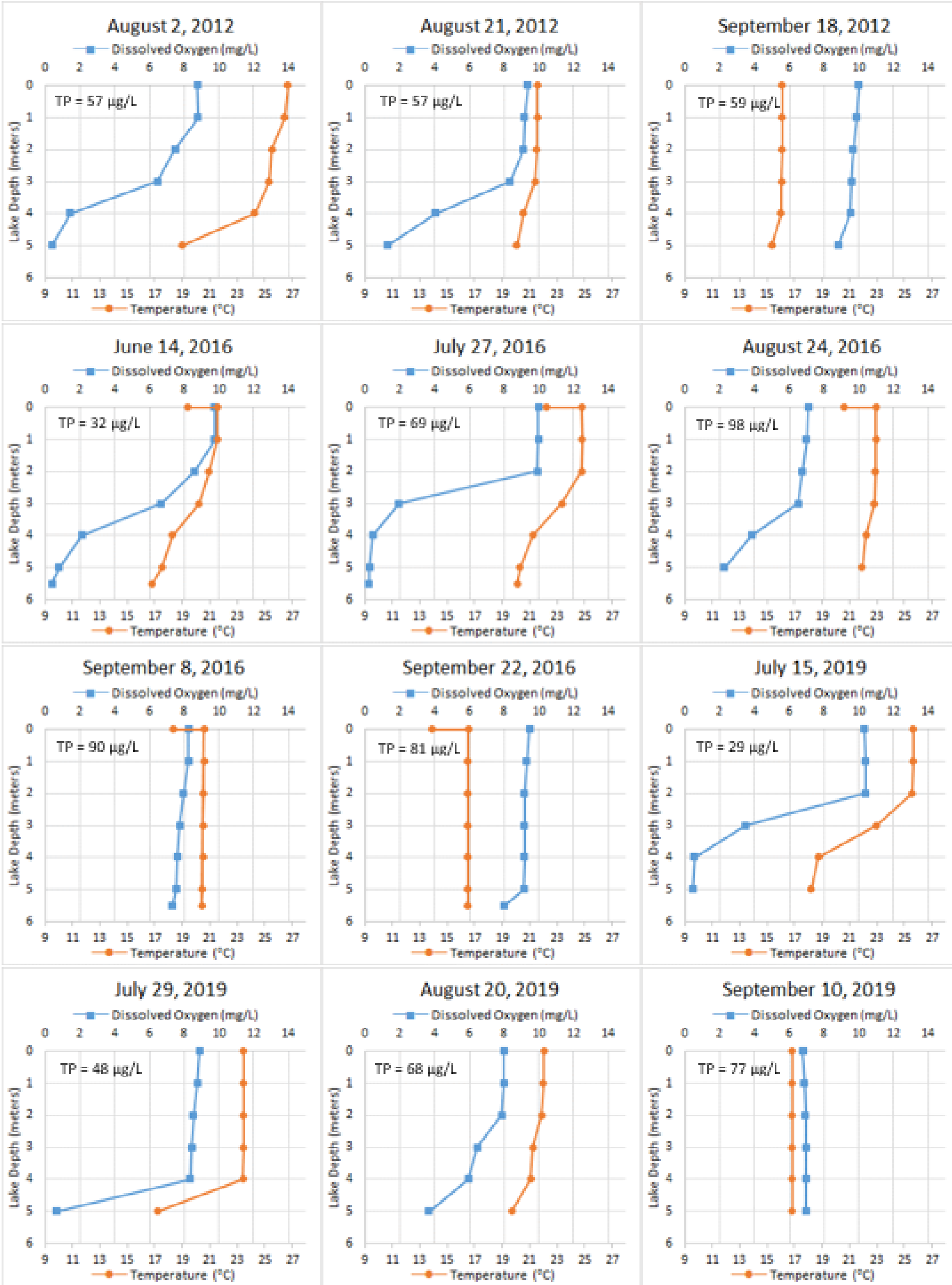
Stream Bank Erosion – Streams can convey water at high velocity and with significant energy during large precipitation events or during snow melt. Changes to the amount of water conveyed by drainage systems, channel widening, and channel straightening further increase stream energy in many streams. The removal of natural vegetation or buffers decreases the stress stream banks can withstand prior to eroding, which can further increase erosion and bank instability.

Internal Load – Internal loading is the release of TP from sediments, usually due to anoxic conditions (DO concentrations < 2.0 mg/L) near the bed of the lake. When a lake undergoes mixing, the water from the bottom of the lake that has high TP due to anoxia gets mixed with water from the rest of the lake, increasing TP concentrations in water samples taken from near the surface of the lake. Internal phosphorus loading can be a substantial part of the mass balance in a lake, especially in lakes with a history of high phosphorus loads. If a lake has a long history of high phosphorus concentrations, it is possible to have internal loading rates higher than external loads. The disturbance of sediment on a lake bottom from carp and other bottom-feeding fish can also lead to the release of phosphorus to the surface water.

To investigate if anoxic conditions are contributing to internal loading in Rockstad Lake, DO and temperature depth profiles were created and are shown in **Figure 26** (a TP result is noted in each profile if sampled the same day). Profiles from September 18, 2012, September 8, 2016, September 22, 2016, and September 10, 2019, show examples of when the lake was fully mixed (i.e., not stratified) and TP concentrations were 59, 90, 81, and 77 µg/L, respectively. Rockstad Lake was most stratified on June 24, 2009, July 22, 2009, September 15, 2009, August 2, 2012, and June 14, 2016, and TP concentrations were 36, 68, 51, 57, and 32 µg/L, respectively. The average TP concentration with the lake was fully mixed and most stratified was 77 and 49 µg/L, respectively, showing that there is internal loading in Rockstad Lake. As will be discussed later in **Section 4.2.1.1**, BATHTUB modeling shows that Rockstad Lake exhibits internal loading roughly equal to that which is intrinsically calculated in the model.

Figure 26. Dissolved oxygen and temperature depth profiles with TP (if available) for Rockstad Lake.





SSTS – A source of phosphorus is SSTS, even those that are compliant and operating correctly. Noncompliant SSTS that are ITPHS can result in an even greater transfer of phosphorus to surface waters. Google Earth imagery from July 29, 2019, showed an estimated 23 households within the drainage area of Rockstad Lake, 6 of which are within 300 yards of Rockstad Lake's shoreline (MPCA, 2007). Those six households were considered in estimating inflow and phosphorus loading to Rockstad Lake from SSTS. Since 1% and 15% of SSTS in Clearwater County (which encompasses the drainage area of Rockstad Lake) are ITPHS and failing (meaning the SSTS fails to protect groundwater), respectively, none of the 6 SSTS are considered ITPHS, 1 is assumed to be failing, and 5 are assumed to be compliant.

Clearwater County continues to improve SSTS assessment and conduct outreach to the public to inform them regarding system maintenance

Atmospheric Deposition – Atmospheric deposition to the surface of lakes can include pollen, soil (aeolian particulates), oil, coal particulate matter, and fertilizers. Regional phosphorus loading for the region is modeled to be 26.1 kg/km^2/year (Barr Engineering, 2007).

Natural Background Sources – "Natural background" is defined in both Minnesota statute and rule. The CWLA (Minn. Stat. § 114D.15, subd. 10) defines natural background as "characteristics of the waterbody resulting from the multiplicity of factors in nature, including climate and ecosystem dynamics, that affect the physical, chemical, or biological conditions in a waterbody, but does not include measurable and distinguishable pollution that is attributable to human activity or influence." Minn. R. 7050.0150, subp. 4 states, "'Natural causes' means the multiplicity of factors that determine the physical, chemical, or biological conditions that would exist in a waterbody in the absence of measurable impacts from human activity or influence."

Natural background sources are inputs that would be expected under natural, undisturbed conditions. Natural background sources of phosphorus can include inputs from natural geologic processes such as phosphorus-bound sediment from upland erosion, atmospheric deposition, and loading from forested land, wildlife, etc. However, natural background levels are implicitly incorporated in the water quality standards used by the MPCA to determine/assess impairment, and therefore natural background is accounted for and addressed through the MPCA's waterbody assessment process. Natural background conditions have been evaluated within the pollutant source summaries above. These source summaries indicate that natural background inputs are generally low compared to livestock, WWTPs, noncompliant SSTSs, and other anthropogenic sources.

Based on the MPCA's waterbody assessment process and the TMDL source assessment exercises, there is no evidence at this time to suggest that natural background sources are a major driver of high phosphorus in Rockstad Lake and/or affect the lake's ability to meet state water quality standards.

4. TMDL development

A waterbody's TMDL represents the LC, or the amount of pollutant that a waterbody can assimilate while still meeting water quality standards. The LC is allocated to the waterbody's pollutant sources and an MOS, the sum of which cannot exceed the LC, or TMDL as shown in the following equation:

$$TMDL = LC = \sum WLA + \sum LA + MOS$$

Where:

LC = loading capacity, or the greatest amount of a pollutant a waterbody can receive and still meet water quality standards (see **Section 4.1.3.1**, **4.1.4.1**, and **4.2.1.1**);

WLA = wasteload allocation, or the portion of the LC allocated to existing or future NPDES/SDS-permitted point sources (see **Section 4.1.3.3**, **4.1.4.3**, and **4.2.1.3**);

LA = load allocation, or the portion of the LC allocated for existing or future NPS including natural background (see **Section 4.1.3.2**, **4.1.4.2**, and **4.2.1.2**);

MOS = margin of safety, or accounting for any uncertainty associated with attaining the water quality standard. The MOS may be explicitly stated as an added, separate quantity in the TMDL calculation or may be implicit, as in a conservative assumption (EPA, 2007) (see **Section 4.1.3.5**, **4.1.4.5**, and **4.2.1.4**).

As stated in the Code of Federal Regulations (40 CFR 130.2(i)), TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures. For this TMDL report, the TMDLs, allocations, and margins of safety are expressed in mass/day. Discussion of each TMDL component as it applies to each pollutant is discussed in greater detail in **Section 4.1.3**, **4.1.4**, and **4.2.1**.

4.1 Streams

4.1.1 Data Sources

4.1.1.1 Hydrological Simulation Program–Fortran

The HSPF model is a comprehensive package for simulation of watershed hydrology, sediment transportation, and water quality for conventional and toxic organic pollutants. HSPF incorporates watershed-scale Agricultural Runoff Model (ARM) and NPS models into a basin-scale analysis framework that includes fate and transport in one dimensional stream channels. It is a comprehensive model of watershed hydrology and water quality that allows the integrated simulation of point sources, land and soil contaminant runoff processes with in-stream hydraulic and sediment-chemical interactions. The result of this simulation is a time history of the runoff flow rate, sediment load, and nutrient and pesticide concentrations, along with a time history of water quantity and quality at the outlet of any subwatershed.

4.1.1.2 Environmental Quality Information Systems

The MPCA uses a database called EQuIS to store water quality data from more than 17,000 sampling locations across the state. EQuIS contains information from Minnesota streams and lakes dating back to 1926. All discrete water quality sampling data used for assessments and data analysis for this TMDL report are stored in an accessible database called EDA (MPCA, 2020).

4.1.2 Data

Flow data and water quality data are two important components in the development of the TMDLs. Observed daily flow data from flow stations were available for 4 of the 13 AUIDs, while flow data was simulated by the HSPF model for the remaining 9 AUIDs. Observed flow data for months when standards apply (April through October for *E. coli* and April through September for TSS) from years 2007 through 2016, and simulated flow data for months when standards apply from years 1996 through 2009 were used to develop the TMDLs. The water quality data were obtained from the MPCA through EDA. Ten years of water quality data (2007 through 2016) during the months when standards applied were used to determine observed loads and reductions for each TMDL. **Table 14** provides a list of the flow stations and water quality stations used to develop the LDCs and their locations can be found in **Figure 7** through **Figure 19**.

Table 14. Flow and water quality monitoring sites with data from 2007 through 2016 used for TMDL development for streams in the WRRW.

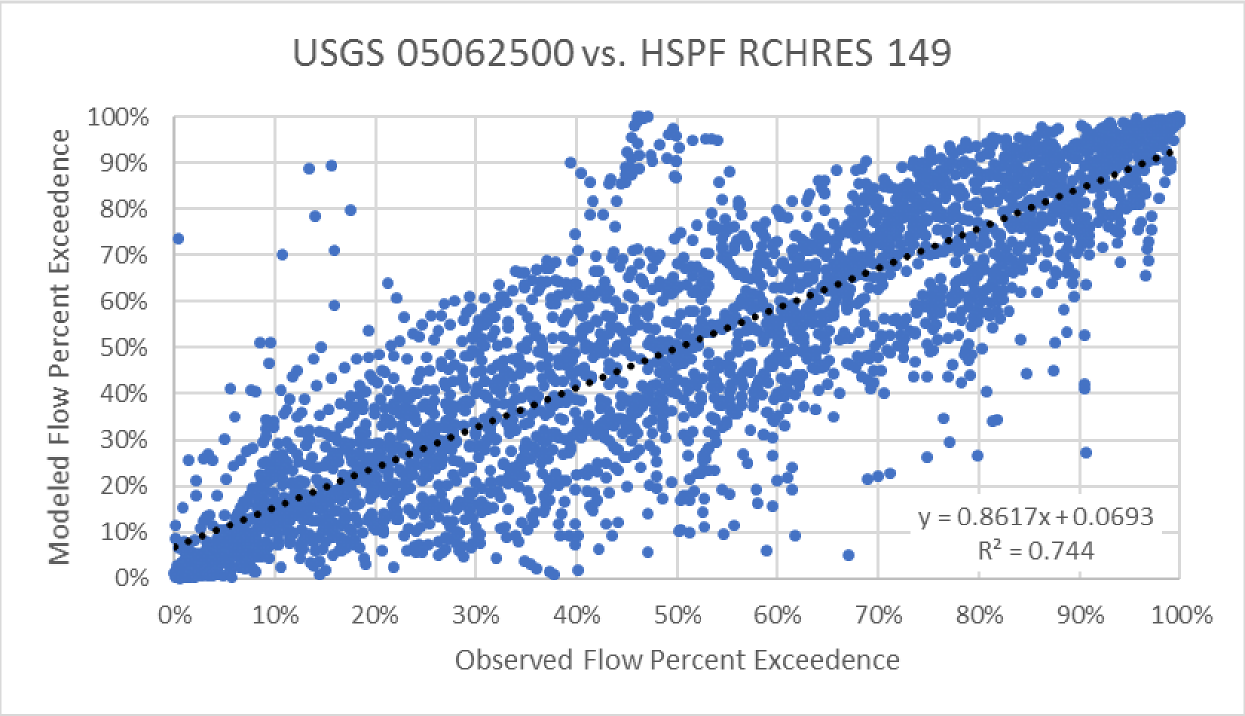
AUID (09020108-###)	Pollutant	Flow Station (USGS, DNR, or HSPF reach or reservoir ID)	Water Quality Stations with TSS and/or *E. coli* data
-501	Turbidity (TSS)	DNR 60112001 USGS 05064000	S000-216, S002-102
-504	TSS	HSPF RCHRES 150	S006-197, S007-619
-544	*E. coli*	HSPF RCHRES 289	S003-157
-546	*E. coli*	HSPF RCHRES 185	S007-791
-553	*E. coli*	HSPF RCHRES 631	S006-194
-577	*E. coli*	HSPF RCHRES 289	S006-193
-643	*E. coli*, Turbidity (TSS)	DNR 60088001 USGS 05062500	S001-155
-644	*E. coli*, Turbidity (TSS)	DNR 60099001 USGS 05063000	S004-201, S004-864
-648	*E. coli*	HSPF RCHRES 149	S003-161, S006-199
-650	*E. coli*	HSPF RCHRES 249	S003-159, S006-195, S007-793
-652	Turbidity (TSS)	HSPF RCHRES 165	S002-110, S007-789
-659	*E. coli*	DNR 60124001 USGS 05063398	S003-164, S007-787
-662	*E. coli*	HSPF RCHRES 511	S003-165, S003-308

4.1.2.1 Flow Transfer

Because the HSPF model was developed to simulate flows for 1995 through 2009 (note that flows from 1995 were not used in the development of TMDLs) and a significant amount of water quality data was measured after 2009, a flow transfer was necessary to include as much data as possible, and in some cases, to include the only available water quality data. A flow transfer is where a relationship is developed between the insufficient flow record in the impaired reach and sufficient flow record near the impaired reach in order to extrapolate the missing data.

For the LDCs in the WRRW with no flow data after 2009, flow transfers were conducted using the observed record from four flow gages where the flow record has sufficient data within the modeling period (1996 through 2009) and beyond (2010 through 2016). To ensure the flow conditions are captured and to limit the influence of magnitude differences in the flow records, the distributions of the flows were compared using the percent exceedances of the flows and a linear relationship was developed. As an example, **Figure 27** shows the relationship between the percent exceedances of the observed record and modeled flow for AUID -648.

Figure 27. Example of the flow transfer relationship between observed flow (USGS 05062500) and modeled flow (HSPF RCHRES 149) for AUID -648.



The linear relationships from the trendlines were used to transform flows in the observed record for days of observed water quality data to extrapolate a flow where simulated flow was not available. It should be noted, the LDCs were created using the available flow record and the flow transfers were used to develop the existing load based on the observed water quality data. **Table 15** shows the regression equations developed and used for the LDCs in the WRRW.

Table 15. Flow transfer regression information used to develop LDCs.

AUID	HSPF Reach or Reservoir ID	Transfer Flow Site	Transfer Equation [a]	R^2
09020108-504	150	DNR 60088001 USGS 05062500	%Model = 0.8544*%Obs+0.0691	0.75
09020108-544	289	DNR 60099001 USGS 05063000	%Model = 0.5546*%Obs+0.2151	0.33
09020108-546	185	DNR 60088001 USGS 05062500	%Model = 0.6326*%Obs+0.1843	0.40
09020108-553	631	DNR 60112001 USGS 05064000	%Model = 0.6433*%Obs+0.1787	0.41
09020108-577	289	DNR 60099001 USGS 05063000	%Model = 0.5546*%Obs+0.2151	0.33
09020108-648	149	DNR 60088001 USGS 05062500	%Model = 0.8617*%Obs+0.0693	0.74

AUID	HSPF Reach or Reservoir ID	Transfer Flow Site	Transfer Equation [a]	R^2
09020108-650	249	DNR 60088001 USGS 05062500	%Model = 0.8584*%Obs+0.071	0.74
09020108-652	165	DNR 60088001 USGS 05062500	%Model = 0.8565*%Obs+0.068	0.75
09020108-662	511	DNR 60124001 USGS 05063398	%Model = 0.8059*%Obs+0.0969	0.66

[a] %Model = the percent exceedance of the model flow and %Obs = the percent exceedance of the observed flow.

4.1.3 *Escherichia coli*

4.1.3.1 Loading capacity methodology

The LC is the greatest amount of a pollutant a waterbody can receive and still meet the water quality standard. The loading capacities for impaired stream reaches in the WRRW were determined using the LDC approach. An LDC is developed by combining the (simulated or observed) river/stream flow as close to the downstream end of the AUID as possible with the observed/measured *E. coli* data available within the segment. Two of the AUIDs (-544 and -577) have the same loading capacities based on simulated flow, because they are both located within the same HSPF subbasin (the downstream end of -544 is the outlet of the subbasin and -577 is located 2.26 river miles upstream of -544). Note that none of the locations where observed or simulated flows were determined are located within tribal reservation boundaries. Methods detailed in the EPA document *An Approach for Using Load Duration Curves in the Development of TMDLs* were used in creating the curves (EPA, 2007).

A system's water quality often varies based on flow regime, with elevated pollutant loadings sometimes occurring more frequently under one flow zone or another. To represent different types of flow events and pollutant loading during these events, five flow zones were identified based on percent exceedance: Very High Flow (0% to 10%), High Flow (10% to 40%), Mid Flow (40% to 60%), Low Flow (60% to 90%), and Very Low Flow (90% to 100%). Loading dynamics during certain flow zones can be indicative of the type of pollutant source causing an exceedance (e.g., point sources contributing more loading under the lowest flow zones). The LDC approach identifies the LC for the flow regime (brown curved line in **Figure 28** through **Figure 37**) and presents the median LC for five flow zones (red dashed lines in **Figure 28** through **Figure 37**).

Benefits of LDC analysis include: (1) the loading capacities are calculated for multiple flow zones, not just a single point; (2) use of the method helps identify specific flow zones and hydrologic processes/patterns where loading may be a concern; and (3) ensuring that the applicable water quality standards are protective across all flow zones. Some limitations with the LDC approach exist: (1) the approach is limited in the ability to track individual loadings or relative source contributions and (2) the method is most appropriate when a correlation between flow and water quality exists and flow is the driving force behind pollutant delivery mechanics.

The LDC method is based on an analysis that encompasses the cumulative frequency of historical flow data over a specified period. Because this method uses a long-term record of daily flow volumes, virtually the full spectrum of allowable loading capacities is represented by the resulting curve. In the *E. coli* TMDL allocation tables of this report (**Table 20** through **Table 29**), only five points on the entire LC curve are depicted (the midpoints of the designated flow zones). However, it should be understood that the entire curve represents the TMDL, and it is what the EPA ultimately approves.

Table 16 provides the methodology to convert flows and concentrations to *E. coli* loads. The LC was calculated using the geometric mean (i.e., geomean) standard of 126 organisms/100 mL and was used in the development of the TMDL summary tables. The water quality standard for *E. coli* applies during April to October. Loads are calculated as organisms per day (org/day) and reported as billions of organisms per day.

Table 16. Converting flow and concentration into *E. coli* load.

Load (org/day) = *E. coli* Standard (organisms/100mL) * Flow (cfs) * Factor			
Multiply by **28.316** to convert	ft^3 per second	→	L/sec
Multiply by **1000** to convert	liters per second	→	mL/sec
Divide by **100** to convert	milliliters per second	→	organisms/sec
Multiply by **86,400** to convert	organisms per second	→	organisms/day

Boundary Conditions

Six AUIDs with *E. coli* TMDLs (-546, -643, -644, -648, -659, and -662) have drainage area within White Earth Reservation, so the LCs for tribal land are included for these AUIDs as BCs, and no reductions are assigned to the tribal land. The BC allocated to tribal runoff is based on the amount of tribal government land located in the drainage area of the impaired stream reach. For example, AUID -546 has a total drainage area of 60.6 square miles, 29.0 square miles (47.9%) of which are located within White Earth Reservation. Thus, 47.9% of the total LC for each flow zone is allocated to the BC. It is understood that the MPCA has no jurisdiction on tribal lands and that the EPA will not approve the part of a TMDL that is located within the boundaries of tribal lands.

Included in the BCs are the permitted *E. coli* loads from eight WWTPs in the WRRW that are located on tribal land. Four of these WWTPs have been issued NPDES permits by EPA, but do not have Minnesota SDS permits, while the other four are NPDES/SDS-permitted. *E. coli* loadings from these facilities located on tribal land are shown in **Table 17**.

Table 17. Upstream wastewater facility *E. coli* loads that are included in boundary conditions.

		A	B	C	
Facility (permit number)	**Downstream impaired AUIDs addressed with *E. coli* TMDLs in this report**	**Size(s) of secondary pond(s) (acres)**	**Permitted maximum daily discharge (liters/day) (=A*0.5*1233480.22)**	**Maximum allowed *E. coli* concentration (org/100 mL)**	**Daily *E. coli* load (10^9 org/day) =B*(C*10)/10^9)**
Bejou WWTP (MNT064688) [a]	643, 644	0.92	567,401	126	**0.7149**
Big Rice Lake Wastewater Lagoon (MN-0068438-3) [b]	643, 644	1.3	801,762	126	**1.0102**
Chippewa Ranch Wastewater Stabilization Lagoon (MN-0059404-5) [b]	643, 644	0.95	585,903	126	**0.7382**

		A	B	C	
Facility (permit number)	Downstream impaired AUIDs addressed with *E. coli* TMDLs in this report	Size(s) of secondary pond(s) (acres)	Permitted maximum daily discharge (liters/day) (=A*0.5*1233480.22)	Maximum allowed *E. coli* concentration (org/100 mL)	Daily *E. coli* load (10^9 org/day) =B*(C*10)/10^9
Mahnomen WWTP (MNT024066) [a]	643, 644	6.4	3,947,137	126	**19.7382**
		19	11,718,062		
Nay-Tah-Waush Wastewater Stabilization Lagoon (MN-0064154-4) [b]	643, 644	3	1,850,220	126	**4.6626**
		3	1,850,220		
Ogema WWTP (MNT049794) [a]	659, 662	1.27	783,260	126	**0.9869**
Waubun WWTP (MNT022110) [a]	643, 644, 648	3.86	2,380,617	126	**2.9996**
White Earth Wastewater Stabilization Lagoon (MN-0064173-4) [b]	659, 662	1.5	925,110	126	**1.1656**

[a] Facility has both an NPDES permit issued by EPA and an SDS permit issued by Minnesota.

[b] Facility has an NPDES permit issued by EPA.

4.1.3.2 Load allocation methodology

The LA represents the portion of the LC designated for NPS of *E. coli*. The LA is the remaining load once the WLA and MOS are determined and subtracted from the LC. The LA includes all sources of *E. coli* that do not require NPDES/SDS permit coverage, including unregulated watershed runoff of fecal contaminants from animal feedlots, pastures, agricultural fields, wildlife, and pets; direct fecal contamination by livestock, wildlife, and pets with access to waterbodies; noncompliant SSTSs that are IPHTs; and a consideration for natural background conditions. Natural background or “natural causes”, as defined in Minn. R. 7050.0150, subp. 4 (2017), can be described as physical, chemical, or biological conditions that would exist in a waterbody that are not a result of human activity. NPS of *E. coli* are discussed in **Section 3.6.1.2**.

4.1.3.3 Wasteload allocations methodology

WLAs represent the regulated portion of the LC and are developed for any NPDES/SDS-permitted facilities (also known as point sources) in the drainage area of an impaired reach. Regulated sources may include facilities that discharge domestic or industrial wastewater, construction stormwater, industrial stormwater, MS4 permitted areas, and CAFOs. The only regulated sources of *E. coli* in the drainage areas of AUIDs with *E. coli* TMDLs are domestic WWTPs and CAFOs. While there is stormwater as a result of permitted construction and industrial activities, see below for an explanation of why WLAs were not developed for stormwater.

Wastewater Treatment Plants

Domestic WWTPs are NPDES/SDS-permitted facilities that process primarily wastewater from domestic sanitary sewer sources (sewage). Pond facilities include city or sanitary district treatment facilities, wayside rest areas, or national or state parks and are limited to controlled discharge typically from a single secondary treatment pond. All pond WWTPs are permitted to discharge only during specified discharge windows in the spring and fall. The discharge windows for pond WWTPs in the WRRW are March 1 through June 30 and September 1 through December 31 with no discharge to ice covered waters.

There are four NPDES/SDS-permitted, domestic WWTPs that are within the drainage areas of AUIDs with *E. coli* TMDLs but not located on tribal land. Specifically, they are municipal WWTPs because they treat wastewater from municipalities. All four of these are Class D pond facilities, each with one or two primary pond cell(s) and one secondary pond cell(s). *E. coli* WLAs for these four WWTPs are based on the maximum daily discharge of six inches per day from the secondary pond(s) and the *E. coli* geomean water quality standard. Although surface water quality is now based on *E. coli*, WWTPs are permitted based on fecal coliform concentrations. Like *E. coli*, fecal coliform are indicators of fecal contamination. The primary function of a bacterial effluent limit is to ensure that the effluent is being adequately treated, either naturally (sunlight) or with a disinfectant, to ensure a complete or near-complete kill of fecal bacteria prior to discharge. The WWTPs, permit numbers, permitted flows, and *E. coli* WLAs are provided in **Table 18**. The permit limits for fecal coliform that are already assigned to these WWTPs are consistent with the WLAs assigned in this report's *E. coli* TMDLs.

Table 18. Calculations of *E. coli* WLAs for NPDES/SDS-permitted, domestic wastewater facilities draining within watersheds of reaches addressed with *E. coli* TMDLs in this report.

				A	B	C	D	E	F	
Facility (NPDES/SDS permit number)	**Receiving water (09020108-###)** [a]	**Downstream impaired AUIDs addressed with *E. coli* TMDLs in this report**	**Average wet weather design flow (mgd)**	**Size(s) of secondary pond(s) (acres)**	**Mean operating depth of A (feet)**	**Permitted maximum daily discharge (liters/day) (=A*0.5*1233480.22)** [d]	**# of days discharging per year at maximum rate ((B/0.5)*2)**	**Maximum allowed *E. coli* concentration (org/100 mL)**	**Daily *E. coli* WLA (10^9 org/day) =C*(E*10)/10^9)**	**Annual *E. coli* WLA (10^9 org/year) (=F*D)**
Borup WWTP (MN0022853)	Unassessed (999) [b]	659	0.02	0.83	3	511,894	12	126	**0.6450**	7.7398
Gary WWTP (MNG585175)	CD 75 (583)	643, 644, 650	0.028	1.5	4	925,110	16	126	**1.1656**	18.6502
Twin Valley WWTP (MNG585137)	Unassessed (999) [c]	643, 644	0.147	5.5	4	3,392,071	16	126	**4.2740**	68.3841
Ulen WWTP (MNG585088)	Wild Rice R, SB (662)	659, 662	0.113	5.25	4	3,237,886	16	126	**4.0797**	65.2758

[a] R=River, CD=County Ditch, SB=South Branch.

[b] After effluent enters the unassessed reach (-999), it flows into CD 10 (-517) approximately 50 feet further downstream.

[c] After effluent enters the unassessed reach (-999), it flows into Wild Rice River (-643) approximately 0.7 miles downstream.

[d] Calculated based on the acreage of the secondary treatment pond and a maximum discharge of six inches per day.

Construction and Industrial Stormwater

WLAs for activities covered under the Construction Stormwater General Permit (MNR100001) were not developed for *E. coli*, since *E. coli* is not a typical pollutant associated with construction sites. Industrial stormwater receives a WLA only if fecal bacteria is part of benchmark monitoring for an industrial site in the drainage area of an impaired waterbody. There are no fecal bacteria benchmarks associated with any Industrial Stormwater General Permit (MNR050000) in the watershed. Therefore, no industrial stormwater *E. coli* WLAs were assigned.

Municipal Separation Storm Sewer System

There are no NPDES/SDS-permitted MS4s in the drainage areas of the *E. coli*-impaired reaches.

NPDES/SDS-permitted animal feedlots

There are four NPDES/SDS-permitted CAFOs in the WRRW, all of which have greater than 1,000 AUs and are located within the drainage area of at least one impaired stream with an *E. coli* TMDL in this report. WLAs are not assigned to these four NPDES/SDS-permitted animal feedlots (this is equivalent to a WLA of zero), because CAFOs and animal feedlots with 1,000 or more AUs must be designed to contain all manure and manure contaminated runoff from precipitation events of equal to or less than a 25-year, 24-hour storm event. Having and complying with an NPDES/SDS permit allows some enforcement protection if a facility discharges due to a 25-year, 24-hour precipitation event (approximately 4.85 inches in the WRRW) (NOAA, 2017), and the discharge does not contribute to a water quality impairment. A current manure management plan that complies with Minn. R. 7020.2225 and the respective permit is required for all CAFOs and animal feedlots with 1,000 or more AUs.

All other non-CAFO feedlots and the land application of all manure are accounted for in the LA for nonpermitted sources.

4.1.3.4 WLAs during low flows

The total daily LC of some stream reaches during low and very low flow zones are very small due to the occurrence of very low flows in the stream/river. Consequently, for some of the impaired reaches the permitted wastewater design discharge is close to or higher than the streamflow during these flow zones. This translates to these point sources appearing to use all of, or exceeding, the LC during these flow periods. In reality, this will never occur as the discharge is a part of the streamflow, so it can never exceed total streamflow. To account for these unique situations, the WLA is expressed as an equation rather than an absolute number. The equation is:

Wasteload Allocation = Point Source Discharge X Water Quality Standard Concentration

Consistent units are used to obtain the load. This assigns a concentration-based limit to the WLA for these lower flow rates.

4.1.3.5 Margin of safety

The MOS accounts for uncertainty concerning the relationship between LAs and WLAs and water quality. The MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as a load set aside).

There is some implicit MOS for each *E. coli* TMDL, because no rate of decay or die-off rate was used in TMDL calculations or in the creation of LDCs. *E. coli* have limited capability of surviving outside of a host, so normally a rate of decay would be incorporated. However, with so many factors affecting the survival of *E. coli* (e.g., sunlight, temperature, salinity, nutrient levels, regrowth, whether the *E. coli is* naturalized, etc.), determining a rate of decay that accurately represents actual conditions is difficult. This contributed to the decision to take the conservative approach by not including a rate of decay.

There is also an explicit MOS which is 10% of the LC; it was applied to each flow zone for each of the *E. coli* TMDLs. In general, the explicit MOS accounts for:

- Uncertainty in the observed daily flow record;
- Uncertainty in simulated flow data from the HSPF model;
- Uncertainty in the observed water quality data; and
- Uncertainty with natural background levels, die-off rates, and regrowth rates.

Some specific activities where human or mechanical error may occur is during data collection, lab analysis, and data analysis.

Most of the MOS is apportioned to uncertainty in the simulated flow data from the HSPF model, so it is apt that the explicit MOS of 10% is supported by the calibration statistics for the WRRW HSPF model (**Table 19**). The average of all 14 error percentages in **Table 19** is -8.68% and the median is -8.2%. The model fit efficiencies for the two flow stations in **Table 19** is 0.726 and 0.741, which were determined to be “good”. Overall, the WRRW HSPF model was rated “good”. More information on the calibration of the WRRW HSPF model can be found in the technical memorandum: *Wild Rice and Marsh Rivers HSPF Model Hydrologic Calibration* (Houston Engineering, Inc, 2015).

Table 19: Hydrologic calibration statistics for the Wild Rice River Watershed HSPF model.

Weight-of-evidence criteria	USGS flow station (HSPF reach or reservoir ID)	
	05062500 (190) [a]	05064000 (730) [b]
Error in total volume	-3.5%	-6.6%
Error in 10% highest flows	-3.3%	-21.1%
Error in 25% highest flows	-8.1%	-12.6%
Error in 50% highest flows	-5.4%	-8.3%
Error in 50% lowest flows	11.3%	9.7%
Error in 25% lowest flows	-15.6%	-15.2%
Error in 10% lowest flows	-24.2%	-18.6%
Model fit efficiency (Nash-Sutcliffe)	0.726	0.741

[a] located at Twin Valley, MN along AUID 643 (Wild Rice River from Marsh Creek to Unnamed creek)

[b] Located at Hendrum, MN along AUID 501 (Wild Rice River from South Branch Wild Rice River to Red River)

4.1.3.6 Seasonal variation and critical conditions

Monthly geometric means for *E. coli* within the impaired reaches are often above the state chronic standard from April through October (**Table 9**). Exceedances of the SSM part of the standard also occurred in several reaches during this time period (**Table 9**). Fecal bacteria are most productive at temperatures similar to their origination environment in animal digestive tracts. Thus, these organisms are expected to be at their highest concentrations during warmer summer months when stream flow is low and water temperatures are high. High *E. coli* concentrations in many reaches continue into the fall, which may be attributed to constant sources of *E. coli* (such as failing SSTS and animal access to the stream) and less flow for dilution. However, some of the data may be skewed as more samples were collected in the summer months (especially June, July, and August) than in the fall. Seasonal and annual variations are accounted for by setting the TMDL across the entire flow record (during the months when the *E. coli* standards apply) and dividing it in five flow zones using the LDC method.

The critical condition for each *E. coli* TMDL is the flow zone that requires the greatest percent reduction in *E. coli* loading. It should be noted that not all flow zones for each *E. coli* TMDL have data available to estimate observed load. Thus, the critical conditions are for flow zones where observed data exists. It is unknown how much of a reduction, if any, would be required in flow zones had there been observed data available or if any of those flow zones would have been a critical condition.

4.1.3.7 Baseline year

The baseline year for each *E. coli* TMDL is the midpoint of the 10-year period that was used to describe current conditions for each stream; since 10 years is an even number, 2 years make up the baseline. Data from years 2007 through 2016 were used, so the baseline years are 2011 through 2012.

4.1.3.8 Percent reduction

The estimated percent reductions provide a rough approximation of the overall reduction needed for the waterbody to meet the TMDL. The percent reduction is a means to capture the level of effort needed to reduce *E. coli* concentrations and loads in the watershed. The percent reductions should not be construed to mean that each of the separate sources listed in the TMDL table needs to be reduced by that amount.

Percent reductions were calculated in two different ways for each *E. coli* TMDL. One way was to calculate them based on the LDC flow zones. For each observed *E. coli* datum collected between April through October during 2007 through 2016, the average flow (simulated or observed) for the day the sample was taken was determined (often using flow transfer as described in **Section 4.1.2.1**) and the percent exceedance of that flow was determined to identify within which flow zone the datum belongs. The geometric mean of all observed data within a flow zone was calculated, then multiplied by the median flow, and lastly, converted to the observed load (blue solid lines in **Figure 28** through **Figure 37**). The observed load was compared to the LC for that flow zone and if the observed load was higher, the percentage that the observed load needs to be reduced to meet the LC was calculated. An overall observed concentration was also determined. This overall observed concentration is one number (versus five numbers from the LDC method) that can be used to set goals for planning purposes. It is the highest observed monthly geometric mean from the months that the standard applies using *E. coli* concentration data from 2007 through 2016. Five or more samples were needed in a month to be considered the highest observed monthly geometric mean. The overall estimated percent reduction is how much the overall observed concentration needs to be reduced to meet the numeric standard concentration of 126 org/100 mL.

4.1.3.9 TMDL summary

The TMDL results are provided below. For each TMDL, a figure of the LDC is provided, followed by the TMDL table with the LC, WLAs, LA, MOS, observed load (if available), and estimated percent reduction (if available) identified by flow zone. If the WLA requires a flow-concentration relationship (see **Section 4.1.3.4**) for low flows it is identified by "***". In addition, the overall observed concentration and overall estimated percent reduction needed to meet the water quality standard is also provided.

The following rounding conventions were used in the TMDL summary tables (mass refers to billions of organisms for *E. coli*):

- Values ≥10 reported in mass/day have been rounded to the nearest whole number (billion).
- Values <10 and ≥1 reported in mass/day have been rounded to the nearest tenth.
- Values <1.0 reported in mass/day have been rounded to the nearest hundredth or so that at least two significant digits are displayed.

The only exceptions to the rounding conventions may be the LCs for TMDLs with BCs, total WLAs, and total LAs. For each TMDL with a BC, the total LC, BC (White Earth Nation LC), and Minnesota LC follow the same rounding convention as the LC with the smallest value. The total WLA is the sum of all individual WLAs and the total LA is what is left after subtracting the MOS and total LA from the LC, thus they may not follow the rounding conventions.

Coon Creek, unnamed creek to Wild Rice River (AUID 09020108-544)

Figure 28. *E. coli* LDC for Coon Creek, unnamed creek to Wild Rice River (AUID 09020108-544).

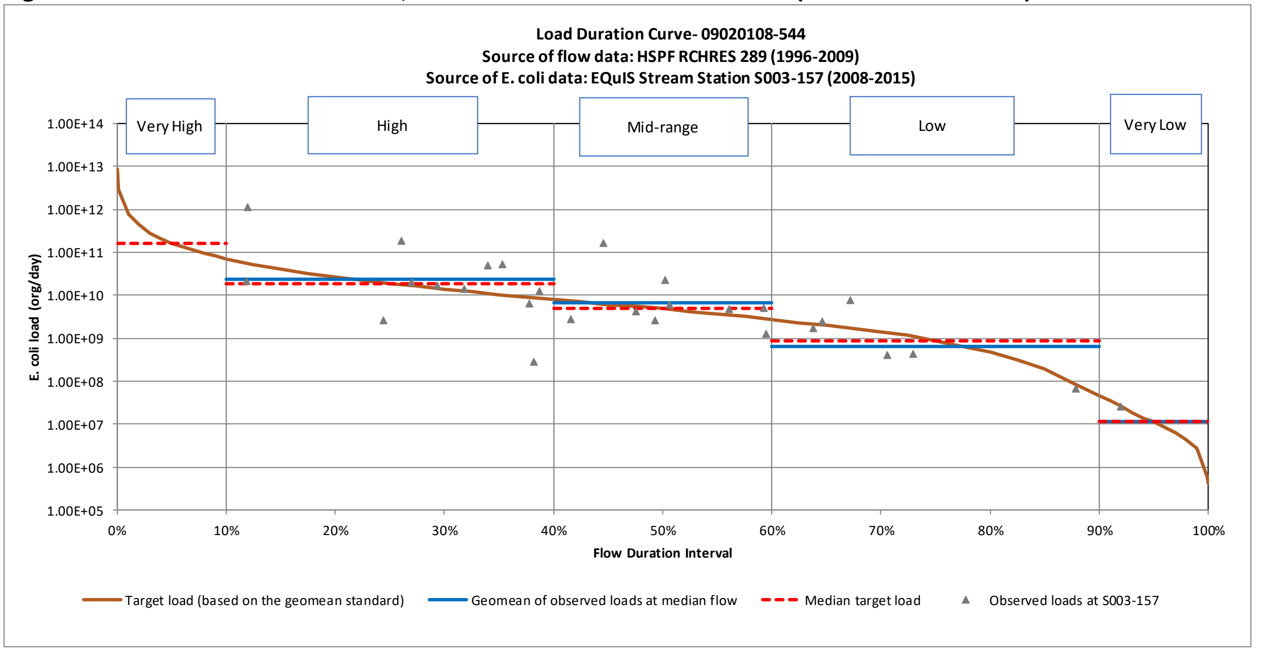


Table 20. *E. coli* TMDL summary for Coon Creek, unnamed creek to Wild Rice River (AUID 09020108-544).

- Listing year: 2018
- Baseline year(s): 2011-2012
- Numeric standard used to calculate TMDL: 126 *E. coli* org/100 mL
- TMDL and allocations apply April through October

E. coli		Flow zone				
		Very High	**High**	**Mid-Range**	**Low**	**Very Low**
		[Billion org/day]				
Total Loading Capacity		**163**	**19**	**4.8**	**0.87**	**0.011**
Wasteload Allocation	**Total WLA**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Load Allocation	**Total LA**	**147**	**17.1**	**4.32**	**0.783**	**0.0099**
Margin of Safety (MOS)		**16**	**1.9**	**0.48**	**0.087**	**0.0011**
Observed Load		-	23	6.5	0.65	0.011
Estimated Percent Reduction		-	17%	26%	0%	0%
Overall Observed Concentration [a]		262 org/100 mL				
Overall Estimated Percent Reduction		52%				

[a] The highest observed monthly geometric mean from the months that the standard applies using *E. coli* data from 2007 through 2016. Five or more samples were needed in a month to be considered the highest observed monthly geometric mean.

Unnamed creek, unnamed creek to Wild Rice River (AUID 09020108-546)

Figure 29. *E. coli* LDC for Unnamed creek, unnamed creek to Wild Rice River (AUID 09020108-546).

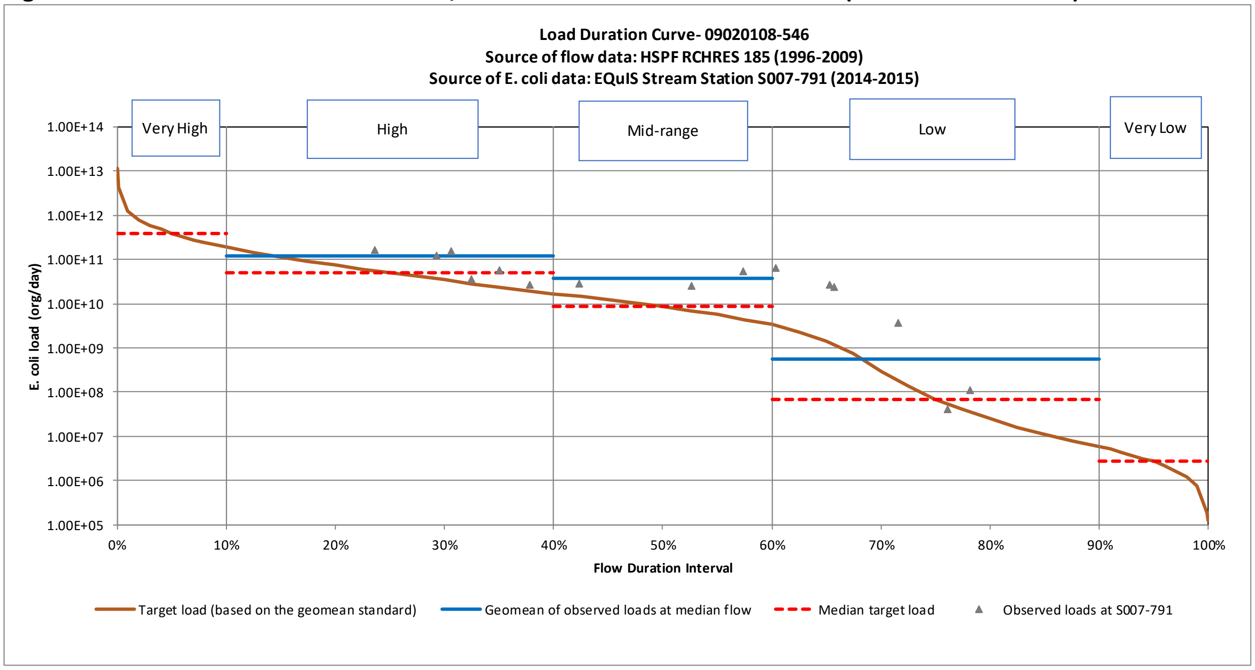


Table 21. *E. coli* TMDL summary for Unnamed creek, unnamed creek to Wild Rice River (AUID 09020108-546).

- Listing year: 2018
- Baseline year(s): 2011-2012
- Numeric standard used to calculate TMDL: 126 *E. coli* org/100 mL
- TMDL and allocations apply April through October

E. coli		Flow zone				
		Very High	High	Mid-Range	Low	Very Low
		[Billion org/day]				
Total Loading Capacity (LC)		387	50	8.5	0.067	0.0027
Boundary Condition (BC)–White Earth Nation LC [a]		185	24	4.1	0.032	0.0013
Minnesota LC		**202**	**26**	**4.4**	**0.035**	**0.0014**
Wasteload Allocation	**Total WLA**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Load Allocation	**Total LA**	**182**	**23.4**	**3.96**	**0.0315**	**0.00126**
Margin of Safety (MOS)		**20**	**2.6**	**0.44**	**0.0035**	**0.00014**
Observed Load		-	117	38	0.56	-
Observed Load minus BC		-	93	33.9	0.528	-
Estimated Percent Reduction		-	72%	87%	93%	-
Overall Observed Concentration [b]		891 org/100 mL				
Overall Estimated Percent Reduction		86%				

[a] No reductions are assigned to the BC for White Earth Nation which was calculated based on the amount of tribal government land located in the impaired stream reach drainage area (47.9%).

[b] The highest observed monthly geometric mean from the months that the standard applies using *E. coli* data from 2007 through 2016. Five or more samples were needed in a month to be considered the highest observed monthly geometric mean.

County Ditch 45, unnamed ditch to unnamed ditch (AUID 09020108-553)

Figure 30. *E. coli* LDC for County Ditch 45, unnamed ditch to unnamed ditch (AUID 09020108-553).

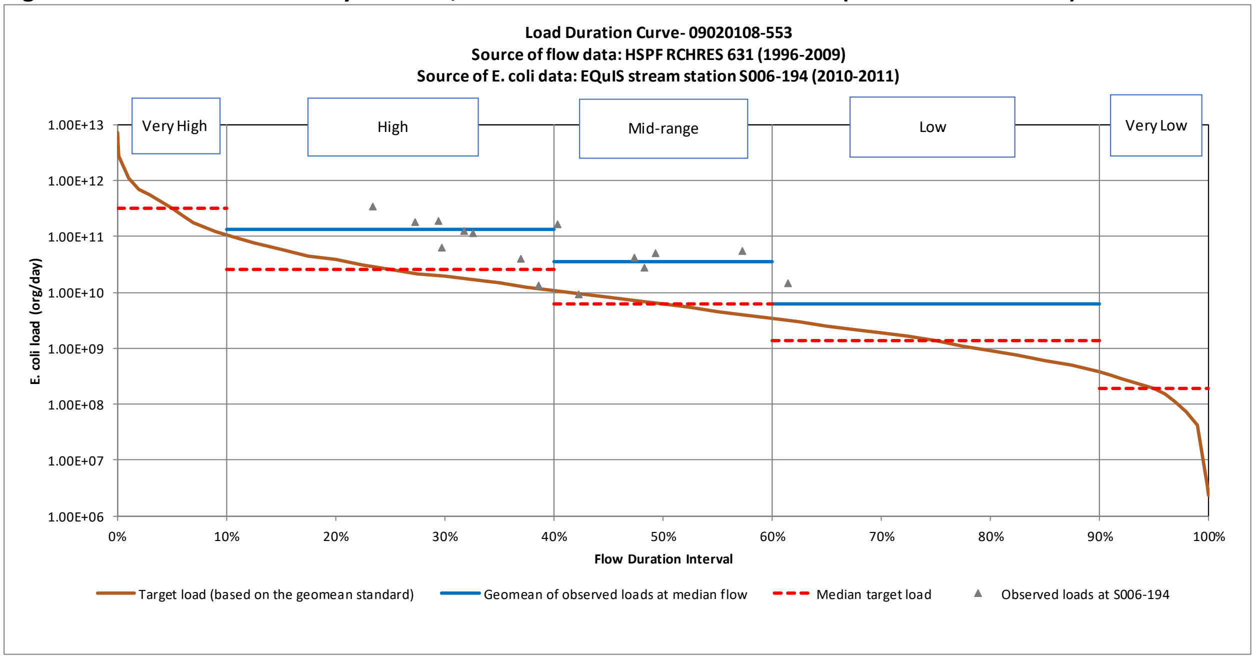


Table 22. *E. coli* TMDL summary for County Ditch 45, unnamed ditch to unnamed ditch (AUID 09020108-553).

- Listing year: 2018
- Baseline year(s): 2011-2012
- Numeric standard used to calculate TMDL: 126 *E. coli* org/100 mL
- TMDL and allocations apply April through October

E. coli		Flow zone				
		Very High	High	Mid-Range	Low	Very Low
		[Billion org/day]				
Total Loading Capacity		**320**	**26**	**6.1**	**1.3**	**0.19**
Wasteload Allocation	**Total WLA**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Load Allocation	**Total LA**	**288**	**23.4**	**5.49**	**1.17**	**0.171**
Margin of Safety (MOS)		**32**	**2.6**	**0.61**	**0.13**	**0.019**
Observed Load		-	135	36	6.2	-
Estimated Percent Reduction		-	81%	83%	79%	-
Overall Observed Concentration [a]		600 org/100 mL				
Overall Estimated Percent Reduction		79%				

[a] The highest observed monthly geometric mean from the months that the standard applies using *E. coli* data from 2007 through 2016. Five or more samples were needed in a month to be considered the highest observed monthly geometric mean.

Coon Creek, unnamed creek to unnamed creek (AUID 09020108-577)

Figure 31. *E. coli* LDC for Coon Creek, unnamed creek to unnamed creek (AUID 09020108-577).

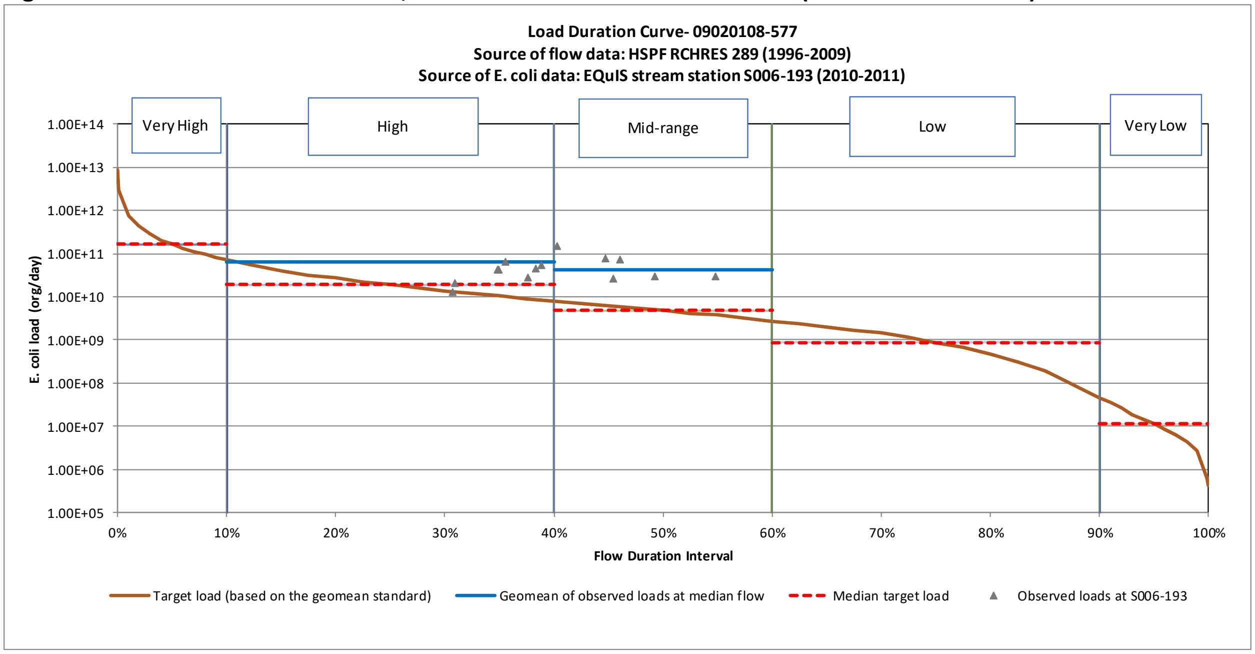


Table 23. *E. coli* TMDL summary for Coon Creek, unnamed creek to unnamed creek (AUID 09020108-577).

- Listing year: 2018
- Baseline year(s): 2011-2012
- Numeric standard used to calculate TMDL: 126 *E. coli* org/100 mL
- TMDL and allocations apply April through October

E. coli		Flow zone				
		Very High	High	Mid-Range	Low	Very Low
		[Billion org/day]				
Total Loading Capacity		**163**	**19**	**4.8**	**0.87**	**0.011**
Wasteload Allocation	**Total WLA**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Load Allocation	**Total LA**	**147**	**17.1**	**4.32**	**0.783**	**0.0099**
Margin of Safety (MOS)		**16**	**1.9**	**0.48**	**0.087**	**0.0011**
Observed Load		-	64	43	-	-
Estimated Percent Reduction		-	70%	89%	-	-
Overall Observed Concentration [a]		652 org/100 mL				
Overall Estimated Percent Reduction		81%				

[a] The highest observed monthly geometric mean from the months that the standard applies using *E. coli* data from 2007 through 2016. Five or more samples were needed in a month to be considered the highest observed monthly geometric mean.

Wild Rice River, Marsh Creek to unnamed creek (AUID 09020108-643)

Figure 32. *E. coli* LDC for Wild Rice River, Marsh Creek to unnamed creek (AUID 09020108-643).

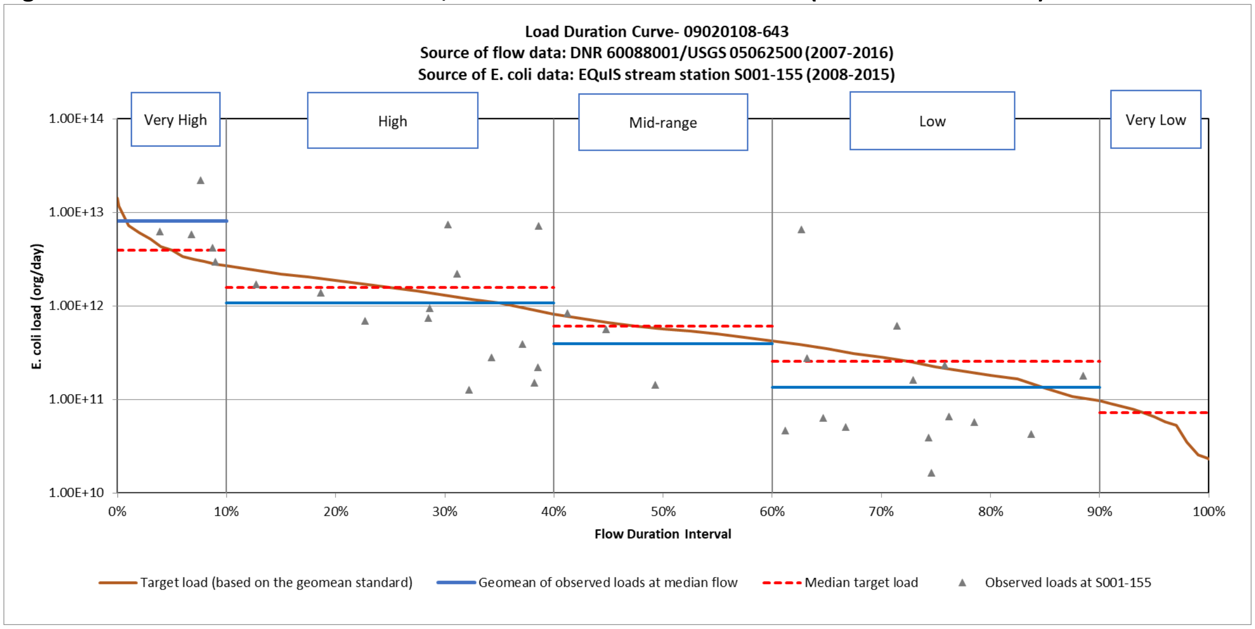


Table 24. *E. coli* TMDL summary for Wild Rice River, Marsh Creek to unnamed creek (AUID 09020108-643).

- Listing year: 2018
- Baseline year(s): 2011-2012
- Numeric standard used to calculate TMDL: 126 *E. coli* org/100 mL
- TMDL and allocations apply April through October

E. coli		Flow zone				
		Very High	High	Mid-Range	Low	Very Low
		[Billion org/day]				
Total Loading Capacity (LC)		3,915	1,574	610	254	73
Boundary Condition (BC) - White Earth Nation LC [a]		2,635	1,059	411	171	49
Minnesota LC		**1,280**	**515**	**199**	**83**	**24**
Wasteload Allocation	**Total WLA**	**5.5**	**5.5**	**5.5**	**5.5**	**5.5**
	Gary WWTP (MNG585175)	1.2	1.2	1.2	1.2	1.2
	Twin Valley WWTP (MNG585137)	4.3	4.3	4.3	4.3	4.3
Load Allocation	**Total LA**	**1,146.5**	**457.5**	**173.5**	**69.2**	**16.1**
Margin of Safety (MOS)		**128**	**52**	**20**	**8.3**	**2.4**
Observed Load		8,020	1,074	395	135	-
Observed Load minus BC		5,385	15	-16	-36	-
Estimated Percent Reduction		76%	0%	0%	0%	-
Overall Observed Concentration [b]		137 org/100 mL				
Overall Estimated Percent Reduction		8.0%				

[a] No reductions are assigned to the BC for White Earth Nation which was calculated based on the amount of tribal government land located in the impaired stream reach drainage area (67.3%). Loading from six wastewater facilities on tribal land (totaling 29.86 billion org/day) is included in the BC.

[b] The highest observed monthly geometric mean from the months that the standard applies using *E. coli* data from 2007 through 2016. Five or more samples were needed in a month to be considered the highest observed monthly geometric mean.

Wild Rice River, unnamed creek to South Branch Wild Rice River (AUID 09020108-644)

Figure 33. *E. coli* LDC for Wild Rice River, unnamed creek to South Branch Wild Rice River (AUID 09020108-644).

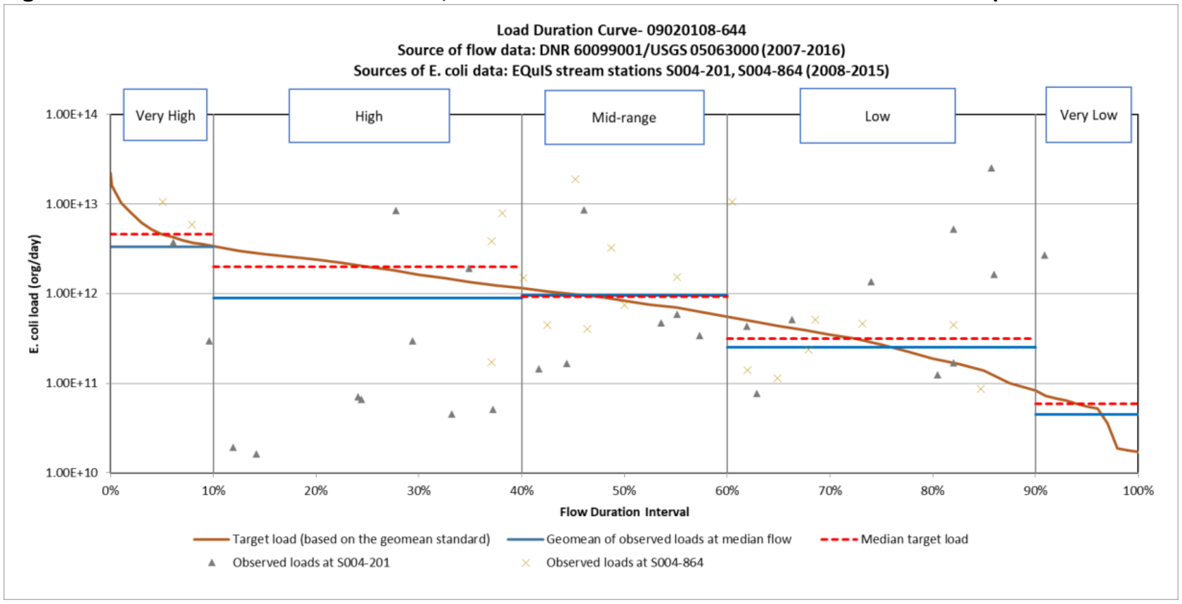


Table 25. *E. coli* TMDL summary for Wild Rice River, unnamed creek to South Branch Wild Rice River (AUID 09020108-644).

- Listing year: 2018
- Baseline year(s): 2011-2012
- Numeric standard used to calculate TMDL: 126 *E. coli* org/100 mL
- TMDL and allocations apply April through October

E. coli		Flow zone				
		Very High	High	Mid-Range	Low	Very Low
		[Billion org/day]				
Total Loading Capacity (LC)		4,602	2,005	918	316	59
Boundary Condition (BC) – White Earth Nation LC [a]		2,959	1,289	590	203	38
Minnesota LC		**1,643**	**716**	**328**	**113**	**21**
Wasteload Allocation	**Total WLA**	**5.5**	**5.5**	**5.5**	**5.5**	**5.5**
	Gary WWTP (MNG585175)	1.2	1.2	1.2	1.2	1.2
	Twin Valley WWTP (MNG585137)	4.3	4.3	4.3	4.3	4.3
Load Allocation	**Total LA**	**1,473.5**	**638.5**	**289.5**	**96.5**	**13.4**
Margin of Safety (MOS)		**164**	**72**	**33**	**11**	**2.1**
Observed Load		3,325	898	952	251	45
Observed Load minus BC		366	-391	362	48	7.0
Estimated Percent Reduction		0%	0%	9%	0%	0%
Overall Observed Concentration [b]		176 org/100 mL				
Overall Estimated Percent Reduction		28%				

[a] No reductions are assigned to the BC for White Earth Nation which was calculated based on the amount of tribal government land located in the impaired stream reach drainage area (64.3%). Loading from six wastewater facilities on tribal land (totaling 29.86 billion org/day) is included in the BC.

[b] The highest observed monthly geometric mean from the months that the standard applies using *E. coli* data from 2007 through 2016. Five or more samples were needed in a month to be considered the highest observed monthly geometric mean.

Spring Creek, 140th Avenue to Wild Rice River (09020108-648)

Figure 34. *E. coli* LDC for Spring Creek, 140th Avenue to Wild Rice River (AUID 09020108-648).

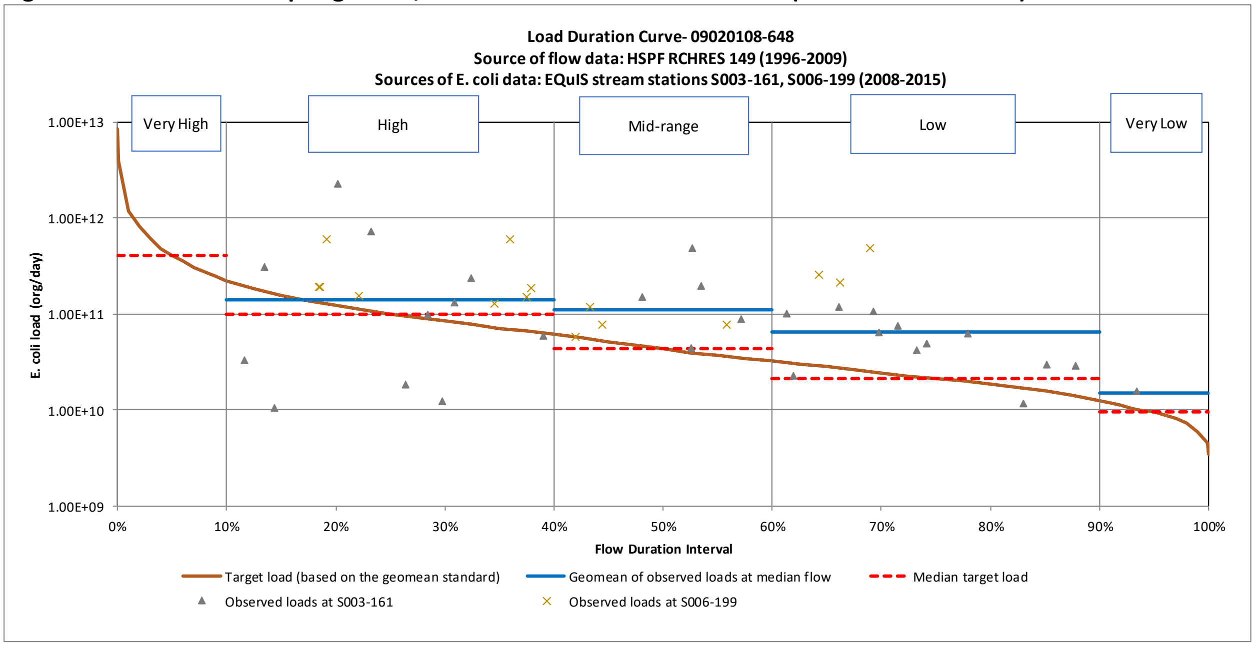


Table 26. *E. coli* TMDL summary for Spring Creek, 140th Avenue to Wild Rice River (AUID 09020108-648).

- Listing year: 2018
- Baseline year(s): 2011-2012
- Numeric standard used to calculate TMDL: 126 *E. coli* org/100 mL
- TMDL and allocations apply April through October

E. coli		Flow zone				
		Very High	High	Mid-Range	Low	Very Low
		[Billion org/day]				
Total Loading Capacity (LC)		411.1	100.7	43.9	21.34	9.48
Boundary Condition (BC) – White Earth Nation LC [a]		401.6	98.4	42.9	20.85	9.26
Minnesota LC		**9.5**	**2.3**	**1.0**	**0.49**	**0.22**
Wasteload Allocation	**Total WLA**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Load Allocation	**Total LA**	**8.55**	**2.07**	**0.9**	**0.441**	**0.198**
Margin of Safety (MOS)		**0.95**	**0.23**	**0.10**	**0.049**	**0.022**
Observed Load		-	141	111	66	15
Observed Load minus BC		-	42.6	68.1	45.15	5.74
Estimated Percent Reduction		-	95%	99%	99%	96%
Overall Observed Concentration [b]		383 org/100 mL				
Overall Estimated Percent Reduction		67%				

[a] No reductions are assigned to the BC for White Earth Nation which was calculated based on the amount of tribal government land located in the impaired stream reach drainage area (97.7%). Loading from one wastewater facility on tribal land (totaling 3.0 billion org/day) is included in the BC.

[b] The highest observed monthly geometric mean from the months that the standard applies using *E. coli* data from 2007 through 2016. Five or more samples were needed in a month to be considered the highest observed monthly geometric mean.

Mashaug Creek, T-92 to Wild Rice River (AUID 09020108-650)

Figure 35. *E. coli* LDC for Mashaug Creek, T-92 to Wild Rice River (AUID 09020108-650).

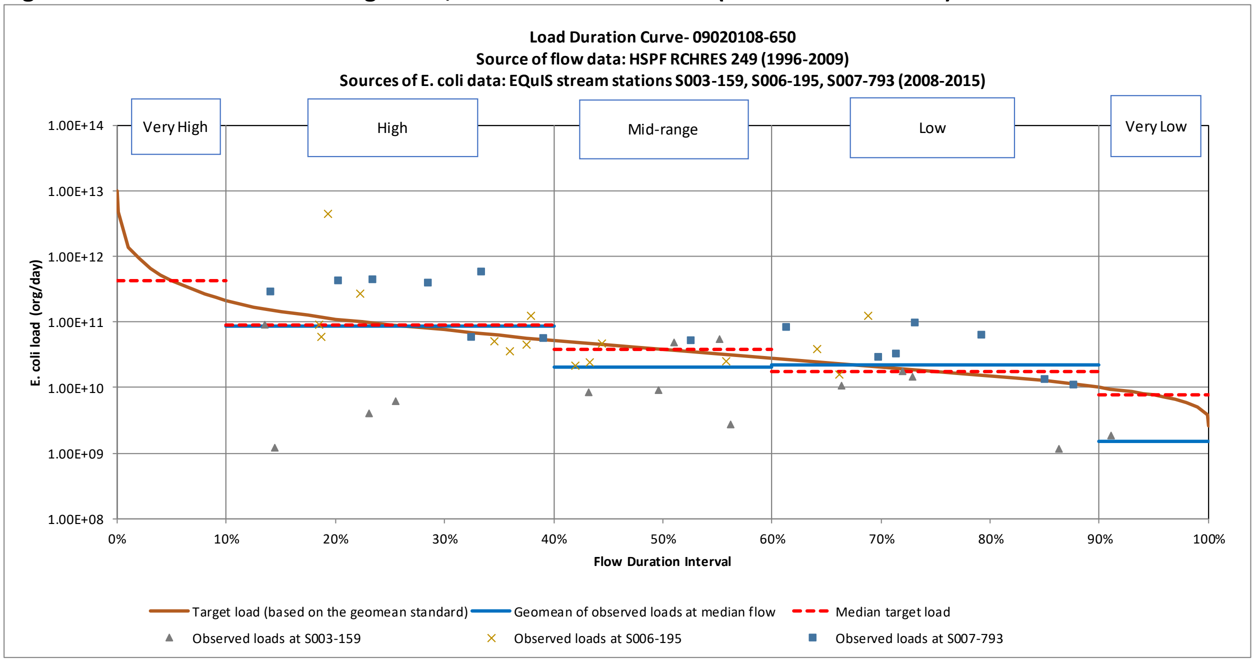


Table 27. *E. coli* TMDL summary for Mashaug Creek, T-92 to Wild Rice River (AUID 09020108-650).

- Listing year: 2018
- Baseline year(s): 2011-2012
- Numeric standard used to calculate TMDL: 126 *E. coli* org/100 mL
- TMDL and allocations apply April through October

E. coli		Flow zone				
		Very High	High	Mid-Range	Low	Very Low
		[Billion org/day]				
Loading Capacity		**430**	**91**	**38**	**18**	**7.7**
Wasteload Allocation	**Total WLA**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**
	Gary WWTP (MNG585175)	1.2	1.2	1.2	1.2	1.2
Load Allocation	**Total LA**	**385.8**	**80.7**	**33**	**15**	**5.73**
Margin of Safety (MOS)		**43**	**9.1**	**3.8**	**1.8**	**0.77**
Observed Load		-	87	21	22	1.5
Estimated Percent Reduction		-	0%	0%	18%	0%
Overall Observed Concentration [a]		236 org/100 mL				
Overall Estimated Percent Reduction		47%				

[a] The highest observed monthly geometric mean from the months that the standard applies using *E. coli* data from 2007 through 2016. Five or more samples were needed in a month to be considered the highest observed monthly geometric mean.

South Branch Wild Rice River, T-246 to Wild Rice River (AUID 09020108-659)

Figure 36. *E. coli* LDC for South Branch Wild Rice River, T-246 to Wild Rice River (AUID 09020108-659).

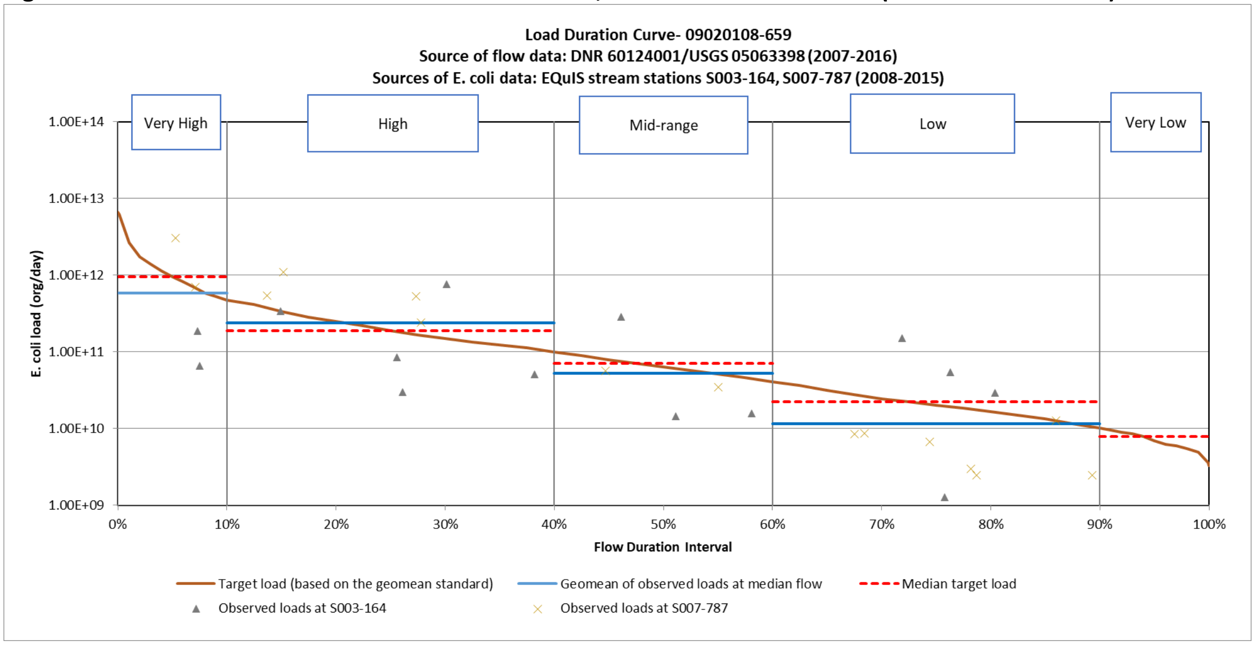


Table 28. *E. coli* TMDL summary for South Branch Wild Rice River, T-246 to Wild Rice River (AUID 09020108-659).

- Listing year: 2018
- Baseline year(s): 2011-2012
- Numeric standard used to calculate TMDL: 126 *E. coli* org/100 mL
- TMDL and allocations apply April through October

E. coli		Flow zone				
		Very High	High	Mid-Range	Low	Very Low
		[Billion org/day]				
Total Loading Capacity (LC)		955	189	71	22.4	7.8
Boundary Condition (BC) – White Earth Nation LC [a]		177	35	13	4.1	1.4
Minnesota LC		**778**	**154**	**58**	**18.3**	**6.4**
Wasteload Allocation	**Total WLA**	**4.75**	**4.75**	**4.75**	**4.75**	**4.75**
	Borup WWTP (MN0022853)	0.65	0.65	0.65	0.65	0.65
	Ulen WWTP (MNG585088)	4.1	4.1	4.1	4.1	4.1
Load Allocation	**Total LA**	**695.25**	**134.25**	**47.45**	**11.75**	**1.01**
Margin of Safety (MOS)		**78**	**15**	**5.8**	**1.8**	**0.64**
Observed Load		591	239	53	12	-
Observed Load minus BC		414	204	40	7.9	-
Estimated Percent Reduction		0%	25%	0%	0%	-
Overall Observed Concentration [b]		296 org/100 mL				
Overall Estimated Percent Reduction		57%				

[a] No reductions are assigned to the BC for White Earth Nation which was calculated based on the amount of tribal government land located in the impaired stream reach drainage area (18.5%). Loading from two wastewater facilities on tribal land (totaling 2.2 billion org/day) is included in the BC.

[b] The highest observed monthly geometric mean from the months that the standard applies using *E. coli* data from 2007 through 2016. Five or more samples were needed in a month to be considered the highest observed monthly geometric mean.

South Branch Wild Rice River, unnamed creek to unnamed creek (AUID 09020108-662)

Figure 37. *E. coli* LDC for South Branch Wild Rice River, unnamed creek to unnamed creek (AUID 09020108-662).

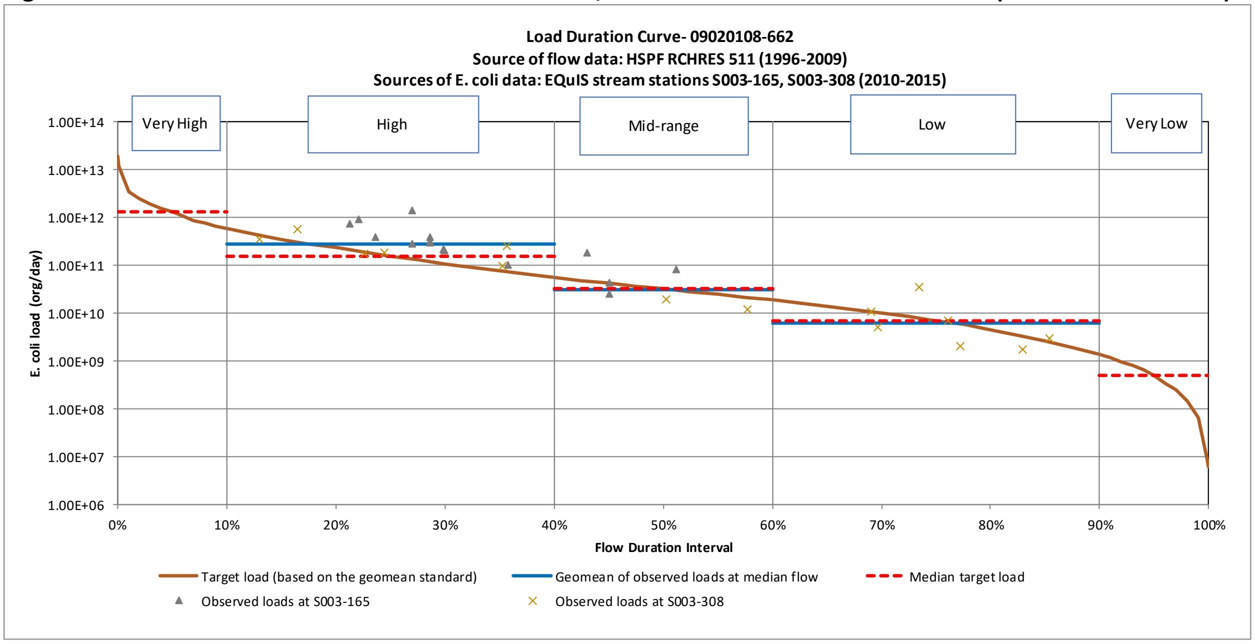


Table 29. *E. coli* TMDL summary for South Branch Wild Rice River, unnamed creek to unnamed creek (AUID 09020108-662).

- Listing year: 2018
- Baseline year(s): 2011-2012
- Numeric standard used to calculate TMDL: 126 *E. coli* org/100 mL
- TMDL and allocations apply April through October

E. coli		**Flow zone**				
		Very High	**High**	**Mid-Range**	**Low**	**Very Low**
		[Billion org/day]				
Total Loading Capacity (LC)		1,306	158	32.4	7.1	0.50
Boundary Condition (BC) – White Earth Nation LC [a]		324	39	8.0	1.8	0.12
Minnesota LC		**982**	**119**	**24.4**	**5.3**	**0.38**
Wasteload Allocation	**Total WLA**	**4.1**	**4.1**	**4.1**	**4.1**	*****
	Ulen WWTP (MNG585088)	4.1	4.1	4.1	4.1	*
Load Allocation	**Total LA**	**879.9**	**102.9**	**17.9**	**0.67**	**0.342**
Margin of Safety (MOS)		**98**	**12**	**2.4**	**0.53**	**0.038**
Observed Load		-	287	32	6.2	-
Observed Load minus BC		-	248	24	4.4	-
Estimated Percent Reduction		-	52%	0%	0%	-
Overall Observed Concentration [b]		193 org/100 mL				
Overall Estimated Percent Reduction		35%				

* The permitted wastewater design flow exceeds the stream flow in the indicated flow zone(s). The allocations are expressed as an equation rather than an absolute number: allocation = (flow contribution from a given source) x 126 org/100 mL (or NPDES/SDS permit concentration).

[a] No reductions are assigned to the BC for White Earth Nation which was calculated based on the amount of tribal government land located in the impaired stream reach drainage area (24.8%). Loading from two wastewater facilities on tribal land (totaling 2.2 billion org/day) is included in the BC.

[b] The highest observed monthly geometric mean from the months that the standard applies using *E. coli* data from 2007 through 2016. Five or more samples were needed in a month to be considered the highest observed monthly geometric mean.

4.1.4 Total Suspended Solids

4.1.4.1 Loading capacity methodology

The LC is the greatest amount of a pollutant a waterbody can receive and still meet the water quality standard. The TSS LCs for impaired stream reaches in the WRRW were determined using the LDC approach. An LDC is developed by combining the (simulated or observed) river/stream flow as close to the downstream end of the AUID as possible with the observed/measured TSS data available within the segment. Note that none of the locations where observed or simulated flows were determined are located within tribal reservation boundaries. Methods detailed in the EPA document *An Approach for Using Load Duration Curves in the Development of TMDLs* were used in creating the curves (EPA, 2007).

A system's water quality often varies based on flow regime, with elevated pollutant loadings sometimes occurring more frequently under one flow zone or another. To represent different types of flow events and pollutant loading during these events, five flow zones were identified based on percent exceedance: Very High Flow (0% to 10%), High Flow (10% to 40%), Mid Flow (40% to 60%), Low Flow (60% to 90%), and Very Low Flow (90% to 100%). Loading dynamics during certain flow zones can be indicative of the type of pollutant source causing an exceedance (e.g., point sources contributing more loading under the lowest flow zones). The LDC approach identifies the LC for the flow regime (brown curved line in **Figure 38** through **Figure 42**) and presents the median LC for five flow zones (red dashed lines in **Figure 38** through **Figure 42**).

Benefits of LDC analysis include: (1) the loading capacities are calculated for multiple flow zones, not just a single point; (2) use of the method helps identify specific flow zones and hydrologic processes/patterns where loading may be a concern; and (3) ensuring that the applicable water quality standards are protective across all flow zones. Some limitations with the LDC approach exist: (1) the approach is limited in the ability to track individual loadings or relative source contributions and (2) the method is most appropriate when a correlation between flow and water quality exists and flow is the driving force behind pollutant delivery mechanics.

The LDC method is based on an analysis that encompasses the cumulative frequency of historical flow data over a specified period. Because this method uses a long-term record of daily flow volumes, virtually the full spectrum of allowable loading capacities is represented by the resulting curve. In the TSS TMDL allocation tables of this report (**Table 33** through **Table 37**), only five points on the entire LC curve are depicted (the midpoints of the designated flow zones). However, it should be understood that the entire curve represents the TMDL, and it is what the EPA ultimately approves.

Table 30 provides the methodology to convert flows and TSS concentrations to TSS loads. The LCs were calculated and the TMDL summary tables were developed using the TSS concentration criteria of 65 mg/L for AUID -501 and 30 mg/L for AUIDs -504, -643, -644, and -652. The water quality standards for TSS apply during April through September. Loads are calculated as tons per day.

Table 30. Converting flows and TSS concentrations to TSS load.

Load (tons/day) = TSS standard (mg/L) * Flow (cfs) * Conversion Factor			
For each flow zone			
Multiply **flow** (cfs) by **28.31** (L/ft^3) and **86,400** (sec/day) to convert	cfs	→	L/day
Multiply **TSS Standard** (mg/L) by **L/day** to convert	L/day	→	mg/day
Divide **mg/day** by **907,184,740** (mg/ton) to convert	mg/day	→	tons/day

Boundary Conditions

All five AUIDs with TSS TMDLs (-501, -504, -643, -644, and -652) have drainage area within White Earth Reservation, so the LCs for tribal land are included for these AUIDs as BCs, and no reductions are assigned to the tribal land. The BC allocated to tribal runoff is based on the amount of tribal government land located in the drainage area of the impaired stream reach. For example, AUID -652 has a total drainage area of 166.3 square miles, 140.6 square miles (84.5%) of which are located within White Earth Reservation. Thus, 84.5% of the total LC for each flow zone is allocated to the BC. It is understood that the MPCA has no jurisdiction on tribal lands and that EPA will not approve that part of a TMDL that is located within the boundaries of tribal lands.

Included in the BCs are the permitted TSS loads from eight WWTPs in the WRRW that are located on tribal land. Four of these WWTPs have been issued NPDES permits by EPA, but do not have Minnesota SDS permits, while the other four are NPDES/SDS-permitted. TSS loadings from these facilities located on tribal land are shown in **Table 31**.

Table 31. Upstream wastewater facility TSS loads that are included in boundary conditions.

		A	B	C	
Facility (NPDES Permit Number)	Immediate/downstream impaired AUIDs addressed in this report	Secondary Pond Size (acres)	Permitted maximum daily discharge (liters/day) (=A*0.5*1233480.22)	Discharge Limit: Calendar month avg (mg/L)	Daily TSS load (US tons/day) (=(B*C)/907,184,740)
Bejou WWTP (MNT064688) [a]	501, 643, 644, 652	0.92	567,401	45	**0.0281**
Big Rice Lake Wastewater Lagoon (MN-0068438-3) [b]	501, 504, 643, 644	1.3	801,762	45	**0.0398**
Chippewa Ranch Wastewater Stabilization Lagoon (MN-0059404-5) [b]	501, 504, 643, 644	0.95	585,903	45	**0.0291**
Mahnomen WWTP (MNT024066) [a]	501, 504, 643, 644	6.4	3,947,137	45	**0.7771**
		19	11,718,062		
Nay-Tah-Waush Wastewater Stabilization Lagoon (MN-0064154-4) [b]	501, 504, 643, 644	3	1,850,220	45	**0.1836**
		3	1,850,220		
Ogema WWTP (MNT049794) [a]	501	1.27	783,260	45	**0.0389**

		A	B	C	
Facility (NPDES Permit Number)	Immediate/downstream impaired AUIDs addressed in this report	Secondary Pond Size (acres)	Permitted maximum daily discharge (liters/day) (=A*0.5*1233480.22)	Discharge Limit: Calendar month avg (mg/L)	Daily TSS load (US tons/day) (=(B*C)/907,184,740)
Waubun WWTP (MNT022110) [a]	501, 504, 643, 644	3.86	2,380,617	45	**0.1181**
White Earth Wastewater Stabilization Lagoon (MN-0064173-4) [b]	501	1.5	925,110	45	**0.0459**

[a] Facility has both an NPDES permit issued by EPA and an SDS permit issued by Minnesota.

[b] Facility has an NPDES permit issued by EPA.

4.1.4.2 Load allocation methodologyu

The LA represents the portion of the LC designated for NPS of TSS. The LA is the remaining load once the WLA and MOS are determined and subtracted from the LC. The LA includes all sources of TSS that do not require NPDES/SDS permit coverage, including overland erosion (primarily from cropland), streambank erosion, wind, and natural background, all of which were evaluated within the pollutant source portion of this report (**Section 3.6.2.2**). While natural background sources are implicitly included in the LA portion of each TMDL table, reductions should focus on the major human attributed NPS identified in the TSS source assessment.

4.1.4.3 Wasteload allocation methodology

WLAs represent the regulated portion of the LC and are developed for any NPDES/SDS-permitted facilities (also known as point sources) in the drainage area of an impaired reach. Regulated sources may include facilities that discharge domestic or industrial wastewater, construction stormwater, industrial stormwater, MS4 permitted areas, and CAFOs. The regulated sources of TSS in the drainage areas of AUIDs with TSS TMDLs in this report are domestic WWTPs, construction stormwater, industrial stormwater, and CAFOs.

Wastewater treatment plants

Domestic WWTPs are NPDES/SDS-permitted facilities that process primarily wastewater from domestic sanitary sewer sources (sewage). Pond facilities include city or sanitary district treatment facilities, wayside rest areas, or national or state parks and are limited to controlled discharge typically from a single secondary treatment pond. All pond WWTPs are permitted to discharge only during specified discharge windows in the spring and fall. The discharge windows for pond WWTPs in the WRRW are March 1 through June 30 and September 1 through December 31 with no discharge to ice covered waters.

There are six NPDES/SDS-permitted, domestic WWTPs that are within the drainage areas of AUIDs with TSS TMDLs but not located on tribal land. Specifically, they are municipal WWTPs because they treat wastewater from municipalities. All six of these are Class D pond facilities, each with one or two primary pond cell(s) and one secondary pond cell(s). TSS WLAs for these six WWTPs are based on the maximum daily discharge of six inches per day from the secondary pond(s) and the calendar month average discharge limit of TSS.

The WWTPs, permit numbers, permitted flows, permitted concentration limits, and TSS WLAs are provided in **Table 32**. The permit limits for TSS that are already assigned to these WWTPs are consistent with the WLAs assigned in this report's TSS TMDLs.

Table 32. TSS WLAs for NPDES/SDS permits within the drainage areas of impaired reaches in the WRRW.

				A	B	C	D	E	F	
Facility (NPDES/SDS Permit Number)	**Receiving water (09020108-###) [a]**	**Immediate/downstream impaired AUIDs addressed in this report**	**Average Wet Weather Design Flow (mgd)**	**Secondary Pond Size (acres)**	**Mean Operating Depth of A (feet)**	**Permitted maximum daily discharge (liters/day) (=A*0.5*1233480.22) [d]**	**# of days discharging per year at maximum rate ((B/0.5)*2)**	**Discharge Limit: Calendar month avg (mg/L)**	**Daily TSS WLA (US tons/day) (=(C*E)/907,184,740)**	**Annual TSS WLA (US tons/year) (=F*D)**
Borup WWTP (MN0022853)	Unassessed (999) [b]	501	0.02	0.83	3	511,894	12	45	**0.0254**	0.3047
Felton WWTP (MNG585149)	Unnamed ditch (663)	501	0.053	3.34	4	2,059,912	16	45	**0.1022**	1.6349
Gary WWTP (MNG585175)	CD 75 (583)	501, 643, 644	0.028	1.5	4	925,110	16	45	**0.0459**	0.7342
Hendrum WWTP (MNG585176)	Wild Rice R (501)	501	0.05	4.67	3.5	2,880,176	14	45	**0.1429**	2.0002
Twin Valley WWTP (MNG585137)	Unassessed (999) [c]	501, 643, 644	0.147	5.5	4	3,392,071	16	45	**0.1683**	2.6922
Ulen WWTP (MNG585088)	Wild Rice R, SB (662)	501	0.113	5.25	4	3,237,886	16	45	**0.1606**	2.5698

[a] R=River, CD=County Ditch, SB=South Branch.
[b] After effluent enters the unassessed reach (-999), it flows into CD 10 (-517) approximately 50 feet further downstream.
[c] After effluent enters the unassessed reach (-999), it flows into Wild Rice River (-643) approximately 0.7 miles downstream.
[d] Calculated based on the acreage of the secondary treatment pond and a maximum discharge of six inches per day.

Construction and industrial stormwater

Stormwater runoff from construction sites that disturb: (a) one acre of soil or more, (b) less than one acre of soil and are part of a "larger common plan of development or sale" that is greater than one acre, or (c) less than one acre, but determined to pose a risk to water quality are regulated under the NPDES/SDS Construction Stormwater General Permit (MNR100001). This permit requires and identifies best management practice (BMPs) to be implemented to protect water resources from mobilized sediment and other pollutants of concern. If the owner/operators of impacted construction sites obtain and abide by the NPDES/SDS Construction Stormwater General Permit, the stormwater discharges associated with those sites are expected to meet the TSS WLAs set in this TMDL report.

Similar to construction activities, industrial sites are regulated under general permits, in this case either the NPDES/SDS Industrial Stormwater Multi-Sector General Permit (MNR050000) or the NPDES/SDS General Permit for Nonmetallic Mining and Associated Activities (MNG490000). Like the NPDES/SDS Construction Stormwater General Permit, these permits identify BMPs to be implemented to protect water resources from pollutant discharges at the site. If the owner/operators of industrial sites abide by the necessary NPDES/SDS general stormwater permits, the discharges associated with those sites are expected to meet the TSS WLAs set in this TMDL report.

The WLAs for construction and industrial stormwater discharges that are covered by the state's general construction and industrial stormwater permits (NPDES/SDS permit # MNR100001, MNR050000, and MNG490000) were combined and addressed through a categorical allocation, because they make up a very small fraction of the watershed area. The annual average area under construction in the five of the six counties that make up >99% of the WRRW is 0.014% in Becker County, 0.063% in Clay County, 0.004% in Clearwater County, 0.035% in Mahnomen County, and 0.014% in Norman County based on construction activity covered under the Construction Stormwater General Permit (MNR100001) from 2015 through 2019 (MPCA, 2020). With the addition of an implicit MOS and to account for the transient nature of construction activities, 0.05% of the watershed is assumed to be under construction at any given time. Stormwater from industrial activities can contribute to the TSS load of waterbodies, but there is very little industrial activity within the WRRW. The annual average area under industrial activities from 2015 through 2019 in the five of the six counties that make up >99% of the WRRW is assumed to be the same as what has undergone construction activities (0.05%). Therefore, to calculate the WLA for construction and industrial stormwater, 0.1% of the LC for each TSS TMDL is assigned to construction/industrial stormwater WLA.

Municipal Separation Storm Sewer System

There are no permitted MS4s in the drainage areas of impaired reaches.

NPDES/SDS-permitted animal feedlots

There are four NPDES/SDS-permitted CAFOs in the WRRW, all of which have greater than 1,000 AUs and are located within the drainage area of at least one impaired stream with a TSS TMDL in this report. WLAs are not assigned to these four NPDES/SDS-permitted animal feedlots (this is equivalent to a WLA of zero), because CAFOs and animal feedlots with 1,000 or more AUs must be designed to contain all manure and manure contaminated runoff from precipitation events of equal to or less than a 25-year, 24-hour storm event. Having and complying with an NPDES/SDS permit allows some enforcement protection if a facility discharges due to a 25-year, 24-hour precipitation event (approximately 4.85 inches in the WRRW) (NOAA, 2017), and the discharge does not contribute to a water quality impairment. A current manure management plan that complies with Minn. R. 7020.2225 and the respective permit is required for all CAFOs and animal feedlots with 1,000 or more AUs.

All other non-CAFO feedlots and the land application of all manure are accounted for in the LA for nonpermitted sources.

4.1.4.4 WLAs during low flows

The total daily LC of some stream reaches during low and very low flow zones are very small due to the occurrence of very low flows in the stream/river. Consequently, for some of the impaired reaches the permitted wastewater design discharge is close to or higher than the streamflow during these flow zones. This translates to these point sources appearing to use all of, or exceeding, the LC during these flow zones. In reality, this will never occur as the discharge is a part of the streamflow, so it can never exceed total streamflow. To account for these unique situations, the WLA are expressed as an equation rather than an absolute number. The equation is:

Wasteload Allocation = Point Source Discharge X Water Quality Standard Concentration

Consistent units are used to obtain the load. This assigns a concentration-based limit to the WLA for these lower flow rates.

4.1.4.5 Margin of safety

The MOS accounts for uncertainty concerning the relationship between load and WLAs and water quality. The MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as a load set aside).

There is a small, implicit MOS included in each categorical WLA for construction and industrial stormwater as discussed previously.

There is also an explicit MOS which is 10% of the LC; it was applied to each flow zone for each of the TSS TMDLs. In general, the explicit MOS accounts for:

- Uncertainty in the observed daily flow record;
- Uncertainty in simulated flow data from the HSPF model;
- Uncertainty in the observed water quality data; and

Some specific activities where human or mechanical error may occur is during data collection, lab analysis, and data analysis.

Most of the MOS is apportioned to uncertainty in the simulated flow data from the HSPF model, so it is apt that the explicit MOS of 10% is supported by the calibration statistics for the WRRW HSPF model (**Table 19**). The average of all 14 error percentages in **Table 19** is -8.68% and the median is -8.2%. The model fit efficiencies for the two flow stations in **Table 19** is 0.726 and 0.741 which were determined to be “good”. Overall, the WRRW HSPF model was rated “good”. More information on the calibration of the WRRW HSPF model can be found in the technical memorandum: *Wild Rice and Marsh Rivers HSPF Model Hydrologic Calibration* (Houston Engineering, Inc, 2015).

4.1.4.6 Seasonal variation and critical conditions

Both seasonal variation and critical conditions are accounted for in this TMDL through the application of LDCs. LDCs evaluate water quality conditions across all flow zones including high flow, runoff conditions where sediment transport tends to be greatest. Seasonality is accounted for by addressing all flow conditions in a given reach. The critical condition for each TSS TMDL is the flow zone that requires the greatest percent reduction in TSS loading. The critical conditions for the TSS TMDLs occurs during the highest flow zones. It should be noted that not all flow zones for each TSS TMDL have data available to estimate observed load. Thus, the critical conditions are for flow zones where observed data exists. It is unknown how much of a reduction, if any, would be required in flow zones had there been observed data available or if any of those flow zones would have been a critical condition.

4.1.4.7 Baseline year

The baseline year for each TSS TMDL is the midpoint of the 10 year period that was used to describe current conditions for each stream; since 10 years is an even number, 2 years make up the baseline. Data from years 2007 through 2016 were used, so the baseline years are 2011 through 2012.

4.1.4.8 Percent reduction

The estimated percent reductions provide a rough approximation of the overall reduction needed for the waterbody to meet the TMDL. The percent reduction is a means to capture the level of effort needed to reduce TSS concentrations and loads in the watershed. The percent reductions should not be construed to mean that each of the separate sources listed in the TMDL table needs to be reduced by that amount.

Percent reductions were calculated in two different ways for each TSS TMDL. One way was to calculate them based on the LDC flow zones. For each observed TSS datum collected between April through September during 2007 through 2016, the average flow (simulated or observed) for the day the sample was taken was determined (often using flow transfer as described in **Section 4.1.2.1**) and the percent exceedance of that flow was determined to identify within which flow zone the datum belongs. The 90th percentile of all observed concentrations within a flow zone was calculated, then multiplied by the median flow, and lastly, converted to the observed load (blue solid lines in **Figure 38** through **Figure 42**). The observed load was compared to the LC for that flow zone and if the observed load was higher, the percentage that the observed load needs to be reduced to meet the LC was calculated. An overall observed 90th percentile concentration was also calculated. This overall observed 90th percentile concentration is one number (versus five numbers from the LDC method) that can be used to set goals for planning purposes. It is the 90th percentile of all observed concentrations from the months that the standard applies using TSS data from 2007 through 2016. The overall estimated percent reduction is how much the overall observed 90th percentile concentration needs to be reduced to meet the numeric standard concentration of 30 or 65 mg/L.

4.1.4.9 TMDL summary

The TMDL results are provided below. For each TMDL, a figure of the LDC is provided, followed by the TMDL table with the LC, WLAs, LA, MOS, observed load (if available), and estimated percent reduction (if available) identified by flow zone. If the WLA requires a flow-concentration relationship (see **Section 4.1.4.4**) for low flows it is identified by "***". In addition, the overall observed 90th percentile concentration and overall estimated percent reduction needed to meet the water quality standard is also provided.

The following rounding conventions were used in the TMDL summary tables:

- Values ≥10 reported in tons/day have been rounded to the nearest ton.
- Values <10 and ≥1 reported in tons/day have been rounded to the nearest tenth of a ton.
- Values <1.0 reported in ton/day have been rounded to the nearest hundredth of a ton or so that at least two significant digits are displayed.

The only exceptions to the rounding conventions may be the LCs for TMDLs with BCs, total WLAs, and total LAs. For each TMDL with a BC, the total LC, BC (White Earth Nation LC), and Minnesota LC follow the same rounding convention as the LC with the smallest value. The total WLA is the sum of all individual WLAs and the total LA is what is left after subtracting the MOS and total LA from the LC, thus they may not follow the rounding conventions.

Wild Rice River, South Branch Wild Rice River to Red River (AUID 09020108-501).

Figure 38. TSS LDC for Wild Rice River, South Branch Wild Rice River to Red River (AUID 09020108-501).

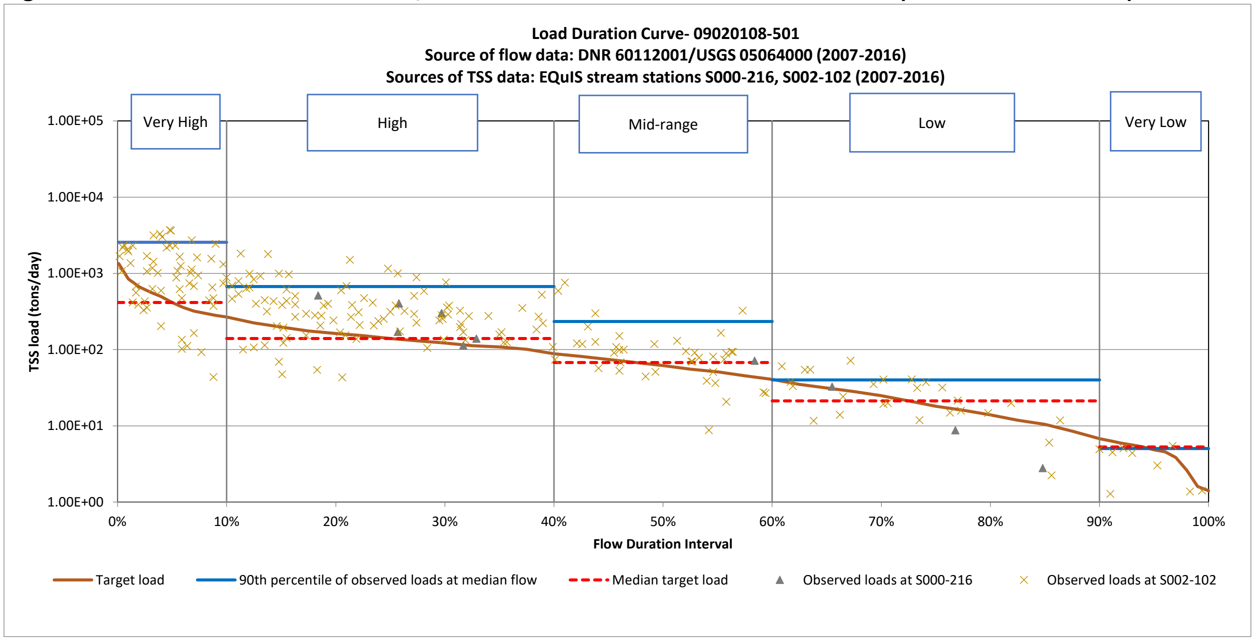


Table 33. TSS TMDL summary for Wild Rice River, South Branch Wild Rice River to Red River (AUID 09020108-501).

- Listing year: 2006
- Baseline year(s): 2011-2012
- Numeric standard used to calculate TMDL: 65 mg/L TSS
- TMDL and allocations apply April through September

Total Suspended Solids		Flow zone				
		Very High	High	Mid-Range	Low	Very Low
		[U.S. tons/day]				
Total Loading Capacity (LC)		416	140	68	21	5.3
Boundary Condition (BC) – White Earth Nation LC [a]		198	67	32	10	2.5
Minnesota LC		**218**	**73**	**36**	**11**	**2.8**
Wasteload Allocation	**Total WLA**	**0.861**	**0.714**	**0.677**	**0.652**	**0.6438**
	Borup WWTP (MN0022853)	0.025	0.025	0.025	0.025	0.025
	Felton WWTP (MNG585149)	0.10	0.10	0.10	0.10	0.10
	Gary WWTP (MNG585175)	0.046	0.046	0.046	0.046	0.046
	Hendrum WWTP (MNG585176)	0.14	0.14	0.14	0.14	0.14
	Twin Valley WWTP (MNG585137)	0.17	0.17	0.17	0.17	0.17
	Ulen WWTP (MNG585088)	0.16	0.16	0.16	0.16	0.16
	Construction/Industrial Stormwater	0.22	0.073	0.036	0.011	0.0028
Load Allocation	**Total LA**	**195.139**	**64.986**	**31.723**	**9.248**	**1.8762**
Margin of Safety (MOS)		**22**	**7.3**	**3.6**	**1.1**	**0.28**
Observed 90th percentile Load		2,552	671	233	40	5.0
Observed 90th percentile Load minus BC		2,354	604	201	30	2.5
Estimated Percent Reduction		91%	88%	82%	63%	0%
Overall Observed 90th percentile concentration		320 mg/L				
Overall Estimated Percent Reduction		80%				

[a] No reductions are assigned to the BC for White Earth Nation which was calculated based on the amount of tribal government land located in the impaired stream reach drainage area (47.5%). Loading from eight wastewater facilities on tribal land (totaling 1.26 U.S. tons/day) is included in the BC.

Wild Rice River, White Earth River to Marsh Creek (AUID 09020108-504)

Figure 39. TSS LDC for Wild Rice River, White Earth River to Marsh Creek (AUID 09020108-504).

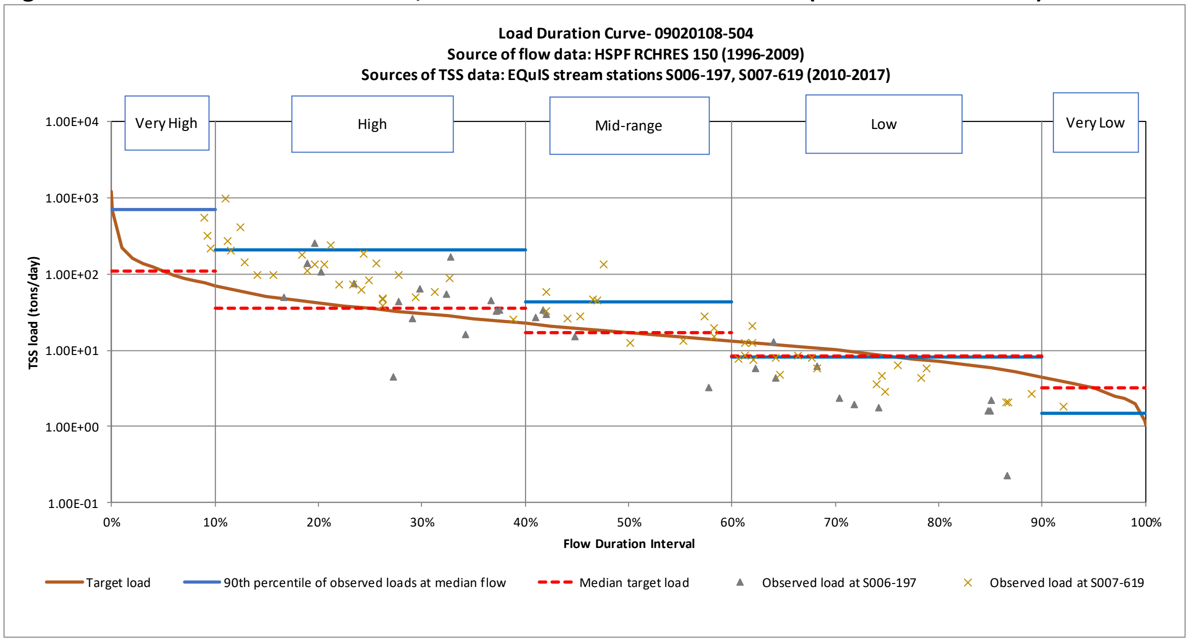


Table 34. TSS TMDL summary for Wild Rice River, White Earth River to Marsh Creek (AUID 09020108-504).

- Listing year: 2018
- Baseline year(s): 2011-2012
- Numeric standard used to calculate TMDL: 30 mg/L TSS
- TMDL and allocations apply April through September

Total Suspended Solids		Flow zone				
		Very High	High	Mid-Range	Low	Very Low
		[U.S. tons/day]				
Total Loading Capacity (LC)		110	35.4	16.7	8.5	3.16
Boundary Condition (BC) – White Earth Nation LC [a]		91	29.3	13.8	7.0	2.62
Minnesota LC		**19**	**6.1**	**2.9**	**1.5**	**0.54**
Wasteload Allocation	**Total WLA**	**0.019**	**0.0061**	**0.0029**	**0.0015**	**0.00054**
	Construction/Industrial Stormwater	0.019	0.0061	0.0029	0.0015	0.00054
Load Allocation	**Total LA**	**17.081**	**5.4839**	**2.6071**	**1.3485**	**0.48546**
Margin of Safety (MOS)		**1.9**	**0.61**	**0.29**	**0.15**	**0.054**
Observed 90th percentile Load		709	210	43	8.2	1.5
Observed 90th percentile Load minus BC		618	180.7	29.2	1.2	-1.12
Estimated Percent Reduction		97%	97%	90%	0%	0%
Overall Observed 90th percentile concentration		122 mg/L				
Overall Estimated Percent Reduction		75%				

[a] No reductions are assigned to the BC for White Earth Nation which was calculated based on the amount of tribal government land located in the impaired stream reach drainage area (82.8%). Loading from five wastewater facilities on tribal land (totaling 1.15 U.S. tons/day) is included in the BC.

Wild Rice River, Marsh Creek to unnamed creek (AUID 09020108-643)

Figure 40. TSS LDC for Wild Rice River, Marsh Creek to unnamed creek (AUID 09020108-643).

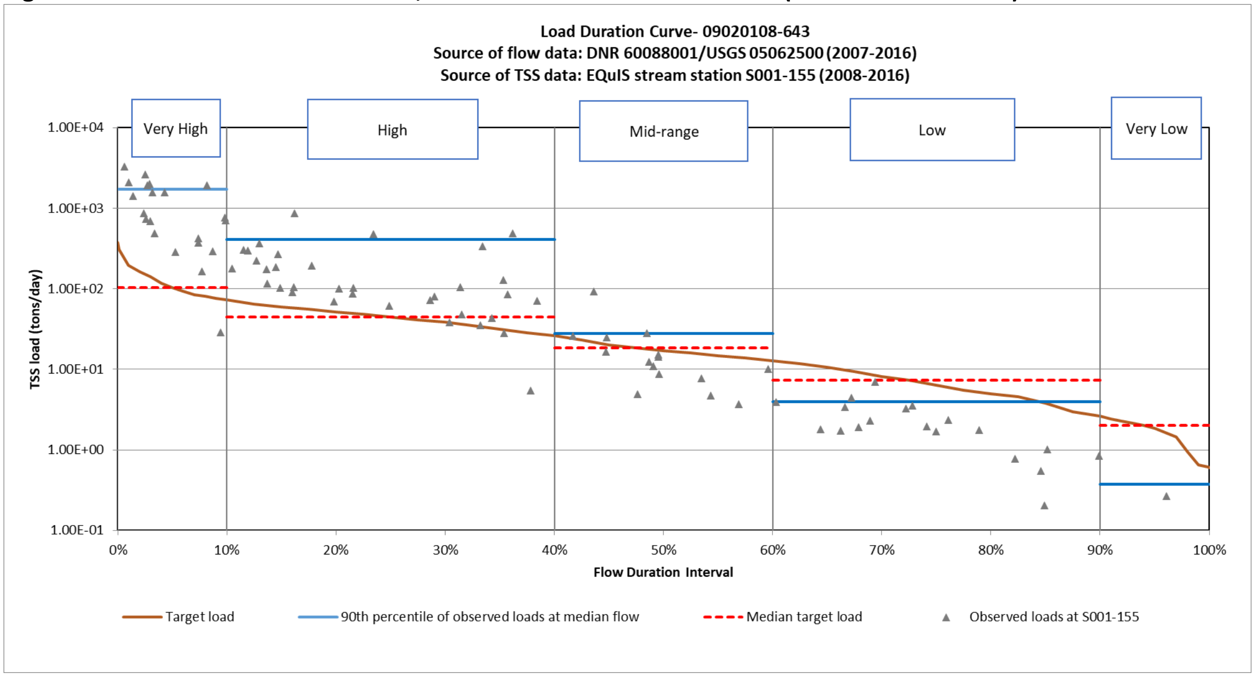


Table 35. TSS TMDL summary for Wild Rice River, Marsh Creek to unnamed creek (AUID 09020108-643).

- Listing year: 2010
- Baseline year(s): 2011-2012
- Numeric standard used to calculate TMDL: 30 mg/L TSS
- TMDL and allocations apply April through September

Total Suspended Solids		Flow zone				
		Very High	High	Mid-Range	Low	Very Low
		[U.S. tons/day]				
Total Loading Capacity (LC)		104	44	18.4	7.3	2.01
Boundary Condition (BC) – White Earth Nation LC [a]		70	30	12.4	4.9	1.35
Minnesota LC		**34**	**14**	**6.0**	**2.4**	**0.66**
Wasteload Allocation	**Total WLA**	**0.25**	**0.23**	**0.222**	**0.2184**	**0.21666**
	Gary WWTP (MNG585175)	0.046	0.046	0.046	0.046	0.046
	Twin Valley WWTP (MNG585137)	0.17	0.17	0.17	0.17	0.17
	Construction/Industrial Stormwater	0.034	0.014	0.0060	0.0024	0.00066
Load Allocation	**Total LA**	**30.35**	**12.37**	**5.178**	**1.9416**	**0.37734**
Margin of Safety (MOS)		**3.4**	**1.4**	**0.60**	**0.24**	**0.066**
Observed 90th percentile Load		1705	411	28	3.9	0.37
Observed 90th percentile Load minus BC		1635	381	15.6	-1	-0.98
Estimated Percent Reduction		98%	96%	62%	0%	0%
Overall Observed 90th percentile concentration		330 mg/L				
Overall Estimated Percent Reduction		91%				

[a] No reductions are assigned to the BC for White Earth Nation which was calculated based on the amount of tribal government land located in the impaired stream reach drainage area (67.3%). Loading from six wastewater facilities on tribal land (totaling 1.18 U.S. tons/day) is included in the BC.

Wild Rice River, unnamed creek to South Branch Wild Rice River (AUID 09020108-644)

Figure 41. TSS LDC for Wild Rice River, unnamed creek to South Branch Wild Rice River (AUID 09020108-644).

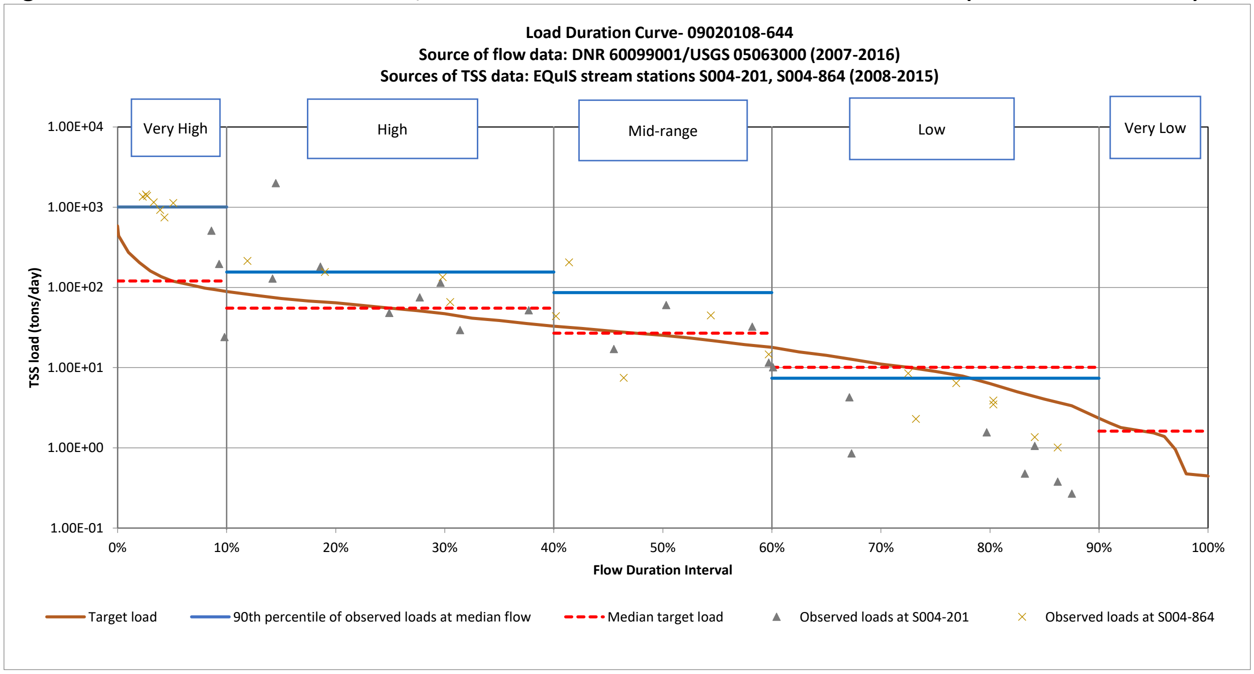


Table 36. TSS TMDL summary for Wild Rice River, unnamed creek to South Branch Wild Rice River (AUID 09020108-644).

- Listing year: 2010
- Baseline year(s): 2011-2012
- Numeric standard used to calculate TMDL: 30 mg/L TSS
- TMDL and allocations apply April through September

Total Suspended Solids		Flow zone				
		Very High	High	Mid-Range	Low	Very Low
		[U.S. tons/day]				
Total Loading Capacity (LC)		121	55	26.9	10.1	1.62
Boundary Condition (BC) – White Earth Nation LC [a]		78	35	17.3	6.5	1.04
Minnesota LC		**43**	**20**	**9.6**	**3.6**	**0.58**
Wasteload Allocation	**Total WLA**	**0.259**	**0.236**	**0.2256**	**0.2196**	**0.21658**
	Gary WWTP (MNG585175)	0.046	0.046	0.046	0.046	0.046
	Twin Valley WWTP (MNG585137)	0.17	0.17	0.17	0.17	0.17
	Construction/Industrial Stormwater	0.043	0.020	0.0096	0.0036	0.00058
Load Allocation	**Total LA**	**38.441**	**17.764**	**8.4144**	**3.0204**	**0.30542**
Margin of Safety (MOS)		**4.3**	**2.0**	**0.96**	**0.36**	**0.058**
Observed 90th percentile Load		1,010	156	86	7.4	-
Observed 90th percentile Load minus BC		932	121	68.7	0.9	-
Estimated Percent Reduction		95%	83%	86%	0%	-
Overall Observed 90th percentile concentration		216 mg/L				
Overall Estimated Percent Reduction		86%				

[a] No reductions are assigned to the BC for White Earth Nation which was calculated based on the amount of tribal government land located in the impaired stream reach drainage area (64.3%). Loading from six wastewater facilities on tribal land (totaling 1.18 U.S. tons/day) is included in the BC.

Marsh Creek, -95.9973 47.4054 to Wild Rice River (AUID 09020108-652)

Figure 42. TSS LDC for Marsh Creek, -95.9973 47.4054 to Wild Rice River (AUID 09020108-652).

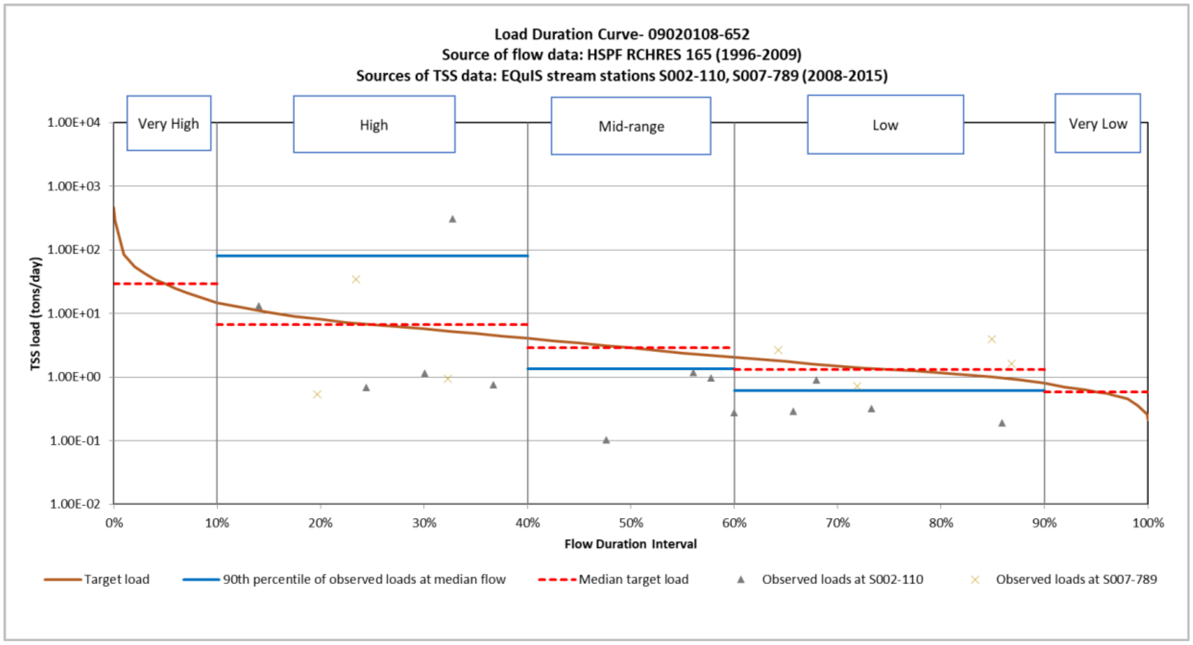


Table 37. TSS TMDL summary for Marsh Creek, -95.9973 47.4054 to Wild Rice River (AUID 09020108-652).

- Listing year: 2008
- Baseline year(s): 2011-2012
- Numeric standard used to calculate TMDL: 30 mg/L TSS
- TMDL and allocations apply April through September

Total Suspended Solids		Flow zone				
		Very High	High	Mid-Range	Low	Very Low
		[U.S. tons/day]				
Total Loading Capacity (LC)		29.2	6.7	2.91	1.31	0.589
Boundary Condition (BC) – White Earth Nation LC [a]		24.7	5.7	2.46	1.11	0.498
Minnesota LC		**4.5**	**1.0**	**0.45**	**0.20**	**0.091**
Wasteload Allocation	**Total WLA**	**0.0045**	**0.0010**	**0.00045**	**0.00020**	**0.000091**
	Construction/Industrial Stormwater	0.0045	0.0010	0.00045	0.00020	0.000091
Load Allocation	**Total LA**	**4.0455**	**0.899**	**0.40455**	**0.1798**	**0.081809**
Margin of Safety (MOS)		**0.45**	**0.10**	**0.045**	**0.020**	**0.0091**
Observed 90th percentile Load		-	81	1.4	0.62	-
Observed 90th percentile Load minus BC		-	75.3	-1.06	-0.49	-
Estimated Percent Reduction		-	99%	0%	0%	-
Overall Observed 90th percentile concentration		102 mg/L				
Overall Estimated Percent Reduction		71%				

[a] No reductions are assigned to the BC for White Earth Nation which was calculated based on the amount of tribal government land located in the impaired stream reach drainage area (84.5%). Loading from one wastewater facility on tribal land (totaling 0.028 U.S. tons/day) is included in the BC.

4.2 Lake

4.2.1 Total Phosphorus

4.2.1.1 Loading capacity methodology

The evaluation of phosphorus loads and reservoir/lake water quality responses for Rockstad Lake were determined using a modified version of the spreadsheet BATHTUB model. The spreadsheet BATHTUB model is currently available as a “beta” version from Dr. William W. Walker (Walker, 2019). The modifications to the “beta” version of the BATHTUB spreadsheet were done by the MPCA and include the following:

- Incorporated an alternative option for calculating excess internal loading, whereby a phosphorus release rate is specified and only applies on a specified number of days to a specified proportion of the lake (note for comparison that the unmodified BATHTUB spreadsheet applies the release rate to the entire area of the lake for 365 days);
- Incorporated three options for estimating loading from watershed runoff. One option was the same as that in the unmodified BATHTUB spreadsheet where outputs from another model such as surface water assessment tool (SWAT) are entered (this is the only option if both phosphorus and ortho-phosphorus [ortho-P] loading need to be calculated). Another option was to calculate watershed loading of phosphorus (but not ortho-P) based on the average runoff for the basin, land cover within the waterbody’s drainage area, and event mean concentrations (EMCs) of phosphorus for the basin. The third option calculates watershed loading of phosphorus (but not ortho-P) based on the watershed area, annual runoff depth, and average TP concentration in runoff; and
- Incorporated an alternative option to model multiple lakes/segments in a chain that takes the outflow phosphorus load from the upstream lake/segment and adds it as an input to the downstream lake/segment.

BATHTUB is a steady-state model that simulates eutrophication-related water quality conditions in lakes and reservoirs based on phosphorus loading characteristics, hydrology, and lake morphometry. The core of BATHTUB is a mass-balance phosphorus model that accounts for: water and phosphorus inputs from tributaries (if applicable), watershed runoff, the atmosphere, sources internal to the lake, and (if appropriate) groundwater; and outputs through the lake outlet, groundwater (if appropriate), water loss via evaporation, and phosphorus sedimentation and retention in the lake sediments. The BATHTUB model can simulate water quality either on a seasonal scale or an annual scale, depending on the characteristic of the waterbody being evaluated. Due to the small drainage area of Rockstad Lake and residence time of longer than a year, an annual scale was chosen.

Typically, lake and reservoir systems are represented by a flow network of segments and tributaries. The segments are lake or reservoir drainage areas or portions of drainage areas for which water eutrophication parameters are being estimated, and tributaries are defined by mass balances of flow and pollutant loading to a particular segment. Rockstad Lake was modeled as a single segment using the BATHTUB spreadsheet model that was modified by the MPCA as described above.

BATHTUB model inputs

The BATHTUB model required inputs including lake morphometry, observed lake water quality, precipitation, evaporation, atmospheric deposition, watershed loading rates (specific inputs included the average runoff for the Red River Basin, land cover, and EMCs), and SSTS estimates.

Lake morphometry - Morphometry for Rockstad Lake that was used as inputs in the BATHTUB model included the following measurements: lake surface area (0.551629 km^2) and mean depth (3.05 m).

Observed TP - Observed TP was modeled using data retrieved from EDA (MPCA, 2020). There were 23 TP samples collected from June through September in 2009 through 2020, the long-term average of which (57.9 µg/L) used as input for the BATHTUB model. Data collected during the growing season was used, because it is the period during which algal growth is greatest and represents critical conditions in the lake. It also represents the months of data used to assess TP against eutrophication standards.

Precipitation and evaporation - The annual precipitation estimate (0.621792 m) was determined using 2009 through 2020 records from Minnesota Department of Natural Resources (DNR) *Minnesota Climate Trends* (DNR, 2021) and the evaporation rate was set equal to that of precipitation. The precipitation and evaporation estimates only apply to the lake surface area.

Atmospheric Deposition - Atmospheric deposition refers to the phosphorus that reaches a lake's surface from the atmosphere. It is estimated that total atmospheric deposition rate during dry, average, and wet years in the Red River Basin is 24.6, 26.1, and 27.9 $kg/km^2/yr$, respectively (Barr Engineering, 2007). A dry (10^{th} percentile), average (50^{th} percentile), and wet (90^{th} percentile) year in eastern WRRW is estimated to be 20 to 22 inches, 25 to 27 inches, and 31 to 33 inches, respectively (Barr Engineering, 2007). Annual precipitation for the WRRW was retrieved for years 2004 through 2020 and ranged from 18.75 to 32.1 in/yr (DNR, 2021) with an average of 24.48 in/yr. Since this average precipitation (24.48 in/yr) is closest to the range for the average (50^{th} percentile) year, the atmospheric deposition rate for an average year (26.1 $kg/km^2/yr$) was used to calculate total atmospheric deposition for the Rockstad Lake TP TMDL. Reducing atmospheric deposition was not considered when identifying the LC of Rockstad Lake.

Watershed loading rates - As mentioned in the second bullet point of **Section 4.2.1.1**, MPCA's modified BATHTUB spreadsheet had three options for estimating watershed loading rates. The option used for the Rockstad Lake TP TMDL was based on the average runoff for the Red River Basin (3.42 inches/year), km^2 of each land cover type within Rockstad Lake's 13.02 km^2 drainage area (15% water, 3% urban, 58% forest, 2% grassland, 15% pasture, and 7% agriculture), and EMCs of phosphorus for each land cover type in the Red River Basin. The EMCs used to identify baseline conditions of TP were 50 µg/L from water runoff, 200 µg/L from urban runoff, 50 µg/L from forest runoff, 50 µg/L from grassland runoff, 150 µg/L from pasture runoff, and 200 µg/L from agriculture runoff (MPCA, 2016).

Subsurface Sewage Treatment Systems - SSTSs contribute phosphorus even when compliant, but noncompliant (failing and ITPHS) SSTS contribute an even greater amount of phosphorus.

Google Earth imagery from July 29, 2019, showed an estimated 23 households within the drainage area of Rockstad Lake, 6 of which are within 300 yards of Rockstad Lake's shoreline (MPCA, 2007). Those six households were considered in estimating inflow and phosphorus loading to Rockstad Lake from SSTS. **Table 13** shows that 1% and 15% of SSTS in Clearwater County are ITPHS and failing, respectively, so none of the 6 SSTS are considered ITPHS, 1 is assumed to be failing, and 5 are assumed to be compliant. Soil retention of phosphorus and water from failing and compliant SSTS is assumed to be 45%, and 85% (MPCA, 2007), respectively. If the average person contributes 29,200 gallons of water (MPCA, 2014) and 0.8845 kg of phosphorus (MPCA, 2004) to an SSTS per year, and it is conservatively estimated that there are 3 people per household, then the one failing SSTS contributes 48,180 gallons of water and 1.459425 kg of phosphorus to Rockstad Lake per year and the five compliant SSTS contribute 65,700 gallons of water and 1.990125 kg of phosphorus to Rockstad Lake per year.

All total, it is estimated that SSTS contribute 113,880 gallons (0.000431083 cubic hectometers [hm^3]) of inflow and 3.44955 kg of phosphorus to Rockstad Lake per year. To simulate a reduction in contribution from SSTS to identify the LC with the BATHTUB model, if all six SSTS were compliant, it was estimated that they would contribute 78,840 gallons (0.000298442 hm^3) of inflow and 2.38815 kg of phosphorus to Rockstad Lake per year.

BATHTUB phosphorus sedimentation model

BATHTUB includes several different phosphorus sedimentation models to choose from. First-order settling velocity was chosen as the sedimentation model because it resulted in a simulated in-lake TP concentration that was closest to the observed TP concentration. This model assumes that sedimentation per unit area is proportional to the average concentration of phosphorus in the water column.

BATHTUB model calibration

The BATHTUB model was calibrated to the long-term average of existing TP data that was collected between June and September in 2009 through 2020. This was necessary, because while the chosen sedimentation model was the best choice of those available, it did not simulate TP concentrations to exactly match observed concentrations. Prior to calibration, the simulated in-lake concentration was 64.9 µg/L, which was greater than the observed value of 57.9 µg/L. Two methods were available to calibrate the model: add excess internal loading or increase the phosphorus decay calibration.

The BATHTUB model implicitly assumes an average rate of internal loading. If Rockstad Lake's simulated TP concentration had been lower than the observed TP concentration, an explicit, additional internal load could have been added to calibrate the model (first bullet point in **Section 4.2.1.1**). However, since the simulated concentration was higher than the observed concentration, the phosphorus decay calibration was increased to 1.36, thus increasing the phosphorus sedimentation rate (mg/m^3) and bringing the simulated concentration equal to that of the observed concentration (57.9 µg/L).

Determination of loading capacity and reductions

The greatest amount of phosphorus loading that Rockstad Lake can receive without exceeding water quality standards (i.e., LC) was determined by reducing loads from phosphorus sources in the calibrated BATHTUB model until the simulated phosphorus concentration matched 30.0 µg/L. The phosphorus sources from which loads were reduced were SSTS and watershed runoff (by reducing EMC values).

Using the simulated annual load and annual LC of TP to Rockstad Lake, the load reduction was calculated as shown in **Table 38**.

Table 38. Observed and simulated mean total phosphorus conditions and necessary reductions in Rockstad Lake.

Lake Name DNR Lake ID #	**Observed average TP** (µg/L)	**Simulated TP of calibrated model** (µg/L)	**TP standard** (µg/L)	**Simulated annual TP load** (lbs)	**Simulated annual TP load capacity** (lbs)	**Load reduction to achieve TP Standard** (%)
Rockstad 15-0075-00	57.9	57.9	30	234	121	48

4.2.1.2 Load allocation methodology

The LA represents the portion of the LC designated for NPS of TP. The LA is the remaining load once the WLAs and MOS are determined and subtracted from the LC. The LA includes all sources of phosphorus that do not require NPDES/SDS permit coverage, including unregulated watershed runoff, excess internal loading (beyond what is intrinsically included in the BATHTUB model), SSTS, and atmospheric deposition. Natural background conditions were evaluated, where possible, within the pollutant source summaries in **Section 3.6.3**. Natural background sources of phosphorus to Rockstad Lake are implicitly included in the LA portion (specifically watershed runoff) of the TMDL table, and reductions should focus on the major human attributed sources identified in the source assessment.

4.2.1.3 Wasteload allocation methodology

WLAs represent the regulated portion of the LC and are developed for any NPDES/SDS-permitted facilities (also known as point sources) in the drainage area of an impaired lake. Regulated sources may include facilities that discharge domestic or industrial wastewater, construction stormwater, industrial stormwater, MS4 permitted areas, and CAFOs. The regulated sources of phosphorus in the drainage areas of Rockstad Lake in this report are construction stormwater and industrial stormwater.

Wastewater Treatment Plants

There are no WWTPs requiring a WLA in the drainage area of Rockstad Lake.

Municipal Separation Storm Sewer System

There are no MS4 permitted areas in the drainage area of Rockstad Lake.

Construction and industrial permits

Stormwater runoff from construction sites that disturb: (a) one acre of soil or more, (b) less than one acre of soil and are part of a “larger common plan of development or sale” that is greater than one acre, or (c) less than one acre, but determined to pose a risk to water quality are regulated under the NPDES/SDS Construction Stormwater General Permit (MNR100001). This permit requires and identifies BMPs to be implemented to protect water resources from mobilized sediment and other pollutants of concern such as phosphorus. If the owner/operators of impacted construction sites obtain and abide by the NPDES/SDS Construction Stormwater General Permit, the stormwater discharges associated with those sites are expected to meet the TP WLA set in the TMDL for Rockstad Lake.

Similar to construction activities, industrial sites are regulated under general permits, in this case either the NPDES/SDS Industrial Stormwater Multi-Sector General Permit (MNR050000) or the NPDES/SDS General Permit for Nonmetallic Mining and Associated Activities (MNG490000). Like the NPDES/SDS Construction Stormwater General Permit, these permits identify BMPs to be implemented to protect water resources from pollutant discharges at the site. If the owner/operators of industrial sites abide by the necessary NPDES/SDS general stormwater permits, the discharges associated with those sites are expected to meet the TP WLA set in the TMDL for Rockstad Lake.

The WLAs for construction and industrial stormwater discharges that are covered by the state's general construction and industrial stormwater permits (NPDES/SDS permit # MNR100001, MNR050000, and MNG490000) were combined and addressed through a categorical allocation, because they make up a very small fraction of the watershed area. The annual average area under construction in Clearwater County, within which the drainage area of Rockstad Lake is located, is 0.004% based on construction activity covered under the Construction Stormwater General Permit (MNR100001) from 2015 through 2019 (MPCA, 2020). With the addition of an implicit MOS and to account for the transient nature of construction activities, 0.05% of the watershed is assumed to be under construction at any given time. Stormwater from industrial activities can contribute to the phosphorus load of Rockstad Lake, but there is very little industrial activity within the WRRW. The annual average area under industrial activities from 2015 through 2019 in Clearwater County is assumed to be the same as what has undergone construction activities (0.05%). Therefore, to calculate the WLA for construction and industrial stormwater, 0.1% of the LC for the TP TMDL is assigned to construction/industrial stormwater WLA.

NPDES/SDS-permitted animal feedlots

There are no NPDES/SDS-permitted CAFOs in the drainage area of Rockstad Lake. Any non-CAFO feedlots and the land application of all manure are accounted for in the watershed runoff portion of the LA for nonpermitted sources.

4.2.1.4 Margin of safety

The MOS accounts for uncertainty in the lake model and observed water quality data. The MOS can be explicitly defined as a set-aside amount or it can be estimated implicitly due to conservative modeling and assessment methods used throughout the TMDL study. The Rockstad Lake TP TMDL uses a small implicit and larger explicit MOS. The small, implicit MOS was described above and is included in the categorical WLA for construction/industrial stormwater. The larger, explicit MOS was set at 10% to account for the uncertainty within the lake model and forcing data.

4.2.1.5 Seasonal variation and critical conditions

Lakes are generally not sensitive to short term changes in water quality, but rather respond to long-term changes and variation in seasonal and/or annual loads. Water quality monitoring suggests in-lake water quality varies over the course of the growing season, with TP and Chl-*a* concentrations generally peaking in mid to late summer. The standard applies from June through September, and MPCA guidelines for assessing lake TP is defined as the June through September mean concentration. The BATHTUB model was used to calculate the LC for Rockstad Lake, incorporating mean growing season TP values and annual loads. Calibration to the summer critical period provides adequate protection during times of the year with reduced loading.

4.2.1.6 Baseline year

The baseline year for the Rockstad Lake TP TMDL is the midpoint of the years used to describe current TP conditions for the lake. Since data from the years 2009 through 2020 were used, two years make up the baseline, 2014 through 2015.

4.2.1.7 Percent reduction

The estimated percent reductions provide a rough approximation of the overall reduction needed for the waterbody to meet the TMDL. The percent reduction is a means to capture the level of effort needed to reduce phosphorus concentrations in the watershed. The percent reductions should not be construed to mean that each of the separate sources listed in the TMDL table needs to be reduced by that amount. The reductions needed to meet each individual allocation and the LC are calculated as the existing load minus the TMDL load.

4.2.1.8 TMDL summary

The allowable TP load (TMDL) for Rockstad Lake was divided among the WLA, LA, and the MOS as described in the above sections. **Table 39** summarizes the observed and allowable TP loads (Load Capacity in **Table 39**), the allocations, MOS, and required reductions. Observed and allowable TP loads are presented per year and per day. Loads per day are calculated by dividing load per year by 365. Values in the TMDL summary table have been rounded to three significant digits.

Table 39. Total phosphorus TMDL for Rockstad Lake (15-0075-00).

- Listing year or proposed year: 2018
- Baseline year(s): 2014-2015
- Numeric standard used to calculate TMDL: 30 µg/L
- TMDL and allocations apply January through December

Rockstad (15-0075-00)		Observed TP Load		Allowable TP Load		Estimated TP Load Reduction	
		lbs/year	lbs/day	lbs/year	lbs/day	lbs/year	%
Wasteload Allocation	**Total WLA**	**0.121**	**0.000332**	**0.121**	**0.000332**	**0**	**0**
	Construction/Industrial Stormwater	0.121	0.000332	0.121	0.000332	0	0
Load Allocation	**Total LA**	**234**	**0.641**	**109**	**0.298**	**125**	**53**
	Watershed Runoff	195	0.533	71.8	0.197	123	63
	Atmosphere	31.7	0.0868	31.7	0.0868	0	0
	Excess internal load [a]	N/A	N/A	N/A	N/A	N/A	N/A
	SSTS	7.60	0.0208	5.26	0.0144	2.34	31
Margin of Safety (MOS)		**N/A**	**N/A**	**12.1**	**0.0332**	**N/A**	**N/A**
Loading Capacity		**234**	**0.641**	**121**	**0.332**	**113**	**48%**

[a] This is internal loading that occurs in excess of what is intrinsically included in the BATHTUB model.

5. Future growth considerations

According to the *Minnesota State Demographic Center* (MN Dept of Administration, 2021), from 2020 through 2039 the populations in the counties that overlap with the WRRW are projected to decrease in Mahnomen (-0.40%), Norman (-16%), and Polk (-5.0%) and increase in Becker (+8.5%), Clay (+14%), and Clearwater (+0.38%) with an overall projected increase of 7% among all 6 counties.

5.1 New or expanding permitted MS4 WLA transfer process

Future transfer of watershed runoff loads in this report's TMDLs may be necessary if any of the following scenarios occur within the project watershed boundaries.

- One or more nonpermitted MS4s become permitted. If this has not been accounted for in the WLA, then a transfer must occur from the LA.
- Expansion of a U.S. Census Bureau Urban Area encompasses new regulated areas for existing permittees. An example is existing state highways that were outside an urban area at the time the TMDL was completed but are now inside a newly expanded urban area. This will require either a WLA to WLA transfer or a LA to WLA transfer.
- A new MS4 or other stormwater-related point source is identified and is covered under an NPDES/SDS permit. In this situation, a transfer must occur from the LA.

Load transfers will be based on methods consistent with those used in setting the allocations in this TMDL. In cases where WLA is transferred from or to a permitted MS4, the permittees will be notified of the transfer and have an opportunity to comment.

5.2 New or expanding wastewater (TSS and *E. coli* TMDLs only)

The MPCA, in coordination with the EPA Region 5, has developed a streamlined process for setting or revising WLAs for new or expanding wastewater discharges to waterbodies with an EPA approved TMDL for TSS or *E. coli* as described by MPCA (MPCA, 2012). This procedure will be used to update WLAs in approved TMDLs for new or expanding wastewater dischargers whose permitted effluent limits are at or below the instream target and will ensure that the effluent concentrations will not exceed applicable water quality standards or surrogate measures. The process for modifying any and all WLAs will be handled by the MPCA, with input and involvement by the EPA, once a permit request or reissuance is submitted. The overall process will use the permitting public notice process to allow for the public and EPA to comment on the permit changes based on the proposed WLA modification(s). Once any comments or concerns are addressed, and the MPCA determines that the new or expanded wastewater discharge is consistent with the applicable water quality standards, the permit will be issued and any updates to the TMDL WLA(s) will be made.

6. Reasonable assurance

A TMDL needs to provide reasonable assurance that water quality targets will be achieved through the specified combination of point and NPS reductions reflected in the LAs and WLAs. According to EPA guidance (EPA, 2002), "*When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur... the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable. This information is necessary for EPA to determine that the TMDL, including the load and wasteload allocations, has been established at a level necessary to implement water quality standards*." In the WRRW, considerable reductions in NPS are required.

The MPCA will:

- Evaluate existing programmatic, funding, and technical capacity to implement basin and watershed strategies.
- Identify gaps in current programs, funding, and local capacity to achieve the needed controls.
- Build program capacity for short-term and long-term goals. Demonstrate increased implementation and/or pollutant reductions.
- Commit to track/monitor/assess and report progress at set regular times.

6.1 Reduction of permitted sources

6.1.1 Permitted construction stormwater

Regulated construction stormwater was given a categorical WLA for each TSS and TP TMDL in this report. Construction activities disturbing one acre or more are required to obtain NPDES/SDS permit coverage through the MPCA. Compliance with TMDL requirements are assumed when a construction site owner/operator meets the conditions of the Construction General Permit and properly selects, installs, and maintains all BMPs required under the permit, including any applicable additional BMPs required in Section 23 of the Construction General Permit for discharges to impaired waters, or compliance with local construction stormwater requirements if they are more restrictive than those in the State General Permit.

6.1.2 Permitted industrial stormwater

Industrial stormwater was given a categorical WLA for each TSS and TP TMDL in this report. Industrial activities require permit coverage under the state's NPDES/SDS Industrial Stormwater Multi-Sector General Permit (MNR050000) or NPDES/SDS Nonmetallic Mining/Associated Activities General Permit (MNG490000). If a facility owner/operator obtains stormwater coverage under the appropriate NPDES/SDS permit and properly selects, installs, and maintains BMPs sufficient to meet the benchmark values in the permit, the stormwater discharges would be expected to be consistent with the WLAs in this TMDL report.

6.1.3 Permitted wastewater

The current permits for the six WWTPs that have WLAs in this report have pollutant limits that are consistent with the WLAs. Had this not been the case, or if changes necessitate it in the future, any NPDES-permitted facility discharging wastewater that has a reasonable potential to cause or contribute to the water quality impairments addressed by these TMDLs include, or will include upon permit reissuance, water quality based effluent limits that are consistent with the assumptions and requirements of these TMDL WLAs. Discharge monitoring is conducted by permittees and routinely submitted to the MPCA for review.

NPDES/SDS permits for discharges that may cause or have reasonable potential to cause or contribute to an exceedance of a water quality standard are required to contain water quality-based effluent limits (WQBELs) consistent with the assumptions and requirements of the WLAs in this TMDL report. Attaining the WLAs, as developed and presented in this TMDL report, is assumed to ensure meeting the water quality standards for the relevant impaired waters listings. During the permit issuance or reissuance process, wastewater discharges will be evaluated for the potential to cause or contribute to violations of water quality standards. WQBELs will be developed for facilities whose discharges are found to have a reasonable potential to cause or contribute to exceedances of applicable water quality standards. The WQBELs will be calculated based on low flow conditions, may vary slightly from the TMDL WLAs, and will include concentration based effluent limitations.

6.1.4 Permitted feedlots

See the discussion of the state’s Feedlot Program in **Section 6.2.2**, which applies to both permitted and nonpermitted feedlots.

6.2 Reduction of nonpermitted sources

Reliable means of reducing NPS pollutant loads are fully addressed in the *Final Wild Rice River Watershed Restoration and Protection Strategy Report* (MPCA, 2022), a document that was written as a companion to this TMDL report. The WRAPS report covers all waterbodies in the WRRW, providing strategies to restore waters that are impaired and protect those that are unimpaired. In order for the impaired waters to meet water quality standards, the vast majority of pollutant reductions in the WRRW will need to come from NPS. Agricultural drainage and surface runoff are major contributors of nutrients, fecal contamination (as indicated by elevated *E. coli* levels), sediment, and increased flows throughout the watershed. As described in the *Final Wild Rice River Watershed Restoration and Protection Strategy Report* (MPCA, 2022), the BMPs included therein have all been demonstrated to be effective in reducing transport of pollutants to surface water. The combinations of BMPs discussed throughout the WRAPS process were derived from *The Minnesota Nutrient Reduction Strategy* (NRS) (MPCA, 2014) and related tools. As such, they were vetted by a statewide engagement process prior to being applied in the WRRW.

Selection of sites for BMPs will be led by local government units (LGUs), tribal government, county SWCDs, watershed districts, and county planning and zoning, with support from state and federal agencies. These BMPs are supported by programs administered by the SWCDs and the Natural Resource Conservation Service (NRCS). Local resource managers are well-trained in promoting, placing, and installing these BMPs. Some counties within the basin have shown significant levels of adoption of these practices. State and local agencies will need to work with landowners to identify priority areas for BMPs and practices that will help reduce nutrient runoff, as well as streambank and overland erosion. Agencies, organizations, LGUs, and citizens alike recognize that resigning waters to an impaired condition is not acceptable. Throughout the course of the WRAPS and TMDL meetings, local stakeholders endorsed the BMPs selected in the WRAPS report. These BMPs reduce pollutant loads from runoff (i.e. phosphorus, sediment, and pathogens) and loads delivered through drainage tiles or groundwater flow.

To help achieve NPS reductions, a large emphasis has been placed on public participation, where the citizens and communities that hold the power to improve water quality conditions are involved in discussions and decision-making. The watershed's citizens and communities will need to voluntarily adopt the practices at the necessary scale and rates to achieve the 10-year targets presented in the *Final Wild Rice River Watershed Restoration and Protection Strategy Report* (MPCA, 2022). The WRAPS report also presents the allocations of the pollutant/stressor goals and targets to the primary sources and the estimated years to meet the goals developed by the WRAPS Local Work Group. The strategies identified and relative adoption rates developed by the WRAPS Local Work Group were used to calculate the adoption rates needed to meet the pollutant 10-year targets. In addition to public participation, several government programs are in place to support a political and social infrastructure that aims to increase the adoption of strategies that will improve watershed conditions and reduce loading from NPS.

Several nonpermitted pollutant reduction programs exist to support implementation of NPS reduction BMPs in the WRRW. These programs identify BMPs, provide means of focusing BMPs, and support their implementation via state initiatives, ordinances, and/or dedicated funding. The number of BMPs per HUC-12 subwatershed is tracked on the MPCA's Healthier Watersheds webpage (MPCA, 2019). As of July 2020, the number of BMPs implemented per HUC-12 from 2004 through 2019 ranged from 2 to 207 (**Figure 43**). All of the BMPs that have been implemented within the WRRW from 2004 through 2019 are listed below in **Table 40**.

Figure 43. Number of BMPs implemented in the WRRW from 2004 to 2019 per HUC-12 subwatershed; data from the MPCA's Healthier Watersheds webpage (MPCA, 2019).

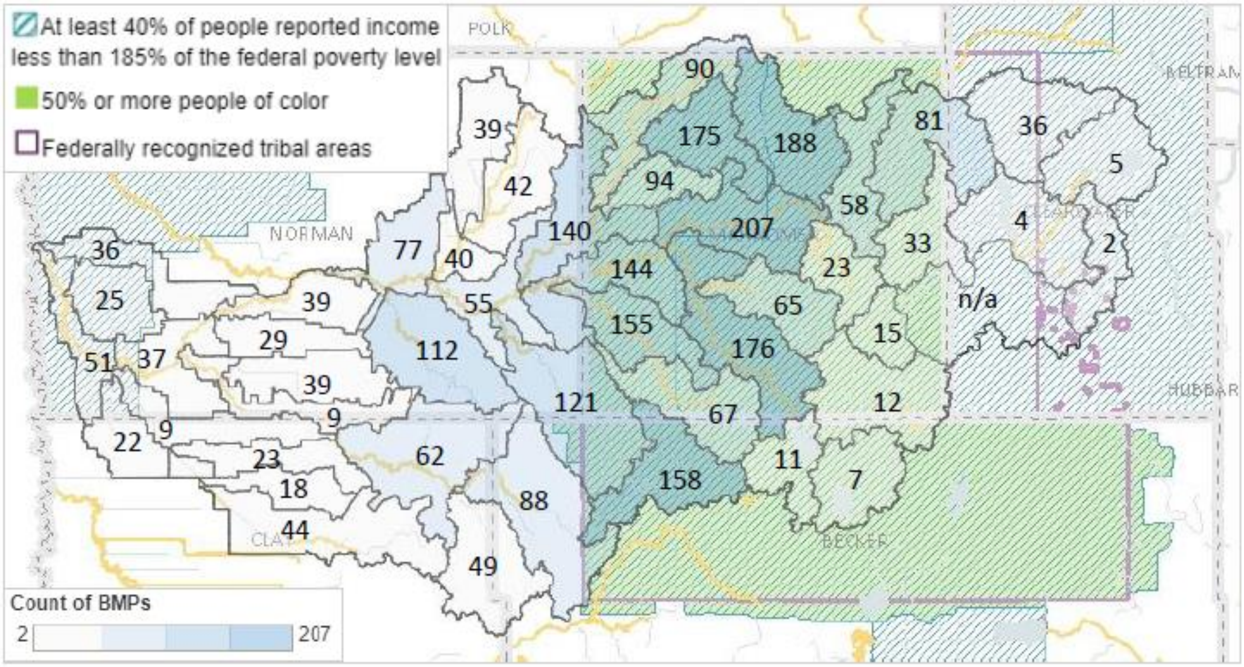


Table 40. BMPs that have been implemented within the WRRW from 2004-2019 (MPCA, 2019).

Strategy	Practice Description	Total BMPs	Installed Amount (by unit)	Units
Nutrient management (cropland)	Nutrient Management	358	67,425	Acres
Designed erosion control	Water & Sediment Control Basins	327	1,806	Acres
	Field Border	8	157	Acres
	Grassed Waterway	3	3	Acres
	Sediment Basin	2	4	Count
Tillage/residue management	Residue and Tillage Management, Reduced Till	163	40,459	Acres
	Residue and Tillage Management, No-Till	52	10,259	Acres
	Residue Management, Mulch Till	50	3,264	Acres
	Residue Management, No-Till/Strip Till	30	2,309	Acres
Living cover to crops in fall/spring	Cover Crop	145	14,654	Acres
Tile inlet improvements	Subsurface Drain	155	5,560	Acres
Converting land to perennials	Conservation Cover	56	3,907	Acres
	Critical Area Planting	20	10	Acres
	Conservation Easement	6	279	Acres
Pasture management	Prescribed Grazing	47	3,264	Acres
	Access Control	37	1,340	Acres
Habitat & stream connectivity	Upland Wildlife Habitat Management	53	174	Acres
	Wetland Wildlife Habitat Management	9	84	Acres
	Tree/Shrub Establishment	6	361	Acres

Strategy	Practice Description	Total BMPs	Installed Amount (by unit)	Units
Crop Rotation	Conservation Crop Rotation	43	951	Acres
Stream banks, bluffs & ravines	Grade Stabilization Structure	33	33	Count
	Streambank and Shoreline Protection	15	3,371	Feet
Buffers and filters - field edge	Filter Strip	30	180	Acres
	Riparian Forest Buffer	12	30	Acres
	Riparian Herbaceous Cover	3	3	Acres
Wetland restoration/creation	Wetland Enhancement	2	47	Acres
	Wetland Restoration	2	47	Acres
	Wetland Creation	1	5	Acres
Tile drainage treatment/storage	Drainage Water Management	1	1	Count
Septic System Improvements	Septic System Improvement	1	1	Count
Other	50+ other practices (e.g., dam, dike, fence, conservation easement, etc.)	1392	Varied	Varied

The following examples describe large-scale programs that have proven to be effective and/or will reduce pollutant loads going forward.

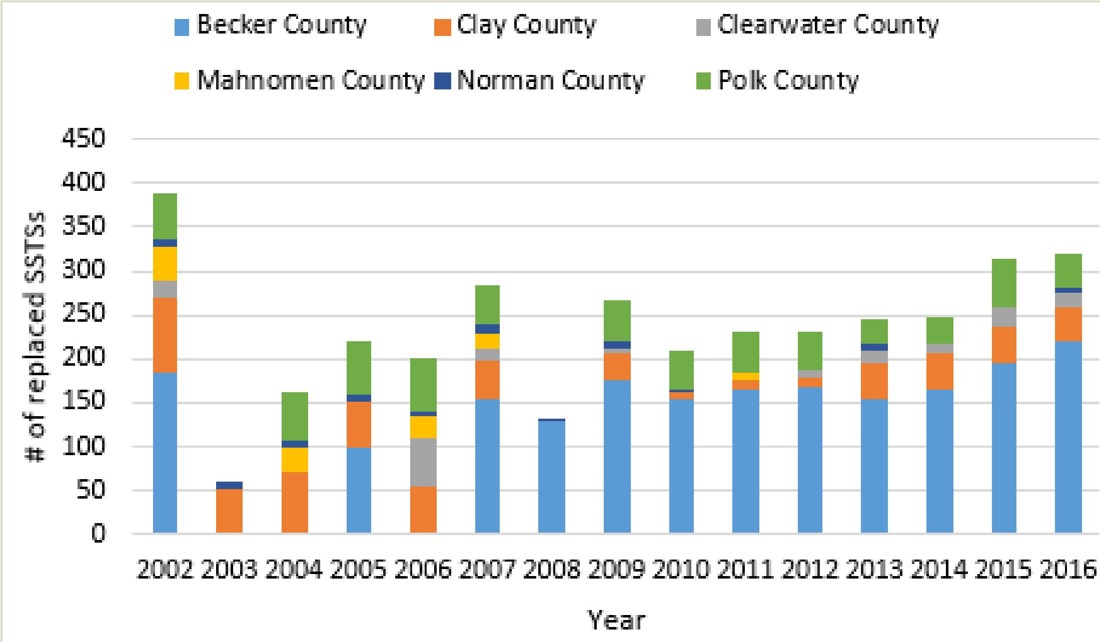
6.2.1 Subsurface Sewage Treatment Systems Program

SSTSs are regulated through Minn. Stat. §§ 115.55 and 115.56. SSTS specific rule requirements can be found in Minn. R. 7080 through 7083. Regulations include the following:

- Minimum technical standards for design and installation of individual and mid-size SSTS;
- A framework for local units of government to administer SSTS programs;
- Statewide licensing and certification of SSTS professionals, SSTS product review and registration, and establishment of the SSTS Advisory Committee; and
- Various ordinances for SSTS installation, maintenance, and inspection.

Each county maintains an SSTS ordinance, in accordance with the Minnesota Statutes and Minnesota Rules, establishing minimum requirements for regulation of SSTS, for the treatment and dispersal of sewage within the applicable jurisdiction of the county: to protect public health and safety; to protect groundwater quality; and to prevent or eliminate the development of public nuisances. Ordinances serve the best interests of the county's citizens by protecting health, safety, general welfare, and natural resources. In addition, each county zoning ordinance prescribes the technical standards that on-site septic systems are required to meet for compliance, and outlines the requirements for the upgrade of systems found not to be in compliance. This includes systems subject to inspection at transfer of property, upon the addition of living space that includes a bedroom and/or a bathroom, and at discovery of the failure of an existing system. **Figure 44** shows the number of SSTS replacements in the six counties that overlap with the boundary of the WRRW.

Figure 44. SSTS replacements by county and year (MPCA, n.d.).



6.2.2 Animal feedlot program

This section describes the MPCA's Feedlot Program, which addresses both permitted and nonpermitted feedlots. The Feedlot Program implements rules governing the collection, transportation, storage, processing, and disposal of animal manure and other livestock operation wastes. Minn. R. ch. 7020 regulates feedlots in the state of Minnesota. All feedlots capable of holding 50 or more AUs, or 10 in shoreland areas, are subject to this rule. The focus of the rule is on animal feedlots and manure storage areas that have the greatest potential for environmental impact. Feedlots holding 1,000 or more AUs are permitted in Minnesota.

The Feedlot Program is implemented through cooperation between MPCA and delegated county governments in 50 counties in the state. The MPCA works with county representatives to provide training, program oversight, policy and technical support, and formal enforcement support when needed. A county participating in the program has been delegated authority by the MPCA to administer the Feedlot Program. These delegated counties receive state grants to help fund their feedlot programs based on the number of feedlots in the county and the level of inspections they complete. In recent years, annual grants given to these counties statewide totaled about two million dollars (MPCA, 2017). The delegated counties in the project area for this report are Clay, Norman, and Polk, and the counties that are not delegated are Becker, Clearwater, and Mahnomen. In the counties that are not delegated, the MPCA is tasked with running the Feedlot Program.

6.2.3 Minnesota buffer law

Minnesota's buffer law (Minn. Stat. § 103F.48) requires perennial vegetative buffers of up to 50 feet along lakes, rivers, and streams and buffers of 16.5 feet along ditches. These buffers help filter out phosphorus, nitrogen, and sediment. Alternative practices are allowed in place of a perennial buffer in some cases. Amendments enacted in 2017 clarify the application of the buffer requirement to public waters, provide additional statutory authority for alternative practices, address concerns over the potential spread of invasive species through buffer establishment, establish a riparian protection aid program to fund local government buffer law enforcement and implementation, and allowed landowners to be granted a compliance waiver until July 1, 2018, when they filed a compliance plan with the appropriate SWCD.

BWSR provides oversight of the buffer program, which is primarily administered at the local level. Compliance with the buffer law is 94% to 100% (the highest compliance level) for all six counties in the WRRW as of March 2021 (BWSR, 2021).

6.2.4 Minnesota Agricultural Water Quality Certification Program

The Minnesota Agricultural Water Quality Certification Program (MAWQCP) administered by the Minnesota Department of Agriculture (MDA) is a voluntary opportunity for farmers and agricultural landowners to take the lead in implementing conservation practices that protect our water. Those who implement and maintain approved farm management practices will be certified and, in turn, obtain regulatory certainty for a period of 10 years.

Through this program, certified producers receive:

- Regulatory certainty: certified producers are deemed to be in compliance with any new water quality rules or laws during the period of certification;
- Recognition: certified producers may use their status to promote their business as protective of water quality; and
- Priority for technical assistance: producers seeking certification can obtain specially designated technical and financial assistance to implement practices that promote water quality.

Through this program, the public receives assurance that certified producers are using conservation practices to protect Minnesota's lakes, rivers, and streams. Since the start of the program in 2014, the program has achieved the following (estimates as of January 3, 2022):

- Enrolled over 806,000 acres;
- Included 1,155 producers;
- Added more than 2,300 new conservation practices;
- Kept over 40,000 tons of sediment out of Minnesota rivers;
- Saved over 119,000 tons of soil and over 51,000 pounds (lbs) of phosphorus on farms; and
- Cut greenhouse gas emissions by more than 42,900 U.S. tons annually.

Approximately 6,548 acres in the WRRW are certified under the MAWQCP (through December 31, 2020).

6.2.5 Section 319 Small Watershed Focus Program

The federal CWA Section 319 grant program provides funding to states to address NPS water pollution in watersheds. The MPCA has adopted a Section 319 Small Watersheds Focus Program to focus on geographically smaller and longer term watershed projects. The intent of the program is to make measureable progress for targeted waterbodies in the Section 319 focus watersheds, ultimately restoring impaired waters and preventing degradation of unimpaired waters. No subwatersheds of the WRRW have been selected for this funding yet.

6.2.6 Minnesota Nutrient Reduction Strategy

The Minnesota NRS (MPCA, 2014) guides activities that support nitrogen and phosphorus reductions in Minnesota waterbodies and those waterbodies downstream of the state (e.g., Lake Winnipeg). The NRS was developed by an interagency coordination team with public input. Fundamental elements of the NRS include:

- Defining progress with clear goals;
- Building on current strategies and success;
- Prioritizing problems and solutions;
- Supporting local planning and implementation; and
- Improving tracking and accountability.

Included within the strategy discussion are alternatives and tools for consideration by drainage authorities and local water resource managers, information on available tools and approaches for identifying areas of phosphorus and nitrogen loading and tracking efforts within a watershed, and additional research priorities. The NRS is focused on incremental progress and provides meaningful and achievable nutrient load reduction milestones that allow for better understanding of incremental and adaptive progress toward final goals. The strategy has set a reduction of 10% for phosphorus and 13% for nitrogen in the Red River Basin (relative to average 2003 conditions).

Successful implementation of the NRS will require broad support, coordination, and collaboration among agencies, academia, local government, and private industry. The MPCA is implementing a framework to integrate its water quality management programs on a major watershed scale, a process that includes:

- IWM;
- Assessment of watershed health;
- Development of WRAPS reports to inform local water planning; and
- Management of NPDES and other regulatory and assistance programs.

This framework will result in nutrient reduction for the Red River Basin as a whole and the major watersheds within the basin.

6.2.7 Conservation easements

Conservation easements are a critical component of the state’s efforts to improve water quality by reducing soil erosion, reducing phosphorus and nitrogen loading, and improving wildlife habitat and flood attenuation on private lands. Easements protect the state’s water and soil resources by permanently restoring wetlands, adjacent native grassland wildlife habitat complexes, and permanent riparian buffers. In cooperation with county SWCDs, BWSR's programs compensate landowners for granting conservation easements and establishing native vegetation habitat on economically marginal, flood prone, environmentally sensitive, or highly erodible lands. These easements vary in length of time from 10 years to permanent/perpetual easements. Types of conservation easements in Minnesota include Conservation Reserve Program (CRP), Conservation Reserve Enhancement Program (CREP), Reinvest in Minnesota (RIM), and the Wetland Reserve Program (WRP) or Permanent Wetland Preserve (PWP). As of August 20, 2020, in the five counties that make up >99% of the WRRW (Becker, Clay, Clearwater, Mahnomen, and Norman), there were 55,097 acres of short-term conservation easements such as CRP and 25,800 acres of long term or permanent easements (CREP, RIM, WRP) (BWSR, 2019).

6.3 Summary of local plans

Minnesota has a long history of water management by local government, which included developing water management plans along county boundaries since the 1980s. The BWSR-led One Watershed, One Plan (1W1P) program is rooted in work initiated by the Local Government Water Roundtable (Association of Minnesota Counties, Minnesota Association of Watershed Districts, and Minnesota Association of SWCDs). The Roundtable recommended that local governments organize to develop focused implementation plans based on watershed boundaries. That recommendation was followed by the legislation (Minn. Stat. § 103B.801) that established the 1W1P program, which provides policy, guidance, and support for developing comprehensive watershed management plans:

- Align local water planning purposes and procedures on watershed boundaries to create a systematic, watershed-wide, science-based approach to watershed management.
- Acknowledge and build off existing local government structure, water plan services, and local capacity.
- Incorporate and make use of data and information, including WRAPS.
- Solicit input and engage experts from agencies, citizens, and stakeholder groups; focus on implementation of prioritized and targeted actions capable of achieving measurable progress.
- Serve as a substitute for a comprehensive plan, local water management plan, or watershed management plan developed or amended, approved, and adopted.

The Wild Rice – Marsh Comprehensive Watershed Management Plan (a result of the 1W1P program), which includes the area of the WRRW along with the smaller Marsh River Watershed, was developed in 2019 and 2020 and approved by BWSR on December 17, 2020 (WRWD, 2020). Its development was led by the Wild Rice Watershed District. The plan incorporates information that resulted from the Wild Rice River WRAPS project including, but not limited to, impairments, TMDL reduction goals, and implementation strategies. In this plan, seven issues were identified as top priorities and include sediment loading, altered hydrology, flooding, soil health, phosphorus loading, channel integrity, and wild rice protection, the first two of which directly relate to the TSS TMDLs in this report. The plan has many goals that can decrease sediment loading, but the most relevant goal is sediment reduction, specifically decreasing sediment loading in the WRRW to achieve the reductions needed to meet the TSS TMDLs in this report. The plan lists ditch stabilization and reducing runoff volume by increasing water storage to address the altered hydrology priority issue. Increased *E. coli* is considered a mid-level priority in the plan. The short-term goal is to implement 20 projects to decrease *E. coli* loading, and the long-term goal is to implement projects at all potential loading sites. These *E. coli* goals are applicable to the entire plan area, which includes two major watersheds, but the WRRW makes up the majority of the plan area. Lakes that are impaired due to eutrophication are targeted for phosphorus reduction in the plan including Rockstad Lake, albeit at a lower priority than larger, deeper lakes such as Tulaby Lake.

6.4 Funding

Funding sources to implement TMDLs can come from local, state, federal, and/or private sources. Examples include BWSR's Watershed-based Implementation Funding, Clean Water Fund Competitive Grants (e.g., Projects and Practices), and conservation funds from Natural Resources Conservation Service (NRCS) (e.g., Environmental Quality Incentives Program and Conservation Stewardship Program).

Watershed-based implementation funding is a noncompetitive process to fund water quality improvement and protection projects for lakes, rivers/streams, and groundwater. This funding allows collaborating local governments to pursue timely solutions based on a watershed's highest priority needs. The approach depends on the completion of a comprehensive watershed management plan developed under the 1W1P program to provide assurance that actions are prioritized, targeted, and measurable.

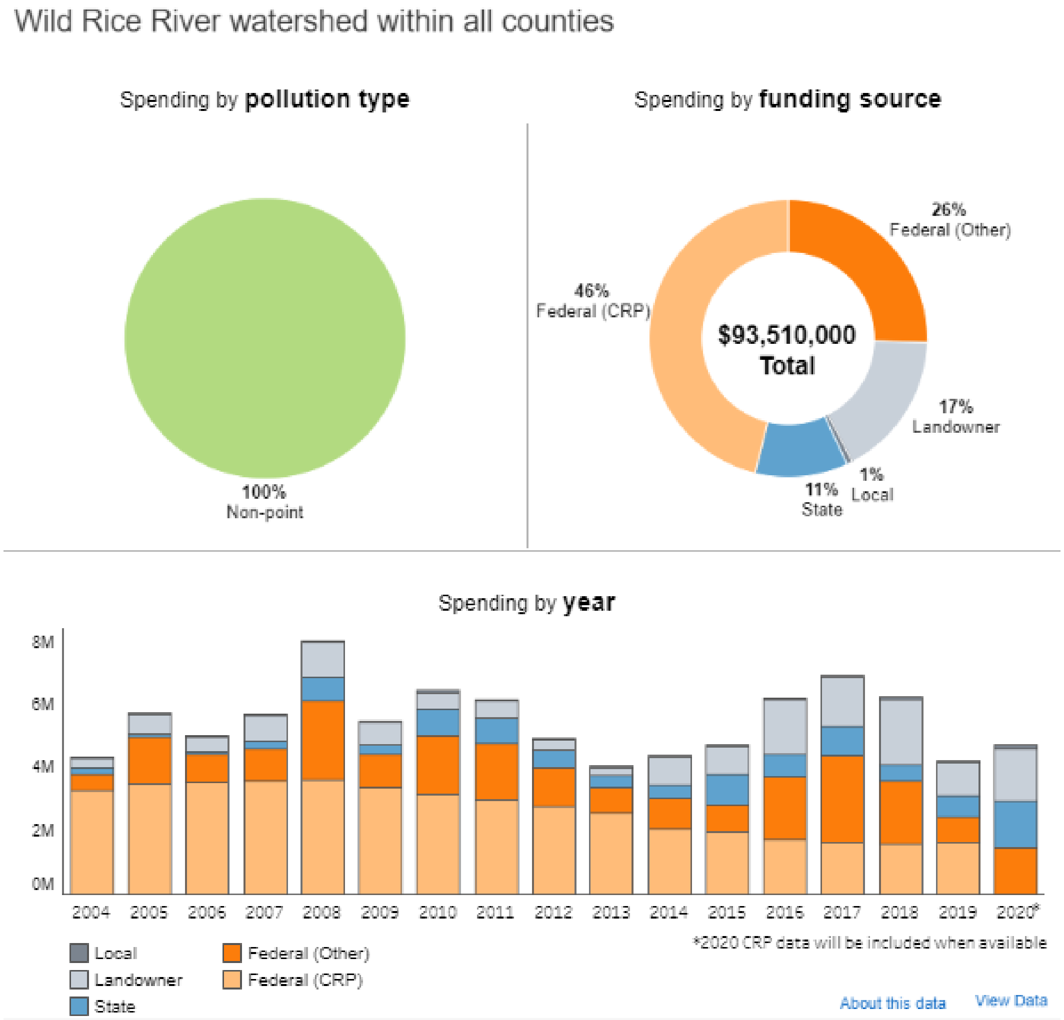
BWSR has begun the transition of moving more of its available funding away from competitive grants and toward watershed-based implementation funding to accelerate water management outcomes, enhance accountability, and improve consistency and efficiency across the state. This approach allows more clean water projects to be implemented and helps local governments spend limited resources where they are most needed.

Watershed-based implementation funding assurance measures are based on fiscal integrity and accountability for achieving measurable progress towards water quality elements of comprehensive watershed management plans. Assurance measures will be used as a means to help grantees meaningfully assess, track, and describe use of these grant funds to achieve clean water goals through prioritized, targeted, and measureable implementation. The following assurance measures are supplemental to existing reporting and on-going grant monitoring efforts:

- Understand contributions of prioritized, targeted, and measurable work in achieving clean water goals.
- Review progress of programs, projects, and practices implemented in identified priority areas.
- Complete Clean Water Fund grant work on schedule and on budget.
- Leverage funds beyond the state grant.

Over $93,000,000 has been spent on watershed implementation projects in the WRRW since 2004 (**Figure 45**).

Figure 45. Spending for WRRW implementation projects as summarized on MPCA's Healthier Watersheds webpage (MPCA, 2019).



6.5 Reasonable assurance conclusion

In summary, significant time and resources have been devoted to identifying the best BMPs, providing means of focusing them in the WRRW, and supporting their implementation via state initiatives and dedicated funding. The WRRW TMDL and WRAPS process engaged partners to arrive at reasonable examples of BMP combinations that attain pollutant reduction goals. Data and information gathered during the WRRW TMDL and WRAPS process went into the Wild Rice – Marsh Comprehensive Watershed Management Plan (a result of the 1W1P program), which includes the area of the WRRW. With completion and approval of the Wild Rice – Marsh Comprehensive Watershed Management Plan in 2020, watershed partners now qualify for watershed-based implementation funding, which is a noncompetitive process to fund water quality improvement and protection projects for lakes, rivers/streams, and groundwater. The first allocation of this funding for the Wild Rice – Marsh River planning area is expected to be $1,371,259 in fiscal year 2023. This funding allows collaborating local governments to pursue timely solutions based on a watershed's highest priority needs. Minnesota is a leader in watershed planning as well as monitoring and tracking progress toward water quality goals and pollutant load reductions.

7. Monitoring

The MPCA has three water quality monitoring programs for collecting data, enabling water quality condition assessments to be completed, and creating a long-term data set to track progress towards water quality goals. These programs will continue to collect and analyze data in the Wild Rice River Basin as part of *Minnesota's Water Quality Monitoring Strategy* (MPCA, 2011). Data needs are considered by each program and additional monitoring is implemented when deemed necessary and feasible. These monitoring programs are summarized below:

IWM (MPCA, 2017) data provides a periodic but intensive "snapshot" of water quality throughout the watershed. This program collects water quality and biological data at stream and lake monitoring stations across the WRRW for 2 years, every 10 years. The most recent IWM in the WRRW occurred in 2014 and 2015. To measure pollutants across the watershed, the MPCA will re-visit and re-assess the watershed, as well as have capacity to visit new sites in areas of interest. This work is scheduled to start its second iteration in the Wild Rice River in 2024.

Watershed Pollutant Load Monitoring Network (MPCA, 2019) data provide a continuous and long-term record of water quality conditions at the major watershed and subwatershed scale. This program collects pollutant samples and flow data to calculate continuous daily flow, sediment loads, and nutrient loads. In the WRRW, there are four sites: a watershed site near Hendrum, two subwatershed sites in the mainstem near Mahnomen and near Twin Valley, and a subwatershed site in the South Branch Wild Rice River near Felton.

Citizen Stream and Lake Monitoring Program (MPCA, 2020) data provide a continuous record of waterbody transparency throughout much of the watershed. This program relies on a network of private citizen volunteers who make monthly lake and river measurements. There are currently 14 stations (7 in lakes and 7 in streams) in the WRRW where citizen volunteers collect transparency data.

8. Implementation strategy summary

The strategies described in this section are potential actions to reduce *E. coli* (by reducing fecal contamination), TSS, and lake nutrients (TP) in the WRRW in Minnesota. A more detailed discussion on implementation strategies can be found in the *Final Wild Rice River Watershed Restoration and Protection Strategy Report* (MPCA, 2022).

8.1 Permitted sources

8.1.1 Construction stormwater

Exactly half of each categorical WLA for stormwater is attributed to construction stormwater. The construction stormwater portion of the WLAs that is discharged from sites where there is construction activity reflects the number of construction sites greater than one acre expected to be active in the watershed at any one time, and the BMPs and other stormwater control measures that should be implemented at the sites to limit the discharge of pollutants of concern. The BMPs and other stormwater control measures that should be implemented at construction sites are defined in Minnesota's NPDES/SDS General Stormwater Permit for Construction Activity (MNR100001). If a construction site owner/operator obtains coverage under the NPDES/SDS General Stormwater Permit and properly selects, installs, and maintains all BMPs required under the permit, including those related to impaired waters discharges and any applicable additional requirements found in Section 23 of the Construction General Permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL. Construction activity must also meet all local government construction stormwater requirements.

8.1.2 Industrial stormwater

Exactly half of each categorical WLA for stormwater is attributed to industrial stormwater. The industrial stormwater portion of the WLAs that is discharged from sites where there is industrial activity reflects the number of sites in the watershed for which NPDES/SDS industrial stormwater permit coverage is required, and the BMPs and other stormwater control measures that should be implemented at the sites to limit the discharge of pollutants of concern. Minnesota's NPDES/SDS Industrial Stormwater Multi-Sector General Permit (MNR050000) and NPDES/SDS Nonmetallic Mining/Associated Activities General Permit (MNG490000) establish benchmark concentrations for pollutants in industrial stormwater discharges. If a facility owner/operator obtains stormwater coverage under the appropriate NPDES/SDS permit and properly selects, installs, and maintains BMPs sufficient to meet the benchmark values in the permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL report. Industrial activity must also meet all local government stormwater requirements.

8.1.3 Wastewater

The MPCA issues permits for WWTP that discharge into waters of the state. The permits have site specific limits that are based on water quality standards. WWTPs discharging into impaired reaches did not require any changes to their discharge permit limits due to the WLAs calculated in this TMDL report. Permits regulate discharges with the goals of protecting public health and aquatic life, and assuring that every facility treats wastewater. In addition, SDS permits set limits and establish controls for land application of sewage and industrial by-products.

8.2 Nonpermitted sources

A summary of potential BMPs to reduce NPS is provided in **Table 41**. A goal of implementing BMPs to reduce *E. coli*, sediment, and phosphorus loading from NPS is to meet the TMDLs in this report (no reductions in these pollutants is required from point sources). Potential BMPs and implementation strategies are explored more thoroughly in the *Final Wild Rice River Watershed Restoration and Protection Strategy Report* (MPCA, 2022) and the *Wild Rice – Marsh River Watershed 1W1P* (WRWD, 2020).

Table 41. Summary of agricultural BMPs for agricultural sources and their primary targeted pollutants.

BMP (NRCS standard)	Targeted pollutant(s)		
	E. coli	Sediment	Phosphorus
Filter strips (636)	X	X	X
Riarian buffers (390)	X	X	X
Clean water diversion (362)	X		X
Access control/fencing (472 and 382)	X	X	X
Water storage facilities (313) and nutrient management (590)	X		X
Drainage water management (554)			
Grassed waterways (412)		X	X
Water and sediment control basins (638)		X	X
Conservation cover (327)		X	X
Conservation/reduced tillage (329 and 345)		X	X
Cover crops (340)		X	X

8.3 Cost

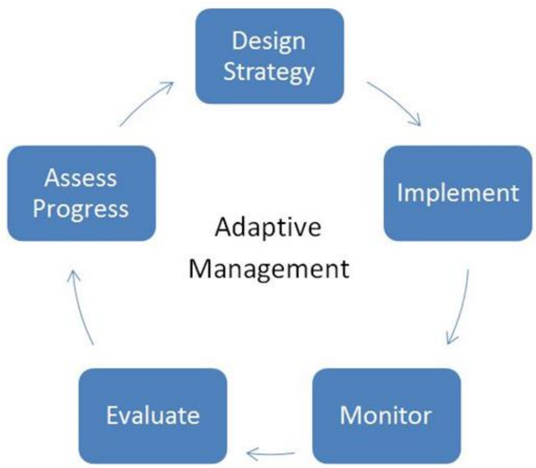
The CWLA requires that a TMDL include an overall approximation of the cost to implement a TMDL [Minn. Stat. 2007 § 114D.25]. The costs to implement the activities outlined in the *Final Wild Rice River Watershed Restoration and Protection Strategy Report* (MPCA, 2022) are approximately $40 to $50 million over the next 20 years. This range reflects the level of uncertainty in the source assessment and addresses the high priority sources identified in **Section 3.6**. The cost includes increasing local capacity to oversee implementation in the watershed and the voluntary actions needed to achieve reductions. Required buffer installation and replacement of ITPHS systems are not included.

8.4 Adaptive management

Adaptive management is an iterative implementation process that makes progress toward achieving water quality goals while using new data and information to reduce uncertainty and adjust implementation activities. Adaptive management is an ongoing process of evaluating and adjusting the strategies and activities that will be developed to implement the TMDL studies. The implementation of practicable controls should take place even while additional data collection and analysis are conducted to guide future implementation actions. Adaptive management does not include changes to water quality standards or LC. Any changes to water quality standards or LC must be preceded by appropriate administrative processes, including public notice and an opportunity for public review and comment.

The *Final Wild Rice River Watershed Restoration and Protection Strategy Report* (MPCA, 2022) provides details of the management strategies and activities listed in **Section 8.2**. The WRAPS report focuses on adaptive management (**Figure 46**) to evaluate project progress as well as to determine if the implementation approach should be amended. Implementation of TMDL-related activities can take many years, and water quality benefits associated with these activities can also take many years. As the pollutant source dynamics within the watershed are better understood, implementation strategies and activities will be adjusted and refined to efficiently meet the TMDLs and lay the groundwork for de-listing the impaired reaches. The follow up water monitoring program outlined in **Section 7** will be integral to the adaptive management approach, providing assurance that implementation measures are succeeding in attaining water quality standards.

Figure 46. Adaptive management.



9. Public participation

An open house style meeting was held on May 30, 2018, to provide an opportunity for the public to learn about and provide input on the Wild Rice River WRAPS project. It was held in Twin Valley, Minnesota, which is in the WRRW. The meeting was advertised to the public and governments (local, state, and tribal) with flyers, emails, phone calls, and a written and broadcast version of a press release. MPCA gave a presentation and encouraged discussions and questions. State and local government units set up many informational booths and were present to answer questions.

Another mode of getting local and public input for the WRAPS project was to gather it from meetings that were already taking place on topics related to water quality. For example, the timing of the 1W1P process overlapped with that of the WRAPS project, so there were several 1W1P meetings where information gathered was directly applicable to development of the TMDL and WRAPS reports.

9.1 Public notice

An opportunity for public comment on the draft TMDL report was provided via a public notice in the State Register from March 14, 2022 through April 13, 2022. No comment letters were received during the public comment period.

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Appendix A: *E. coli*/bacteria source estimates calculator spreadsheet for the WRRW.

Figure A-1. ***E. coli*** **source estimates calculator spreadsheet for the WRRW.**

Bacteria Source Estimates Calculator

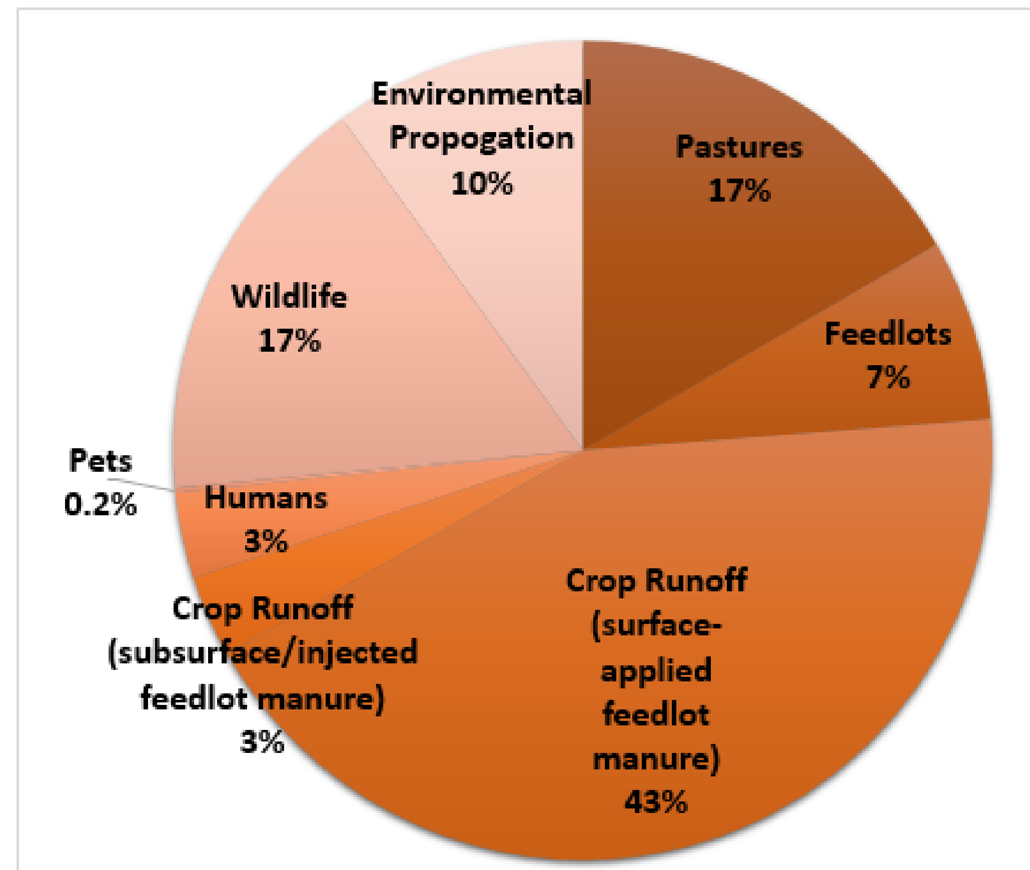
DIRECTIONS : [green cell] = enter value for watershed (known or assumption).

Watershed	wat.
Total area (ac)	1047069
Total Pasture (ac) with grazing animals	16964
Pasture <1000ft of water body (ac)	2724
Total AUs	32218
% feedlot AUs whose manure stockpiles w/o runoff controls	47%
number of pasture acres per 1 grazed AU	2
% Feedlot manure applied Surface	47%
% Feedlot manure applied Subsurface	53%
Pasture >1000 ft (ac)	14240
pasture <1000ft Aus	1362
pasture >1000ft AUs	7120
Feedlot AUs	23736
Feedlot inadequate runoff AUs	11156
Feedlot surface applied AUs	11156
Feedlot subsurface applied AUs	12580
Human population	13564
number of failing septics per 1,000 acres	0.1
number of people per failing septic	3
# humans comparable to 1 AU	7
# acres per 1 wildlife AU of total watershed	400
humans per pet (one pet for every x humans)	3
# pets comparable to 1 AU	30
% of total load due to environmental propogation	10%
people using failing septics	245
% of human wastewater inadequatetly treated (on failing septics)	2%
of human wastewater is adequately treated	98%
Human - inadequate treatment AUs	35
Human - adequate treatment AUs	1903
Pet AUs	151
Wildlife AUs	2618
Wet conditons (time with active runoff)	5%
Dry conditions (no active runoff)	95%

Total Livestock AUs data includes pastured animals
each AU produces 1 unit of manure/bacteria

Calculator by J Boettcher
Calculation method based on GBE fecal TMDL, but with other/additional assumptions and calculation methods

	condition	Pastures adjacent waterways	Other pastures	Pastures	Feedlots	Crop Runoff (surface-applied feedlot	Crop Runoff (subsurface/injected feedlot	Humans	Pets	Wildlife	Environmental Propogation	Human - adequately treated wastewater	Human - inadequately treated wastewater	SUM of Crop applied manure
Delivery ratio (assumed)	wet	5.0%	0.5%		0.5%	3.0%	0.2%		1.0%	3.0%		0.05%	2.0%	
Production x Delivery ratio x % of time		3.4	1.8		2.8	16.7	1.3		0.1	3.9		0.0	0.0	
Delivery ratio (assumed)	dry	0.1%	0.0%		0.0%	0.0%	0.0%		0.0%	0.1%		0.05%	1.0%	
Production x Delivery ratio x % of time		1.3	0.0		0.0	0.0	0.0		0.0	2.5		0.9	0.3	
Total Delivered Units		4.7	1.8	6.5	2.8	16.7	1.3	1.3	0.1	6.4	4	1.0	0.4	18.0
Total Delivered Percentage		12.1%	4.6%	16.6%	7.2%	42.9%	3.2%	3.4%	0.2%	16.5%	10.0%	2.4%	0.9%	46.2%



Notes on the *E. coli* source estimates calculator spreadsheet for the WRRW:

- The **Total Pasture (ac) with grazing animals** value was determined based on the following assumptions. Approximately 67,855 acres of land cover (Homer, et al., 2015) are pasture/hay. Assuming half of the pasture/hay land cover is pasture and half of that pasture has grazing animals on it, the total number of acres that have grazing animals is assumed to be 16,964.
- Values related to livestock AUs include AUs from both permitted and nonpermitted animal feedlots.
- The **Total AUs** cell was filled in with 32,218 based on MPCA's animal feedlots data (MPCA, 2020).
- The **% feedlot AUs whose manure stockpiles w/o runoff controls** was estimated based on animal feedlot data (MPCA, 2020). Most animal feedlots that are turkey, chicken, and pig operations keep animals in total confinement and have runoff controls and larger, permitted animal feedlots are more likely than the smaller, nonpermitted ones to have runoff control. These animal feedlots (permitted ones and those with turkeys, chickens, and pigs) comprise approximately 53% of the AUs in the WRRW. The remaining 47% of AUs reside on bovine, sheep/goat, and horse, etc. feedlots that are smaller and are assumed to not have runoff controls, so 47% was chosen as the value. These same feedlots were assumed to be ones to surface apply manure so **% Feedlot manure applied Surface** was set to 47% as well.
- The **number of pasture acres per 1 grazed AU** is based on the recommendation (NRCS, 2009) that a cow/calf pair (~1 AU) requires 1.5 to 2 acres of forage space for 12 months. The upper end of the range (2 acres) was used as the estimate in the spreadsheet.
    - Also, of the 116 animal feedlots in the WRRW, 98 have pastures. Those 98 pastures have a total of 17,133 AUs, which is very similar to the number of estimated pasture acres (16,964). Since approximately half of the AUs are assumed to be in the pasture at any given time (the other half may be in the feedlot area for example), there are 8,567 AUs in pastures, which equates to a ratio of 2 acres to 1 AU.
- Of the 116 animal feedlots in the WRRW, 98 have pastures. Of those 98, 25 are flagged for being near a river/stream or shoreland. Those 25 feedlots with pastures have a total of 2723 AUs. Assuming that approximately half of these AUs will be in the pasture at any given time (the other half may be in the feedlot area for example), there are 1,362 AUs in pastures that are near a waterbody. Since the ratio of acres to AU is 2 to 1, the **Pasture <1000ft of waterbody (ac)** was estimated to be 2,724.
- **Human population** and **number of people per failing septic** were estimated based on township demographic data (MN Dept of Administration, 2019).
- The **number of failing septics per 1,000 acres** was based on the raw data used to develop the *2018 SSTS Annual Report* (MPCA, 2019). Estimates of ITPHS septic systems were used instead of those that are "failing" as ITPHS systems are sources of *E. coli*.
- The remaining values were best estimates or default values.