Watershed

February 2024

Draft Root River Watershed Total Maximum Daily Load Report 2024

Pollutant reduction calculations for recently listed *E. coli*, total suspended solids, and nitrate impaired streams.

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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Cover photo credit: Spring Valley Creek, 2018. Tiffany Schauls

Document number: wq-iw9-28b

Contents

List of tables

List of figures

Abbreviations

1W1P	One Watershed, One Plan
AU	animal unit
BMP	best management practice
BWSR	Board of Water and Soil Resources
CAFO	concentrated animal feeding operation
CBOD	carbonaceous biological oxygen demand
Chl-*a*	chlorophyll-*a*
Ck	creek
cm	centimeter
CRP	Conservation Reserve Program
CREP	Conservation Reserve Enhancement Program
DO	dissolved oxygen
DWSMA	drinking water supply management area
DNR	Minnesota Department of Natural Resources
E. coli	*Escherichia coli*
EPA	U.S. Environmental Protection Agency
EQuIS	Environmental Quality Information System
HSPF	Hydrologic Simulation Program–Fortran
HUC	Hydrologic Unit Code
IBI	index of biotic integrity
ITPHS	imminent threat to public health and safety
IWM	intensive watershed monitoring
LA	load allocation
lb	pound
lb/day	pounds per day
LDC	load duration curve
LGU	local government unit
m	meter
MAWQCP	Minnesota Agricultural Water Quality Certification Program

MDA	Minnesota Department of Agriculture
mg/L	milligrams per liter
mL	milliliter
MNDOT	Minnesota Department of Transportation
MOS	margin of safety
MPCA	Minnesota Pollution Control Agency
MS4	municipal separate storm sewer system
NPDES	National Pollutant Discharge Elimination System
N	nitrogen
NRCS	Natural Resources Conservation Service
NPS	Nonpermitted source
NRS	Nutrient Reduction Strategy
NVSS	nonvolatile suspended solid
org/100mL	organisms per 100 milliliter
PFA	public facilities authority
PWP	Permanent Wetland Preserve
RIM	Reinvest in Minnesota
RRFSP	Root River Field to Stream Partnership
RRW	Root River Watershed
SDS	state disposal system
SIC	standard industrial classification
SID	stressor identification
SSTS	subsurface sewage treatment systems
SWCD	soil and water conservation district
TBEL	technology based effluent limit
T-tube	transparency tube
TMDL	total maximum daily load
TP	total phosphorus
TSS	total suspended solids
WASCOB	water and sediment control basin

WBIF	watershed-based implementation funding
WHAF	watershed health assessment framework
WID	water body identification
WLA	wasteload allocation
WRAPS	Watershed Restoration and Protection Strategy
WRP	Wetland Reserve Program
WQBEL	water quality-based effluent limit
WQS	water quality standards
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 (WQS) and/or designated uses. The TMDL establishes the maximum amount of a pollutant a water body can receive on a daily basis and still meet WQS. The TMDL is divided into wasteload allocations (WLA) for permitted sources, or pollutant sources that require a National Pollutant Discharge Elimination System (NPDES) permit, load allocations (LA) for nonpermitted sources and natural background, and a margin of safety (MOS). The phrase "nonpermitted" does not indicate that the pollutants are illegal, but rather that they do not require an NPDES permit. Some nonpermitted sources are unregulated (like commercial fertilizer application), and some nonpermitted sources are regulated through non-NPDES state programs or local permitting authorities.

$$\mathbf{TMDL = \Sigma WLA + \Sigma LA + MOS}$$

This 2023 TMDL study for the Root River Watershed (RRW) is part of the work being completed in the state of Minnesota's Cycle 2 Watershed Approach. Nineteen impairments from 10 water bodies are addressed in this report through 2 nitrate TMDLs, 7 total suspended solids (TSS) TMDLs, and 1 *Escherichia coli* (*E. coli)* TMDL.

The RRW is one of the largest watersheds in the state of Minnesota. It drains approximately 1,670 square miles (Minnesota portion only) and spans six counties in southeastern Minnesota: Mower, Dodge, Olmsted, Fillmore, Winona, and Houston. Many headwaters of the watershed, including the Root River, begin as drainage ditches in Mower County. These headwaters flow through intensely farmed areas, woodlands, and rolling terrain emptying into the Mississippi River 81 miles later.

Since the Cycle 1 TMDLs (MPCA 2016), the RRW has been re-visited for intensive watershed monitoring (IWM) and re-assessed for meeting WQS. Information from multiple sources was used to evaluate the ecological health of each water body including:

- All available water quality data over the past 10 years (2011 through 2020)
- Published studies
- Cycle 2 Stressor Identification (SID) investigation
- Extended Hydrologic Simulation Program-Fortran (HSPF) model (October 2015 through September 2021)
- Previous HSPF model time series: October 1993 through October 2015
- Stakeholder input

This document addresses select RRW impairments identified as needing TMDLs on the 2022 303(d) impaired waters list. Information in this report is presented by hydrologic unit code (HUC) 12 watershed level, where appropriate. Many elements impacting water quality described in this 2023 TMDL study have remained unchanged from the 2016 TMDL (MPCA 2016). The reader will be referred to sections of the 2016 TMDL for additional information. Similar to the 2016 TMDL, a load duration curve (LDC) was constructed for each impaired stream. The LDCs were then used to determine loading capacities for the impaired water bodies to meet WQS.

General strategies and cost estimates for implementation to address the impairments are included. Implementation efforts for both NPS and permitted pollutants are needed to address the TMDLs in this report. NPS contributions are not regulated and will need to be addressed on a voluntary basis. Permitted sources will be addressed through the MPCA's NPDES/State Disposal System (SDS) permit programs. Notably, Spring Valley WWTP (NPDES permit MN0051934) received a new 10 mg/L nitrate permit limit during development of this TMDL; this permit limit will achieve the WLA provided for the facility in this TMDL report.

1. Project overview

1.1 Introduction

Section 303(d) of the federal Clean Water Act requires that total maximum daily loads (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 water bodies. The term "TMDL" refers to the maximum amount of a given pollutant a water body can receive on a daily basis and still achieve WQS. A TMDL study determines what is needed to attain and maintain WQS 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.

This TMDL study addresses aquatic recreation, aquatic life and drinking water impairments on 10 water bodies in the RRW. Other completed studies for this watershed referenced in the development of this TMDL include:

- 2016 Root River TMDL (MPCA 2016)
- Root River Watershed Assessment and Trends Update (MPCA 2021)
- Root River SID Update (MPCA 2022)
- Revised Regional TMDL Evaluation of Fecal Coliform Bacteria impairments in the Lower Mississippi River Basin in Minnesota (MPCA 2006)

Because the TMDLs calculated in this report cover the same pollutants as the 2016 TMDL report, this study should be considered (for planning purposes) an addendum. Findings from this TMDL will be used in conjunction with existing studies to aid in identifying priority areas in the RRW. No TMDLs from the 2016 report are being revised in this report.

1.2 Identification of water bodies

This TMDL report applies to 19 impairments on 10 water bodies across 6 HUC-12 subwatersheds of the RRW (Figure 1). An impairment refers to an individual listing parameter for an individual water body identification (WID). One WID could have multiple impairments if it is listed for more than one parameter.

- 2 aquatic life (AQL) and 2 drinking water (DW) impairments in the Mill Creek HUC-12
- 5 AQL impairments in the Bear Creek HUC-12
- 3 AQL and 2 DW impairments in the Spring Valley Creek HUC-12
- 2 AQL impairments in the Camp Creek HUC-12
- 1 aquatic recreation (AQR) impairment in the Upper South Fork Root River HUC-12

- 2 AQL impairments in the Riceford HUC-12

These impairments are addressed through 7 TSS TMDLs, 2 nitrate TMDLs, and 1 *E. coli* TMDL. Two nitrate impairments, Unnamed Creek (Mill Creek Tributary) (-A47) and Unnamed Creek (Spring Valley Creek Tributary) (-D53), did not receive their own TMDLs and were instead included in their downstream nitrate impairment's TMDL (those for Mill Creek (-536) and Spring Valley Creek (-548), respectively). This is appropriate as both unnamed creeks have the same designated use as the respective downstream impairments and are tributaries located wholly within the drainage areas to their downstream impairments. No NPDES permitted sources are impacted by these inclusions.

Although TMDLs are not developed in this report for nonpollutant stressors to biological impairments, all stressors—not just those with associated TMDLs—are addressed in the concurrently developed Watershed Restoration and Protection Strategies (WRAPS) report update. The WRAPS report update provides an opportunity to call for environmental improvements in situations where TMDLs alone would not. Examples of nonpollutant stressors in southeast Minnesota include lack of suitable habitat, flow alteration, and lack of stream connectivity—none of which are driven by pollutants and as such are not addressed by TMDLs. TMDLs typically are not developed for nonpollutant stressors because they are not subject to load quantification.

Table 1 below and Table 65 in Appendix A (which includes all impairments in this watershed) summarize RRW impairments and those addressed by TMDLs in this document.

Figure 1. RRW impairments addressed in this TMDL and their applicable HUC-12 watersheds.

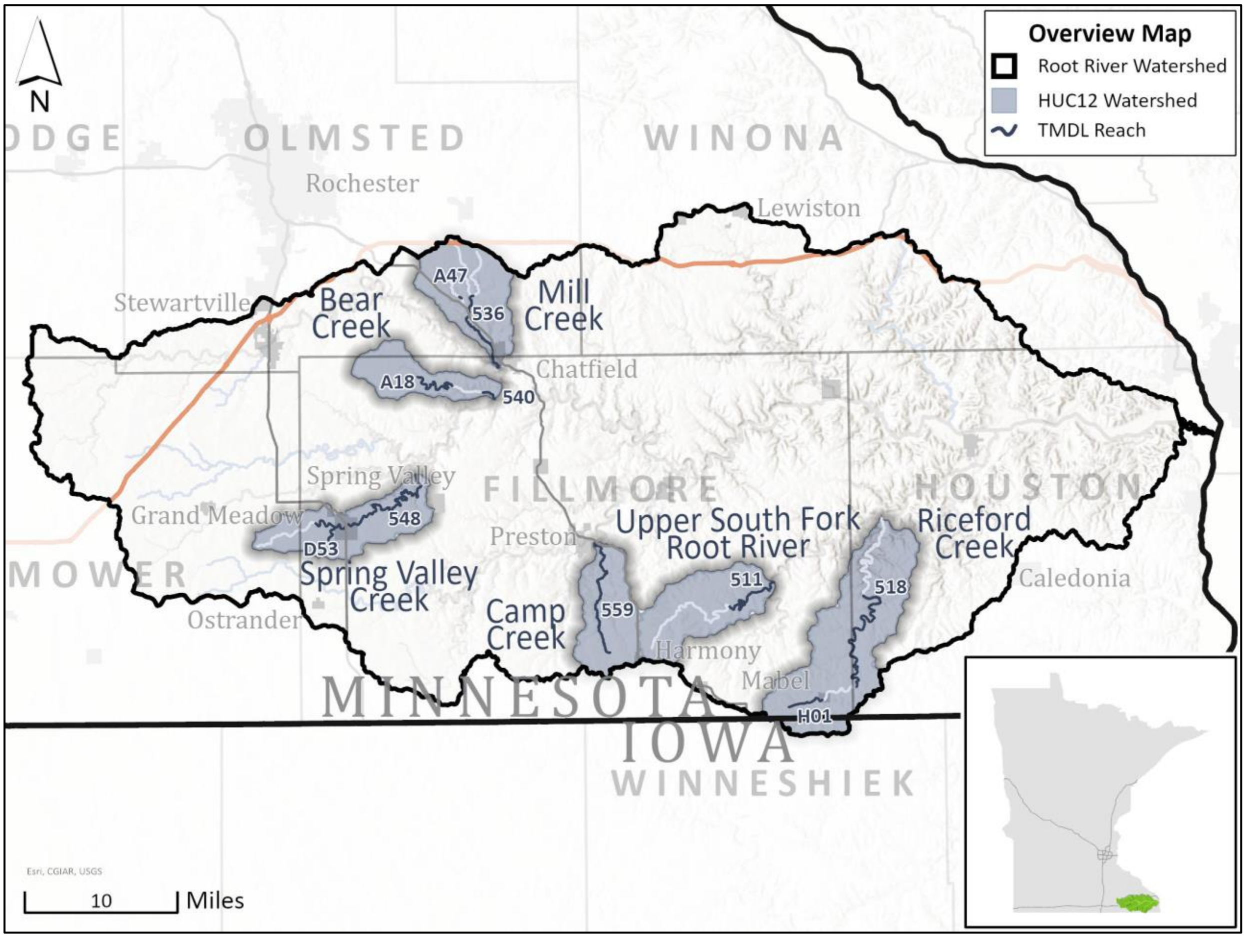


Table 1. Impaired water bodies in the RRW addressed in this TMDL report.

WID	Water body name	Water body description	Use class	Listing year	Affected designated use [a]	Listing parameter	TMDL pollutant	Category 4A upon TMDL approval [b]
07040008-536	Mill Creek	T105 R12W S14, north line to N Br Root R	1B, 2Ag	2020	AQL	Macroinvertebrate bioassessment	TSS	N [c]
						Fish bioassessment		
				2022	DW	Nitrate	Nitrate	Y
07040008-A47	Unnamed Creek (Mill Creek Tributary)	T105 R12W S14, west line to Unnamed cr	1B, 2Ag	2022	DW	Nitrate	Nitrate	Y [d]
07040008-A18	Bear Creek (Lost Creek)	Unnamed cr to T104 R12W S10, east line	2Ag	2022	AQL	TSS	TSS	Y
						Fish bioassessments	TSS	N [c]
						Macroinvertebrate bioassessment		
07040008-540	Upper Bear Creek	T104 R11W S18, west line to M Br Root R	2Ag	2012	AQL	Fish bioassessments	TSS	N [c]
						Macroinvertebrate bioassessment		
07040008-548	Spring Valley Creek	T103 R13W S29, west line to Deer Cr	1B, 2Ag	2022	AQL	TSS	TSS	Y
				2012	AQL	Fish bioassessments	TSS	N [c]
						Macroinvertebrate bioassessment		
				2022	DW	Nitrate	Nitrate	Y
07040008-D53	Unnamed creek (Spring Valley Creek Tributary)	T103 R13W S32, south line to Spring Valley Cr	1B, 2Ag	2022	DW	Nitrate	Nitrate	Y [e]
07040008-559	Camp Creek	Headwaters to S Br Root R	2Ag	2012	AQL	Fish bioassessments	TSS	N [c]
						Macroinvertebrate bioassessment		
07040008-511	South Fork Root River	T102 R9W S26, west line to Wisel Cr	2Ag	2022	AQR	*E. coli*	*E. coli*	Y
07040008-H01	Riceford Creek	-91.814, 43.512 to T101 R8W S17, east line	2Bg	2020	AQL	Macroinvertebrate bioassessment	TSS	N [c]

WID	Water body name	Water body description	Use class	Listing year	Affected designated use [a]	Listing parameter	TMDL pollutant	Category 4A upon TMDL approval [b]
07040008-518	Riceford Creek	T101 R7W S19, south line to T102 R7W S30, north line	2Ag	2012	AQL	Macroinvertebrate bioassessment	TSS	N [c]

a. AQR: aquatic recreation; AQL: aquatic life; DW: drinking water

b. Impairment will be categorized as 4A (impaired and a TMDL study has been approved by EPA) upon approval of this TMDL and will appear as 4A in the next impaired waters list. For a biological impairment to be categorized as 4A, TMDLs for all stressors needed to achieve attainment of applicable WQS must be approved by EPA. If there are remaining conclusive stressors, the impairment will remain in category 5 until TMDLs are developed for all conclusive pollutant stressors.

c. This TMDL addresses only one of the identified pollutant stressors causing aquatic life impairment; reach will remain as category 5 until all identified stressors are addressed (see Appendix A for full list of stressors).

d. Impairment is addressed by downstream TMDL developed for nitrate drinking water impairment in Mill Creek (07040008-536) in this report.

e. Impairment is addressed by downstream TMDL developed for nitrate drinking water impairment in Spring Valley Creek (07040008-548) in this report.

1.3 Tribal lands

The RRW is located on the traditional homelands of the Dakota Oyate. However, no part of the RRW is located within the boundary of a federally recognized Tribal land, and the TMDL does not allocate pollutant load to any federally recognized Tribal Nation in the RRW.

1.4 Priority ranking

The Minnesota Pollution Control Agency (MPCA's) schedule for TMDL completions, as indicated on Minnesota's Section 303(d) impaired waters list, reflects Minnesota's priority ranking of these TMDLs. The MPCA has aligned TMDL priorities with the watershed approach. The schedule for TMDL completion corresponds to the WRAPS report completion generally following the two-year IWM. The MPCA developed a TMDL priority framework (MPCA 2022a) to meet the needs of U.S. Environmental Protection Agency (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), which was updated in 2022 ("*2022-2032 Vision for the Clean Water Act Section 303(d) Program,"* (EPA 2022)). 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 Clean Water Act requires states to designate beneficial uses for all waters and develop WQS to protect each use. WQS 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.
- 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 Clean Water Act goals. Minnesota's WQS 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
- Class 7 – limited resource value waters

The Class 2 aquatic life beneficial use includes a tiered aquatic life uses 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 water body.

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:

- Cold water aquatic life and habitat, also protected for drinking water: Classes 1B; 2A, 2Ae, or 2Ag; 3; 4A and 4B; and 5
- Cool and warm water aquatic life and habitat, also protected for drinking water: Classes 1B or 1C; 2Bd, 2Bde, 2Bdg, or 2Bdm; 3; 4A and 4B; and 5
- Cool and warm water aquatic life and habitat and wetlands: Classes 2B, 2Be, 2Bg, 2Bm, or 2D; 3; 4A and 4B; and 5
- 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 water bodies 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 water body type and use subclass (exceptional, general, and modified).

Both Class 2A 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 recreational activities, its trophic status is evaluated using total phosphorus (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.

2.3 Antidegradation policies and procedures

The purpose of the antidegradation provisions in Minn. R. ch. 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.
- Proposed activities with the potential for water quality impairments associated with thermal discharges are consistent with Section 316 of the Clean Water Act, United States Code, Title 33, Section 1326.

2.4 Root River Watershed water quality standards

WQS for *E. coli*, nitrate and TSS are presented in Table 2 and further explained in the following subsections. These standards serve as targets for the applicable RRW TMDLs.

Table 2. Water quality standards and surrogate pollutant information for the RRW TMDL.

Parameter	Stream class (River Nutrient Region)	Water quality standard	Numeric standard/target
E. coli	Class 2A and 2B	Not to exceed 126 organisms per 100 milliliters (org/100 mL) as a geometric mean of not less than five samples representative of conditions within any calendar month, nor shall more than 10% of all samples taken during any calendar month individually exceed 1,260 org/100 mL. The standard applies April 1–October 31.	≤ 126 organisms/ 100 mL water (monthly geometric mean) ≤ 1,260 organisms/ 100 mL water (individual sample)
TSS	2A – Cold water (Statewide)	10 mg/L (milligrams per liter); TSS standard may be exceeded for no more than 10% of the time. The standard applies April 1–September 30.	≤ 10 mg/L
	2B- Cool water or warmwater (South River Nutrient Region)	65 mg/L; TSS standard may be exceeded for no more than 10% of the time. This standard applies April 1–September 30.	≤ 65 mg/L
Transparency (surrogate measure used to determine if a stream exceeds the TSS standard)	2A	TSS WQS is not met if transparency (T)-tube < 55 cm; TSS WQS is met if T-tube > 95 cm; Transparency may be below the standard no more than 10% of the time. This standard applies April 1–September 30.	> 95 cm transparency
	2B	TSS WQS is not met if T-tube < 10 cm; TSS WQS is met if T-tube > 15 cm; Standard may be exceeded for no more than 10% of the time. This standard applies April 1–September 30.	> 15 cm transparency
Nitrate	Class 1B/1C	10 mg/L; no more than 1 exceedance of the acute standard in 3 years.	≤ 10 mg/L

2.4.1 *E. coli*

In Minnesota, *E. coli* is used as an indicator species of potential waterborne pathogens. The MPCA uses *E. coli* bacteria, which are commonly found in fecal waste and are easy to measure, as an indicator species of potential waterborne pathogens. Using indicator bacteria to assess the presence of pathogens is not a perfect process though it is the best available at this time. There are two *E. coli* standards for Class 2 waters—one is applied to monthly *E. coli* geometric mean concentrations, and the other is applied to individual samples. Exceedances of either *E. coli* standard in Class 2 waters indicates that a water body does not meet the applicable designated use. The standard applies from April through October.

2.4.2 TSS and Transparency

Exceedances of the TSS standard in streams indicate that a water body does not meet the aquatic life designated use. The TSS standard for all class 2A streams is 10 mg/L, and the TSS standard for Class 2B streams in the South River Nutrient Region is 65 mg/L (Table 2). For assessment, this concentration is not to be exceeded in more than 10% of samples within a 10-year period. The TSS standard applies April 1 through September 30.

Transparency values, as measured by transparency tubes (T-tube), reliably predict TSS and can serve as surrogates (MPCA 2022e). While TSS measurements themselves are generally preferred, datasets for T-tube are often more robust, and their relative strength is considered in assessments.

The T-tube surrogate thresholds for determining if a stream exceeds the TSS standard are different than for determining if a stream meets the standard. A stream is considered to exceed the standard for TSS and/or the T-tube surrogate if 1) the standard is not met more than 10% of the days of the assessment season (April through September) as determined from a data set that gives an unbiased representation of conditions over the assessment season, and 2) there are at least three such measurements exceeding the standard.

A stream is considered to meet the standard for TSS and/or the T-tube surrogate if the standard is met at least 90% of the days of the assessment season. A designation of meeting the standard for TSS and/or T-tube generally requires at least 20 suitable measurements from a data set that gives an unbiased representation of conditions over at least two different years. However, if it is determined that the data set adequately targets periods and conditions when exceedances are most likely to occur, a smaller number of measurements may suffice.

T-tube measurements that fall between the two relevant surrogate values are considered indeterminate in exceeding or meeting the TSS standard. For Class 2A waters in the Southern River Nutrient Region, 55 cm and 95 cm represent the lower and upper surrogate values, respectively. If a stream satisfies neither the T-tube criterion for exceeding the TSS standard nor the T-tube criterion for meeting the TSS standard, the stream is considered to have insufficient information regarding TSS levels. For 2B waters in the Southern River Nutrient Region, 10 cm and 15 cm represent the lower and upper surrogate values, respectively. If a stream satisfies neither the criterion for exceeding the standard nor the criterion for meeting the standard, the stream is considered to have insufficient information regarding TSS levels (MPCA 2022e).

It is possible to de-list or correct a TSS impairment where no TSS data exists using surrogate T-tube data alone if the original listing was also based on surrogate T-tube or S-tube data and that the same data requirements that apply to TSS also apply to the surrogate data set as spelled out in the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment (2022e).

2.4.3 Nitrate

Nitrate nitrogen (referred to as 'nitrate' throughout this document) poses a risk to human health at concentrations exceeding 10 mg/L in drinking water. Humans, especially infants under six months of age, who are exposed to nitrate in drinking water at concentrations exceeding the 10 mg/L federal safe drinking water standard can develop methemoglobinemia, a blood disorder that interferes with the ability of blood to carry oxygen. The 10 mg/L nitrate standard is an acute toxicity standard. The MPCA assesses Class 1B and 1C designated surface waters for potential impairment by nitrate. This is especially important in southeast Minnesota's karst region where an increasing trend of nitrate concentrations in streams is observed, as well as the public health and economic impact arising from elevated nitrate concentrations in drinking water (MPCA 2020), given the close connection between surface water and ground water in Karst settings. For assessment, MPCA compares 24-hour average nitrate concentrations to the 10 mg/L standard. Two 24-hour averages exceeding 10 mg/L within a three-year period indicate impairment (MPCA 2022e)

3. Watershed and water body characterization

The RRW covers 1,064,961 acres in southeast Minnesota (Figure 1). This watershed lies within the Driftless Area ecoregion and is known for its unique karst features and coldwater trout streams. Waters in the RRW eventually drain to the Mississippi River east of Hokah, Minnesota. Overall, the RRW is rural in nature. Several towns are scattered across the watershed; the most sizeable in population are Chatfield, Preston, Spring Valley, Lanesboro, Houston, and Hokah. Row crop agriculture (i.e., corn and soybeans) is the dominant land use. While there are water quality impairments of aquatic life and aquatic recreation throughout the RRW, this watershed continues to support high quality streams. Fish and macroinvertebrates data collected in 2018 and 2019 found the aquatic life communities generally scoring higher than the community scores in 2008. Water chemistry showed little change from the previous assessment in 2010. Dissolved oxygen (DO) and phosphorus are considered nonissues while TSS, *E. coli*, and nitrate continue to be problematic (MPCA 2023a). More detailed information on the RRW can be found in the 2016 TMDL (MPCA 2016).

Much of the information in this TMDL report is derived from the MPCA's HSPF model application of the RRW (Tetra Tech 2013, Tetra Tech 2018, Tetra Tech 2022, and MPCA 2023). HSPF is a comprehensive model of watershed hydrology and water quality that allows the integrated simulation of point sources, land and soil contaminant runoff processes, and in-stream hydraulic and sediment-chemical interactions. The results provide hourly runoff flow rates, sediment concentrations, and nutrient concentrations, along with other water quality constituents, at the outlet of any modeled subwatershed. Within each subwatershed, the upland areas are separated into multiple land cover categories, and loads generated from these land cover categories can be tabulated from the HSPF model. The model evaluates both permitted and nonpermitted sources of pollutants including watershed runoff, near channel sources, and wastewater permitted sources. In this TMDL, HSPF is used to simulate flows in the impaired streams and to estimate TSS and nitrate loading by source. These model outputs also assist in best management practice (BMP) selection.

The Root River HSPF model was updated in 2018 (Tetra Tech 2018) to better simulate surface water leaching through karst and then extended through the year 2021 by Tetra Tech and MPCA in 2022 (Tetra Tech 2022 and MPCA 2023). This 2021 model extension included updating meteorological data, stream flow, surface water quality data, atmospheric deposition and permitted point source discharge data. Model documentation contains additional details about model development (Tetra Tech 2013, Tetra Tech 2018, Tetra Tech 2022, and MPCA 2023).

3.1 Climate trends

Changes in climate have been documented not only globally, but locally in the RRW. Climate summaries for Minnesota watersheds are provided by Minnesota Department of Natural Resources (DNR) through their Watershed Health Assessment Framework (WHAF) tool. In the RRW, temperature and precipitation records from 1895 to 2018 indicate changes in climate. Overall, data show that the RRW is experiencing warmer temperatures (Figure 3) and wetter conditions. Warming is most notable during the winter months (Figure 2), and more precipitation is more pronounced during spring and summer (Figure 4).

Figure 2. Monthly minimum temperature distribution and departure from record mean temperature 1899 - 2018 (degrees Fahrenheit) in the RRW. DNR, 2019.

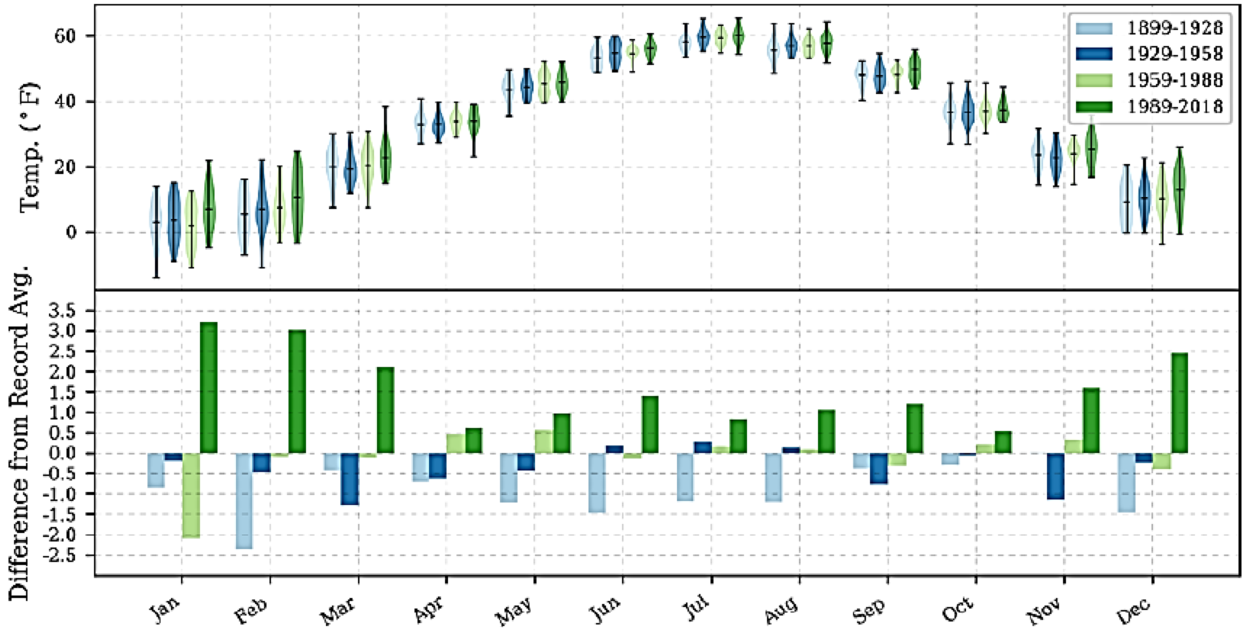


Figure 3.1899 - 2018 Annual average temperature in degrees Fahrenheit for the RRW. DNR, 2019.

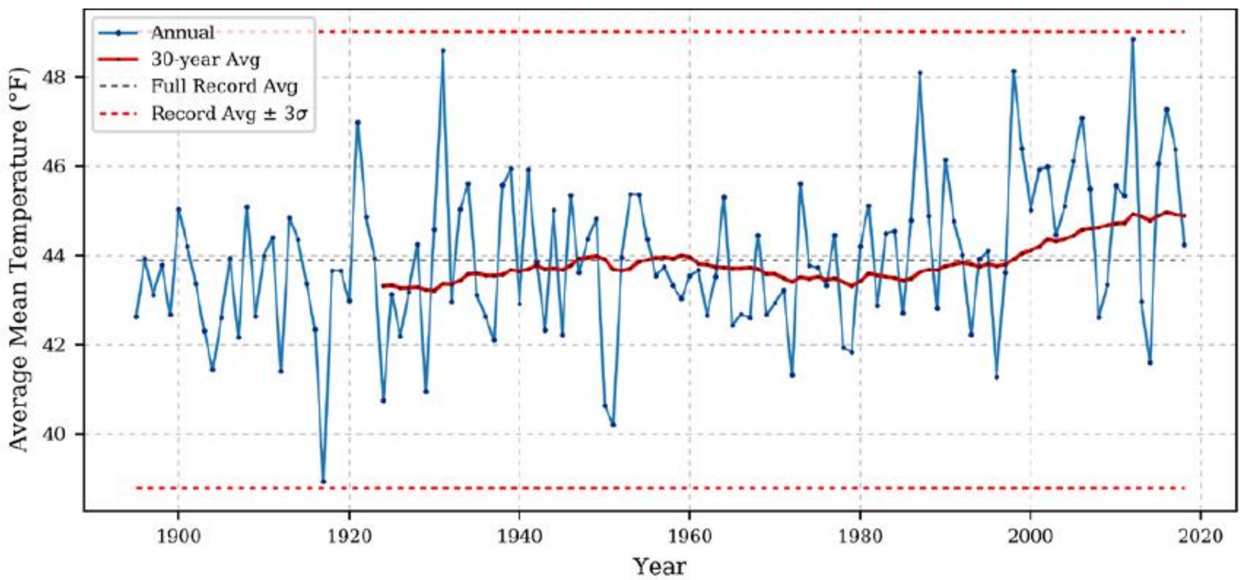
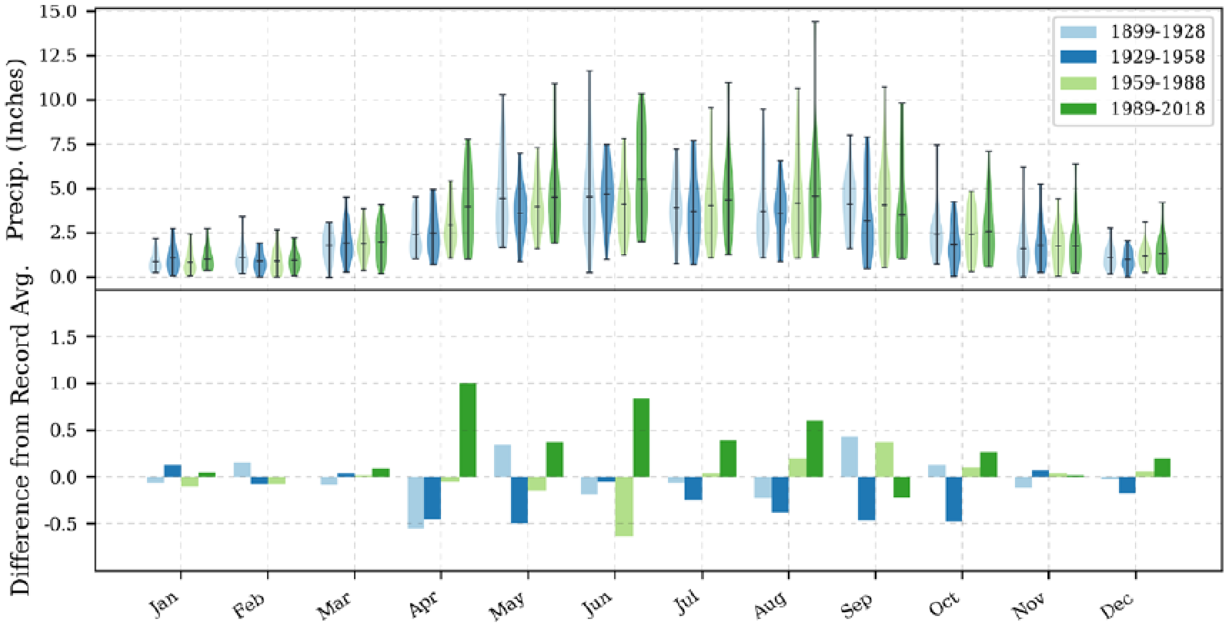


Figure 4. Monthly precipitation distribution and departure from record mean precipitation (inches) in the RRW from 1899 - 2018. DNR, 2019.



DNR has also been tracking hydrologic trends in the RWW using data from 1890 through 2020 (Station E43017001). Hydrologic data includes average precipitation, average stream flow and average peak flows. DNR's Evaluation of Hydrologic Change RRW Report identifies the water year that represents the period of greatest hydrologic difference. For the Root River, 1991 was the year when significant changes in hydrologic conditions occurred (DNR 2022). For more information on how this change point was established, see DNR 2022. Since 1991, the following has been noted for the Root River at Houston, Minnesota:

- Average annual precipitation has increased by five inches
- Low flows are occurring 65% less often
- The Root River rises 40% faster
- River base flows are more than doubling in the month of August
- Channel forming flows are slightly increasing

3.2 Streams by subwatershed

The impaired waters addressed in this TMDL are located in the following HUC-12 level subwatersheds:

- Mill Creek (070400080107)
- Bear Creek (070400080207)
- Spring Valley Creek (070400080205)
- Camp Creek (070400080407)
- Upper South Fork Root River (070400080801)
- Riceford Creek (070400080804)

Drainage areas for impaired streams were delineated using multiple data sources, starting with watershed delineations from the RRW HSPF model. The model watershed boundaries are based on DNR Level 7 watershed boundaries. Where additional watershed breaks were needed to define the impairment watersheds, USGS Stream Stats (https://streamstats.usgs.gov/ss/) was used. For some impairments, drainage areas and applicable HUC-12 watersheds are the same. Table 3 summarizes watershed information for each impaired stream included in this TMDL report. Drainage areas are shown individually in Section 5.

Table 3. Subwatersheds and impaired waters relevant to this TMDL.

HUC-12		Impaired water(s)				
Name	**Area (square miles)**	**Name**	**WID**	**Stream length (miles)**	**Drainage area (square miles)**	**Designated trout stream?**
Mill Creek (070400080107)	31.93	Mill Creek	07040008-536	8.07	31.93	Yes
		Unnamed Creek (Mill Ck trib)	07040008-A47	0.20	6.34	No (classified 2A)
Bear Creek (070400080207)	18.74	Bear Creek (Lost Ck)	07040008-A18	5.57	13.94	Yes
		Upper Bear Creek	07040008-540	1.10	18.74	Yes
Spring Valley Creek (070400080205)	30.16	Spring Valley Creek	07040008-548	17.65	30.16	Yes
		Unnamed creek (Spring Valley Creek Tributary)	07040008-D53	1.36	2.33	No (classified 2A)
Camp Creek (070400080407)	26.62	Camp Creek	07040008-559	11.74	26.62	Yes
Upper South Fork Root River (070400080801)	32.12	South Fork Root River	07040008-511	6.58	32.12	Yes
Riceford Creek (070400080804)	64.57 [a]	Riceford Creek	07040008-518	13.52	47.16 [a]	Yes
		Riceford Creek	07040008-H01	2.59	8.42 [a]	No (classified 2B)

a. Subwatershed area includes 4.6 square miles of area in the state of Iowa.

3.3 Land cover

The RRW has a diverse landscape made up primarily of cropland, forest/shrub and pasture/grasslands. Another notable feature of the landscape in the RRW is the presence of karst geology. This “leaky” geology, made of shallow limestone/sandstone bedrock, is due to the absence of glaciers from the last ice age. Because of this geology, there is little to no agricultural drainage tiling, no lakes, and vulnerable drinking water aquifers. Three distinct geomorphic regions cover the watershed (from west to east): till covered karst, near surface karst, and bluffland karst. Till covered karst in the western part of the watershed tends to be flat and used for crop production. Land in the near surface karst region in the central portion of the RRW is steep and rugged with soluble limestone underneath. Water has carved sinkholes, caves and tunnels throughout this limestone. Bluffland karst, in the eastern portion, is dominated by steep bluffs and limited but still active agricultural use. Land use since the 2016 TMDL (which used 2011 land cover data) has not drastically changed at the HUC-8 level watershed scale (Figure 5). For the purposes of this TMDL, land cover is also provided at a finer HUC-12 level scale (Table 4). Land cover by HUC-12 is also provided in Section 5.

Figure 5. Land cover in the RRW HUC-8 (CDL 2021).

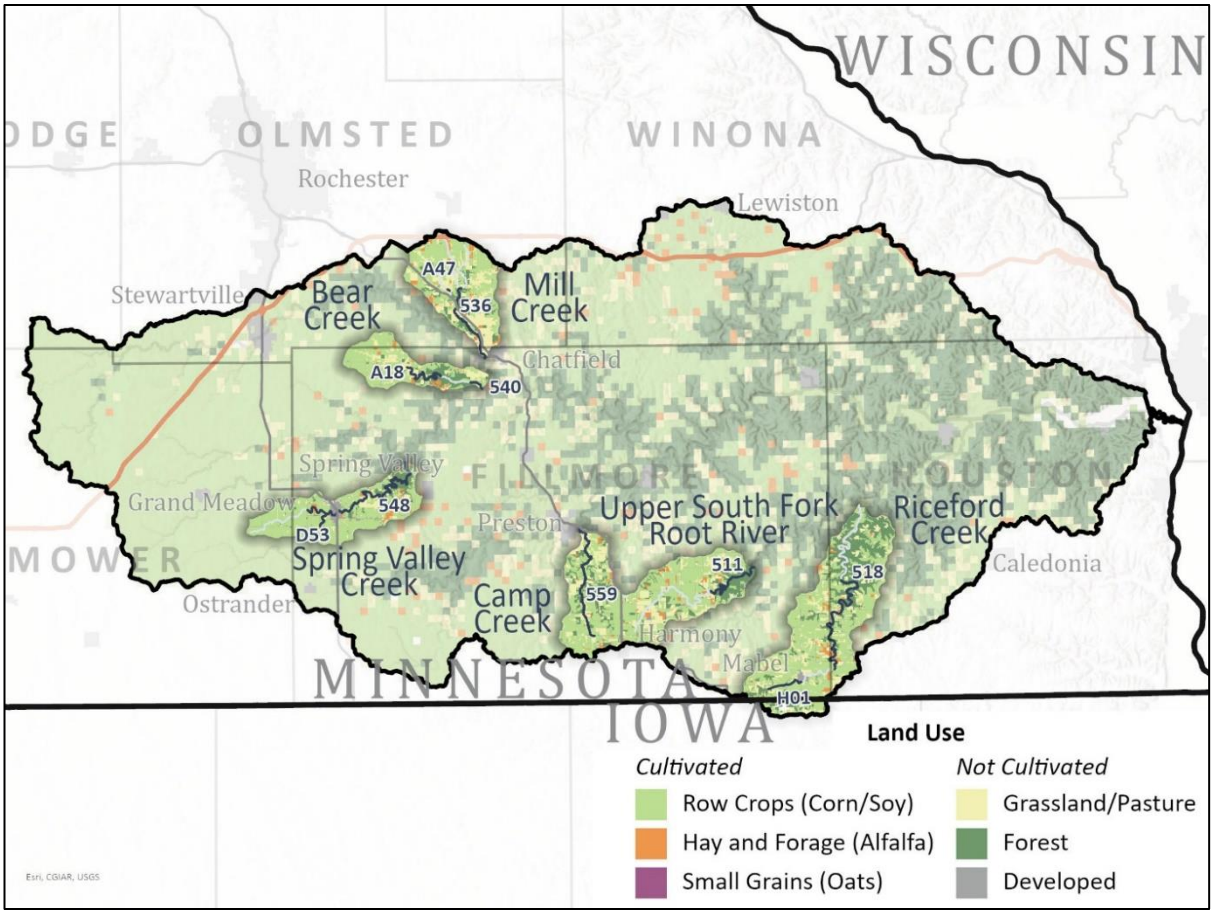


Table 4. Land cover summaries for RRW HUC-12s (CDL 2021).

HUC-12 Name	HUC-12 number	HUC-12 area (acres)	Top three land cover (%) [a]
Mill Creek	070400080107	20,429	Row crops (44%) Grass/pasture (22%) Deciduous forest (16%)
Bear Creek	070400080207	6,580	Row crops (55%) Deciduous forest (18%) Grass/pasture (15%)
Spring Valley Creek	070400080205	19,317	Row crops (65%) Deciduous forest (12%) Grass/pasture (9%)
Camp Creek	070400080407	17,047	Row crops (52%) Deciduous forest (21%) Grass/pasture (17%)
Upper South Fork Root River	070400080801	20,568	Row crops (51%)

HUC-12 Name	HUC-12 number	HUC-12 area (acres)	Top three land cover (%) [a]
			Grass/pasture (20%) Deciduous forest (17%)
Riceford Creek	070400080804	41,347 [b]	Row crop (47%) [b] Deciduous forest (24%) [b] Grass/pasture (17%) [b]

a. Row crop acres include the total corn and soybean acres reported in the 2021 Cropland Data Layer (CDL).
b. Includes both Minnesota and Iowa.

3.4 Water quality

Flow and water quality data are presented to evaluate impairments and trends in water quality. Data from the last 10 years (2011 through 2020) were used in the water quality summary tables, except for T-tube data, which is provided from 2012 through 2021. Prior to 2012, the maximum T-tube reading possible (based on T-tube design) was 60 cm. Starting in 2012, the maximum possible reading has been 100 cm, due to the new T-tube design. T-tube data from before 2012 are not presented here. Water quality data from the MPCA's Environmental Quality Information System (EQuIS) and the simulated daily average flows from the RRW HSPF model (2021 extension) were used for the analyses in this section. Water quality monitoring results were averaged if more than one sample was taken per day.

3.4.1 Flow data

Simulated daily average flows from the RRW HSPF model (2021 model extension) were used in developing the TMDLs in this report (Table 5). The HSPF model is calibrated to flow monitoring data and provides long term, continuous flow estimates. Simulated flows are available at the downstream end of each model reach. In some cases, HSPF-simulated flows were area-weighted to the drainage area of impaired streams. The area-weighting approach assigns flow to a given reach based on the proportion of the impaired water drainage area within the HSPF catchment.

The model reports (Tetra Tech 2013a, Tetra Tech 2013b, and MPCA 2023) describe the framework and the data that were used to develop the model. See also the brief summary of HSPF modeling in the introduction to Section 3.

Table 5. Model reaches used to simulate stream flow in impaired reaches in the RRW.
Reach numbers refer to the RRW HSPF model (2021 model extension). The simulation is from 1994–2021.

Reach name	WID	HSPF model reach number
Mill Creek	07040008-536	158
Bear Creek (Lost Creek)	07040008-A18	148
Upper Bear Creek	07040008-540	176
Spring Valley Creek	07040008-548	141
Camp Creek	07040008-559	124
South Fork Root River	07040008-511	170
Riceford Creek	07040008-518	110
Riceford Creek	07040008-H01	110 (area weighted)

Flow duration curves (FDCs) were developed for each impaired reach addressed in this TMDL using simulated daily average flows (1994 through 2021) from the RRW HSPF model (2021 model extension). Simulated flows from all months (even those outside of the time period that the standards are in effect) were used to develop FDCs. Flow duration curves relate mean daily flow to the percent of time those values have been met or exceeded. For example, an average daily flow at the 50% exceedance value is the midpoint or median flow value; average daily flow in the reach equals the 50% exceedance value 50% of the time. The curve is divided into flow zones, including very high flows (0% to 10%), high flows (10% to 40%), mid-range flows (40% to 60%), low flows (60% to 90%), and very low flows (90% to 100%).

Flow duration curves were then used to develop the pollutant LDC for the TSS, nitrate and *E. coli* TMDLs. See Section 4.2 for a discussion on LDCs.

3.4.2 TSS and Transparency

TSS data are only available for impairments in Mill Creek, Spring Valley Creek, and Camp Creek HUC-12s, but transparency data are available for all impairments receiving a TSS TMDL in this report. Water quality analysis in this report therefore focuses largely on transparency. Monitoring sites for each impaired reach are listed in Table 6.

In general, transparency was poorer (lower T-tube measurement) during high flow conditions across all impairments receiving a TSS TMDL in this report (Figure 6). Where TSS data are available, TSS follows a similar trend (see Section 5 for stream specific water quality data analysis). This is typically the case in southeast Minnesota streams—very clear at low flows, very turbid at higher flows following rain events.

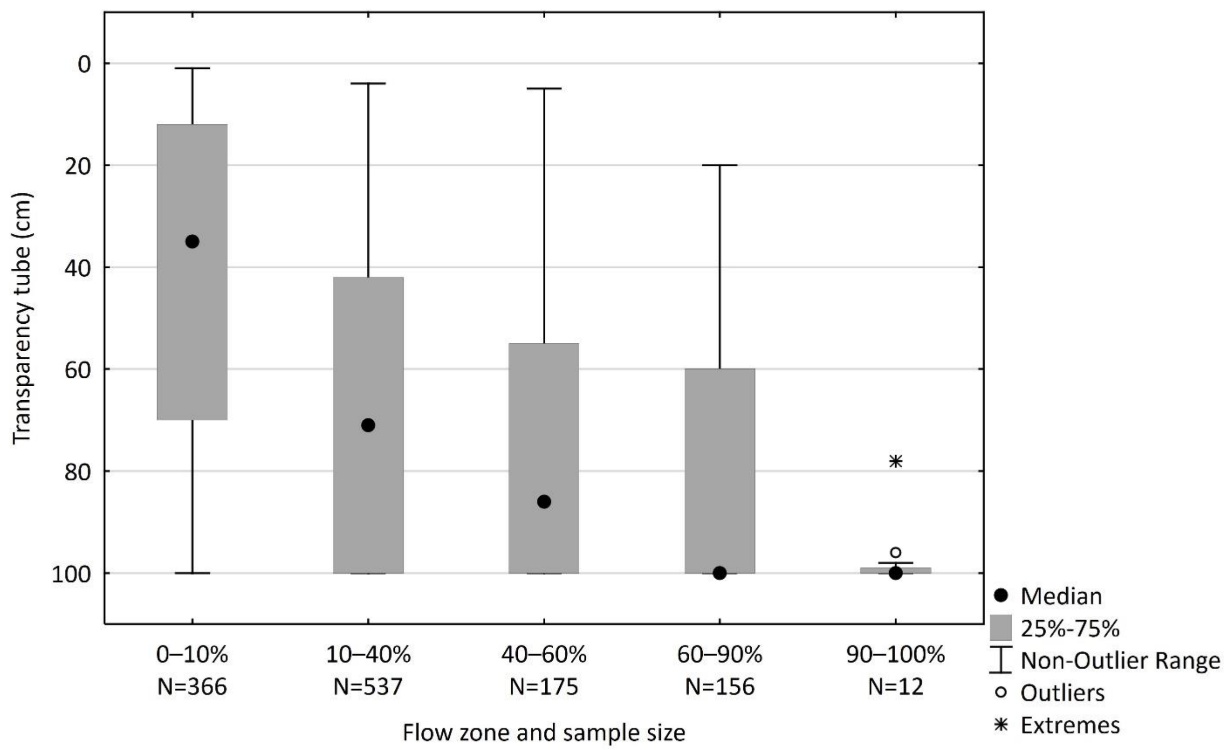
Water quality summary tables and LDCs are presented for each impairment in Section 5.

Table 6. Monitoring stations used in TSS and/or transparency analysis for the RRW TMDL (2018–2020).

HUC-12	Impaired reach name	WID	Parameter(s)	Monitoring site(s)
Mill Creek (070400080107)	Mill Creek	-536	TSS and transparency	S004-828 S015-302 S006-362
Bear Creek (070400080207)	Bear/Lost Creek	-A18	Transparency	S004-725
	Upper Bear Creek	-540	Transparency	S003-386
Spring Valley Creek (070400080205)	Spring Valley Creek	-548	TSS and transparency	S000-769 S004-237 S000-773 S000-772 S000-771 S000-770 S000-769
Camp Creek (070400080407)	Camp Creek	-559	TSS (limited) and transparency	S016-193 S016-192 S010-670 S005-073 S016-194 S010-634

HUC-12	Impaired reach name	WID	Parameter(s)	Monitoring site(s)
Riceford Creek (070400080804)	Riceford Creek	-H01	Transparency	S005-391
	Riceford Creek	-518	Transparency	S000-929 S008-042 S015-314 S015-317

Figure 6. All T-tube data for impairments receiving a TSS TMDL by flow zone (2011–2021; Apr–Sep).



3.4.3 Nitrate

Nitrate data within the last 10 years exist for years 2018 through 2020 for impaired streams. Monitoring stations for each impaired reach are listed in Table 7. The highest observed nitrate concentration in Mill Creek (-536) was 12.1 mg/L and occurred in August 2019. Spring Valley Creek (-548) experienced its highest nitrate concentration of 11.9 mg/L in July 2019. Highest nitrate concentrations are generally observed in the more upstream reaches. While no clear relationship between nitrate and flow in the limited dataset available applies across all impaired streams in this report, nitrate concentrations throughout the RRW typically are highest at monitoring stations in headwater portions of the watershed where groundwater influence is also high, and dilute during rain events (MPCA 2023a, Barry et. al 2018, Barry et. al 2020). Water quality summary tables and LDCs are presented for each impairment in Section 5. Information on nitrate sources and transport are provided in Section 3.5.2.

Table 7. Monitoring stations used in the nitrate analysis of the RRW TMDL (2018–2020).

HUC-12	Impaired reach name	WID	Monitoring site(s)
Mill Creek (070400080107)	Mill Creek	-536	SP00084 S006-882 S006-880 S006-879 S006-362 S015-302 S004-828
	Unnamed Creek	-A47	S006-885
Spring Valley Creek (070400080205)	Spring Valley Creek	-548	S015-311 S004-237 S000-773 S000-772 S000-771 S000-770 S000-769
	Unnamed Creek	-D53	S015-312

3.4.4 *E. coli*

E. coli data are available for the South Fork Root River (-511) in the years 2018 and 2019. *E. coli* concentrations ranged from 7 to over 4,000 org/100 mL, and there was no clear seasonal pattern. The monthly geometric mean standard was exceeded in all three months that were monitored (June, July, and August), and the individual sample standard was exceeded in June and August. *E. coli* concentrations tended to increase with flow. Water quality summary tables and the LDC for the South Fork Root River (-511) are presented for in Section 5.

Table 8. Monitoring stations used in *E. coli* analysis for South Fork Root River (-511; 2018–2019) in the RRW.

HUC-12	Impaired reach name	WID	Monitoring site(s)
Upper South Fork Root River (070400080801)	South Fork Root River	-511	S001-393

3.5 Pollutant source summary

Pollutants in the RRW originate from permitted and nonpermitted sources. The permitted sources discussed here are pollutant sources that require a NPDES permit. Most Minnesota NPDES permits are also SDS permits; however, some permitted sources require SDS permit coverage alone without NPDES permit coverage (e.g., spray irrigation, large septic systems, land application of biosolids, and some feedlots).

Nonpermitted sources discussed here are pollutant sources that do not require an NPDES permit. The phrase “nonpermitted” does not indicate that the pollutants are illegal, but rather that they are not subject to an NPDES permit. Some nonpermitted sources are unregulated (like commercial fertilizer application), and some nonpermitted sources are regulated through non-NPDES state programs or local permitting authorities.

Permitted sources evaluated in this TMDL include municipal wastewater, NPDES/SDS permitted animal feeding operations, and construction and industrial stormwater. There are no NPDES/SDS permitted municipal separate storm sewer systems (MS4) or permitted industrial wastewater dischargers in the impaired subwatersheds discussed in this report.

The following sections summarize all potential pollutant sources for the impaired stream reaches discussed in this TMDL report. For additional discussion of these sources and their level of contribution to water quality impairments at the HUC-12 level, refer to Section 5.

3.5.1 Total suspended sediment

Loading of TSS to streams originates from near channel, in channel, overland flow from storm events, and permitted sources. The impairments receiving a TSS TMDL in this report and their associated HUC-12 subwatershed are provided in Table 9.

Table 9. HUC-12 subwatersheds with relevant stream reaches described in the TSS source summary.

HUC-12	Stream receiving a TSS TMDL in this report (WID)
Mill Creek (070400080107)	Mill Creek (-536)
Bear Creek (070400080207)	Bear Creek (-A18)
	Upper Bear Creek (-540)
Spring Valley Creek (070400080205)	Spring Valley Creek (-548)
Camp Creek (070400080407)	Camp Creek (-559)
Riceford Creek (070400080804)	Riceford Creek (-H01)
	Riceford Creek (-518)

Permitted sources

The permitted sources of TSS within the drainage areas to impairments receiving a TSS TMDL in this study include municipal wastewater and construction and industrial stormwater. There are no permitted separate storm sewer systems or industrial wastewater dischargers within these drainage areas.

Municipal wastewater

Two municipal wastewater treatment plants (WWTPs) are located within the drainage areas of impairments receiving a TSS TMDL described in this report (Table 10).

Table 10. Municipal wastewater treatment plants located within the drainage areas of impaired waters receiving a TSS TMDL.

NPDES permit type	Facility name	Permit number	HUC-12 location
Municipal Wastewater	Spring Valley WWTP	MN0051934	Spring Valley Creek (070400080205)
Municipal Wastewater	Mabel WWTP	MN0020877	Riceford Creek (070400080804)

Spring Valley WWTP is a Class B facility with mechanical separation. The facility continuously discharges to Spring Valley Creek (-548). Spring Valley WWTP's NPDES permit includes a limit for TSS (30 mg/L) and requires weekly monitoring for TSS (reported via calendar monthly average). See Section 5 for additional discussion on Spring Valley WWTP's TSS contributions.

Mabel WWTP is a Class C facility with mechanical separation. The facility continuously discharges to Riceford Creek (-516), which is the next upstream WID from (-518). Mabel WWTP's NPDES permit includes a 30 mg/L limit for TSS and requires bi-monthly monitoring for TSS. Refer to Section 5 for additional discussion of Mabel WWTP's contributions to Riceford Creek's TSS impairment.

Construction stormwater

Construction stormwater is regulated through an NPDES/SDS permit. Untreated stormwater that runs off a construction site often carries sediment to surface water bodies. Phase II of the stormwater rules adopted by the EPA requires an NPDES/SDS permit for a construction activity that disturbs one acre or more of soil; a permit is needed for smaller sites if the activity is either part of a larger development or if the MPCA determines that the activity poses a risk to water resources. Coverage under the construction stormwater general permit requires sediment and erosion control measures that reduce stormwater pollution during and after construction activities (see Section 9.1.1).

The average percent watershed acreage under a construction stormwater permit within the RRW from 2018 through 2022 is 0.05%. Pollutant loading from construction stormwater is inherently incorporated in the watershed runoff estimates and is not considered a significant source.

Industrial stormwater

Industrial stormwater is regulated through an NPDES/SDS permit when stormwater discharges have the potential to come into contact with materials and activities associated with the industrial activity. At the writing of this report, two permitted industrial stormwater (general permit) sites were active in the drainage areas of surface waters subject to this report (Table 11).

Table 11. Permitted industrial stormwater (general permit) facilities within the drainage areas of impaired water receiving a TSS TMDL.

Facility name	Permit number	Impaired stream (-WID)	SIC description (code)	Sector
Bill Funk Trucking	MNR053CCT	Mill Creek (-536)	Trucking (4212)	P
Griffin Quarry	MNR053BMN	Mill Creek (-536)	Construction sand and gravel (1442)	J

Sector P: Motor Freight Transportation Facilities, Passenger Transportation Facilities, Petroleum Bulk Oil Stations and Terminals, Rail Transportation Facilities, and United States Postal Service Transportation Facilities

Sector J: Mineral Mining and Processing Facilities

In addition to the facilities listed in Table 11, nine nonmetallic mining facilities are located within the drainage areas of TSS impairments subject to this TMDL report (Table 12). Nonmetallic mining facilities can have wastewater, stormwater and/or dewatering discharges, however, only nonspecific stormwater discharge occurs at the facilities listed in Table 12. These facilities are therefore required to submit annual discharge monitoring reports. The nonmetallic mining general permit (MNG490000) requires permittees with facilities that discharge stormwater within one mile of trout waters to develop stormwater control measures to protect surface water quality. In addition, a 65 mg/L TSS intervention limit applies to the discharge at a stormwater monitoring location instead of a 100 mg/L TSS intervention limit applied to facilities greater than one mile from trout waters.

All industrial stormwater facilities must comply with sector specific requirements on monitoring, site activities and site discharge (see MPCA's NPDES/SDS Industrial Stormwater General Permit). Industrial stormwater is not considered a significant source of TSS if facilities are in compliance with permit requirements.

Table 12. Permitted nonmetallic mining facilities located within drainage areas of impaired waters receiving a TSS TMDL.

Facility name	Permit number	Impaired stream (-WID)	Subsector description (code)	TSS intervention limit
Bruening Rock Products – Harmony: Big Springs Quarry (SD 008)	MNG490115	Camp Creek (-559)	Crushed and broken limestone (J2-1422)	65 mg/L
Bruening Rock Products – Harmony: Elton Sand Pit (SD 009)	MNG490115		Construction sand and gravel and industrial sand mining (J1-1442)	65 mg/L
Bruening Rock Products – Harmony: Underpass Quarry Houston County (SD 024)	MNG490115	Riceford Creek (-518)	Crushed and broken limestone (J2-1422)	65 mg/L
Bruening Rock Products – Harmony: Oefstedahl Sand Pit-Houston County (SD 039)	MNG490115		Construction sand and gravel and industrial sand mining (J1-1442)	65 mg/L
Bruening Rock Products – Harmony: Swenson Quarry-Fillmore County (SD 041)	MNG490115		Crushed and broken limestone (J2-1422)	65 mg/L
Mathy Construction – Engrav Quarry #521 (SD104)	MNG490081		Crushed and broken limestone (J2-1422) and asphalt paving mixtures and blocks (D1-2951)	65 mg/L
Gjere Construction – Gjere Quarry (SD 001)	MNG490391		Construction sand and gravel and industrial sand mining (J1-1442) and Crushed and broken limestone (J2-1422)	100 mg/L
Mathy Construction – Willey Dr. Quarry #445 (SD 059)	MNG490081	Mill Creek (-536)	Crushed and broken limestone (J2-1422) and asphalt paving mixtures and blocks (D1-2951)	100 mg/L
Croell Inc. Spring Valley (SD 008)	MNG490540	Spring Valley Creek (-548)	Concrete block and brick (E2-3271) and Ready-mix concrete (E2-3273)	65 mg/L

Nonpermitted sources

The majority of nonpermitted sediment loading to rivers and streams in the RWW is derived from near channel areas such as erosion from stream banks and flood plains. Runoff from agricultural areas and steep sloped areas in the watershed are also a significant source of sediment. Several existing studies confirm and support these statements:

- ***Sediment fingerprinting for sources and transport pathways in the Root River, southeastern Minnesota. (Belmont 2011).*** This study used geochemical tracers to verify the variability of historic erosion in the RRW, the amount of readily erodible legacy sediment, and confirms that the dominant source of sediment in the RRW is legacy or historical nonfield sediment originating from near channel sources (e.g., floodplains and streambanks).
- ***Identifying Sediment Sources and Sinks in the Root River, Southeastern Minnesota (Stout et al. 2014).*** This publication summarizes a shift in hydrologic regime and subsequent sediment fluxes for the RRW. It identifies near channel sources as the dominant sediment load contributor and that suspended sediment in the Root River today is from floodplains and terraces.
- ***An integrated sediment budget for the RRW, southeastern Minnesota. (Belmont et al. 2016).*** This study investigated sediment inputs from major tributaries of the Root River: North Branch, Middle Branch, South Branch, Rush Creek, Money Creek and South Fork Root River. The budget confirmed that near channel sources (streambank erosion) contribute the most sediment load to the RRW and that sediment concentrations increase with river flow at a greater rate in the RRW than almost any other river in the state of Minnesota.

While some of these studies are at least 10 years old, the conclusions remain the same today. The majority of nonpermitted sediment loading to rivers and streams in the RWW is derived from near channel areas such as erosion from stream banks and flood plains. Runoff from agricultural areas and steep sloped areas in the watershed are also a significant source of sediment. Additional information on sediment sources throughout the entire RRW is provided in the RRW WRAPS Update Report (MPCA 2024a).

Natural background sources

"Natural background" is defined in both Minnesota statute and rule. The Clean Water Legacy Act (Minn. Stat. § 114D.15, subd. 10) defines natural background as "characteristics of the water body resulting from the multiplicity of factors in nature, including climate and ecosystem dynamics, that affect the physical, chemical, or biological conditions in a water body, 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 water body 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 can include inputs from natural geologic processes such as soil loss from upland erosion and stream development, atmospheric deposition, and loading from forested land, wildlife, etc. However, for each impairment, natural background levels are implicitly incorporated in the

WQS used by the MPCA to determine/assess impairment, and therefore natural background is accounted for and addressed through the MPCA's water body assessment process. Natural background conditions were evaluated within the source assessment portion of this study. These source assessment exercises indicate that natural background inputs are generally low compared to livestock, cropland, streambank, failing SSTSs, and other anthropogenic sources.

Based on the MPCA's water body 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 any of the impairments and/or affect the water bodies' ability to meet state WQS.

3.5.2 Nitrate

Nitrate concentrations in rivers across the State of Minnesota are largely trending upwards, meaning higher concentrations of nitrate are being detected (MPCA 2020). In the case of the RRW, surface water nitrate is not showing an upward or downward trend. Declining nitrate trends throughout the state are rare. Unique to the karst region of Minnesota, nitrate enters aquifers through surface leaching and disappearing streams (surface streams that disappear subsurface and then resurface downstream). This results in baseflow to cold water streams comprising of mostly groundwater inputs and the groundwater flow path being the main transport for nitrate loading to surface waters in the RRW (Masarik 2007). Nitrate concentrations throughout the RRW typically are highest at monitoring stations in headwater portions of the watershed where groundwater influence is also high, and dilute during rain events (MPCA 2023a, Barry et. al 2018, Barry et. al 2020). Nitrate can also enter surface waters through overland runoff, agricultural drain tiles, and via permitted sources, as discussed in this section, but those modes of transport are less significant. The reaches impaired due to nitrate addressed by this TMDL report and their associated HUC-12 subwatershed are provided in Table 13.

Table 13. HUC-12 subwatersheds with relevant stream reaches described in the nitrate source summary.

HUC-12	Nitrate impaired stream (-WID)
Mill Creek (070400080107)	Mill Creek (-536)
	Unnamed Creek / "Mill Creek tributary" (-A47)
Spring Valley Creek (070400080205)	Spring Valley Creek (-548)
	Unnamed Creek/ "Spring Valley Creek tributary" (-D53)

Nitrate contamination in groundwater and surface water is one of the longest-standing issues in the RRW, southeastern Minnesota, and many locations statewide. Identifying and addressing nitrate contamination is a top priority of state and local watershed partners. Many statewide initiatives provide technical resources and financial support to local groups in their effort to reduce nitrate. Section 6 of this TMDL highlights these and many other programs and entities working on nitrate (and other pollutant) reduction efforts.

Permitted sources

Permitted point sources contribute 5% of the nitrogen loading in the Lower Mississippi River Basin (MPCA 2013). In the RRW, permitted point sources contribute roughly 1% of the nitrogen load when comparing annual kilograms of total nitrogen discharging from permitted facilities to the annual kilograms of total nitrogen discharging at the outlet of the RRW (2009 through 2020).

Permitted sources within the drainage areas of nitrate impaired reaches addressed by this TMDL report include municipal wastewater and NPDES/SDS permitted feedlots. NPDES permitted construction stormwater is not a nitrogen source. There are currently no permitted industrial stormwater facilities with nitrate or nitrogen monitoring benchmarks and no permitted industrial wastewater in the affected subwatersheds.

Municipal wastewater

Spring Valley WWTP (Table 10) is a Class B facility with mechanical separation. The facility continuously discharges to Spring Valley Creek (-548). Spring Valley WWTP's NPDES permit was reissued on September 1, 2023, and now includes weekly monitoring for total nitrite + nitrate, total ammonia, and total Kjeldahl nitrogen and a new total nitrogen limit of 10 mg/L (monthly average). A compliance schedule (final compliance date of January 31, 2031) has been included in this permit reissuance to allow Spring Valley WWTP time to construct treatment improvements and pursue treatment optimizations that will allow the facility to attain compliance with the new total nitrogen limit. Construction is currently underway at the facility. See Section 5 for additional discussion of Spring Valley WWTP's contributions to the nitrate load in Spring Valley Creek.

NPDES/SDS permitted animal feeding operations

Feedlots, manure storage areas, and manure land application sites can be a source of nutrients due to vertical leaching into groundwater and runoff from these areas. Although TMDL reports typically consider only NPDES permitted sources in discussions of permitted sources, this discussion of permitted feedlots includes NPDES and SDS permitted feedlots because of similar discharge requirements.

Concentrated animal feeding operation (CAFO) is a federal definition that implies not only a certain number of animals but also specific animal types. The MPCA uses the federal definition of a CAFO in its permit requirements of animal feedlots along with the state definition of an animal unit (AU). In Minnesota, all CAFOs and non-CAFOs that have 1,000 or more AUs must operate under an NPDES or SDS permit.

CAFOs with fewer than 1,000 AUs and that are not required by federal law to maintain NPDES permit coverage may choose to operate without an NPDES permit. A current manure management plan that complies with Minn. R. 7020.2225 and the respective permit is required for all permitted CAFOs and feedlots with 1,000 or more AUs.

CAFOs and feedlots with 1,000 or more AUs must be designed to contain all manure, manure contaminated runoff, process wastewater, and the precipitation from a 25-year, 24-hour storm event. While discharges are not allowed under typical circumstances, having and complying with an NPDES or SDS permit authorizes discharges to waters of the United States and waters of the state (with NPDES permits) or waters of the state (with SDS permits) due to a 25-year, 24-hour precipitation event (approximately 5.7 inches in the RRW) when the discharge does not cause or contribute to nonattainment of applicable state WQS. Large CAFOs with fewer than 1,000 AUs that have chosen to forego NPDES permit coverage are not authorized to discharge and must contain all runoff, regardless of the precipitation event. Large CAFOs permitted with an SDS permit are authorized to discharge to waters of the state, although they are not authorized to discharge to waters of the U.S. Therefore, many large CAFOs in Minnesota have chosen to obtain an NPDES permit, even if discharges have not occurred at the facility.

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 feedlots with NPDES permits, surface applied solid manure is prohibited during the month of March. Winter application of solid manure (December through February) requires fields are approved in their manure management plan and the feedlot owner/operator must follow a standard list of setbacks and BMPs. Winter application of surface applied liquid manure is prohibited except for emergency manure application as defined by the NPDES permit. "Winter application" refers to application of manure to frozen or snow-covered soils, except when manure can be applied below the soil surface.

There is only one animal feeding operation NPDES permit within the Mill Creek (-536) impairment subwatershed, Schoenfelder Farms LLP permit number MNG442167. This permit is a multi-site NPDES permit that includes two locations, both located within the impaired subwatershed. All NPDES and SDS permitted feedlots are designed to contain all manure, manure-contaminated runoff, process wastewater, and the precipitation from a 25-year, 24-hour storm event, and as such they are not considered a significant source of nitrogen. All other feedlots are considered nonpermitted sources for the purposes of this TMDL report. In addition, the land application of all manure, regardless of whether the source of the manure originated from permitted (e.g., CAFOs) or nonpermitted feedlots, is considered a nonpermitted source and discussed below.

Nonpermitted sources

Nonpermitted sources are the main contributor to nitrate concentrations in the RRW. The largest nonpermitted sources of nitrate in the RRW include animal manure or commercial nitrogen fertilizer applied to agricultural fields, which enters surface waters through groundwater inputs. The primary mode of transport for nitrate to surface waters in the RRW is vertical leaching from the land's surface to underlying groundwater aquifers or drain tiles. Nitrate-laden groundwater then enters surface waters through springs and groundwater seeps that are common in the RRW (MPCA 2023a). In areas with agricultural drainage tile, nitrate rich drain tile water discharges directly to streams (MPCA 2013). Surface runoff of nitrate (urban use of fertilizer, for example) represents a much smaller mode of transport due to the unique geology of the RRW.

The Root River Field to Stream Partnership (RRFSP) has been monitoring nutrient impacts from agricultural fields since 2010. This data provides invaluable insight into when agricultural fields contribute nitrate to surface waters in the RRW. Recent monitoring efforts found the following:

- Of the nitrogen applied, 80% is lost through sub-surface leaching and is detected as nitrate in tile drainage, springs, streams and rivers, and groundwater.
- Surface runoff is a smaller, but still present, mode of transport for nitrate and total nitrogen. March is a high-risk period for nitrate runoff due to frozen ground.

- May and June are high risk periods for total nitrogen losses due to heavy precipitation events. Over 50% of annual nutrient loss occurs at these times (MDA 2022a).

Commercial nitrogen fertilizer

Nitrogen is introduced onto agricultural fields by commercial fertilizer application, animal manure application, legume fixation and/or atmospheric deposition. The nitrogen in these sources can be converted to nitrate through the nitrification process. Of these four potential sources of nitrogen, commercial nitrogen fertilizer and animal manure are the most dominant sources in the RRW.

Non-NPDES/SDS permitted animal feedlots and manure application

Feedlots under 1,000 AUs and those that are not federally defined as CAFOs do not operate with NPDES 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 nondelegated. 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 MPCA every other year. Non-CAFOs in nondelegated counties are inspected by MPCA on an as-needed or complaint-driven basis. Fillmore County is delegated to administer feedlot regulations for non-CAFOs within the Spring Valley Creek Subwatershed. The MPCA administers the feedlot program within Olmsted County (Mill Creek Subwatershed).

Manure that is generated on feedlots is usually stockpiled on site or on crop fields or stored in liquid manure storage areas on site until field conditions and the crop rotation allow for applying the manure as fertilizer. Animal manure is applied to crop fields as a fertilizer. While there are multiple benefits to using animal manure for fertilizer (organic matter, cost effectiveness, valuable nutrients), the nitrogen present in manure may convert to nitrate and leach through the soil profile. The likelihood of nitrate leaching increases depending on the amount of manure being produced and land applied within a subwatershed, as well as sensitive landscape features such as shallow bedrock and coarse textured soils. Information on non-NPDES/SDS permitted animal feedlots is provided in Table 14for Spring Valley Creek and Mill Creek HUC-12 Subwatersheds. These are the only two subwatersheds with nitrate TMDLs discussed in this report.

The majority of AUs in the Spring Valley Creek Subwatershed are beef. Of the 17 total registered and active feedlots in the subwatershed, 8 (47%) have no manure storage. The majority of AUs within the Mill Creek Subwatershed are also beef. Of the total 15 registered and active feedlots in the Mill Creek Subwatershed, 10 (67%) have no manure storage. Feedlots with limited or no manure storage have a higher potential to add nitrogen and nutrients to fields at consequential times (e.g. when no vegetation is present to uptake nitrogen). Feedlots located in shoreland (see definition above) may have the potential for direct manure runoff.

Table 14. Non-NPDES/SDS permitted animal feedlot information for nitrate impairments (MPCA 2022f).

	Registered AUs				Feedlots		
HUC-12	**Beef**	**Swine**	**Dairy**	**Total**	**Manure storage**	**No manure storage**	**Total**
Mill Creek (070400080107)	1,894.6	1,440	412.4	3747.1	5	10	15
Spring Valley Creek (070400080205)	1,542.85	630	575	2,747.85	9	8	17

Natural background sources

Based on the MPCA's water body assessment process and the TMDL source assessment exercises, there is no evidence at this time to suggest that natural background sources (see Section 3.5.1 for definition of natural background) are a major driver of any of the impairments and/or affect the water bodies' ability to meet state WQS.

3.5.3 *E. coli*

Pathogens such as *Giardia*, *Cryptosporidium*, other protozoa, viruses, and bacteria in surface water can pose a potential health risk to those who come into contact with contaminated water. The following sections discuss likely sources of pathogens and the associated *E. coli* indicator bacteria. Because this report addresses one *E. coli* impairment on the South Fork Root River only those potential sources in the drainage area to the South Fork Root River (-511) are discussed. Nonpermitted sources of *E. coli* include runoff from non-NPDES/SDS permitted animal feedlots, land application of manure, pastureland, under-treated domestic sewage, and wildlife. There are no permitted sources of *E. coli* in the impaired drainage area. More information on the *E. coli* sources throughout the RRW is provided in the RRW WRAPS Update Report (MPCA 2023a).

Nonpermitted sources

Nonpermitted sources of *E. coli* evaluated in this TMDL report include non-NPDES/SDS permitted animal feedlots, land application of manure, pastureland, nonpermitted wastewater, and natural background and naturalized sources of *E. coli*. Because of the lack of permitted sources of *E. coli* in the drainage area to South Fork Root River (-511), bacteria loading is originating from nonpermitted sources.

Non-NPDES/SDS permitted animal feedlots and manure application

Manure that is generated on feedlots is usually stockpiled on site or on crop fields, or stored in liquid manure storage areas on site until field conditions and the crop rotation allow for applying the manure as fertilizer. Manure can be delivered to surface waters from failure of manure containment, runoff from the feedlot itself, or runoff from fields where the manure is applied. Cattle accessing streams for watering also contribute manure if they are allowed to defecate in the stream channel. The timing of manure spreading, as well as the application rate and method, affects the likelihood of pollutant loading to nearby water bodies. The spreading of manure on frozen soil in the late winter is likely to result in surface runoff with precipitation and snowmelt runoff events. Deferring manure application until snow has melted and soils have thawed decreases overland runoff associated with large precipitation events. Injecting or incorporating manure is a preferred BMP to reduce the runoff of waste and associated pollutants. Incorporating manure into the soil reduces the risk of surface runoff associated with large precipitation events.

Facilities that obtain an interim or construction short form feedlot permit, in addition to feedlots with an operating permit (NPDES or SDS), are required to develop and maintain a manure management plan.

While a full accounting of the fate and transport of manure was not conducted for this project, a large portion of manure is ultimately applied to the land surface and, therefore, a potential source of *E. coli* to impaired streams. 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. Specific information on Minnesota's feedlot program is provided in the nitrate source summary Section 3.5.2.

Table 15 summarizes non-NPDES/SDS permitted animal feedlot information for South Fork Root River HUC-12 Subwatershed. The majority of AUs subwatershed are beef. Of all registered feedlots in the subwatershed, 65% have no manure storage. The registered feedlots that have no recorded manure storage indicate that pastures are part of their operation. Aerial imagery shows at least four registered feedlots with pastures crossing or adjacent to the river within the upper portions of the drainage area. While many of the pastures are well maintained, runoff from feeding areas and/or cattle congregation in surface waters are potential sources of *E. coli.*

Table 15. Non-NPDES/SDS permitted animal feedlots information for Upper South Fork Root River (MPCA 2022f).

	Registered AUs				**Feedlots**		
HUC-12	**Beef**	**Swine**	**Horse**	**Total**	**Manure storage**	**No manure storage**	**Total**
Upper South Fork Root River (070400080801)	2,519.34	1,434	6	3,959.34	8	15	23

Nonpermitted wastewater

<u>Individual subsurface sewage treatment systems</u>

Adequate wastewater treatment is vital to protecting the health, safety, and environment in Minnesota. SSTSs that fail to treat wastewater adequately threaten groundwater used for drinking water and surface water used for recreation. Inadequate treatment of wastewater/sewage, which contains bacteria, viruses, parasites, nutrients, and chemicals, can result in contamination of drinking water sources. Additionally, straight-pipe wastewater "systems," which route raw wastewater to the ground or nearby waters, can directly impact lakes, streams, and wetlands.

SSTSs can fail for a variety of reasons, including excessive water use, poor design, physical damage, and lack of maintenance. Common limitations that contribute to failure include seasonal high water table, fine-grained soils, bedrock, and fragipan (i.e., altered subsurface soil layer that restricts water flow and root penetration). Septic systems can fail hydraulically through surface breakouts or hydrogeologically from inadequate soil filtration. Failure potentially results in higher levels of pollutant loading to nearby surface waters. At a minimum, a system that is considered an imminent public health threat (IPHT) is a system with a discharge of sewage or sewage effluent to the ground surface, drainage systems, ditches, or storm water drains or directly to surface water; systems that cause a reoccurring sewage backup into a dwelling or other establishment; systems with electrical hazards; or sewage tanks with unsecured, damaged, or weak maintenance hole covers (Minn. R. 7080.1500, subp.4).

Like other counties in Minnesota, Fillmore County reports estimated SSTS compliance to the MPCA. From 2017 through 2021, Fillmore County reported relatively stable compliance rates (Table 16). While these compliance rates may be stable, additional work is needed to return failing and IPHT systems into compliance.

Table 16. Reported SSTS compliance for Fillmore County 2017–2021.

	% Failing	# Failing	% IPHT	# IPHT	% Compliant	# Compliant	Total SSTS*
2017	5%	257	3%	154	93%	4,784	5,144
2018	10%	581	5%	291	85%	4,939	5,811
2019	5%	209	3%	125	93%	3,888	4,181
2020	5%	227	3%	136	93%	4,214	4,531
2021	5%	229	2%	92	93%	4,265	4,586

* Compliance numbers may not always add up to total SSTS due to rounding in reporting

Other potential wastewater sources of *E. coli* in the watershed may include straight pipe discharges, earthen pit outhouses, and land application of septage. Straight pipe systems are unpermitted and illegal sewage disposal systems that transport raw or partially treated sewage directly to a lake, stream, drainage system, or the ground's surface. Straight pipe systems are required to be addressed 10 months after discovery (Minn. Stat. § 15.55, subd. 11). Fillmore County did not document any straight pipe discharges from 2017 through 2022. Outhouses, or privies, are legal disposal systems and are regulated under Minn. R. 7080.2150, subp. 2F and Minn. R. 7080.2280.

To ensure that effective sewage treatment occurs across the state, the MPCA regularly conducts surveys of local governmental units to identify areas in the state that may be areas of concern; these areas are defined as five or more homes within a half mile of each other that have inadequate sewage treatment. These areas are generally unincorporated communities, may not have an organized structure, may consist of families with limited financial resources, and many times do not qualify for the same financial assistance as large incorporated communities. As of 2022, there are no communities in the impairment watershed for the South Fork Root River (-511) identified as areas and communities with SSTS concerns.

Natural background sources

Based on the MPCA's water body assessment process and the TMDL source assessment exercises, there is no evidence at this time to suggest that natural background sources (see Section 3.5.1 for definition of natural background) are a major driver of any of the impairments and/or affect the water bodies' ability to meet state WQS.

Naturalized *E. coli*

The adaptation and evolution of naturalized *E. coli* that allow it to survive and reproduce in the environment make it physically and genetically distinct from *E. coli* that cannot survive outside of a warm-blooded host. This naturalized *E. coli* may be a source of *E. coli* to the impairments.

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 warm-blooded host 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 1) natural background sources such as wildlife and 2) 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 et al. 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 et al. 2006). A study by Chandrasekaran et al. (2015) 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. Survival and growth of fecal coliform has been documented in storm sewer sediment in Michigan (Marino and Gannon 1991), and *E. coli* regrowth was documented on concrete and stone habitat within an urban Minnesota watershed (Burns & McDonnell Engineering Company, Inc. 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 (e.g., Jamieson et al. 2005).

Although naturalized *E. coli* likely exist in the watershed, nonnaturalized sources of *E. coli* were also noted in the source assessment. This suggests that naturalized *E. coli* are not the sole driver of impairment and/or the only source affecting the water bodies' ability to meet state WQS.

4. TMDL development

A water body's TMDL represents the loading capacity, or the amount of pollutant that a water body can assimilate while still meeting WQS. The loading capacity is divided up and allocated to the water body's pollutant sources. The allocations include WLAs for NPDES-permitted sources, LAs for nonpermitted sources (including natural background), and an MOS, which is implicitly or explicitly defined. The sum of the allocations and MOS cannot exceed the loading capacity, or TMDL. This section describes the approach used to derive the TMDLs and allocations in the RRW. TMDL summaries for each impairment addressed in this report are provided in Section 5.

4.1 Overall approach

LDCs were used to develop all TMDLs in this report. More details on this approach are provided in the following sections.

4.2 Loading capacity methodology

The loading capacity for the impairments in this TMDL report were developed using the LDC methodology. To develop the LDCs, all simulated daily average flows used in the flow duration (see Section 3.4.1 for a description of flow) were multiplied by the water quality standard for the applicable pollutant and converted to a daily load to create "continuous" LDCs that represent the load in the stream when the stream meets its water quality standard under all flow conditions. Loads calculated from water quality monitoring data are also plotted on the LDCs, based on the concentration of the sample multiplied by the simulated flow on the day that the sample was taken. Each load calculated from a water quality sample that plots above the LDC represents a sample with a pollutant concentration higher than the water quality standard used to the develop the LDC, whereas those that plot below the LDC are less than the water quality standard used to develop the LDC. LDCs are provided in Section 5.

The loading capacity was calculated as simulated flow at the downstream end of each impaired reach multiplied by an applicable water quality standard. For the class 2A streams with TSS impairments, the coldwater standard of 10 mg/L was used. The coolwater water quality standard of 65 mg/L was used for the impaired class 2B stream. For nitrate impairments, the drinking water standard of 10 mg/L was used, and for the *E. coli* impairment, the monthly geometric mean standard of 126 org/100 mL was used. The LDC provides loading capacities along all flows observed in the stream along with observed loads calculated from monitoring data and simulated flow. For any given flow in the LDC, the loading capacity is determined by selecting the point on the LDC that corresponds to the flow exceedance (along the x-axis).

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 TMDL equation table of this report, only five points on the entire loading capacity curve are depicted (the midpoints of the designated flow zones). However, the entire curve represents the TMDL and is what the EPA ultimately approves.

4.3 Seasonal variation and critical conditions

The application of LDCs in the TMDLs addresses seasonal variation and critical conditions. LDCs evaluate pollutant loading across all flow regimes including high flow, which is when pollutant loading from watershed runoff is typically the greatest, and low flow, which is when loading from direct sources to the stream typically has the most impact. Because flow varies seasonally, LDCs address seasonality through their application across all flow conditions in the impaired water body.

Seasonal variation and critical conditions are addressed by the WQS. The TSS standard for aquatic life applies from April through September, when aquatic organisms are most active and when high stream TSS concentrations generally occur. The *E. coli* standards for aquatic recreation apply from April through October. This time period is when aquatic recreation is more likely to occur in Minnesota waters and when high *E. coli* generally occur. The nitrate standard applies year-round.

4.4 Baseline year

The baseline year for the TMDLs included in this report is 2015, which is the midpoint of the water quality data timeframe used to develop the TMDLs (2011 through 2020).

4.5 Margin of safety

The MOS accounts for uncertainty concerning the relationship between water quality and allocated loads. 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).

An explicit MOS of 10% was included in the TMDLs to account for uncertainty that the pollutant allocations would attain the water quality targets. The use of an explicit MOS accounts for environmental variability in pollutant loading, variability in water quality monitoring data, calibration and validation processes of modeling efforts, uncertainty in modeling outputs, conservative assumptions made during the modeling efforts, and limitations associated with the drainage area-ratio method used to extrapolate flow data. This MOS is considered to be sufficient given the robust datasets used and quality of modeling. The RRW HSPF model (2021 model extension) was calibrated and validated using 2 stream flow gaging stations: Root River near Houston (USGS 05385000) and Upper Iowa River near Bluffton, Iowa (USGS 05387440), and by using data collected by the Watershed Pollutant Load Monitoring Network (WPLMN) at the Root River near Mound Prairie stream gauge (station id: S004-858) (Tetra Tech 2013, Tetra Tech 2018, Tetra Tech 2022, and MPCA 2023).

Calibration results indicate that the HSPF model (2021 model extension) is a valid representation of hydrologic and water quality conditions in the modeled watersheds. Flow data used to develop the stream TMDLs are derived from HSPF-simulated daily flow data, and the sediment and nitrate source assessments are supported by HSPF-simulated pollutant outputs.

4.6 Percent reduction

The estimated percent reductions provide a rough approximation of the overall reduction needed for the water body to meet the TMDL. The percent reduction is a means to capture the level of effort needed to reduce pollutant 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.

For TSS TMDLs for impaired streams with TSS data, the percent reduction needed to meet the standard was calculated as the existing 90th percentile TSS concentration (April through September data) minus the water quality standard (10 mg/L for cold water and 65 mg/L for cool water) divided by the existing 90th percentile TSS concentration. By using the 90th percentile TSS concentration, the percent reduction calculation approximates the reduction in concentration (as opposed to load) needed to meet the water quality standard overall, aggregated across all flow conditions.

For TSS TMDLs for impaired streams with only transparency data, an estimated improvement in T-tube measurement, or improvement in transparency depth, is provided. This estimated improvement was calculated as the difference between the 10th percentile T-tube measurement and the T-tube water quality threshold for meeting standards (95 cm for cold water streams or 15 cm for cool water streams) divided by the 10th percentile T-tube measurement.

For nitrate TMDLs, the percent reduction needed to meet standard was calculated as the existing nitrate concentration minus the water quality standard (10 mg/L) divided by the existing nitrate concentration. The existing concentration for each impairment was calculated as the second highest existing concentration relative to 10 mg/L. This aligns with the MPCA's assessment procedure for nitrate impairments (MPCA 2022e) which allows for one exceedance of the standard in three years. By using the existing nitrate concentration, the percent reduction calculation approximates the reduction in concentration (as opposed to load) needed to meet the water quality standard overall, aggregated across all flow conditions.

For the *E. coli* TMDL, the percent reduction needed to meet the standard was calculated as the maximum monthly observed geometric mean concentration minus the geometric mean standard (126 org/100 mL) divided by the maximum monthly observed geometric mean concentration. By using the highest observed monthly geometric mean, the percent reduction calculation approximates the reduction in concentration (as opposed to load) needed to meet the monthly geometric mean standard overall, aggregated across all flow conditions.

4.7 TSS

This section describes the approach used to derive the TSS TMDLs and allocations for the following impaired streams in the RRW:

- Mill Creek (-536)
- Bear Creek/Lost Creek (-A18)
- Upper Bear Creek (-540)
- Spring Valley Creek (-548)
- Camp Creek (-559)
- Riceford Creek (-518)
- Riceford Creek (-H01)

Because the TSS standards for the impairments addressed in this report apply April through September, the TSS TMDLs and allocations for these streams also apply April through September.

4.7.1 Load allocation methodology

The LA is allocated to existing or future nonpermitted pollutant sources. The LAs for the TSS TMDLs were calculated as the loading capacity minus the MOS, the boundary condition, and the WLAs as applicable.

Natural background conditions were also evaluated, where possible, within the modeling and source assessment portion of this TMDL (Section 3.5) For TSS impairments, natural background sources are implicitly included in the LA portion of the TMDL tables, and reductions should focus on the major human attributed sources identified in the source assessment.

4.7.2 Wasteload allocation methodology

The WLA is allocated to existing or future NPDES-permitted pollutant sources. TSS WLAs were calculated for municipal wastewater facilities and industrial and construction stormwater. There are no MS4s or permitted industrial wastewater dischargers within the impairment subwatersheds addressed in this report; WLAs for these types of systems were therefore not developed.

Municipal and industrial wastewater

WLAs were developed for two municipal wastewater treatment systems in this TMDL. There are no industrial wastewater dischargers in the RRW. Individual WLAs were developed for each wastewater facility and calculated as the product of each facility's design flow (average wet weather design flow) and TSS permit limit (Table 17). Existing effluent limits are consistent with TSS WLA assumptions.

Table 17. Individual wastewater TSS wasteload allocations in the RRW TMDL.

Facility name	Permit number	Surface discharge station	Design flow (mgd) [a]	Impaired water body WID	Pollutant	Permit limit (mg/L)	Wasteload allocation	Existing permit consistent with WLA assumptions
Mabel WWTF	MN0020877	SD002	0.189	07040008-536	TSS	30	0.023 tons/day = 21 kg/day	Yes
Spring Valley WWTF	MN0051934	SD002	0.936	07040008-548	TSS	30	0.12 tons/day = 106 kg/day	Yes

a. Flow used to calculate the WLA.

The TSS permit limits of both facilities are greater than the impaired water bodies' TSS standard of 10 mg/L. TSS is composed of both organic (measured as volatile suspended solids [VSS]) and inorganic (measured as nonvolatile suspended solids [NVSS]) particles. Most of the TSS in municipal wastewater discharges is organic matter, which does not tend to persist in the environment. Effluent TSS discharged by municipal activated sludge WWTPs is typically composed of only 19% NVSS (MPCA 2015).

In MPCA's memo, "Compatibility of existing technology based effluent limits (TBELs) with new TSS water quality standards" (MPCA 2015), it is assumed that the intent of the TSS standards is to represent the concentration of inorganic particles in the stream. The WLAs for both WWTFs are expressed in terms of TSS. It is assumed that the 30 mg/L TSS effluent limit is sufficient to ensure that effluent NVSS concentrations will not exceed the 10 mg/L inorganic TSS concentration and that the facilities will meet their WLAs. Effluent monitoring may be required to confirm this assumption. Future NPDES permits for the facilities may contain water quality based effluent limits (WQBELs) to account for the relationship between NVSS and TSS in the discharge. If WWTP effluents are found to cause or a have reasonable potential to cause or contribute to excursions above 10 mg/L NVSS, future permits may include more restrictive water quality based effluent limits.

Industrial stormwater

WLA for industrial stormwater is provided based on acreage of "industrial disturbed areas" of industrial stormwater permitted facilities within the impaired subwatersheds. Acreages for nonmetallic mining operations were estimated using aerial imagery on Google Earth. Acreages by impairment are provided in Table 18.

Table 18. Acres used to calculate TSS WLAs for industrial stormwater.

Applicable HUC-12 watershed	Water body name (WID	Industrial disturbed area in drainage area (acres)	Source
Mill Creek (070400080107)	Mill Creek (-536)	61	Industrial stormwater permit and estimates from aerial imagery
	Unnamed Creek / "Mill Creek tributary" (-A47)		
Bear Creek (070400080207)	Bear Creek (-A18)	No current industrial stormwater facilities, WLA set to construction stormwater WLA	
	Upper Bear Creek (-540)		
Spring Valley Creek (070400080205)	Spring Valley Creek (-548)	2.2	Estimated using aerial imagery
	Unnamed Creek/ "Spring Valley Creek tributary" (-D53)		
Camp Creek (070400080407)	Camp Creek (-559)	76.5	Estimated using aerial imagery
Riceford Creek (070400080804)	Riceford Creek (-H01)	51	Estimated using aerial imagery
	Riceford Creek (-518)		

For drainage areas of impaired streams with no current industrial stormwater permitted facilities, a small WLA is set equal to the construction stormwater WLA; no reductions are needed to meet the TMDL for these drainage areas at this time.

Construction stormwater

The five-year average (2018 through 2022) percent of the RRW area that is under permitted construction activity is approximately 0.05%. The TSS WLA for construction stormwater was calculated as the loading capacity minus the MOS multiplied by 0.05%.

4.7.3 Boundary condition

Boundary conditions are used to set aside load for a geographic area in a TMDL watershed without establishing LAs or WLAs for that area. If part of an impairment watershed is in another state, a boundary allocates a lump sum load to the area that does not fall under Minnesota's jurisdiction. Minnesota cannot establish allocations for other jurisdictions, and any reductions noted in this TMDL that are needed in the neighboring jurisdiction are consistent with Minnesota's WQS and not more stringent.

A boundary condition load is assigned for impaired segments that have a portion of their watershed in Iowa: Riceford Creek (-518) and Riceford Creek (-H01).

The boundary condition load assumes, for calculation purposes, that that WQS are being met at the state line. Boundary conditions are calculated using the proportion of the total watershed area in Iowa. The boundary condition allocation is equal to the percent of the total watershed area in Iowa, multiplied by the loading capacity. In the TMDL tables (Section 5), the boundary condition load is assigned to the portion of the watershed in Iowa, and the remaining allocations in the tables are assigned to the portion of the watershed in Minnesota.

4.8 Nitrate

This section describes the approach used to derive the nitrate TMDLs and allocations for the following impaired streams in the RRW:

- Mill Creek (-536)
- Spring Valley Creek (-548)

Because the nitrate standards for the impairments addressed in this report apply year-round, the nitrate TMDLs and allocations also apply year-round.

4.8.1 Load allocation methodology

The LA is allocated to existing or future nonpermitted pollutant sources. The LA was calculated as the loading capacity minus the MOS and the WLAs as applicable.

Natural background conditions were also evaluated, where possible, within the modeling and source assessment portion of this TMDL (Section 3.5). For nitrate impairments addressed in this TMDL report, natural background sources are implicitly included in the LA portion of the TMDL tables, and reductions should focus on the major human attributed sources identified in the source assessment.

4.8.2 Wasteload allocation methodology

The WLA is allocated to existing or future NPDES-permitted pollutant sources. There are no MS4s within the impairment subwatersheds addressed in this report, and construction stormwater is not considered a source of nitrate (see Section 3.5.2 for source assessment information). WLAs for these sources were therefore not developed. There are currently no industrial wastewater or stormwater sources within the impairment subwatersheds addressed in this report, but a small WLA was developed for potential future industrial stormwater activity. The total nitrogen permit limit (10 mg/L) for Spring Valley WWTF is consistent with the nitrate WLA assumptions. Total nitrogen is the sum of nitrite plus nitrate (as N) + TKN (ammonia + organic nitrogen). Therefore, compliance with the permit effluent limit will require the facility to discharge nitrate at a concentration below 10 mg/L.

Municipal wastewater

A nitrate WLA was assigned to the Spring Valley WWTF based on the nitrate drinking water standard (10 mg/L) multiplied by the facility's average wet weather design flow (Table 19). Existing effluent limits are consistent with nitrate WLA assumptions.

Table 19. Individual wastewater nitrate wasteload allocations in the RRW TMDL.

Facility name	Permit number	Surface discharge station	Average wet weather design flow (mgd) [a]	Impaired water body WID	Pollutant	Permit limit	Wasteload allocation	Existing permit consistent with WLA assumptions
Spring Valley WWTF	MN0051934	SD002	0.936	07040008-548	nitrate	10 mg/L total nitrogen	78 lbs nitrate/day	Yes [b]

a. Flow used to calculate the WLA

b. The permit limit for total nitrogen (sum of nitrite plus nitrate (as N) + TKN (ammonia + organic nitrogen)) is consistent with the nitrate WLA because it is more restrictive. Compliance with a 10 mg/L total nitrogen effluent limit will require the facility to discharge nitrate at a nitrate concentration below 10 mg/L

Industrial stormwater

There are currently no permitted industrial stormwater facilities with nitrate or nitrogen benchmarks in the affected subwatersheds; however, a small WLA is set aside for activity under these general permits in the TMDL allocation tables. No reductions are needed at this time to meet the TMDL.

NPDES/SDS permitted animal feeding operations

WLAs are not assigned to CAFOs, including CAFOs with NPDES or SDS permits, and CAFOs not requiring permits; this is equivalent to a WLA of zero. Although the NPDES and SDS permits allow discharge of manure and manure contaminated runoff due to a precipitation event greater than or equal to a 25-year, 24-hour precipitation event, the permits prohibit discharges that cause or contribute to nonattainment of WQS.

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

4.9 *E. coli*

Because the *E. coli* standards for the impairments addressed in this report apply April through October, the *E. coli* TMDLs and allocations also apply April through October. There is only one *E. coli* impairment addressed in this TMDL report.

There are no NPDES permitted facilities within the impairment subwatershed of the *E. coli* impaired reach. No WLAs were developed for this *E. coli* TMDL.

4.9.1 Load allocation methodology

The LA is allocated to existing or future nonpermitted pollutant sources. The LA was calculated as the TMDL minus the MOS.

Natural background conditions were also evaluated, where possible, within the modeling and source assessment portion of this TMDL (Section 3.4). For all impairments addressed in this TMDL report, natural background sources are implicitly included in the LA portion of the TMDL tables, and reductions should focus on the major human attributed sources identified in the source assessment.

5. TMDL summary by HUC-12 Watershed

This section includes the TMDLs and the supporting information for each impaired water addressed in this TMDL report. Information in this section also provides additional understanding of the context of each impairment, pollutant sources driving each impairment, necessary pollutant reductions, and implementation recommendations by HUC-12.

5.1 Mill Creek HUC-12 (070400080107)

There are TSS and nitrate TMDLs on two class 2A impaired stream reaches in the Mill Creek HUC-12 Watershed:

- TSS TMDL on Mill Creek (-536)
- Nitrate TMDL on Mill Creek (-536) and Unnamed Creek (Mill Creek Tributary) (-A47)

Overall, a 17% reduction in TSS concentration is needed in Mill Creek (-536) (Table 20). The LDCs, water quality analysis, and TSS source assessment indicate that the exceedances occur under mid to very high flows, with the most occurring under high flows. Load reductions, with a focus on higher flow events, are needed to address numerous source types including overland runoff from agricultural areas, and in-channel erosion.

Table 20. TSS TMDL summary table for Mill Creek HUC-12 (070400080107).

WID	Water body name	Existing 90th percentile TSS concentration (mg/L)	TSS standard (mg/L)	Percent reduction in concentration needed to meet TSS standard
-536	Mill Creek	12	< 10 mg/L	17%

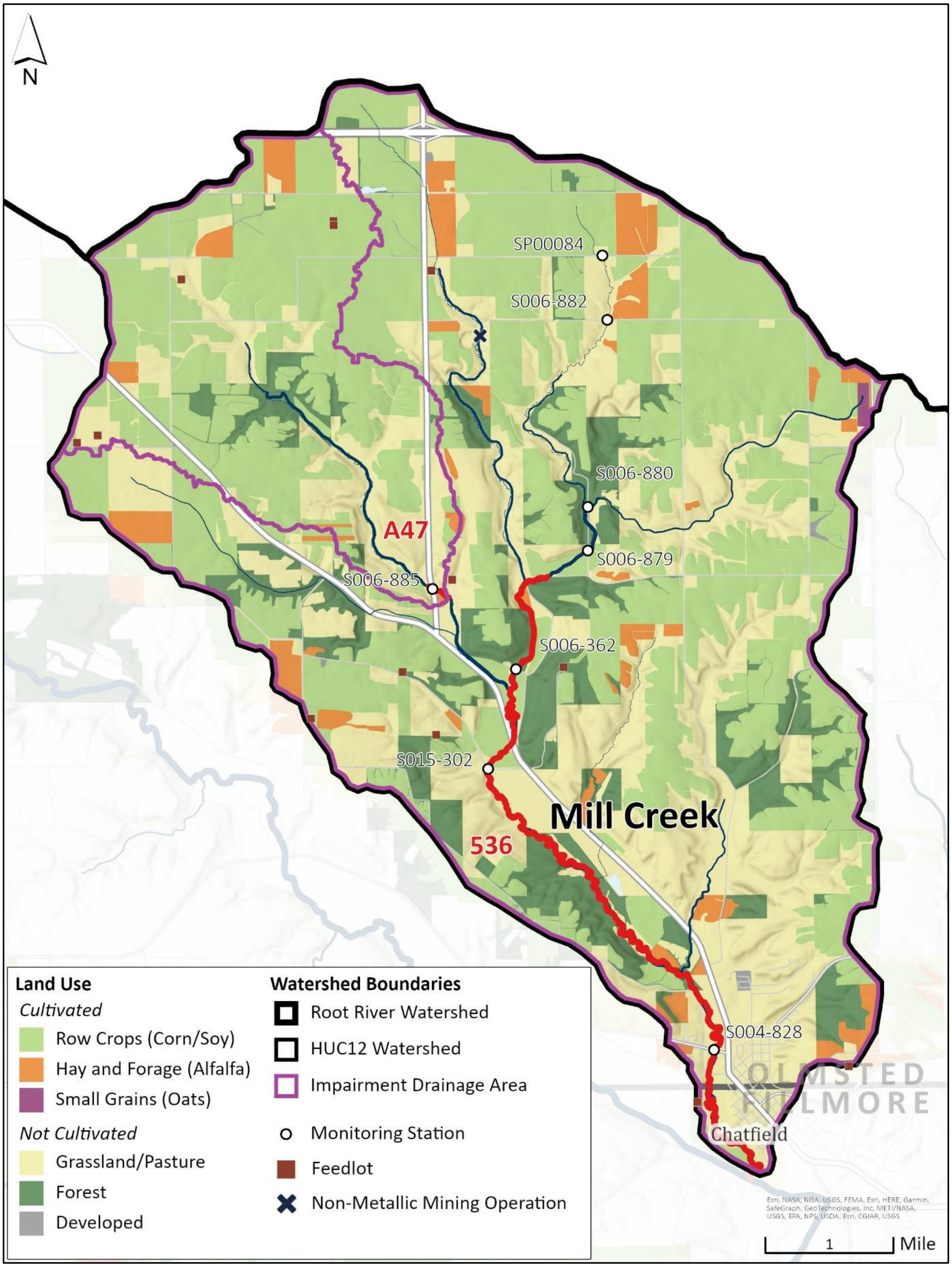
The estimated percent reductions needed to meet the nitrate TMDL for Mill Creek (-536) and Unnamed Creek (Mill Creek Tributary) (-A47) is 10% (Table 22). Load reductions are needed to address nitrate loading from row crop agriculture.

Table 21. Nitrate TMDL summary for Mill Creek HUC-12 (070400080107).

WID	Water body name	Maximum observed concentration (mg/L)	Percent reduction in concentration needed to meet nitrate standard
-536	Mill Creek	11.1	10%

The primary land covers in the Mill Creek Watershed are row crops (44%), grass and pasture (22%), and deciduous forest (16%; Table 4, Figure 7).

Figure 7. Mill Creek HUC-12 (070400080107).



5.1.1 TSS: Mill Creek (-536)

Water quality

TSS data for Mill Creek (-536) are primarily available from 2018–2020 at the monitoring station S004-828, at Highway 30 in Chatfield. Simulated flow data from the RRW HSPF model (2021 model extension) were used to approximate the stream flow conditions when each water quality sample was taken.

The TSS standard for cold water streams (10 mg/L) was exceeded in 57% of samples with the highest concentrations in 2019 (Table 22 and Figure 8), which was a record high flow year in southeastern Minnesota, and in the spring and early summer months (Table 23). TSS concentrations are generally highest and T-tube measurements lowest under high flows (Figure 9 and Figure 10).

On May 28, 2019, TSS was measured at three monitoring sites (S006-362, S015-302, and S004-828) under extremely high flow conditions (top 1% of simulated flows). TSS concentration increased from upstream to downstream, 180 mg/L, 200 mg/L, and 230 mg/L TSS, respectively.

Table 22. Annual summary of TSS data for Mill Creek (-536; 2018-2020; April–September).

TSS standard for Class 2A streams: 10 mg/L TSS

Monitoring site: S004-828

Year	Sample count	Mean (mg/L)	Median (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
2018	5	10	8	2	20	2	40%
2019	7	67	42	6	230	5	71%
2020	2	28	28	5	50	1	50%

Table 23. Monthly summary of TSS data for Mill Creek (-536; 2018–2020).

Monitoring site: S004-828. The TSS standard (10 mg/L) applies Apr–Sep; additional months are shown in this table to illustrate water quality trends.

Month	Sample count	Mean (mg/L)	Median (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
May	4	74	29	6	230	2	50%
June	3	38	23	20	71	3	100%
July	2	28	28	13	42	2	100%
Aug	2	9	9	7	10	0	0%
September	3	31	5	2	86	1	33%

Figure 8. TSS concentration by year, Mill Creek (-536, S004-828).

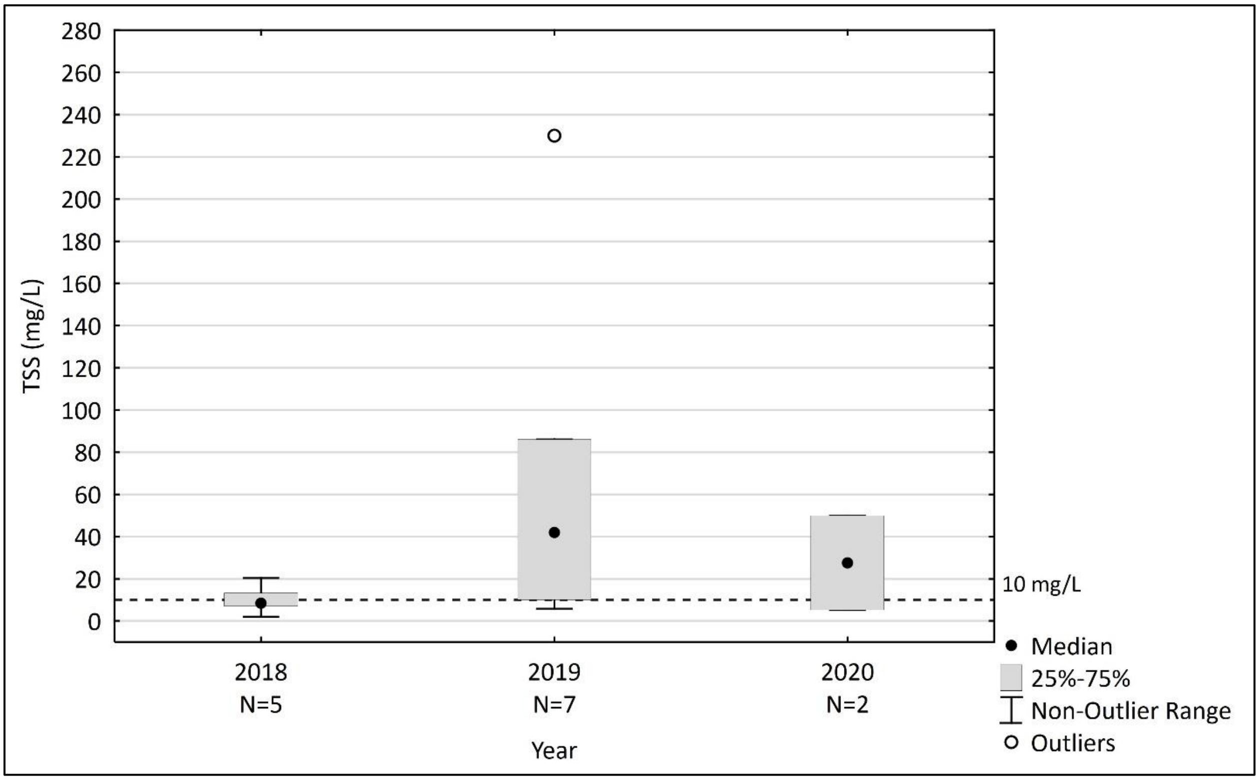


Figure 9. Simulated flow and monitored TSS concentration, Mill Creek (-536, S004-828).

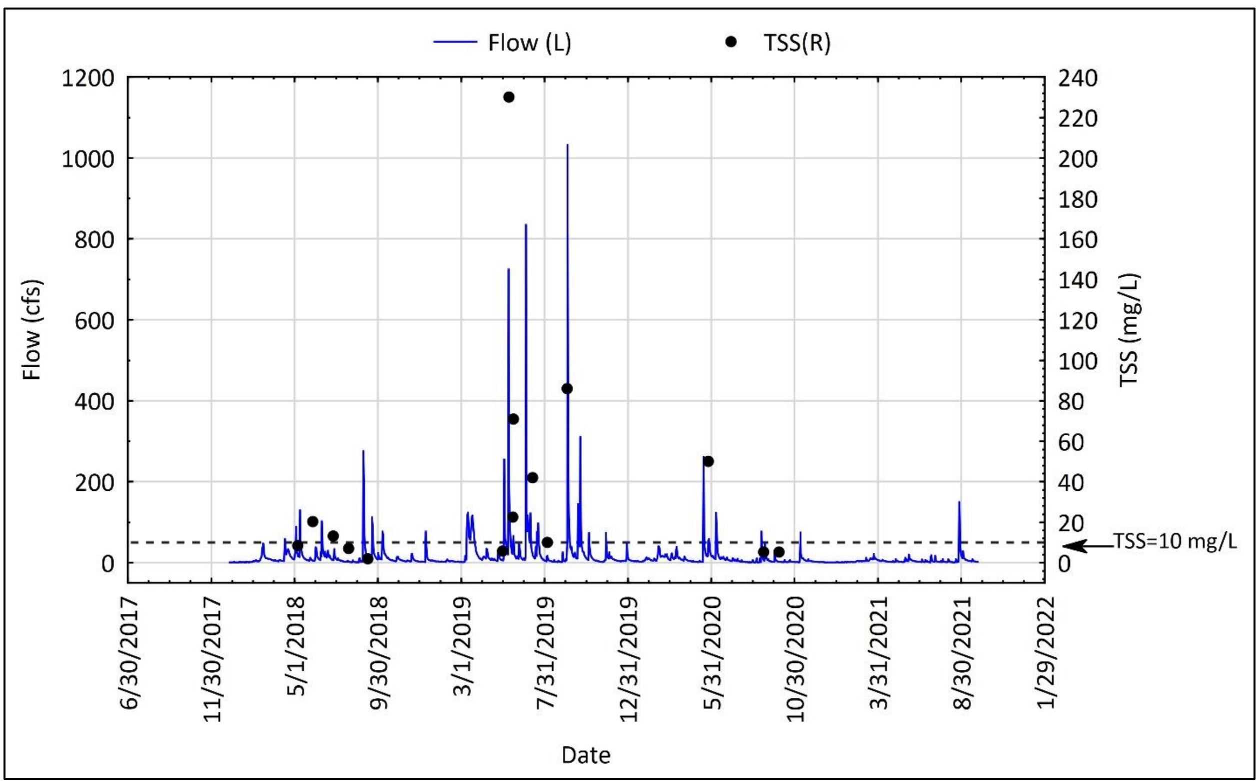
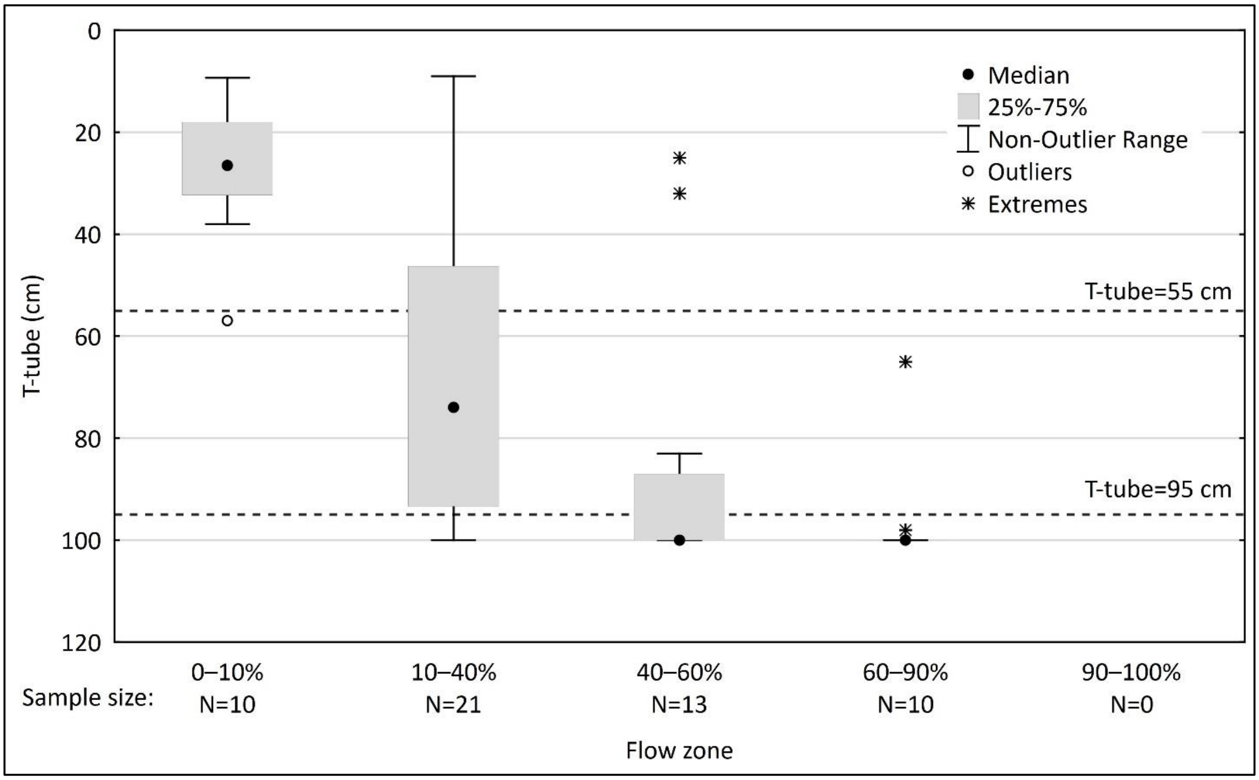


Figure 10. Monitored T-tube measurements by flow zone, Mill Creek (-536, S004-828), 2018–2021.



55 cm and 95 cm are the lower and upper surrogate values, respectively, for assessment (Section 2.4.2).

Sediment sources

The most significant sediment sources to Mill Creek (-536) are in-channel erosion and overland runoff from cropland. The RRW HSPF model (2021 model extension) outputs show that conventional farm fields and pasturelands contribute a majority of the overland TSS load (Table 24). Altered hydrology drives the availability and transport of sediment. In the headwaters of Mill Creek (-536), straightened and channelized stream channels change the timing of stream flow by increasing peak flow. This is largely due to the channel being disconnected from the floodplain. Disconnection from the floodplain not only alters peak flow but also overall available stream flow. Low stream flow conditions can also occur without a connection to a floodplain. High peak flows introduce an influx of sediment from both overland and in-channel areas. When low stream flow conditions occur shortly following peak flow, fine sediment falls out of the water column and coats channel substrate, vegetation, and woody debris. This phenomenon is also supported by MPCA monitoring staff observations that note the declines and recoveries of transparency in Mill Creek (-536) are closely tied to rain events.

Permitted sources (construction stormwater and industrial stormwater (Table 11) including nonmetallic mining operations (Table 12)) are not significant sources of sediment if operating in compliance with their permits, but may contribute at certain times of the year, particularly during extreme precipitation events.

Table 24. Average annual TSS contributions to Mill Creek by source, 10/1/1994 – 9/30/2021 (MPCA 2023).

Source		Average annual % of TSS load[a]
In-channel		17%
Overland runoff	Cropland	53%
	Pasture	22%
	Developed	7%
	Forest, open water, wetland, and barren	2%

a. Percentages are rounded to nearest whole number and therefore may not add up to 100%.

TMDL

Exceedances of the TSS loading capacity in Mill Creek (-536) are seen in the very high, high, and mid flow zones, with the majority of exceedances occurring in the very high flow zone (Figure 11). The Mill Creek (-536) TMDL summary is provided in Table 25.

Figure 11. Mill Creek (-536) TSS load duration curve.

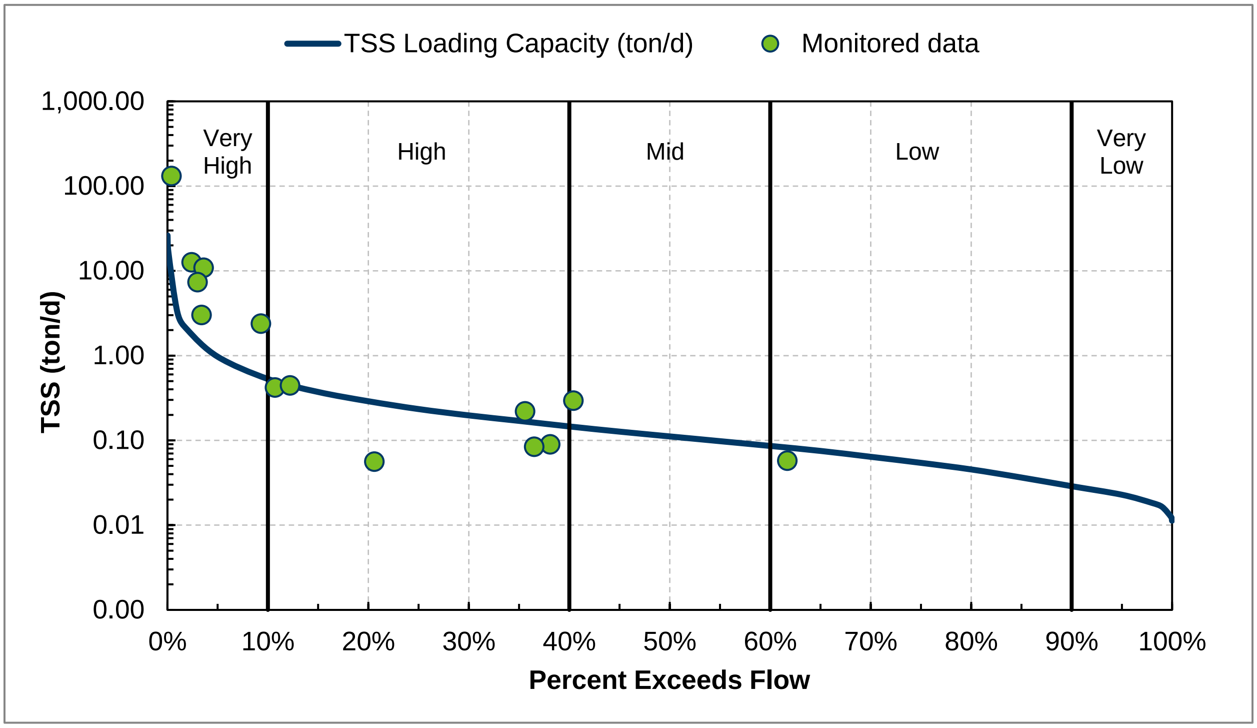


Table 25. Mill Creek (-536) TSS TMDL summary

- Listing year: 2020
- Baseline year: 2015
- Numeric standard used to calculate TMDL: 10 mg/L TSS
- TMDL and allocations apply Apr–Sep

TMDL parameter		TMDL TSS load (tons/day) by flow zone				
		Very high	High	Mid	Low	Very low
WLA	Industrial stormwater (MNR050000 and MNG490000)	0.0026	0.00063	0.00030	0.00015	0.000061
WLA	Construction stormwater (MNR100001)	0.00044	0.00011	0.000050	0.000024	0.000010
LA		0.87	0.21	0.10	0.048	0.020
MOS		0.097	0.023	0.011	0.0054	0.0023
TMDL		0.97	0.23	0.11	0.054	0.023
Existing 90th percentile concentration (mg/L)		12				
Estimated percent reduction		17%				

5.1.2 Nitrate: Mill Creek (-536 and -A47)

This nitrate TMDL applies to both Mill Creek (-536) and its tributary Unnamed Creek (-A47). This is possible as both impairments have the same designated use, are held to the same nitrate standard (10 mg/L), and the drainage area for Unnamed Creek (-A47) is entirely within the drainage area for Mill Creek (-536). Land cover is similar in both drainage areas and no NPDES permitted sources are impacted.

Water quality

Nitrate data for Mill Creek (-536) are available from 2019–2020 at the monitoring stations S006-362, S015-302, and S004-828. Nitrate data are available for Unnamed Creek (-A47) from 2019–2020 for monitoring station S006-885 (Table 26 and Table 27).

Nitrate levels exceeded the standard on Mill Creek (-536) approximately 14% of the time with the highest frequency of exceedances occurring on the most upstream monitoring site (S006-362). Exceedances of the water quality standard were observed in the summer months of June, July, August, and September.

Simulated flow data from the RRW HSPF model (2021 model extension) were used to approximate the stream flow conditions on Mill Creek (-536) when each water quality sample was taken. No relationship was observed between nitrate levels and flow in either year; however, nitrate concentrations throughout the RRW typically are highest at monitoring stations in headwater portions of the watershed where groundwater's influence on the stream flow is high and dilute during rain events (MPCA 2023a, Barry et. al 2018, Barry et. al 2020).

Data from longitudinal monitoring conducted in 2020 throughout the Mill Creek HUC-12 show nitrate concentrations well above the standard in the upstream reaches of the watershed and lower in the downstream portion of the watershed (Figure 12). The highest nitrate concentrations were observed at monitoring station SP00084, a spring to Mill Creek. The highest single concentration (19.5 mg/L) of nitrate was also observed at monitoring station SP00084 and occurred in July 2020.

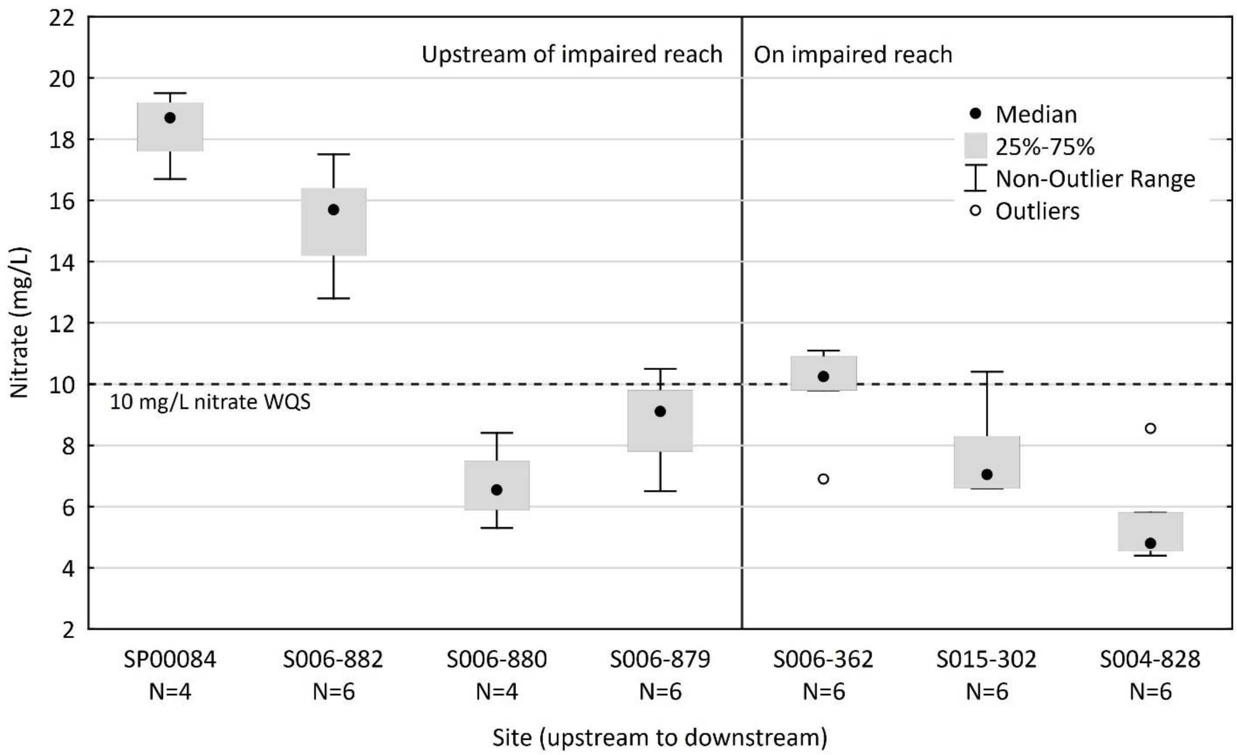
Table 26. Annual summary of nitrate data for Mill Creek (-536) and Unnamed Creek (-A47).
Nitrate standard for Class 1B and 1C designated surface waters: 10 mg/L

Year	Sample count	Mean (mg/L)	Median (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
Mill Creek (-536)							
Site S006-362							
2019	9	9.2	9.7	5.2	12.1	2	22%
2020	6	9.9	10.3	6.9	11.1	4	67%
Site S015-302							
2019	9	7.7	7.7	5.3	9.2	0	0%
2020	6	7.7	7.1	6.6	10.4	1	16%
Site S004-828							
2019	12	6.3	6.3	4.4	8.1	0	0%
2020	6	5.5	4.8	4.4	8.6	0	0%
Unnamed Creek (-A47)							
Site S006-885							
2019	11	10.2	11	6.3	11.8	7	64%
2020	6	10.8	10.8	9	12.9	4	67%

Table 27. Monthly summary of nitrate data for Mill Creek (-536; 2019–2020).
Nitrate standard for Class 1B and 1C designated surface waters: 10 mg/L
Monitoring sites S006-362, S015-302, and S004-828 combined due to low monthly sample counts.

Month	Sample count	Mean (mg/L)	Median (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
March	3	5.0	5.2	4.4	5.3	0	0%
April	3	7.3	7.7	6.2	8.0	0	0%
May	9	7.4	7.0	5.8	9.9	0	0%
June	8	8.9	8.8	6.4	11.1	3	37%
July	6	7.2	7.5	4.6	10.1	1	16%
August	7	8.1	7.3	5.0	12.1	2	28%
September	6	7.2	6.8	4.4	10.4	1	16%
October	6	7.8	8.1	4.6	9.8	0	0%

Figure 12. Longitudinal nitrate concentrations in 2020 in the Mill Creek -536 Watershed.



Nitrate sources

The primary source of nitrate to Mill Creek (-536) is loading from agricultural areas. Especially in the upper portions of the watershed, nitrogen from commercial fertilizer and animal manure spread on cropland can be converted to nitrate and vertically leach into underlying groundwater. This nitrate-laden groundwater then re-enters surfaces waters through the many spring inflows within the drainage area to Mill Creek (-536) (**Figure 13**). A high density of row crop land use combined with a high density of springs results in a higher likelihood of elevated nitrate in surface water. Outputs from the RRW HSPF model (2021 model extension) support these findings and show cropland and pastures as the primary sources of nitrogen in the Mill Creek HUC-12 Subwatershed (Table 28). Total nitrogen is the sum of nitrate, nitrite, organic nitrogen, and ammonia. Of all types of cropland modeled by HSPF (conventional tillage, conservation tillage and manured areas), manured areas contribute 54% of the nitrogen load to Mill Creek.

Figure 13. Mill Creek HUC-12 Watershed location of mapped springs.

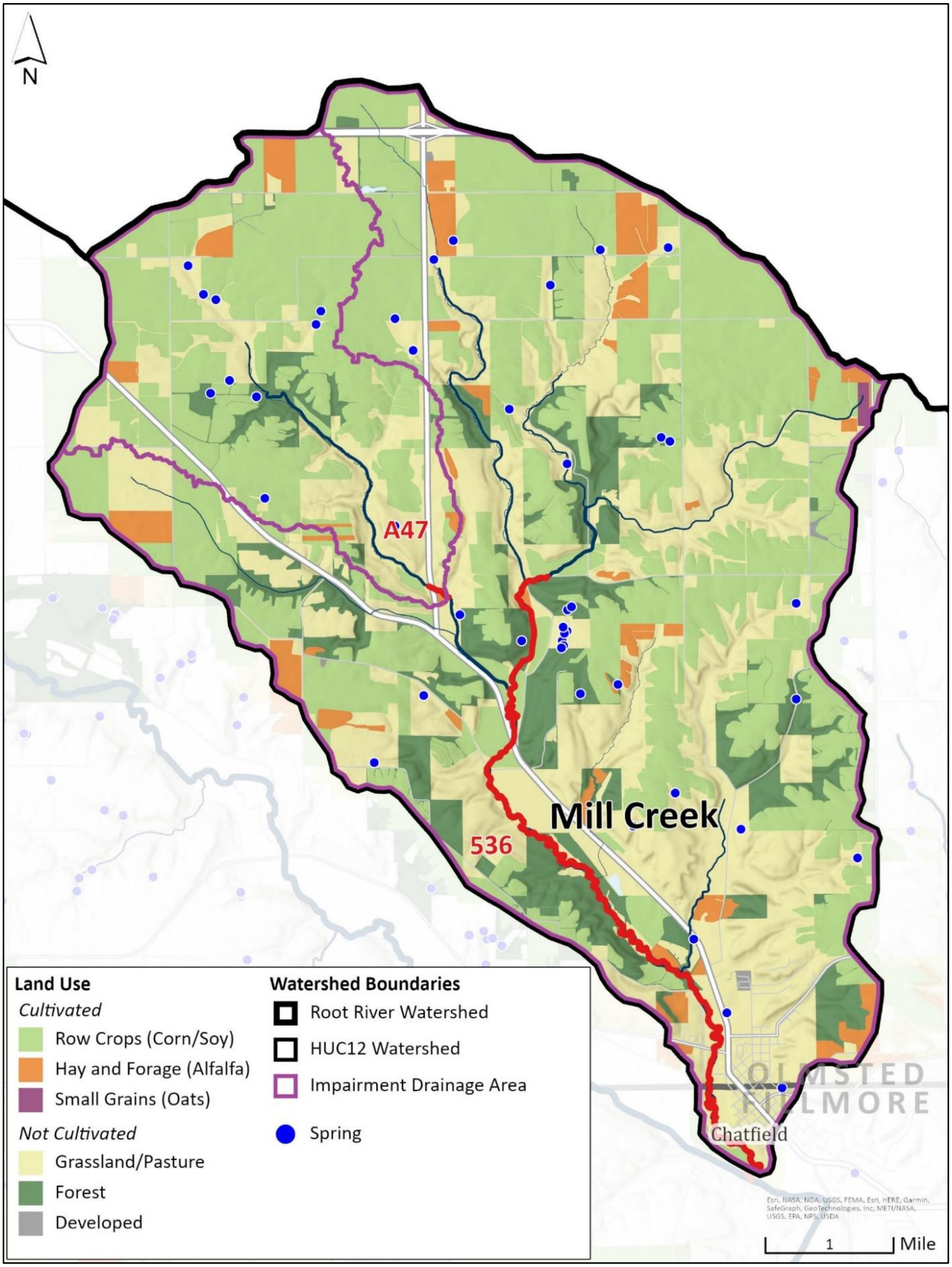


Table 28. Average annual total nitrogen contributions to Mill Creek by source 10/1/1994 – 9/30/2021 (MPCA 2023).

Source		Average annual total nitrogen loading (%)[a]
Nonpermitted	Cropland—conventional acres	25%
	Cropland—manured acres	36%
	Cropland—conservation tilled acres	5%
	Pasture	28%
	Developed	3%
	Forest	3%
	Open Water, Wetland, Barren	< 1%

a. Percentages are rounded to nearest whole number and therefore may not add up to 100%.

TMDL

The Mill Creek nitrate TMDL addresses both reaches in the Mill Creek Watershed with nitrate impairments: -536 and -A47.

Exceedances of the nitrate loading capacity in the Mill Creek impaired reach (-536) are seen in all flow zones that have corresponding monitoring data: very high, high, mid, and low flow zones (Figure 14). The Mill Creek nitrate TMDL summary is provided in Table 29.

Figure 14. Nitrate load duration curve for Mill Creek (-536).

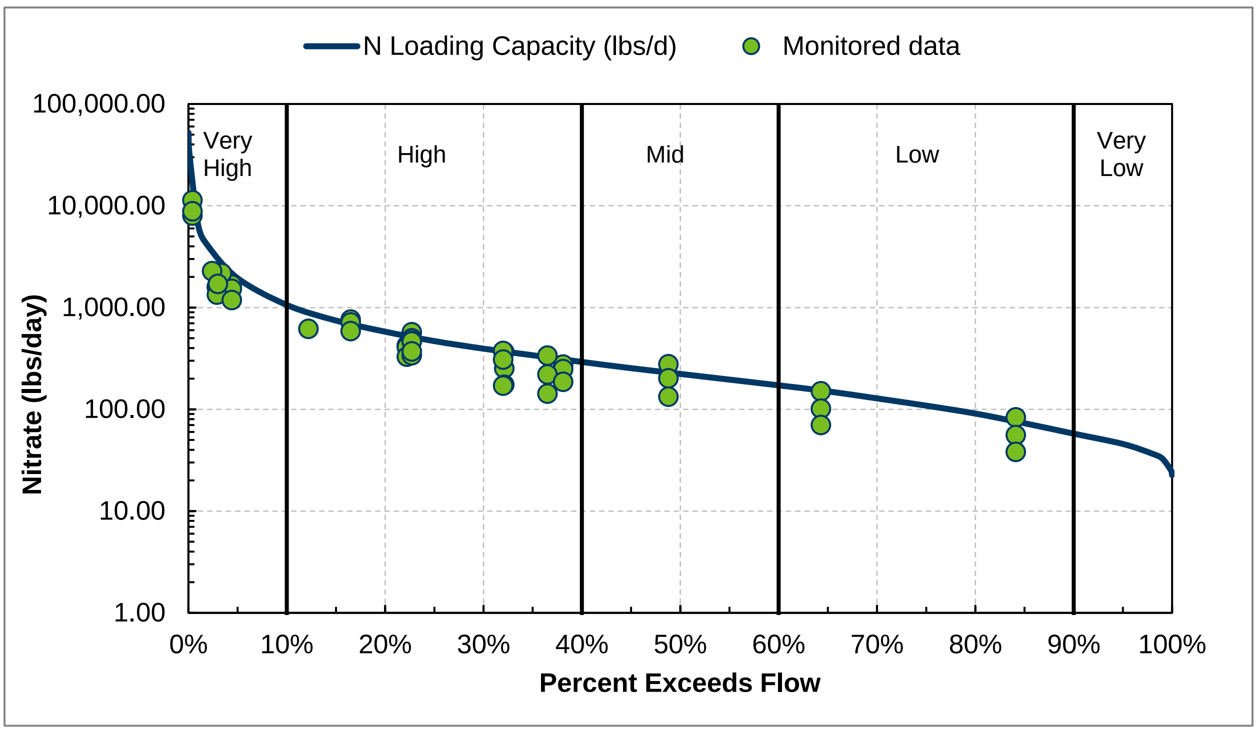


Table 29. Mill Creek (-536) nitrate TMDL summary

- Impairments addressed by this TMDL: -536 and -A47
- Listing year: 2022
- Baseline year: 2015
- Numeric standard used to calculate TMDL: 10 mg/L nitrate

TMDL parameter		TMDL nitrate load (lbs/day) by flow zone				
		Very high	High	Mid	Low	Very low
WLA	Schoenfelder Farms LLP (MNG442167)	0	0	0	0	0
	Industrial stormwater (MNR050000)	0.87	0.21	0.10	0.049	0.021
LA		1,747	421	201	98	41
MOS		194	47	22	11	4.6
TMDL		1,941	468	223	109	46
Maximum observed nitrate concentration (mg/L)		11.1				
Estimated percent reduction		10%				

5.2 Bear Creek HUC-12 (070400080207)

There are TSS TMDLs on two class 2A impaired stream reaches in the Bear Creek HUC-12 Watershed:

- Bear Creek/Lost Creek (-A18)
- Upper Bear Creek (-540)

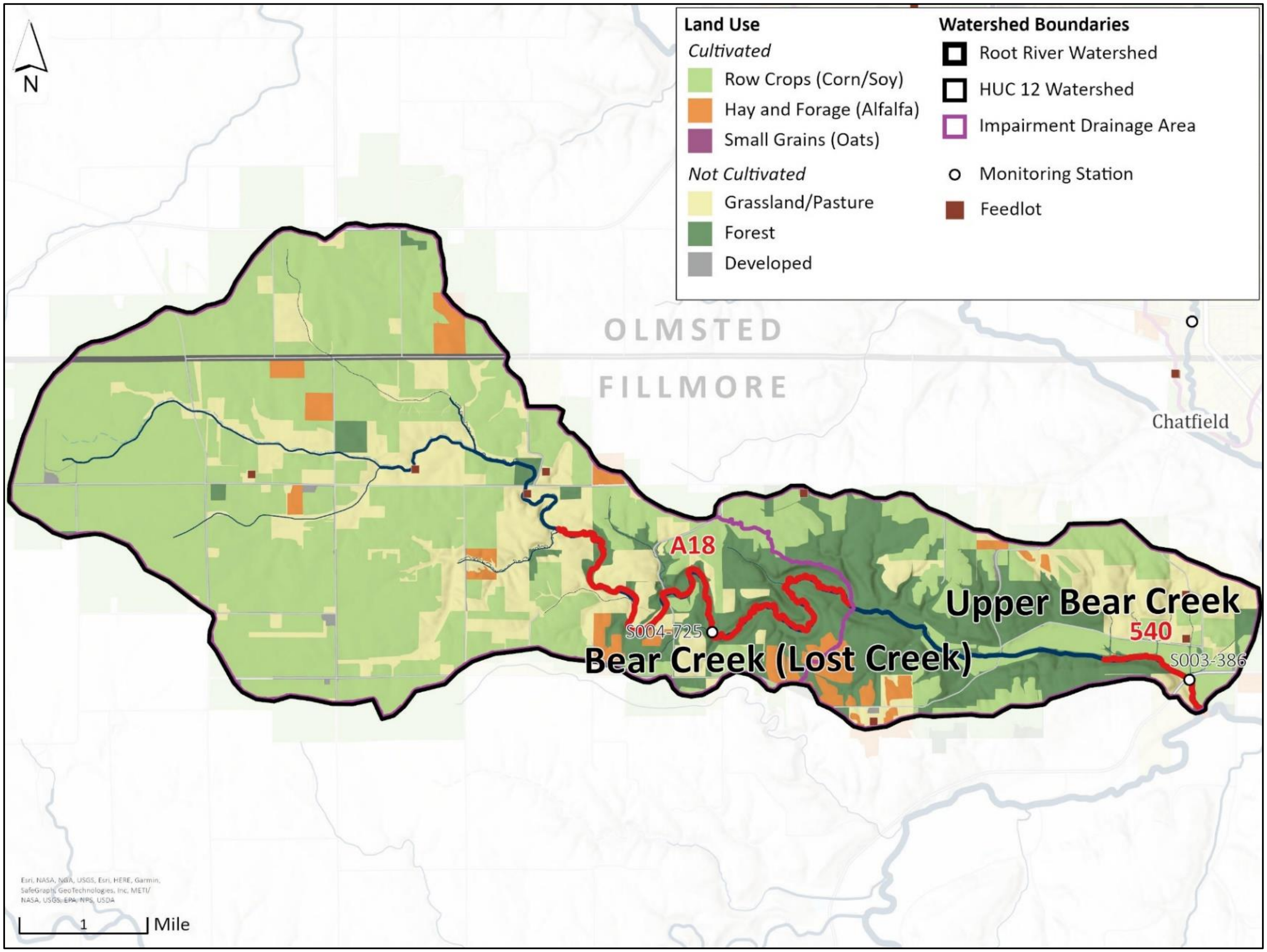
A 77 cm and 65.4 cm improvement in transparency depth is needed in the Bear Creek/Lost Creek (-A18) and Upper Bear Creek (-540) impaired streams, respectively (Table 30). Water quality analysis indicate that the exceedances of the transparency standard typically occur under high flows.

Table 30. TSS TMDL summary table for Bear Creek HUC-12 (070400080207).

WID	Water body name	Existing 10th percentile transparency depth (cm)	Transparency standard (cm)	Needed improvement in transparency (cm)
-A18	Bear Creek/Lost Creek	18	> 95	77
-540	Upper Bear Creek	29.6	> 95	65.4

The primary land covers in the Beach Creek Watershed are row crops (55%), deciduous forest (18%), and grass/pasture (15%; Table 4. Figure 15).

Figure 15. Bear Creek HUC-12 (070400080207).



5.2.1 TSS: Bear Creek/Lost Creek (-A18) and Upper Bear Creek (-540)

Water quality

There are no TSS data available within the last 10 years for Bear/Lost Creek (-A18) and Upper Bear Creek (-540). Instead, T-tube data are available at monitoring site S004-725 for Bear/Lost Creek (-A18) and monitoring site S003-386 for Upper Bear Creek (-540). Simulated flow data from the RRW HSPF model (2021 model extension) were used to approximate the stream flow conditions when each water quality sample was taken.

Annual transparency means in Bear Creek/Lost Creek (-A18) vary but there is no clear trend (Table 31). Transparency is typically lowest during May through July (Table 32) when flows are on average higher. Transparency is lowest under high flows and improves as flows decrease (Figure 16).

T-tube measurements are limited on Upper Bear Creek (-540) with only monthly measurements in 2019 (Table 31, Table 32). The pattern of low transparency under high flows in Upper Bear Creek (-540) mirrors that of upstream Bear/Lost Creek (-A18) (Figure 16 and Figure 17).

Table 31. Annual summary of T-tube data for Bear Creek/Lost Creek (-A18) and Upper Bear Creek (-540); April–September.
Surrogate T-tube measurement used to determine if a stream exceeds the TSS standard for Class 2A streams: < 55 cm
Monitoring site: S004-725 and S003-386

Year [a]	Sample count	Mean (cm)	Median (cm)	Minimum (cm)	Maximum (cm)	Number of measurements < 55 cm	Frequency of measurements < 55 cm
Bear Creek/Lost Creek A18, site S004-725							
2012	67	77	87	5	100	13	19%
2013	61	68	96	1	100	20	33%
2014	75	67	75	5	100	29	39%
2015	88	70	69	6	100	21	24%
2016	106	60	66	5	100	44	42%
2017	77	63	65	6	100	35	45%
2018	75	61	53	6	100	38	51%
2019	89	64	65	3	100	33	37%
2020	83	69	71	12	100	33	40%
Upper Bear 540, site S003-386							
2019	5	74	100	8	100	1	20%

a. Prior to 2012, the maximum T-tube reading possible (based on T-tube design) was 60 cm. Starting in 2012, the maximum possible reading has been 100 cm. Data from before 2012 are not presented here.

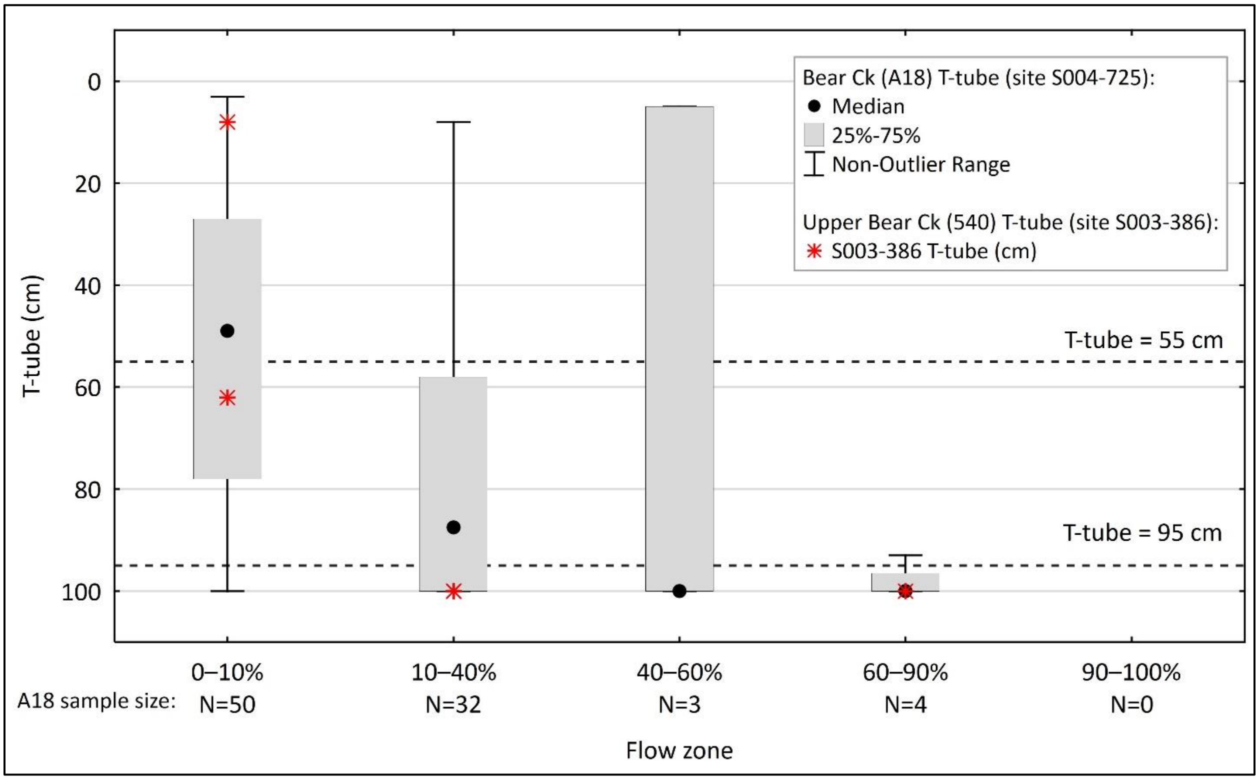
Table 32. Monthly summary of T-tube data for Bear Creek/Lost Creek (-A18) and Upper Bear Creek (-540); 2012–2020.
Monitoring site: S004-725, and S003-386.
Surrogate T-tube measurement used to determine if a stream exceeds the TSS standard for Class 2A streams: < 55 cm
The transparency surrogate measurement applies Apr–Sep; additional months are shown in this table to illustrate water quality trends.

Month	Sample count	Mean (cm)	Median (cm)	Minimum (cm)	Maximum (cm) [a]	Number of measurements < 55 cm	Frequency of measurements < 55 cm
Bear Creek/Lost Creek A18, site S004-725							
February	1	100	100	100	100	0	0%
March	45	74	86	5	100	12	27%
April	85	70	100	5	100	27	32%
May	116	67	71	1	100	41	35%
June	185	53	51	1	100	100	54%
July	172	64	62	5	100	66	38%
Aug	71	87	100	6	100	9	13%
September	92	76	100	5	100	23	25%
October	72	81	100	4	100	15	21%
November	27	100	100	100	100	0	0%
December	4	100	100	100	100	0	0%
Upper Bear Creek 540, site S003-386							
February	1	6	NA [b]	NA [b]	NA [b]	1	100%
March	1	13	NA [b]	NA [b]	NA [b]	1	100%
May	1	8	NA [b]	NA [b]	NA [b]	0	0%
June	1	62	NA [b]	NA [b]	NA [b]	1	100%
July	6	66	66	18	100	1	17%
Aug	2	80	80	60	100	0	0%
September	1	100	NA [b]	NA [b]	NA [b]	0	0%
October	1	6	NA [b]	NA [b]	NA [b]	0	0%

a. Prior to 2012, the maximum T-tube reading possible (based on T-tube design) was 60 cm. Starting in 2012, the maximum possible reading has been 100 cm. Data from before 2012 are not presented here.

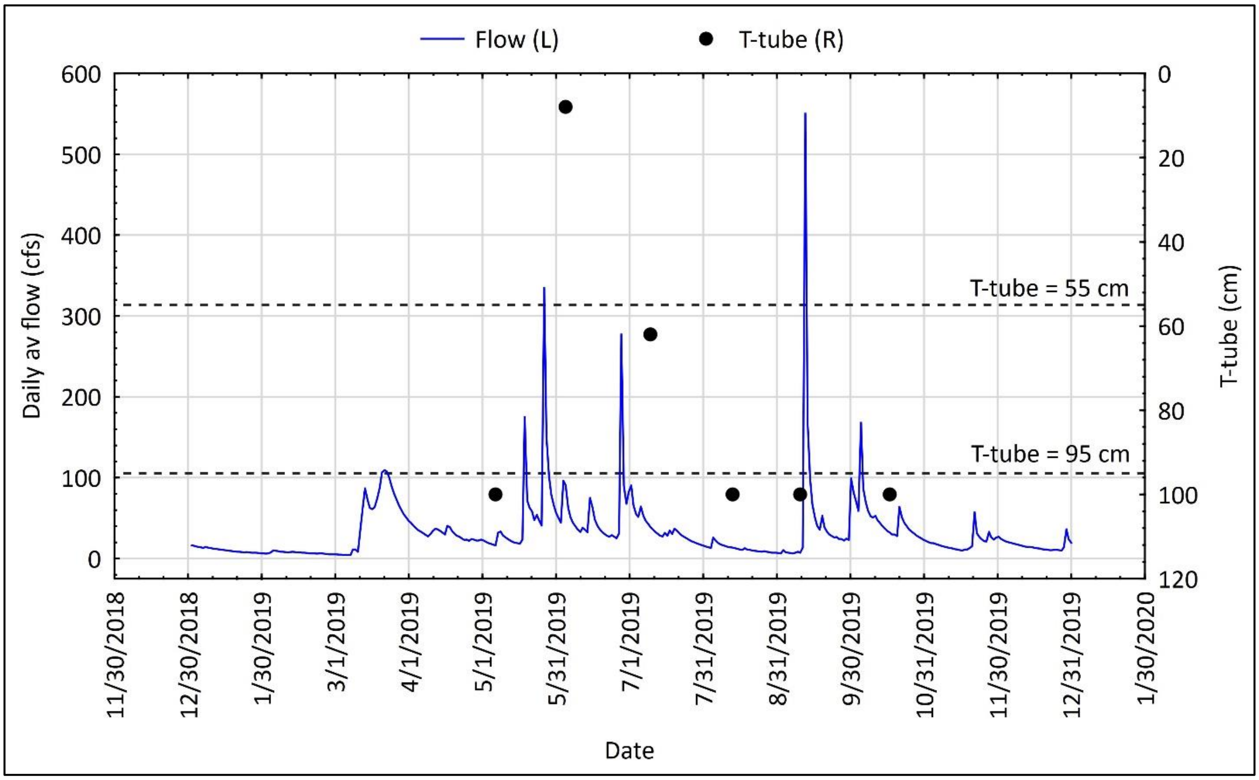
b. Statistics are not applicable because there is only one measurement per month.

Figure 16. Transparency tube by flow zone at Bear Creek/Lost Creek (-A18) and Upper Bear Creek (-540); Apr–Sep, 2019. 55 cm and 95cm represent the upper and lower surrogate values for the TSS water quality standard. The TSS WQS is not met if



the T-tube < 55 cm and the TSS WQS is met if T-tube > 95 cm.

Figure 17. Simulated flow and monitored T-tube, Upper Bear Creek (-540, S003-386).



55 cm and 95cm represent the upper and lower surrogate values for the TSS water quality standard. The TSS WQS is not met if the T-tube < 55 cm and the TSS WQS is met if T-tube > 95 cm.

Sediment sources

The two major sources of sediment to the Bear Creek HUC-12 Watershed are in-channel erosion and overland runoff. Outputs from the RRW HSPF model (2021 model extension) show that much of the overland TSS loading in the Bear Creek HUC-12 Watershed is from cropland and pastures (Table 33). Permitted sources of sediment are not considered major sources of sediment to Bear Creek/Lost Creek (-A18) nor Upper Bear Creek (-540). Sediment fingerprinting by Belmont et al. (2016) found that in the North Branch Root River HUC-10 (in which the Bear Creek HUC-12 lies) only 26% of the sediment was sourced from agricultural fields. This means that much of the sediment load is coming from the stream bank itself or in-channel sources. SID supports this conclusion as the areas of Bear Creek/Lost Creek and Upper Bear Creek are known to have stream instability. Even though row crop land is a less significant sediment source, specific areas may be disproportionately contributing sediment to Bear Creek HUC-12. Cropland near surface waters with steep slopes or concentrated flow areas void of conservation BMPs (grassed waterways, WASCOBs, perennial vegetation) are high risk areas for sediment loading to TSS impairments in the Bear Creek HUC-12.

Table 33. Average annual TSS contributions to Bear Creek by source 10/1/1994 – 9/30/2021 (MPCA 2023).

Source		Average annual % of TSS load [a]
In channel		26%
Overland runoff	Cropland	54%
	Pasture	15%
	Developed	3%
	Forest, open water, wetland, and barren	1%

a. Percentages rounded to nearest whole number and therefore may not add up to 100%

TMDL

The LDC for Bear Creek/Lost Creek (-A18) is provided in Figure 18and the TSS TMDL summary is provided in Table 34. The LDC for Upper Bear Creek (-540) is provided in Figure 18 and the TMDL summary is provided in Table 35.

Figure 18. Bear Creek/Lost Creek (-A18) TSS load duration curve.

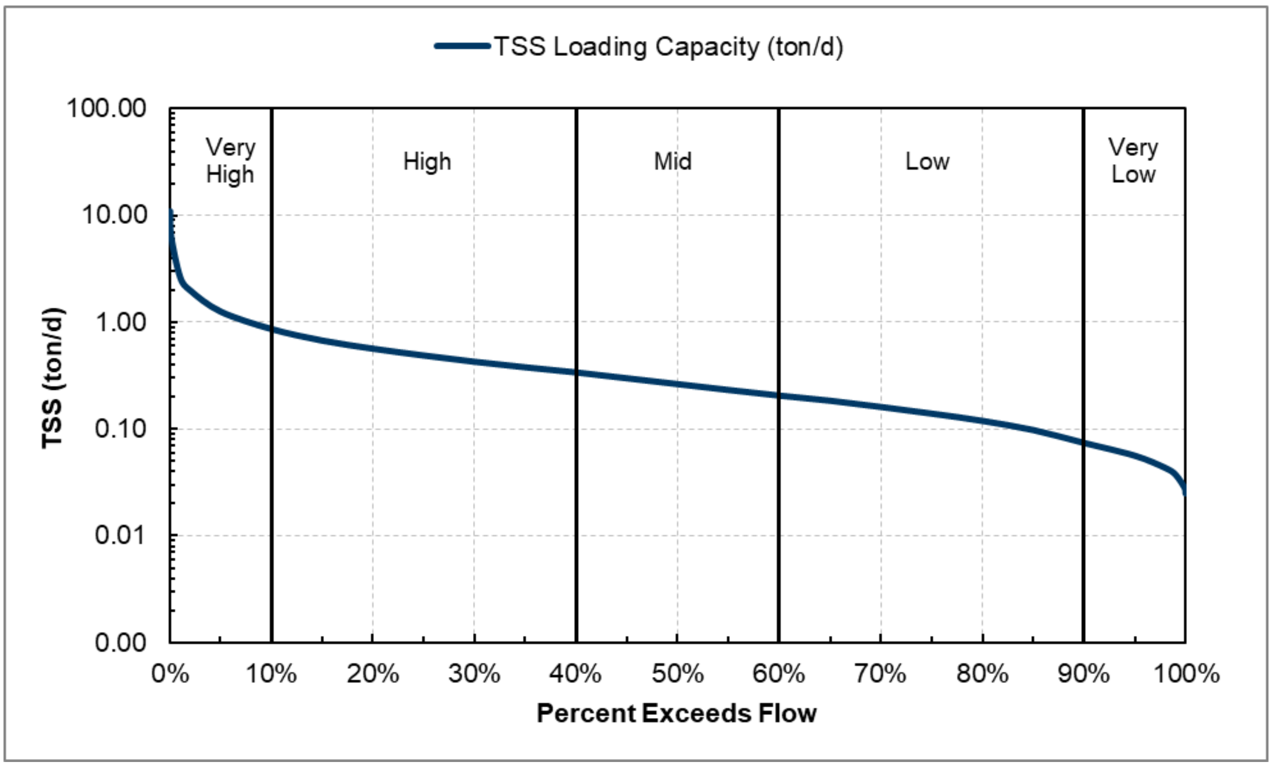


Table 34. Bear Creek/Lost Creek (-A18) TSS TMDL summary.

- Listing year: 2022
- Baseline year: 2015
- Numeric standard used to calculate TMDL: 10 mg/L TSS
- TMDL and allocations apply Apr–Sep

TMDL parameter		TMDL TSS load (tons/day) by flow zone				
		Very high	High	Mid	Low	Very low
WLA	Construction stormwater (MNR100001)	0.0003	0.00013	0.00007	0.00004	0.00002
	Industrial stormwater (MNR050000 and MNG490000)	0.0003	0.00013	0.00007	0.00004	0.00002
LA		1.1	0.44	0.23	0.13	0.051
MOS		0.13	0.049	0.026	0.014	0.0056
TMDL		1.2	0.49	0.26	0.14	0.056
Existing 90th percentile concentration (mg/L)		Insufficient data to calculate [a]				
Estimated percent reduction						

a. In order to meet the T-tube water quality standard of > 95 cm, transparency will need to improve by approximately 77 cm from the 10th percentile transparency depth of 18 cm.

Figure 19. Upper Bear Creek (-540) TSS load duration curve.

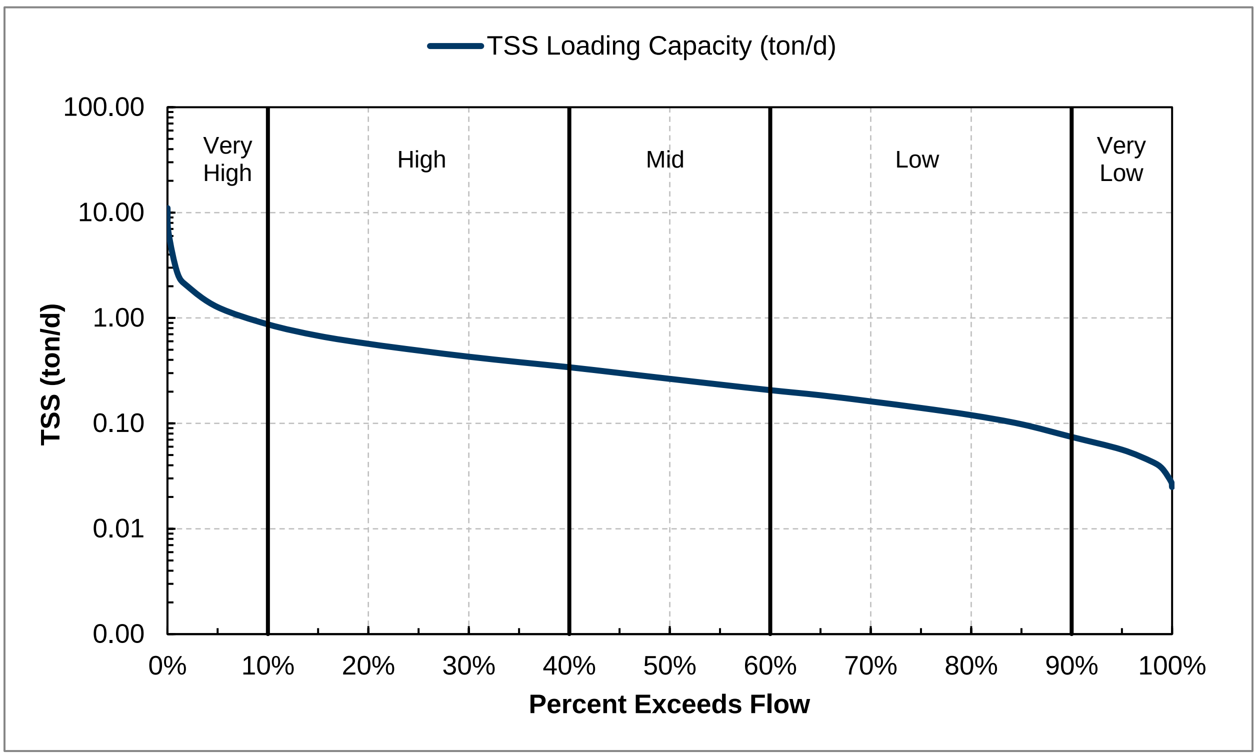


Table 35. Upper Bear Creek (-540) TSS TMDL summary.

- Listing year: 2022
- Baseline year: 2015
- Numeric standard used to calculate TMDL: 10 mg/L TSS
- TMDL and allocations apply Apr–Sep

TMDL parameter		TMDL TSS load (tons/day) by flow zone				
		Very high	High	Mid	Low	Very low
WLA	Construction stormwater (MNR100001)	0.00059	0.00023	0.00012	0.000064	0.000026
	Industrial stormwater (MNR050000 and MNG490000)	0.00059	0.00023	0.00012	0.000064	0.000026
LA		1.2	0.45	0.24	0.13	0.052
MOS		0.13	0.050	0.027	0.014	0.0058
TMDL		1.3	0.50	0.27	0.14	0.058
Existing 90th percentile concentration (mg/L)		Insufficient data to calculate [a]				
Estimated percent reduction						

a. In order to meet the T-tube water quality standard of > 95 cm, transparency will need to improve by approximately 221% or 65.4 cm from 29.6 cm, which is the 10th percentile transparency depth.

5.3 Spring Valley Creek HUC-12 (070400080407)

There are TMDLs for two class 2A impaired stream reaches in the Spring Valley Creek HUC-12 Watershed:

- TSS TMDL on Spring Valley Creek (-548)
- Nitrate TMDL on Spring Valley Creek (-548). This TMDL also applies to Unnamed creek (Spring Valley Creek Tributary) (-D53) which is a tributary to Spring Valley Creek (-548).

Overall, a 64% reduction in TSS is needed in Spring Valley Creek (-548) (Table 36). The LDCs, water quality analysis, and TSS source assessment indicate that the exceedances occur under mid to very high flows, with the most occurring under high flows. Load reductions, with a focus on higher flow events, are needed to address numerous source types including overland runoff from agricultural areas, and in-channel erosion.

Table 36. TSS TMDL summary table for Spring Valley Creek HUC-12 (070400080407).

WID	Water body name	Existing 90th percentile TSS concentration (mg/L)	TSS standard (mg/L)	Percent reduction in concentration needed to meet TSS standard
-548	Spring Valley Creek	28	< 10 mg/L	64%

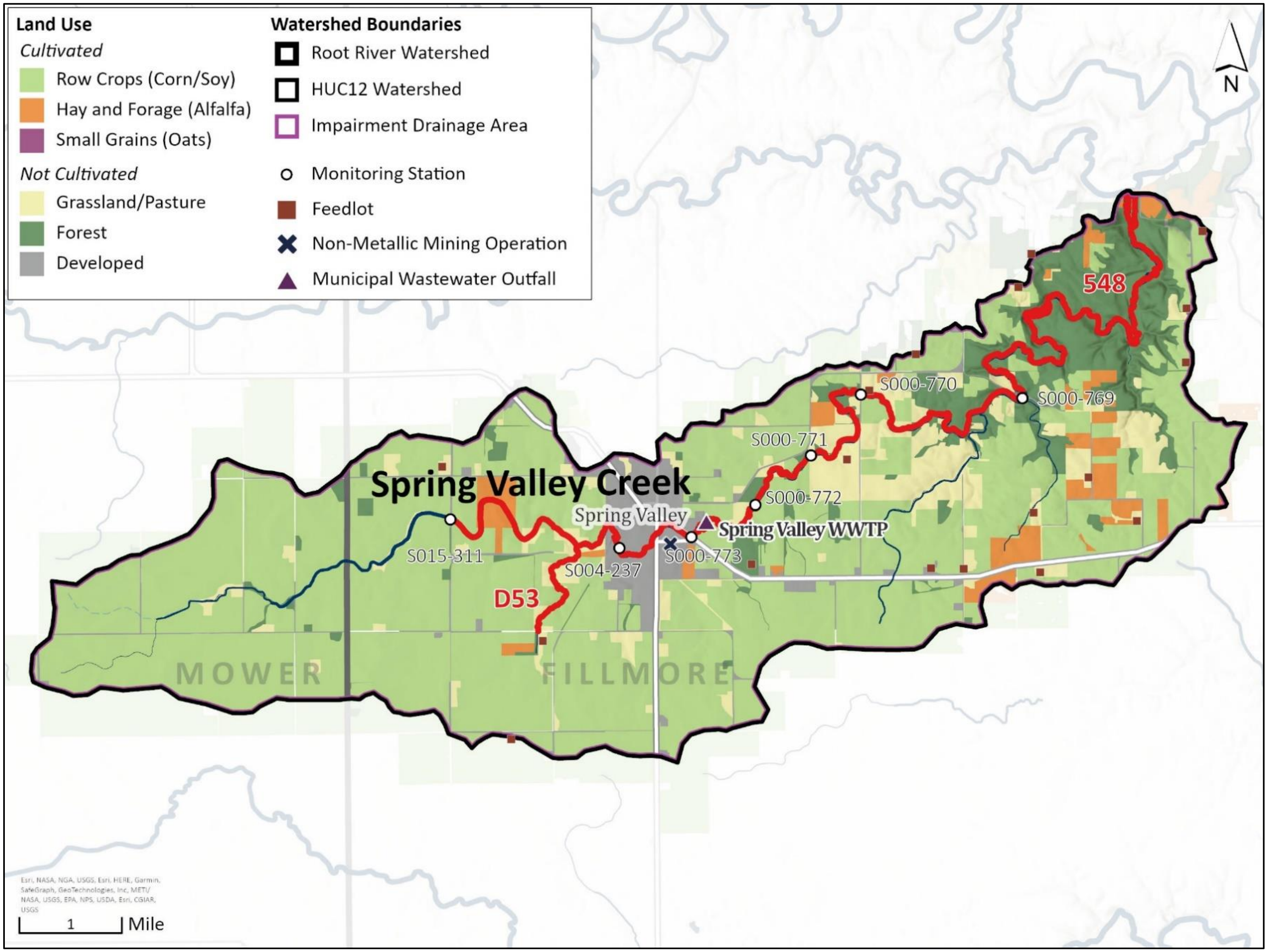
The estimated percent reductions needed to meet the nitrate TMDL for Spring Valley Creek (-548) is 10% (Table 37). Load reductions are needed to address nitrate loading from row crop agriculture.

Table 37. Nitrate TMDL summary for Spring Valley Creek HUC-12 (070400080407).

WID	Water body name	Maximum observed concentration (mg/L)	Percent reduction in concentration needed to meet nitrate standard
-536	Mill Creek	11.1	10%

The primary land covers in the Spring Valley Creek Watershed are row crops (65%), deciduous forest (12%), and grass/pasture (9%; Table 4, Figure 20).

Figure 20. Spring Valley Creek HUC-12 (070400080407).



5.3.1 TSS: Spring Valley Creek (-548)

Water quality

TSS and transparency data for Spring Valley Creek (-548) are available from 2018–2019 at the monitoring station S000-769. Simulated flow data from the RRW HSPF model (2021 extension) were used to approximate the stream flow conditions when each water quality sample was taken.

TSS exceedances were not observed in 2018 (n = 5) but were observed in 2019 (n=4) (Table 38), during which higher flows were observed (Figure 21).

T-tube measurements were lower under high flows, meaning transparency was lower (Figure 22). T-tube measurements from multiple sites in 2019 indicate a similar relationship between flow and transparency along Spring Valley Creek (Figure 23).

In summary, the very limited TSS data show high levels of sediment in Spring Valley Creek at high flows, with supporting data from a more extensive T-tube record.

Table 38. Annual summary of TSS data for Spring Valley Creek (-548; April–September).
TSS standard for Class 2A streams: 10 mg/L TSS
Monitoring site: S000-769

Year	Sample count	Mean (mg/L)	Median (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
2018	5	6	5	2	9	0	0%
2019	4	24	21	12	40	4	100%

Table 39. Monthly summary of TSS data for Spring Valley Creek (-548; 2018–2019).
Monitoring site: S000-769. Median values were not calculated due to insufficient sample counts. The TSS standard (10 mg/L) applies Apr–Sep; additional months are shown in this table to illustrate water quality trends.

Month	Sample count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
May	1	9	9	9	0	0%
June	2	10	9	12	1	50%
July	2	11	5	18	1	50%
Aug	2	21	2	40	1	50%
September	2	14	3	25	1	50%

Figure 21. TSS and flow vs. time in Spring Valley Creek (-548, S000-769).

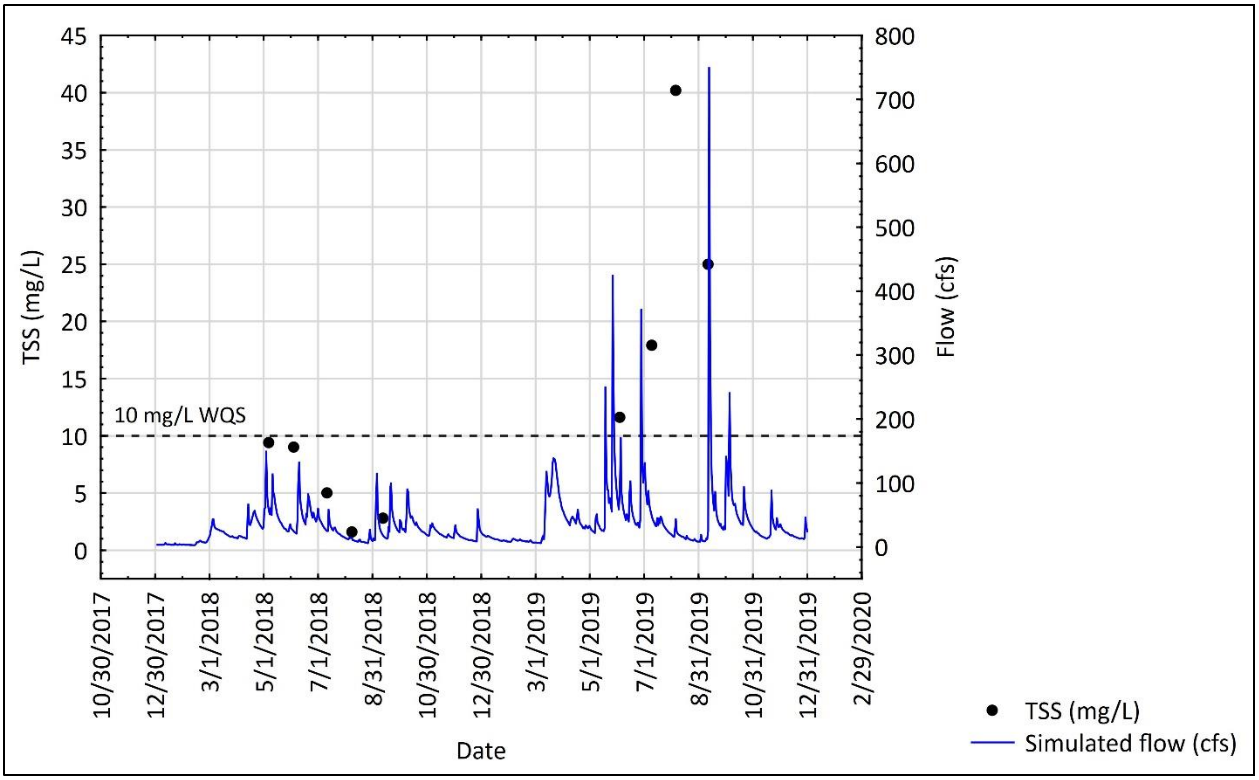
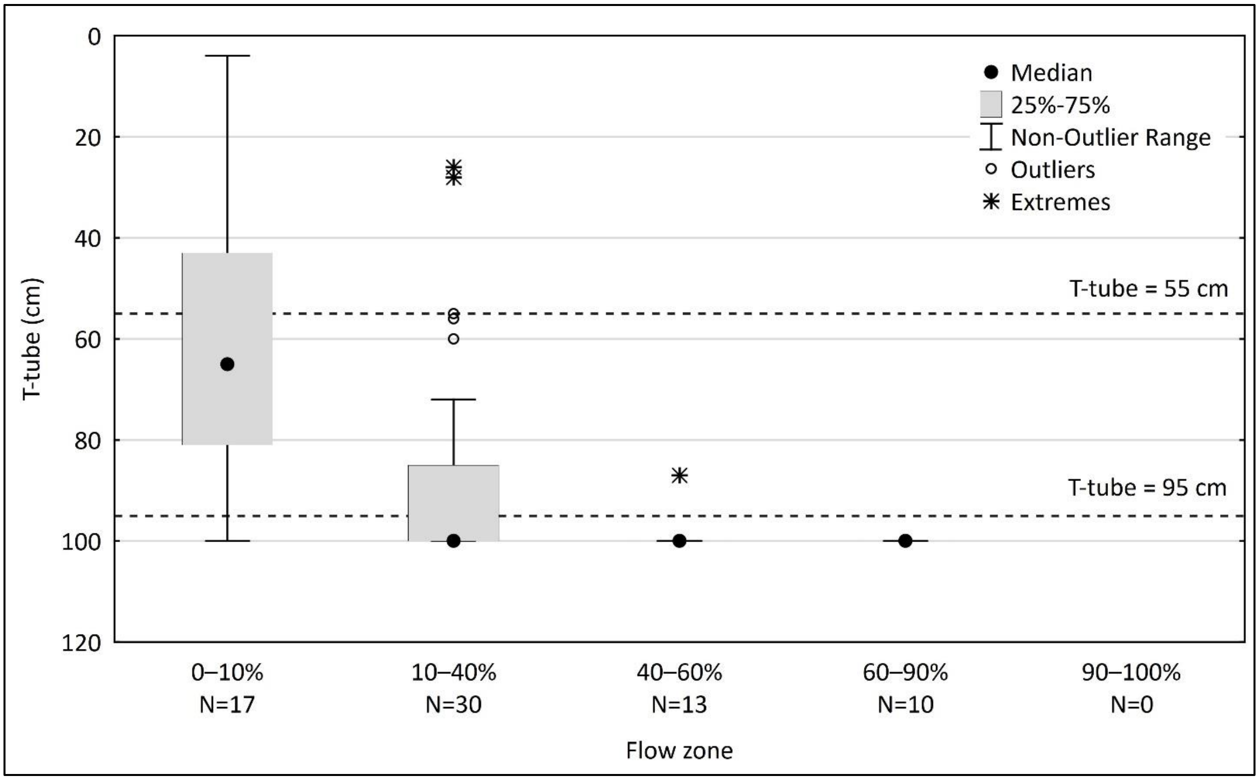
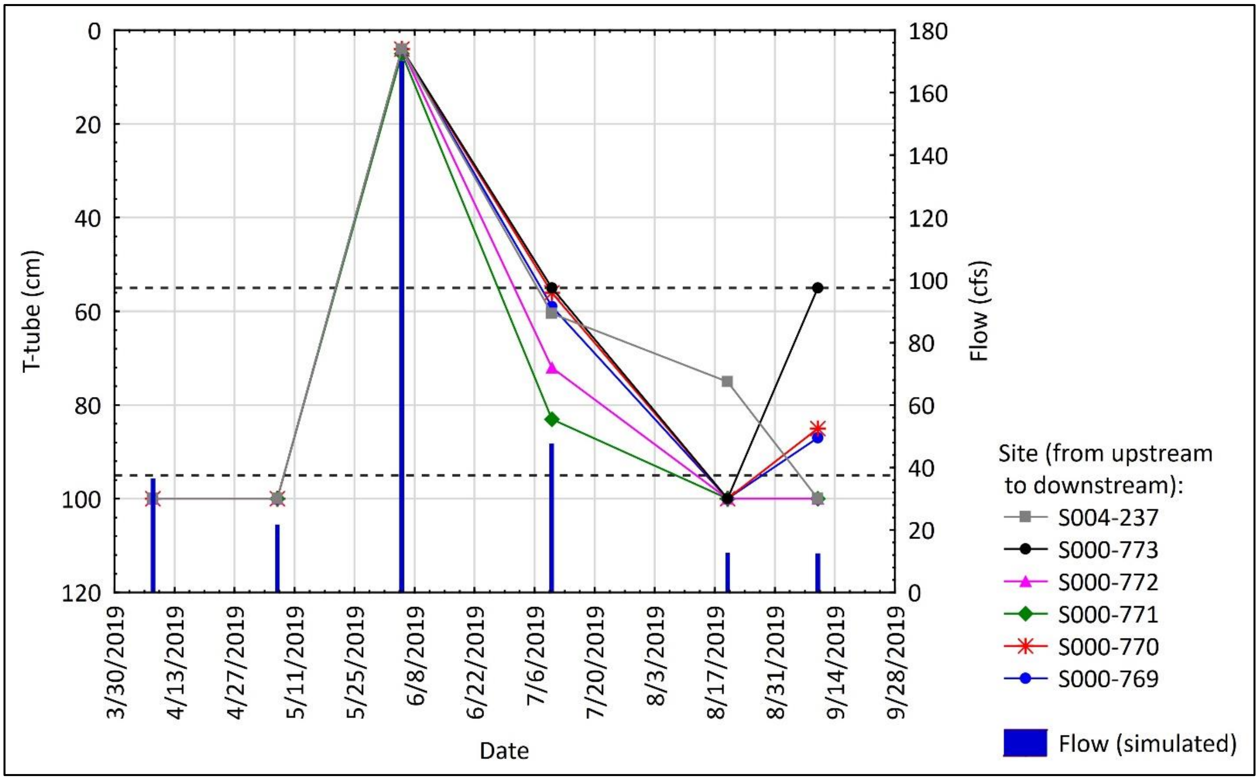


Figure 22. Transparency tube by flow zone at Spring Valley Creek (-548 site S000-769; Apr–Sep, 2012–2020).



a. Prior to 2012, the maximum T-tube reading possible (based on T-tube design) was 60 cm. Starting in 2012, the maximum possible reading has been 100 cm. Data from before 2012 are not presented here.
b. 55 cm and 95cm represent the upper and lower surrogate values for the TSS water quality standard. The TSS WQS is not met if the T-tube < 55 cm and the TSS WQS is met if T-tube > 95 cm.

Figure 23. T-tube site comparison Spring Valley Creek (-548, 2019).



55 cm and 95cm represent the upper and lower surrogate values for the TSS water quality standard. The TSS WQS is not met if the T-tube < 55 cm and the TSS WQS is met if T-tube > 95 cm. Lines are included for ease of visibility and do not represent trends.

Sediment sources

According to outputs from the RRW HSPF model (2021 model extension), the largest nonpermitted source of sediment to Spring Valley Creek is overland runoff followed very closely by in-channel sources (Table 40). Of the nonpermitted overland runoff sources, cropland contributes a majority of the TSS load.

Table 40. Average annual TSS contributions to Spring Valley Creek (HSPF Reach 183) by source (MPCA 2023).

Source		Average annual % of TSS load[a]
Nonpermitted in-channel		37%
Permitted	Spring Valley WWTP	0.1%
Nonpermitted overland runoff	Cropland	58%
	Pasture	1%
	Developed	3%
	Forest	< 1%

a. Percentages rounded to nearest whole number and therefore may not add up to 100%.

Permitted sources of sediment to Spring Valley Creek (-548) are not considered significant as long as permittees are complying with permit requirements. Spring Valley WWTP is not considered a significant source of TSS to Spring Valley Creek (-548). Average effluent TSS concentrations from February 2017 to April 2022 were 4.65 mg/L. No exceedances of the 30 mg/L TSS limit have been reported within that time frame. Permitted construction stormwater and industrial stormwater (Table 11) including nonmetallic mining facilities (Table 12) are also not significant sources of TSS to Spring Valley (-548).

TMDL

Exceedances of the TSS loading capacity in Spring Valley Creek (-548) are seen in the very high and high flow zones, with the majority of exceedances occurring in the very high flow zone Figure 24). The Spring Valley Creek TMDL summary is provided in Table 36. Existing effluent limits are consistent with TSS WLA assumptions.

Figure 24. Spring Valley Creek (-548) TSS load duration curve.

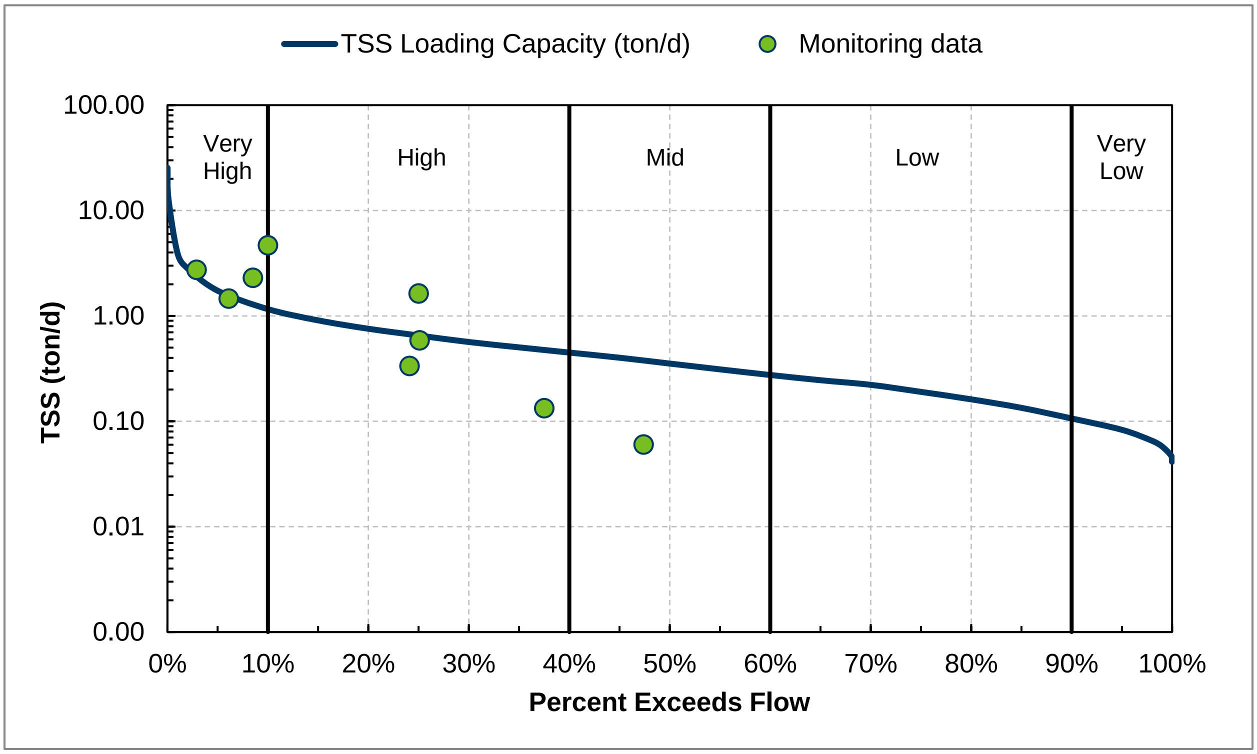


Table 41. Spring Valley Creek (-548) TSS TMDL summary.

- Listing year: 2022
- Baseline year: 2015
- Numeric standard used to calculate TMDL: 10 mg/L TSS
- TMDL and allocations apply Apr–Sep

TMDL parameter		TMDL TSS load (tons/day) by flow zone				
		Very high	High	Mid	Low	Very low
WLA	Industrial stormwater (MNR050000 and MNG490000)	0.00018	0.000067	0.000036	0.000020	0.0000085
	Construction stormwater (MNR100001)	0.00078	0.00029	0.00016	0.000086	0.000037
	Spring Valley WWTF (MN0051934)	0.12	0.12	0.12	0.12	--[a]
LA		1.4	0.47	0.20	0.051	0.07
MOS		0.17	0.065	0.035	0.019	0.0083
TMDL		1.7	0.65	0.35	0.19	0.083
Existing 90th percentile TSS concentration (mg/L)		28				
Estimated percent reduction		64%				

a. The permitted wastewater design flows exceed the simulated stream flow in the indicated flow zone. As this scenario is not possible, the WLA for Spring Valley WWTF is instead expressed as an equation rather than an absolute number: allocation = (flow contribution from a given source) x 10 mg/L.

5.3.2 Nitrate: Spring Valley (-548 and -D53)

This nitrate TMDL applies to both Spring Valley Creek (-548) and its tributary Unnamed Creek (-D53). This is possible as both impairments have the same drinking water designated use and the drainage area for Unnamed Creek (-D53) is entirely within the drainage area for Spring Valley Creek (-548). In addition, land cover is similar in both drainage areas and no NPDES permitted sources are impacted by this decision.

Water quality

Nitrate data from Spring Valley Creek (-548) are available from 2018–2019 at seven monitoring stations: S015-311, S004-237, S000-773, S000-772, S000-771, S000-770, and S000-769. Nitrate data from Unnamed Creek (-D53) are available on monitoring station S015-312 for 2019.

Nitrate concentrations on Spring Valley Creek (-548) exceeded the standard approximately 21% of the time with the highest frequency of exceedances occurring at monitoring station S015-311 (Table 42). In the years 2018 and 2019, exceedances of the water quality standard were observed in the months May, July, August, and September. Of the samples taken in the month of July, 75% exceeded the standard (Table 43). 100% of the samples taken on Unnamed Creek (-D53) exceeded the nitrate standard; however, data are limited to 2019.

Higher levels of exceedances of the nitrate WQS in Spring Valley Creek (-548) in the month of July (Table 43) are likely tied to precipitation and nutrient application timing. In 2018 and 2019, high precipitation events were recorded for early summer. High precipitation events promote leaching of nitrogen through the soil profile if it is not up taken by crops. This in turn increases the nitrogen concentration of groundwater and inputs of groundwater to surface waters. The nitrogen exceedances in July may be representing this phenomenon.

Simulated flow data from RRW HSPF model (model extension) were used to approximate the stream flow conditions for Spring Valley (-548) when each water quality sample was taken. No relationship was observed between nitrate levels and flow.

Data collected throughout the watershed in 2019 indicate that nitrate concentrations tend to be highest upstream and in tributaries to Spring Valley Creek (-548) (Figure 25). Average nitrate concentrations generally decrease from upstream to downstream monitoring locations (Figure 26).

Table 42. 2019 annual summary of nitrate data for Spring Valley Creek (-548) and Unnamed Creek (-D53).
Nitrate standard for Class 1B and 1C designated surface waters: 10 mg/L

Site	Sample count	Mean (mg/L)	Median (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
Spring Valley Creek							
2018							
S000-769	5	8.8	9.0	7.3	10.5	1	20%
2019							
S015-311	6	9.0	9.1	6.0	11.9	3	50%
S004-237	6	8.9	9.3	5.8	11.1	2	33%
S000-773	6	8.6	8.7	5.8	11.0	1	17%
S000-772	6	8.6	8.9	5.8	10.9	1	17%
S000-771	5	8.4	8.2	5.9	10.5	1	20%
S000-770	6	7.8	7.7	5.6	10.4	1	17%
S000-769	9	6.5	6.5	1.5	9.8	0	0%
Unnamed Creek (-D53)							
2019							
S015-312	5	11.8	11.9	11.1	12.2	5	100%

Table 43. Monthly summary of nitrate data for Spring Valley Creek (-548 and -D53; 2018–2019).
Nitrate standard for Class 1B and 1C designated surface waters: 10 mg/L
Monitoring sites combined for years 2018 and 2019 due to low monthly sample counts.

Month	Sample count	Mean (mg/L)	Median (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
April	6	7.1	7.45	6.1	7.7	0	0%
May	8	8.4	8.25	7.2	10.5	1	13%
June	9	6.5	5.8	5.0	9.3	0	0%
July	8	10.7	10.7	9.6	11.9	6	75%
August	9	8.7	9.1	5.5	10.0	1	11%
September	9	7.7	8.2	1.5	10.3	2	22%
Total	**48**	**8.2**	**8.2**	**1.5**	**11.9**	**10**	**21%**

Figure 25. Nitrate + nitrite nitrogen concentrations in the Spring Valley Creek Watershed by monitoring station. Monitoring year 2019. Monitoring stations listed upstream to downstream, including tributaries.

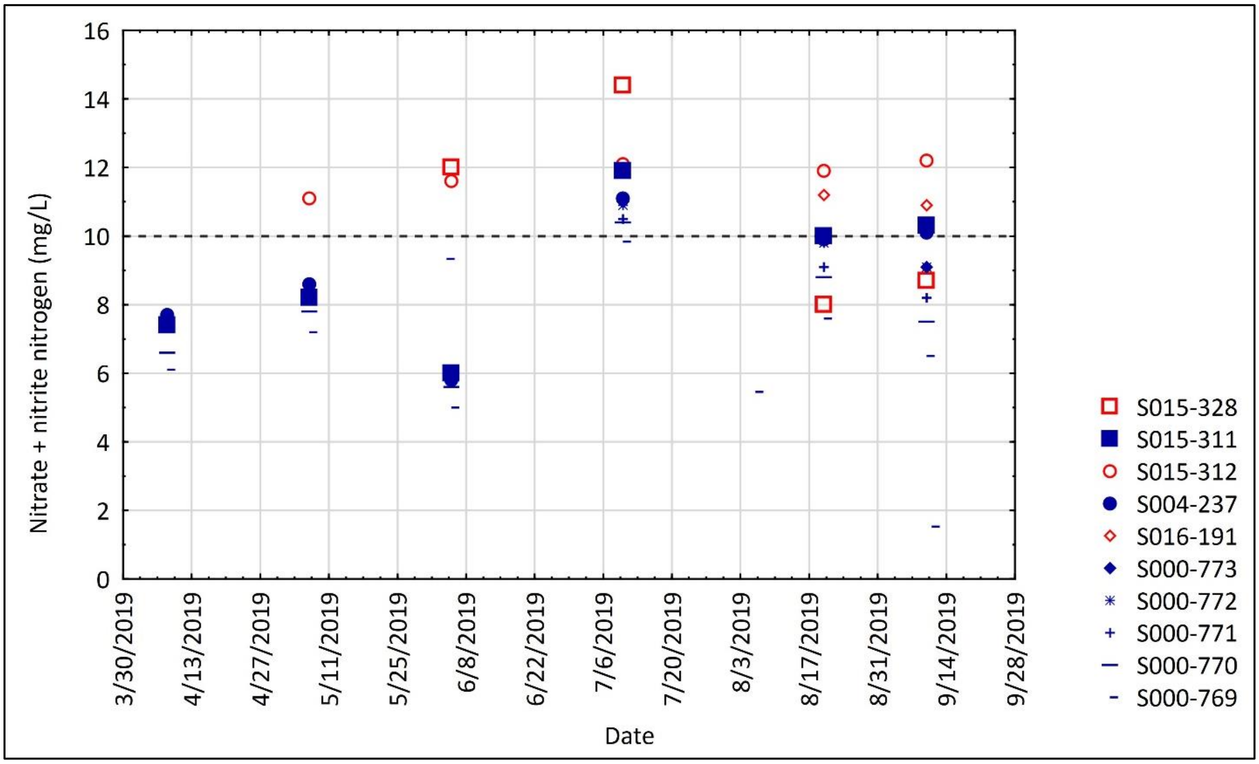
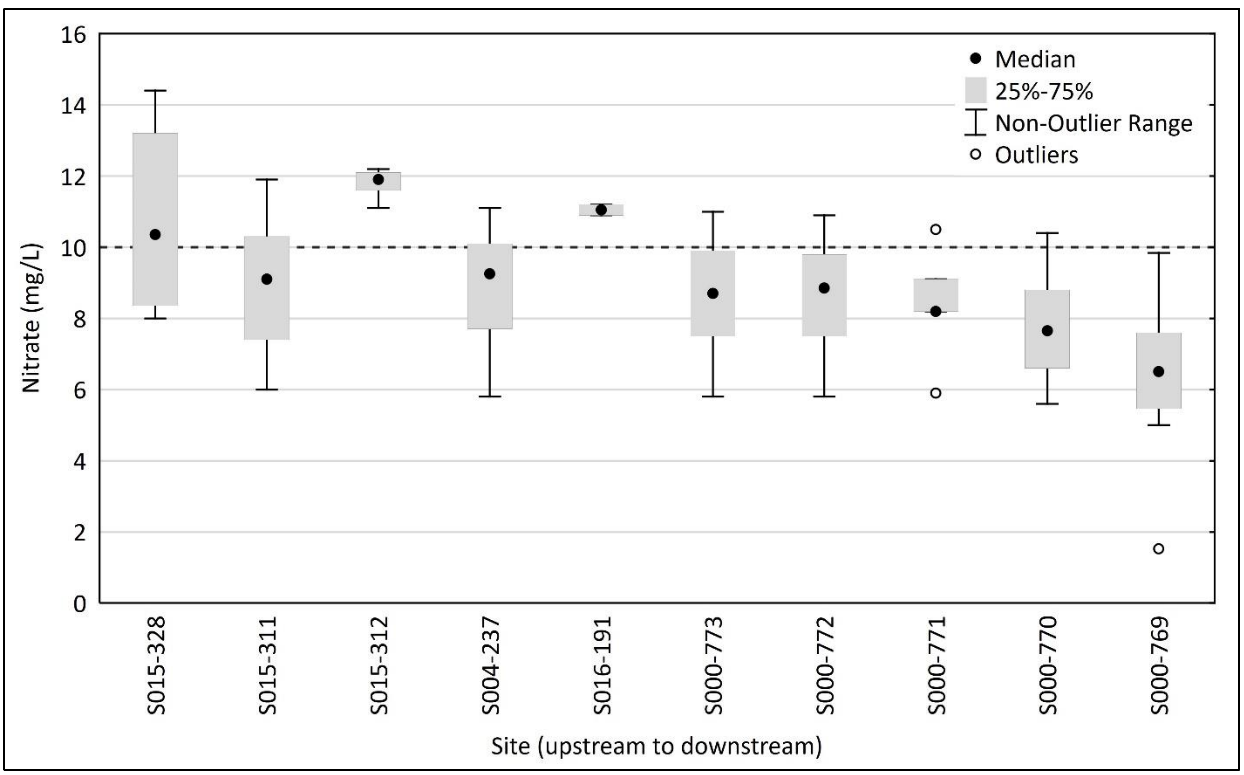


Figure 26. Nitrate concentrations in the Spring Valley Creek Watershed from monitoring year 2019, upstream to downstream stations.



Nitrate sources

Nitrate transport in the Spring Valley Creek (-548) drainage area is complex. MPCA (2022) found the highest nitrate concentrations (10 to 14 mg/L) in headwater areas and a decrease in nitrate concentrations to 6 to 8 mg/L further downstream; this is also seen in the water quality analysis conducted in this TMDL report. It is likely that increases in downstream water inputs dilute the nitrate concentration in Spring Valley Creek. Land use is also a factor in nitrate load as cultivated row crop acreage deceases in downstream areas of this watershed (Figure 20).

Outputs from the RRW HSPF model (2021 model extension) show that nonpermitted sources are the largest contributor of total nitrogen loading in the Spring Valley (-548) Watershed. Of these nonpermitted sources, 88% is coming from cropland (Table 44). In addition, conventionally tilled cropland acres contribute an estimated 51% of the nitrogen load followed by cropland acres with conservation tillage (23%) and manured acres (12%).

Nitrogen from commercial fertilizer and animal manure spread on cropland can be converted to nitrate and vertically leach into underlying groundwater. This nitrate-laden groundwater then re-enters surface waters through the many spring inflows within the drainage area to Spring Valley Creek (-548). Nitrate can also enter surface waters through drain tiles and/or overland runoff, but those modes of transport are less significant in the Spring Valley Creek Subwatershed. The prevalence of springs and the coldwater status of Spring Valley Creek imply that groundwater is expressing a strong presence.

Table 44. Average annual total nitrogen contributions to Spring Valley Creek (HSPF Reach 183) by source (MPCA 2023) 10/1/1994 – 9/30/2021.

Source		Average annual total nitrogen loading (%)[a]
Permitted	Spring Valley WWTP	3%
Nonpermitted	Cropland—conventional acres	51%
	Cropland—conservation tilled acres	23%
	Cropland—manured acres	12%
	Pasture	7%
	Developed	3%
	Forest	1%
	Open Water, Wetland, Barren	< 1%

a. Percentages rounded to nearest whole number and therefore may not add up to 100%.

Spring Valley WWTP is also a source of nitrate to Spring Valley Creek (-548). Discharge monitoring report (DMR) summarized monthly total nitrate concentrations (March 2014 through April 2022) from Spring Valley WWTP effluent are provided in Table 45.

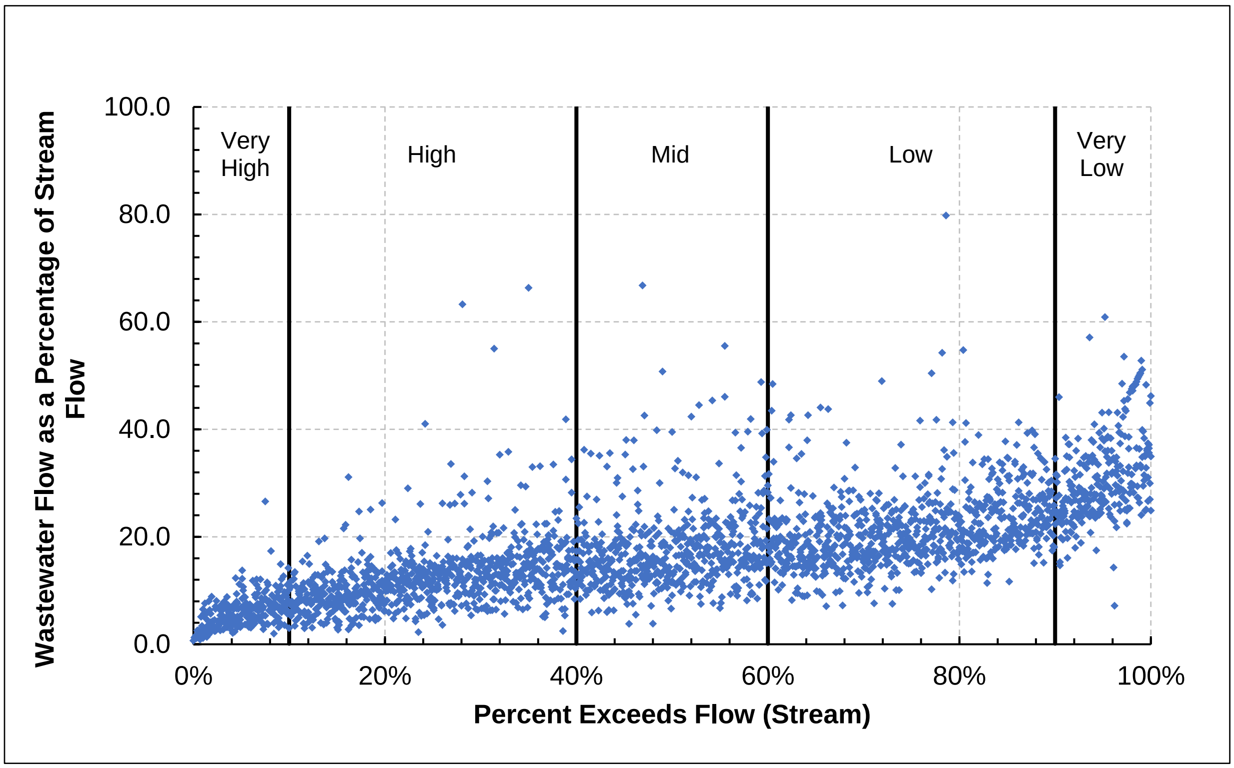
Table 45. Summarized monthly average total nitrate concentrations reported from Spring Valley WWTP effluent monitoring.

	Nitrate concentration	Month and year	Stream flow category
Max DMR	43.9 mg/L	November 2017	Mid – Low flow
Min DMR	5.34 mg/L	July 2014	High flow
Average DMR	18.9 mg/L	-	

Nitrate standard for Class 1B and 1C designated surface waters: 10 mg/L

While nitrate concentrations in Spring Valley WWTP effluent are often above the WQS for nitrate (10 mg/L), monitored effluent flows typically make up 50% or less of the HSPF simulated stream baseflow (Figure 27). In these cases, Spring Valley Creek's baseflow provides a buffer to the in-stream concentration of nitrogen. During periods of low stream baseflow or periods during which effluent from Spring Valley WWTP makes up a larger portion of the stream baseflow, nitrogen from the Spring Valley WWTP can be a significant source of nitrate to the impaired stream. Spring Valley WWTP's NPDES permit was reissued on September 1, 2023, and now includes weekly monitoring for total nitrite + nitrate, total ammonia, and total Kjeldahl nitrogen and a new total nitrogen limit of 10 mg/L (monthly average), which is consistent with the WLA assumptions in this report. A compliance schedule (final compliance date of January 31, 2031) has been included in this permit reissuance to allow Spring Valley WWTP time to construct treatment improvements and pursue treatment optimizations that will allow the facility to attain compliance with the new total nitrogen limit. Construction is currently underway at the facility.

Figure 27. Spring Valley WWTP effluent as a percentage of HSPF simulated stream flow in Spring Valley Creek (2014–2022).



TMDL

The Spring Valley Creek nitrate TMDL addresses both reaches in the Spring Valley Creek Watershed with nitrate impairments: -548 and -D53.

Exceedances of the nitrate loading capacity in the Spring Valley Creek impaired reach (-548) are seen in the very high and mid flow zones (Figure 28). The Spring Valley Creek nitrate TMDL summary is provided Table 46. Existing effluent limits are consistent with nitrate WLA assumptions.

Figure 28. Spring Valley Creek (07040008-548) nitrate load duration curve.

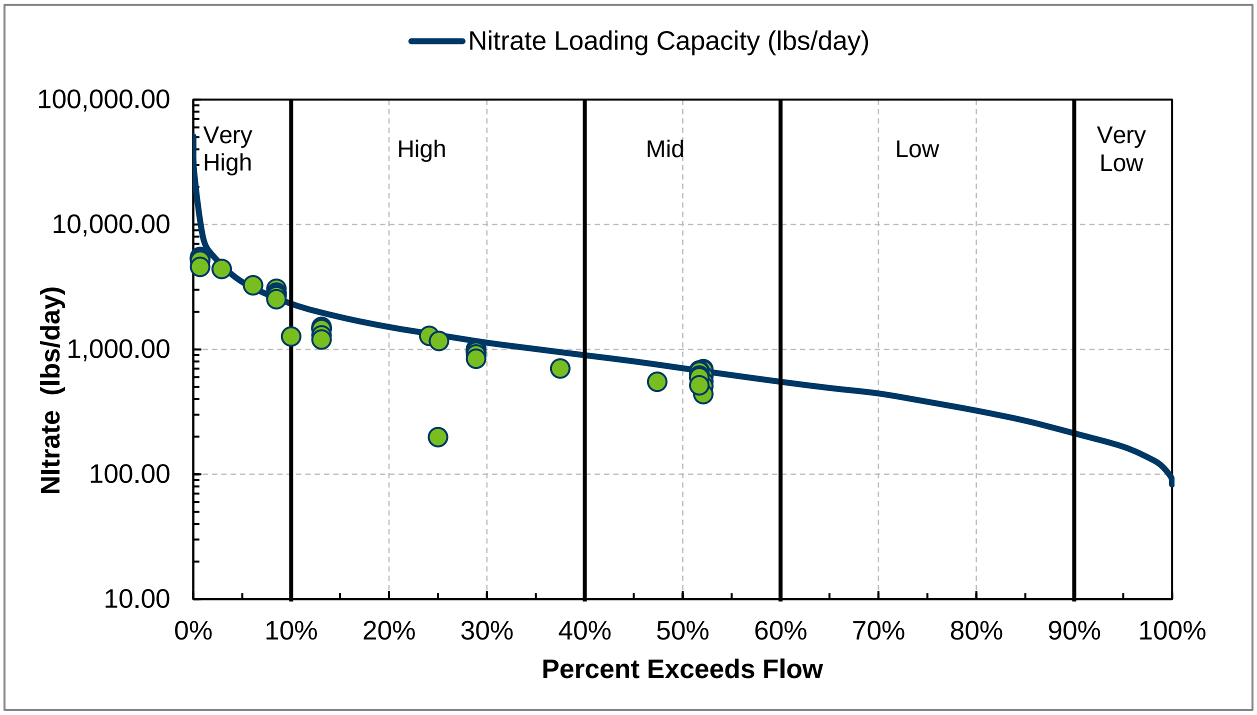


Table 46. Spring Valley Creek (07040008-548) nitrate TMDL summary.

- Impairments addressed by this TMDL: -548 and -D53
- Listing year: 2022
- Baseline year: 2015
- Numeric standard used to calculate TMDL: 10 mg/L nitrate

TMDL parameter		TMDL nitrate load (lbs/day) by flow zone				
		Very high	**High**	**Mid**	**Low**	**Very low**
WLA	**Spring Valley WWTP (MN0051934)**	78	78	78	78	78
	Industrial stormwater (MNR050000)	1.6	0.59	0.32	0.17	0.075
LA		3,044	1,096	557	265	71
MOS		347	130	71	38	17
TMDL		3,469	1,304	706	381	166
Maximum observed nitrate concentration (mg/L)		11.1				
Estimated percent reduction		10%				

5.4 Camp Creek HUC-12 (070400080407)

A TSS TMDL was developed to address fish and invertebrate impairments on Camp Creek (-559).

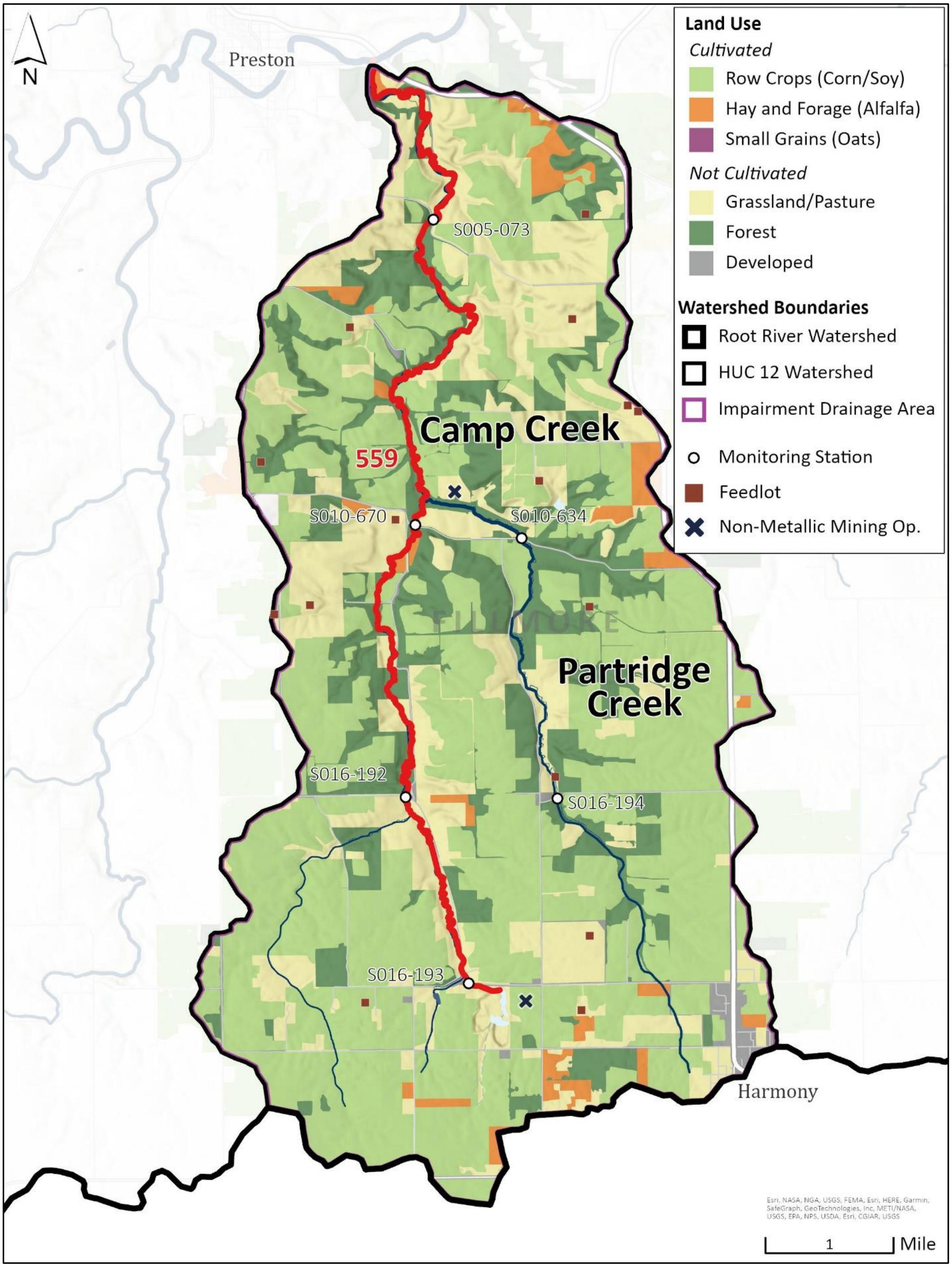
An 88.7 cm improvement in transparency depth is needed in the Camp Creek (-559) impaired stream (Table 47). Water quality analysis indicate that the exceedances of the transparency standard typically occur under high flows.

Table 47. TSS TMDL summary table for Camp Creek HUC-12 (070400080407).

WID	Water body name	Existing 10th percentile transparency depth (cm)	Transparency standard (cm)	Needed improvement in transparency (cm)
-559	Camp Creek	6.3	> 95	88.7

The primary land covers in the Camp Creek Watershed are row crops (52%), deciduous forest (21%), and grass/pasture (17%; Table 4, Figure 29).

Figure 29. Camp Creek HUC-12 (070400080407).



5.4.1 TSS: Camp Creek (07040008-559)

Water quality

There are only two TSS monitoring samples on the impaired reach: 42 mg/L on 8/6/2019 from S005-073 and 11 mg/L on 10/29/2019 from S016-193. T-tube measurements, however, were recorded in 2019 at multiple sites on eight days, including two sites on Partridge Creek, which is a tributary to Camp Creek. Simulated flow data from the RRW HSPF model (2021 model extension) were used to approximate the stream flow conditions when each water quality sample was taken.

Transparency measurements indicating the TSS standard was not met occurred at all monitoring stations in 2019 (Table 48). No seasonal trends were observed (Table 49).

Transparency was poorer on the days with higher flows (Figure 30). Transparency was similar among sites on approximately half of the days that were sampled; on the other days the transparency varied among the sites, although with no consistent pattern (Figure 31).

Table 48. 2019 summary of T-tube measurements for Camp Creek by site (07040008-559; April–September 2019).
Surrogate T-tube measurement used to determine if a stream exceeds the TSS standard for Class 2A streams: < 55 cm

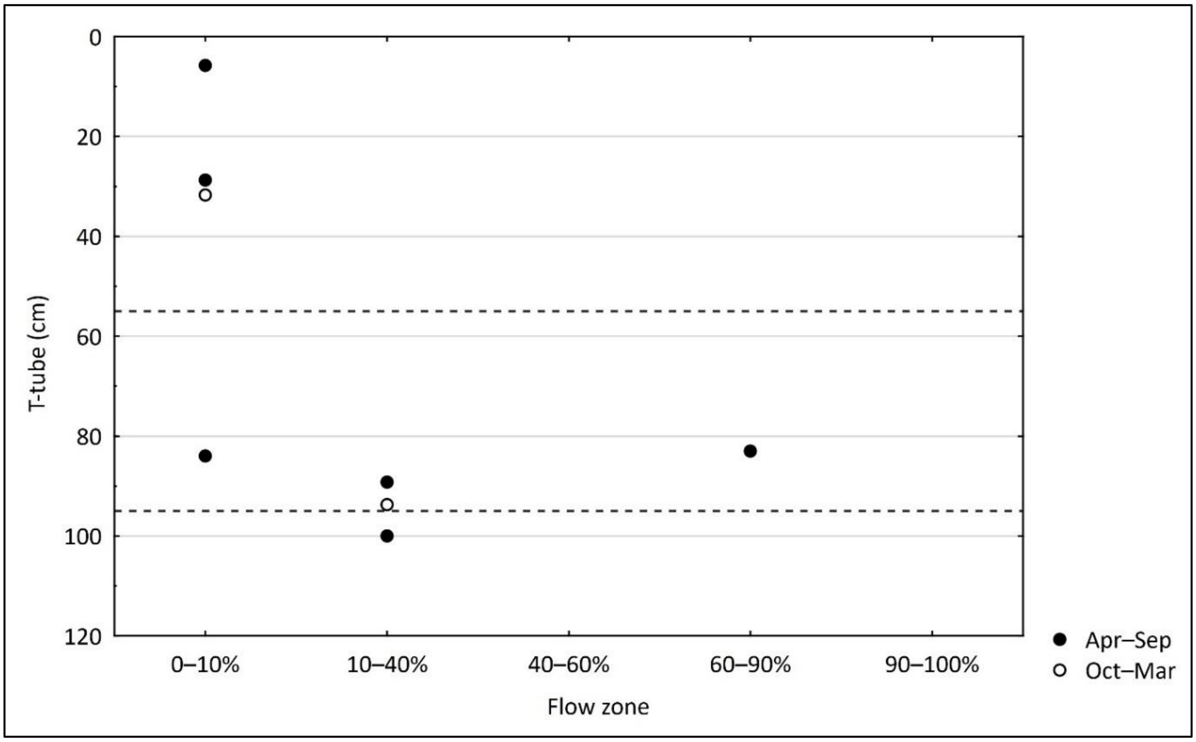
Site	Sample count	Mean (cm)	Median (cm)	Minimum (cm)	Maximum (cm)	Number of measurements < 55 cm	Frequency of measurements < 55 cm
S005-073	6	75	92	5	100	1	17%
S010-670	6	64	77.5	5	100	2	33%
S016-192	6	64	78.5	7	100	2	33%
S016-193	6	58	64.5	6	100	2	33%

Table 49. Monthly summary of T-tube measurements for Camp Creek (070400080407-559; 2019).
Surrogate T-tube measurement used to determine if a stream exceeds the TSS standard for Class 2A streams: < 55 cm
The transparency standard applies Apr–Sep; additional months are shown in this table to illustrate water quality trends.

Month	Sample count	Mean (cm)	Median (cm)	Minimum (cm)	Maximum (cm) [a]	Number of measurements < 55 cm	Frequency of measurements < 55 cm
March	4	32	30	28	39	4	100%
April	4	89	100	57	100	0	0%
May	4	100	100	100	100	0	0%
June	4	84	82	72	100	0	0%
July	4	29	21	13	60	3	75%
August	4	83	87.5	57	100	0	0%
September	4	6	5.5	5	7	4	100%
October	4	94	100	75	100	0	0%

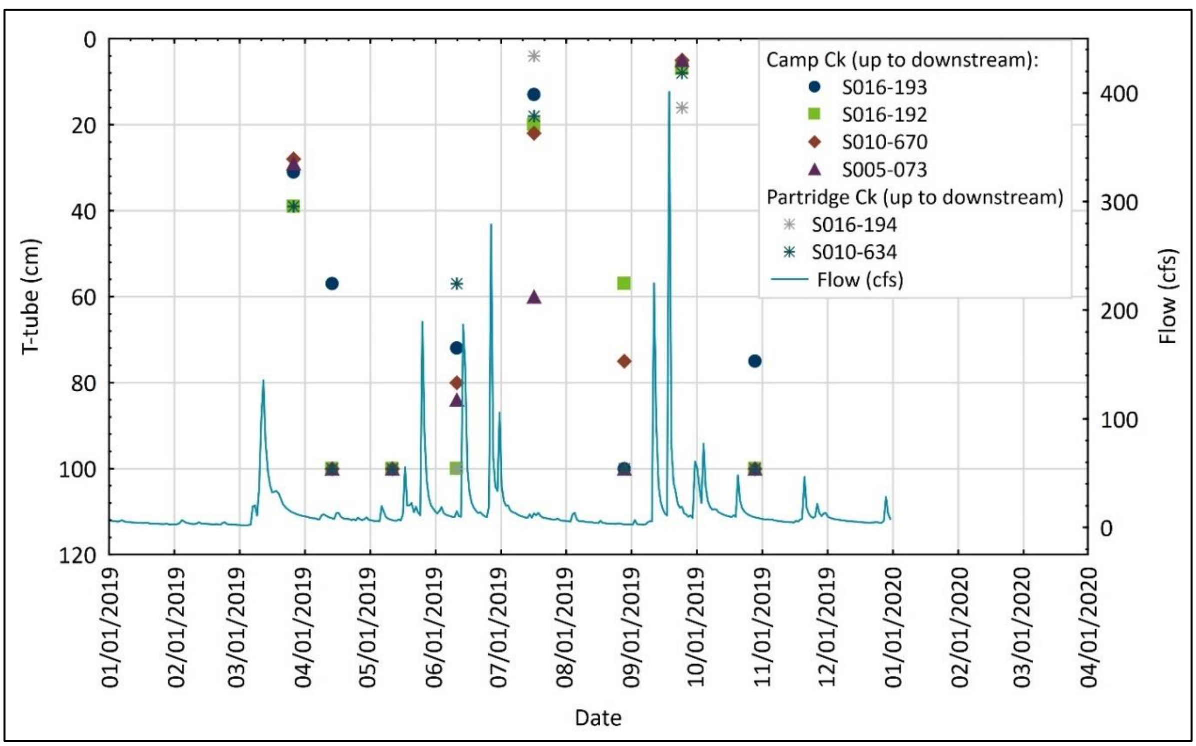
a. Prior to 2012, the maximum T-tube reading possible (based on T-tube design) was 60 cm. Starting in 2012, the maximum possible reading has been 100 cm. Data from before 2012 are not presented here.

Figure 30. Transparency tube by flow zone for Camp Creek (07040008-559; 2019).



Measurements were taken at four sites on each of eight days. Points in the graph represent daily averages.
55 cm and 95cm represent the upper and lower surrogate values for the TSS water quality standard. The TSS WQS is not met if the T-tube < 55 cm and the TSS WQS is met if T-tube > 95 cm.

Figure 31. Simulated flow and monitored T-tube by site, Camp Creek (-559) and Partridge Creek, tributary to Camp Creek (-559).



Sediment sources

Sediment sources for Camp Creek are in-channel, quarry sedimentation, and overland runoff. Belmont et al. (2016) determined that for nonpoint sediment loads, approximately 50% comes from agricultural fields while the remaining 50% likely comes from in-channel. The RRW HSPF model (2021 model extension) is calibrated to these findings. Of the watershed TSS load sources, conventional farm fields and pasturelands are the top two TSS sources (Table 50). SID work notes several areas of Camp Creek with severely eroded and instable streambanks. A permitted quarry in the headwaters of Camp Creek (Big Springs Quarry J2-1422 (SD 008)) had permit violations and sediment loading noted during an MPCA inspection. The MPCA and partner agencies are working together with the quarry operator to address sediment issues found on site. This quarry is likely contributing to the lower transparency levels seen in the headwaters of Camp Creek compared to levels in downstream sections. The remaining permitted construction stormwater, industrial stormwater (Table 11) and nonmetallic mining facilities (Table 12) in Camp Creek are not considered significant sediment sources as long as they are in compliance with their permits. Flow alteration is also a likely contributor to sedimentation issues and stream instability. Camp Creek's TSS impairment is tied to changes in land use, precipitation, and flow, all of which impact sedimentation dynamics throughout the stream.

Table 50. Average annual TSS contributions to Camp Creek by source (MPCA 2023).

Source		Average annual % of TSS load[a]
In channel		23%
Nonpermitted	Cropland	49%
	Pasture	22%
	Developed	4%
	Forest, open water, wetland, barren	2%

a. Percentages rounded to nearest whole number and therefore may not add up to 100%.

TMDL

The LDC for Camp Creek (-559) is provided in Figure 32 and the TSS TMDL summary is provided in Table 51.

Figure 32. Camp Creek (07040008-559) TSS load duration curve.

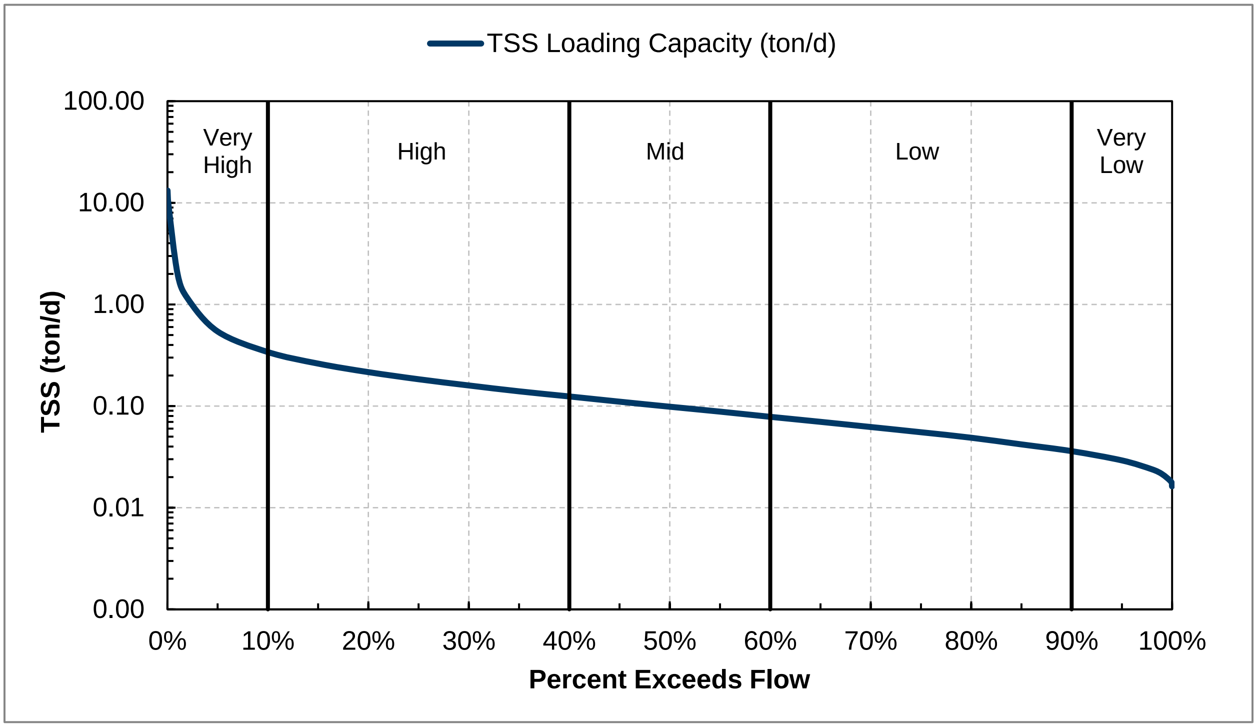


Table 51. Camp Creek (07040008-559) TSS TMDL summary.

- Listing year: 2012
- Baseline year: 2015
- Numeric standard used to calculate TMDL: 10 mg/L TSS
- TMDL and allocations apply Apr–Sep

TMDL parameter		TMDL TSS load (tons/day) by flow zone				
		Very high	**High**	**Mid**	**Low**	**Very low**
WLA	**Industrial stormwater (MNR050000 and MNG490000)**	0.0022	0.00074	0.00040	0.00022	0.00012
	Construction stormwater (MNR100001)	0.00015	0.000050	0.000027	0.000015	0.0000079
LA		0.48	0.16	0.088	0.049	0.026
MOS		0.054	0.018	0.0099	0.0055	0.0029
TMDL		0.54	0.18	0.10	0.055	0.029
Existing 90th percentile concentration (mg/L)		Insufficient data to calculate [a]				
Estimated percent reduction						

a. In order to meet the T-tube water quality standard of > 95 cm, transparency will need to improve by approximately 88.7 cm from the 10th percentile transparency depth of 6.3 cm.

5.5 Upper South Fork Root River HUC-12 (070400080801)

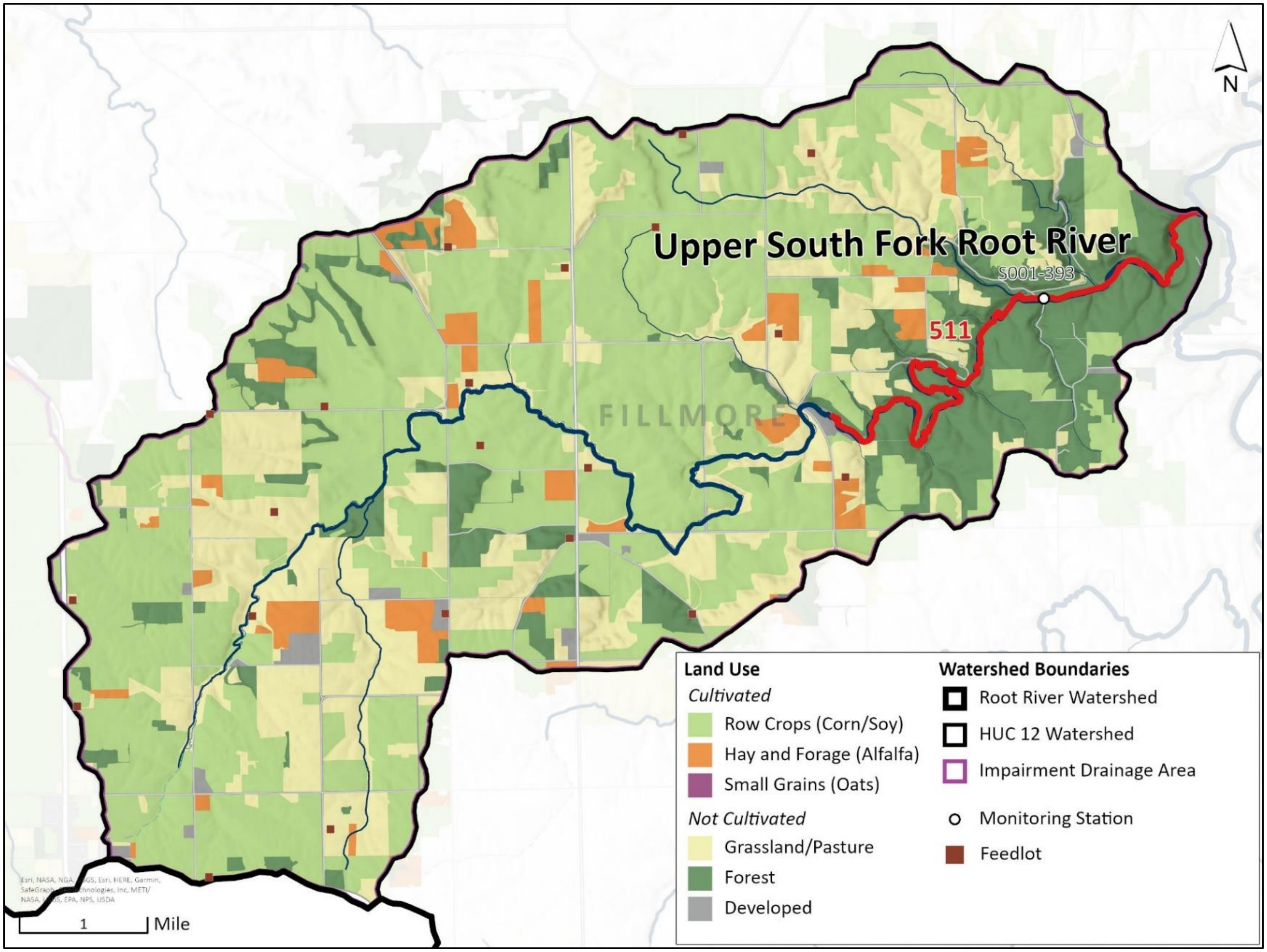
An *E. coli* TMDL was developed to address an aquatic recreation impairment on South Fork Root River (-511). The estimated percent reduction needed to meet the *E. coli* TMDL is 76% (Table 52). The LDC indicates that exceedances of the *E. coli* standard occur under high and very high flows. Load reductions are needed to address multiple source types including animal feeding operations, pastured areas, and nonpermitted sources (NPS) of wastewater.

Table 52. Upper South Fork Root River HUC-12 (070400080801) TMDL summary.

WID	Water body name	Maximum observed monthly geometric mean	Percent reduction in concentration needed to meet *E. coli* standard
-511	South Fork Root River	516	76%

The primary land covers in the Upper South Fork River Watershed are row crops (51%), grass/pasture (20%), and deciduous forest (17%; Table 4, Figure 33).

Figure 33. Upper South Fork Root River HUC-12 (070400080801).



5.5.1 *E. coli:* South Fork Root River (07040008-511)

Water quality

E. coli data from the South Fork Root River (-511) Subwatershed are available from 2018 and 2019 at monitoring station S001-393. Simulated flow data from the RRW HSPF model (2021 model extension) were used to approximate the stream flow conditions when each water quality sample was taken.

E. coli concentrations ranged from 7 to over 4,000 org/100 mL, and there was no clear seasonal pattern (Figure 34, Table 53, Table 54). The monthly geometric mean standard was exceeded in all three months that were monitored (June, July, and August), and the individual sample standard was exceeded in June and August (Table 54). *E. coli* concentrations tended to increase with flow (Figure 35).

Figure 34. *E. coli* concentrations for South Fork Root River (07040008-511, site S001-393).

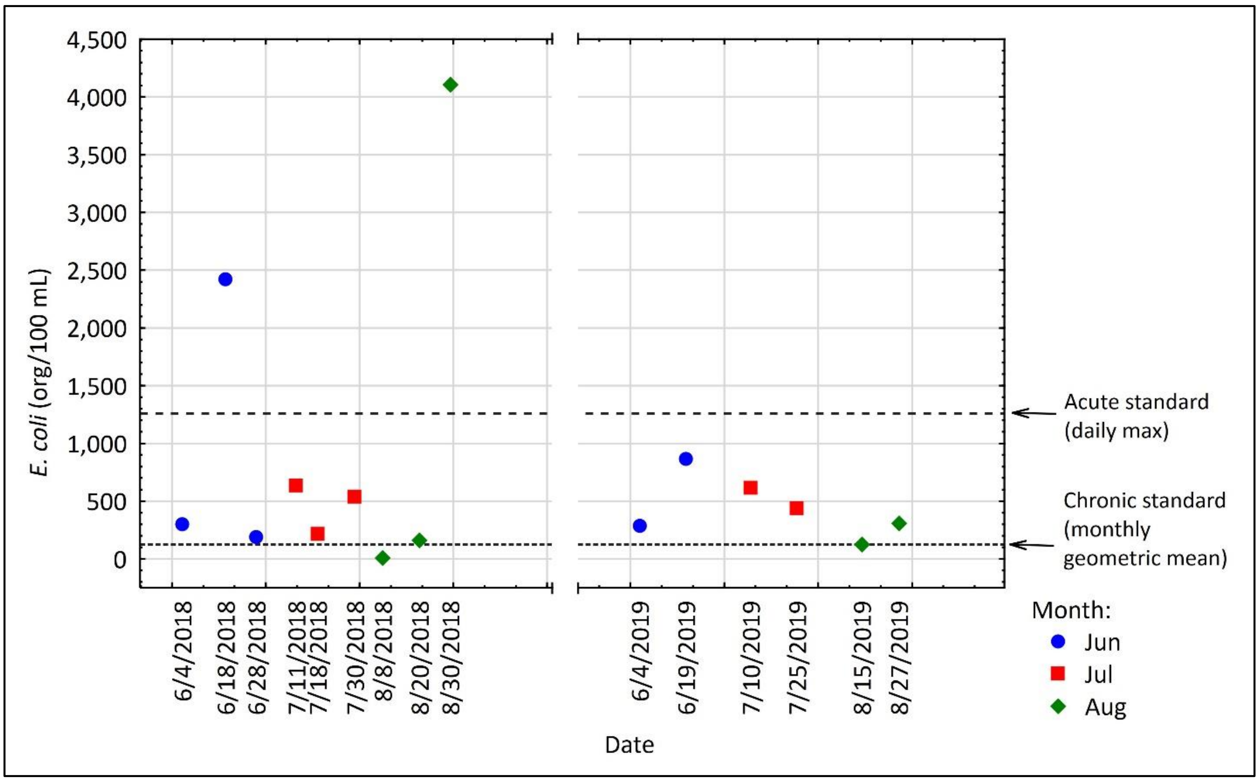


Figure 35. South Fork Root River (07040008-511) *E. coli* concentration versus stream flow.

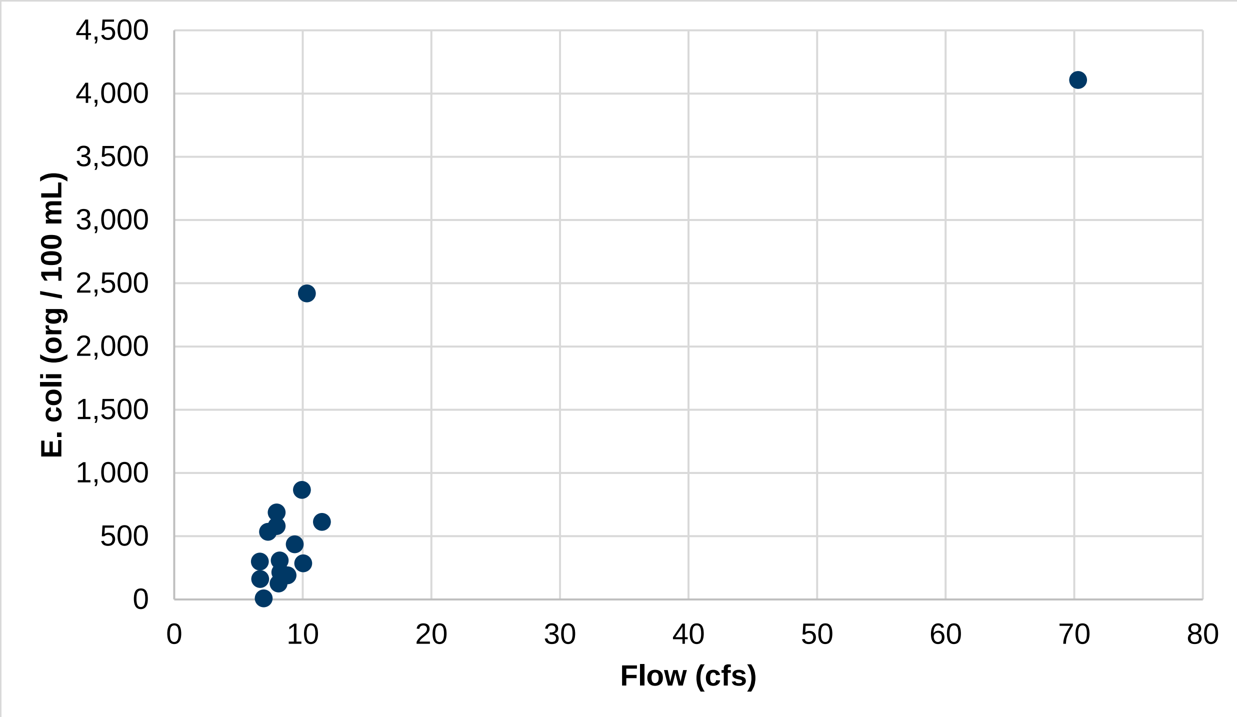


Table 53. Annual summary of *E. coli* data at South Fork Root River (07040008-511, site S001-393; Jun–Aug).
E. coli concentrations not to exceed 126 org/100 mL as a geometric mean nor shall more than 10% of all samples taken during any calendar month individually exceed 1,260 org/100 mL. The standard applies April 1–October 31.

Year	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of individual standard exceedances	Frequency of individual standard exceedance
2018	9	332	7	4,106	2	22%
2019	6	369	125	866	0	0%

Table 54. Monthly summary of *E. coli* data for South Fork Root River (07040008-511, site S001-393; 2018–2019).
Values with asterisks indicate months in which the monthly geometric mean standard of 126 org/100 mL was exceeded or the individual standard of 1,260 org/100 mL was exceeded in greater than 10% of the samples.

Month	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of individual standard exceedances	Frequency of individual standard exceedance
June	5	508 *	190	2,420	1	20% *
July	5	454 *	214	633	0	0%
August	5	180 *	7	4,106	1	20% *

E. coli sources

As there are no NPDES-permitted facilities in the Upper South Fork Root River (-511) drainage area, nonpermitted sources are contributing *E. coli* to surface waters. Manure runoff from cropland, animal feedlots, pastures, and SSTS are potential significant *E. coli* sources in this subwatershed. Animal feedlots with no manure storage have higher risks of *E. coli* loading since manure either stays on animal lots or is land applied more frequently. Both instances can add *E. coli* to surface water, particularly during storm events. Sixty-five percent of the registered feedlots in this subwatershed do not have manure storage on site (Table 15). Those without manure storage all have pasture as part of their operation. Pastures within shoreland areas have a higher likelihood of contributing *E. coli* because animals can have constant access to streams. SSTS is likely a reduced risk source compared to animal feedlots, manure runoff or pastures. Noncompliant systems; however, may contribute *E. coli* and could be a majority source particularly during low flow conditions.

TMDL

Exceedances of the *E. coli* TMDL loading capacity in the South Fork Root River (-511) are seen in the very high flow zone (Figure 36). The South Fork Root River (-511) TMDL summary is provided in Table 55.

Figure 36. South Fork Root River (07040008-511) *E. coli* load duration curve.

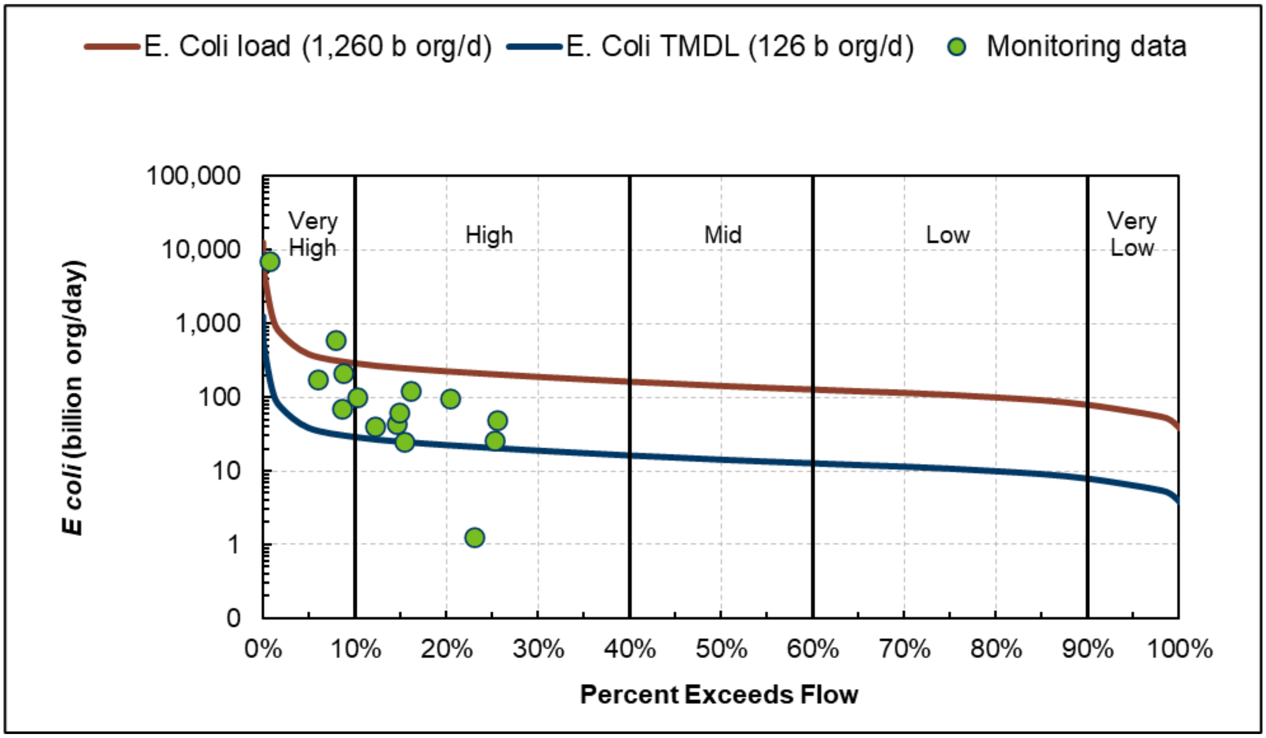


Table 55. Upper South Fork Root River (07040008-518) *E. coli* TMDL summary.

- Listing year: 2022
- Baseline year: 2015
- Numeric standard used to calculate TMDL: geometric mean of 126 org/100 mL)
- TMDL and allocations apply Apr–Oct

TMDL parameter	TMDL *E. coli* load (billion org/day) by flow zone				
	Very high	High	Mid	Low	Very low
LA	35	19	13	10	5.8
MOS	3.9	2.1	1.4	1.1	0.64
TMDL	39	21	14	11	6.4
Maximum monthly geometric mean (org/100 mL)	516				
Estimated percent reduction	76%				

5.6 Riceford Creek HUC-12 (070400080804)

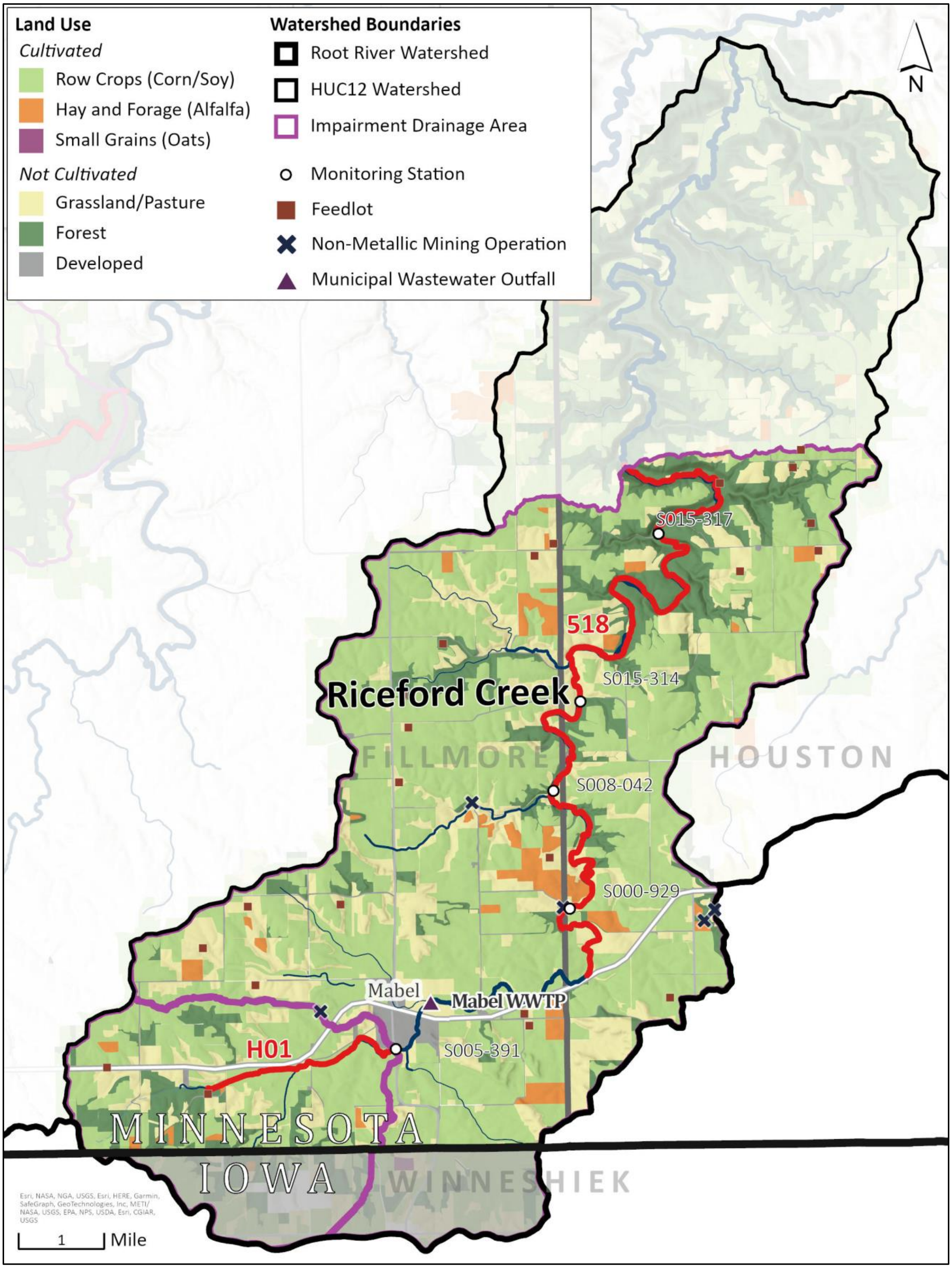
Two TSS TMDLs were developed to address two macroinvertebrate impairments on Riceford Creek (-518 and -H01). A 9 cm and 74.5 cm improvement in transparency depth is needed in the Riceford Creek (-H01) and Riceford Creek (-518) impaired streams, respectively (Table 56). Water quality analysis indicate that the exceedances of the transparency standard typically occur under high flows.

Table 56. TSS TMDL summary table for the Riceford Creek HUC-12 (070400080804).

WID	Water body name	Existing 10th percentile transparency depth (cm)	Transparency standard (cm)	Needed improvement in transparency (cm)
-H01	Riceford Creek	6.0	> 15	9
-518	Riceford Creek	20.5	> 95	74.5

The primary land covers in the Riceford Creek Watershed are row crop (47%), deciduous forest (24%), and grass/pasture (17%; Table 4, Figure 37).

Figure 37. Riceford Creek HUC-12 (070400080804).



5.6.1 TSS: Riceford Creek (07040008-H01) and (07040008-518)

Water quality

There are no TSS monitoring data from the impaired reaches. T-tube measurements; however, were recorded from 2012 through 2021 at monitoring station S005-391 for Riceford Creek (-H01) and monitoring stations S000-929, S008-042, S015-314, and S015-317 for Riceford Creek (-518). Simulated flow data from the RRW HSPF model (2021 model extension) were used to approximate the stream flow conditions when each water quality sample was taken.

Annual transparency means in Riceford Creek (-H01) were below the transparency threshold for impairment for six of the years 2012 through 2021, but there is no clear annual trend (Table 57). Monthly transparency means for the years 2012 through 2021 are at or below the transparency threshold for impairment in all months with available data except for October (Table 58).

Fewer years (2014, 2015, and 2019) of T-tube measurements are available for downstream impairment Riceford Creek (518). The frequency of T-tube measurements below the transparency threshold decreased from 2014 through 2019 but more years of monitoring data are needed to confirm if this is a trend or not (Table 57). Monthly T-tube measurements are also typically below the transparency threshold, with the highest frequencies of exceedance occurring in the months of July and June (Table 59).

T-tube data indicate poorer transparency at high flows on both impaired reaches (Figure 38).

T-tube measurements were recorded in 2019 at multiple sites on six days, at multiple sites throughout the watershed. T-tube measurements tend to be lower in the upstream reaches and tributaries (Figure 39).

Table 57. Annual summary of T-tube measurements for Riceford Creek (-H01 and -518; April-Sept 2012–2021).
Surrogate T-tube measurement used to determine if a stream exceeds the TSS standard for Class 2A streams: < 55 cm

Year	Sample count	Mean (cm)	Median (cm)	Minimum (cm)	Maximum (cm) [a]	Number of measurements < 55 cm	Frequency of measurements < 55 cm
Riceford Creek H01							
2012	9	67	71	33	100	3	33%
2013	10	55	57	7	100	5	50%
2014	24	35	35	3	88	20	83%
2015	27	40	36	1	100	20	74%
2016	31	37	31	4	100	23	74%
2017	17	40	33	1	95	11	65%
2018	23	33	21	4	100	17	74%
2019	6	61	70	7	100	2	33%
2020	21	39	26	2	100	14	67%
2021	20	55	49.5	7	100	11	55%
Riceford Creek 518							
2014	19	61	50	15	100	10	53%
2015	21	49	45	20	90	13	62%

Year	Sample count	Mean (cm)	Median (cm)	Minimum (cm)	Maximum (cm) [a]	Number of measurements < 55 cm	Frequency of measurements < 55 cm
2019	22	70	82.5	8	100	8	36%

a. Prior to 2012, the maximum T-tube reading possible (based on T-tube design) was 60 cm. Starting in 2012, the maximum possible reading has been 100 cm. Data from before 2012 are not presented here.

Table 58. Monthly summary of T-tube measurements for Riceford Creek (-H01, 2012–2021).
Monitoring site: S005-391.
Surrogate T-tube measurement used to determine if a stream exceeds the TSS standard for Class 2A streams: < 55 cm
The transparency standard applies Apr–Sep; additional months are shown in this table to illustrate water quality trends.

Month	Sample count	Mean (cm)	Median (cm)	Minimum (cm)	Maximum (cm) [a]	Number of measurements < 55 cm	Frequency of measurements < 55 cm
March	3	53	67	22	70	1	33%
April	20	55	52.5	1	100	11	55%
May	42	44	42	1	100	28	67%
June	39	20	21	2	60	38	97%
July	33	45	43	2	93	20	60%
Aug	29	51	51	4	100	16	55%
Sept	25	48	52	4	100	13	52%
Oct	18	73	74	5	100	3	17%

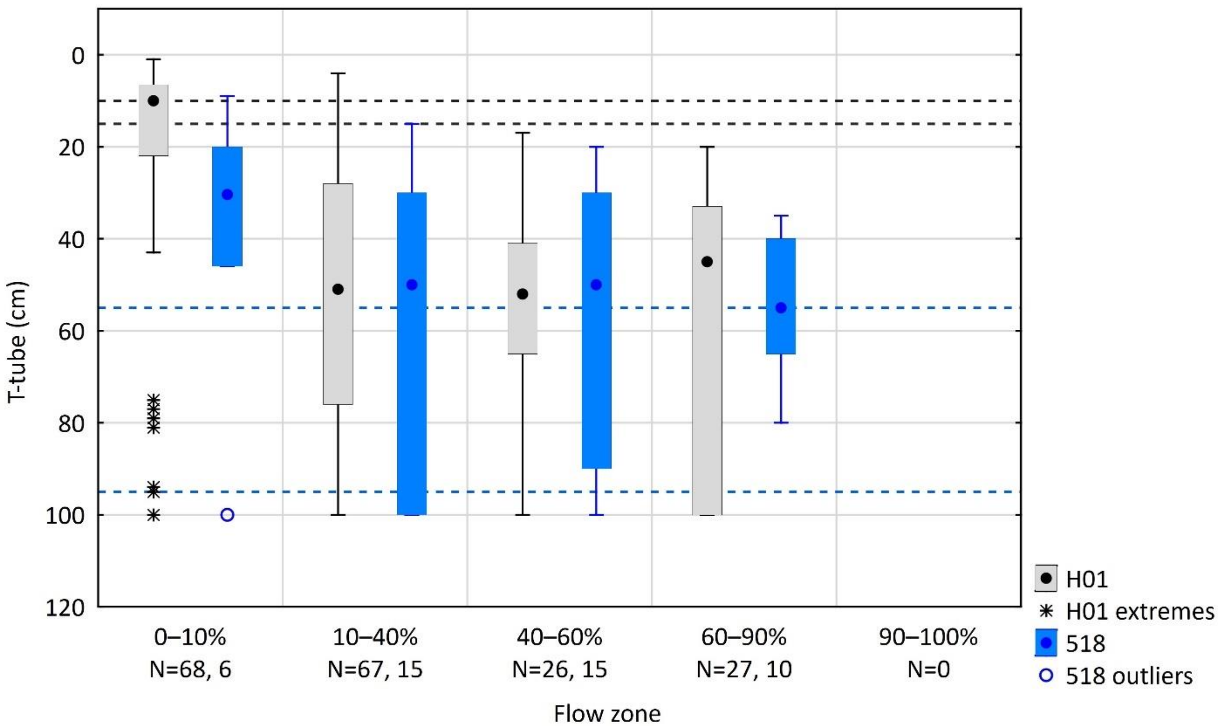
a. Prior to 2012, the maximum T-tube reading possible (based on T-tube design) was 60 cm. Starting in 2012, the maximum possible reading has been 100 cm. Data from before 2012 are not presented here.

Table 59. Monthly summary of T-tube measurements for Riceford Creek (07040008-518; 2012–2021).
Monitoring sites combined due to low sample count.
Surrogate T-tube measurement used to determine if a stream exceeds the TSS standard for Class 2A streams: < 55 cm
The transparency standard applies Apr–Sep; additional months are shown in this table to illustrate water quality trends.

Month	Sample count	Mean (cm)	Median (cm)	Minimum (cm)	Maximum (cm) [a]	Number of measurements < 55 cm	Frequency of measurements < 55 cm
March	8	46	25.5	0	100	5	62.5%
April	11	73	90	20	100	3	27%
May	11	79	90	25	100	2	18%
June	9	44	45	25	55	8	88%
July	9	24	25	8	40	9	100%
Aug	11	76	100	25	100	3	27%
Sept	11	56	50	19	100	6	54.5%
Oct	6	87	95	50	100	1	17%

b. Prior to 2012, the maximum T-tube reading possible (based on T-tube design) was 60 cm. Starting in 2012, the maximum possible reading has been 100 cm. Data from before 2012 are not presented here.

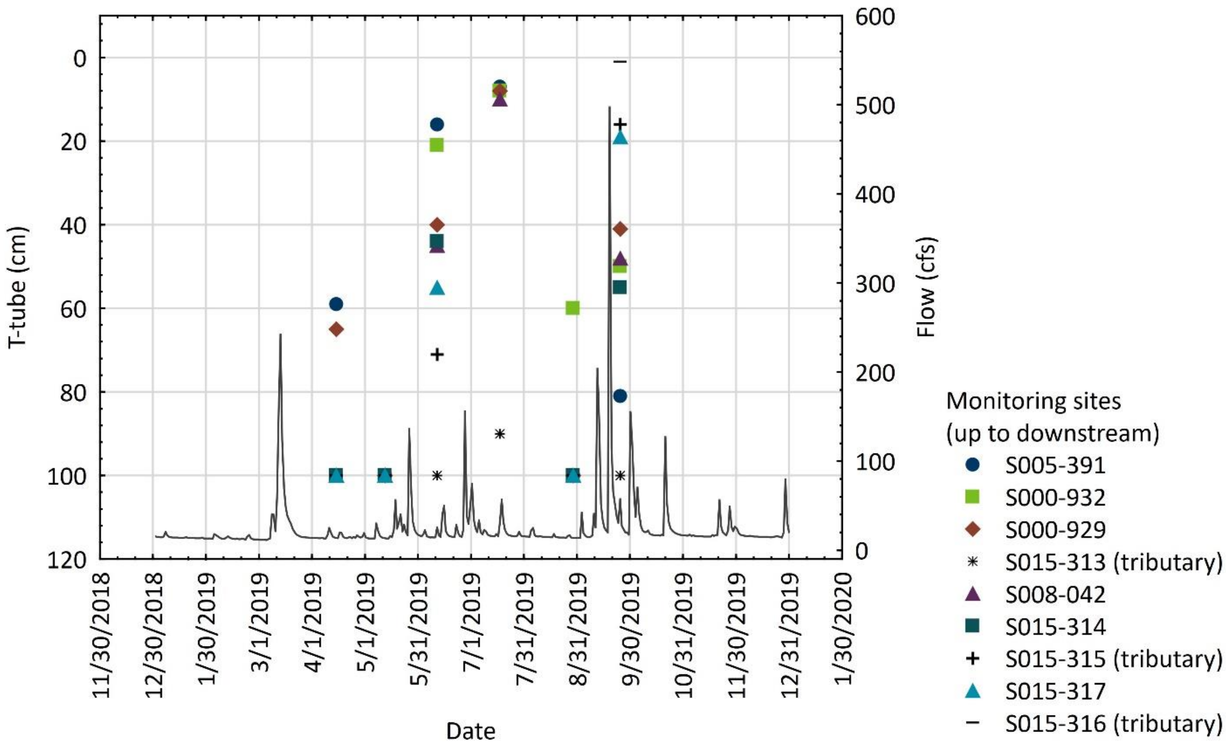
Figure 38. Transparency tube by flow zone at Riceford Creek (07040008-H01 site S005-391 and 07040008-518 sites S000-929, S008-042, S015-314, S015-317; Apr–Sep, 2012–2021[a]).



a. Prior to 2012, the maximum T-tube reading possible (based on T-tube design) was 60 cm. Starting in 2012, the maximum possible reading has been 100 cm. Data from before 2012 are not presented here.

b. 55 cm and 95cm represent the upper and lower surrogate values for the TSS water quality standard for 2A stream segment 518. The TSS WQS is not met if the T-tube < 55 cm and the TSS WQS is met if T-tube > 95 cm. 10 cm and 15 cm represent the upper and lower surrogate values for 2B stream segment H01.

Figure 39. Simulated flow and monitored T-tube by site, 2019, Riceford Creek Watershed.



Sediment sources

Belmont et al. (2016) notes that the predominant (71%) source of the sediment for the tributaries in the South Fork Root River HUC-10 (including Riceford Creek) comes from floodplain/in-channel areas. The RRW HSPF model (2021 model extension) is calibrated to these findings.

Field staff have noted areas above the city of Mabel with severe bank erosion, and water transparency has been steadily declining in this area since 2008. This headwater area of Riceford Creek also has heavily modified stream channels, and channelization is likely exacerbating influx of sediment, particularly during times of peak flow. SID staff noted that the headwaters area of Riceford Creek has lower transparency than downstream stream sections due to seasonal timing, geomorphology and karst. In spring months there is less crop cover to trap sediment from increased overland runoff. The gradual gradient of the headwater section of Riceford Creek does not allow sediment to settle out of the water column, resulting in low transparency. Lastly, there are more spring/groundwater inputs in the drainage area of (-518) which dilutes turbidity and increases water clarity.

Outputs from the RRW HSPF model (2021 model extension) also show that, of the TSS watershed loads, conventional farm fields and pasturelands contribute the majority of TSS to Riceford Creek (**Table 60**).

Table 60. Average annual TSS overland watershed loads in the Riceford Creek (-518) drainage area by land use (MPCA 2023).

Source		% of TSS load[a]
In channel		57%
Permitted	Mabel WWTP	0.03%
Nonpermitted	Cropland	30%
	Pasture	11%
	Developed	2%
	Forest, open water, wetland, barren	< 1%

a. Percentages rounded to the nearest whole number and therefore may not add up to 100%.

Permitted sources of sediment to Riceford Creek (--518) are not considered significant as long as permittees are complying with permit requirements. Discharge monitoring reports support the conclusion that Mabel WWTP does not contribute a significant amount of TSS that would impact water transparency. No exceedances of the 30 mg/L TSS limit were reported since January 2017. Since January 2017, Mabel WWTP has reported three overflows (6/9/2018, 8/27/2018 and 3/14/2019) related to extreme precipitation events. These overflows likely had a higher impact to nutrient and bacteria loads rather than turbidity. Permitted construction stormwater, industrial stormwater (Table 11) and nonmetallic mining (Table 12) facilities are likely not significant sources of TSS but may contribute TSS particularly during extreme rain events.

TMDL

The LDC for Riceford Creek (-H01) is provided in Figure 40 and the TSS TMDL summary is provided in Table 61. The LDC for Riceford Creek (-518) is provided in Figure 41 and the TSS TMDL summary is provided in Table 62. Existing effluent limits are consistent with TSS WLA assumptions. A boundary condition was set at the Iowa border for both impairments.

Figure 40. Riceford Creek (07040008-H01) TSS load duration curve.

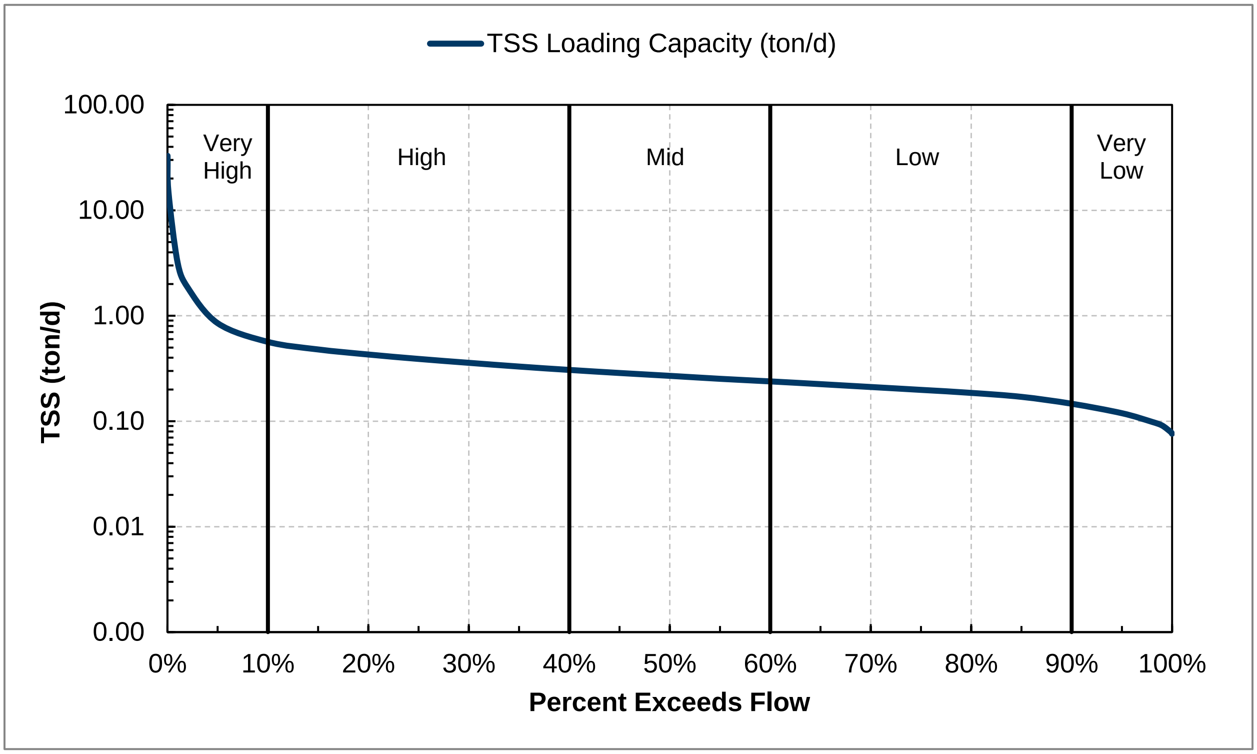


Table 61. Riceford Creek (07040008-H01) TSS TMDL summary.

- Listing year: 2020
- Baseline year: 2015
- Numeric standard used to calculate TMDL: 65 mg/L TSS
- TMDL and allocations apply Apr–Sep

TMDL parameter		TMDL TSS load (tons/day) by flow zone				
		Very high	High	Mid	Low	Very low
WLA	Construction stormwater (MNR100001)	0.00038	0.00018	0.00012	0.000089	0.000054
	Industrial stormwater (MNR050000 and MNG490000)	0.00038	0.00018	0.00012	0.000089	0.000054
LA (Minnesota portion)		0.53	0.24	0.17	0.12	0.075
Boundary condition (at Iowa border) [a]		0.23	0.11	0.073	0.054	0.032
MOS		0.085	0.039	0.027	0.020	0.012
TMDL		0.85	0.39	0.27	0.20	0.12
Existing 90th percentile concentration (mg/L)		Insufficient data to calculate [b]				
Estimated percent reduction						

a. This boundary condition load is assigned to the portion of the impairment subwatershed in Iowa and is not a TMDL allocation (Section 4.7.3). Minnesota cannot establish allocations for other jurisdictions, and any reductions noted in this TMDL that are needed from the watershed area in Iowa are consistent with Minnesota's WQS and not more stringent. The remaining load in this table after the boundary condition is removed represents the Minnesota allocations

b. In order to meet the T-tube water quality standard of > 15 cm, transparency will need to improve by approximately 9 cm from the 10th percentile transparency depth of 6 cm.

Figure 41. Riceford Creek (07040008-518) TSS load duration curve.

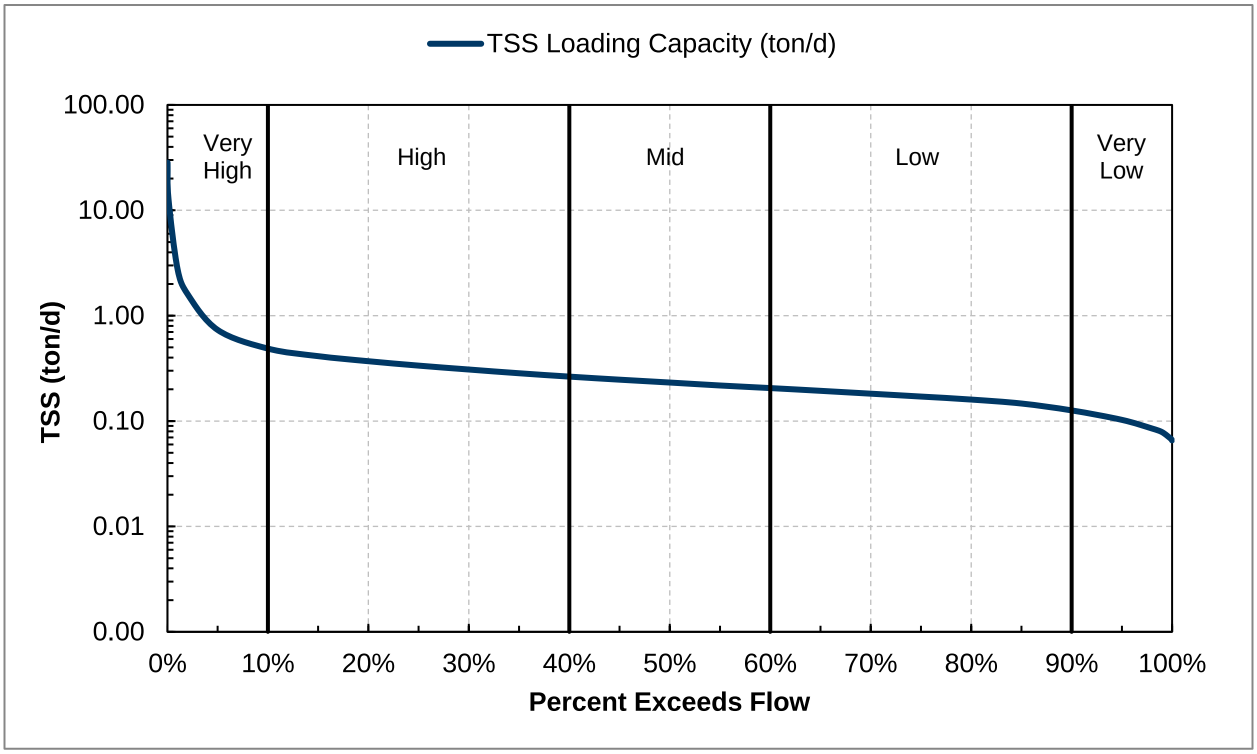


Table 62. Riceford Creek (07040008-518) TSS TMDL summary.

- Listing year: 2012
- Baseline year: 2015
- Numeric standard used to calculate TMDL: 10 mg/L TSS
- TMDL and allocations apply Apr–Sep

		TMDL TSS load (tons/day) by flow zone				
TMDL parameter		Very high	High	Mid	Low	Very low
WLA	Industrial stormwater (MNR050000and MNG490000)	0.0011	0.00051	0.00035	0.00026	0.00016
	Construction stormwater (MNR100001)	0.00033	0.00015	0.00010	0.000077	0.000046
	Mabel WWTF (MN0020877)	0.023	0.023	0.023	0.023	0.023
LA (Minnesota portion)		0.56	0.25	0.16	0.11	0.06
Boundary condition (Iowa border) [a]		0.07	0.032	0.022	0.016	0.0099
MOS		0.073	0.034	0.023	0.017	0.010
TMDL		0.73	0.34	0.23	0.17	0.10
Existing 90th percentile concentration (mg/L)		Insufficient data to calculate [b]				
Estimated percent reduction						

a. This boundary condition load is assigned to the portion of the impairment subwatershed in Iowa and is not a TMDL allocation (Section 4.7.3) Minnesota cannot establish allocations for other jurisdictions, and any reductions noted in this TMDL that are needed from the watershed area in Iowa are consistent with Minnesota's WQS and not more stringent. The remaining load in this table after the boundary condition is removed represents the Minnesota allocations

b. In order to meet the t-tube water quality standard of > 95 cm, transparency will need to improve by approximately 74.5 cm from the 10th percentile transparency depth of 20.5 cm.

6. Future growth considerations

Changes in population and land use over time could result in changing sources of pollutants in the RRW. The city of Rochester has grown 11% since 2010 and will likely continue to expand into the boundary of the RRW in the next 10 years (US Census 2022). The city of Stewartville is currently not an MS4 community but it is anticipated that it will be within the next 10 years. Those results may also change the urbanized area, which would then also change the regulated area for Minnesota Department of Transportation (MNDOT), Marion Township and Olmsted County. The number of registered feedlots may continue to decline, but the number of AUs per facility could continue to increase. Additional NPDES permitted feedlots in the watershed may exist in the future. Possible changes and how they may or may not impact the TMDL allocations are discussed below.

6.1 New or expanding permitted MS4 WLA transfer process

While there are no current MS4s within the drainage areas of the impairments addressed by this TMDL report, future transfer of watershed runoff loads in this TMDL may be necessary if any of the following scenarios occur within the drainage areas to the impairments addressed by this TMDL.

1. One or more nonpermitted MS4s become permitted. In this TMDL, this will require a LA to WLA transfer.
2. Expansion of a U.S. Census Bureau Urbanized 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. In this TMDL, this will require a LA to WLA transfer.
3. A new MS4 or other stormwater-related point source is identified and is covered under an NPDES 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.

6.2 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 water bodies with an EPA approved TMDL for TSS or *E. coli* (described in MPCA 2012). This procedure is only approved for TSS and *E. coli* and 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 WQS 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 WQS, the permit will be issued and any updates to the TMDL WLA(s) will be made.

7. Reasonable assurance

"Reasonable assurance" shows that elements are in place, for both permitted and nonpermitted sources, that are making (or will make) progress toward needed pollutant reductions.

7.1 Reduction of permitted sources

7.1.1 Permitted construction stormwater

Permitted construction stormwater was given categorical WLAs in this study. Construction activities disturbing one acre or more are required to obtain NPDES 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.

7.1.2 Permitted industrial stormwater

Industrial stormwater was given categorical WLAs in this study. 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 WLA in this TMDL report.

7.1.3 Permitted wastewater

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 WQS 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 WQS. WQBELs will be developed for facilities whose discharges are found to have a reasonable potential to cause or contribute to exceedances of applicable WQS. The WQBELs will be calculated based on low flow conditions, may vary slightly from the TMDL WLAs, and may include concentration based effluent limitations.

The MPCA tracks improvements in TSS, TP and carbonaceous biochemical oxygen demand (CBOD) loads from WWTP effluent through the Healthier Watersheds website: https://www.pca.state.mn.us/water/wastewater-treatment-plant-progress. Both Mabel and Spring Valley WWTPs show a declining trend in TSS loads in their effluent from 2019 through 2021.

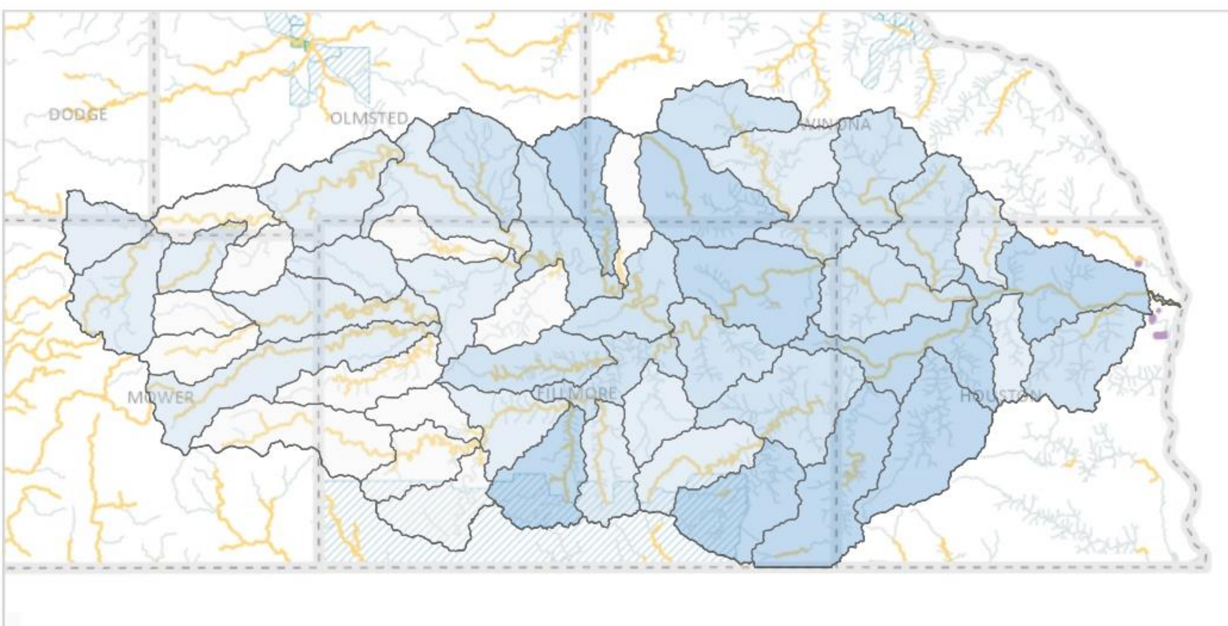
7.1.4 Permitted feedlots

See the discussion of the state's Feedlot Program in Section 7.2.2, which applies to both permitted and nonpermitted feedlots.

7.2 Reduction of nonpermitted sources

Several nonpermitted reduction programs exist to support implementation of nonpermitted source reduction BMPs in the RRW. These programs identify BMPs, provide means of focusing BMPs, and support their implementation via state initiatives, ordinances, and/or dedicated funding. **Figure 42** shows the number of BMPs that have been implemented per subwatershed, as tracked on the MPCA's Healthier Watersheds website (https://www.pca.state.mn.us/water/healthier-watersheds).

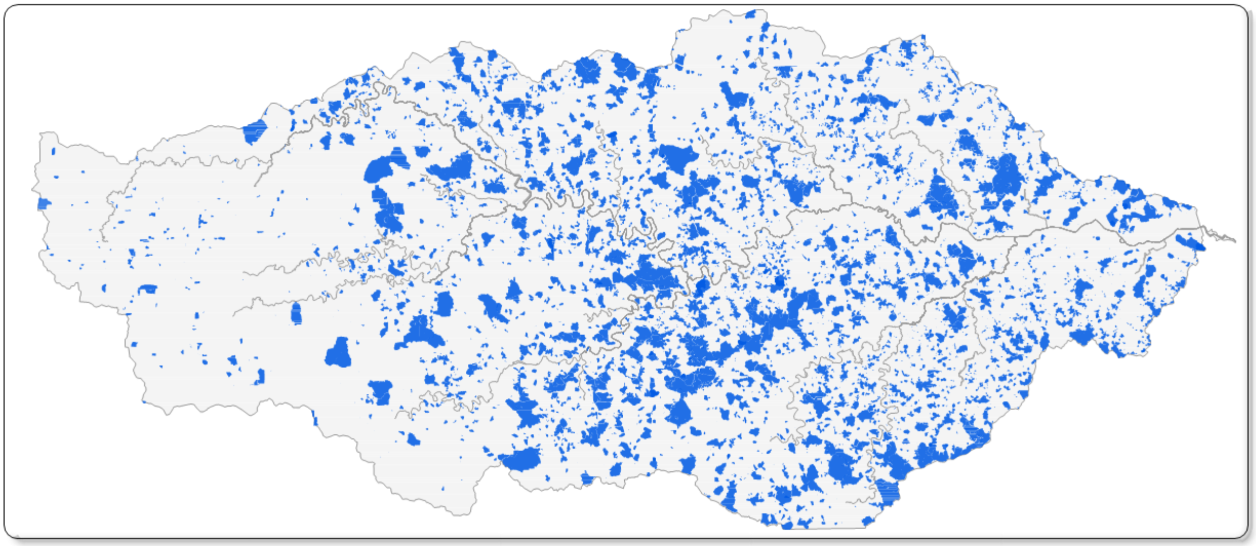
Figure 42. Number of BMPs per subwatershed; data from the MPCA's Healthier Watersheds website (as of June 29, 2023).



Six soil and water conservation districts (SWCDs) are active in the project area and provide technical and financial assistance on topics such as feedlot runoff, erosion, water storage, soil health and drinking water quality. The SWCD staff work to address TSS, bacteria and nitrate impairments by planning and implementing conservation projects with landowners as well as providing education to the public through outreach. Specific projects and outreach topics include cover crop plantings, water and sediment control basin (WASCOB) installation, grassed waterways, rotational grazing, and conservation easements.

In addition to reported BMPs, Winona State University recently conducted a BMP mapping project in the RRW. The purpose of this project was to account for all WASCOBs in the entire HUC-8 as well as all structural BMPs in select priority subwatersheds. Most of the mapping was done using aerial imagery, however, field verification was performed for select WASCOBs. The findings of this project were that WASCOBs and pond dams are treating 191,800 acres of land (18%) in the RRW (Figure 43) (Otten 2021).

Figure 43. Land area treated by WASCOBs and pond dams in the RRW (Otten 2021).



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

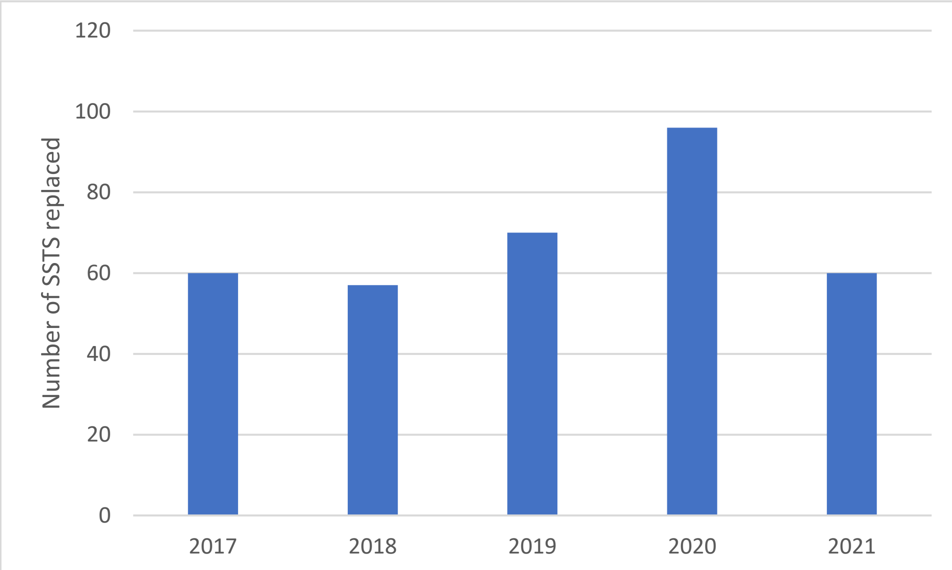
7.2.1 SSTS regulation

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
- Various ordinances for SSTS installation, maintenance, and inspection

Each county maintains an SSTS ordinance, in accordance with Minn. Stat. and Minn. R., 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 and/or environmental 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. Since 2017, Fillmore County, within the South Fork Root River Subwatershed, has replaced an average of 69 systems per year (Figure 44).

Figure 44. SSTS replacements in Fillmore County (2017–2021).



State-sponsored funding programs are available for community-wide septic system assessments. The Public Facilities Authority (PFA) administers the Small Community Wastewater Treatment Program, which provides grants of up to $60,000 to local government unit (LGUs) to "conduct preliminary site evaluations and prepare feasibility reports, provide advice on possible SSTS alternatives, and help develop the technical, managerial, and financial capacity to build, operate, and maintain SSTS systems" (PFA website). These studies assess current SSTS compliance status as well as potential future individual and/or community SSTS solutions.

Also, the Minnesota Board of Water and Soil Resources (BWSR) has provided grant funds in the past to local governments for large-scale SSTS compliance inspection projects. These projects typically involve riparian communities on impaired water bodies.

7.2.2 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 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. All feedlots capable of holding 50 or more AUs, or 10 in shoreland areas, are required to register. A feedlot holding 1,000 or more AUs is required to obtain an NPDES/SDS permit.

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 Mower, Dodge, Fillmore, Houston, and Winona and the county that is not delegated is Olmsted. In the counties that are not delegated, the MPCA is tasked with running the Feedlot Program.

From 2017 through 2022, 417 feedlot facilities were inspected in the RRW, with 410 of those inspections occurring at non-CAFO facilities and 7 at CAFO facilities. There have been an additional 7 facilities with manure application reviews within the watershed; all 7 of those inspections were conducted at non-CAFO facilities.

The Feedlot Program continuously evaluates program requirements to determine if program enhancements are needed. In the most recent reissuance of the Feedlot General Permit, requirements were added to avoid nitrogen loss, including additional restrictions on winter application of solid manure, cover crop requirements from September, and additional nitrogen loss BMP options for early October.

In late 2023, in response to a Safe Drinking Water Act petition regarding nitrate water contamination issues in southeastern Minnesota, EPA advised that "Minnesota should consider adopting monitoring requirements in NPDES/SDS permits related to (1) subsurface discharges from manure, litter, and process wastewater storage, as well as (2) discharges from land application." The EPA also encouraged Minnesota "to consider modifications to the state's Technical Standards for Nutrient Management with regard to land application of manure, litter or process wastewater, and any Minnesota guidelines for land application of commercial fertilizer, specific to Karst areas." The Feedlot Program is considering these recommendations. Also, the Minnesota State Legislature passed a statute in 2023 requiring the MPCA and other state agencies to submit recommendations to the legislature in January 2024 for measures to prevent fish kills in the Karst region of southeastern Minnesota. The MPCA will continue to work with the EPA, state legislature, and stakeholders to determine if Feedlot Program rules and permits require modification to more effectively address water quality problems in southeastern Minnesota.

7.2.3 Minnesota buffer law

The Riparian Protection and Water Quality Practices statute (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 ranges from 94% to 100% for counties in the RRW as of January 2023.

7.2.4 Minnesota Agricultural Water Quality Certification Program

The Minnesota Agricultural Water Quality Certification Program (MAWQCP) administered through 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
- 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 March 2023):

- Enrolled 919,405 acres
- Included 1,313 producers
- Added 2,605 new conservation practices
- Kept over 46,127 tons of sediment out of Minnesota rivers
- Saved 136,541 tons of soil and 57,920 pounds of phosphorus from leaving farm fields
- Cut greenhouse gas emissions by 49,913 metric tons annually

As of October 2022, approximately 38,658 acres in the RRW are certified under the MAWQCP.

7.2.5 Minnesota Nutrient Reduction Strategy

The *Minnesota Nutrient Reduction Strategy* (NRS; MPCA 2014) guides activities that support nitrogen and phosphorus reductions in Minnesota water bodies and water bodies downstream of the state (e.g., Lake Winnipeg, Lake Superior, and the Gulf of Mexico). The NRS was developed by an interagency steering team with help from public input, and a progress report was completed in 2020. *5-year Progress Report on Minnesota's Nutrient Reduction Strategy* (MPCA 2020) provides an update on progress made in the state towards achieving the nutrient reduction goals and associated BMP implementation outlined in the original 2014 strategy. *Watershed Nutrient Loads to Accomplish Minnesota's Nutrient Reduction Strategy Goals* (MPCA 2022d) integrates the state's NRS into local watershed work by developing load reduction planning goals on a HUC-8 watershed basis.

Fundamental elements of the *Minnesota Nutrient Reduction Strategy* include:

- Defining progress with clear goals

- Building on current strategies and success
- Prioritizing problems and solutions
- Supporting local planning and implementation
- 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 approaches for reducing 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 set a reduction goal of 45% for both phosphorus and nitrogen in the Mississippi River Basin (relative to average 1980 through 1996 conditions), a similar level of nutrient reduction for the Red River/Lake Winnipeg Basin (relative to the mid to late 1990s), and a no net increase goal from the 1970s for the Lake Superior Basin. The strategy also emphasizes the need to achieve local nutrient reduction needs within HUC-8 watersheds. HSPF modeling described in *Watershed Nutrient Loads to Accomplish Minnesota's Nutrient Reduction Strategy* (2022 interim guidance) estimates that the RRW needs to reduce phosphorus loading by approximately 108 metric tons/year and nitrogen loading by 3,820 metric tons/year.

Successful implementation of the NRS will continue to require broad support, coordination, and collaboration among agencies, academia, local government, and private industry. Minnesota is implementing a watershed approach 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 (including TMDLs) and updates that include BMP scenarios to achieve nutrient load reductions
- Comprehensive local water planning and implementation
- Management of NPDES and other regulatory and assistance programs

This framework will result in nutrient reduction for the Mississippi River basin as a whole including the RRW within the basin. Minnesota's NRS is currently undergoing an update that will include a focus on strategies to increase adoption of BMPs.

7.2.6 Groundwater Protection Rule

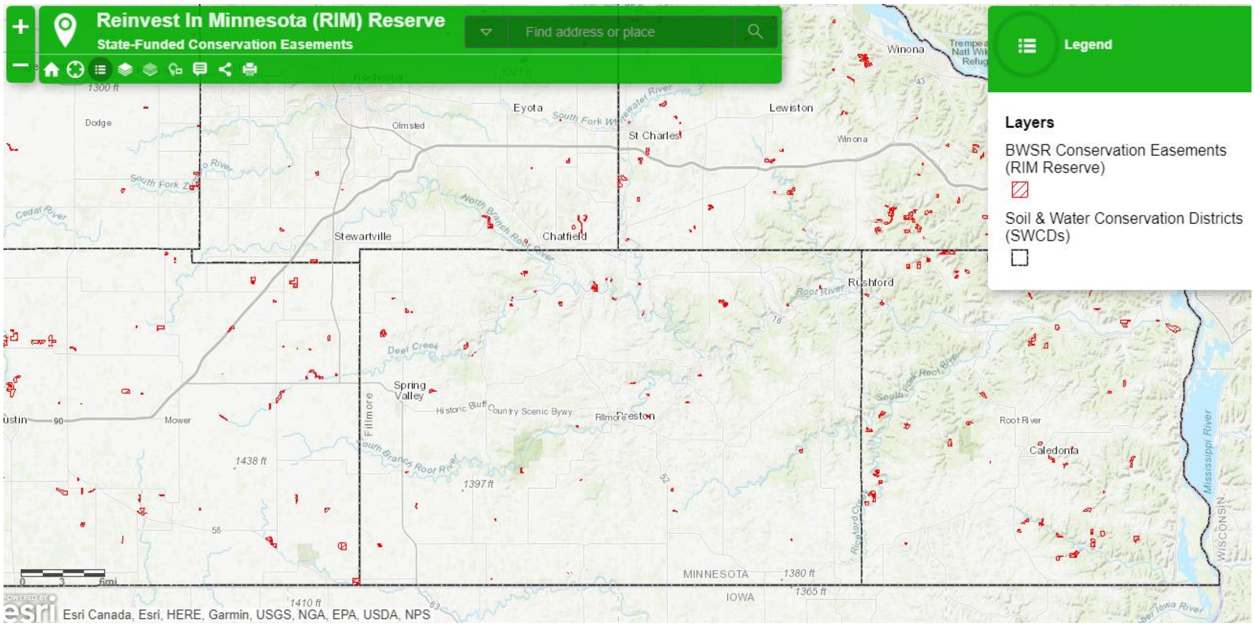
The Groundwater Protection Rule (Minn. R. ch. 1573) minimizes potential sources of nitrate pollution to the state's groundwater and protects drinking water. The rule restricts fall application of nitrogen fertilizer in areas vulnerable to contamination, including a majority of the RRW, and it outlines steps to reduce the severity of the problem in areas where nitrate in public water supply wells is already elevated. The rule is intended to promote appropriate nitrogen fertilizer BMPs and to involve local farmers and agronomists in adopting the most current science based and economically viable practices that can reduce nitrate in groundwater. Although the rule primarily addresses groundwater protection, BMPs implemented to comply with the rule will also benefit surface waters impacted by high levels of nitrogen.

The municipal supply well of the Chatfield Drinking Water Supply Management Area (DWSMA), located in the Mill Creek HUC-12 Subwatershed, was monitored in accordance with Part 2 of MDA's Groundwater Protection Rule. Chatfield DWSMA is currently a Level 1 DWSMA as NO3-N concentration within the municipal supply well was at least 5.4 mg/L, but less than 8 mg/L, within the last 10 years (2012 through 2022). The overall nitrate concentration trend in the supply well is increasing, however. This increasing trend in nitrate isn't necessarily a reflection of degrading land use practices as there has been focused BMP implementation in the DWSMA (email correspondence with MDH staff on August 4, 2022), and may be more of a result of historical practices. Springshed mapping or groundwater age dating may aid in better understanding of how historic and current land uses are influencing nitrate trends in this DWSMA.

7.2.7 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, state and federal 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. Conservation easement types 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), among others. As of August 2022, in the counties that are located in the RRW, there were 58,676 acres of short-term conservation easements such as CRP and 9,835 acres of long term or permanent easements (CREP, RIM, WRP) (BWSR 2022). RIM state-funded conservation easements are shown in Figure 45.

Figure 45. Reinvest In Minnesota (RIM) Reserve state-funded conservation easements in the counties that are located in the RRW (data from BWSR 2022).



7.3 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 of existing local government structure, water plan services, and local capacity.
- Incorporate and make use of data and information, including WRAPS reports.
- Solicit input and engage experts from agencies, residents, 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 Root River 1W1P (2017) was one of the first plans approved under the 1W1P program and has received watershed based implementation funds since 2018. The planning boundary includes the RRW, Upper Iowa River Watershed and the Mississippi River – Reno Watershed. Since it was approved in 2017, approximately $6 million has been allocated to the project area for practice implementation, technical assistance, and community outreach. This includes the following fund awards: 2018 – 2019: $851,301.00, 2020 - 2021: $1,469,595.00, 2022 – 2023: $1,469,595, and 2024 – 2025: $2,300,950.00. The fiscal year 2022–2023 work plan for the Root River 1W1P planning area prioritized implementation and other work outlined in Figure 46 and Table 63.

Figure 46. Priority subwatersheds for the draft Root River 1W1P 2024-2025 Work Plan (HEI 2023). Hashed subwatersheds indicate priority subwatersheds.

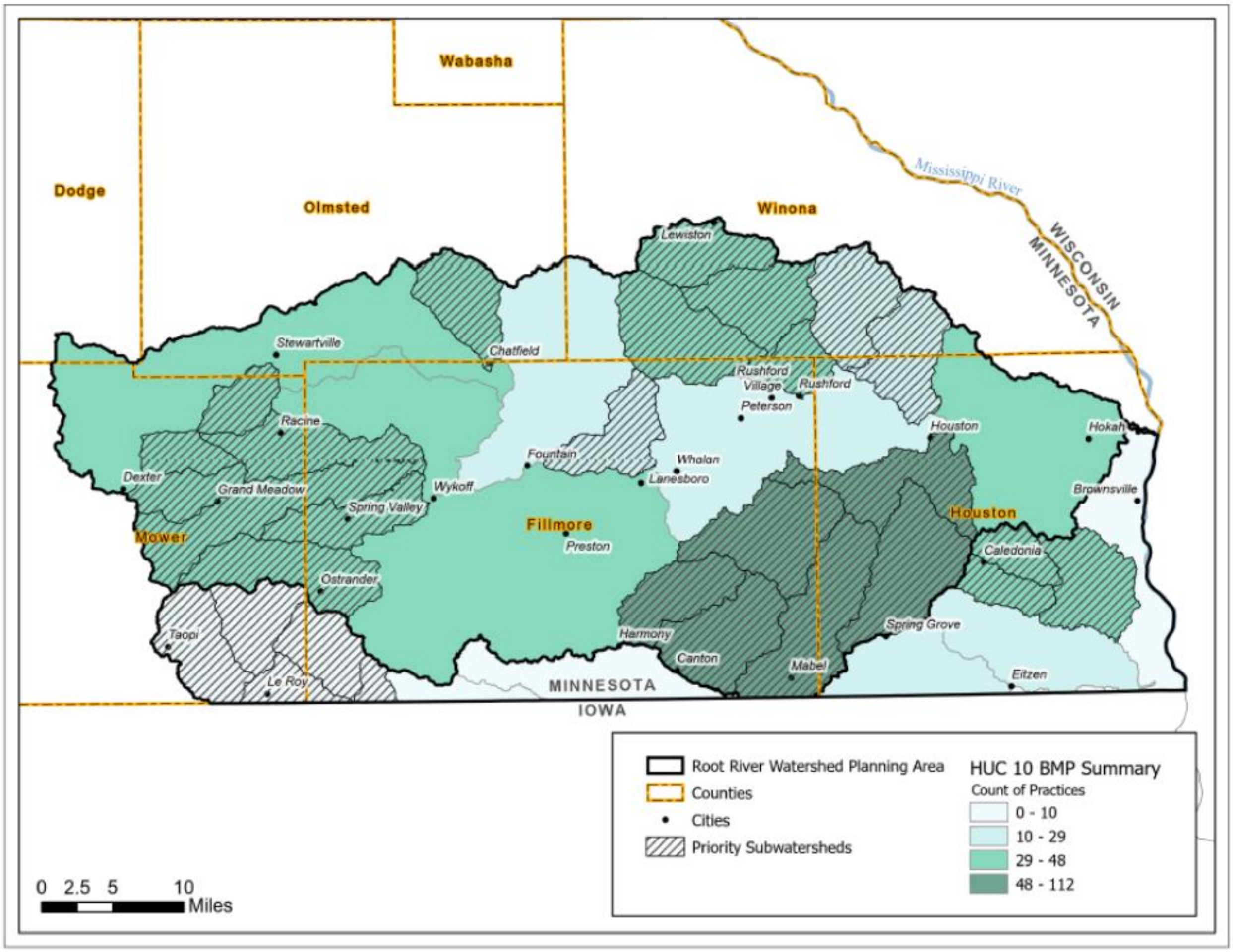


Table 63. Priority resource concerns from the draft Root River 1W1P 2024 - 2025 Work Plan

Priority resource concerns
Plan and implement BMPs which address Total Nitrogen, Pesticides and Bacteria entering Groundwater in Drinking Water Supplies (Public and Private).
Plan and implement BMPs which address Sediment, Total Nitrogen, TP, Bacteria and Excess Runoff entering Surface Water in Streams and Rivers.
Plan and implement BMPs which address Excess Runoff entering Surface Water causing Flooding.
Promote adoption of BMPs by increasing engagement and communication with local landowners/agricultural producers, to increase understanding of on-farm production issues, identify solutions to overcome fiscal and operational hurdles to conservation practice implementation and communicate the benefits of implementation activities.

Priority resource concerns
Improve or maintain communities' cultural, economic, natural and water resources by promoting decisions which enhance the livability of a community, characterized by a healthy environment, access to recreational and economic opportunities, high public safety and financial stability.

7.4 Examples of pollution reduction efforts

Local watershed partners have been working in the RRW for years to address water quality issues through implementing BMPs. Efforts to reduce nitrate contributions to groundwater and therefore also trout stream baseflows continue to be widespread throughout the RRW. More detail on these efforts is included in the RRW WRAPS Report Update (MPCA 2023a). Three subwatersheds within the RRW have had notable efforts to address nitrate and other pollutants since 2017 to highlight:

- **Headwaters South Branch Root River:** Many BMPs (mostly prairie strips) upstream of 760th Avenue have been put on the landscape through RRFSP recommendations. Not many of these practices were established at the time of Cycle 2 Assessment. Partners are hopeful an improvement in water quality will be evident in the next water quality assessment cycle (2031).
- **Mill Creek:** In the drainage area of (-A47), six basin edge of field projects and several terrace rehab projects have been completed.
- **Riceford Creek:** Outreach to watershed landowners resulted in six grade stabilization projects being implemented. Cedar tree revetment in the Rooster Valley area has been recently established to prevent streambank erosion. Several WASCOBs are planned for this subwatershed in 2022/2023 as well as additional landowner outreach for terrace rehabilitation.

7.5 Funding

Funding sources to implement TMDLs can come from local, state, federal, and/or private sources. Examples of some of the major funding sources include BWSR's Clean Water Fund Watershed-based Implementation Funding (WBIF), Clean Water Fund Competitive Grants (e.g., Projects and Practices), CWA Section 319 funds and conservation funds from Natural Resources Conservation Service (NRCS) (e.g., Environmental Quality Incentives Program and Conservation Stewardship Program).

WBIF 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. The Root River 1W1P group has received approximately $6 million in WBIF since 2017.

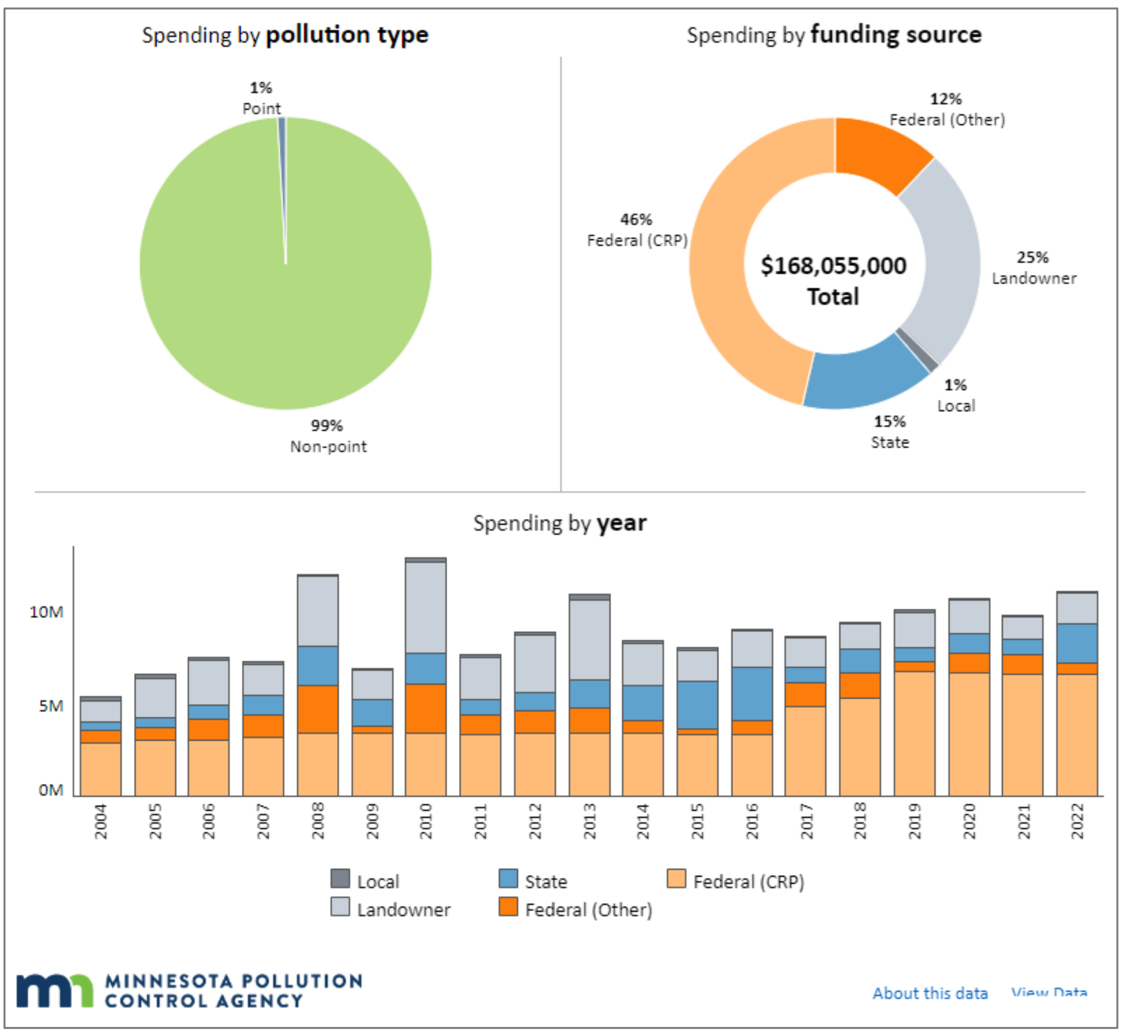
BWSR has been moving more of its available funding away from competitive grants and toward WBIF to accelerate water management outcomes, enhance accountability, and improve consistency and efficiency across the state. This approach allows more clean water projects identified through planning to be implemented without having to compete for funds, helping local governments spend limited resources where they are most needed.

WBIF assurance measures summarize and systematically evaluate how WBIF dollars are being used to achieve clean water goals identified in comprehensive watershed plans. The measures will be used by BWSR to provide additional context about watershed plan implementation challenges and opportunities. 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.

Approximately $168,055,000 has been spent cumulatively on watershed implementation projects in the RRW from 2004 through 2022 (MPCA, 2023b) (Figure 47). Most recently, Fillmore and Winona Counties have been awarded over $300,000 in competitive Clean Water Funds for drinking water protection. This work is underway and will continue for two to three years.

Figure 47. Spending for watershed implementation projects in the RRW; data from the MPCA's Healthier Watersheds website.



7.6 Other partners and organizations

Restoring and protecting waters within the RRW would not be possible without the efforts from partnering organizations and nonprofits. The partners below play critical roles on many directives including but not limited to landowner outreach, land acquisition, habitat improvement projects and public communication.

- **Friends of the Root River**. Friends of the Root River is a citizen group working to protect and restore the river. This organization often partners with Root River 1W1P to hold public education and outreach events.
- **Fishers and Farmers Partnership**. Fishers and Farmers is a regionally based organization that spans across the Upper Mississippi River Basin. They distribute funds for local, farmer-driven projects, facilitate public outreach and education, and offer science-based agriculture and stream health resources to inform rural community goals.
- **The Nature Conservancy**. The Nature Conservancy is a global nonprofit organization that works to conserve natural resources. Much of the work The Nature Conservancy does in the RRW is related to management and restoration of forests and prairies and securing land for permanent easements or long-term protection.
- **Trout Unlimited**. Trout Unlimited is a nation-wide nonprofit organization working to conserve, protect and restore coldwater fisheries and their watersheds. TU has developed and managed several stream restoration projects in Southeastern Minnesota, including in the RRW.
- **Root River Field to Stream Partnership.** The RRFSP is a unique water monitoring project located in southeast Minnesota. This partnership combines rigorous data collection, strong personal relationships, and real conservation action. The RRFSP project uses both edge-of-field and in-stream monitoring to characterize water quality and pollutant transport in three study areas within the RRW.

7.7 Reasonable assurance conclusion

In summary, significant time and resources have been devoted to identifying the best strategies and BMPs, providing means of focusing them in RRW, and supporting their implementation via state, local, and federal initiatives and dedicated funding. The RRW WRAPS and TMDL process engaged partners to arrive at reasonable scenarios of BMP combinations that attain pollutant reduction goals (MPCA 2023a). Minnesota is a leader in watershed planning and implementation, as well as monitoring and tracking progress toward water quality goals and pollutant load reductions.

8. Monitoring

Monitoring is important for several reasons including:

- Evaluating water bodies to determine if they are meeting WQS and tracking trends
- Assessing potential sources of pollutants
- Determining the effectiveness of implementation activities in the watershed
- Delisting of waters that are no longer impaired

Monitoring is also a critical component of an adaptive management approach and can be used to help determine when a change in management is needed. The RRW began Cycle 2 IWM in 2018 which continued through 2019, as part of the MPCA's Watershed Approach. Additional optional monitoring recommendations are provided below by pollutant for the impairments addressed in this TMDL, subject to resources availability. This monitoring is needed in addition to or included in Cycle 3 IWM (which will occur 2028-2029). An expanded list of monitoring needs for the RRW and information on overall monitoring programs in the RRW can be found in the 2016 RRW TMDL (2016) and in the Root River WRAPS Update (MPCA 2023a).

TSS

Sources of TSS in the RRW have been well studied and documented as noted in Section 3.5.1. Existing TSS and transparency monitoring in the impairment drainage areas addressed by this TMDL should continue throughout TMDL implementation.

Nitrate

There are numerous existing monitoring programs that monitor for nitrate in the RRW. The MDA's Southeast Minnesota volunteer nitrate monitoring network and the MPCA and DNR Sentinel Spring Monitoring program are two main examples. These programs should continue to be supported. Additional state programs monitoring nitrates include MDA's RRFSP and Well Testing Program. See the Root River WRAPS Update (MPCA 2024a) for descriptions of these programs and recent data summaries. Additional resources are needed in southeast MN (including the RRW) to further improve monitoring of nitrate (BALMM 2020). Those needs include continued support of studying "lag time" of nitrate, impacts of increased tiling in karst landscapes, and maintain and expand nitrate monitoring networks.

E. coli

Monitoring in support of source identification is especially important for *E. coli* impaired streams. As sources of *E. coli* are often widespread and intermittent, additional *E. coli* samples throughout the South Fork Root River (-511) drainage area will help to further assess potential sources and focus implementation activities for the stream.

- Microbial Source Tracking (MST) could be used to further evaluate sources of *E. coli* and target restoration activities.
- Longitudinal, or synoptic, sampling can be done to identify hotspots along an impaired segment where higher concentrations of *E. coli* are found.

This information, paired with sanitary sewer surveys and field reconnaissance, can be used to further investigate sources of *E. coli.*

Aquatic life

Monitoring for aquatic macroinvertebrates and fish identifies whether waters meet aquatic life uses. This biological monitoring is accomplished through IWM as well as long term biological stations established throughout the state of Minnesota. Waters not meeting aquatic life uses are investigated through SID to determine stressors of fish and/or macroinvertebrate communities. Pollutant stressors are often addressed via TMDLs. Aquatic life monitoring should continue as planned for the reaches addressed by this TMDL.

9. Implementation strategy summary

Summaries of general implementation strategies for this RRW TMDL are provided in the following sections for both permitted and nonpermitted sources of pollutants. HUC-12 specific strategies (for permitted and nonpermitted sources) are provided in Section 5. Many practices listed in this section can be used to target multiple pollutants (e.g., manure storage practices can help to reduce nitrate and *E. coli* loading, and cover crops can help to reduce nitrate and TSS loading, etc.) and should be prioritized whenever possible.

9.1 Permitted sources

9.1.1 Construction stormwater

The WLA for stormwater discharges 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 Stormwater 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.

9.1.2 Industrial stormwater

The WLA for stormwater discharges from sites where there is industrial activity reflects the number of sites in the watershed for which NPDES 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) with stormwater components 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.

9.1.3 Wastewater

Spring Valley WWTP's NPDES permit was recently reissued (9/1/2023) and now includes weekly monitoring for total nitrite + nitrate, total ammonia, and total Kjeldahl nitrogen. It also includes a total nitrogen limit of 10 mg/L (monthly average) that complies with the nitrate WLA (Table 37). Spring Valley WWTP is currently rehabilitating their facility to focus on pre-treatment collection.

Mabel WWTP's NPDES permit includes a 30 mg/L TSS limit. This facility has had zero reported exceedances of the 30 mg/L TSS limit since January 2017. No further implementation at this facility is required to address the TSS impairment of Riceford Creek.

9.1.4 Feedlots

The NPDES and SDS feedlot permits include design, construction, operation, and maintenance standards that all CAFOs must follow. WLAs are not assigned to CAFOs in this TMDL report, including CAFOs with NPDES or SDS permits, and CAFOs not requiring permits; this is equivalent to a WLA of zero. If the CAFOs are properly permitted and operate under the applicable NPDES or SDS permit, then the CAFOs are expected to be consistent with this TMDL. MPCA inspections of large CAFOs focus on high risk facilities located within or near environmental justice areas, waters impaired by *E. coli* or excess nutrients, drinking water supply and vulnerable groundwater areas, and other sensitive water features, and on facilities that haven't been inspected in the most recent five years. CAFOs that are found to be noncompliant are required to return to compliance in accordance with applicable NPDES or SDS conditions and Minn. R. ch. 7020.

9.2 Nonpermitted sources

Several different implementations strategies can be used to reduce pollutant loading from nonpermitted sources. Table 64 lists examples of recommended strategies developed in consultation with local partners. In November 2023, the Root River 1W1P underwent a mid-point review, which will refine watershed implementation goals and strategies in future work plans. The Root River WRAPS Update (MPCA 2024a) summarizes recent tools, data and recommendations to serve the 1W1P update. In addition, HUC-12 specific implementation recommendations are provided in Section 0.

Table 64. Example BMPs to address for nonpermitted sources.

Strategy	BMP examples	Targeted TMDL pollutant(s)
Perennial vegetation	CRP prairie filter strips, grassed waterways and prairie restorations	Nitrate and TSS
Soil health practices	Cover crops and no-till/reduced tillage	Nitrate and TSS
Increasing water storage	WASCOBs, pond dams, terraces, floodplain restorations, controlled drainage and wetland restorations	TSS
Compliance of local programs	Feedlot inspections and SSTS inspections	Nitrate and *E. coli*
Nutrient management	Reducing commercial fertilizer rates, using manure management plans and using nitrate stabilizers	Nitrate and *E. coli*
Mapping	Develop map of springs and springsheds	Nitrate

9.3 Implementation recommendations by HUC-12 Watershed

9.3.1 Mill Creek

TSS TMDL implementation recommendations

Overland runoff is the largest source of sediment in the Mill Creek HUC-12 Watershed and stream bank erosion is a major contributor. TSS levels are highest in the headwater tributaries of Mill Creek and levels off below the confluence with the main stem of the stream. Implementation should focus on reducing TSS runoff from the headwater portion of the drainage area and reducing stream peak flow. Recommended BMPs are those that reduce sediment loss from the land (riparian vegetative buffers and good grazing practices) and BMPs that slow water movement (WASCOBs, terraces, grade stabilization structures, floodplain restoration) and increase infiltration (perennial vegetation, cover crops, etc.). Implementation efforts should begin by installing watershed BMPs and follow with in-channel BMPs such as bank stabilization and floodplain restoration when feasible.

When implementing the above strategies and BMPs, other stressors to the biological community that are not addressed by this TMDL report (physical habitat and flow alteration) should be considered and addressed wherever feasible.

Nitrate TMDL implementation recommendations

Nitrogen reduction efforts should be focused on the upper NW portion of the Mill Creek (-536) drainage area. Recommended strategies and BMPs will reduce nitrogen fertilizer inputs (including manure) on agricultural fields; therefore, reducing the amount of nitrate available to leach into groundwater and ultimately emerge in the groundwater fed impaired streams. This can be done through nutrient management plans and public outreach/education. Cover crops and perennial vegetation can also reduce nitrate leaching, particularly during critical leaching months (May and June).

While surface runoff of nitrate is a less significant source than groundwater inputs, incorporating fertilizer and manure, using reduced tillage, planting grassed waterways, and installing WASCOBs can reduce nitrate-laden surface runoff to streams.

Because of the RRW's karst geology, nitrate easily leaches into groundwater and enters surface waters through springs and groundwater seeps. Springsheds do not always follow surface watershed boundaries and may cross watershed boundaries. Mapping springsheds through dye-tracing can help to better understand the area of influence on impaired streams and should be conducted throughout the Mill Creek (-536) impairment watershed, with a focus in the upper portion of the watershed. Mapping is a critical tool for nitrate reduction for these impairments because it helps to define the land surface that impacts the underlying aquifer. Springsheds outside the surface watershed may also need to be targeted for nitrogen reduction practices.

In addition, feedlot and manure application compliance verification is particularly important for the sites that lack long term storage (pits, basins, etc.) that are designed to protect surface waters from pollutant loading.

9.3.2 Bear Creek

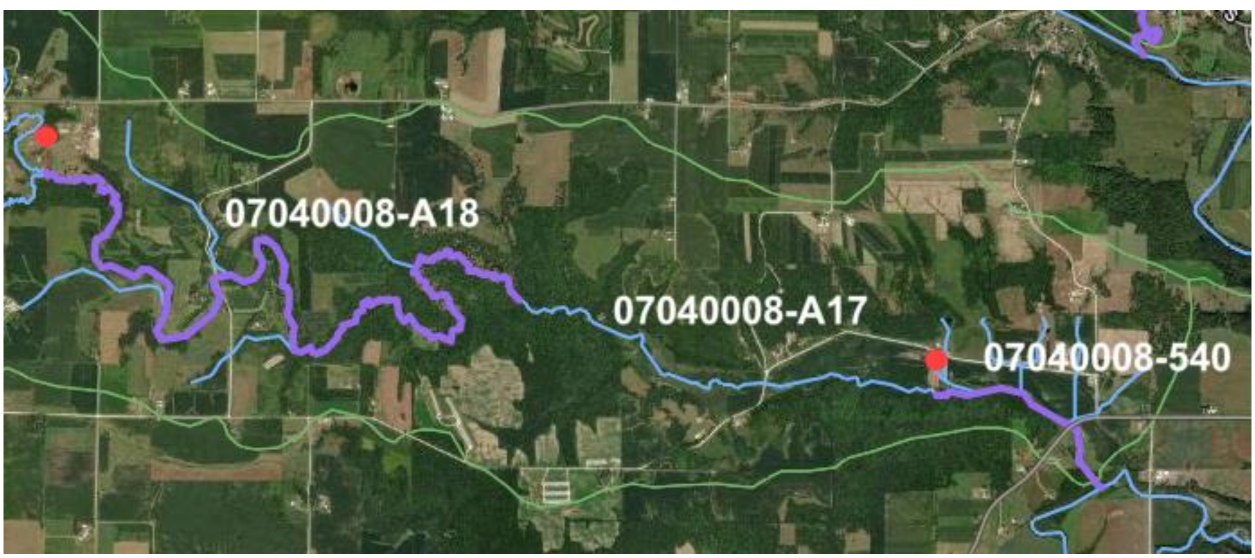
TSS TMDL implementation recommendations

Overland runoff is the largest source of sediment in the Bear Creek HUC-12 Watershed and stream bank erosion is a major contributor. Recommended BMPs are those that reduce sediment loss from the land (riparian vegetative buffers and good grazing practices) and BMPs that slow water movement (WASCOBs, terraces, grade stabilization structures, floodplain restoration) and increase infiltration (perennial vegetation, cover crops, etc.). Implementation efforts should begin by installing watershed BMPs and follow with in-channel BMPs such as bank stabilization and floodplain restoration when feasible.

Another consideration for implementation is that the TSS impairment in the Bear Creek HUC-12 Watershed occurs on two WIDs (-A18 and -540) (Figure 48). In between these two WIDs is another stream section (-A17) that is designated cool water (2B) and was assessed in 2020 as meeting standards for TSS and aquatic life. Although (-A17) may be meeting standards, the standard threshold for cool water streams is less restrictive (65 mg/L) than the upstream (-A18) and downstream (-540) cold water TSS standard (10 mg/L). TSS reduction practices in the drainage area of (-A17) may be needed for (-540) to achieve reductions identified in this TMDL.

When implementing the above implementation strategies and BMPs, other stressors present that are not addressed by this TMDL report (physical habitat and flow alteration) should be considered and addressed wherever feasible.

Figure 48. Bear Creek stream WIDs and impaired sections (in purple). Red dots are beginnings of impaired WIDs.



9.3.3 Spring Valley Creek HUC-12 (070400080407)

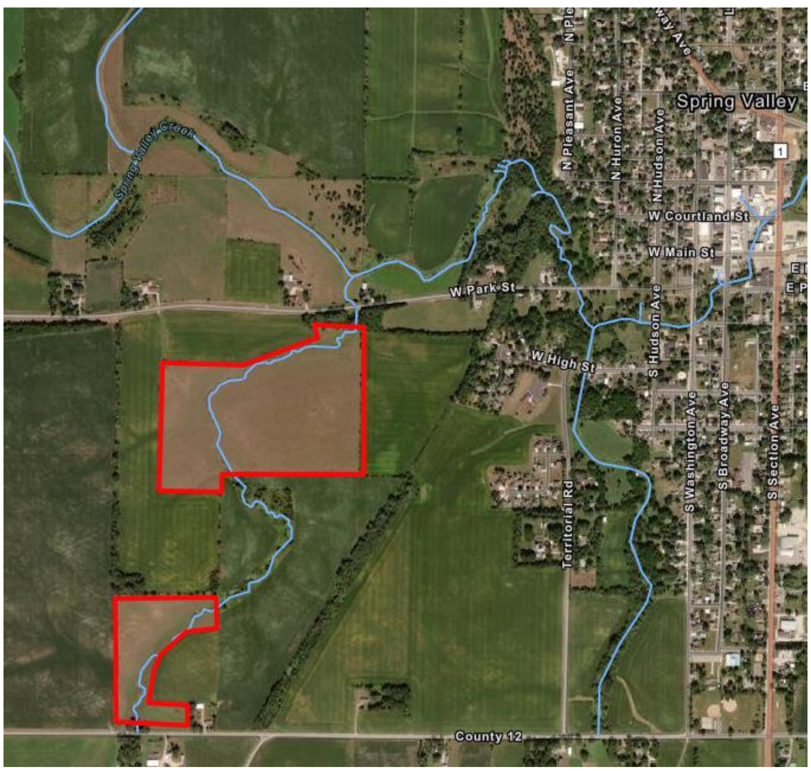
TSS TMDL implementation recommendations

Overland runoff is the largest source of sediment in the Spring Valley Creek HUC-12 Watershed and stream bank erosion is a major contributor. Recommended BMPs are those that reduce sediment loss from the land (riparian vegetative buffers and good grazing practices) and BMPs that slow water movement (WASCOBs, terraces, grade stabilization structures, floodplain restoration) and increase infiltration (perennial vegetation, cover crops, etc.).

Select riparian areas of Spring Valley Creek should be targeted for bank stabilization and/or floodplain reconnection. For example, SID work located a hot spot for overland TSS runoff in the drainage area to Spring Valley Creek (-D53). Aerial imagery shows large areas of what appears to be minimally vegetated pastures (Figure 49). These specific areas could be contributing to the sediment load particularly during times of overland runoff. MPCA staff also noted that even during times of low flow, increased turbidity was noted from this tributary. This is likely due to an influx of sediment from unstable banks combined with low stream gradient.

When implementing the above recommendations, other stressors to the biological community that are not addressed by this TMDL report (physical habitat, temperature and flow alteration) should be considered and addressed wherever feasible.

Figure 49. High risk areas (outlined in red) for sediment loading in the drainage area of Unnamed Creek (-D53), tributary to Spring Valley (-548).



Nitrate TMDL implementation strategies

Similar to Mill Creek, reducing nitrogen fertilizer inputs (including manure) on agricultural fields will be the most effective strategy for reducing nitrate to Spring Valley Creek (-548) as it reduces the amount of nitrate available to leach into groundwater and ultimately emerge in groundwater fed impaired streams. This can be done through nutrient management plans and public outreach/education. Cover crops, reduced tillage, and perennial vegetation can also reduce nitrate leaching, particularly during critical leaching months (May and June).

While surface runoff of nitrate is a less significant source than groundwater inputs, incorporating fertilizer and manure, using reduced tillage, planting grassed waterways, and installing WASCOBs can reduce nitrate-laden surface runoff to streams.

In addition, feedlot compliance verification is particularly important for feedlots that lack long term storage (pits, basins, etc.) that are designed to protect surface waters from pollutant loading.

Springshed mapping is available for select middle portions of the Spring Valley HUC-12. Additional springshed mapping is needed for the upper portion of this subwatershed to appropriately define the land surface that impacts the underlying aquifer. Springsheds outside the surface watershed may also need to be targeted for nitrogen reduction practices.

Spring Valley WWTP's NPDES permit was recently reissued on September 1, 2023. The NPDES permit now includes weekly monitoring for total nitrite + nitrate, total ammonia, and total Kjeldahl nitrogen. It also includes a total nitrogen limit of 10 mg/L (monthly average) that will comply with the nitrate WLA (Table 37). Spring Valley WWTP is currently rehabilitating their facility to focus on pre-treatment collection.

9.3.4 Camp Creek HUC-12 (070400080407)

TSS TMDL Implementation strategies

Overland runoff is the largest source of sediment in the Camp Creek HUC-12 Watershed and stream bank erosion is a major contributor. Implementation should focus on reducing TSS runoff from the headwater portion of the drainage area and reducing stream peak flow. Recommended BMPs are those that reduce sediment loss from the land (riparian vegetative buffers and good grazing practices) and BMPs that slow water movement (WASCOBs, terraces, grade stabilization structures, floodplain restoration) and increase infiltration (perennial vegetation, cover crops, etc.). Implementation efforts should begin by installing watershed BMPs and follow with in-channel BMPs such as bank stabilization and floodplain restoration when feasible.

When implementing the above strategies, other stressors to the biological community that are not addressed by this TMDL report (nitrate, physical habitat, temperature and flow alteration) should be considered and addressed wherever feasible.

Camp Creek (-559) has a quarry located in the headwaters. An inspection completed by MPCA in 2022 found the quarry was not meeting the requirements of its stormwater discharge permit. The failures could allow the quarry to contribute significant sediment loading to Camp Creek (-559) (MPCA 2022c). The implementation and maintenance of appropriate BMPs in the quarry is needed to reduce the impacts on in-stream transparency and TSS. The SID report for the RRW (2022) identified temperature as an additional stressor to Camp Creek (-599). Quarry management practices to address the TSS impairment on this reach should also address temperature to the extent possible and practical.

9.3.5 Upper South Fork Root River HUC-12 (070400080801)

***E. coli* TMDL implementation strategies**

Recommended strategies to address the *E. coli* impairment on South Fork Root River (-511) are provided below by the sources most likely contributing *E. coli* to the system.

- **Manure runoff from cropland:** The timing of manure spreading, as well as the application rate and method, affects the likelihood of pollutant loading to nearby water bodies. The spreading of manure on frozen soil in the late winter is likely to result in surface runoff with precipitation and snowmelt runoff events. Deferring manure application until snow has melted and soils have thawed decreases overland runoff associated with large precipitation events. Injecting or incorporating manure is a preferred practice to reduce the runoff of waste and associated pollutants. Incorporating manure into the soil reduces the risk of surface runoff associated with large precipitation events. Tools like MDA's Runoff Risk Advisory Forecast are helpful in identifying high run-off risk fields.
- **Non-NPDES/SDS permitted animal feeding operations and pastureland:** Efforts should be made at the facilities to reduce runoff from individual feedlots and manure storage areas. Animal feeding operations with pastured areas should strive to restrict livestock from continuous access to the impaired stream and consider alternative watering. Rotational grazing for livestock can also work to reduce runoff from pastured areas. In addition, feedlot compliance verification is particularly important for the sites that lack long term storage (pits, basins, etc.) that are designed to protect our surface waters from pollutant loading.
- **Nonpermitted wastewater**: The most cost-effective implementation activity for managing *E. coli* loads from SSTSs is regular maintenance. The EPA recommends that septic tanks be pumped every three to five years depending on the tank size and number of residents in the household (EPA 2002). Annual inspections, in addition to regular maintenance, ensure that systems function properly. State rules mandate a 10-month deadline for IPHTs to be brought into compliance. Local units of government set corrective timelines for noncompliant SSTSs that are not IPHTs. The reductions in loading resulting from upgrading or replacing failing systems in the watershed depend on the level of failure present in the watershed. Public education is another crucial component of reducing pollutant loading from SSTSs. Education can occur through public meetings, routine SSTS service provider home visits, mass mailings, and radio and television advertisements. An inspection program can also help with public education because inspectors can educate owners about proper operation and maintenance during inspections.

It is important to understand which sources are significantly contributing *E. coli* to the Upper South Fork Root River when conducting TMDL implementation. Longitudinal *E. coli* monitoring at different points along the stream reach can help determine areas where concentrations of *E. coli* are highest. Sampling under both high and low flows can also provide insight on the sources of *E. coli* in the reach and the conditions under which exceedances occur. Microbial source tracking can provide additional clarity on *E. coli* sources, if needed, by using host-associated quantitative Polymerase Chain Reaction (qPCR) methods to identify microbial contamination from key animal groups such as human, ruminant (e.g., cattle, deer), avian (i.e., birds) and canine. See Section 8 for more information on monitoring recommendations.

9.3.6 Riceford Creek HUC-12 (070400080804)

TSS TMDL implementation strategies

Overland runoff is the largest source of sediment in the Riceford Creek HUC-12 Watershed and stream bank erosion is a major contributor. Implementation should focus on reducing TSS runoff from the headwater portion of the drainage area and reducing stream peak flow. Recommended BMPs are those that reduce sediment loss from the land (riparian vegetative buffers and good grazing practices) and BMPs that slow water movement (WASCOBs, terraces, grade stabilization structures, floodplain restoration) and increase infiltration (perennial vegetation, cover crops, etc.). Implementation efforts should begin by installing watershed BMPs and follow with in-channel BMPs such as bank stabilization and floodplain restoration when feasible.

Of all subwatersheds discussed in this report, Riceford Creek has the most nonmetallic mining facilities (Table 12). Ensuring the compliance of these facilities will safeguard Riceford Creek from point source TSS loads.

When implementing the above strategies, other stressors to the biological community that are not addressed by this TMDL report (nitrate, habitat and flow alteration) should be considered and addressed wherever feasible.

Another consideration for implementation strategies is that Riceford Creek's TSS standard is higher in the warm headwaters section (65 mg/L) and lower in the downstream coldwater section (10 mg/L). Additional work may be needed in the drainage area of (-H01) beyond meeting the 65 mg/L TSS standard so that the downstream section (-518) can meet the 10 mg/L TSS standard.

9.4 Water quality trading

Water quality trading can help achieve compliance with WLAs or water quality based effluent limits. Water quality trading can also offset increased pollutant loads in accordance with antidegradation regulations. Water quality trading reduces pollutants (e.g., TP or TSS) in rivers and lakes by allowing a permitted discharger to enter into agreements under which the permittee "offsets" its pollutant load by obtaining reductions in a pollutant load discharged by another permitted source or by a nonpermitted source or sources in the same watershed. The MPCA must establish specific conditions governing trading in the discharger's NPDES permit or in a general permit that covers the discharger. The MPCA implements water quality trading through permits. See MPCA's *Water Quality Trading Guidance* (MPCA 2022b) for more information.

9.5 Cost

Total implementation cost for this TMDL was developed using cost information in the 2016 RRW TMDL (MPCA 2016) and is approximately $1.8 million. Cost details are provided below by pollutant.

TSS

The 2016 RRW TMDL estimated that it would cost $195 million over 10 years to address the TSS impairments in the watershed. As this estimate is based on a watershed based treatment approach for the entire RRW, it is assumed that the previously estimated $195 million is sufficient to fund implementation of the TSS TMDLs in this report as well. No further costs are assigned.

Nitrate

The drainage areas for nitrate impaired streams in this RRW TMDL cover approximately 39,738 acres, or 3.7% of the total watershed area of approximately 1,064,961 acres of the entire RRW (Minnesota portion only). An estimated cost of $250,000 to $400,000 is needed to implement the nitrate TMDLs in this report. This estimate is based on implementation of cover crop and fertilizer management practices. To estimate implementation costs for the nitrate impairments in this TMDL, an implementation strategy scenario was developed using MPCA's Pollutant Load Reduction Calculator to achieve the load reductions provided in the TMDL tables. Costs from the University of Minnesota's Nitrogen Best Management spread sheet were then applied. A conservative reduction of 12% was used for each nitrate impairment (email correspondence with NRS staff on August 4, 2023).

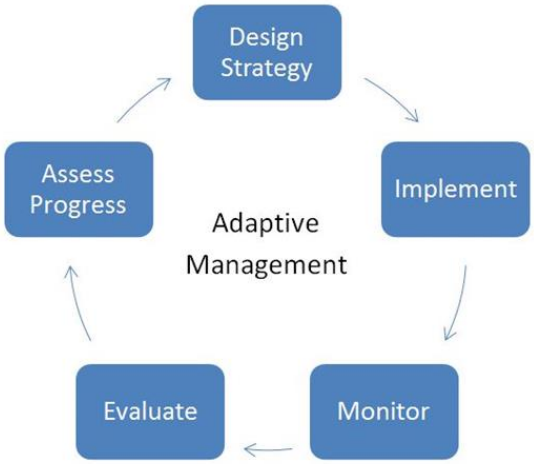
E. coli

The cost estimate for addressing the *E. coli* impairment on the South Fork Root River (-511) is based on unit costs provided in the 2016 RRW TMDL. The unit cost for bringing AUs under manure management plans and feedlot lot runoff controls is estimated at $350/AU. This value is based on the USDA EQIP payment history and includes buffers, livestock access control, manure management plans, waste storage structures, and clean water diversions. Repair or replacement of IPHTs and failing SSTS was estimated at $7,500/system in the 2016 TMDL. Multiplying those unit costs by an area weighted estimate of 12 imminent threat to public health and safety (ITPHS) and failing SSTS and a reported 3959 AU in the impaired drainage area of the South Fork River (-511) provides a total implementation cost of approximately $1.4 million.

9.6 Adaptive management

The implementation strategies and the more detailed WRAPS report update prepared concurrently with this TMDL report are based on the principle of adaptive management (Figure 50). Continued monitoring and "course corrections" responding to monitoring results are the most appropriate strategy for attaining the water quality goals established in this TMDL report. Management activities will be changed or refined as appropriate over time to efficiently meet the TMDL and lay the groundwork for de-listing the impaired water bodies.

Figure 50. Adaptive management.



10. Public participation

An opportunity for public comment on the draft TMDL report was provided via a public notice in the State Register from February 20, 2024 through March 21, 2024. There were xx comment letters received and responded to as a result of the public comment period. For further information on public participation for this TMDL report, please see the WRAPS report.

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Appendices

Appendix A

This appendix lists all of the impairments in the RRW along with the TMDL status of each impairment (Table 65). Planned recategorizations are provided for listings that have been further assessed and for which recategorization will be considered. Recategorizations will not be final until they are approved by EPA as part of Minnesota's list of impaired water bodies; therefore, this table represents a snapshot in time, and the EPA category or planned recategorization may change.

Table 65. Impaired water bodies in the RRW.

Water body name	Water body description	WID (HUC-8-)	Use class [a]	Year added to list	Affected designated use [b]	Listing parameter	Stressors to bioassessment impairments		EPA category in next impaired waters list [c]	TMDL developed in this report
							Confirmed	Inconclusive		
Mill Creek	T105 R12W S14, north line to N Br Root R	-536	1B, 2Ag	2020	AQL	Benthic macroinvertebrates	TSS, nitrate. Physical habitat, flow alteration		5	Yes: TSS
				2020	AQL	Fish	TSS, nitrate, Physical habitat, flow alteration		5	Yes: TSS
				2012	AQR	*E. coli*			4A	No: completed in 2017
				2022	DW	Nitrate			4A	Yes: nitrate
Willow Creek	T101 R11W S12, west line to S Br Root R	-558	1B, 2Ag	2012	AQL	Benthic macroinvertebrates	Nitrate and Physical Habitat		4A	No: completed in 2017
				2010	DW	Nitrate			4A	No: completed in 2017
				2012	AQR	*E. coli* (2017)			4A	No: completed in 2017
Unnamed Ck	Unnamed cr to Unnamed cr	-F46	2Bg	2012	AQL	Benthic macroinvertebrates	Physical habitat	Dissolved Oxygen, Eutrophication, Flow Alteration, Nitrates, Pesticides	5	No: inconclusive stressors
Unnamed Ck	Unnamed cr to N Br Root R	-706	2Bg	2012	AQL	Benthic macroinvertebrates	Physical habitat	Dissolved Oxygen, Eutrophication, Flow Alteration, Nitrates, Pesticides, Suspended Solids	5	No: inconclusive stressors
South Fork Bear Ck	Headwaters to Kedron Cr	-544	2Bg	2012	AQL	Benthic macroinvertebrates	Physical habitat	Flow Alteration, Nitrates, Pesticides, Suspended Solids	5	No: inconclusive stressors
Middle Branch Root R.	N Br Root R to Lynch Cr	-534	2Bg	2012	AQL	Benthic macroinvertebrates	Physical habitat	Dissolved Oxygen, Eutrophication, Flow Alteration, Nitrates, Pesticides	5	No: inconclusive stressors
				2010	AQR	*E. coli*			4A	No: completed in 2017

Water body name	Water body description	WID (HUC-8-)	Use class [a]	Year added to list	Affected designated use [b]	Listing parameter	Stressors to bioassessment impairments: Confirmed	Stressors to bioassessment impairments: Inconclusive	EPA category in next impaired waters list [c]	TMDL developed in this report
				2004	AQC	Mercury			4A	No: completed in 2008
Rice Creek	T104 R11W S23, west line to M Br Root R	-581	1B, 2Ag	2012	AQL	Benthic macroinvertebrates	Physical habitat, nitrate	Flow Alteration, Longitudinal Connectivity, Pesticides, Suspended Solids, Temperature)	5	No: inconclusive stressors
						Fish				
Unnamed Ck (Wadden Valley Ck)	Unnamed cr to M Br Root R	-605	2Bg	2012	AQL	Benthic macroinvertebrates		Physical habitat, nitrate & DO	5	No: inconclusive stressors
				2022		Fish			5	No: inconclusive stressors
Forestville Creek	Unnamed cr to S Br Root R	-563	1B, 2Ag	2006	AQL	Turbidity			5	No: Additional data needed.
				2008	AQR	*Fecal coliform (E. coli)*			4A	No: completed in 2017
				2010	DW	Nitrate			4A	No: completed in 2017
Pine Creek	Headwaters to T105 R9W S32, south line	-576	2Bg	2012	AQL	Benthic macroinvertebrates	Physical habitat	DO, Eutrophication, Flow Alteration, Nitrates, Pesticides, TSS	5	No: inconclusive stressors
Money Creek	Unnamed cr to M Br Root R	-F48	2Bg	2012	AQL	Benthic macroinvertebrates		Physical habitat, nitrate and DO	5	No: inconclusive stressors
Money Creek	T105 R7W S21, north line to Root R	-521	2Bg	2008	AQL	Turbidity			5	No: MIBI and FIBI meeting; additional info needed prior to writing TSS TMDL.
				2004	AQR	Fecal coliform			4A	No: completed in 2006

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							Confirmed	Inconclusive		
Unnamed Creek	T104 R8W S32, east line to Unnamed cr	-659	1B, 2Ag	2012	AQL	Benthic macroinvertebrates	Physical habitat	TSS, Flow Alteration, Pesticides,	5	No: inconclusive stressors
South Fork Root River	T102 R9W S26, west line to Wisel Cr	-511	1B, 2Ag	2008	AQL	Turbidity			5	No: MIBI and FIBI meeting; additional info needed prior to writing TSS TMDL.
				2010	AQC	Mercury			4A	No: completed in 2008.
				2022	AQR	*E. coli*			4A	Yes: *E. coli*
Silver Creek	T105 R6W S35, north line to T104 R6W S14, south line	-640	1B, 2Ag	2012	AQL	Benthic macroinvertebrates	Physical habitat	Temperature, nitrate and TSS	5	No: inconclusive stressors
Trout Run Ck	T105 R10W S18, north line to Unnamed cr	-G87	1B, 2Ag	2012	AQL	Benthic macroinvertebrates	Nitrate and Physical habitat	DO, Eutrophication, Flow Alteration, Pesticides	5	No: inconclusive stressors
Etna Creek	Unnamed cr to S Br Root R	-562	1B, 2Ag	2010	DW	Nitrate			4A	No: completed in 2017
Etna Ck	T102 R13W S36, west line to Unnamed cr	-597	1B, 2Ag	2012	AQL	Benthic macroinvertebrates	Nitrate	Physical habitat, Flow Alteration, Pesticides	5	No: TMDL deferred because water quality standard not established (nitrate); nonpollutant
Rush Ck	Unnamed cr to Pine Cr	-524	1B, 2Ag	2012	AQL	Benthic macroinvertebrates	Nitrate and Physical habitat	DO, Eutrophication, Flow Alteration, Pesticides	5	No: inconclusive stressors

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							Confirmed	Inconclusive		
South Fork Root River	Wisel Cr to T102 R8W S2, east line	-510	1B, 2Ag	2012	AQL	Benthic macroinvertebrates	Nitrate and Physical habitat	TSS, Temperature, Flow Alteration, Pesticides	5	No: inconclusive stressors
				2010	AQC	Mercury			4A	No: completed in 2008
Sorenson Creek	Unnamed cr to Unnamed cr	-F52	2Bg	2012	AQL	Benthic macroinvertebrates	Nitrate and Physical habitat	DO, Eutrophication, Flow Alteration, Pesticides	5	No: inconclusive stressors
Riceford Creek	T101 R7W S19, south line to T102 R7W S30, north line	-518	1B, 2Ag	2012	AQL	Benthic macroinvertebrates	Physical habitat, TSS, nitrate	Pesticides	5	Yes: TSS
Root River	Thompson Cr to Mississippi R	-501	2Bg	2012	AQL	Benthic macroinvertebrates	Physical habitat, TSS, Nitrate*	Flow Alteration, Pesticides	5	No: TSS TMDL completed in 2017
				1994		Turbidity			4A	No: TSS TMDL completed in 2017
				1994	AQR	Fecal coliform			4A	No: completed in 2006
				2010	AQC	Mercury			4A	No: completed in 2008
Root River	S Fk Root R to Thompson Cr	-502	2Bg	2012	AQL	Benthic macroinvertebrates	TSS, Physical habitat and Nitrate*	Flow Alteration, Pesticides	5	No: TSS TMDL completed in 2017
						Turbidity			4A	No: TSS TMDL completed in 2017
				2010	AQC	Mercury			4A	No: completed in 2008
Root River	Money Cr to S Fk Root R	-520	2Bg	2012	AQL	Benthic macroinvertebrates	Physical habitat and TSS	Nitrate, Flow Alteration, Pesticides	5	No: TSS TMDL completed in 2017
				2022		TSS			4A	No: TSS TMDL completed in 2017

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				2010	AQC	Mercury			4A	No: completed in 2008
Root River	Rush Cr to Money Cr	-522	2Bg	2012	AQL	Benthic macroinvertebrates	Physical habitat and TSS	Nitrate, Flow Alteration, Pesticides	5	No: TSS TMDL completed in 2017
				2010	AQC	Mercury			4A	No: completed in 2008
Root River	M Br Root R to Rush Cr	-527	2Bg	2012	AQL	Benthic macroinvertebrates	Physical habitat and TSS	Nitrate, Flow Alteration, Pesticides	5	No: TSS TMDL completed in 2017
				2010		Turbidity			4A	No: TSS TMDL completed in 2017
				2010	AQC	Mercury			4A	No: completed in 2008
Middle Branch Root R	Trout Run Cr to S Br Root R	-528	2Bg	2022	AQL	TSS			4A	No: TSS TMDL completed in 2017
				2004	AQC	Mercury			4A	No: completed in 2008
Middle Branch Root	Upper Bear Cr to N Br Root R	-506	2Bg	2002	AQC	Mercury			4A	No: completed in 2008
				2012	AQR	*E. coli*			4A	No: completed in 2017
Upper Bear Creek	T104 R11W S18, west line to M Br Root R	-540	1B, 2Ag	2012	AQL	Fish	Nitrate, TSS, Flow Alteration and Physical habitat	Physical Connectivity and Pesticides	5	Yes: TSS
						Benthic macroinvertebrates				Yes: TSS
Bear Creek	Kedron Cr to M Br Root R	-542	2Bg	2012	AQR	*E. coli*			4A	No: completed in 2017
Spring Valley Creek	T103 R13W S29, west line to Deer Cr	-548	1B, 2Ag	2012	AQL	Fish	Nitrate, TSS, Physical habitat, Flow Alteration and Temperature	DO, Eutrophication, Metals/Toxic, Pesticides	5	Yes: TSS
				2012		Benthic macroinvertebrates				
				2022		TSS			4A	Yes: TSS

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				2012	AQR	*E. coli*			4A	No: completed in 2017
				2022	DW	Nitrate			4A	Yes: nitrate
North Branch Root	Unnamed cr to Mill Cr	-716	2Bg	2012	AQL	Benthic macroinvertebrates	TSS and Physical habitat	Nitrate, Flow Alteration, Pesticides	5	No: TSS TMDL completed in 2017
				2008		Turbidity			4A	No: completed in 2017
North Branch Root	Headwaters to Carey Cr	-717	2Bg	2012	AQL	Benthic macroinvertebrates	TSS, Physical habitat and DO	Nitrate, Eutrophication, Flow Alteration, Pesticides	5	No: TSS TMDL completed in 2017
				2008		Turbidity			4A	No: TMDL completed in 2017
South Branch Root River	Duschee Cr to M Br Root R	-550	1B, 2Ag	2012	AQR	*E. coli*			4A	No: TMDL completed in 2017
				2022	AQL	TSS			4A	No: TMDL completed in 2017
Watson Creek	T103 R11W S30, west line to S Br Root R	-552	1B, 2Ag	2010	Drinking water	Nitrate			4A	No: TMDL completed in 2017
				2012	AQR	*E. coli*			4A	No: TMDL completed in 2017
					AQL	Fish	TSS, nitrate, Physical habitat, flow alteration and Temperature	Pesticides	4A	No: TSS and N TMDL completed in 2017
						Benthic macroinvertebrates			4A	No: TSS and N TMDL completed in 2017
				2022		TSS			4A	No: TMDL completed in 2017

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South Branch Root	T102 R12W S21, north line to Canfield Cr	-556	1B, 2Ag	2006	AQL	TSS			4A	No: TMDL completed in 2017
Camp Creek	Headwaters to S Br Root R	-559	1B, 2Ag	2012	AQL	Fish	Nitrate, TSS, Physical habitat, flow alteration and Temperature	Pesticides	5	Yes: TSS
						Benthic macroinvertebrates				
So. Fk. Root R.	Beaver Cr to Root R	-508	2Bg	2012	AQL	Benthic macroinvertebrates	TSS, Physical habitat and Nitrate*	Flow Alteration, Pesticides	5	No: TSS TMDL completed in 2017
						Turbidity			4A	No: TMDL completed in 2017
				2010	AQC	Mercury			4A	No: TMDL completed in 2010
				2012	AQR	*E. coli*			4A	No: TMDL completed in 2017
So. Fk. Root R.	Riceford Cr to Beaver Cr	-509	2Bg	2012	AQL	Benthic macroinvertebrates	TSS and Physical habitat	Nitrate, Flow Alteration, Pesticides	5	No: TSS TMDL completed in 2017
				2010	AQC	Mercury			4A	No: TMDL completed in 2010
So. Fk. Root R.	Headwaters to T102 R9W S27, east line	-573	2Bg	2012	AQL	Benthic macroinvertebrates	TSS, Physical habitat, Nitrate*, Eutrophication, Flow Alteration and DO	Temperature and Pesticides	5	No: TSS TMDL completed in 2017
						Turbidity			4A	No: TMDL completed in 2017

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							Confirmed	Inconclusive		
				2010	AQC	Mercury			4A	No: TMDL completed in 2017
Canfield Creek	T102 R12W S25, west line to S Br Root R	-557	1B, 2Ag	2010	DW	Nitrate			4A	No: TMDL completed in 2017
Deer Creek	Headwaters to M Br Root R	-546	2Bg	2012	AQR	*E. coli*			4A	No: TMDL completed in 2017
Robinson Creek	Headwaters to N Br Root R	-503	2Bg	1994	AQR	Fecal coliform			4A	No: TMDL completed in 2006
Root River, Middle Branch	Rice Cr to Trout Run Cr	-530	2Bg	2004	AQC	Mercury			4A	No: TMDL completed in 2008
Root River, Middle Branch	Lynch Cr to Rice Cr	-532	2Bg	2004	AQC	Mercury			4A	No: TMDL completed in 2008
Root River, Middle Branch	Bear Cr to T103 R12W S9, north line	-B95	1B, 2Bdg	2002	AQC	Mercury			4A	No: TMDL completed in 2008
Root River, Middle Branch	T103 R12W S4, south line to Upper Bear Cr	-B96	2Bg	2002	AQC	Mercury			4A	No: TMDL completed in 2008
Root River, Middle Branch (Deer Creek)	Spring Valley Cr to Bear Cr	-545	1B, 2Bdg	2006	AQC	Mercury			4A	No: TMDL completed in 2008
North Branch Root River	Mill Cr to M Br Root R	-535	2Bg	2012	AQR	*E. coli*			4A	No: TMDL completed in 2017
South Branch Root River	Willow Cr to Camp Cr	-554	1B, 2Ag	2006	AQL	Turbidity			4A	No: TSS TMDL completed in 2017

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							Confirmed	Inconclusive		
South Branch Root River	Canfield Cr to Willow Cr	-555	1B, 2Ag	2004	AQL	Turbidity			4A	No: TMDL completed in 2017
					AQR	Fecal coliform			4A	No: TMDL completed in 2006
				2010	DW	Nitrate			4A	No: TMDL completed in 2017
South Branch Root River	Headwaters to T102 R14W S14, north line	-H18	2Bg	2004	AQR	Fecal coliform			4A	No: TMDL completed in 2006
				2022	AQL	Benthic macroinvertebrates	Nitrate, DO, Habitat, Flow alteration	TSS and Pesticides	5	No: Deferred due to no N standard and inconclusive stressor
South Branch Root River	T102 R14W S11, south line to T102 R12W S16, south line	-H19	2Bg	2004	AQL	Fecal coliform			4A	No: TMDL completed in 2006
South Fork Root River	T102 R8W S1, west line to Riceford Cr	-572	2Bg	2010	AQC	Mercury			4A	No: TMDL completed in 2010
Rush Creek	Pine Cr to Root R	-523	1B, 2Ag	2012	AQR	*E. coli*			4A	No: TMDL completed in 2017
Thompson Creek	T103 R5W S12, south line to Root R	-507	1B, 2Ag	2012	AQR	*E. coli*			4A	No: TMDL completed in 2017
Trout Run Creek	Unnamed cr to M Br Root R	-G88	1B, 2Ag	2012	AQR	*E. coli*			4A	No: TMDL completed in 2017

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							Confirmed	Inconclusive		
Bear Creek (Lost Creek)	Unnamed cr to T104 R12W S10, east line	-A18	1B, 2Ag	2022	AQL	Benthic macroinvertebrates	Nitrate, TSS, Habitat and Flow alteration	Connectivity	5	No: TMDL deferred because water quality standard not established (nitrate); nonpollutant stressor (flow and habitat)
				2022	AQL	Fish				
				2022	AQL	TSS			4A	Yes: TSS
Bear Creek, North Fork	Unnamed cr to Unnamed cr	-F45	2Bg	2020	AQL	Benthic macroinvertebrates	Not determined		5	No: additional work needed to determine stressors
Bridge Creek	Unnamed cr to Unnamed cr	-G92	1B, 2Ag	2022	AQL	Benthic macroinvertebrates	Habitat and flow alteration	TSS and Pesticides	5	No: inconclusive stressors
Corey Creek	T105 R6W S18, east line to Money Cr	-631	1B, 2Ag	2012	AQL	Fish	Flow Alteration, Connectivity, Habitat, Temperature		4C	No: recategorized to 4C
County Ditch 8	Unnamed cr to Deer Cr	-F44	2Bg	2020	AQL	Benthic macroinvertebrates	Not determined		5	No: additional work needed to determine stressors
Crystal Creek	T102 R11W S35, south line to Willow Cr	-601	1B, 2Ag	2022	DW	Nitrate			4A	No: N TMDL completed in 2017
Jordan Creek	Unnamed cr to Unnamed cr	-713	2Bg	2020	AQL	Benthic macroinvertebrates	Not determined		5	No: additional work needed to determine stressors
Judicial Ditch 1	Unnamed cr to S Br Root R	-561	2Bg	2020	AQL	Benthic macroinvertebrates	Not determined		5	No: additional work needed

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							Confirmed	Inconclusive		
										to determine stressors
Riceford Creek	-91.814, 43.512 to T101 R8W S17, east line	-H01	2Bg	2020	AQL	Benthic macroinvertebrates	Nitrate, TSS, Habitat and Flow alteration		5	Yes: TSS TMDL
Unnamed creek (Bloody Run Creek)	T102 R11W S24, west line to Willow Cr	-F08	1B, 2Ag	2020	AQL	Benthic macroinvertebrates	Not determined		5	No: additional work needed to determine stressors
				2020		Fish	Not determined		5	No: additional work needed to determine stressors
				2022	DW	Nitrate			4A	No: N TMDL completed in 2017
Unnamed creek (Mill Creek Tributary)	T105 R12W S14, west line to Unnamed cr	-A47	1B, 2Ag	2022	DW	Nitrate			4A	Yes: nitrate TMDL
Unnamed creek (Spring Valley Creek Tributary)	T103 R13W S32, south line to Spring Valley Cr	-D53	1B, 2Ag	2022	DW	Nitrate			4A	Yes: nitrate TMDL
Unnamed creek (Watson Creek Tributary)	T103 R11W S30, south line to Watson Cr	-E61	1B, 2Ag	2022	DW	Nitrate			4A	No: N TMDL completed in 2017
Unnamed creek (Watson Creek Tributary)	T103 R11W S30, north line to Watson Cr	-E62	1B, 2Ag	2022	DW	Nitrate			4A	No: N TMDL completed in 2017

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							Confirmed	Inconclusive		
Unnamed creek (Watson Creek Tributary)	T103 R11W S30, north line to Watson Cr	-E63	1B, 2Ag	2022	DW	Nitrate			4A	No: N TMDL completed in 2017
Unnamed creek (Watson Creek Tributary)	Unnamed cr to Unnamed cr	-E75	1B, 2Ag	2022	DW	Nitrate			4A	No: N TMDL completed in 2017

* Stressor has not been addressed by a TMDL.

a. 1B: domestic consumption; 2Ag: aquatic life and recreation—general cold water habitat; 2Bg: aquatic life and recreation—general warm water habitat; 2Bdg aquatic life and recreation – general warm water habitat also protected as a source for drinking water; 7: limited resource value water.

b. AQR: aquatic recreation, AQL: aquatic life, AQC: aquatic consumption, DW: drinking water

c. 4A: Impaired and a TMDL study has been approved by USEPA. All TMDLs needed to result in attainment of applicable WQS for this impairment have been approved or established by EPA. For biological impairments, there are no remaining inconclusive stressors.
4C: Impaired but a TMDL study is not required because the impairment is not caused by a pollutant.
4D: Impaired but a TMDL study is not required because the impairment is due to natural conditions with insignificant anthropogenic influence.
5: Impaired and a TMDL study has not been approved by EPA