Watershed

November 2020

Mississippi River – Sartell Watershed *E. coli and Phosphorus* Total Maximum Daily Load

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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Abbreviations

1W1P	One Watershed, One Plan
AFO	animal feeding operation
AUID	assessment unit identification
BMP	best management practice
BWSR	Board of Water and Soil Resources
CAFO	concentrated animal feeding operation
CFR	Code of Federal Regulations
cfu	colony forming unit
chl-*a*	chlorophyll-*a*
CWA	Clean Water Act
CWF	Clean Water Fund
DO	dissolved oxygen
DMR	discharge monitoring report
DNR	Minnesota Department of Natural Resources
DWSMA-SW	Drinking Water Supply Management Area–Surface Water
E. coli	*Escherichia coli*
EPA	United States Environmental Protection Agency
EQuIS	Environmental Quality Information System
HSPF	Hydrologic Simulation Program–Fortran
HUC	hydrologic unit code
ITPHS	imminent threat to public health and safety
kg	kilogram
L	liter
LA	load allocation
lb	pound
lb/yr	pounds per year
m	meter
MBS	Mississippi–Brainerd/Sartell
MDA	Minnesota Department of Agriculture
MDH	Minnesota Department of Health

mgd	million gallons per day
mL	milliliter
MnDOT	Minnesota Department of Transportation
MOS	margin of safety
MPCA	Minnesota Pollution Control Agency
MRSW	Mississippi River–Sartell Watershed
MS4	municipal separate storm sewer system
N	sample count
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
org/day	organisms per day
SDS	State Disposal System
SSTS	subsurface sewage treatment system
SWCD	Soil and Water Conservation District
SWPPP	stormwater pollution prevention plan
TMDL	total maximum daily load
TP	total phosphorus
TSS	total suspended solids
USGS	United States Geological Survey
WLA	wasteload allocation
WPLMN	Watershed Pollutant Load Monitoring Network
WRAPS	Watershed Restoration and Protection Strategy
WWTP	wastewater treatment plant
µg	microgram

Executive summary

The Federal Clean Water Act (CWA), Section 303(d) requires total maximum daily loads (TMDLs) to be produced for surface waters that do not meet applicable water quality standards necessary to support their designated uses (i.e., an impaired water). A TMDL determines the maximum amount of a pollutant a receiving waterbody can assimilate while still achieving water quality standards and allocates allowable pollutant loads to various sources needed to meet water quality standards. This TMDL study addresses the impairments in the 1,025-square mile Mississippi River–Sartell Watershed (MRSW) in central Minnesota. These impairments include high levels of *Escherichia coli* (*E. coli*) and total phosphorus (TP), affecting aquatic recreation and limited resource value designated uses. Seventeen TMDLs are provided: fifteen *E. coli* stream TMDLs and two TP lake TMDLs.

Land cover in the watershed is predominantly agricultural with the dominant crops being corn, alfalfa, and soybeans. Developed land covers are scattered throughout the watershed, with more densely developed areas near the cities of Sartell and St. Cloud.

Potential sources of *E. coli* in the watershed include stormwater, wastewater, animal feeding operations (AFOs), wildlife, pets, septic systems and other human sources, and natural growth. The pollutant load capacity of the *E. coli*-impaired streams was determined using load duration curves. These curves represent the allowable pollutant load at any given flow condition. Water quality data were compared with the load duration curves to determine load reduction needs. The *E. coli* data, when taken as a whole, indicate that exceedances of the *E. coli* standard occur across all flow regimes, and *E. coli* load reductions are needed to address multiple source types. The estimated percent reductions needed to meet the *E. coli* TMDLs range from 45% to 97%.

Potential source of phosphorus in the watershed include stormwater, wastewater, AFOs, septic systems and untreated wastewater, loading from lakebed sediments and as a result of in-lake vegetation (referred to as internal load), streambank erosion, and atmospheric deposition. The nutrient loading capacity for each phosphorus-impaired lake was calculated using BATHTUB, an empirical model of reservoir eutrophication developed by the U.S. Army Corps of Engineers. The models were calibrated to existing water quality data. Reductions in phosphorus are presented on an average annual basis and will need to come primarily from agricultural runoff. The estimated percent reductions for Two Rivers Lakes was 54% and 45% for Platte Lake. A 10% explicit margin of safety (MOS) was incorporated into all (phosphorus and *E. coli*) TMDLs to account for uncertainty.

The TMDL implementation strategy (Section 9) highlights an adaptive management process to achieving water quality standards and restoring beneficial uses. Implementation strategies include agricultural runoff control and soil improvements (e.g., conservation tillage and cover crops); feedlot runoff control; nutrient management; pasture management; septic system improvements; converting land to perennials; buffers and filter strips; urban stormwater runoff control; and in-lake management. Public participation included meetings and information communication with watershed stakeholders at various points during the project. The TMDL study is supported by previous work including the *Mississippi River–Sartell Watershed Communication Plan* (Tetra Tech 2017), *Mississippi River–Sartell Monitoring and Assessment Report* (MPCA 2019a), *Mississippi River–Sartell Stressor Identification Report* (MPCA 2019b), and the *Upper Mississippi–Sartell Watershed HSPF Model Recalibration* (Tetra Tech 2019).

1. Project overview

1.1 Background

The Federal CWA, Section 3039d) requires that TMDLs be developed for waters that do not support their designated uses (i.e., an impaired water). In simple terms, a TMDL study determines what is needed to attain and maintain water quality standards in waters that are not currently meeting them. A TMDL study identifies pollutant sources as specifically as possible and allocates pollutant loads among those sources. The total of all allocations, including wasteload allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources (including natural background), and the MOS, which is implicitly or explicitly defined, cannot exceed the maximum allowable pollutant load.

This TMDL study covers 2 eutrophication (phosphorus) and 15 *E. coli* impairments in the MRSW (United States Geological Survey [USGS] Hydrologic Unit Code [HUC] 8 07010201). The project area covers the 1,025-square mile watershed in the Upper Mississippi River Basin in central Minnesota (Figure 1). The MRSW is also known locally as the Platte–Spunk Rivers Watershed.

Other TMDL reports address impairments in this watershed:

- Little Rock Creek Watershed: The Little Rock Creek Watershed TMDL Report: Dissolved Oxygen (DO), Nitrate, Temperature and Fish Bioassessment Impairments (Benton SWCD 2015) addresses aquatic life impairments and a drinking water impairment on Little Rock Creek and a drinking water impairment on Bunker Hill Creek. The Little Rock Lake Nutrient TMDL (Benton SWCD 2011) addresses an aquatic recreation impairment on Little Rock Lake.
- *E. coli* TMDLs: In the *Upper Mississippi River Bacteria TMDL Study and Protection Plan* (MPCA 2014a), *E. coli* TMDLs were developed on nine reaches in the MRSW to address aquatic recreation impairments. For planning purposes, the *E. coli* TMDLs in this report should be considered an addendum to the Upper Mississippi River TMDL work.
- Mercury. Some of the waterbodies in the MRSW are also impaired due to mercury; however, this report does not cover toxic pollutants. Mercury impaired lakes are addressed by a statewide TMDL study approved in 2007 (MPCA 2007a) and supporting updates approved in 2010, 2013, and 2014. For more information on mercury impairments, see the *Minnesota Statewide Mercury TMDL* (MPCA 2007a).

The aquatic consumption impairment on the Mississippi River main stem, from the Swan River to the Sauk River, is addressed in the statewide mercury TMDL (MPCA 2007a); there are no other impairments on the Mississippi River main stem in the MRSW.

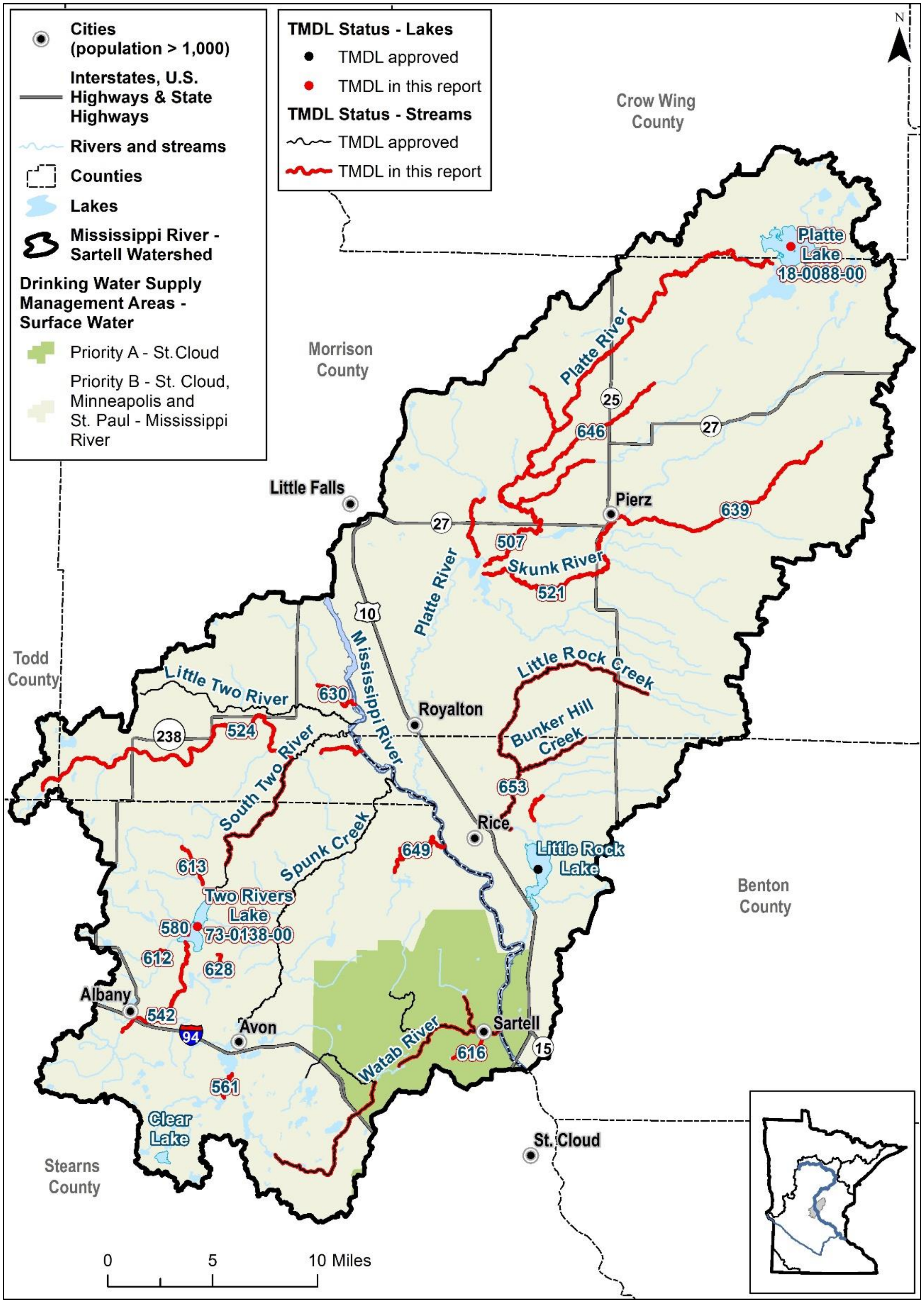

Figure 1. MRSW.

Numeric labels are lake IDs or the last three digits of stream AUIDs. Waterbodies with numeric labels are those with *E. coli* or phosphorus impairments, which are the impairments for which TMDLs are developed in this report. See Table 1 for a full list of impairments. Little Rock Creek, Bunker Hill Creek, South Two Rivers, South Fork Watab River, and Watab River have both TMDLs addressed in this report and approved TMDLs.

1.2 Identification of waterbodies

Waterbodies were assessed for impairment by the Minnesota Pollution Control Agency (MPCA), and results are presented in the *Mississippi River–Sartell Monitoring and Assessment Report* (MPCA 2019a). There are 3 impaired lakes and 28 impaired reaches, or assessment units, in the MRSW that do not have approved TMDLs (Table 1, Figure 1). The lakes have aquatic recreation impairments as identified by eutrophication indicators and/or aquatic life impairments as identified by fish bioassessments. The stream impairments affect aquatic life, aquatic recreation, and/or limited resource value designated uses based on DO, pathogens (fecal coliform or *E. coli*), fishes bioassessments, or macroinvertebrate assessments. Aquatic consumption impairments are not addressed in this report and therefore are not presented in Table 1.

Causes of the fish and macroinvertebrate impairments were investigated in the stressor identification reports (MPCA 2019b and DNR 2019). If the identified stressor(s) is a pollutant (e.g., TSS), and if there is a state water quality standard for that pollutant, a TMDL can be developed. Non-pollutant stressors (e.g., habitat) are not subject to load quantification and therefore do not require TMDLs. All aquatic life use impairments—not just those with associated TMDLs—are addressed in the watershed restoration and protection strategies (WRAPS) report (see Section 9 for more information on the MPCA's watershed approach). Appendix A lists the aquatic life impairments for which TMDLs are not developed.

For this report, the impairments are listed in tables ordered from upstream to downstream. All stream assessment unit identifications (AUIDs) for streams begin with 07010201, which is the eight-digit HUC for this watershed. The reaches are identified in this report with the last three digits of the full AUID. For example, AUID 07010201-507 is referred to as reach 507.

Table 1. Impaired waterbodies in the MRSW without approved TMDLs.

HUC10 Name	Waterbody Name	Reach Description	AUID [a] /Lake ID	Use Class [b]	Year Added to List	Affected Use	Pollutant or Stressor	TMDL Developed in This Report
City of Sartell–Mississippi River	Hay Creek	Unnamed cr to Mississippi R	630	2Bg	2020 [c]	Aquatic Recreation	*E. coli*	Y
Two River	North Two River	Headwaters (Mary Lk 77-0019-00) to South Two R	524	2Bg	2020 [c]	Aquatic Recreation	*E. coli*	Y
Two River	South Two River	T125 R31W S21, south line to T125 R31W S23, east line	542	7	2020 [c]	Limited Resource Value	*E. coli*	Y
Two River	Unnamed creek	Headwaters to Pelican Lk	628	2Bg	2020 [c]	Aquatic Recreation	*E. coli*	Y
Two River	South Two River	Schwinghammer Lk to Two River Lk	532	2Bg	2020 [c]	Aquatic Life	Dissolved oxygen	N [d]
Two River	Unnamed creek	Unnamed cr to Unnamed cr	612	2Bg	2020 [c]	Aquatic Recreation	*E. coli*	Y
Two River	Unnamed creek	Unnamed cr to Two Rivers Lk	580	2Bg	2020 [c]	Aquatic Recreation	*E. coli*	Y
Two River	Two Rivers Lake	–	73-0138-00	2B	2010	Aquatic Recreation	Nutrient/eutrophication biological indicators	Y
Two River	Two Rivers Lake	–	73-0138-00	2B	2020 [c]	Aquatic Life	Fishes bioassessments	N [d]
Two River	Krain Creek	Unnamed cr to Unnamed cr	613	2Bg	2020 [c]	Aquatic Recreation	*E. coli*	Y
Two River	South Two River	River St. to Two R.	643	2Bg	2020 [c]	Aquatic Life	Fishes bioassessments	N [e]
City of Sartell-Mississippi River	Hazel Creek	Unnamed ditch to Mississippi R	569	2Bg	2020 [c]	Aquatic Life	Fishes bioassessments	N [e]

HUC10 Name	Waterbody Name	Reach Description	AUID [a] /Lake ID	Use Class [b]	Year Added to List	Affected Use	Pollutant or Stressor	TMDL Developed in This Report
Spunk Creek	Clear Lake	–	73-0172-00	2B	2020 [c]	Aquatic Life	Fishes bioassessments	N [d]
	Spunk Branch	Kalla Lk to Upper Spunk Lk	561	2Bg	2020 [c]	Aquatic Recreation	*E. coli*	Y
Skunk River	Hillman Creek	370th Ave to Skunk R	639	2Bg	2020 [c]	Aquatic Recreation	*E. coli*	Y
	Skunk River	Hillman Cr to Platte R	521	2Bg	2008	Aquatic Recreation	Fecal coliform	Y
Upper Platte River	Platte Lake	–	18-0088-00	2B	2010	Aquatic Recreation	Nutrient/eutrophication biological indicators	Y
	Unnamed Creek	Unnamed cr to Platte R	634	2Bg	2020 [c]	Aquatic Life	Fishes bioassessments	N [e]
	Big Mink Creek	Headwaters to 235th Ave	646	2Bg	2020 [c]	Aquatic Recreation	*E. coli*	Y
	Big Mink Creek	235th Ave to Platte R	647	2Bg	2020 [c]	Aquatic Life	Aquatic macroinvertebrate bioassessments	N [d]
	Little Mink Creek	-94.119 46.014 to Platte R	645	2Bg	2020 [c]	Aquatic Life	Aquatic macroinvertebrate bioassessments	N [d]
	Platte River	Headwaters (Platte Lk 18-0088-00) to Skunk R	507	2Bg	2020 [c]	Aquatic Life	Fishes bioassessments	N [e]
					2020 [c]	Aquatic Recreation	*E. coli*	Y
	Unnamed Creek	-94.26 46.016 to Unnamed Cr	651	2Bg	2020	Aquatic Life	Aquatic macroinvertebrate bioassessments	N [e]
	Rice Creek	Pelkey Lk to Rice Lk	618	2Bg	2020 [c]	Aquatic Life	Aquatic macroinvertebrate bioassessments	N [e]
City of Sartell-Mississippi River	Stony Creek	-94.31 45.728 to Mississippi R	649	2Bg	2020 [c]	Aquatic Recreation	*E. coli*	Y

HUC10 Name	Waterbody Name	Reach Description	AUID [a] /Lake ID	Use Class [b]	Year Added to List	Affected Use	Pollutant or Stressor	TMDL Developed in This Report
Little Rock Creek	Little Rock Creek	T39 R30W S22, south line to T38 R31W S23, west line	652	1B, 2Ag	2020 [c]	Aquatic Life	Fishes bioassessments	N [e]
	Bunker Hill Creek	T38 R30W S6, north line to Little Rock Cr	511	1B, 2Ag	2020 [c]	Aquatic Life	Aquatic macroinvertebrate bioassessments	N [d]
					2020 [c]	Aquatic Life	Fishes bioassessments	N [d]
	Little Rock Creek	T39 R31W S22, east line to T38 R31W S28, east line	653	1B, 2Ag	2020 [c]	Aquatic Recreation	*E. coli*	Y
					2020 [c]	Aquatic Life	Aquatic macroinvertebrate bioassessments	N [f]
					2020 [c]	Aquatic Life	Fishes bioassessments	N [f]
	Zuleger Creek	Unnamed cr. to Unnamed cr.	539	2Bg	2020 [c]	Aquatic Life	Aquatic macroinvertebrate bioassessments	N [e]
					2020 [c]	Aquatic Life	Fishes bioassessments	N [e]
Watab River	Watab River, South Fork	Little Watab Lk to Watab R	554	2Bg	2020 [c]	Aquatic Life	Fishes bioassessments	N [e]
	County Ditch 13	Bakers Lk to Watab R	564	2Bg	2020 [c]	Aquatic Life	Dissolved oxygen	N [d]
	County Ditch 16	Headwaters to Watab R	616	2Bg	2020 [c]	Aquatic Recreation	*E. coli*	Y
	Watab River	Rossier Lk to Mississippi R	528	2Bg	2020 [c]	Aquatic Life	Fishes bioassessments	N [e]

a. The AUIDs begin with 07010201; the values in this column are the last 3 digits of the AUID.
b. Stream use classes—1B: domestic consumption (requires moderate treatment); 2Ag: aquatic life and recreation—general cold water habitat (lakes and streams); 2Bg: aquatic life and recreation—general warm water habitat (lakes and streams); 7: limited resource value water. Note that lakes are classified as 2B – aquatic life and aquatic recreation.
c. Expected to be listed on the 2020 303(d) impaired waters list.
d. TMDLs have been deferred; insufficient data are available to support TMDL development at this time. See Appendix A for more information.
e. Non-pollutant stressor(s). See Appendix A for more information.
f. Previously completed TMDL addresses impairment. See Appendix A for more information.

1.3 Priority ranking

The MPCA's schedule for TMDL completions, as indicated on Minnesota's Federal CWA Section 303(d) impaired waters list, reflects Minnesota's priority ranking of this TMDL. The MPCA has aligned TMDL priorities with the watershed approach and WRAPS cycle. The schedule for TMDL completion corresponds to the WRAPS report completion on the 10-year cycle. The MPCA developed a state plan, Minnesota's TMDL Priority Framework Report (MPCA 2015), to meet the needs of the United States 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). As part of these efforts, the MPCA identified water quality impaired segments that will be addressed by TMDLs by 2022. The MRSW waters addressed by this TMDL are part of that MPCA prioritization plan to meet EPA's national measure.

2. Applicable water quality standards and numeric water quality targets

Water quality standards are designed to protect designated uses. The standards consist of the designated uses, criteria to protect the uses, and other provisions such as anti-degradation policies that protect the waterbody.

2.1 Designated uses

Use classifications are defined in Minn. R. 7050.0140, and water use classifications for individual waterbodies are provided in Minn. R. chs. 7050.0470, 7050.0425, and 7050.0430. This TMDL report addresses the waterbodies that do not meet the standards for class 1, 2, and 7 waters. The impaired streams in this report are classified as class 1B, 2Ag, 2Bg, and/or 7 waters and the lakes addressed in this report are classified as class 2B waters (Table 1).

Class 1B waters are protected for domestic consumption (requires moderate treatment). Class 2Ag waters are protected for aquatic life and recreation—general cold water habitat (lakes and streams). Class 2B waters are protected for aquatic life and recreation. Class 2Bg waters are protected for aquatic life and recreation—general warm water habitat. Class 7 waters are limited resource value waters and are protected for aesthetic qualities, secondary body contact use, and groundwater for use as a potable water supply.

2.2 Water quality standards

Water quality standards for class 1 waters are defined in Minn. R. 7050.0221, standards for class 2 waters are defined in Minn. R. 7050.0222, and standards for class 7 waters are defined in Minn. R. 7050.0227. Water quality standards for *E. coli* and eutrophication (phosphorus) are presented in Table 2 and Table 3, respectively.

In Minnesota, *E. coli* is used as an indicator species of potential waterborne pathogens. There are two *E. coli* standards each for class 2 and class 7 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 or 7 waters indicates that a waterbody does not meet the applicable designated use. The class 2 standard applies from April through October, whereas the class 7 standard applies from May through October.

Exceedances of the eutrophication standard in lakes indicate that the lake does not meet the aquatic recreation designated use. Chlorophyll-*a* (chl-*a*) and Secchi transparency standards must be met in lakes, in addition to meeting phosphorus standards. In developing the lake nutrient standards for Minnesota lakes (Minn. R. 7050), the MPCA evaluated data from a large cross-section of lakes in each of the state's ecoregions (MPCA 2005). Clear relationships were established between the causal factor TP and the response variables chl-*a* and Secchi transparency. Based on these relationships, it is expected that by meeting the phosphorus target in each lake, the chl-*a* and Secchi transparency standards (Table 3) will likewise be met.

The numeric water quality standards for these parameters (Table 2 and Table 3) serve as targets for the applicable MRSW TMDLs.

Table 2. Water quality standards for *E. coli* parameters in class 2 and class 7 streams.

Stream Class	Water Quality Standard	Numeric Standard/Target
Class 2	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 organisms per 100 milliliters. The standard applies only between April 1 and October 31.	≤ 126 organisms / 100 mL water (monthly geometric mean) ≤ 1,260 organisms / 100 mL water (individual sample)
Class 7	Not to exceed 630 organisms per 100 milliliters as a geometric mean of not less than five samples representative of conditions within any calendar month, nor shall more than 10% of all samples taken during any calendar month individually exceed 1,260 organisms per 100 milliliters. The standard applies only between May 1 and October 31.	≤ 630 organisms / 100 mL water (monthly geometric mean) ≤ 1,260 organisms / 100 mL water (individual sample)

Table 3. Eutrophication standards for class 2B lakes.

Parameter	Two Rivers Lake (73-0138): Lake Standard in North Central Hardwood Forest Ecoregion	Platte Lake (18-0088): Lake Standard in Northern Lakes and Forests Ecoregion
Phosphorus, total (micrograms per liter [µg/L])	≤ 40	≤ 30
Chlorophyll-a (µg/L)	≤ 14	≤ 9
Secchi Transparency (meters [m])	≥ 1.4	≥ 2.0

3. Watershed and waterbody characterization

The MRSW spans approximately 1,020 square miles and is located in central Minnesota in the North Central Hardwood Forests and Northern Lakes and Forests ecoregions. It is one of 15 major watersheds in the Mississippi River - Headwaters (HUC4 0701) Basin and drains portions of Benton, Crow Wing, Mille Lacs, Morrison, Stearns, and Todd counties. Major communities located in the watershed include Lastrup, Pierz, Buckman, Royalton, Upsala, Bowlus, Rice, Holdingford, Avon, St. Joseph, and Sartell.

The Mississippi River flows through the watershed. The primary tributaries to the north of the Mississippi River are the Platte River and Little Rock Creek. The primary tributaries to the south of the river are Hay Creek, Little Two River, Two River, Spunk Creek, Stony Creek, and the Watab River. The MRSW has 879 total river miles and contains 232 lakes with a total area of 13,319 acres.

The MRSW is located in a drinking water supply management area for a surface water intake (Drinking Water Supply Management Area–Surface Water; DWSMA-SW), as designated by the Minnesota Department of Health (MDH). The southeast portion of the watershed is in the Saint Cloud Priority A area, and the rest of the watershed is in the St. Cloud Priority B area (Figure 1). A small part of the watershed is located in the Saint Paul–Mississippi River and Minneapolis Priority B areas.

Over 96% of the watershed is privately owned (NRCS n.d.). No part of the MRSW is located within the boundary of a Native American Reservation.

3.1 Lakes

Lake morphometry data and watershed areas for the impaired lakes are presented in Table 4. The location of the impaired lakes are shown in Figure 1.

Table 4. Lake morphometry and watershed area.

Lake Name	Lake ID	HUC10 Name	Surface Area (acres)	Mean Depth (m)	Max Depth (m)	Littoral Area [a]	Watershed Area (incl. lake surface area; acres)	Watershed Area : Surface Area
Two Rivers Lake	73-0138-00	Two River	584	6.40	19.2	35%	37,753	65:1
Platte Lake	18-0088-00	Upper Platte River	1,661	2.44	7.0	97%	21,159	13:1

a. Percent lake surface area less than 15 feet (4.6 m) deep

3.2 Streams

Watershed areas that drain to impaired streams receiving TMDLs range from 645 to 115,019 acres. Watershed areas for each impaired stream reach is presented in Table 5. The location of the impaired stream reaches are shown in Figure 1.

Table 5. Watershed areas of impaired streams receiving TMDLs.

HUC10 Name	Waterbody Name	AUID	Watershed Area (acres) [a]
City of Sartell–Mississippi River	Hay Creek	630	11,168
Two River	North Two River	524	31,503
	South Two River	542	13,990
	Unnamed creek	628	645
	Unnamed creek	612	3,670
	Unnamed creek	580	4,885
	Krain Creek	613	7,158
Spunk Creek	Spunk Branch	561	12,360
Skunk River	Hillman Creek	639	29,470
	Skunk River	521	87,946
Upper Platte River	Big Mink Creek	646	14,040
	Platte River	507	115,019
City of Sartell–Mississippi River	Stony Creek	649	10,866
Little Rock Creek	Little Rock Creek	653	43,316
Watab River	County Ditch 16	616	1,951

a. Watershed area includes all drainage area to the impairment

3.3 Subwatersheds

The subwatershed boundaries of the impaired waterbodies (Figure 2) were developed using multiple data sources, starting with watershed delineations from the MPCA's Hydrologic Simulation Program–Fortran (HSPF) model application of the MRSW (Tetra Tech 2019). The model subwatershed boundaries are based on Minnesota Department of Natural Resources (DNR) Level 8 watershed boundaries and modified with a 30-meter digital elevation model. Where additional watershed breaks were needed to define the impairment subwatersheds, DNR Level 8 and Level 9 watershed boundaries and the USGS StreamStats program (Version 4.0) were used. StreamStats was developed by the USGS as a web-based geographic information systems application for use in informing water resource planning and management decisions. The tool allows users to locate gages and define drainage basins in order to determine upstream drainage basin area and other useful parameters.

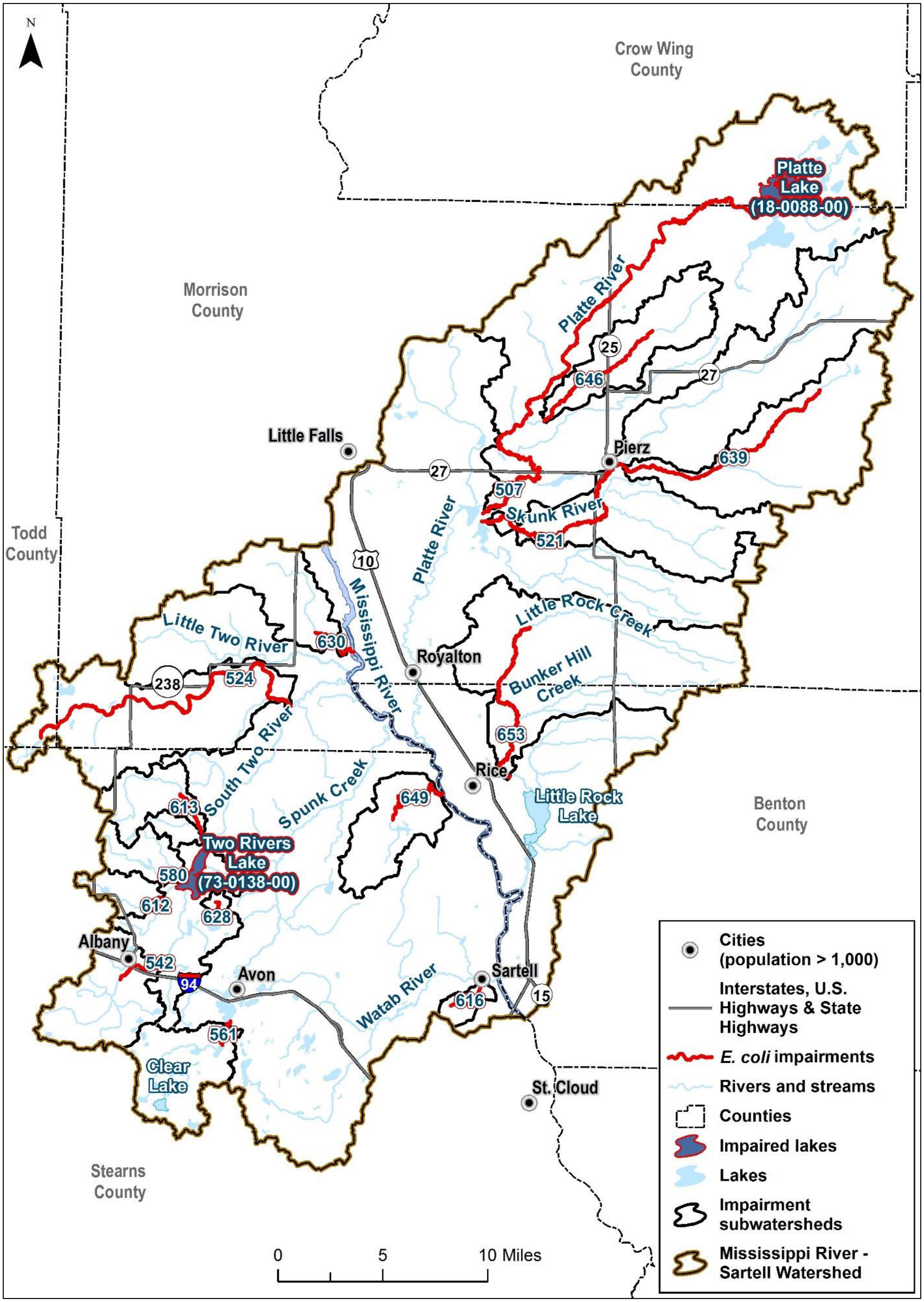

Figure 2. MRSW TMDL impairment subwatersheds.

3.4 Land use

Land cover in the MRSW is predominantly agricultural with the dominant crops being corn, alfalfa, and soybeans (Table 6, Figure 3). Other crops, including dry beans, fallow/idle cropland, rye, spring wheat, oats, potatoes, peas, and barley are typically minor but represent 5% or more of the watershed in the Little Rock Creek and Watab River subwatersheds. Developed land covers are scattered throughout the watershed, with more densely developed areas near the cities of Sartell and St. Cloud.

Pre-settlement land cover in the MRSW consisted predominantly of forests of big woods and hardwoods (oak, maple, basswood, and hickory), oak openings and barrens, aspen–oak land, and conifer bogs and swamps (Figure 4). European settlement in the 1800s resulted in loss of many ecosystems including prairie systems, oak openings, and oak savannahs in the MRSW. In addition, many hardwood forest species such as oak, elm, and walnut were cleared to create new agricultural fields. The forests and wetlands in the northern portion of the watershed remain today.

Table 6. Land cover in impaired subwatersheds (2017 Cropland Data Layer).
Percentages rounded to the nearest whole number.

HUC10 Name	Waterbody Name	Stream AUID / Lake ID	Percent of Watershed (%)								
			Developed	Corn	Alfalfa	Soybeans	Other crops	Grassland/pasture	Forest	Wetlands	Open water
City of Sartell–Mississippi River	Hay Creek	630	5	28	10	11	2	24	12	8	<1
Two River	North Two River	524	5	25	14	9	2	20	16	7	2
	South Two River	542	12	24	11	18	1	17	10	3	4
	Unnamed creek	628	8	22	12	2	<1	36	11	6	3
	Unnamed creek	612	6	29	23	12	2	19	7	2	<1
	Unnamed creek	580	5	23	18	7	<1	30	12	3	2
	Two Rivers Lake	73-0138-00	8	22	14	11	1	22	12	5	5
	Krain Creek	613	5	26	19	12	2	19	11	5	1
Spunk Creek	Spunk Branch	561	4	10	9	4	1	21	32	9	10
Skunk River	Hillman Creek	639	2	4	5	2	<1	20	42	25	<1
	Skunk River	521	3	12	7	5	1	18	33	21	<1
Upper Platte River	Platte Lake	18-0088-00	4	3	2	1	1	8	43	25	14
	Big Mink Creek	646	4	22	13	7	1	20	18	15	<1
	Platte River	507	4	13	7	5	1	17	27	22	4
City of Sartell–Mississippi River	Stony Creek	649	5	19	9	11	2	16	26	12	<1
Little Rock Creek	Little Rock Creek	653	3	32	9	15	8	11	12	10	<1
Watab River	County Ditch 16	616	34	21	2	8	7	15	3	8	2

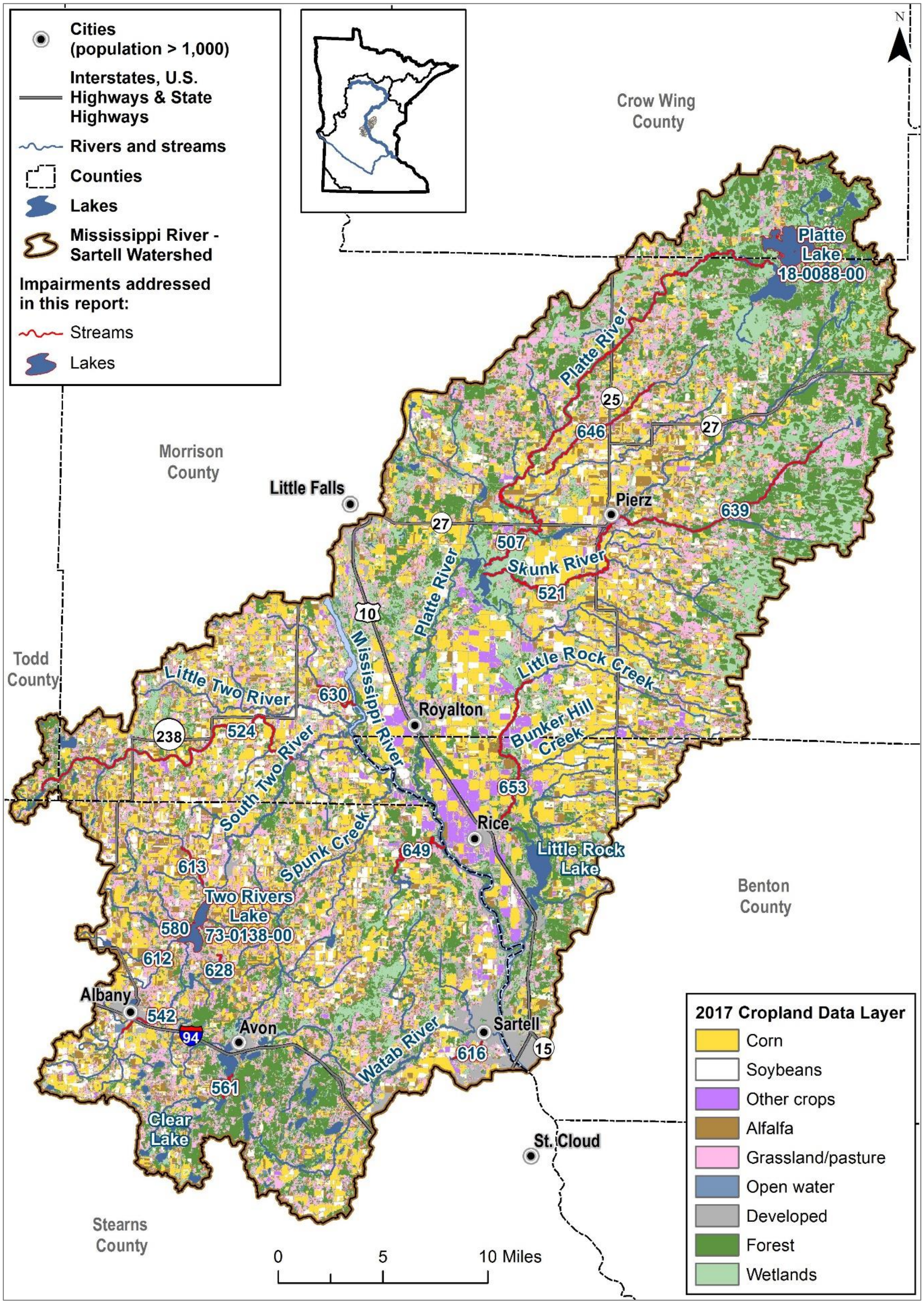

Figure 3. Land cover in the MRSW.

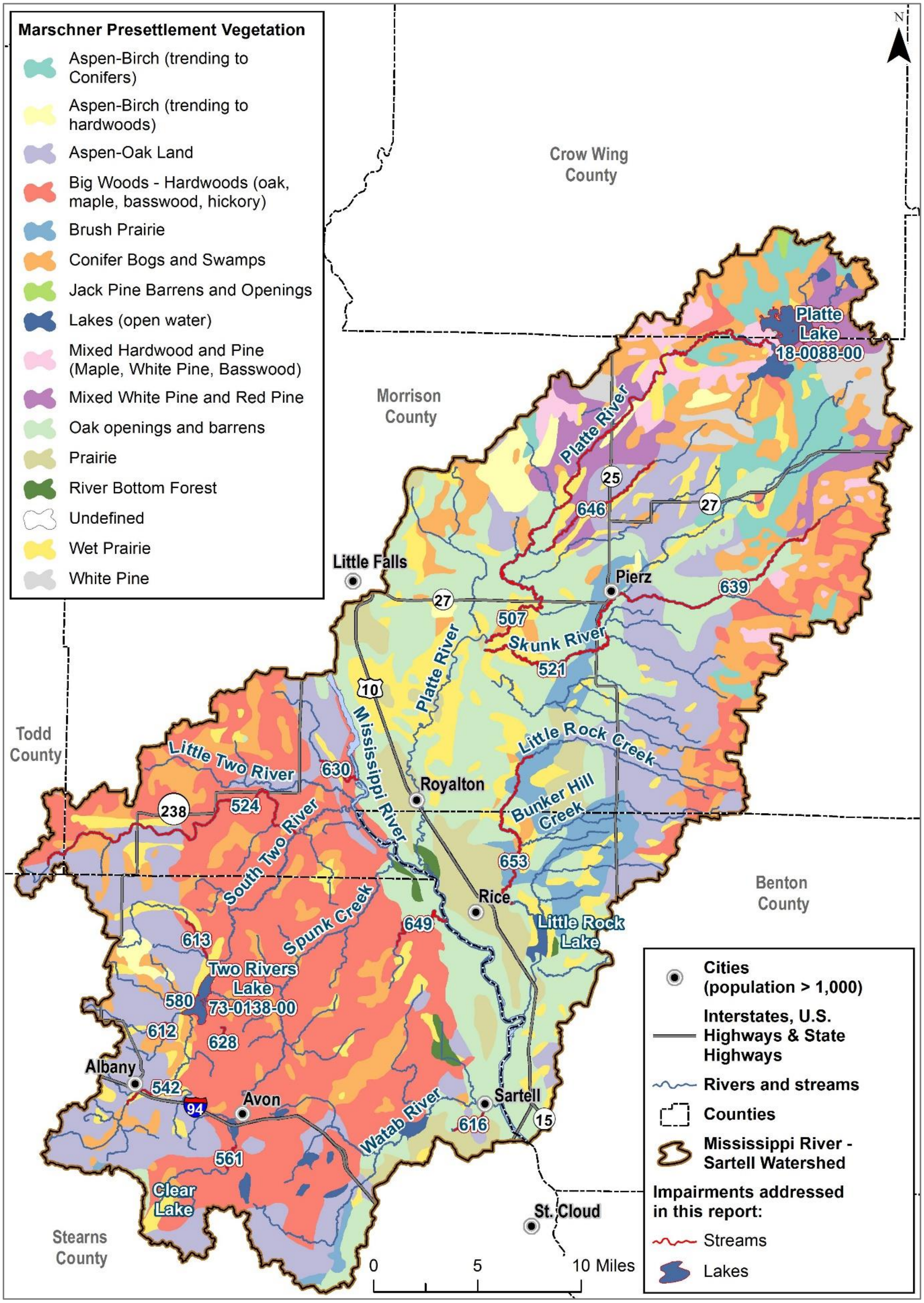

Figure 4. Pre-settlement land cover in the MRSW.

3.5 Current/historic water quality

Flow and water quality data are presented to evaluate the impairments and trends in water quality. Data from the last 10 years (2008 through 2017) were used in the water quality summary tables. If data from 2008 through 2017 were not available, data prior to the 10-year time period were evaluated, as available, to examine trends in water quality. Water quality data from the Environmental Quality Information System (EQuIS) database were used for the analysis. The following describes the analyses completed for impaired lakes and streams.

3.5.1 Streams

The analyses used the following sources of flow data (Table 7):

- The MPCA provided flow data from Hydstra, a database that stores MPCA and DNR stream gaging data.
- Daily average flows were simulated with the MPCA's HSPF model application for the MRSW (2018-10-31 version). The simulated flows were calibrated and validated with data from five flow gaging stations. Simulated flows are available at the downstream end of each model reach. The model report (Tetra Tech 2019 and references within) describes the framework and the data that were used to develop the model and includes information on the calibration.

Because the simulated flows from the HSPF model integrate flow monitoring data and provide long-term, continuous flow estimates, simulated flows were used in developing the stream TMDLs. The drainage area-ratio method was used to extrapolate gage flows to the locations of the segment outlet.

For additional information regarding HSPF modeling, see the brief summary in Section 3.6.3 or modeling documentation (Tetra Tech 2019).

Table 7. Model reaches used to simulate stream flow in impaired reaches.
Reach numbers refer to the MRSW HSPF model (Tetra Tech 2019). The simulation is from 1996–2015.

Reach Name	AUID	Model Reach Number
Hay Creek	630	601
North Two River	524	623
South Two River	542	613
Unnamed Creek	628	615
Unnamed Creek	612	615
Unnamed Creek	580	617
Krain Creek	613	619
Spunk Branch	561	896
Hillman Creek	639	819
Skunk River	521	830
Big Mink Creek	646	735
Platte River	507	770
Stony Creek	649	911

Reach Name	AUID	Model Reach Number
Little Rock Creek	653	935
County Ditch 16	616	961

Water quality data from 2008 to 2017 were summarized for the *E. coli* impairments. Data were summarized by year to evaluate trends in long-term water quality and by month to evaluate seasonal variation. The summaries of data by year only consider data taken during the time period that the standard is in effect (April/May through October for class 2 and class 7 waters, respectively). Where there are multiple sites along one assessment unit, data from the sites were combined and summarized together. The frequency of exceedances represents the percentage of samples that exceed the water quality standard.

E. coli load duration curves are provided in Section 5: *TMDL Summaries* for each impaired stream. Water quality is often a function of stream flow, and load duration curves are used to evaluate the relationships between hydrology and water quality. For example, *E. coli* concentrations can increase with rising flows if manure applied to cropland is a substantial source. Other parameters may be more concentrated at low flows and diluted by increased water volumes at higher flows. The load duration curve approach provides a visual display of the relationship between stream flow and water quality. Load duration curves were developed as follows.

<u>Develop flow duration curves</u>: 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 developed using daily average flow (1996 through 2015) from HSPF modeling (Tetra Tech 2019). Table 7 presents the modeled stream segment number used to develop the flow duration curve for each impaired segment. Simulated flows from all months (even those outside of the time period that the standard is in effect) were used to develop the flow duration curves.

<u>Develop load duration curves</u>: To develop load duration curves, all average daily flows were multiplied by the water quality standard (i.e., 126 or 630 org/100 mL *E. coli*) and converted to a daily load to create "continuous" load duration curves 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 load duration curve, based on the concentration of the sample multiplied by the simulated flow on the day that the sample was taken. Three nearby gages (MPCA/DNR gages on Little Rock Creek [H15029001], the Platte River [H15030001] and Two Rivers [H15067002]) were used to plot water quality samples from 2016 and 2017, which are not simulated in the HSPF model. Each load calculated from a water quality sample that plots above the load duration curve represents an exceedance of the water quality target whereas those that plot below the load duration curve are less than the water quality target.

Water quality summary tables and load duration curves are presented for each impairment in Section 5, and Table 8 summarizes the *E. coli* water quality data.

The number of *E. coli* samples per impaired reach ranges from 15 to 45. The maximum recorded *E. coli* concentration per reach ranges from 921 to 24,000 org/100 mL. The frequencies of exceedance of the monthly geometric mean standard range from 33 to 100%, and the frequencies of exceedance of the individual sample standard range from 0% to 73% (Table 8).

Exceedances of the single sample standard occur across all flow conditions (Figure 5). The maximum observed *E. coli* concentration is lower in the very low flow zone than in the other flow zones. However, the sample count (N) is smaller in the very low flow zone and therefore more data are needed under very low flows to confirm this observation. The percent of exceedances of the single sample standard in each flow zone is relatively consistent, ranging from 16% to 32% (Table 9).

Table 8. Summary of *E. coli* data (2008–2017) for impaired reaches.
Summaries include data from months during which the standard applies (see Section 2.2). *E. coli* units are org/100 mL.

Reach Name (Description)	AUID	Sample Count	Geometric Mean	Max-imum [a]	Number of Exceedances of Individual Standard	Frequency of Exceedance [b]
Hay Creek (Unnamed cr to Mississippi R)	630	15	269	≥ 2,420	2	67% / 13%
North Two River (Headwaters (Mary Lk 77-0019-00) to South Two R)	524	15	695	20,000	4	100% / 27%
South Two River (T125 R31W S21, south line to T125 R31W S23, east line)	542	22	1,641	6,131	16	100% / 73%
Unnamed creek (Headwaters to Pelican Lk)	628	45	219	≥ 2,420	10	75% / 22%
Unnamed creek (Unnamed cr to Unnamed cr)	612	22	1,700	8,164	16	100% / 73%
Unnamed creek (Unnamed cr to Two Rivers Lk)	580	22	130	921	0	67% / 0%
Krain Creek (Unnamed cr to Unnamed cr)	613	22	238	≥ 2,420	2	100% / 9%
Spunk Branch (Kalla Lk to Upper Spunk Lk)	561	22	207	≥ 2,420	1	67% / 5%
Hillman Creek (370th Ave to Skunk R)	639	15	357	16,000	3	67% / 20%
Skunk River (Hillman Cr to Platte R)	521	15	1,214	24,000	7	100% / 47%
Big Mink Creek (Headwaters to 235th Ave)	646	15	137	1,203	0	33% / 0%
Platte River (Headwaters (Platte Lk 18-0088-00) to Skunk R)	507	30	228	14,000	5	67% / 17%
Stony Creek (-94.31 45.728 to Mississippi R)	649	20	433	≥ 2,420	3	100% / 15%
Little Rock Creek (T39 R31W S22, east line to T38 R31W S28, east line)	653	17	169	24,000	3	33% / 18%

Reach Name (Description)	AUID	Sample Count	Geometric Mean	Max-imum [a]	Number of Exceedances of Individual Standard	Frequency of Exceedance [b]
County Ditch 16 (Headwaters to Watab R)	616	22	346	1,733	3	100% / 14%

a. The maximum recordable value for *E. coli* concentration depends on the extent of sample dilution and is often 2,420 org/100 mL. Concentrations that are noted as 2,420 org/100 mL are likely higher, and the magnitude of the exceedances is not known.

b. For *E. coli* impairments, the frequencies of exceedance are presented first for the monthly geometric mean standard and second for the individual sample standard. The monthly frequencies of exceedance are calculated as the number of months (aggregated across all years of data) when the monthly standard was exceeded divided by the number of months that have five or more samples.

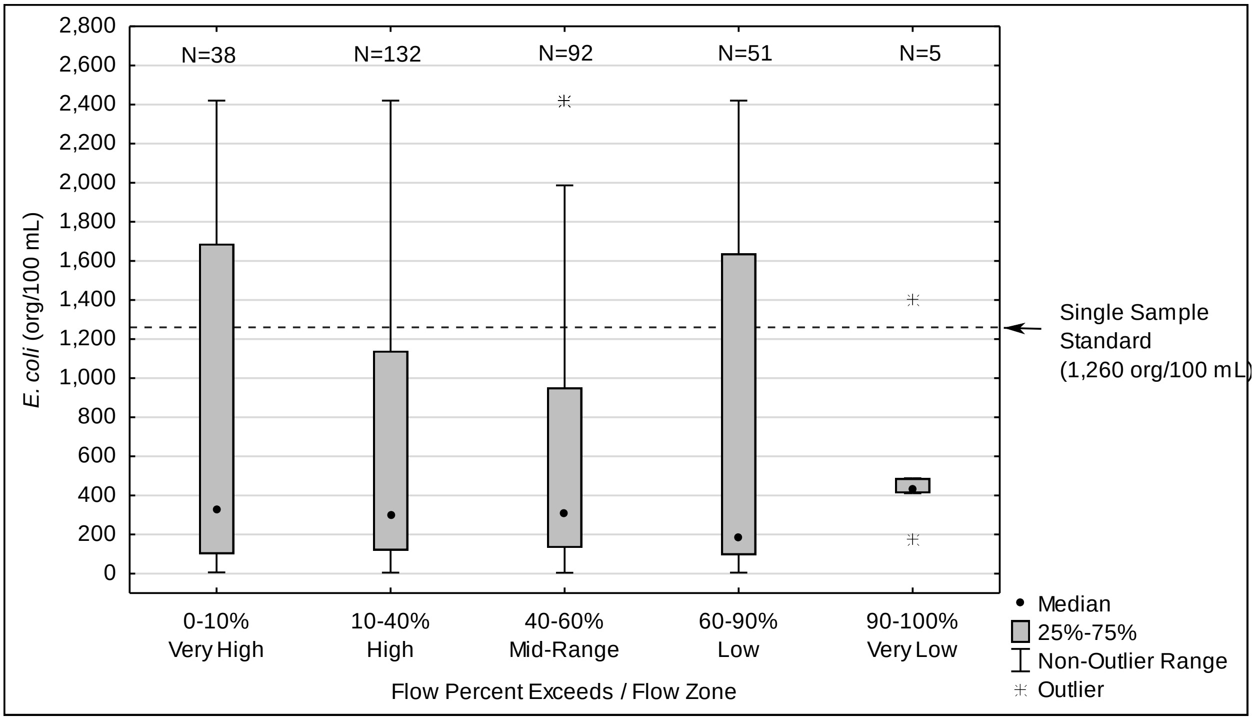

Figure 5. Box plot of *E. coli* concentration by flow zone for all reaches with *E. coli* impairments.

The maximum recordable *E. coli* concentration depends on the extent of sample dilution and is often 2,420 org/100 mL. However, 13 samples in this data set were diluted before the laboratory analysis, and high *E. coli* concentrations are reported. In this figure, concentrations > 2,420 were lowered to 2,420 to remove the influence that the diluted samples have on the overall statistics of each group.

Table 9. Number of individual standard exceedances by flow zone.

Flow Zone	Number of Single Sample Standard Exceedances	Sample Count	Percent of Single Sample Standard Exceedances
Very High	12	38	32%
High	32	132	24%
Mid-Range	15	92	16%
Low	15	51	29%
Very Low	1	5	20%
Total	*75*	*318*	*24%*

3.5.2 Lakes

Water quality data from 2008 to 2017 were summarized for TP, chl-*a*, and Secchi transparency. Data were summarized over the entire period to evaluate compliance with the water quality standards and by year to evaluate trends in water quality. The summaries include monitoring data from the growing season (June through September); the water quality standards apply to growing season means. Data from prior to 2008 are presented in the figures to illustrate longer term data. Results are presented in Section 5: *TMDL Summaries* and are summarized in Table 10. For both impaired lakes, the average phosphorus and chl-*a* concentrations exceed the relevant standards. The Secchi standard is violated in Platte Lake but not in Two Rivers Lake.

The *Platte Lake - Lake Water Quality* report (RMB Environmental Laboratories, Inc. 2013) presents additional analyses of water quality data. The data show a long-term declining trend in water transparency in Platte Lake (see also Figure 32 for the long-term transparency data).

Table 10. Water quality data summary (2008–2017) of impaired lakes.

Parameter	Two Rivers Lake (73-0138-00), Site 204		Platte Lake (18-0088-00), Sites 208–211	
	Average of Annual Growing Season Means (Jun–Sep)	North Central Hardwood Forests Lake Water Quality Standard	Average of Annual Growing Season Means (Jun–Sep)	Northern Lakes and Forests Lake Water Quality Standard
TP (µg/L)	64	≤ 40	48	≤ 30
Chl-*a* (µg/L)	34	≤ 14	21	≤ 9
Secchi (m)	1.8	≥ 1.4	1.1	≥ 2.0

3.6 Pollutant source summary

Source assessments are used to evaluate the type, magnitude, timing, and location of pollutant loading to a waterbody. Source assessment methods vary widely with respect to their applicability, ease-of-use, and acceptability. The purpose of this section is to identify possible sources of *E. coli* and phosphorus in the subwatersheds of the impaired waterbodies. Types of pollutants are first discussed in a non-pollutant specific context (Section 3.6.1) and followed by source assessment summaries for each pollutant (Section 3.6.2 for *E. coli* and Section 3.6.3 for phosphorus). Some of the source summaries are quantitative and some are qualitative in nature.

3.6.1 Pollutant source types

The pollutant sources evaluated in this report are permitted sources such as wastewater, stormwater, and permitted AFOs; and non-permitted sources such as watershed runoff, septic systems, and internal loading. This section describes and defines permitted and non-permitted sources of pollution in a general sense. Pollutant specific information on pollutant sources of *E. coli* are provided in Section 3.6.2 and Section 3.6.3 for phosphorus.

Permitted sources of pollution

In this TMDL report, permitted sources of pollution only include those sources that are regulated through National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) permits in the impaired subwatersheds and include permitted stormwater (including stormwater runoff from permitted MS4s, construction stormwater, and industrial stormwater), wastewater, and NPDES/SDS permitted AFOs. Other, non-NPDES/SDS permitted sources such as county-permitted activities are not addressed in this section (see Non-permitted sources of pollution). Only permitted sources of pollution will be provided a WLA as part of TMDL development.

Permitted stormwater

Permitted stormwater delivers and transports pollutants to surface waters and is generated in the watershed during precipitation events. The sources of pollutants in stormwater are many, including but not limited to decaying vegetation (leaves, grass clippings, etc.), domestic and wild animal waste, soil, deposited particulates from the air, road salt, and oil and grease from vehicles. Three types of permitted stormwater exist in the watershed:

- *Municipal separate storm sewer systems (MS4s)*. In 1990, the EPA adopted rules governing incorporated places and counties that operate MS4s; medium and large MS4s were designated at this time. Later, in 1999, the EPA adopted additional rules (Phase II stormwater rules) that regulate small MS4s, which are designated because they are within an urbanized area identified in a decennial census. Additionally, the Phase II stormwater rules allow state regulatory agencies to designate Phase II MS4s that are outside of the urbanized area. Under Phase II of the NPDES/SDS stormwater program, MS4 communities outside of urbanized areas with populations greater than 10,000 (or greater than 5,000 if they discharge to or have the potential to discharge to an outstanding value resource, trout lake, trout stream, or impaired water) and MS4 communities within urbanized areas are permitted MS4s.

  MS4s are defined by the EPA as stormwater conveyance systems owned or operated by an entity such as a state, city, township, county, district, or other public body having jurisdiction over disposal of stormwater or other wastes. The Phase II General NPDES/SDS Municipal Stormwater Permit for MS4 communities has been issued to cities, townships, and counties in the watershed. The Minnesota Department of Transportation (MnDOT) also is a permitted MS4 in the watershed; however, the rights of way that are regulated through MnDOT's MS4 permit are not located in the impaired subwatersheds. The municipal stormwater permit holds permittees responsible for stormwater discharging from the conveyance system they own and/or operate. The conveyance system includes ditches, roads, storm sewers, stormwater ponds, etc. Under the NPDES/SDS stormwater program, permitted MS4 entities are required to obtain a permit, then develop and implement an MS4 Stormwater Pollution Prevention Program (SWPPP), which outlines a plan to reduce pollutant discharges, protect water quality, and satisfy water quality requirements in the Federal CWA. An annual report is submitted to the MPCA each year by the permittee documenting progress on implementation of the SWPPP.

  Permitted MS4s can be a source of pollutants to surface waters through the impact of urban systems on stormwater runoff. The entire jurisdictional boundaries of permitted MS4 communities are mapped in Figure 6. In addition to communities, Stearns County is also a regulated MS4 entity for county-owned roads in the watershed. (Note that the specific areas that are regulated through the MS4 permit are estimated in Section 4.7.2 and Figure 12) In the case of St. Cloud, a small portion of the city's jurisdictional boundary is included in the HUC 8 watershed; this area is included Figure 12. However, there is no part of St. Cloud's MS4 that drains to the impaired subwatersheds included in this report. There are no permitted MS4s in the two impaired lake subwatersheds.

- *Construction stormwater* is regulated through an NPDES/SDS permit. Untreated stormwater that runs off of a construction site often carries sediment to surface waterbodies. Because phosphorus travels adsorbed to sediment, construction sites can also be a source of phosphorus to surface waters. 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. Phosphorus from construction stormwater is inherently incorporated in the watershed runoff estimates. Construction stormwater is not considered a source of bacteria.
- *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. Industrial stormwater is not considered a source of bacteria and phosphorus loading from industrial stormwater is inherently incorporated in the watershed runoff estimates. It is estimated that a small percent of the TMDL project area is permitted through the industrial stormwater permit, and industrial stormwater is not considered a significant source.

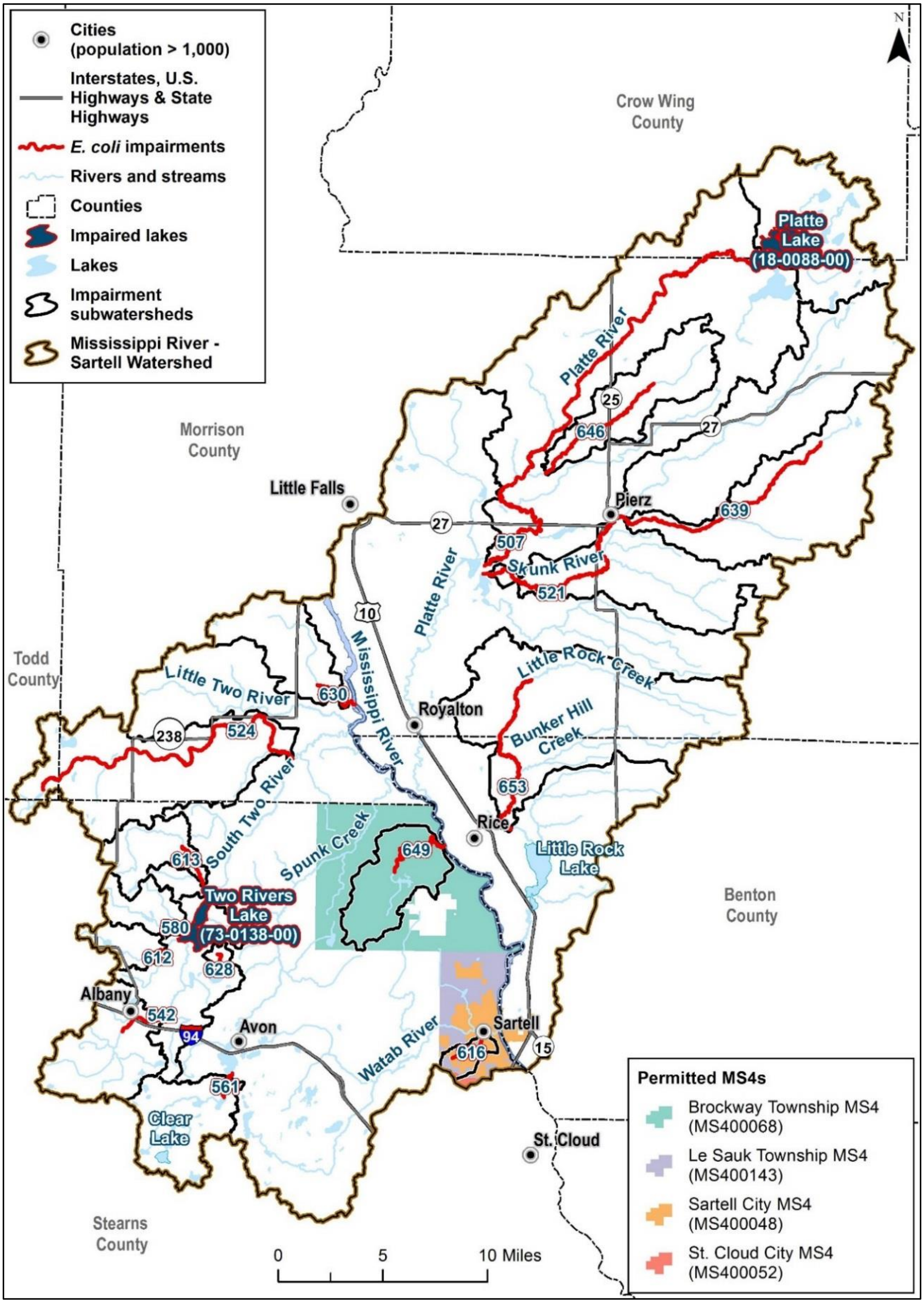

Figure 6. Permitted MS4 cities and townships (jurisdictional boundaries) in the impairment subwatersheds.
St. Cloud's permitted MS4 does not discharge to any impaired subwatershed. Stearns County is also a permitted MS4 in the impaired subwatersheds.

Wastewater

Permitted wastewater in the watershed includes municipal/domestic (Figure 7 and Table 11) and industrial wastewater:

- *Municipal/Domestic wastewater* is the domestic sewage and wastewater collected and treated by municipalities and other private entities prior to being discharged to surface waters. These facilities are required to disinfect their discharge for a specified period of time, as included in Figure 7.
- *Industrial wastewater* is wastewater generated from industries, businesses, and other privately owned facilities that is collected and treated prior to being discharged to surface waters. There are no permitted industrial wastewater discharges impacting impaired subwatersheds.

Both municipal/domestic and industrial wastewater dischargers must obtain NPDES/SDS permits. As described in section 4, there are no required changes to the permits associated with facilities included in Table 11 below.

Table 11. NPDES/SDS permitted facilities.

Wastewater Facility	NPDES/SDS Permit #	Impaired Waterbody Name	Impaired Waterbody AUID
Richland Prairie Sewer Treatment Facility	MNG580211	Skunk River	521
Bowlus WWTP	MN0020923	North Two River	524
Albany WWTP	MN0020575	South Two River	542
		Two Rivers Lake	73-0138-00

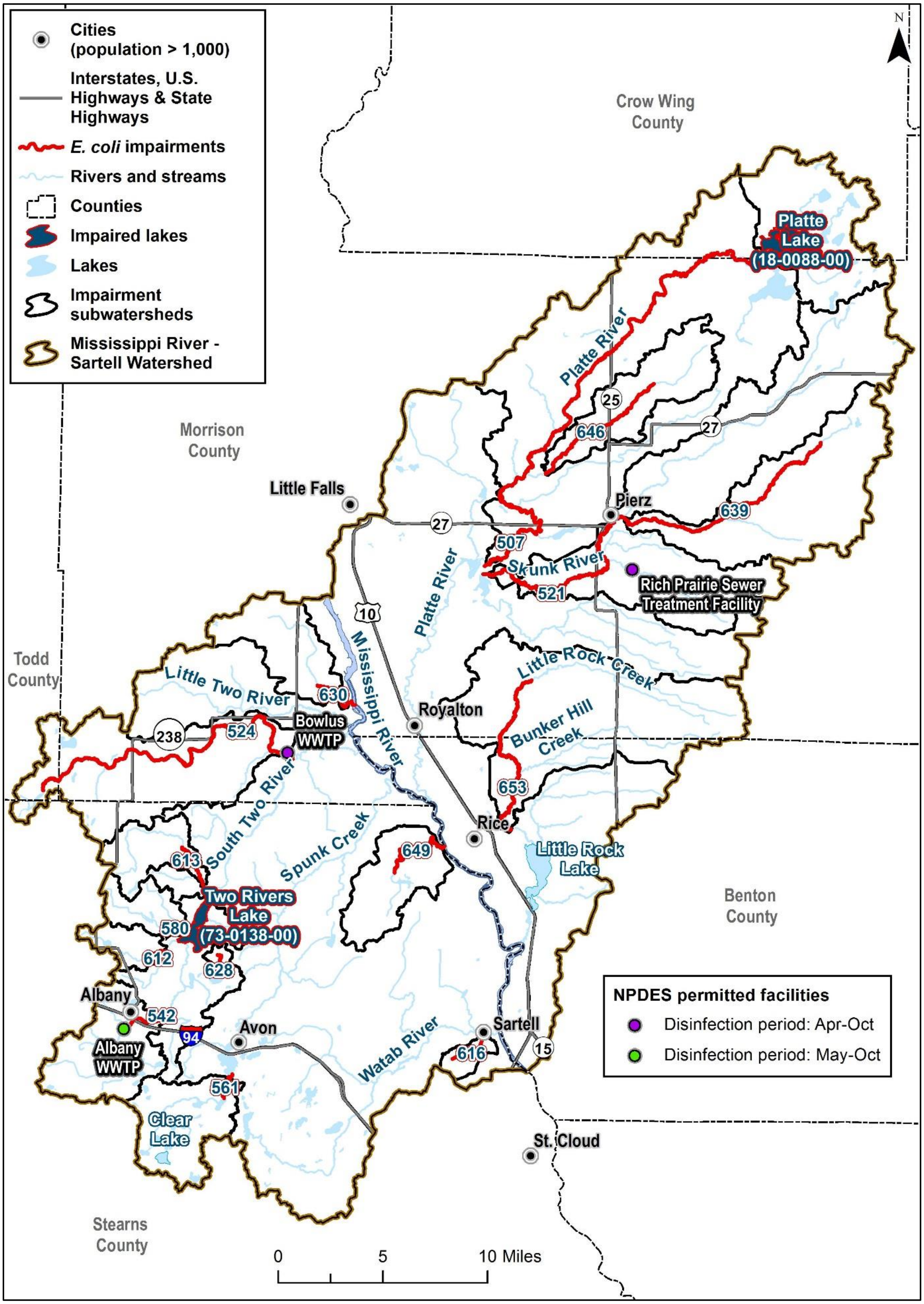

Figure 7. Permitted municipal/domestic wastewater facilities in impairment subwatersheds.

NPDES-permitted animal feeding operations

AFOs can be sources of pollutants to waterbodies. AFOs are areas where animals are held in confined spaces. Manure may accumulate in these areas, and vegetative cover may not be maintained due to the density of animals. In Minnesota, NPDES/SDS permits are issued to AFOs with over 1,000 animal units (AUs) and to all federally defined (concentrated AFOs) CAFOs (Figure 8). Most NPDES/SDS-permitted AFOs are also CAFOs, although there are some CAFOs that have fewer than 1,000 AUs. Except for basin overflows that are caused by extreme climatic events, permitted AFOs must be designed to contain runoff (40 Code of Federal Regulations [CFR] 412.31). Facilities that are permit compliant are not considered to be a substantial pollutant source to surface waters. This excludes manure hauled off site for spreading on cropland, though this manure is typically regulated by Manure Management Plans. This also assumes permit-compliant CAFOs and limited manure basin overflows from NPDES/SDS-permitted AFOs due to extreme climatic events. Note, however, that manure hauled off site for spreading on land can be a source of *E. coli* (see Section 3.6.2).

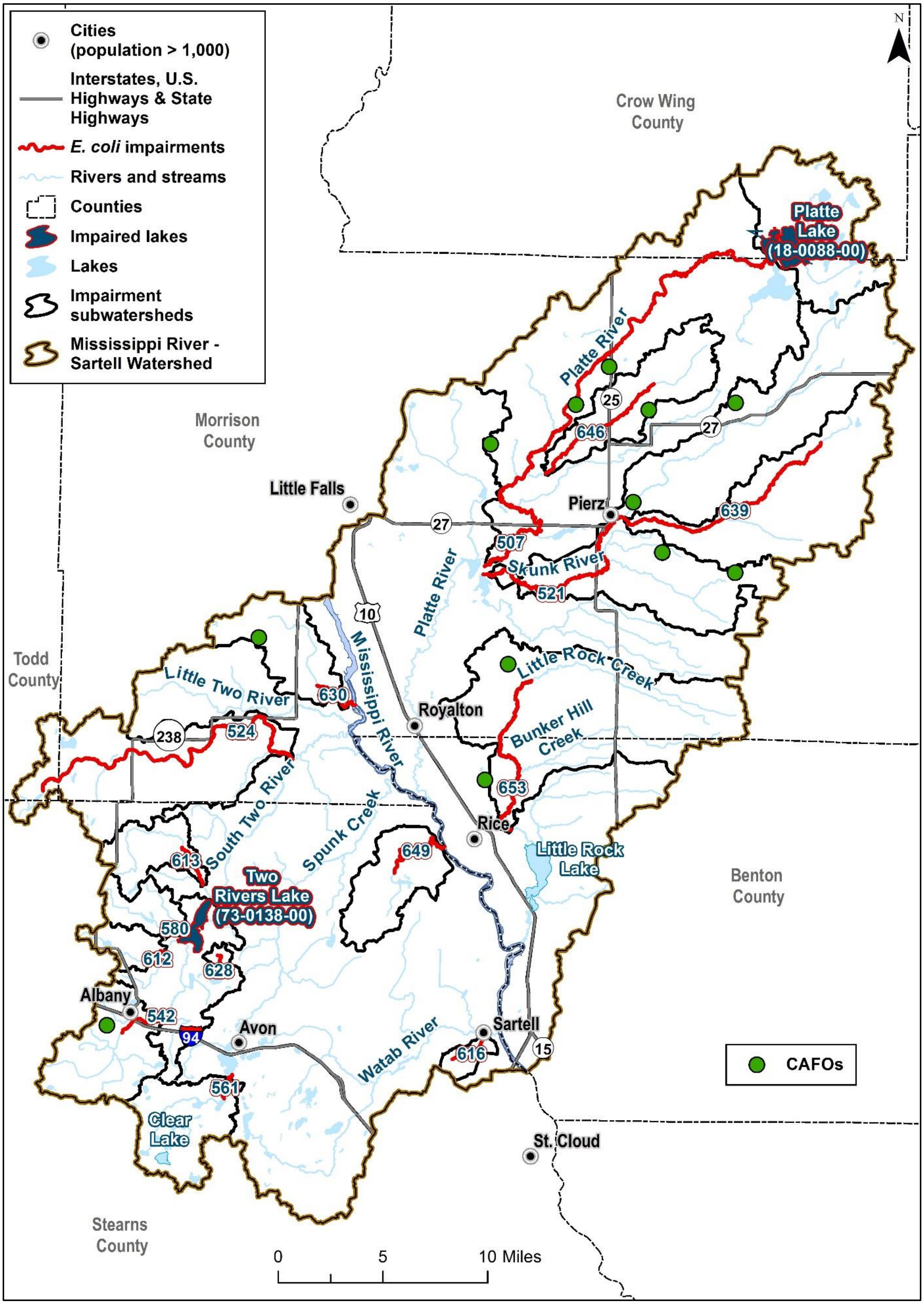

Figure 8. CAFOs in impairment subwatersheds.

Non-permitted/Non-NPDES/SDS sources of pollution

Non-permitted pollutant sources to the impaired waterbodies include non-permitted watershed runoff (including runoff from AFOs and non-permitted stormwater), human sources of waste such as faulty septic systems, land application of septage from Subsurface Sewage Treatment Systems (SSTS), and internal loading and atmospheric deposition of phosphorus. It should be noted that in addition to the NPDES/SDS permitted pollutant sources that have been assigned WLAs, other regulated activities in the watershed have potential to contribute pollutants to surface waters. These include wastewater spray irrigation and land application of wastewater biosolids and industrial byproducts. Although these activities are not assigned TMDLs because they are not authorized to discharge directly to surface waters, they are regulated and managed to minimize impacts to surface water and groundwater resources.

Some nonpermitted pollutant loading is from natural background, which is the landscape condition that occurs outside of human influence. Minn. R. 7050.0150, subp. 4, defines the term *natural causes* as “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.” See Section 3.4 for information on pre-settlement land cover. Non-permitted natural background sources of *E. coli* and phosphorus can include runoff from undisturbed land, wildlife waste, natural stream development, atmospheric deposition, and a background level of internal loading.

Non-permitted watershed runoff

Watershed runoff, which transports and delivers pollutants such as *E. coli* and phosphorus to surface waters, is generated in the watershed during precipitation events. The sources of pollutants in watershed runoff are many, including soil particles, crop and lawn fertilizer, decaying vegetation (leaves, grass clippings, etc.), feedlots, and domestic pet and wildlife waste.

Runoff from non-NPDES/SDS permitted and non-CAFO AFOs, referred to as “non-permitted” in this report, are included in watershed runoff. AFOs under 1,000 AUs and those that are not federally defined (CAFOs) do not operate with NPDES/SDS permits; however, the requirements under Minn. R. ch. 7020, 7050, and 7060 still apply. Manure may accumulate in AFOs, and vegetative cover may not be maintained due to the density of animals. In Minnesota, feedlots with greater than 50 AUs, or greater than 10 AUs in shoreland areas, are required to register with the state. Facilities with fewer AUs are not required to register with the state.

The MPCA and MPCA-delegated counties regulate AFOs in Minnesota. In the MRSW, Stearns and Morrison counties are delegated counties. The primary goal of the state program for AFOs is to ensure that surface waters are not contaminated by the runoff from feeding facilities, manure storage or stockpiles, and land with improperly applied manure. Livestock are also part of hobby farms, which are small-scale farms that are not large enough to require registration but may have small-scale feeding operations and associated manure application or stockpiles.

The animals raised in AFOs produce manure that is stored in pits, lagoons, tanks, and other storage devices. The manure is then applied or injected to area fields as fertilizer according to Manure Management Plans. When stored and applied properly, this beneficial re-use of manure provides a natural source for crop nutrition. It also lessens the need for fuel and other natural resources that are used in the production of fertilizer. AFOs, however, can pose environmental concerns because manure can leak or spill from storage pits, lagoons, tanks, etc.; and improper application of manure can contaminate surface or groundwater.

The MPCA Data Desk provided the feedlot locations and numbers and types of animals in registered feedlots (Figure 9). This estimate includes the maximum number of animals that each registered feedlot can hold; therefore, the actual number of livestock in registered facilities is likely lower. Some feedlot owners have signed open lot agreements with the MPCA (Figure 9). There are 70 open lot agreements within the impairment subwatersheds. In an open lot agreement, a feedlot owner commits to correcting open lot runoff problems. In exchange for this commitment, the open lot agreement provides a flexible time schedule to feedlot owners to correct open lot runoff problems and a conditional waiver from retroactive enforcement penalties.

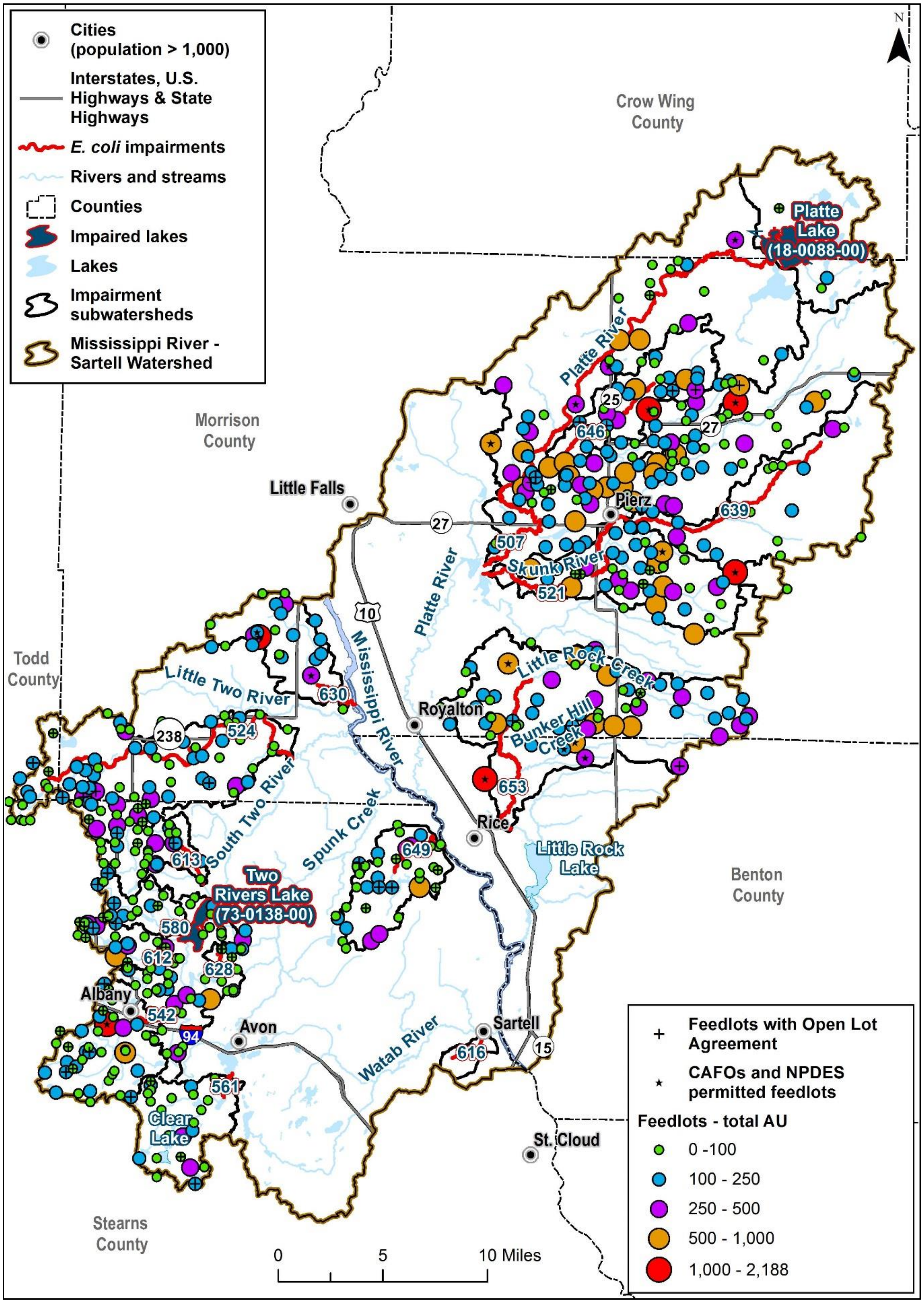

Figure 9. Registered feedlots in the MRS impaired subwatersheds.
Source: MPCA Data Desk

Human sources

SSTSs can contribute pollutants to nearby waters. 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 *E. coli* discharges and higher levels of phosphorus loading.

Septic systems that are conforming and are appropriately sited are assumed to not contribute *E. coli* to surface waters but still discharge small amounts of phosphorus. Septic systems that do not protect groundwater from contamination are identified as failing to protect groundwater. Septic systems that discharge untreated sewage to the land surface or directly to streams are considered imminent threats to public health and safety (ITPHS) and can contribute *E. coli* and phosphorus to surface waters.

Overall estimated percentages of ITPHS are low, ranging from one to 6% of total systems (Table 12). ITPHS typically include effluent ponding at ground surface, effluent backing up into home, unsafe tank lids, electrical hazards, or any other unsafe condition deemed by a certified SSTS inspector. Therefore, not all of the ITPHSs discharge pollutants directly to surface waters. The number of systems estimated as failing to protect groundwater, however, are higher and range between 3% and 27%.

Table 12. Estimated percentages of septic system compliance by county (2018 permitting year data).
Data from MPCA, received on September 9, 2018. These percentages are reported as estimates by local units of government for planning purposes and general trend analysis. These values may be inflated due to relatively low total SSTS estimated per jurisdiction. Additionally, estimation methods for these figures can vary depending on local unit of government resources available.

County	Compliant (%)	Failing to Protect Groundwater (%)	Estimated Percentage ITPHS (%)
Benton County	70	25	5
Crow Wing County	96	3	1
Mille Lacs County	74	20	6
Morrison County	89	10	1
Stearns County	88	10	2

Other human-derived sources of pollutants in the watershed 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 surface. Straight pipe systems are required to be addressed 10 months after discovery (Minn. Stat. § 15.55, subd. 11). Earthen pit outhouses likely exist in the watershed, but their numbers and locations are unknown and were not quantified. Outhouses, or privies, are legal disposal systems and are regulated under Minn. R. 7080.2150, subp. 2F, and Minn. R. 7080.2280.

Application of biosolids from wastewater treatment plants (WWTPs) could also be a potential source of pollutants. Application is regulated under Minn. R. ch. 7401, and includes pathogen reduction in biosolids prior to spreading on agricultural fields or other areas. Proper application should not result in violations of the *E. coli* water quality standards.

Internal loading and streambank erosion

Internal phosphorus loading from lake bottom sediments can be a substantial component of the phosphorus budget in lakes. The sediment phosphorus originates as an external phosphorus load that settles out of the water column to the lake bottom. Internal loading can be a result of low oxygen concentrations in the water overlying the lake sediment, curlyleaf pondweed decay, bottom-feeding fish, and wind energy in shallow depths. Streambank erosion along river and stream segments may also contribute sediment and associated phosphorus to a body of water. These mechanisms are further discussed in Section 3.6.3.

Atmospheric deposition

Phosphorus is bound to atmospheric particles that settle out of the atmosphere and are deposited directly onto surface water. Phosphorus loading from atmospheric deposition to the surface area of impaired lakes was estimated using the average for the Upper Mississippi River basin (0.24 pounds (lb) per acre per year, Barr Engineering 2007).

3.6.2 Stream *E. coli* source summary

E. coli sources evaluated in this study are non-permitted watershed runoff (wildlife, feedlots, domestic pets, stormwater), permitted stormwater, permitted wastewater, permitted AFOs, SSTSs, and natural growth of *E. coli*. *E. coli* is unlike other pollutants in that it is a living organism and can multiply and persist in soil and water environments (Ishii et al. 2006, Chandrasekaran et al. 2015, Sadowsky et al. n.d., and Burns & McDonnell 2017). Use of watershed models for estimating relative contributions of *E. coli* sources delivered to streams is difficult and generally has high uncertainty. Thus, a simpler weight of evidence approach was used to determine the likely primary sources of *E. coli*, with a focus on the sources that can be effectively reduced with management practices.

Permitted sources of *E. coli* to impaired streams

Permitted stormwater

Permitted MS4s can be a source of *E. coli* to surface waters through the same source types and mechanisms of delivery as non-permitted stormwater. There are currently four permitted MS4s in the *E. coli* impaired subwatersheds (Table 13).

Table 13. Permitted MS4s in *E. coli* impaired subwatersheds.

Waterbody Name	AUID	MS4	NPDES Permit #
Stony Creek	649	Brockway Township	MS400068
County Ditch 16	616	Le Sauk Township	MS400143
		City of Sartell	MS400048
		Stearns County	MS400159

Permitted wastewater

Wastewater dischargers that operate under NPDES/SDS permits are required to disinfect wastewater to reduce fecal coliform concentrations to 200 organisms/100 mL or less as a monthly geometric mean. Like *E. coli*, fecal coliform are an indicator of fecal contamination. The primary function of a fecal bacteria effluent limit is to assure that the effluent is being adequately treated with a disinfectant to assure a complete or near complete kill of fecal bacteria prior to discharge (MPCA 2007b). Dischargers to class 2 waters are required to disinfect from April 1 through October 31, and dischargers to class 7 waters are required to disinfect from May 1 through October 31. There are no permitted combined sewer overflows in the impaired subwatersheds.

Monthly geometric means of effluent monitoring data are used to determine compliance with permits. There are four wastewater dischargers with fecal coliform limits in the impaired subwatersheds. Of these facilities, two facilities have documented fecal coliform permit exceedances as provided in discharge monitoring reports (DMRs) for the time period between 2008 and 2017 (Table 14). There are no documented exceedances of the in-stream *E. coli* standard in the receiving impaired reaches at the same time as the wastewater discharge permit exceedances. Exceedances of wastewater fecal coliform permit limits could lead to exceedances of the in-stream *E. coli* standard at times. However, because the wastewater exceedances are infrequent, wastewater discharges are not considered a significant source.

Table 14. Wastewater treatment facilities with documented fecal coliform permit exceedances (2008–2017).

Wastewater Facility (NPDES/SDS Permit #)	Impaired Waterbody Name	Impaired Waterbody AUID	Number of Permit Exceedances (2008–2017)	Reported Fecal Coliform Calendar Monthly Geometric Means that Exceed Permit Limit (org/100 mL)
Bowlus WWTP (MN0020923)	North Two River	524	2	270 260
Albany WWTP (MN0020575)	South Two River	542	1	440

Permitted animal feeding operations

In the subwatersheds of the *E. coli* impairments, there are 20 AFOs that either operate under NPDES/SDS permits and/or are federally defined CAFOs. The amount of *E. coli* produced in CAFOs and NPDES/SDS permitted feedlots relative to the *E. coli* produced on all feedlots (permitted and non-permitted) was estimated for each impaired watershed (Table 15). All other watershed characteristics being equal, a watershed with a high percentage of *E. coli* produced from CAFO and NPDES/SDS permitted feedlots would be expected to have less *E. coli* loading from feedlots to surface waters than a watershed with a low percentage, as long as the CAFOs and permitted feedlots were meeting their requirement to completely contain runoff.

In the *E. coli* impaired subwatersheds, the percent of *E. coli* production generated from CAFOs and NPDES/SDS permitted feedlots ranges from 0% to 40% (Table 15 and Figure 9).

Table 15. Percent of *E. coli* production from CAFOs and NPDES/SDS permitted feedlots located in *E. coli* impaired subwatersheds relative to the *E. coli* produced on all feedlots.

Waterbody Name	AUID	Percent of *E. coli* Production Generated from CAFOs and NPDES/SDS Permitted Feedlots (%)
Hay Creek	630	40%
North Two River	542	24%
Big Mink Creek	646	26%
Platte River	507	21%
Little Rock Creek	653	15%

E. coli impairments not listed either do not have CAFOS or NPDES/SDS permitted feedlots, or do not have any feedlots in their subwatersheds.

Non-permitted sources of *E. coli* to impaired streams

Non-permitted stormwater runoff

Impervious areas (such as roads, driveways, and rooftops) can directly connect the location where *E. coli* is deposited on the landscape to points where stormwater runoff carries *E. coli* into surface waters. For example, there is a greater likelihood that uncollected pet waste in an urban area will reach surface waters through stormwater runoff than it would in a rural area with less impervious surface. Wildlife, such as birds and raccoons, can be another source of *E. coli* in urban stormwater runoff (Wu et al. 2011, Jiang et al. 2007). Several sources of *E. coli* loads were identified in the Minnehaha Creek Watershed in the City of Minneapolis, including lawns and grassy areas along parkways, stream sediment, streambank and riparian sediment, road construction activity, organic debris in street gutters, and improperly managed temporary toilets (Burns & McDonnell Engineering Company, Inc. 2017). These results may be indicative of other suburban and urban areas in the MRSW, such as *E. coli* impaired County Ditch 16 near the City of Sartell.

Non-NPDES/SDS permitted and Non-CAFO animal feeding operations

AFOs are potential sources of fecal bacteria to streams in the MRSW, particularly when direct access is not restricted and/or where feeding structures are located adjacent to riparian areas. Animal waste from AFOs can be delivered to surface waters from failure of manure containment or runoff from the AFO itself. In addition, improperly treated or applied manure that is applied to agricultural fields can be a source of *E. coli* to impaired streams. The numbers of viable organisms of *E. coli* produced per animal in non-permitted registered feedlots was estimated based on animal type (Table 16). See Figure 9 for a map of the registered feedlots in the impaired subwatersheds.

Table 16. *E. coli* production by livestock animal type.
Estimates are from animals in non-permitted registered feedlots.

Waterbody Name	AUID	Percent of *E. coli* Production (%) [a]					*E. coli* Production (billion colony forming units [cfu]/day)[b]
		Cattle	Poultry	Goats/Sheep	Horses	Pigs	
Hay Creek	630	63%	0%	0%	0%	37%	1.14×10^4
North Two River	524	41%	43%	2%	0%	15%	6.03×10^4
South Two River	542	51%	32%	17%	0%	0%	2.13×10^4
Unnamed Creek	628	100%	0%	0%	<1%	0%	4.46×10^2
Unnamed Creek	612	35%	64%	0%	0%	1%	2.06×10^4
Unnamed Creek	580	45%	1%	35%	0%	19%	1.03×10^4
Krain Creek	613	52%	42%	1%	0%	5%	1.90×10^4
Spunk Branch	561	42%	53%	3%	1%	0%	1.15×10^4
Hillman Creek	639	21%	78%	0%	0%	0%	2.61×10^4
Big Mink Creek	646	17%	29%	0%	0%	54%	7.04×10^4
Platte River	507	13%	48%	1%	0%	38%	2.98×10^5
Stony Creek	649	16%	82%	1%	0%	1%	4.27×10^4

Waterbody Name	AUID	Percent of *E. coli* Production (%) [a]					*E. coli* Production (billion colony forming units [cfu]/day)[b]
		Cattle	Poultry	Goats/Sheep	Horses	Pigs	
Little Rock Creek	653	9%	74%	0%	0%	17%	1.95×10^4
County Ditch 16	616	No feedlots located in the impaired watershed					

a. Production rates for cattle (2.7×10^9), poultry (1.3×10^8), goats and sheep (9.0×10^9), and pigs (4.5×10^9) are from Metcalf and Eddy (1991). The production rate for horses (2.1×10^8) is from American Society of Agricultural Engineers (1998). The production rates are provided in the literature as fecal coliform organisms produced per animal per day; these rates were converted to *E. coli* production rates by multiplying by 0.5 (Doyle and Erickson 2006). Production rate units are organisms per day per head.

b. Colony forming unit (cfu) is a unit used to estimate the number of viable *E. coli* cells in a sample.

Wildlife

In the rural portions of the watershed there are deer, waterfowl, and other animals, with greater numbers in conservation and remnant natural areas, wetlands and lakes, and river and stream corridors. Deer densities in the deer permit areas within the MRSW ranged from 13 to 18 deer per square mile in 2015 (Farmland Wildlife Populations Research Group 2015), while non-permitted livestock AU densities in *E. coli* impaired subwatersheds ranged from 54 to 254 AUs per square mile, with the exception of County Ditch 16, which doesn't contain any registered feedlots. Additionally, the per animal *E. coli* production rates of deer and waterfowl are substantially less than the production rates of cattle and poultry, the most common livestock types in the watershed (Table 17). Given the much larger volume of livestock waste compared to wildlife waste, it appears unlikely that the production of *E. coli* from wildlife substantially contributes to the impairments. There may, however, be some instances of large geese or other waterfowl populations for some stream reaches. In urban areas wildlife may provide a more significant portion of *E. coli* loads. Recent studies in Minneapolis using microbial markers show that birds are a primary source of the *E. coli* entering stormwater conveyances (Burns & McDonnell Engineering Company, Inc. 2017). No additional information on localized wildlife communities near *E. coli* impaired waters were identified by stakeholders.

Table 17. *E. coli* production rates of wildlife relative to livestock.

Animal Type	Production Rate (organisms per day [org/day] per head)	Reference
Deer	1.8×10^8	Zeckoski et al. 2005
Waterfowl	1.0×10^7	Alderisio and DeLuca 1999 and City of Eden Prairie 2008
Cattle	2.7×10^9	Metcalf and Eddy 1991
Poultry	1.3×10^8	Metcalf and Eddy 1991

Domestic pets

When pet waste is not disposed of properly, it can be picked up by runoff and washed into nearby waterbodies. Dogs are considered the primary source of *E. coli* from domestic pets. Because cats generally bury their waste, *E. coli* from cats typically does not reach surface waterbodies through runoff. Waste from pets can be a source of concern in subwatersheds with a higher density of developed area.

Compared to rural areas, developed areas have higher densities of pets and a higher delivery of waste to surface waters due to connected impervious surfaces.

Natural growth of E. coli

When evaluating sources of *E. coli* in the MRSW, it is important to recognize the natural growth of *E. coli* in soil and sediment. Research in the last 15 years has found the persistence of *E. coli* in soil, beach sand, and sediments throughout the year in the north central United States without the continuous presence of sewage or mammalian sources. An Alaskan study (Adhikari et al. 2007) found that total coliform bacteria in soil were able to survive for six months in subfreezing conditions. A study of cold water streams in southeastern Minnesota completed by the MPCA staff found the resuspension of *E. coli* in the stream water column due to stream sediment disturbance. A recent study near Duluth, Minnesota (Ishii et al. 2010) found that *E. coli* were able to grow in agricultural field soil. 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 stormsewer sediment in Michigan (Marino and Gannon 1991).

Subsurface sewage treatment systems

Overall estimated percentages of ITPHS are low, ranging from 1% to 6% of total systems (Table 12) and likely do not contribute a significant amount of *E. coli* to impaired streams unless they are located near or adjacent to an impaired stream. Without location information, however, ITPHSs should still be considered a potential source of *E. coli.*

Summary

The behavior of fecal bacteria in the environment is complex. Concentrations of fecal bacteria in a waterbody depend not only on their source but also factors such as weather, flow, and water temperature. As these factors fluctuate, the concentrations of fecal bacteria in the water may increase or decrease. Some fecal bacteria can survive and grow in the environment while others tend to die off with time (Ishii et al. 2006, Chandrasekaran et al. 2015, Sadowsky et al. n.d., and Burns & McDonnell 2017). See *Water Quality and Bacteria Frequently Asked Questions* (MPCA 2019c) for additional background information about sources of fecal bacteria. The MPCA uses the *E. coli* water quality standard to identify waterbodies that may be contaminated with fecal waste. Higher levels of *E. coli* in the water may or may not be accompanied by higher levels of pathogens and an increased risk of harm; varying survival rates of bacteria make it impossible to definitively state when pathogens are present.

Sources in the entire drainage area to each impaired waterbody were considered. The summary of *E. coli* sources to impaired streams (Table 18) identifies which source types exist in each impaired watershed and which of the source types should be a source of concern, based on the following:

- Waste from livestock is a source of concern when feedlots facilities are numerous and/or are located close to surface waterbodies. Tile drains that transport runoff to surface water bodies increase the distance at which a feedlot facility is considered a source of concern. In addition, areas on which livestock manure is land applied are also a potential source of *E. coli*. Specific information on locations of tile drains and land application areas are not known at this time. Non-CAFO and non-NPDES/SDS-permitted feedlots are typically more of a concern than CAFOs or NPDES/SDS-permitted AFOs because non- CAFO and non-NPDES/SDS-permitted feedlots are not required to completely contain runoff. The requirements under Minn. R. chs. 7020, 7050, and 7060, however, still apply.

- Permitted and non-permitted stormwater runoff is considered a likely source of *E. coli* for streams that flow through developed areas of cities. Stormwater runoff is considered a potential source of *E. coli* for streams that do not flow directly through developed areas in their watershed. If there is minimal or no developed areas in the watershed, stormwater runoff is considered an unlikely source of *E. coli*. Waste from wildlife and pets is considered with stormwater runoff because waste from these sources is delivered to surface waters through stormwater runoff.
- Effluent from WWTPs is typically below the *E. coli* standard and is not considered a significant source.
- ITPHS do not make up a large percentage of total SSTSs in the MRSW. However, they should be addressed as they pose a threat to human and environmental health and are a potential source of *E. coli*.

The monitoring data and source assessment suggest that the *E. coli* stream impairments are due to a mix of sources (Figure 5 and Table 18). Livestock is the primary source of concern in the majority of impaired subwatersheds. In the subwatersheds with developed areas, stormwater runoff, which includes loads from wildlife and pets, has the potential to be a primary source.

Table 18. Summary of *E. coli* sources to impaired streams.
● Likely *E. coli* source; ○ Potential *E. coli* source; – Unlikely *E. coli* source

Waterbody Name	AUID	Source			
		Livestock	Stormwater Runoff, Permitted and Non-permitted (Including Wildlife and Domestic Pets) [a]	ITPHS [a]	Permitted Wastewater
Hay Creek	630	●	–	○	–
North Two River	524	●	–	○	○ Bowlus WWTP
South Two River	542	●	–	○	○ Albany WWTP
Unnamed creek	628	●	–	○	–
Unnamed creek	612	●	–	○	–
Unnamed creek	580	●	–	○	–
Krain Creek	613	●	–	○	–
Spunk Branch	561	●	○ [b]	○	–
Hillman Creek	639	●	–	○	–
Skunk River	521	●	–	○	○ Rich Prairie Sewer Treatment Facility
Big Mink Creek	646	●	–	○	–
Platte River	507	●	–	○	–
Stony Creek	649	●	○ Brockway Township	○	–
Little Rock Creek	653	●	–	○	–
County Ditch 16	616	–	● Le Sauk Township, City of Sartell, Stearns County	–	–

a. Relatively low percentages of SSTSs in the MRSW are estimated to be ITPHS. However, until location specific information is known about the ITPHS, they remain a potential source of *E. coli* to the impaired streams.

b. Lakes and wetlands separate the feedlots and the impaired stream segment; wildlife congregating near these bodies of water may be a significant source of *E. coli.*

3.6.3 Lake phosphorus source summary

Phosphorus is an essential nutrient for aquatic and terrestrial life and is found naturally throughout a watershed. However, there are several potential sources of phosphorus contributing excess amounts to impaired waterbodies. Where applicable, average annual phosphorus loads were estimated with the MRS HSPF model (Tetra Tech 2019).

Permitted sources of phosphorus to impaired lakes

Permitted stormwater

There are no permitted MS4s in the impaired lake subwatersheds. On average, based on county-wide data, less than 0.1% of the watershed area is permitted under the construction stormwater permit in any given year (Minnesota Stormwater Manual contributors 2018). There are three permitted industrial stormwater sites in the Two Rivers Lake Watershed and none in the Platte Lake Watershed. Construction stormwater and industrial stormwater are not considered a significant source.

Permitted wastewater

There is one municipal wastewater facility in the impaired lakes subwatersheds that is permitted to discharge phosphorus to surface waters—the Albany WWTP in the Two Rivers Lake Watershed (Figure 7). The WWTP's surface discharge is located over six miles upstream of Two Rivers Lake. NPDES/SDS permits can limit the load or concentration of phosphorus, as TP, that a WWTP may discharge. The Albany WWTP has a 1.0 mg/L TP calendar monthly average limit and a 12-month moving total load limit of 840 lb (381 kilogram [kg]) TP. Average annual (2008 through 2015) TP loads from the Albany WWTP were estimated with DMR data available in the MPCA's Wastewater Data Browser.

Permitted animal feeding operations

There is one NPDES/SDS-permitted AFO in the impaired lakes subwatersheds—a CAFO with primarily beef cattle located in the Two Rivers Lake Watershed, approximately seven miles upstream of Two Rivers Lake (Figure 8).

Non-permitted sources of phosphorus to impaired lakes

Watershed runoff

Phosphorus loads for each of the modeled land covers in watershed runoff were quantified with HSPF. 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. Model documentation contains additional details about the model development and calibration (Tetra Tech 2019).

Modeled streams do not typically include ditches, ephemeral streams, or small perennial streams. Tile drains with surface inlets can also be direct sources of phosphorus load as they directly and efficiently remove water from agricultural land, carrying with it nutrients that may otherwise be trapped in vegetation. Loads from tile drainage were not explicitly quantified in the HSPF model.

Subsurface sewage treatment systems

In shoreland areas, a conforming system is estimated to contribute on average 20% of the phosphorus that is found in the system, and failing systems and ITPHS systems are estimated to contribute on average 43% (assumptions from Barr Engineering 2004). It was assumed that SSTSs within 1,000 feet of the lake's shoreline contribute phosphorus to the lakes. The numbers of SSTSs around Two Rivers Lake were estimated from Stearns County parcel data. Residential and/or homestead parcels within the 1,000-foot shoreline zone were included in the estimates. The numbers of SSTSs around Platte Lake were estimated from aerial imagery. The estimated percentages of conforming systems, systems that are failing to protect groundwater, and ITPHS systems were provided by MPCA (Table 12).

Phosphorus loads from SSTS were estimated with a spreadsheet approach using the MPCA's *Detailed Assessment of Phosphorus Sources to Minnesota Watersheds* (Barr Engineering 2004). Total loading is based on the number of conforming and failing SSTSs (Table 19), an average of 2.32 people per household (Barr Engineering 2004), and an average value for phosphorus production per person per year (MPCA 2014b).

Table 19. Septic system inventory.

Lake Name	Lake ID	Estimated Number of Conforming SSTS	Estimated Number of SSTS Failing to Protect Groundwater	Estimated Number of ITPHS
Two Rivers Lake	73-0138-00	146	17	3
Platte Lake	18-0088-00	143	11	2

Internal loading

There are multiple mechanisms by which phosphorus can be released back into the water column as internal loading:

- Low oxygen concentrations (also called anoxia) in the water overlying the sediment can lead to phosphorus release. In a shallow lake such as Platte Lake that undergoes intermittent mixing of the water column throughout the growing season (i.e., polymixis), the released phosphorus can mix with surface waters throughout the summer and become available for algal growth. In Platte Lake, DO is at times low near the bottom sediments, but the stratification is not stable throughout the growing season (see Figure 33). In deeper lakes such as Two Rivers Lake with a more stable summer stratification period, the released phosphorus remains in the bottom water layer until the time of fall mixing, when it mixes with surface waters. In 2016, the deep hole in Two Rivers Lake stratified during the growing season (Figure 29), and phosphorus concentrations in the bottom layer increased throughout the growing season (Figure 30).
- Curlyleaf pondweed (*Potamogeton crispus*), which can reach nuisance levels in shallow lakes, decays in the early summer and releases phosphorus to the water column. Curlyleaf pondweed has been observed in Platte Lake (DNR 2003).
- Bottom-feeding fish such as carp and black bullhead forage in lake sediments. This physical disturbance can release phosphorus into the water column. Fisheries data available on the DNR's Lake Finder website indicate that carp and black bullhead are present in both Two Rivers Lake and Platte Lake.

- Wind energy in shallow depths can mix the water column and disturb bottom sediments, which leads to phosphorus release.
- Other sources of physical disturbance, such as motorized boating in shallow areas, can disturb bottom sediments and lead to phosphorus release.

To estimate internal loads, an additional phosphorus load was added to the Platte Lake phosphorus budget to calibrate the lake response model (see Section 4.8); this load was attributed to internal loading. However, a portion of the load that was attributed to internal loading could be from watershed or septic system loads that were not quantified with the available data.

An additional phosphorus load was not needed to calibrate the Two Rivers Lake model, and internal load was not quantified in Two Rivers Lake. However, because internal loading is inherent in the BATHTUB model, the model assumes that an average amount of internal loading is present, whether or not the load is explicitly quantified. Phosphorus monitoring data in Two Rivers Lake indicate lake stratification and high phosphorus concentrations in the hypolimnion (Figure 29 and Figure 30), suggesting that internal loading affects the water quality of the lake. Although not explicitly quantified, internal loads from upstream lakes and wetlands can also contribute phosphorus loads to the impaired lakes. There are several smaller lakes in the Two Rivers Lake Watershed, including Schwinghammer, Pelican, Little Pine, and Pine Lake, and there are multiple smaller lakes in the Platte Lake Watershed. Limited water quality data are available on most of these lakes.

Streambank erosion

A DNR evaluation of streambank erosion in the Two Rivers Lake Watershed concluded that there are unstable reaches that could contribute sediment and associated phosphorus to Two Rivers Lake (personal communication, Reid Northwick). However, excessive streambank erosion was not observed and is not likely to be a primary cause of lake impairment. Phosphorus loads from streambank erosion were not explicitly quantified.

Summary

Cropland is the primary source of phosphorus to the impaired lakes (Table 20, Figure 10, and Figure 11). Other loads include runoff from pasture, forests, and wetlands.

Table 20. Lake phosphorus source assessment.

Source		Two Rivers Lake (73-0138)		Platte Lake (18-0088)	
		TP Load (lb/yr)	TP Load (%)	TP Load (lb/yr)	TP Load (%)
Watershed	Cropland	18,064	82%	2,374	49%
	Pasture	1,546	7%	329	7%
	Feedlots	193	<1%	3	<1%
	Developed	280	1%	111	2%
	Grassland	752	3%	144	3%
	Forest	239	1%	587	12%
	Wetlands	126	<1%	489	10%
Septics		200	1%	180	4%
Internal		not quantified		216	4%
Atmospheric Deposition		140	<1%	400	8%
Point Source		416 [a]	2%	0	0%
Total		21,956	100%	4,833	100%

a. Albany WWTP effluent, calculated from DMRs as the 2008–2015 average of the annual maximum calendar year to date loads. The long-term average effluent TP load is 11.2 lb/day.

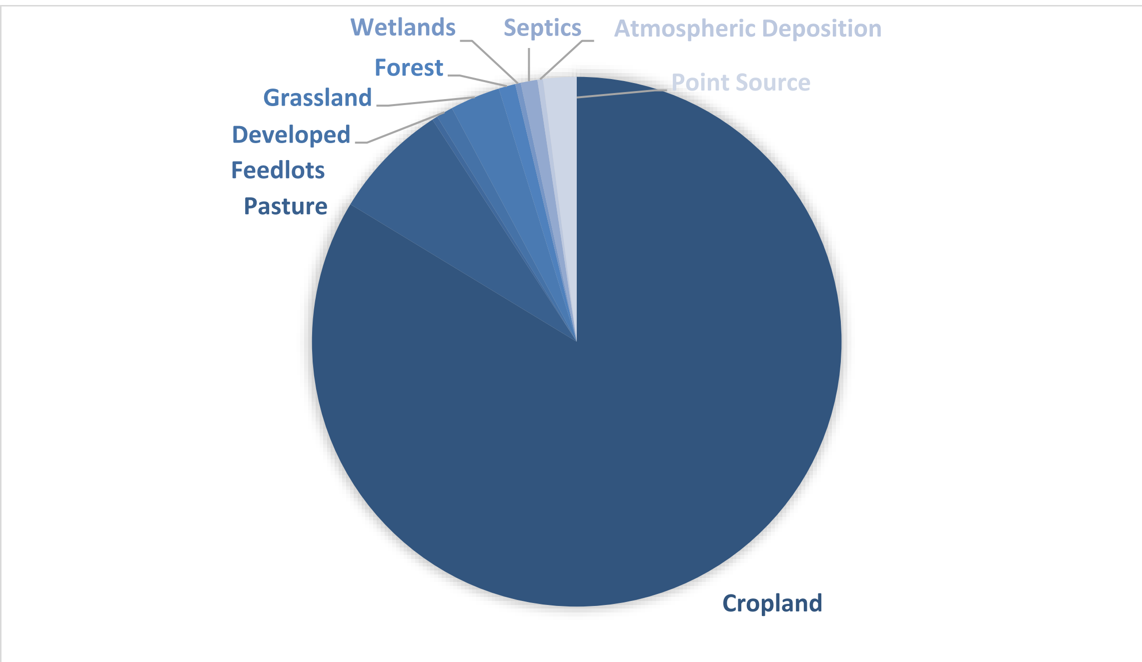

Figure 10. Sources of phosphorus to Two Rivers Lake (73-0138).

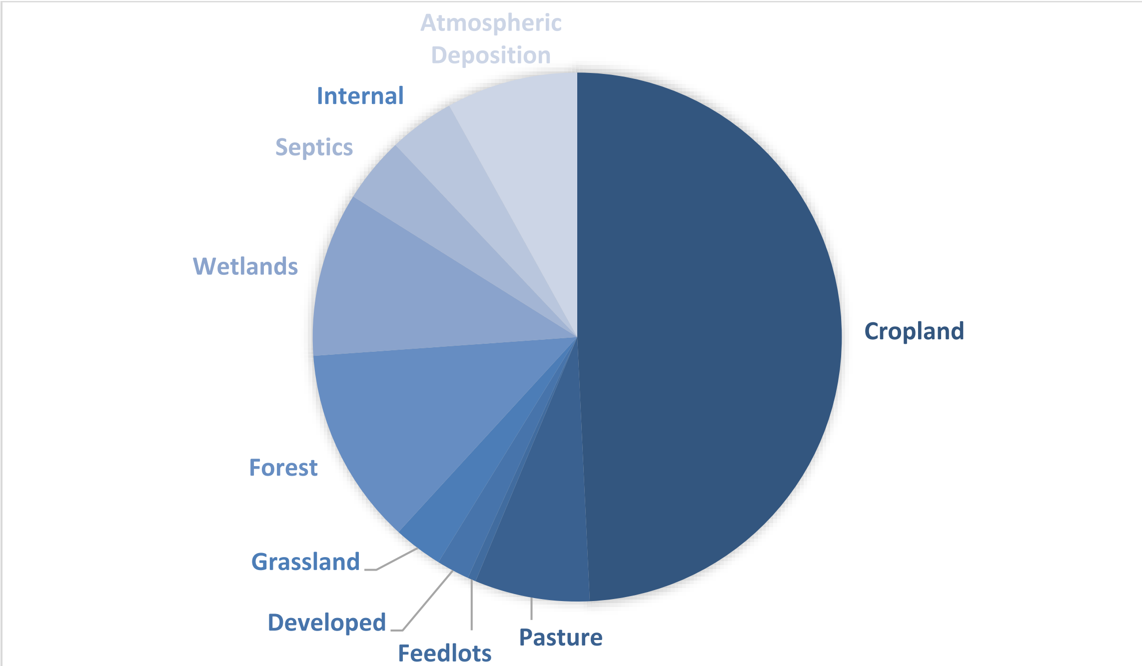

Figure 11. Sources of phosphorus to Platte Lake (18-0088)

4. TMDL development approach

A TMDL is the total amount of a pollutant that a receiving waterbody can assimilate while still achieving water quality standards. TMDLs can be expressed in terms of mass per time or by other appropriate measures. A TMDL for a waterbody that is impaired as a result of excessive loading of a particular pollutant can be described by the following equation:

TMDL = WLA + LA + MOS

where:

TMDL = total maximum daily load, also known as loading capacity, which is the greatest pollutant load a waterbody can receive without violating water quality standards.

WLA = wasteload allocation, or the portion of the TMDL allocated to existing or future permitted point sources of the relevant pollutant.

LA = load allocation, or the portion of the TMDL allocated to existing or future nonpoint sources of the relevant pollutant.

MOS = margin of safety, or an accounting of uncertainty about the relationship between pollutant loads and receiving water quality. The MOS can be provided implicitly through analytical assumptions or explicitly by reserving a portion of the loading capacity (EPA 1999).

This section describes the approaches used to derive the TMDLs and allocations. A brief summary of the TMDLs is presented in Section 5, and the allocations for each of the various sources and parameters are provided in Section 5: *TMDL Summaries*.

4.1 Overall approach

E. coli TMDLs for streams: Assimilative loading capacities for the streams were developed using load duration curves. See Section 3.5 for a description of load duration curve development. The load duration curves provide assimilative loading capacities and show load reductions necessary to meet water quality standards. Both seasonal variation and critical conditions are accounted for in the stream TMDLs through the application of load duration curves. For any given flow in the load duration curve, the loading capacity is determined by selecting the point on the load duration curve that corresponds to the flow exceedance (along the x-axis). Load duration curves were developed for each impaired reach (Section 5).

The load duration curve method is based on an analysis that encompasses the cumulative frequency of historic 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 tables in this report (Section 5) only five points on the entire load duration curve are depicted (the midpoints of the designated flow zones). The entire curve; however, represents the TMDL and is what is ultimately approved by the EPA.

Phosphorus TMDLs for lakes: Allowable pollutant loads in lakes were determined using the lake response model BATHTUB. BATHTUB is a steady state model that predicts eutrophication response in lakes based on empirical formulas developed for nutrient balance calculations and algal response (Walker 1987). The model was developed by the U.S. Army Corps of Engineers and has been used extensively in Minnesota and across the Midwest for lake nutrient TMDLs. The BATHTUB model requires nutrient loading inputs from the upstream watershed and atmospheric deposition, morphometric data for the lake, and estimates of mixing depth and non-algal turbidity. Watershed loads were derived from the HSPF model (Tetra Tech 2019; see Section 3.6.3 for a brief description of the model).

Additional details on the approaches used to develop the TMDL components are provided in the following sections.

4.2 Margin of safety

The purpose of the MOS is to account for uncertainty that the allocations will result in attainment of water quality standards. Section 303(d) of the CWA and EPA's regulations in 40 CFR 130.7 require that:

> TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numeric water quality standards with seasonal variations and a MOS, which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality.

The MOS can either be implicitly incorporated into conservative assumptions used to develop the TMDL or be added as a separate explicit component of the TMDL (EPA 1991). 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, as described below.

The MRS HSPF model was calibrated and validated using six stream flow gaging stations (Tetra Tech 2019). One gage is on the main stem Mississippi River at Royalton, and the remaining sites gage tributary stream flows. Calibration results indicate that the HSPF model is a valid representation of hydrologic and water quality conditions in the watershed. Flow data used to develop the stream TMDLs are derived from HSPF-simulated daily flow data.

The HSPF model was also used to estimate watershed phosphorus loading to the impaired lakes. The BATHTUB models used to develop the lake TMDLs show generally good agreement between the observed lake water quality and the water quality predicted by the lake response models (see Appendix B for details). The watershed loading models and lake response models reasonably reflect the watershed and lake conditions.

4.3 Seasonal variation and critical conditions

The CWA requires that TMDLs take into account critical conditions for flow, loading, and water quality parameters as part of the analysis of loading capacity.

Both seasonal variation and critical conditions are accounted for in the *E. coli* TMDLs through the application of load duration curves. Load duration curves evaluate water quality conditions across all flow regimes including high flow, which is the runoff condition where pollutant transport and loading from upland sources tend to be greatest, and low flow, when loading from wastewater and other direct sources to the waterbodies has the greatest impact. Seasonality is accounted for by addressing all flow conditions in a given reach. Seasonal variation is also addressed by the water quality standards' application during the period when high pollutant concentrations are expected via storm event runoff.

Seasonal variations are addressed in the lake phosphorus TMDLs by assessing conditions during the summer growing season, which is when the water quality standards apply (June 1 through September 30). The frequency and severity of nuisance algal growth in Minnesota lakes is typically highest during the growing season. The nutrient standards set by the MPCA—which are a growing season concentration average, rather than an individual sample (i.e., daily) concentration value—were set with this concept in mind. Additionally, by setting the TMDL to meet targets established for the most critical period (summer), the TMDL will inherently be protective of water quality during all other seasons.

4.4 Baseline year

The monitoring data used to calculate the percent reductions are from 2008 through 2017. Because projects undertaken recently may take a few years to influence water quality, the baseline year for crediting load reductions for a given waterbody is 2012, the midpoint of the time period. Any activities implemented during or after the baseline year that led to a reduction in pollutant loads to the waterbodies may be considered as progress towards meeting a WLA or LA. If a BMP was implemented during or just prior to the baseline year, the MPCA may consider evidence presented by the MS4 permit holder to demonstrate that the BMP should be considered as progress towards meeting a WLA. BMPs present on the landscape during the model simulation time period are implicitly accounted for in the model.

4.5 Construction and industrial stormwater WLAs

Construction stormwater is permitted through the Construction Stormwater General Permit MNR100001, and a single categorical phosphorus WLA for construction stormwater is provided for each of the impaired lakes. The average annual percent area of each county that is permitted through the construction stormwater permit (provided in the Minnesota Stormwater Manual [Minnesota Stormwater Manual contributors 2018]) was area-weighted for each impairment watershed. For each applicable TMDL, the construction stormwater WLA was calculated as the percent area multiplied by the loading capacity (i.e., TMDL) less the MOS and wastewater WLAs. It is assumed that loads from permitted construction stormwater sites that operate in compliance with their permits are meeting the WLA.

Industrial stormwater is permitted through the General Permit MNR050000 for Industrial Stormwater Multi-Sector. A single categorical phosphorus WLA for industrial stormwater is provided for each impaired lake. Permitted industrial stormwater sources are not expected to be sources of *E. coli* and are not provided WLAs. MPCA's industrial stormwater permit does not regulate discharges of *E. coli*. The permit does not contain *E. coli* benchmarks; industrial stormwater permittees are required to sample their stormwater for parameters that more closely match the potential contribution of pollutants for their industry sector or subsector. For example, recycling facilities and auto salvage yards are required to sample for TSS, metals, and other pollutants likely present at these types of facilities.

Permitted industrial activities make up a small portion of the impaired lake watershed areas, and the industrial stormwater WLA for each impaired lake was set equal to the construction stormwater WLA. It is assumed that loads from permitted industrial stormwater sites that operate in compliance with the permit are meeting the WLA.

4.6 Natural background consideration

Natural background conditions refer to 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. For each impairment, natural background levels are implicitly incorporated in the water quality standards used by the MPCA to determine/assess impairment and therefore natural background is accounted for and addressed through the MPCA's waterbody assessment process.

Determining the extent that natural background conditions are included in the overall waterbody assessment process is decided through the assessment processes described in Section III of the Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 305(b) Report and 303(d) List. The various steps of the assessment process including: Desktop assessment, Watershed Assessment Team and Professional Judgement Group incorporate a comprehensive professional evaluation and interpretation process into the final waterbody assessment decisions. In the case of the MRSW, natural background conditions were also evaluated, where possible, within the modeling and source assessment portion of this study. These source assessment exercises indicate natural background inputs are generally low compared to livestock, cropland, WWTPs, failing SSTSs, and other anthropogenic sources.

Based on the MPCA's waterbody assessment process and the TMDL source assessment exercises, there is no evidence to suggest that natural background sources are a major driver of any of the impairments and/or affect the waterbodies' ability to meet state water quality standards. For all impairments addressed in this TMDL study, natural background sources are implicitly included in the LA portion of the TMDL allocation tables, and TMDL reductions should focus on the major anthropogenic sources identified in the source assessment.

4.7 *E. coli*

4.7.1 Loading capacity and percent reductions

Loading capacities were developed using load duration curves developed from simulated flows. (See Section 3.5 for a description of load duration curve development and Section 4.1 for more background on the load duration curve method.) The loading capacity was calculated as flow multiplied by the *E. coli* geometric mean standard (126 org/100 mL for class 2 streams and 630 org/100 mL for the class 7 stream). It is assumed that practices that are implemented to meet the geometric mean standard will also address the individual sample standard (1,260 org/100 mL), and that the individual sample standard will also be met. While the *E. coli* TMDLs will focus on the geometric mean portion of the water quality standard, attainment of both parts of the water quality standard is required.

The estimated percent reduction needed to meet each TMDL was calculated by comparing the highest observed (monitored) monthly geometric mean from the months that the standard applies to the geometric mean standard (monitored – standard / monitored). Monthly geometric means were used to estimate percent reduction only if they are based on five or more samples. The estimated percent reductions provide a rough approximation of the overall reduction needed for the waterbody to meet the TMDL. 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.

4.7.2 Wasteload allocation methodology

WLAs are provided for municipal WWTPs and for permitted MS4 communities. Because NPDES/SDS-permitted AFOs are required to completely contain runoff (except for basin overflows that are caused by extreme climatic events), they are not allowed to discharge *E. coli* to surface waters and WLAs are not provided; this is equivalent to a WLA of zero.

Wastewater

The *E. coli* WLAs for municipal wastewater are based on the *E. coli* geometric mean standard of 126 organisms per 100 mL and the maximum daily discharge volume for each facility (Table 21). All of the WWTPs that receive *E. coli* WLAs have controlled discharges, and there are no required changes to the permit.

The facilities that discharge to class 2 waters are required to disinfect from April 1 through October 31, which is the same time period that the class 2 stream *E. coli* standard applies. Similarly, facilities that discharge to class 7 waters are required to disinfect from May 1 through October 31, which is the time period that the class 7 stream *E. coli* standard applies. It is assumed that if a facility meets the fecal coliform limit of 200 organisms per 100 mL it is also meeting the *E. coli* WLA.

The total daily loading capacity in the low or very low flow zones for some reaches is less than the calculated wastewater treatment facility allowable load. This is an artifact of using design flows for allocation setting and results in these point sources appearing to use all (or more than) the available loading capacity. In reality, actual treatment facility flow can never exceed stream flow as it is a component of stream flow. To account for these unique situations, the WLAs and LAs in these flow zones where needed are expressed as an equation rather than an absolute number:

Allocation = flow contribution from a given source x 126 org *E. coli*/100 mL

This amounts to assigning a concentration-based limit to these sources for the lower flow zones. By definition rainfall and thus runoff is very limited if not absent during low flow. Thus, runoff sources would need little to no allocation for these flow zones.

All wastewater WLAs are listed in the TMDL tables in Section 5 and in Table 21.

Table 21. Individual wastewater wasteload allocations.

Facility	Permit Number	Design Flow (mgd) [a]	*E. coli* Wasteload Allocation (billion organisms per day)	Impaired Waterbody Name	Impaired Waterbody AUID
Albany WWTP	MN0020575	5	23.85 [b]	South Two River	542
Bowlus WWTP	MN0020923	0.277	1.32	North Two River	524
Rich Prairie Sewer Treatment Facility	MNG580211	2.167	10.34	Skunk River	521

a. Maximum daily pond flow, in million gallons per day (mgd).
b. WLAs noted with footnote apply May–Oct; all others apply Apr–Oct.

Municipal Separate Storm Sewer Systems

MS4s are defined by the MPCA as conveyance systems owned or operated by an entity such as a state, city, township, county, district, or other public body having jurisdiction over disposal of stormwater or other wastes. Stormwater runoff that falls under the MS4 general permit is permitted as a point source and, therefore, must be included in the WLA portion of a TMDL. EPA recommends that WLAs be broken down as much as possible in the TMDL, as information allows. This facilitates implementation planning and load reduction goals for the MS4 entities. See the pollutant source summary in Section 3.6 for more information on permitted MS4s.

Two impairment subwatersheds have permitted MS4 area—Stony Creek and County Ditch 16—and three permitted MS4s in the *E. coli* impairment subwatersheds receive WLAs (Table 22, Figure 12). The permitted MS4 areas within each impairment subwatershed were determined using the following approaches:

- **Sartell City MS4**: To account for future growth, the area within the impaired subwatersheds was approximated with future land use plans provided by the city (Proposed_Land_Use shapefile). *Guidance on What Discharges Should be Included in the TMDL WLA for MS4 Stormwater* (MPCA 2011a) was followed to determine which planned land use categories should be used to approximate a permitted MS4's area. For example, developed land uses such as residential and general business categories are considered to be permitted MS4 area. The entire jurisdictional area of Sartell in the County Ditch 16 Subwatershed is considered to be regulated through the MS4 permit (Figure 12).

  The City of Sartell has entered into an orderly annexation agreement with Le Sauk Township; the agreement area includes the entire township (City of Sartell 2016). The WLA for the area in Le Sauk Township that is in the County Ditch 16 Subwatershed is provided as part of the City of Sartell's MS4 WLA.

- **Brockway Township MS4:** The permitted township area was approximated using developed land within the jurisdictional boundary. Developed land includes developed land cover classes in the 2017 Cropland Data Layer: open space, low intensity, medium intensity, and high intensity.

  The *St. Stephen Comprehensive Plan* (Municipal Development Group, Inc. 2005) states that the City of St. Stephen, located adjacent to Brockway Township, might pursue annexation discussions with Brockway Township. In the future land use plan map in the *2030 Stearns County Comprehensive Plan* (Stearns County 2008), portions of the City of St. Stephens that are adjacent to Brockway Township are shown as orderly annexation areas. However, specific information about an orderly annexation agreement was not available at the time of this report; therefore this potential future annexation was not accounted for in the TMDL allocations. If the city were to annex portions of Brockway Township that are in the Stony Creek Subwatershed, the portion of Brockway Township that is represented in the WLA and that is being annexed by the city will be transferred from WLA to LA. (The City of St. Stephen is not a permitted MS4.) See Section 6.1 for more information about transfer of allocations as a result of changes in permitted MS4 boundaries.

- **Stearns County MS4:** The MS4 permits for permitted road authorities apply to roads within the U.S. Census Bureau 2010 urban area. The permitted roads and rights-of-way within Stearns County were approximated by the county road lengths (county roads identified in Stearns County's roads shapefile) in the 2010 urban area multiplied by average right-of-way widths provided by Stearns County: 50 feet on each side of the centerline for CSAH 4 (Veterans Drive) and 40 feet on each side of the centerline for CSAH 133 (2nd Street).
- There are no permitted roads or rights of way managed by MnDOT in the impairment subwatersheds; therefore, MnDOT does not receive a WLA for these TMDLs.

The estimated permitted area of each permitted MS4 within an impaired subwatershed was divided by the total area of the subwatershed to represent the percent coverage of each permitted MS4 within the impaired subwatershed. The WLAs for permitted MS4s were calculated as the percent coverage of each permitted MS4 multiplied by the loading capacity minus the MOS.

Table 22. Permitted MS4s that receive WLAs and estimated permitted areas.

MS4 Name	Permit Number	Regulated Area (ac)	*E. coli* Wasteload Allocation (billion organisms per day) [a]	Impaired Waterbody Name	Impaired Waterbody AUID
Brockway Township	MS400068	497	4.3–0.090	Stony Creek	649
City of Sartell [b]	MS400048	1,873	16–0.60	County Ditch 16	616
Stearns County	MS400159	13	0.11–0.0040	County Ditch 16	616

a. Range of *E. coli* WLAs from very high flows to very low flows.
b. The WLA for the City of Sartell includes 587 acres of regulated area that is currently part of Le Sauk Township (MS4 permit # MS400143) but is expected to be annexed to the City of Sartell as a result of future growth. The Le Sauk Township annexation area represents approximately 31% of the 1,873 acres that are accounted for in the City of Sartell's WLA.

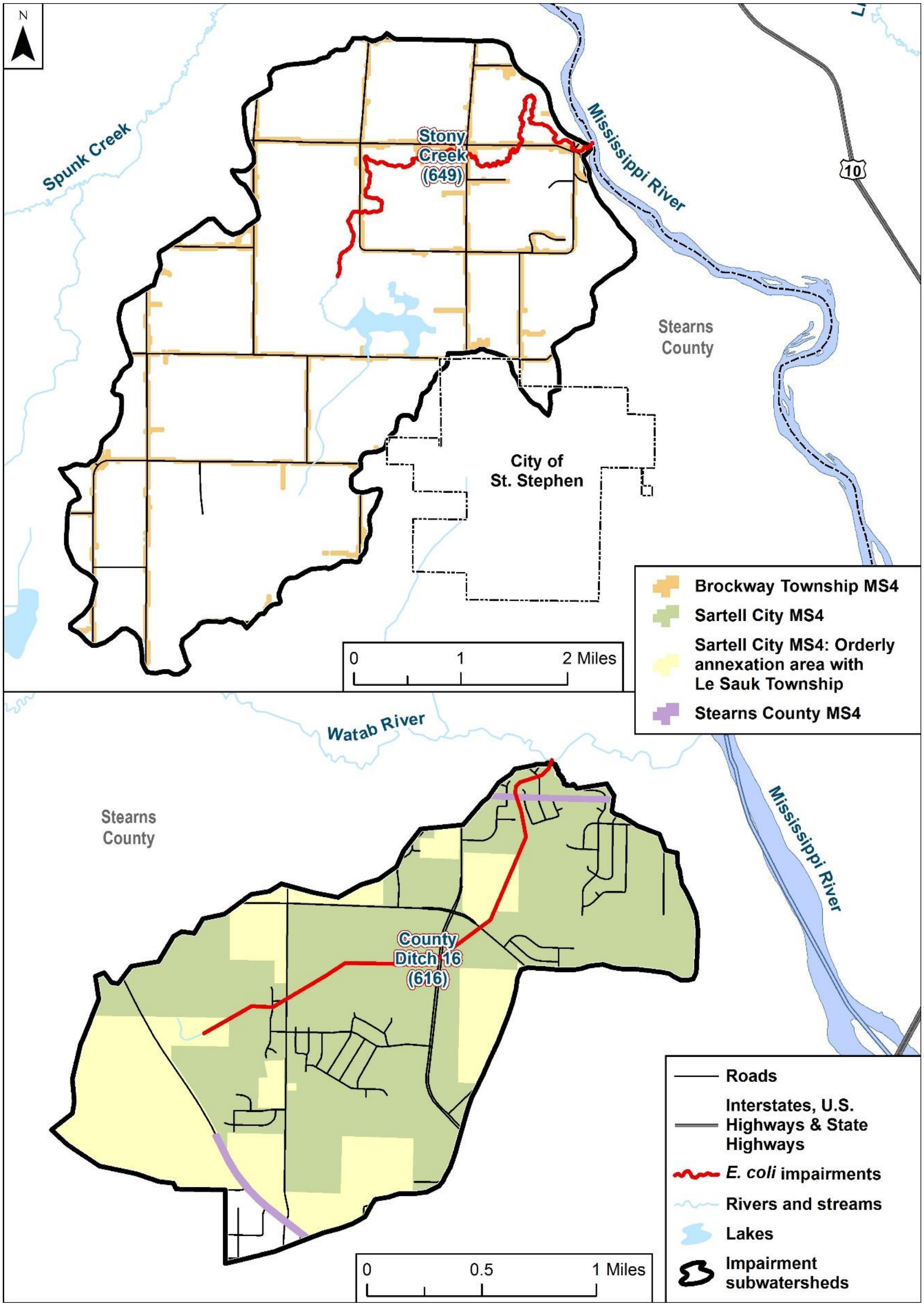

Figure 12. Estimated permitted MS4 areas.

The WLA for Le Sauk Township (light yellow in bottom panel) was allocated to the City of Sartell's permitted MS4 WLA due to an orderly annexation agreement. The City of St. Stephen is not a permitted MS4, but is shown in the top panel due to potential future annexation of portions of Brockway Township. See text for more information.

4.7.3 Load allocation methodology

The LA represents the portion of the loading capacity that is allocated to pollutant loads that are not permitted through an NPDES/SDS permit (e.g., non-permitted watershed runoff, ITPHS, and natural background [see Section 4.6]). The LA for each *E. coli* TMDL was calculated as the loading capacity minus the MOS minus the WLAs.

4.8 Phosphorus

4.8.1 Loading capacity and load reductions

Allowable phosphorus loads in lakes were determined using the lake response model BATHTUB. The BATHTUB model requires nutrient loading inputs from the upstream watershed and atmospheric deposition (Section 3.6.3), lake morphometric data (Table 4), and estimated mixed depth. Annual precipitation from HSPF was used as input to the models.

The BATHTUB models were calibrated to the long-term average phosphorus concentration, consisting of all data from 2008 through 2017 (Section 3.5.2). The models within BATHTUB inherently include an internal load that is typical of lakes in the model development data set. For Platte Lake, the data suggest that internal loads are greater than the average rates inherent in BATHTUB, and an additional internal load was added during model calibration (see *Internal Loading* under *Non-permitted sources of phosphorus* in Section 3.6.3).

After the models were calibrated, the TMDL scenarios were developed by reducing phosphorus load inputs until the lake TP standard was met. The total load to the lake in each TMDL scenario represents the loading capacity, and the percent reduction needed to meet the TMDL was calculated as the existing load minus the loading capacity divided by the existing load. As with the *E. coli* TMDLs, the estimated percent reductions provide a rough approximation of the overall reduction needed for the waterbody to meet the TMDL. 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. Following each lake TMDL table, an additional table with estimated percent reductions by source is provided (Table 70, Table 73).

The complete model inputs and outputs are presented in Appendix B.

4.8.2 Wasteload allocation methodology

WLAs are provided for municipal wastewater and for permitted construction and industrial stormwater. There are no permitted MS4s in the impaired lake subwatersheds. Because CAFOs are required to completely contain runoff, they are not allowed to discharge phosphorus to surface waters and a WLA is not provided for the one CAFO in the Two Rivers Lake Subwatershed; this is equivalent to a WLA of zero.

Wastewater

The Albany WWTP, which discharges in the Two Rivers Lake Subwatershed, is the only permitted wastewater source in the impaired lakes subwatersheds, and represents 2% of the total load to Two Rivers Lake (Table 20). The phosphorus WLA of 840 lb/yr for the Albany WWTP is based on the permitted load (381 kg/yr as a 12-month moving total). This annual allocation is the WLA intended for implementation of the WLA as a permit limit.

The existing 381 kg/year TP effluent limit in the Albany WWTP NPDES/SDS permit is consistent with the TMDL's 840 lb/year WLA. The daily WLA of 2.30 lb/day is included to satisfy the TMDL requirement that all loads must be expressed in daily terms; however, *the daily WLA is not intended for implementation as a permit limit*. The long-term average effluent TP load is 11.2 lb/day. Because the facility does not discharge continuously, this long-term existing daily load (11.2 lb/day), which is greater than the daily WLA (2.30 lb/day), is consistent with a total annual load that meets the existing permit limits and the TMDL's annual WLA. No changes to the permits are needed.

Construction and industrial stormwater

A categorical WLA is provided for construction stormwater and industrial stormwater. See Section 4.5 for more details.

4.8.3 Load allocation methodology

The LA represents the portion of the loading capacity that is allocated to pollutant loads that are not regulated through an NPDES/SDS permit (e.g., unregulated watershed runoff, septic systems, internal loading, and natural background [see Section 4.6]). The LA for each phosphorus TMDL was calculated as the loading capacity minus the MOS minus the WLAs.

5. TMDL summaries

This section provides the water quality summary tables, load duration curves, and TMDLs for streams; and the water quality summary tables and figures, and TMDL tables for lakes. See Sections 3.5 and 4 for an explanation of the data analyses.

E. coli load reductions are needed to address multiple source types (see Section 3.6.2: Stream *E. coli* source summary). Reductions in phosphorus are presented on an average annual basis and will need to come primarily from agricultural runoff (see Section 3.6.3: Lake phosphorus source summary).

The impairments are listed ordered from upstream to downstream. The maximum recordable value for *E. coli* concentration depends on the extent of sample dilution and is often 2,420 org/100 mL. Concentrations that are noted as 2,420 org/100 mL are likely higher, and the magnitude of the exceedances is not known.

Loads in the *E. coli* TMDL tables are rounded to two significant digits, except in the case of values greater than 1,000, which are rounded to the nearest whole number. Loads in the phosphorus TMDL tables are rounded to three significant digits, except in the case of values greater than 1,000, which are rounded to the nearest whole number. Percent reductions are rounded to the nearest whole number.

5.1 *E. coli*

5.1.1 Hay Creek, Unnamed cr to Mississippi R (07010201-630)

Annual and monthly summaries of *E. coli* data for Hay Creek are provided in Table 23 and Table 24, respectively. The load duration curve and TMDL allocations for Hay Creek are presented in Figure 13 and Table 25, respectively. Exceedances of the *E. coli* standard are seen under very high, high, and mid-range flow conditions.

Table 23. Annual summary of *E. coli* data at Hay Creek (AUID 07010201-630; April–October).

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
2008	0	–	–	–	–	–
2009	0	–	–	–	–	–
2010	0	–	–	–	–	–
2011	6	386	102	866	0	–
2012	9	211	5	≥ 2,420	2	22
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–
2016	0	–	–	–	–	–
2017	0	–	–	–	–	–

Table 24. Monthly summary of *E. coli* data at Hay Creek (AUID 07010201-630; 2008–2017).

Values in red 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. Standard applies only to months April–October.

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
Apr	0	–	–	–	–	–
May	0	–	–	–	–	–
Jun	5	365	102	1,300	1	20
Jul	5	764	387	≥ 2,420	1	20
Aug	5	70	5	866	0	–
Sep	0	–	–	–	–	–
Oct	0	–	–	–	–	–

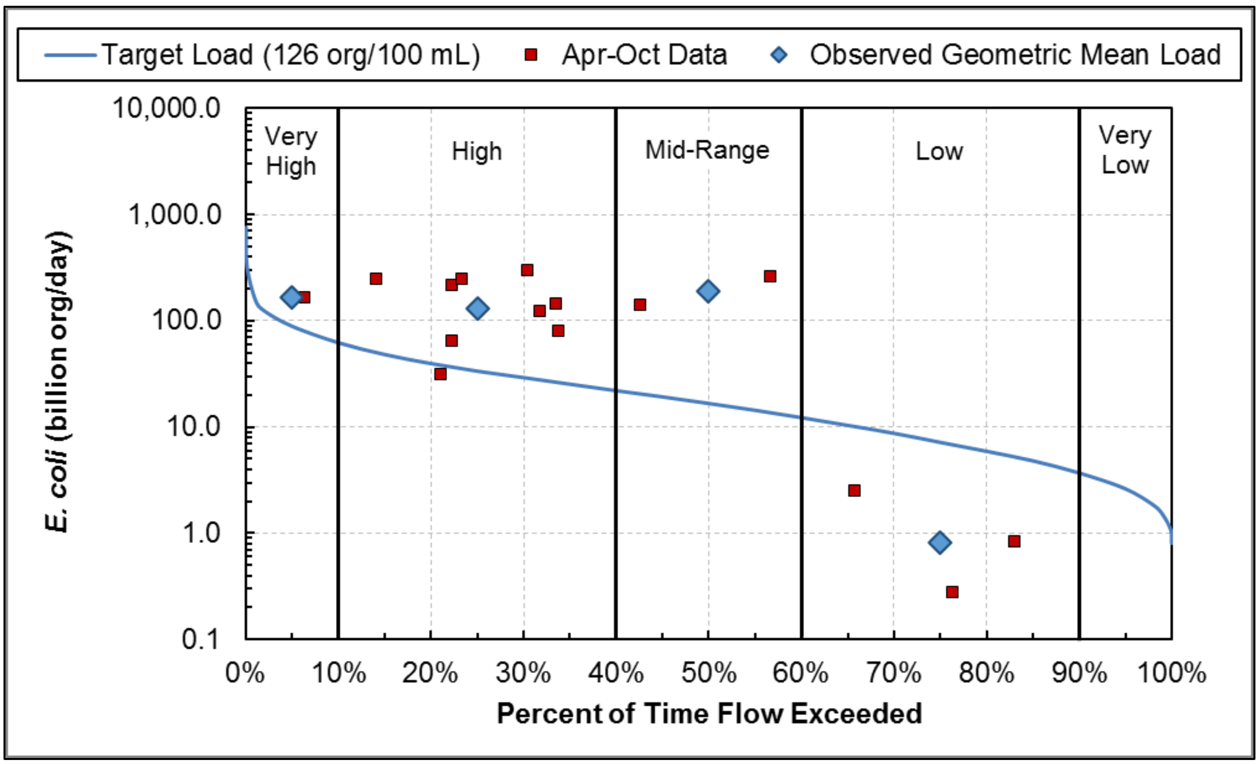

Figure 13. *E. coli* load duration curve, Hay Creek (AUID 07010201-630).

Table 25. *E. coli* TMDL summary, Hay Creek (AUID 07010201-630).

- **303(d) listing year or proposed year: 2020**
- **Baseline year: 2012**
- **Use class: 2Bg**
- **Standard applicable: April–October**

TMDL parameter		Flow zones				
		Very high	High	Mid-range	Low	Very low
Sources		*E. coli* load (B org/d)				
Load	Total LA	80	31	15	6.4	2.3
MOS		8.9	3.4	1.7	0.71	0.26
Total load		89	34	17	7.1	2.6
Maximum monthly geomean (org/100 mL)		764				
Overall estimated percent reduction		84%				

5.1.2 North Two River, Headwaters (Mary Lk 77-0019-00) to South Two R (07010201-524)

Annual and monthly summaries of *E. coli* data for North Two River are provided in Table 26 and Table 27, respectively. The load duration curve and TMDL allocations for North Two River are presented in Figure 14 and Table 28, respectively. Reductions are needed across all flow conditions.

Table 26. Annual summary of *E. coli* data at North Two River (AUID 07010201-524; April–October).

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
2008	0	–	–	–	–	–
2009	0	–	–	–	–	–
2010	0	–	–	–	–	–
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–
2016	9	623	261	10,000	2	22
2017	6	818	52	20,000	2	33

Table 27. Monthly summary of *E. coli* data at North Two River (AUID 07010201-524; 2008–2017).
Values in red 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. Standard applies only to months April–October.

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
Apr	0	–	–	–	–	–
May	0	–	–	–	–	–
Jun	5	466	291	866	0	–
Jul	5	1,666	270	20,000	2	40
Aug	5	432	52	≥ 2,420	2	40
Sep	0	–	–	–	–	–
Oct	0	–	–	–	–	–

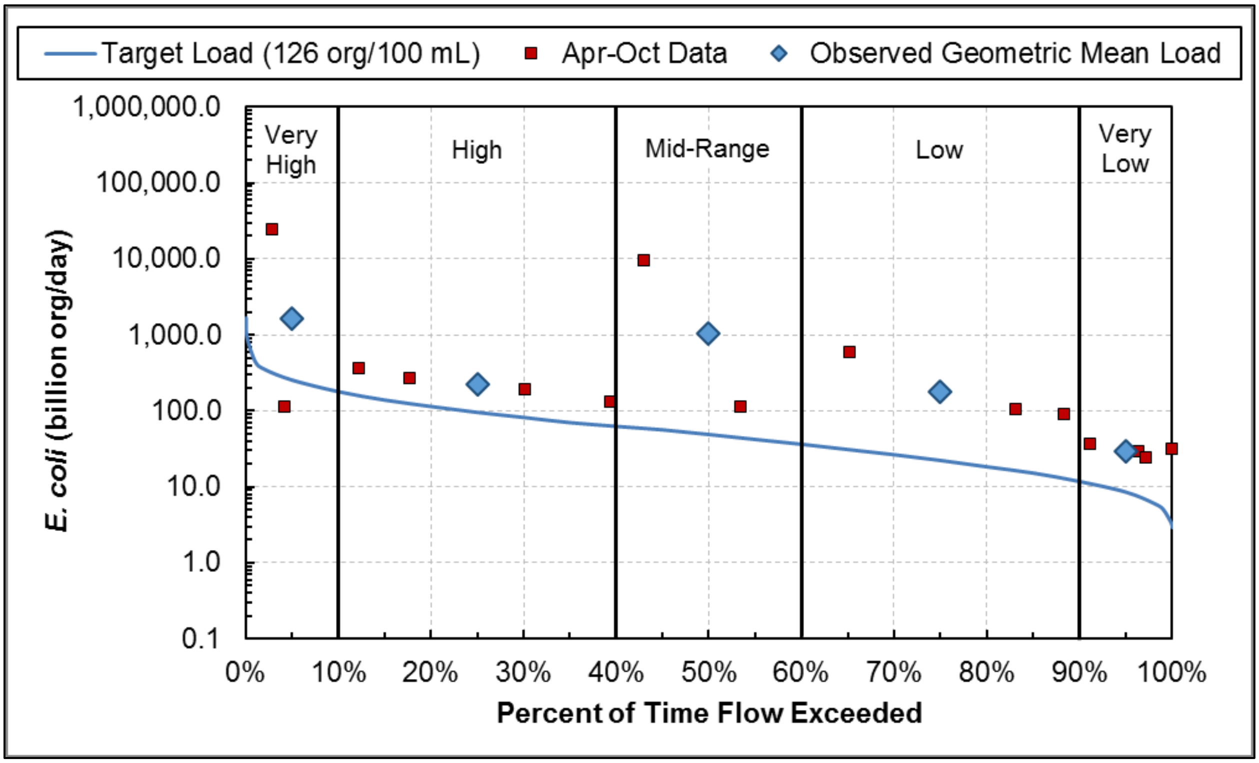

Figure 14. *E. coli* load duration curve, North Two River (AUID 07010201-524).

Table 28. *E. coli* TMDL summary, North Two River (AUID 07010201-524).

- **303(d) listing year or proposed year: 2020**
- **Baseline year: 2012**
- **Use class: 2Bg**
- **Standard applicable: April–October**

TMDL parameter		**Flow zones**				
		Very high	**High**	**Mid-range**	**Low**	**Very low**
Sources		***E. coli* load (B org/d)**				
Wasteload	Bowlus WWTP (MN0020923)	1.32	1.32	1.32	1.32	1.32
	Total WLA	1.3	1.3	1.3	1.3	1.3
Load	**Total LA**	226	84	43	18	6.3
MOS		25	9.5	4.9	2.2	0.85
Total load		252	95	49	22	8.5
Maximum monthly geomean (org/100 mL)		1,666				
Overall estimated percent reduction		92%				

5.1.3 South Two River, T125 R31W S21, south line to T125 R31W S23, east line (07010201-542)

Annual and monthly summaries of *E. coli* data for South Two River are provided in Table 29 and Table 30, respectively. The load duration curve and TMDL allocations for South Two River are presented in Figure 15 and Table 31, respectively. Exceedances of the *E. coli* standard are seen under very high, high, mid-range, and low flow conditions. Data are not available under very low flow conditions.

Table 29. Annual summary of *E. coli* data at South Two River (AUID 07010201-542; May–October).

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
2008	0	–	–	–	–	–
2009	16	1,672	461	≥ 2,420	12	75
2010	6	1,561	613	6,131	4	67
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–
2016	0	–	–	–	–	–
2017	0	–	–	–	–	–

Table 30. Monthly summary of *E. coli* data at South Two River (AUID 07010201-542; 2008–2017).
Values in red indicate months in which the monthly geometric mean standard of 630 org/100 mL was exceeded or the individual standard of 1,260 org/100 mL was exceeded in greater than 10% of the samples. Standard applies only to months May–October.

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
May	0	–	–	–	–	–
Jun	7	1,151	548	≥ 2,420	3	43
Jul	7	2,561	1,733	6,131	7	100
Aug	7	1,417	461	≥ 2,420	5	71
Sep	1 [a]	≥ 2,420	≥ 2,420	≥ 2,420	1	100
Oct	0	–	–	–	–	–

a. Not enough samples to assess compliance with the monthly geometric mean standard.

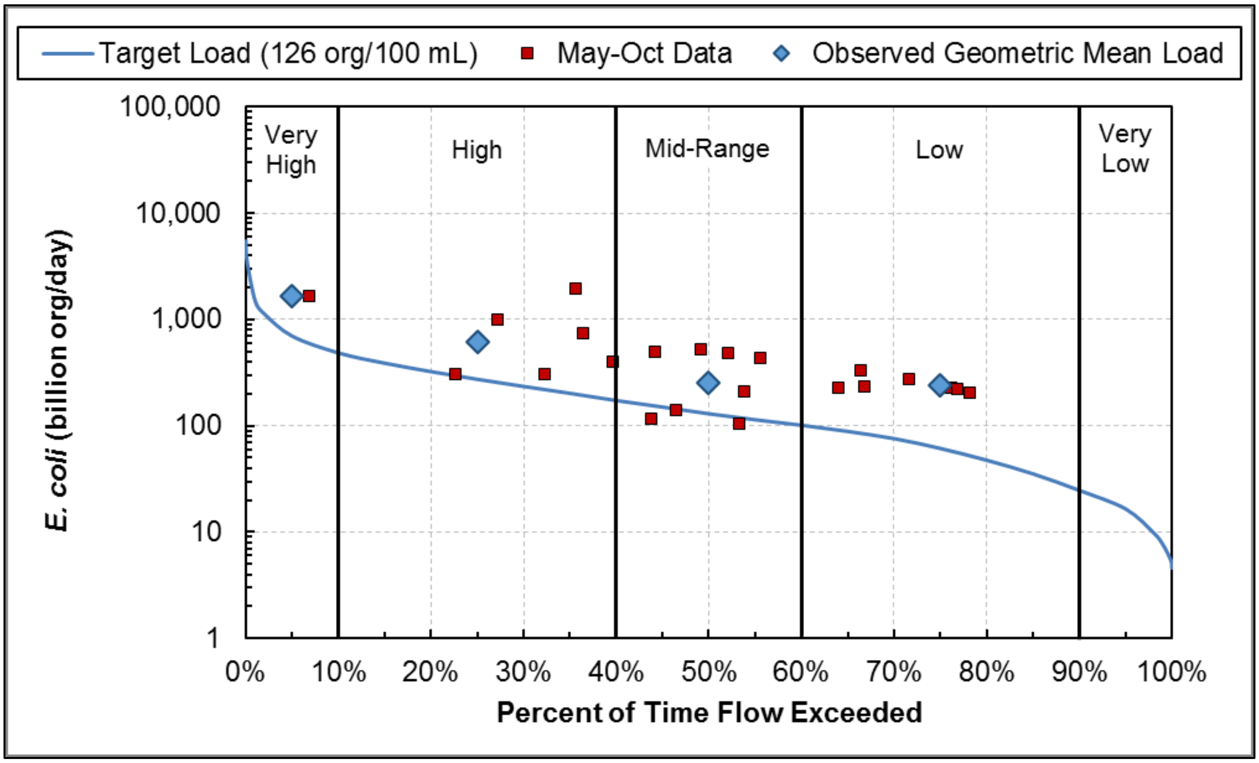

Figure 15. *E. coli* load duration curve, South Two River (AUID 07010201-542).

Table 31. *E. coli* TMDL summary, South Two River (AUID 07010201-542).

- **303(d) listing year or proposed year: 2020**
- **Baseline year: 2012**
- **Use class: 7**
- **Standard applicable: May–October**

TMDL parameter		**Flow zones**				
		Very high	**High**	**Mid-range**	**Low**	**Very low**
Sources		***E. coli* load (B org/d)**				
Wasteload	Albany WWTP (MN0020575)	23.85	23.85	23.85	23.85	– [a]
	Total WLA	24	24	24	24	– [a]
Load	**Total LA**	602	223	93	31	– [a]
MOS		70	27	13	6.1	1.7
Total load		696	274	130	61	17
Maximum monthly geomean (org/100 mL)		2,561				
Overall estimated percent reduction		75%				

a. The permitted wastewater design flows exceed the stream flow in the indicated flow zone(s). The allocations are expressed as an equation rather than an absolute number: allocation = (flow contribution from a given source) x (126 org per 100 mL) x conversion factors. See Section 4.7.2 for more detail.

5.1.4 Unnamed creek, Headwaters to Pelican Lk (07010201-628)

Annual and monthly summaries of *E. coli* data for Unnamed creek are provided in Table 32 and Table 33, respectively. The load duration curve and TMDL allocations for Unnamed creek are presented in Figure 16 and Table 34, respectively. Exceedances of the *E. coli* standard are seen under very high, high, and mid-range flow conditions. Data are not available under low nor very low flow conditions.

Table 32. Annual summary of *E. coli* data at Unnamed Creek (AUID 07010201-628; April–October).

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
2008	0	–	–	–	–	–
2009	0	–	–	–	–	–
2010	0	–	–	–	–	–
2011	26	252	6	≥ 2,420	5	19
2012	6	1,152	224	≥ 2,420	4	67
2013	12	63	5	980	0	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–
2016	0	–	–	–	–	–
2017	0	–	–	–	–	–

Table 33. Monthly summary of *E. coli* data at Unnamed Creek (AUID 07010201-628; 2008–2017).
Values in red 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. Standard applies only to months April–October.

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
Mar	2	240	167	345	NA	–
Apr	0	–	–	–	–	–
May	6	16	5	58	0	–
Jun	21	372	6	≥ 2,420	6	29
Jul	8	339	17	≥ 2,420	2	25
Aug	9	207	17	≥ 2,420	1	11
Sep	0	–	–	–	–	–
Oct	0	–	–	–	–	–

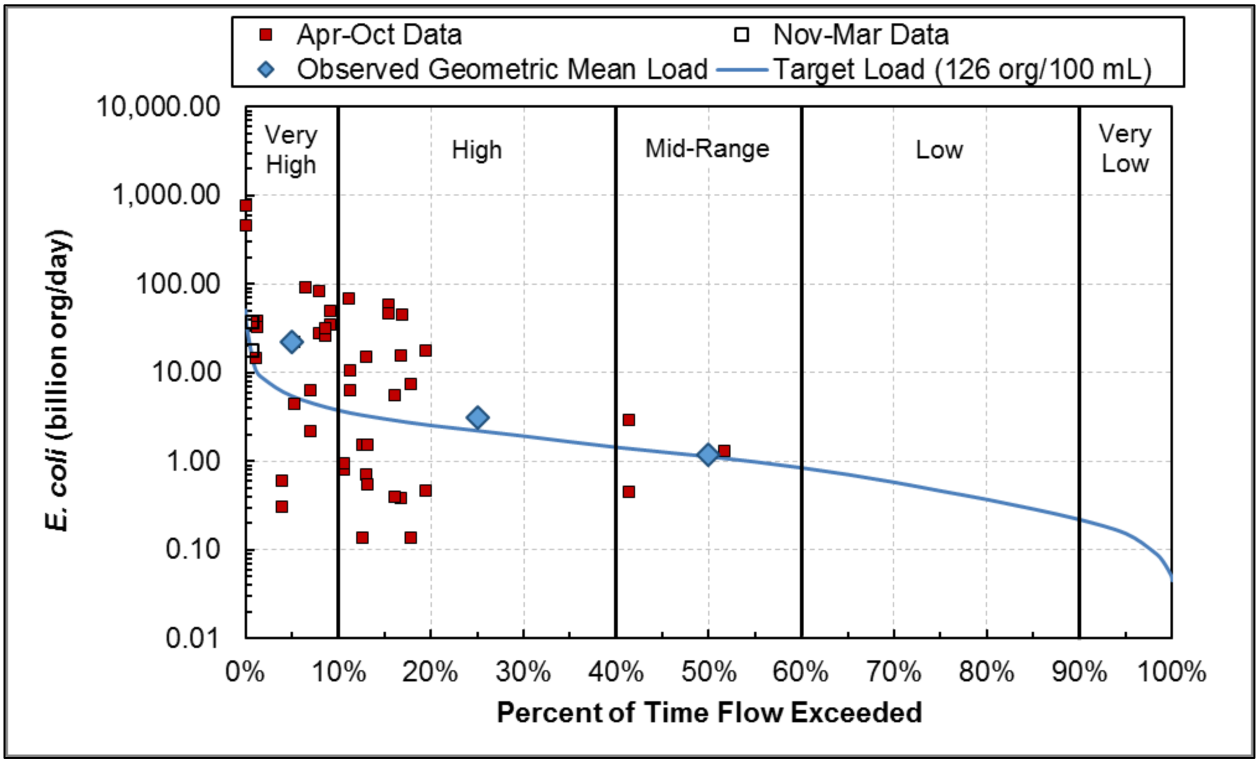

Figure 16. *E. coli* load duration curve, Unnamed Creek (AUID 07010201-628).

Table 34. *E. coli* TMDL summary, Unnamed Creek (AUID 07010201-628).

- **303(d) listing year or proposed year: 2020**
- **Baseline year: 2012**
- **Use class: 2Bg**
- **Standard applicable: April–October**

TMDL parameter		Flow zones				
		Very high	**High**	**Mid-range**	**Low**	**Very low**
Sources		***E. coli* load (B org/d)**				
Load	**Total LA**	4.9	2.0	0.99	0.41	0.13
MOS		0.54	0.22	0.11	0.046	0.015
Total load		5.4	2.2	1.1	0.46	0.15
Maximum monthly geomean (org/100 mL)		372				
Overall estimated percent reduction		66%				

5.1.5 Unnamed creek, Unnamed cr to Unnamed cr (07010201-612)

Annual and monthly summaries of *E. coli* data for Unnamed creek are provided in Table 35 and Table 36, respectively. The load duration curve and TMDL allocations for Unnamed creek are presented in Figure 17 and Table 37, respectively. Exceedances of the *E. coli* standard are seen under very high, high, mid-range, and low flow conditions. Data are not available under very low flow conditions.

Table 35. Annual summary of *E. coli* data at Unnamed Creek (AUID 07010201-612; April–October).

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
2008	0	–	–	–	–	–
2009	16	1,431	52	≥ 2,420	11	69
2010	6	2,688	914	8,164	5	83
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–
2016	0	–	–	–	–	–
2017	0	–	–	–	–	–

Table 36. Monthly summary of *E. coli* data at Unnamed Creek (AUID 07010201-612; 2008–2017).

Values in red 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. Standard applies only to months April–October.

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
Apr	0	–	–	–	–	–
May	0	–	–	–	–	–
Jun	7	1,662	687	≥ 2,420	5	71
Jul	7	1,381	52	8,164	5	71
Aug	7	2,033	921	4,352	5	71
Sep	1 [a]	≥ 2,420	≥ 2,420	≥ 2,420	1	100
Oct	0	–	–	–	–	–

a. Not enough samples to assess compliance with the monthly geometric mean standard.

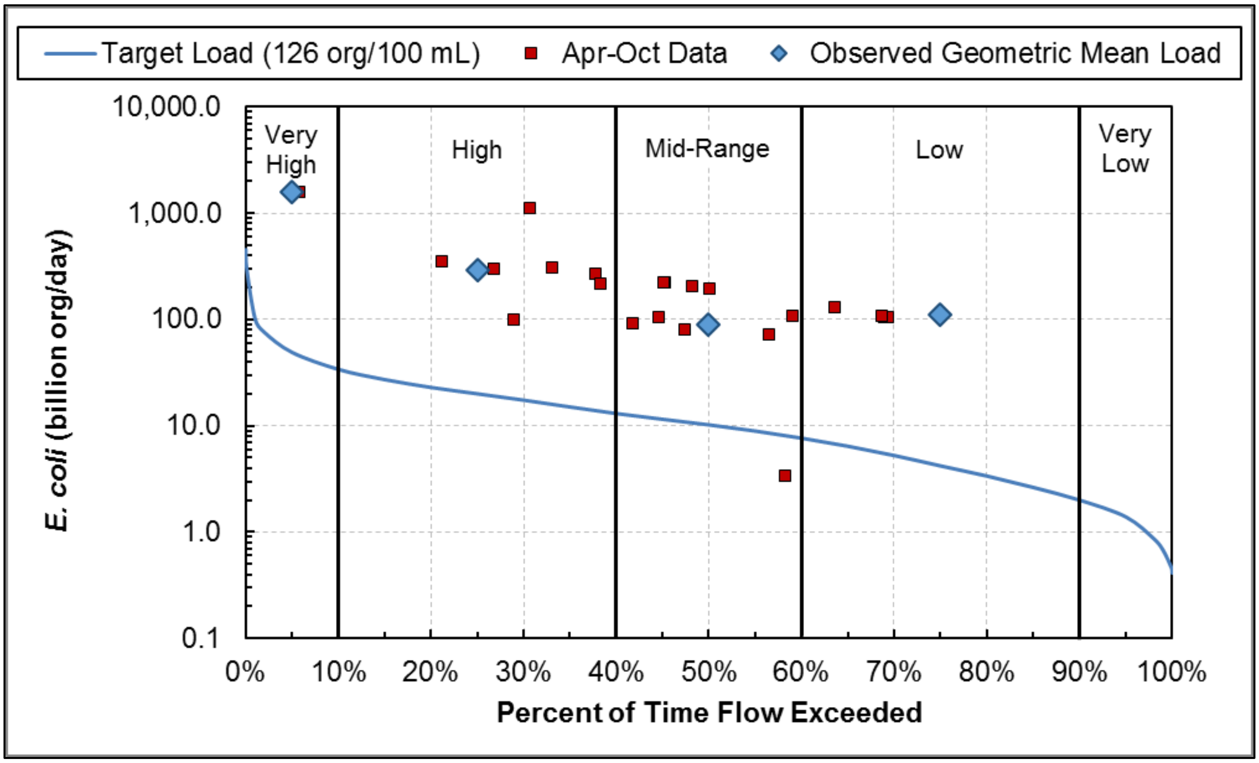

Figure 17. *E. coli* load duration curve, Unnamed Creek (AUID 07010201-612).

Table 37. *E. coli* TMDL summary, Unnamed Creek (AUID 07010201-612).

- **303(d) listing year or proposed year: 2020**
- **Baseline year: 2012**
- **Use class: 2Bg**
- **Standard applicable: April–October**

TMDL parameter		Flow zones				
		Very high	High	Mid-range	Low	Very low
Sources		*E. coli* load (B org/d)				
Load	Total LA	44	18	9.0	3.8	1.3
	MOS	4.9	2.0	1.0	0.42	0.14
	Total load	49	20	10	4.2	1.4
Maximum monthly geomean (org/100 mL)		2,033				
Overall estimated percent reduction		94%				

5.1.6 Unnamed creek, Unnamed creek to Two Rivers Lk (07010201-580)

Annual and monthly summaries of *E. coli* data for Unnamed creek are provided in Table 38 and Table 39, respectively. The load duration curve and TMDL allocations for Unnamed creek are presented in Figure 18 and Table 40, respectively. Exceedances are seen under very high, high, and mid-range flow conditions. Data are not available under very low flow conditions.

Table 38. Annual summary of *E. coli* data at Unnamed Creek (AUID 07010201-580; April–October).

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
2008	0	–	–	–	–	–
2009	16	112	23	365	0	–
2010	6	197	49	921	0	–
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–
2016	0	–	–	–	–	–
2017	0	–	–	–	–	–

Table 39. Monthly summary of *E. coli* data at Unnamed Creek (AUID 07010201-580; 2008–2017).
Values in red 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. Standard applies only to months April–October.

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
Apr	0	–	–	–	–	–
May	0	–	–	–	–	–
Jun	7	48	23	93	0	–
Jul	7	318	140	921	0	–
Aug	7	154	69	365	0	–
Sep	1 [a]	88	88	88	0	–
Oct	0	–	–	–	–	–

a. Not enough samples to assess compliance with the monthly geometric mean standard.

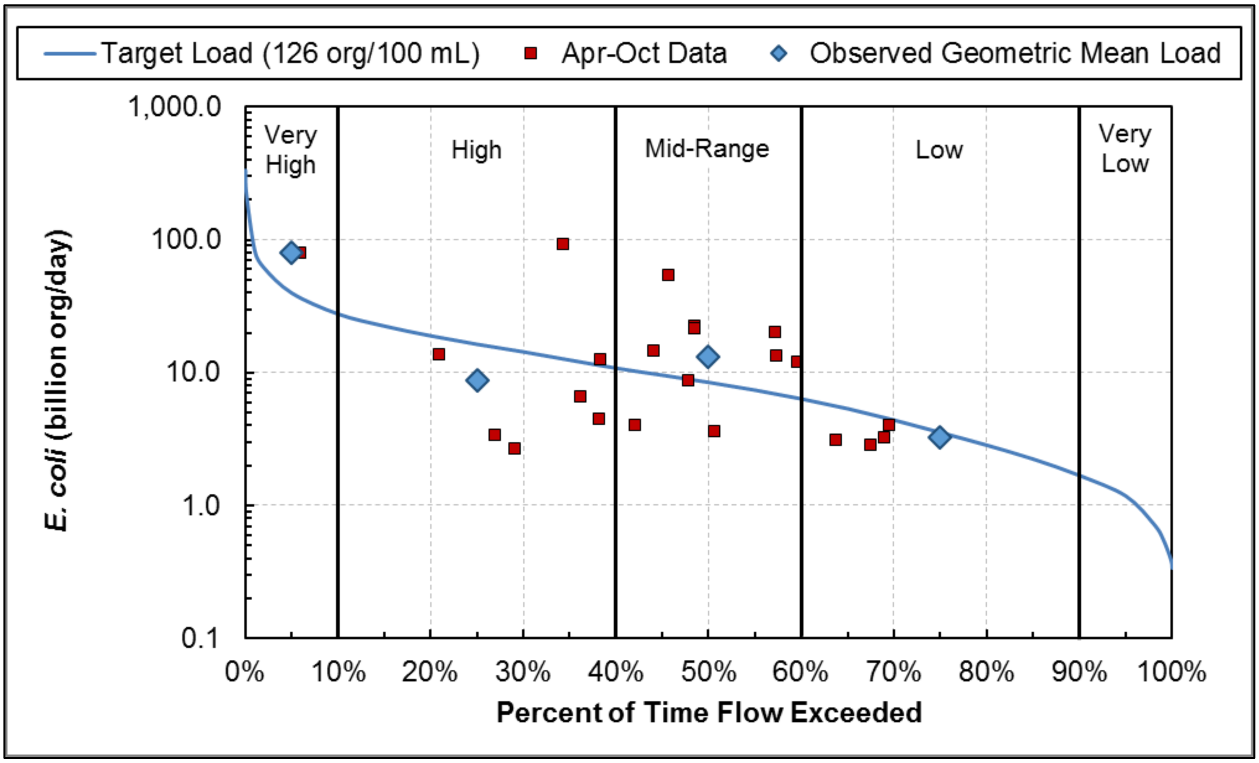

Figure 18. *E. coli* load duration curve, Unnamed Creek (AUID 07010201-580).

Table 40. *E. coli* TMDL summary, Unnamed Creek (AUID 07010201-580).

- **303(d) listing year or proposed year: 2020**
- **Baseline year: 2012**
- **Use class: 2Bg**
- **Standard applicable: April–October**

TMDL parameter		Flow zones				
		Very high	High	Mid-range	Low	Very low
Sources		*E. coli* load (B org/d)				
Load	Total LA	35	14	7.6	3.1	1.1
	MOS	3.9	1.6	0.84	0.35	0.12
	Total load	39	16	8.4	3.5	1.2
Maximum monthly geomean (org/100 mL)		318				
Overall estimated percent reduction		60%				

5.1.7 Krain Creek, Unnamed cr to Unnamed cr (07010201-613)

Annual and monthly summaries of *E. coli* data for Krain Creek are provided in Table 41 and Table 42, respectively. The load duration curve and TMDL allocations for Krain Creek are presented in Figure 19 and Table 43, respectively. Exceedances of the *E. coli* water quality standard are seen under very high, high, mid-range, and low flows. Data are not available under very low flow conditions.

Table 41. Annual summary of *E. coli* data at Krain Creek (AUID 07010201-613; April–October).

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
2008	0	–	–	–	–	–
2009	16	152	71	517	0	–
2010	6	789	276	≥ 2,420	2	33
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–
2016	0	–	–	–	–	–
2017	0	–	–	–	–	–

Table 42. Monthly summary of *E. coli* data at Krain Creek (AUID 07010201-613; 2008–2017).
Values in red 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. Standard applies only to months April–October.

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
Apr	0	–	–	–	–	–
May	0	–	–	–	–	–
Jun	7	159	83	345	0	–
Jul	7	406	74	≥ 2,420	2	29
Aug	7	220	71	770	0	–
Sep	1 [a]	173	173	173	0	–
Oct	0	–	–	–	–	–

a. Not enough samples to assess compliance with the monthly geometric mean standard.

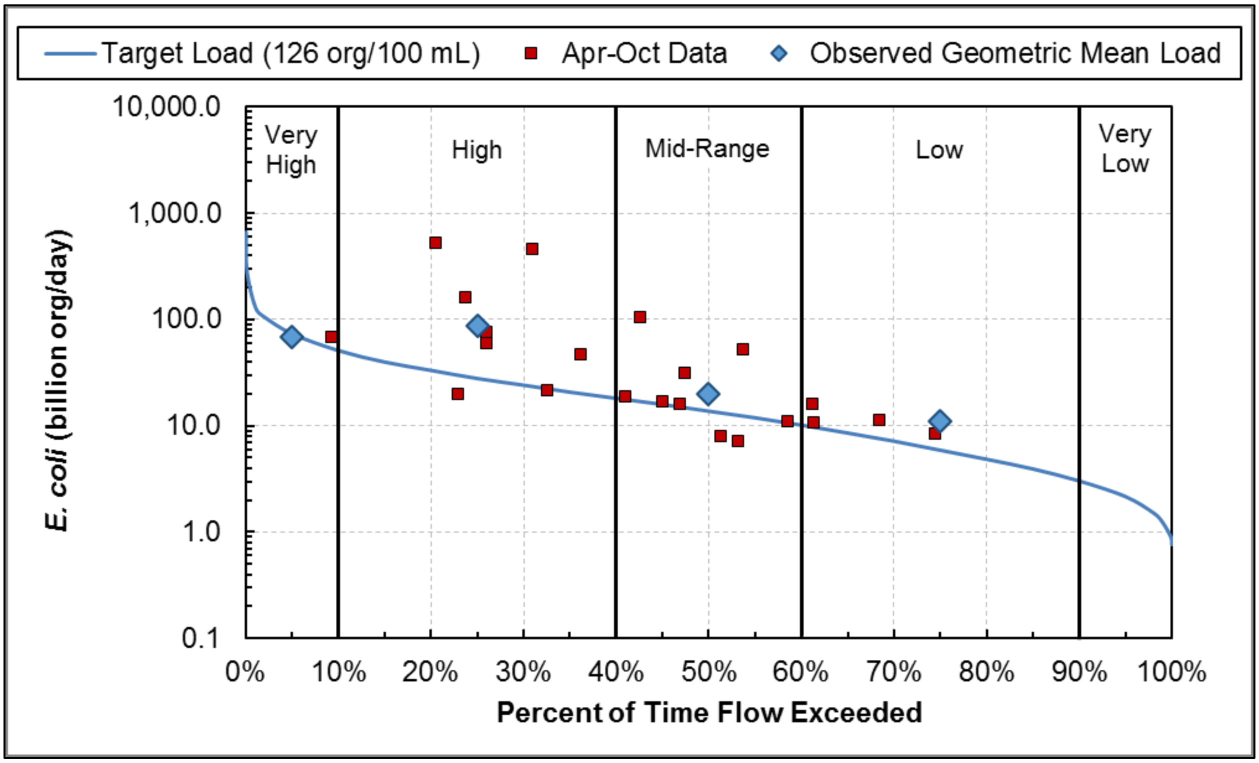

Figure 19. *E. coli* load duration curve, Krain Creek (AUID 07010201-613).

Table 43. *E. coli* TMDL summary, Krain Creek (AUID 07010201-613).

- **303(d) listing year or proposed year: 2020**
- **Baseline year: 2012**
- **Use class: 2Bg**
- **Standard applicable: April–October**

TMDL parameter		Flow zones				
		Very high	**High**	**Mid-range**	**Low**	**Very low**
Sources		***E. coli* load (B org/d)**				
Load	**Total LA**	66	25	13	5.3	2.0
MOS		7.3	2.8	1.4	0.59	0.22
Total load		73	28	14	5.9	2.2
Maximum monthly geomean (org/100 mL)		406				
Overall estimated percent reduction		69%				

5.1.8 Spunk Branch, Kalla Lk to Upper Spunk Lk (07010201-561)

Annual and monthly summaries of *E. coli* data for Spunk Branch are provided in Table 44 and Table 45, respectively. The load duration curve and TMDL allocations for Spunk Branch are presented in Figure 20 and Table 46, respectively. Exceedances of the *E. coli* water quality standard are seen under high, mid-range, and very low flows. Data are not available under very high flow conditions.

Table 44. Annual summary of *E. coli* data at Spunk Branch (AUID 07010201-561; April–October).

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
2008	0	–	–	–	–	–
2009	16	184	77	≥ 2,420	1	6
2010	6	283	56	1,120	0	–
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–
2016	0	–	–	–	–	–
2017	0	–	–	–	–	–

Table 45. Monthly summary of *E. coli* data at Spunk Branch (AUID 07010201-561; 2008–2017).
Values in red 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. Standard applies only to months April–October.

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
Apr	0	–	–	–	–	–
May	0	–	–	–	–	–
Jun	7	257	109	1,120	0	–
Jul	7	195	91	1,046	0	–
Aug	7	125	56	488	0	–
Sep	1 [a]	≥ 2,420	≥ 2,420	≥ 2,420	1	100
Oct	0	–	–	–	–	–

a. Not enough samples to assess compliance with the monthly geometric mean standard.

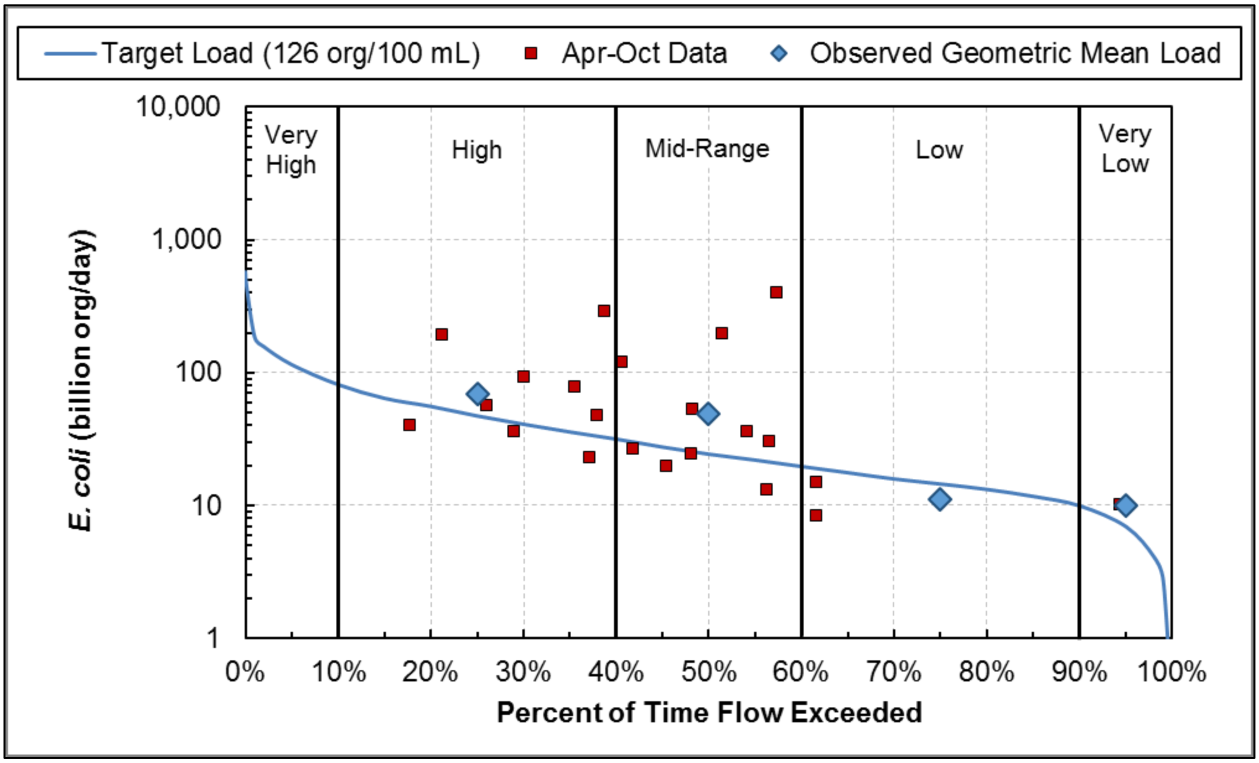

Figure 20. *E. coli* load duration curve, Spunk Branch (AUID 07010201-561).

Table 46. *E. coli* TMDL summary, Spunk Branch (AUID 07010201-561).

- **303(d) listing year or proposed year: 2020**
- **Baseline year: 2012**
- **Use class: 2Bg**
- **Standard applicable: April–October**

TMDL parameter		Flow zones				
		Very high	**High**	**Mid-range**	**Low**	**Very low**
Sources		***E. coli* load (B org/d)**				
Load	**Total LA**	103	42	22	13	6.2
	MOS	12	4.7	2.4	1.4	0.69
	Total load	115	47	24	14	6.9
Maximum monthly geomean (org/100 mL)		257				
Overall estimated percent reduction		51%				

5.1.9 Hillman Creek, 370th Ave to Skunk R (07010201-639)

Annual and monthly summaries of *E. coli* data for Hillman Creek are provided in Table 47 and Table 48, respectively. The load duration curve and TMDL allocations for Hillman Creek are presented in Figure 21 and Table 49, respectively. Exceedances of the *E. coli* water quality standard are seen under very high, high, mid-range and low flow conditions. Data are not available under very low flow conditions.

Table 47. Annual summary of *E. coli* data at Hillman Creek (AUID 07010201-639; April–October).

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
2008	0	–	–	–	–	–
2009	0	–	–	–	–	–
2010	0	–	–	–	–	–
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–
2016	9	357	96	16,000	2	22
2017	6	358	97	11,000	1	17

Table 48. Monthly summary of *E. coli* data at Hillman Creek (AUID 07010201-639; 2008–2017).
Values in red 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. Standard applies only to months April–October.

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
Apr	0	–	–	–	–	–
May	0	–	–	–	–	–
Jun	5	124	96	167	0	–
Jul	5	1,520	222	16,000	2	40
Aug	5	241	120	1,553	1	20
Sep	0	–	–	–	–	–
Oct	0	–	–	–	–	–

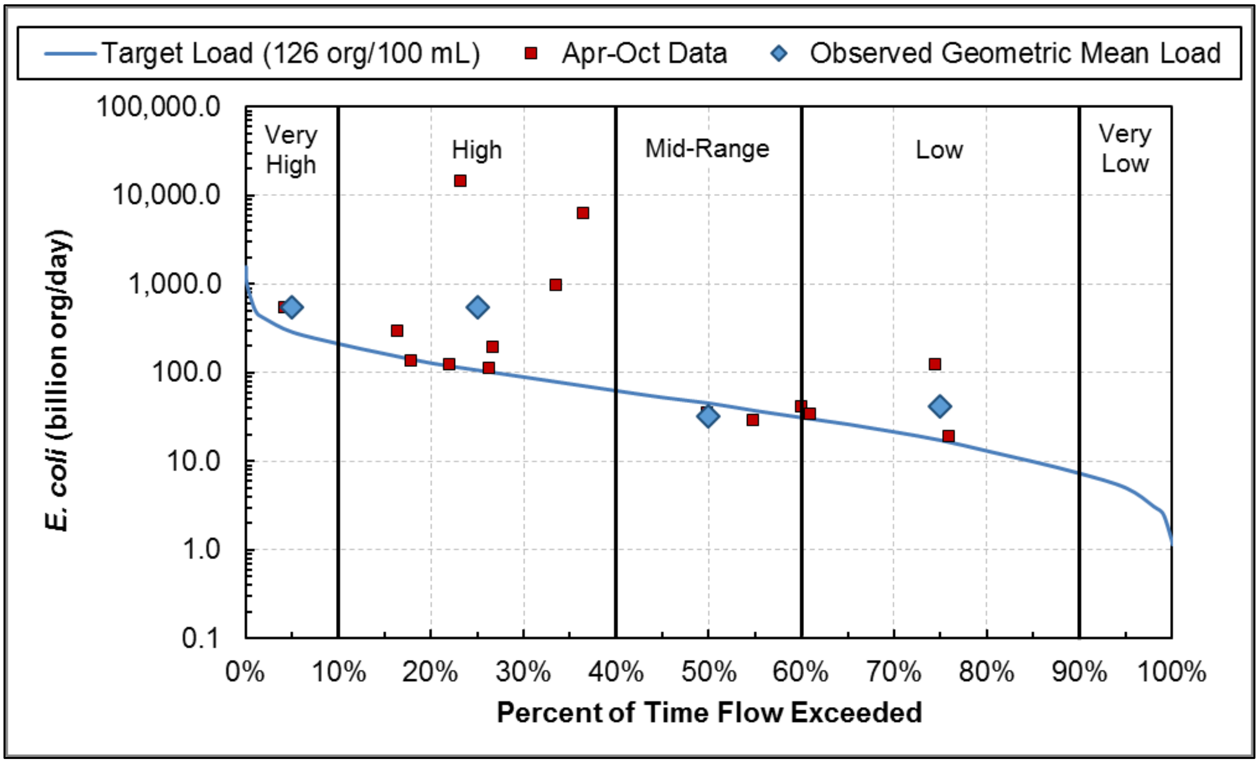

Figure 21. *E. coli* load duration curve, Hillman Creek (AUID 07010201-639).

Table 49. *E. coli* TMDL summary, Hillman Creek (AUID 07010201-639).

- **303(d) listing year or proposed year: 2020**
- **Baseline year: 2012**
- **Use class: 2Bg**
- **Standard applicable: April–October**

TMDL parameter		Flow zones				
		Very high	**High**	**Mid-range**	**Low**	**Very low**
Sources		***E. coli* load (B org/d)**				
Load	**Total LA**	260	96	41	15	4.5
MOS		29	11	4.6	1.7	0.50
Total load		289	107	46	17	5.0
Maximum monthly geomean (org/100 mL)		1,520				
Overall estimated percent reduction		92%				

5.1.10 Skunk River, Hillman Creek to Platte R (07010201-521)

Annual and monthly summaries of *E. coli* data for Skunk River are provided in Table 50 and Table 51, respectively. The load duration curve and TMDL allocations for Skunk River are presented in Figure 22 and Table 52, respectively. Exceedances of the *E. coli* water quality standard are seen under very high, high, mid-range, and low flow conditions. Data are not available under very low flow conditions.

Table 50. Annual summary of *E. coli* data at Skunk River (AUID 07010201-521; April–October).

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
2008	0	–	–	–	–	–
2009	0	–	–	–	–	–
2010	0	–	–	–	–	–
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–
2016	9	1,429	299	24,000	5	56
2017	6	952	290	24,000	2	33

Table 51. Monthly summary of *E. coli* data at Skunk River (AUID 07010201-521; 2008–2017).
Values in red 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. Standard applies only to months April–October.

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
Apr	0	–	–	–	–	–
May	0	–	–	–	–	–
Jun	5	467	290	1,300	1	20
Jul	5	4,925	1,200	24,000	4	80
Aug	5	779	290	1,986	2	40
Sep	0	–	–	–	–	–
Oct	0	–	–	–	–	–

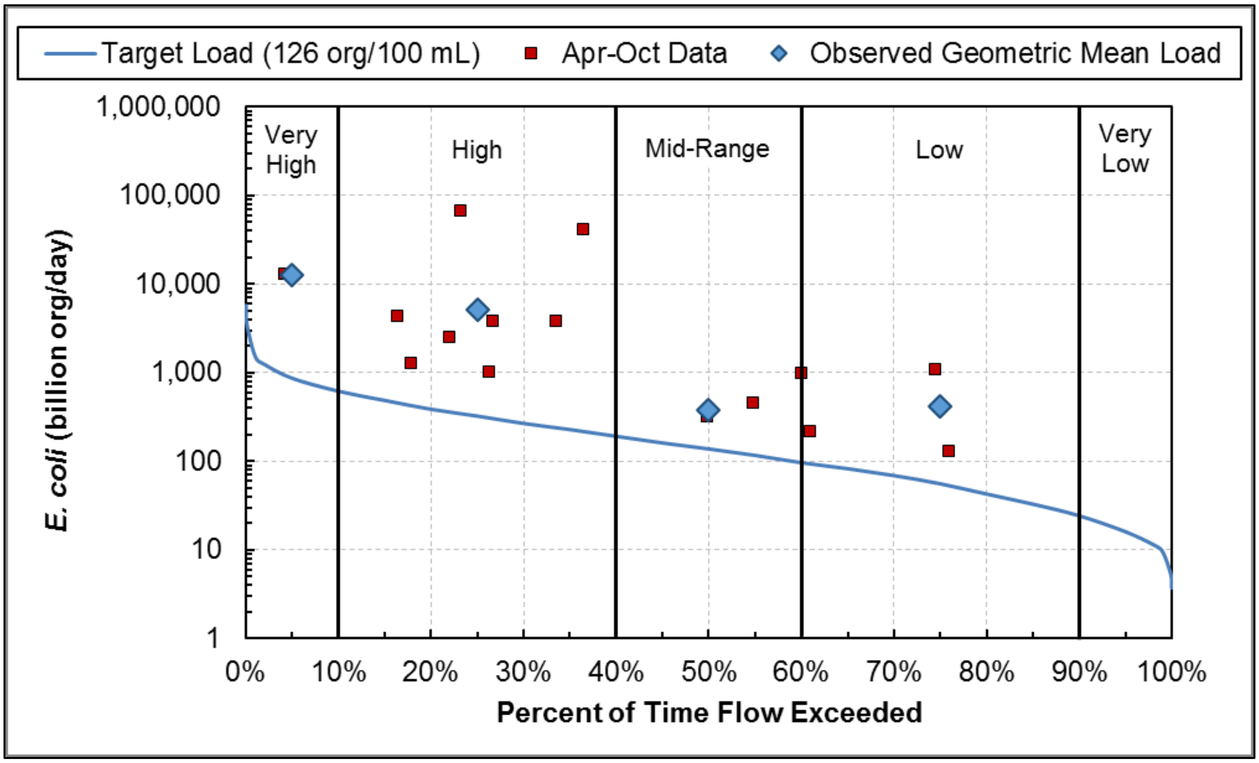

Figure 22. *E. coli* load duration curve, Skunk River (AUID 07010201-521).

Table 52. *E. coli* TMDL summary, Skunk River (AUID 07010201-521).

- **303(d) listing year or proposed year: 2008**
- **Baseline year: 2012**
- **Use class: 2Bg**
- **Standard applicable: April–October**

TMDL parameter		**Flow zones**				
		Very high	**High**	**Mid-range**	**Low**	**Very low**
Sources		***E. coli* load (B org/d)**				
Wasteload	Rich Prairie Sewer Treatment (MNG580211)	10.34	10.34	10.34	10.34	10.34
	Total WLA	10	10	10	10	10
Load	**Total LA**	772	282	114	40	4.4
MOS		87	33	14	5.6	1.6
Total load		869	325	138	56	16
Maximum monthly geomean (org/100 mL)		4,925				
Overall estimated percent reduction		97%				

5.1.11 Big Mink Creek, Headwaters to 235th Ave (07010201-646)

Annual and monthly summaries of *E. coli* data for Big Mink Creek are provided in Table 53 and Table 54, respectively. The load duration curve and TMDL allocations for Big Mink Creek are presented in Figure 23 and Table 55, respectively. Exceedances of the *E. coli* water quality standard are seen under very high, high, and mid-range flow conditions. Data are not available under very low flow conditions.

Table 53. Annual summary of *E. coli* data at Big Mink Creek (AUID 07010201-646; April–October).

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
2008	0	–	–	–	–	–
2009	0	–	–	–	–	–
2010	0	–	–	–	–	–
2011	6	136	38	613	0	–
2012	9	137	46	1,203	0	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–
2016	0	–	–	–	–	–
2017	0	–	–	–	–	–

Table 54. Monthly summary of *E. coli* data at Big Mink Creek (AUID 07010201-646; 2008–2017).
Values in red 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. Standard applies only to months April–October.

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
Apr	0	–	–	–	–	–
May	0	–	–	–	–	–
Jun	5	109	46	187	0	–
Jul	5	300	56	1,203	0	–
Aug	5	78	38	308	0	–
Sep	0	–	–	–	–	–
Oct	0	–	–	–	–	–

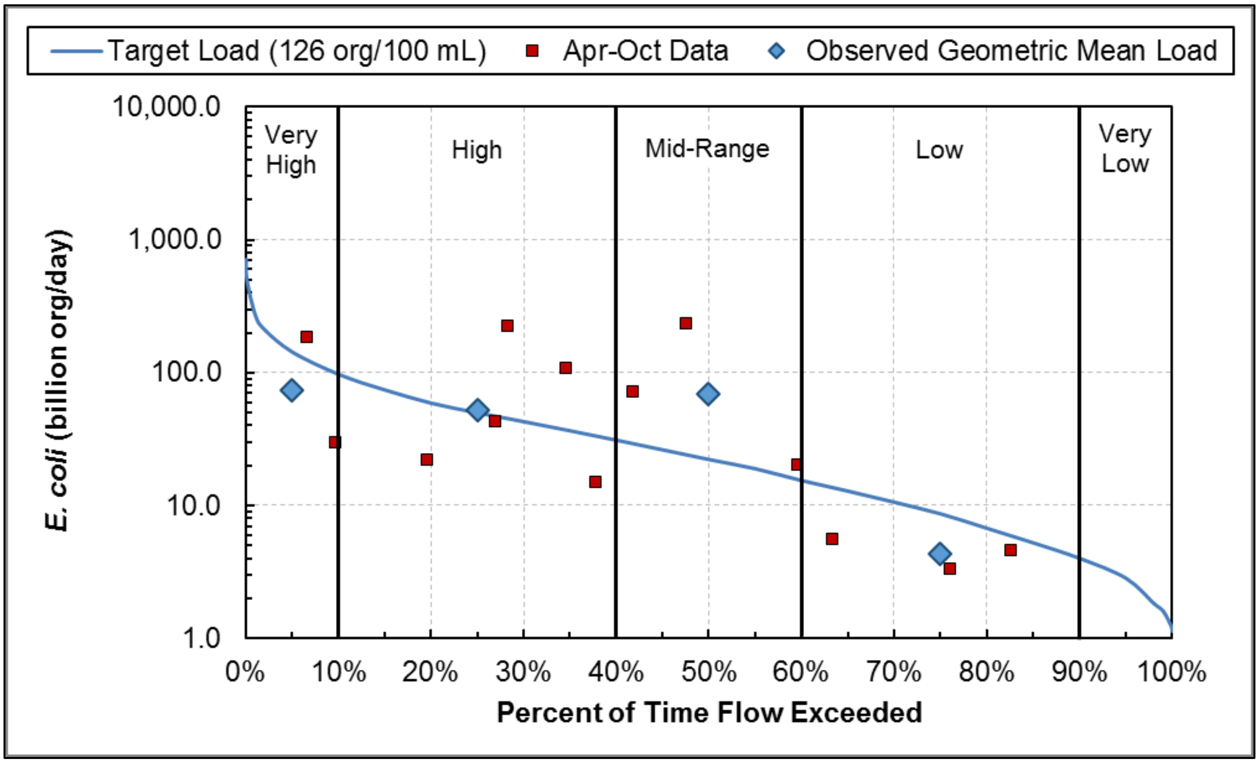

Figure 23. *E. coli* load duration curve, Big Mink Creek (AUID 07010201-646).

Table 55. *E. coli* TMDL summary, Big Mink Creek (AUID 07010201-646).

- **303(d) listing year or proposed year: 2020**
- **Baseline year: 2012**
- **Use class: 2Bg**
- **Standard applicable: April–October**

TMDL parameter		Flow zones				
		Very high	**High**	**Mid-range**	**Low**	**Very low**
Sources		***E. coli* load (B org/d)**				
Load	**Total LA**	130	45	20	7.8	2.5
MOS		14	5.0	2.2	0.87	0.28
Total load		144	50	22	8.7	2.8
Maximum monthly geomean (org/100 mL)		300				
Overall estimated percent reduction		58%				

5.1.12 Platte River, Headwaters (Platte Lk 18-0088-00) to Skunk R (07010201-507)

Annual and monthly summaries of *E. coli* data for Platte River are provided in Table 56 and Table 57, respectively. The load duration curve and TMDL allocations for Platte River are presented in Figure 24 and Table 58, respectively. Exceedances of the *E. coli* water quality standard are seen under high, mid-range, and low flow conditions. Data are not available under very low flow conditions.

Table 56. Annual summary of *E. coli* data at Platte River (AUID 07010201-507; April–October).

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
2008	0	–	–	–	–	–
2009	0	–	–	–	–	–
2010	0	–	–	–	–	–
2011	6	194	52	≥ 2,420	1	17
2012	9	163	4	≥ 2,420	2	22
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–
2016	9	331	82	13,000	1	11
2017	6	256	63	14,000	1	17

Table 57. Monthly summary of *E. coli* data at Platte River (AUID 07010201-507; 2008–2017).

Values in red 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. Standard applies only to months April–October.

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
Apr	0	–	–	–	–	–
May	0	–	–	–	–	–
Jun	10	135	63	816	0	–
Jul	10	1,143	96	14,000	5	50
Aug	10	77	4	579	0	–
Sep	0	–	–	–	–	–
Oct	0	–	–	–	–	–

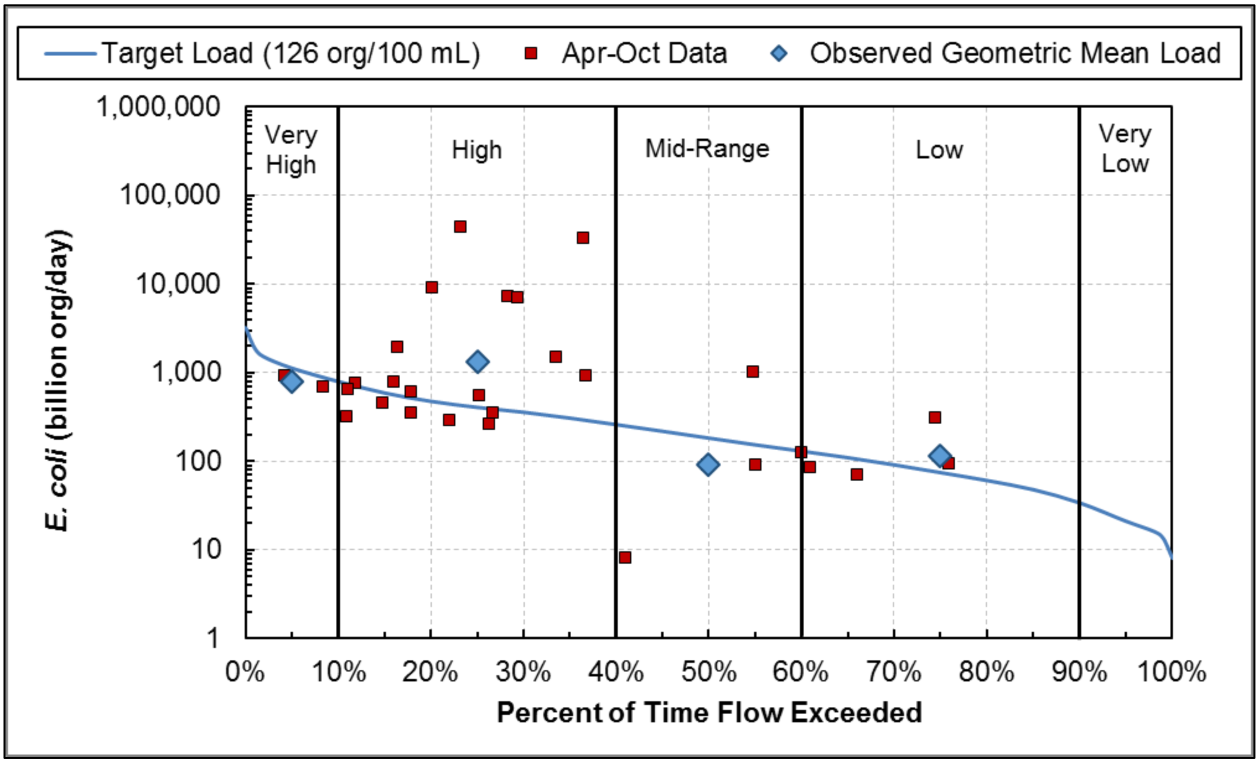

Figure 24. ***E. coli*** **load duration curve, Platte River (AUID 07010201-507).**

Table 58. ***E. coli*** **TMDL summary, Platte River (AUID 07010201-507).**

- **303(d) listing year or proposed year: 2020**
- **Baseline year: 2012**
- **Use class: 2Bg**
- **Standard applicable: April–October**

TMDL parameter		Flow zones				
		Very high	**High**	**Mid-range**	**Low**	**Very low**
Sources		***E. coli*** **load (B org/d)**				
Load	**Total LA**	1,020	366	164	67	19
	MOS	113	41	18	7.4	2.1
	Total load	1,133	407	182	74	21
Maximum monthly geomean (org/100 mL)		1,143				
Overall estimated percent reduction		89%				

5.1.13 Stony Creek, -94.31 45.728 to Mississippi R (07010201-649)

Annual and monthly summaries of *E. coli* data for Stony Creek are provided in Table 59 and Table 60, respectively. The load duration curve and TMDL allocations for Stony Creek are presented in Figure 25 and Table 61, respectively. Exceedances of the *E. coli* water quality standard are seen under high, mid-range, and low flow conditions. Data are not available under very high nor very low flow conditions.

Table 59. Annual summary of *E. coli* data at Stony Creek (AUID 07010201-649; April-October).

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
2008	0	–	–	–	–	–
2009	14	311	51	≥ 2,420	1	7
2010	6	935	261	≥ 2,420	2	33
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–
2016	0	–	–	–	–	–
2017	0	–	–	–	–	–

Table 60. Monthly summary of *E. coli* data at Stony Creek (AUID 07010201-649; 2008–2017).
Values in red 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. Standard applies only to months April-October.

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
Apr	0	–	–	–	–	–
May	0	–	–	–	–	–
Jun	6	284	135	579	0	–
Jul	7	425	51	≥ 2,420	1	14
Aug	7	633	155	≥ 2,420	2	29
Sep	0	–	–	–	–	–
Oct	0	–	–	–	–	–

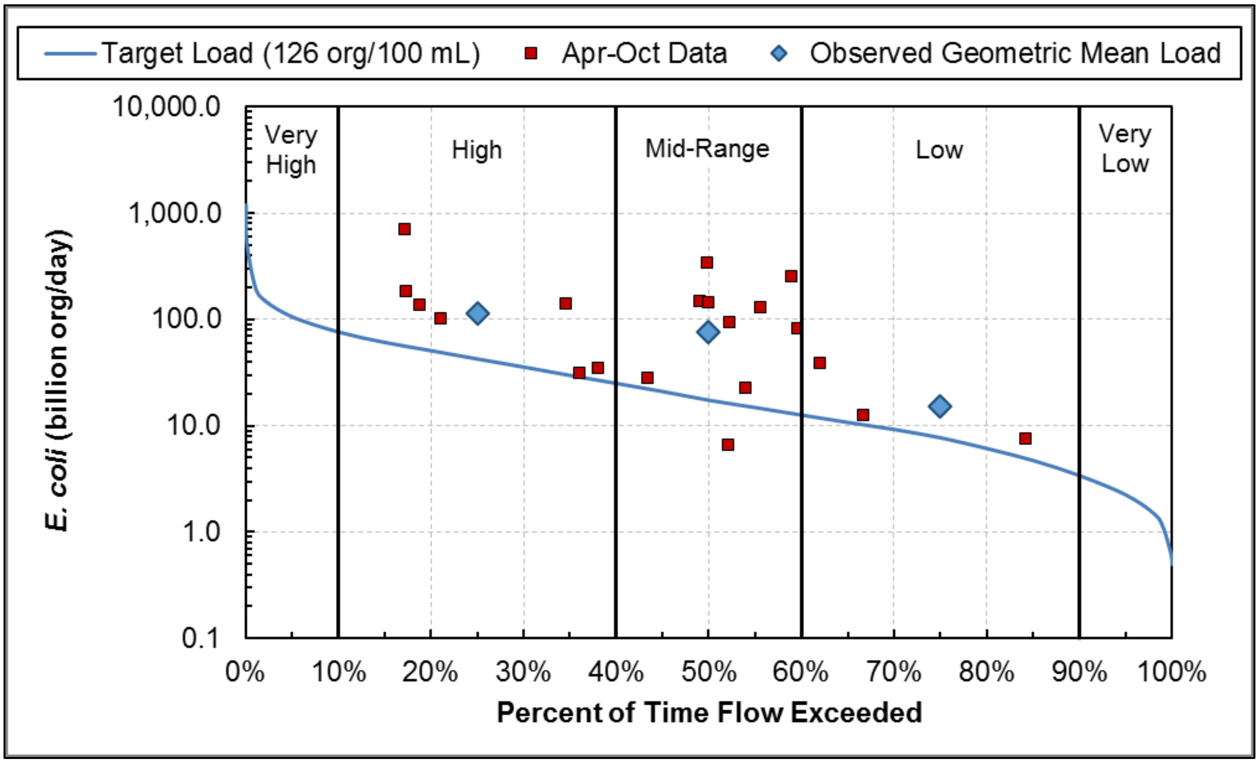

Figure 25. ***E. coli*** **load duration curve, Stony Creek (AUID 07010201-649).**

Table 61. ***E. coli*** **TMDL summary, Stony Creek (AUID 07010201-649).**

- **303(d) listing year or proposed year: 2020**
- **Baseline year: 2012**
- **Use class: 2Bg**
- **Standard applicable: April–October**

TMDL parameter		**Flow zones**				
		Very high	**High**	**Mid-range**	**Low**	**Very low**
Sources		***E. coli*** **load (B org/d)**				
Wasteload	Brockway Township MS4 (MS400068) [a]	4.3	1.7	0.70	0.32	0.090
	Total WLA	4.3	1.7	0.70	0.32	0.090
Load	**Total LA**	91	36	15	6.6	1.9
MOS		11	4.2	1.7	0.77	0.22
Total load		106	42	17	7.7	2.2
Maximum monthly geomean (org/100 mL)		633				
Overall estimated percent reduction		80%				

a. See Table 22 and Figure 12 for the estimated permitted MS4 areas.

5.1.14 Little Rock Creek, T39 R31W S22, east line to T38 R31W S28, east line (07010201-653)

Annual and monthly summaries of *E. coli* data for Little Rock Creek are provided in Table 62 and Table 63, respectively. The load duration curve and TMDL allocations for Little Rock Creek are presented in Figure 26 and Table 64, respectively. Exceedances of the *E. coli* water quality standard are seen under very high, high, and mid-range flow conditions. Data are not available under very low flow conditions.

Table 62. Annual summary of *E. coli* data at Little Rock Creek (AUID 07010201-653; April–October).

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
2008	2	142	88	230	0	–
2009	0	–	–	–	–	–
2010	0	–	–	–	–	–
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–
2016	9	162	38	24,000	1	11
2017	6	191	31	13,000	2	33

Table 63. Monthly summary of *E. coli* data at Little Rock Creek (AUID 07010201-653; 2008–2017).
Values in red 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. Standard applies only to months April–October.

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
Apr	0	–	–	–	–	–
May	0	–	–	–	–	–
Jun	7	72	35	230	0	–
Jul	5	1,344	41	24,000	3	60
Aug	5	71	31	157	0	–
Sep	0	–	–	–	–	–
Oct	0	–	–	–	–	–

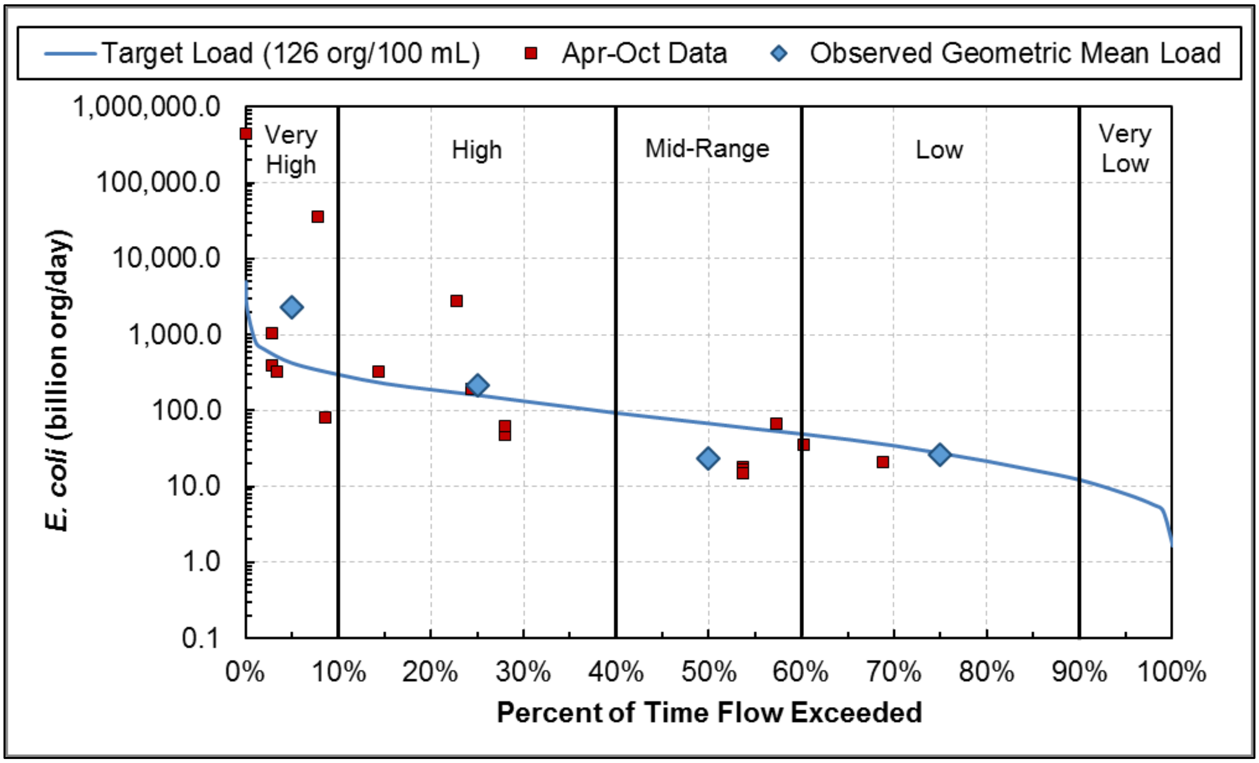

Figure 26. *E. coli* load duration curve, Little Rock Creek (AUID 07010201-653).

Table 64. *E. coli* TMDL summary, Little Rock Creek (AUID 07010201-653).

- **303(d) listing year or proposed year: 2020**
- **Baseline year: 2012**
- **Use class: 1B, 2Ag**
- **Standard applicable: April–October**

TMDL parameter		Flow zones				
		Very high	High	Mid-range	Low	Very low
Sources		*E. coli* load (B org/d)				
Load	Total LA	377	143	60	24	7.2
	MOS	42	16	6.7	2.7	0.80
	Total load	419	159	67	27	8.0
Maximum monthly geomean (org/100 mL)		1,344				
Overall estimated percent reduction		91%				

5.1.15 County Ditch 16, Headwaters to Watab R (07010201-616)

Annual and monthly summaries of *E. coli* data for County Ditch 16 are provided in Table 65 and Table 66, respectively. The load duration curve and TMDL allocations for County Ditch 16 are presented in Figure 27 and Table 67, respectively. Exceedances of the *E. coli* water quality standard are seen under high, mid-range, and low flow conditions. Data are not available under very high nor very low flow conditions.

Table 65. Annual summary of *E. coli* data at County Ditch 16 (AUID 07010201-616; April–October).

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
2008	0	–	–	–	–	–
2009	16	331	101	1,733	2	13
2010	6	389	153	1,733	1	17
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–
2016	0	–	–	–	–	–
2017	0	–	–	–	–	–

Table 66. Monthly summary of *E. coli* data at County Ditch 16 (AUID 07010201-616; 2008–2017).
Values in red 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. Standard applies only to months April–October.

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
Apr	0	–	–	–	–	–
May	0	–	–	–	–	–
Jun	7	547	276	1,733	2	29
Jul	7	332	101	1,733	1	14
Aug	7	229	135	687	0	–
Sep	1 [a]	326	326	326	0	–
Oct	0	–	–	–	–	–

a. Not enough samples to assess compliance with the monthly geometric mean standard.

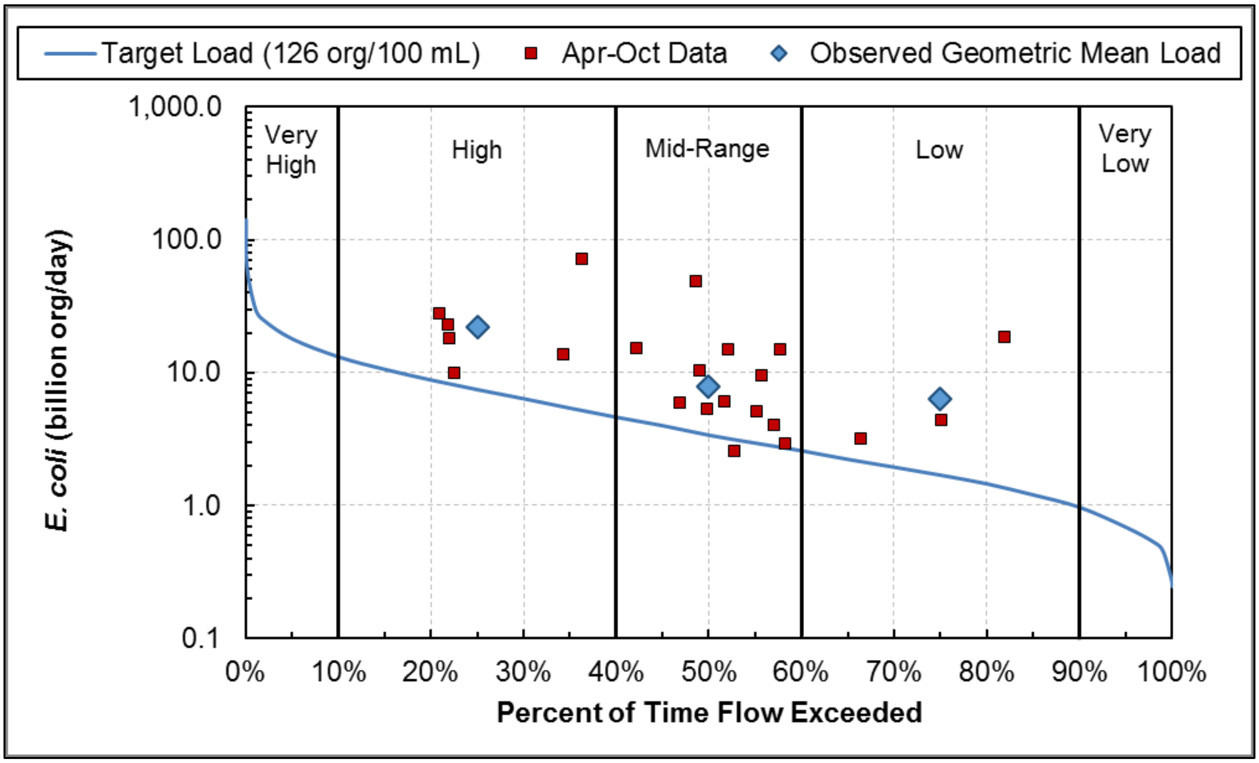

Figure 27. *E. coli* load duration curve, County Ditch 16 (AUID 07010201-616).

Table 67. *E. coli* TMDL summary, County Ditch 16 (AUID 07010201-616).

- **303(d) listing year or proposed year: 2020**
- **Baseline year: 2012**
- **Use class: 2Bg**
- **Standard applicable: April–October**

TMDL parameter		**Flow zones**				
		Very high	**High**	**Mid-range**	**Low**	**Very low**
Sources		***E. coli* load (B org/d)**				
Wasteload a, b	Sartell City MS4 (MS400048)	16	6.5	2.9	1.5	0.60
	Stearns County MS4 (MS400159)	0.11	0.044	0.020	0.010	0.0040
	Total WLA	16	6.5	2.9	1.5	0.60
Load	**Total LA**	0.20	0.25	0.16	0.030	0.021
MOS		1.8	0.75	0.34	0.17	0.069
Total load		18	7.5	3.4	1.7	0.69
Maximum monthly geomean (org/100 mL)		547				
Overall estimated percent reduction		77%				

a. These permitted MS4s also have *E. coli* WLAs in the Watab River TMDL (AUID 07010201-528), which is downstream of County Ditch 16. The MS4 WLAs can be found in Tables 7-1 and 7-3 of the *Upper Mississippi River Bacteria TMDL Study & Protection Plan* (MPCA 2014a).

b. See Table 22 and Figure 12 for the estimated permitted MS4 areas.

5.2 Phosphorus

5.2.1 Two Rivers Lake (73-0138-00)

Table 68. Two Rivers Lake (73-0138-00-204) water quality data summary, 2008–2017.
Values in red indicate violations of the standard.

Parameter	Average of Annual Growing Season Means (Jun–Sep)	Water Quality Standard [a]
TP (µg/L)	64	≤ 40
Chl-*a* (µg/L)	34	≤ 14
Secchi (m)	1.8	≥ 1.4

a. North Central Hardwood Forest ecoregion lake standard

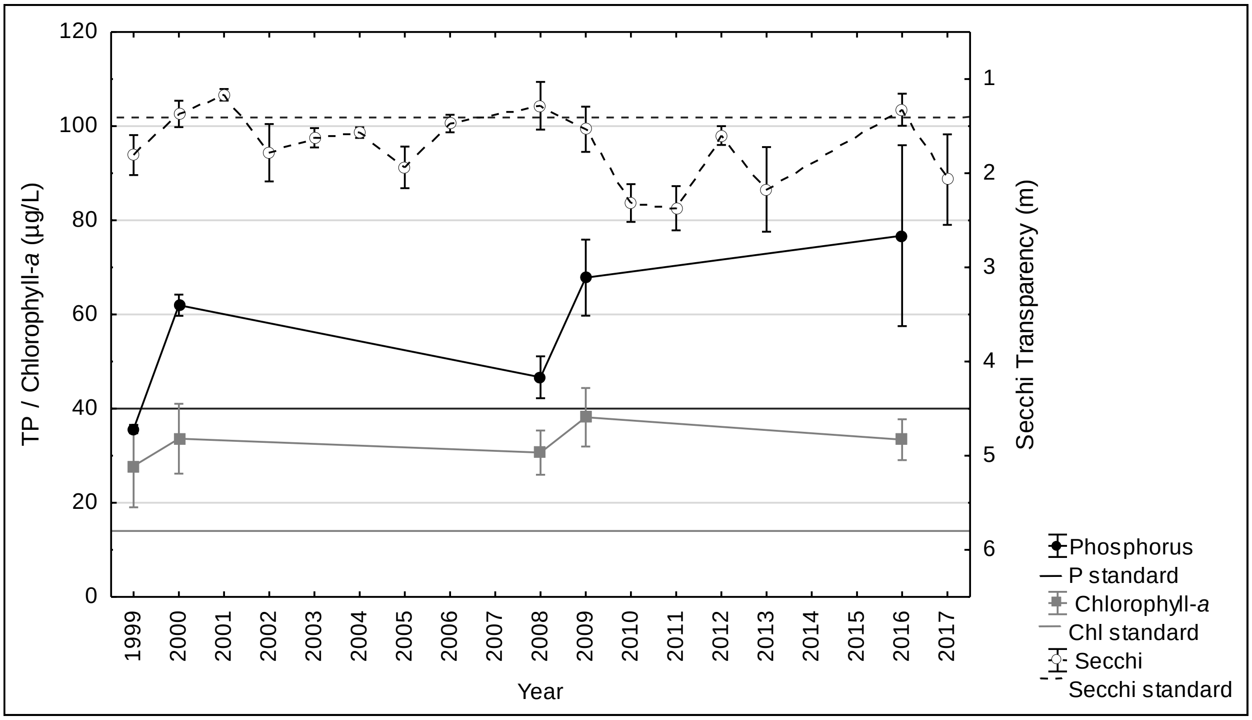

Figure 28. Two Rivers Lake (73-0138-00-204) water quality data, 1999–2017.
Growing season means + / - standard error. Note that data from 1999–2017 are presented here to illustrate long-term data, whereas data from 2008–2017 are summarized in Table 68.

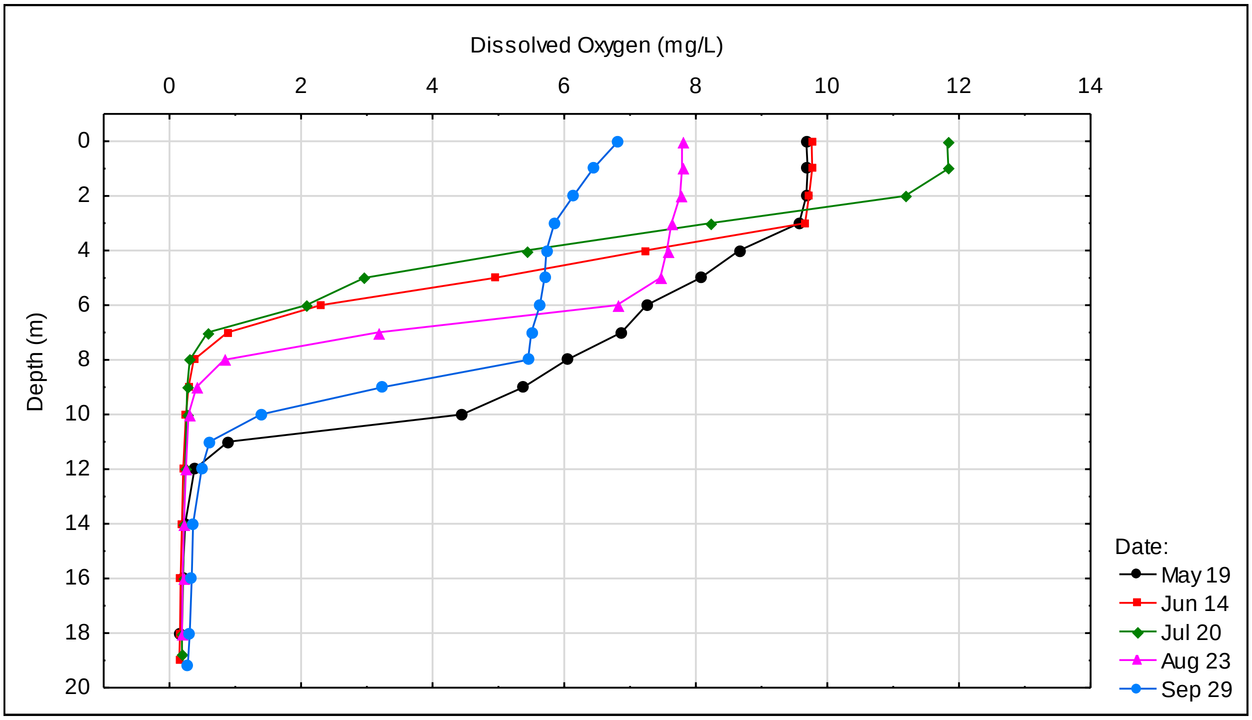

Figure 29. Two Rivers Lake (73-0138-00) 2016 dissolved oxygen depth profiles, site 204.

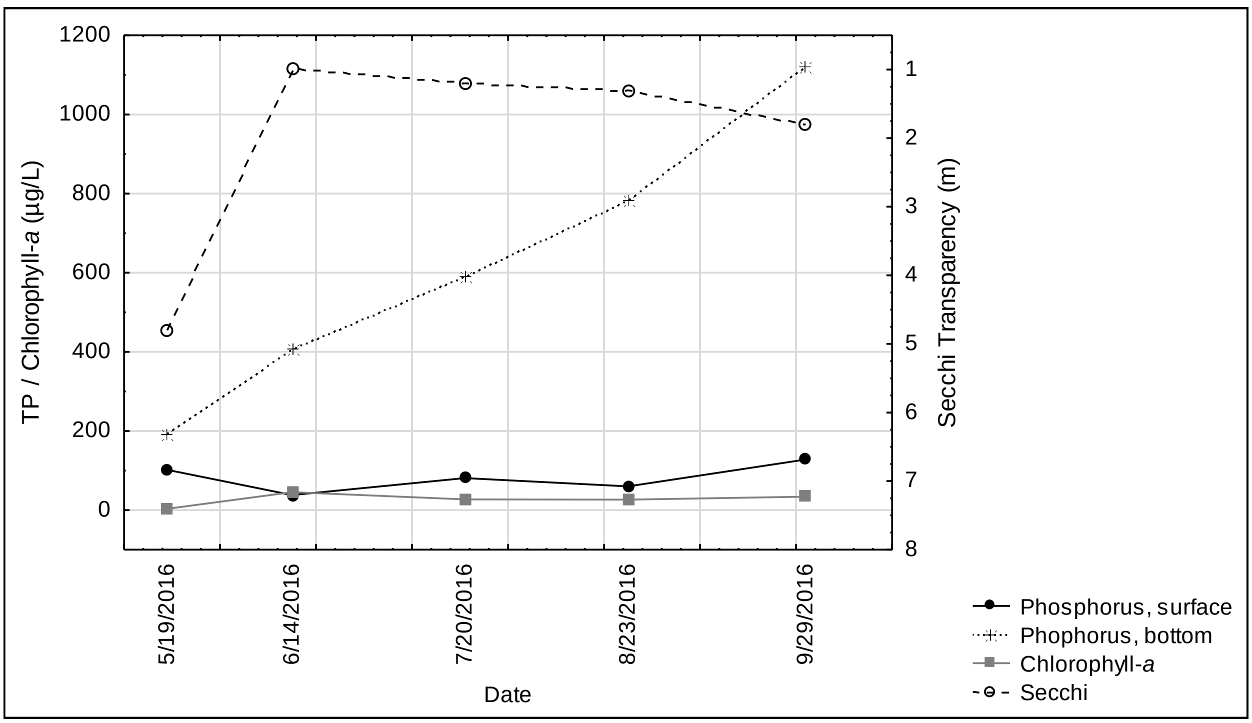

Figure 30. Two Rivers Lake (73-0138-00) 2016 phosphorus, chlorophyll, and Secchi; site 204. (See source assessment Section 3.6.3 for more information).

Table 69. Phosphorus TMDL summary, Two Rivers Lake (73-0138-00).

- **303(d) listing year or proposed year: 2010**
- **Baseline year: 2012**
- **Use class: 2B**
- **Standard applicable: Jun–Sep**

TMDL Parameter	TMDL Allocations	
	TP Load (lb/yr)	TP Load (lb/day)
WLA for Construction Stormwater	4.75	0.0130
WLA for Industrial Stormwater	4.75	0.0130
WLA for Albany WWTP (MN0020575)	840 [a]	2.30 [b]
Load Allocation	5,689	15.6
Margin of Safety	726	1.99
Loading Capacity	7,264	19.9
Other		
Existing Load	21,956	60.2
Percent Load Reduction	67%	67%

a. The phosphorus WLA for the Albany WWTP is based on the existing permitted load for the facility (381 kg/yr, or 840 lb/yr, as a 12-month moving total). This annual allocation is the WLA intended for implementation of the WLA as a permit limit but does not result in changes to permit limits for the Albany WWTP.

b. This daily WLA is included to satisfy the TMDL requirement that all loads must be expressed in daily terms; however, the daily WLA is not intended for implementation as a permit limit. See Section 4.8.2 for additional information.

NA: not applicable

Table 70. Two Rivers Lake (73-0138-00) phosphorus load reductions by source.

Source	Existing Load (lb/yr)	TMDL Allocation (lb/yr)	Load Reduction Needed (lb/yr)	% Reduction
Subwatershed	21,200	5,461	15,739	74%
Septics	200	88 [a]	112	56%
Atmospheric deposition	140	140	0	0%
Albany WWTP	416	840	0[b]	0%
Construction and industrial stormwater	NA	9.5	0	0%
Margin of safety	NA	726	0	0%
Total	21,956	7,264	15,851	72%[c]

a. The loading goal for septic systems assumes that all systems are conforming.

b. Load reductions from the Albany WWTP are not needed. The allocated load for the Albany WWTP is greater than the existing load.

c. The overall percent reduction (72%) takes into account a higher allocation for the Albany WWTP than is currently discharging, the MOS, and the allocation for regulated stormwater, and therefore is greater that the percent reductions presented in the TMDL table (67%).

5.2.2 Platte Lake (18-0088-00)

Table 71. Platte Lake (18-0088-00) water quality data summary, 2008–2017.
Sites 208–211. Values in red indicate violations of the standard.

Parameter	Average of Annual Growing Season Means (Jun–Sep)	Water Quality Standard [a]
TP (µg/L)	48	≤ 30
Chl-*a* (µg/L)	21	≤ 9
Secchi (m)	1.1	≥ 2.0

a. Northern Lakes and Forests ecoregion shallow lake standard

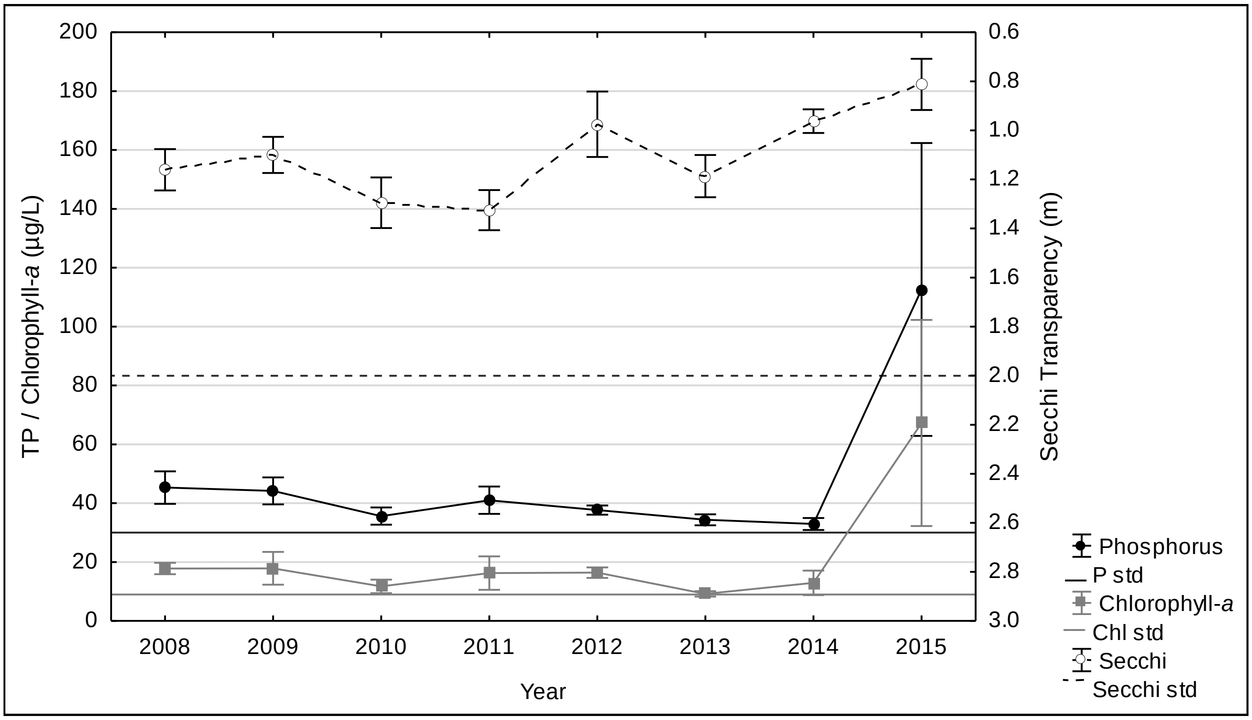

Figure 31. Platte Lake (18-0088-00) water quality data.
Growing season means + / - standard error, sites 208–211.

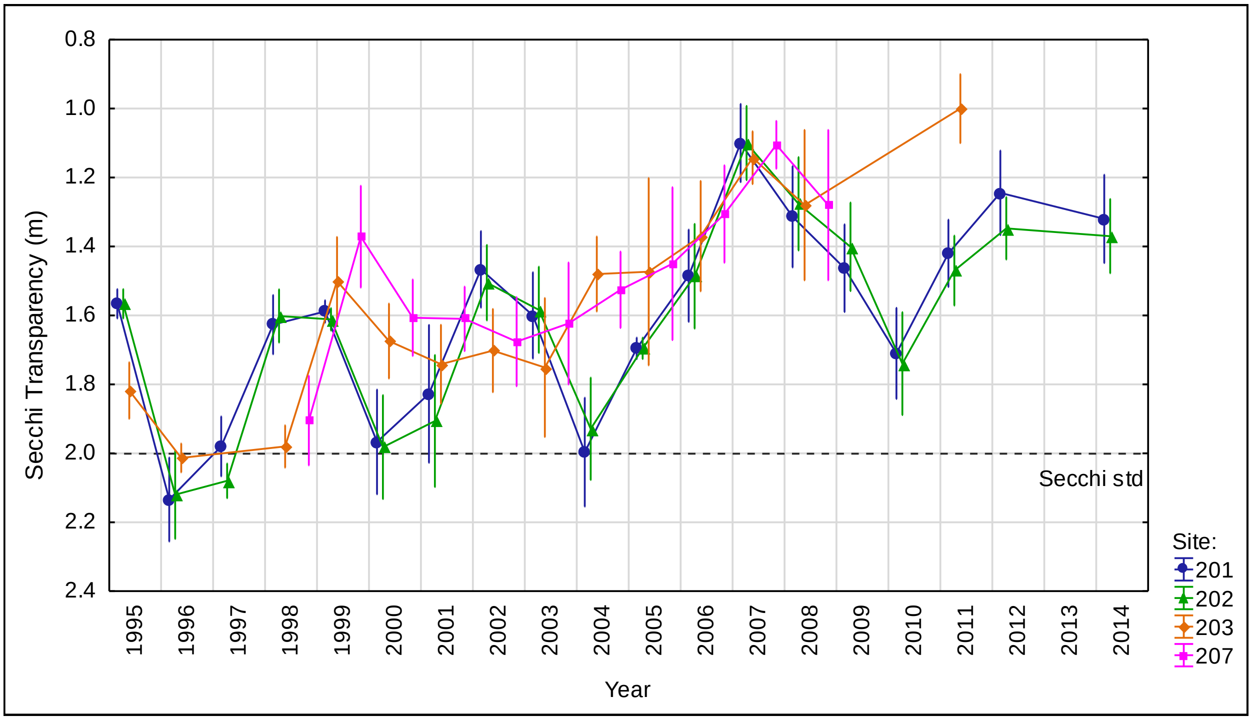

Figure 32. Platte Lake (18-0088-00) long-term transparency by site.
Growing season means + / - standard error, sites 201, 202, 203, and 207.

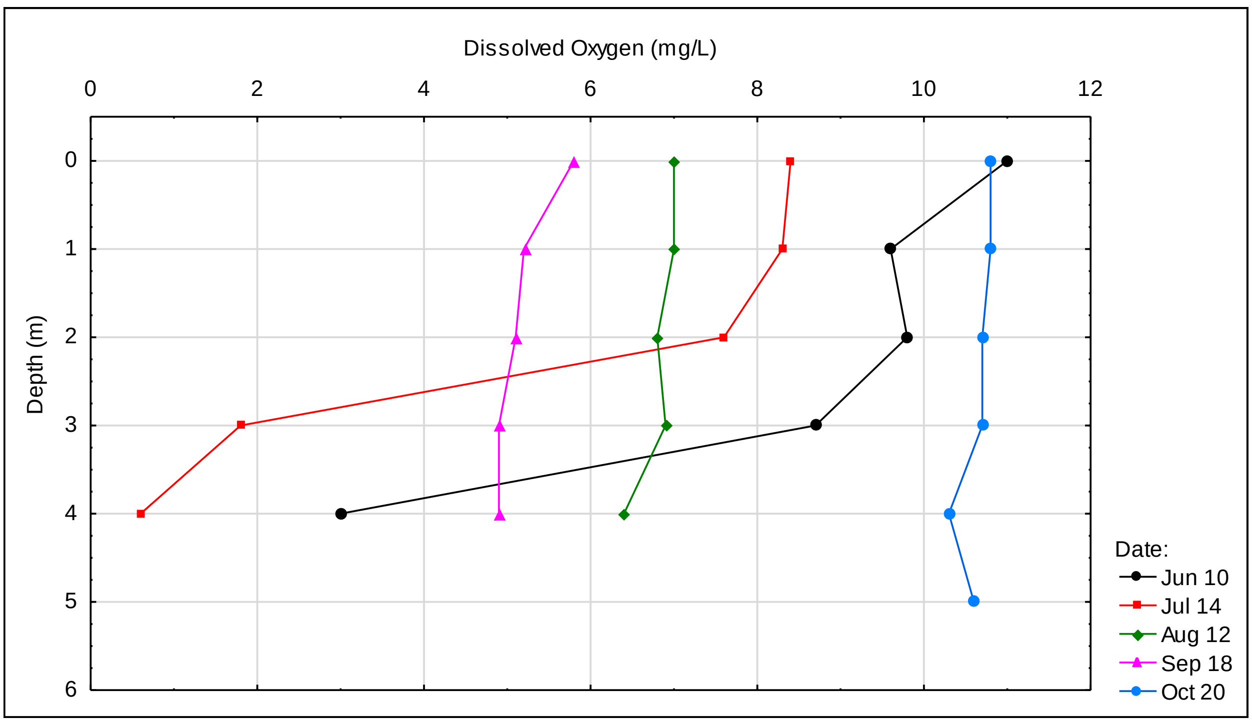

Figure 33. Platte Lake (18-0088-00) 2005 dissolved oxygen depth profiles, site 213. (See source assessment Section 3.6.3 for more information).

Table 72. Phosphorus TMDL summary, Platte Lake (18-0088-00).

- **303(d) listing year or proposed year: 2010**
- **Baseline year: 2012**
- **Use class: 2B**
- **Standard applicable: Jun–Sep**

TMDL Parameter	TMDL Allocations	
	TP Load (lb/yr)	TP Load (lb/day)
WLA for Construction Stormwater	0.623	0.00171
WLA for Industrial Stormwater	0.623	0.00171
Load Allocation	2,077	5.69
Margin of Safety	231	0.633
Loading Capacity	2,309	6.33
Other		
Existing Load	4,833	13.2
Percent Load Reduction	52%	52%

NA: not applicable

Table 73. Platte Lake (18-0088-00) reductions by source.

Source	Existing Load (lb/yr)	TMDL Allocation (lb/yr)	Load Reduction Needed (lb/yr)	% Reduction
Watershed	4,037	1,514	2,523	63%
Septic	180	82 [a]	98	54%
Internal	216	81	135	63%
Atmospheric deposition	400	400	0	0%
Construction and industrial stormwater	NA	1.3	0	0%
Margin of safety	NA	231	0	0%
Total	4,833	2,309	2,756	57% [b]

a. The loading goal for septic systems assumes that all systems are conforming.
b. The overall percent reduction (57%) takes into account the MOS and the allocation for regulated stormwater, and therefore is greater that the percent reductions presented in the TMDL table (52%).

6. Future growth considerations

Land use in the MRSW is predominantly agricultural with sparsely populated rural communities; however, population numbers are expected to climb, with the greatest increase seen in and around the area's cities, major interstates, and lake shorelines. Morrison County's population is projected to increase by just over 40,000, or 21%, from 2010 to 2045, with the largest growth seen in the cities of Harding, Royalton, and Motley (Morrison County 2016). Benton County is expected to see the most growth around the cities of St. Cloud, Sartell, and Sauk Rapids (Benton County 2006). Stearns County, which is considered part of the "growth corridor" between Brainerd, the Twin Cities, and Rochester, is expected to increase by 33% from 2000 to 2030. From 2000 to 2005, Stearns County's population grew by 7.1%, much higher than the statewide average of 4.2% for the same period (Stearns County 2008).

6.1 New or expanding permitted MS4 WLA transfer process

Future transfer of watershed runoff loads in this TMDL may be necessary if any of the following scenarios occur in the project watershed boundaries.

1. New development occurs within a permitted MS4. Newly developed areas that are not already included in the WLA must be transferred from the LA to the WLA to account for the growth.
2. One permitted MS4 acquires land from another permitted MS4. Examples include annexation or highway expansions. In these cases, the transfer is WLA to WLA.
3. One or more non-permitted MS4s become regulated. If this has not been accounted for in the WLA, then a transfer must occur from the LA.
4. Expansion of a U.S. Census Bureau Urban Area encompasses new regulated areas for existing permittees. An example is existing state highways that were outside an urban area at the time the TMDL was completed, but are now inside a newly expanded urban area. This will require either a WLA to WLA transfer or a LA to WLA transfer.
5. A new MS4 or other stormwater-related point source is identified and is covered under a NPDES/SDS Permit. In this situation, a transfer must occur from the LA.

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

6.2 New or expanding wastewater

The MPCA, in coordination with the EPA Region 5, has developed a streamlined process for setting or revising WLAs for new or expanding wastewater discharges to waterbodies with an EPA approved TMDL (described in Section 3.7.1 *New and Expanding Discharges* in MPCA 2012). This procedure will be used to update WLAs in approved TMDLs for new or expanding wastewater dischargers whose permitted effluent limits are at or below the instream target and will ensure that the effluent concentrations will not exceed applicable water quality standards or surrogate measures. The process for modifying any and all WLAs will be handled by the MPCA, with input and involvement by the EPA, once a permit request or reissuance is submitted. The overall process will use the permitting public notice process to allow for the public and EPA to comment on the permit changes based on the proposed WLA modification(s). Once any comments or concerns are addressed, and the MPCA determines that the new or expanded wastewater discharge is consistent with the applicable water quality standards, the permit will be issued and any updates to the TMDL WLA(s) will be made.

For more information on the overall process, visit the MPCA's TMDL Policy and Guidance webpage.

7. Reasonable assurance

A TMDL needs to provide reasonable assurance that water quality targets will be achieved through the specified combination of point and nonpoint source reductions reflected in the LAs and WLAs. According to EPA guidance (EPA 2002a):

> When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint-source load reductions will occur ... the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable. This information is necessary for the EPA to determine that the TMDL, including the LA and WLAs, has been established at a level necessary to implement water quality standards.

In order to address pollutant loading in the MRSW, required point source controls will be effective in improving water quality if accompanied by considerable reductions in nonpoint source loading. Reasonable assurance for permitted sources such as stormwater, CAFOs, and wastewater is provided primarily via compliance with their respective NPDES/SDS permit programs, as described in Section 3.6.

Reasonable assurance for non-permitted sources discussed in Section 3.6 includes supporting evidence that there:

- are reliable means for addressing pollutant loads (i.e., BMPs and pollution reduction programs) (see Section 7.1: *Non-permitted source reduction programs*, and Section 7.3 *Example non-permitted source reduction projects and partners*)
- are reliable means for prioritizing and focusing management (see Section 7.2: *Summary of local planning*)
- is a strategy for implementation (see Section 9: *Implementation strategy summary*)
- are available funds to execute projects (see Section 7.4: *Funding availability*)
- is a system of tracking progress and monitoring water quality response (see Sections 8: *Monitoring plan* and 9.4: *Adaptive management)*
- are non-point source reduction projects at multiple scales (see Section 7.3: *Example non-permitted source reduction projects and partners*)

Reasonable assurance of these six elements is provided by the numerous nonpoint source reduction programs, local planning efforts, funding sources, and the project implementation efforts of partners and participating organizations that continue to work towards improving water quality in the MRSW as described in the following sections. The goals and objectives for the MRSW TMDL are consistent with state-wide source reduction programs and local county water plans, and will be incorporated into the MPCA's WRAPS report for the watershed (see Section 9 for more information on the MPCA's watershed approach).

7.1 Non-permitted source reduction programs

Several non-permitted reduction programs exist to support implementation of nonpoint source reduction BMPs in the MRSW. These programs identify BMPs, provide means of focusing BMPs, and support their implementation via state initiatives, ordinances, and/or provide dedicated funding. The following examples describe large-scale programs that have proven to be effective and/or will reduce pollutant loads going forward.

7.1.1 MPCA Feedlot Program

The MPCA Feedlot Program implements rules governing the collection, transportation, storage, processing, and disposal of animal manure and other livestock operation wastes. Minn. R. ch. 7020 regulates feedlots in the state of Minnesota. All feedlots capable of holding 50 or more AUs, or 10 in shoreland areas, are subject to this rule. A feedlot holding 1,000 or more AUs is NDPES-permitted. The focus of the rule is on animal feedlots and manure storage areas that have the greatest potential for environmental impact. The MPCA has been putting emphasis on impaired waters as part of its inspection commitments to USEPA for the past several years.

The Feedlot Program is implemented through a cooperation between MPCA and 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, or a delegated county, has been given authority by the MPCA to delegate administration of 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 totaled about two million dollars (MPCA 2017). In the MRSW, Stearns and Morrison are delegated counties. The MPCA is tasked with running the Feedlot Program in Benton, Crow Wing, and Mille Lacs counties.

7.1.2 SSTS implementation and enforcement

SSTSs are regulated through Minn. Stat. §§ 115.55 and 115.56. Regulations include:

- Minimum technical standards for 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 septic installation, maintenance, and inspection

In 2008, the MPCA amended and adopted rules concerning the governing of SSTS. In 2010, the MPCA was mandated to appoint a SSTSs Implementation and Enforcement Task Force. Members of the task force include representatives from the Association of Minnesota Counties, Minnesota Association of Realtors, Minnesota Association of County Planning and Zoning Administrators, and the Minnesota Onsite Wastewater Association. The group was tasked with:

- Developing effective and timely implementation and enforcement methods to reduce the number of SSTS that are an ITPHS and enforce all violation of the SSTS rules (see MPCA 2011b)
- Assisting MPCA in providing counties with enforcement protocols and inspection checklists

Currently, a system is in place in the state such that when a straight pipe system or other ITPHS location is confirmed, county health departments send notices of non-compliance. Upon doing so, a 10-month deadline is set for the system to be brought into compliance. All known ITPHS are recorded in a statewide database by the MPCA. From 2006 to 2017, 742 straight pipes were tracked by the MPCA statewide. Seven hundred-one of those were abandoned, fixed, or were found not to be a straight pipe system. There have been 17 Administrative Penalty Orders issued and docketed in court. The remaining straight pipe systems received a notification of non-compliance and are currently within the 10-month deadline. The MPCA, through the Clean Water Partnership Loan Program, awarded $2.45 million to local partners to provide low interest loans for SSTS upgrades in 2016. More information on SSTS financial assistance can be found on the MPCA's website.

7.1.3 Buffer program

The Buffer Law signed by Governor Dayton in June 2015 was amended on April 25, 2016 and further amended by legislation signed by Governor Dayton on May 30, 2017 (Minn. Stat. §103B.101). The Buffer Law requires the following:

- For all public waters, the more restrictive of:
    - a 50-foot average width, 30-foot minimum width, continuous buffer of perennially rooted vegetation, or
    - the state shoreland standards and criteria
- For public drainage systems established under Minn. Stat. §103E, a 16.5-foot minimum width continuous buffer as provided in Minn. Stat. § 103E.021, subd. 1. The buffer vegetation shall not impede future maintenance of the ditch.

Alternative practices are allowed in place of a perennial buffer in some cases. The 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 allow landowners to be granted a compliance waiver until July 1, 2018, when they have filed a compliance plan with the soil and water conservation district (SWCD).

The Board of Water and Soil Resources (BWSR) provides oversight of the buffer program, which is primarily administered at the local level; compliance with the Buffer Law in the state is displayed on the state's *Minnesota Buffer Law* website. As of July 2018, all of the counties within the MRSW had an estimated 95% to 100% compliance rate with buffer law requirements (*Minnesota Buffer Law* website accessed November 5, 2018).

Agricultural Water Quality Certification Program

The Minnesota Agricultural Water Quality Certification Program is a voluntary opportunity for farmers and agricultural landowners to take the lead in implementing conservation practices that protect waters. Those who implement and maintain approved farm management practices are 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 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.

7.1.4 Minnesota's soil erosion law

Minnesota's soil erosion law is found in Minn. Stat. §§ 103F.401 through 103F.455. The law, which dates back to 1984, sets forth a strong public policy stating that a person may not cause excessive soil loss. The law was entirely permissive, however, in that it only encouraged local governments to adopt soil erosion ordinances and could not be implemented without a local government ordinance. The soil erosion law was changed in 2015 when a number of revisions were made by the Legislature and approved by the Governor to broaden its applicability.

Minnesota Laws 2015, regular and first special sessions changed the law by (1) repealing Minn. Stat. § 103F.451, "Applicability," which eliminates the requirement that the law is only applicable with a local government ordinance; (2) creating specific Administrative Penalty Order authority in Minn. Stat. § 103B.101, subd. 12a. for BWSR and counties to enforce the law; and 3) amending Minn. Stat. § 103F.421, "Enforcement," to remove local enforcement only through civil penalty, and to revise requirements for state cost-share of conservation practices required to correct excessive soil loss. By definition, *excessive soil loss* means soil loss that is greater than established soil loss limits or evidenced by sedimentation on adjoining land or in a body of water. The result of the combined changes now sets forth statewide regulation of excessive soil loss regardless of whether a local government has a soil loss ordinance (BWSR 2016a).

7.1.5 Minnesota Nutrient Reduction Strategy

The *Minnesota Nutrient Reduction Strategy* (NRS; MPCA 2014b) guides activities that support nitrogen and phosphorus reductions in Minnesota waterbodies and those downstream of the state (e.g., Lake Winnipeg, Lake Superior, and the Gulf of Mexico). The *NRS* was developed by an interagency coordination team with help from public input. Fundamental elements of the *NRS* include:

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

Included in the strategy discussion are alternatives and tools for consideration by drainage authorities, information on available tools and approaches for identifying areas of phosphorus and nitrogen loading and tracking efforts within a watershed, and additional research priorities. The *NRS* is focused on incremental progress and provides meaningful and achievable nutrient load reduction milestones that allow for better understanding of incremental and adaptive progress toward final goals. It has set a reduction of 45% for both phosphorus and nitrogen in the Mississippi River.

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

- Intensive watershed monitoring
- Assessment of watershed health
- Development of WRAPS reports
- Management of NPDES/SDS and other regulatory and assistance programs

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

7.2 Summary of local planning

Minnesota has a long history of water management by local governments. One Watershed, One Plan (1W1P) is rooted in this history and in work initiated by the Minnesota Local Government Roundtable (an affiliation of the Association of Minnesota Counties, Minnesota Association of Watershed Districts, and Minnesota Association of SWCDs). Roundtable members recommended that the local governments charged with water management responsibility organize and develop focused implementation plans on a watershed scale (BWSR 2016b).

The recommendation was followed by legislation that authorizes BWSR to adopt methods to allow comprehensive plans, local water management plans, or watershed management plans to serve as substitutes for one another or to be replaced with one comprehensive watershed management plan. This legislation is referred to as “1W1P” (Minn. Stat. §103B.101, subd. 14). Further legislation defining purposes and outlining additional structure for 1W1P, officially known as the Comprehensive Watershed Management Planning Program (Minn. Stat. § 103B.801), was passed in May 2015.

BWSR’s vision for 1W1P is to align local water planning on major watershed boundaries with state strategies towards prioritized, targeted, and measurable implementation plans—the next logical step in the evolution of water planning in Minnesota and an important component of the reasonable assurance framework. A 1W1P has not yet been completed for the MRSW. BWSR is committed to completing all 1W1Ps by 2025. The eventual MRSW 1W1P will follow the completion of the WRAPs and is expected to have positive impacts on water quality in the TMDL project focus area.

Until the start of 1W1P development for the MRSW, water planning continues to be done on a county basis, per the Comprehensive Local Water Management Act (Minn. Stat. § 103B.301) (see BWSR’s local water plan map for status of local water management plans and the list below for current plans). Local water plans incorporate implementation strategies aligned with or called for in TMDLs and WRAPS and are implemented by SWCDs, counties, state and federal agencies, and other partners. These local plans and the eventual 1W1Ps evaluate the effectiveness of the previous plan, determine current local priorities, set goals and objectives for those priorities, and set timelines for specific BMPs to achieve the goals and objectives.

The following is a list of local county water plans for major counties in the MRSW.

- Benton County Comprehensive Local Water Management Plan (Benton SWCD 2018).
- Crow Wing County Local Comprehensive Water Plan 2013 through 2023 (Crow Wing County n.d.).
- Mille Lacs County Local Water Resource Management Plan 2006 through 2016 and 2012 Amendments (Mille Lacs SWCD and the Mille Lacs County Local Water Planning Advisory Committee 2012). A new draft plan is currently under development.
- Morrison County Five Year Focus Plan, Comprehensive Local Water Plan 2017 through 2022 (Morrison SWCD 2017).
- Stearns County Local Water Management Plan Amendment (2013 through 2017; Stearns County Environmental Services 2017). Note that an extension has been granted to 2020 to allow for the completion of 1W1Ps and WRAPS within its jurisdiction.

7.3 Example non-permitted source reduction projects and partners

Local SWCDs are active in the project area and impaired subwatersheds. The SWCDs provide technical and financial assistance on topics such as conservation farming, nutrient management, streambank stabilization, and many others. SWCD involvement in the watershed includes conservation farming tours, workshops, educational activities, nitrate tests, agricultural BMP installation and cost share, and tree and rain barrel sales for county residents to help improve water quality and reduce pollutant loading.

In addition to the state-wide programs listed above, several SWCD-led non-permitted source reduction projects that are located in the watershed or influence the watershed were completed in recent years. The following are examples by county.

7.3.1 Benton SWCD

During the years 2012 through 2017, Benton County SWCD implemented a total of 72 projects in the impaired Little Rock Lake Watershed. Projects included test plots, lake buffer strips, and livestock and cropland agricultural BMPs. The projects are estimated to reduce 7.7×10^4 cfus, 2,340 lb of phosphorus, 4,543 lb of nitrogen, and 1,814 tons of total suspended solids (TSS). In addition, a lake water level draw down to address eutrophication occurred in summer 2019.

Major accomplishments since the completion of the 2008 through 2018 water plan include hiring a staff member to expand and build their feedlot and nutrient management programs and completing the County Geologic Atlas, which provided the basis of a sensitive areas management plan for the county, in addition to their day-to-day activities. The plan serves as a guiding document to protect sensitive areas from development or disturbance due to the presence of critical, vulnerable, or rare water resource features.

7.3.2 Morrison SWCD

Morrison SWCD completed several watershed improvement projects over the last few years, including the following examples:

- Swan River Clean Water Act Section 319 project (2010). A Section 319 grant was used by Morrison and Todd SWCDs to work with poultry and hog producers for nutrient management to reduce phosphorus loading to the Swan River. Projects included nutrient management plans, filter strip installation, terraces and sediment basins, and other best management projects for agricultural waste control. The grant totaled $140,000 in projects which included a $70,000 match by Morrison and Todd SWCD.
- Platte River bioengineering and armoring project (2015). The project had several partners including partners from the county, private landowners, and the city. A combination of rip-rap, rock stream barbs, and cedar tree revetments were installed to reduce erosion and provide fish habitat on private property on the Platte River. Funding was provided by the Clean Water Partnership and supplemented with funds from the city, Morrison SWCD cost share, and the private landowner.
- Morrison SWCD currently has a $2.8 million dollar Natural Resources Conservation Services (NRCS) Regional Conservation Partnership Program grant. The funds will be used primarily for Platte River Watershed restoration and brings in additional funding sources for the area. The award also supports a Healthy Forest easement project.

7.3.3 Stearns SWCD

Stearns SWCD completed several watershed improvement projects over the last few years. Some of the projects implemented in the MRSW include:

- Shoreline restoration project (2013). Project replaced a failing retaining wall on a property in East Brockway Township with native vegetation to prevent an estimated 47 lb phosphorus and 56 tons of TSS from entering the Mississippi River per year. Project was located on banks of the Mississippi River.
- Animal manure storage system (2016). Installation of a concrete stacking slab and earthen diversions prevented hold and store and any runoff. Prevents an estimated 10 lb phosphorus and 30 lb of nitrogen from entering Spunk Creek, and reduces 115 lb of biological oxygen demand and 533 lb chemical oxygen demand per year.
- Erosion control (2016). Project consisted of a grassed waterway, earthen diversion, terracing, and a water and sediment control basin to prevent 766 lb phosphorus and 900 tons of TSS from entering Spunk Creek per year.
- Stormwater treatment with vegetative infiltration basins at St. John’s University (2016). Prevents an estimated 3.77 lb of phosphorus and 1,225 lb of TSS from entering Stump Lake and Lake Sagatagan per year.
- Development of the Targeted Two Rivers Conservation Practice Plan (RESPEC 2015) that identified high priority subwatersheds based on HSPF modeling, land use, and several other factors. The HSPF modeling results in this plan were used by Stearns County SWCD to successfully obtain a Clean Water Fund (CWF) grant in 2016. Some of the CWF funds have been spent on a water quality project in the City of Albany. The remainder of the funds are being targeted to water quality projects with landowners in the Two Rivers Lake Subwatershed.

7.3.4 Mississippi Headwaters Board

The Mississippi Headwaters Board implements programs that target improving water quality in the headwaters of the Mississippi. The Mississippi Headwaters Board has recently updated their Comprehensive Management Plan which covers the first 400 miles of the Mississippi River, or from the headwaters to the Morrison and Stearns county border. In 2012, they received an Accelerated Implementation Grant of $100, 000 from the BWSR to complete a study to prioritize conservation project implementation based on areas of concern where: 1) water quality is showing degradation, and 2) areas that are critical to long-term water quality protection.

In addition, The Mississippi Headwaters Board in collaboration with the Trust for Public Land, BWSR, The Nature Conservancy, and DNR has developed the Mississippi Headwaters Habitat Corridor Easement and Acquisition Program to protect and preserve the natural qualities of the Mississippi River. The goal of the program is to create and expand contiguous complexes of permanently protected shoreland and upland for the benefit of fish and wildlife habitat, migratory waterfowl, reduction of forest fragmentation, enhanced recreational opportunities and protection of water quality. Land protection is achieved via fee-title acquisition of land or enrolling land in The RIM conservation easement program.

7.3.5 Mississippi River–Sartell Watershed Communication Plan

While the development and implementation of a communication plan does not directly result in non-permitted source reductions, it plays a large role in establishing an educated and involved community. The MRSW is predominantly composed of privately owned land. As such, participation of private landowners is important to the successful implementation of the TMDL. In November of 2017 a communication plan was developed for the MRSW TMDL and WRAPS development (Tetra Tech 2017). This communication plan is intended to serve as a working document that first outlines the major steps and actions needed to effectively communicate with key target audiences and among core team members. The plan is adaptive and presents an evaluation method that can be used to refine and elevate the plan to include increased engagement and involvement with targeted audiences as implementation moves forward. Local partners may use the plan as a guide for more specific and targeted messaging and incorporate plan elements into their existing communication activities.

The communication plan also identifies the numerous existing organizations involved with education and outreach in the project area and their multiple efforts. On-going events include: conservation and farm tours for residents and elected officials; creation of materials for homeowners, construction contractors, etc.; conservation events like “Take the Day Off,” a collaboration between the Mississippi River Renaissance, Benton and Stearns SWCD, and County Parks with the DNR that offers participants hands-on instruction in a variety of outdoor activities, education on land use impacts to our natural resources, and an increased awareness of the Mississippi River in central Minnesota; annual tree sales; and groundwater well testing demonstrations and kits.

7.3.6 MRSW local partner group

A local partner group was created during the development of the TMDL to support the implementation of MPCA’s watershed approach in the MRSW, including the development of the TMDL. The local partner group consisted of representatives from counties, SWCDs, MPCA, DNR, MDH, NRCS, BWSR, Minnesota

Department of Agriculture (MDA), the Mississippi Headwaters Board, The Nature Conservancy, and lake associations.

7.4 Funding availability

Local partner projects listed above demonstrate a reasonable assurance that funding is available for TMDL implementation and that local partners are capable of acquiring said funding. Potential state and federal funds available to the various watershed entities include grants from Clean Water, Land and Legacy funds, EPA's Section 319 Grant Program for States and Territories, and various NRCS programs. Local sources of funding for counties and other organizations may include county taxes, levies, and fees. In some cases these local financial resources provides funding for significant water quality and quantity improvement projects, local grants, staff, monitoring, and engineering costs.

7.5 Summary

In summary, significant time and resources have been devoted to identifying the best BMPs appropriate to the MSRW, providing means of focusing them in the MRSW, and supporting their implementation via state initiatives and dedicated funding. The MRSW WRAPS and TMDLs process engaged partners to arrive at reasonable examples of BMP combinations that attain pollutant reduction goals. Minnesota is a leader in watershed planning, as well as monitoring and tracking progress toward water quality goals and pollutant load reductions. Finally, examples cited herein confirm that BMPs and restoration projects have proven to be effective over time and as stated by the State of Minnesota Court of Appeals A15-1622 (MCEA vs. MPCA and MCES):

> We conclude that substantial evidence exists to conclude that voluntary reductions from nonpoint sources have occurred in the past and can be reasonably expected to occur in the future. The NRS ... provides substantial evidence of existing state programs designed to achieve reductions in nonpoint source pollution as evidence that reductions in nonpoint pollution have been achieved and can reasonably be expected to continue to occur.

8. Monitoring plan

This monitoring plan provides an overview of what is expected to occur at many scales in multiple subwatersheds within the MRSW, subject to availability of monitoring resources. The designated uses of aquatic life, aquatic recreation, and limited resource value will be the ultimate measures of water quality. Improving the state of these designated uses depends on many factors, and improvements may not be detected over the next 5 to 10 years. Consequently, a monitoring plan is needed to track shorter and longer term changes in water quality and land management. Monitoring is important for several reasons:

- Evaluating waterbodies to determine if they are meeting water quality standards 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. Several types of monitoring will be important to measuring success. The six basic types of monitoring listed below are based on the EPA's *Protocol for Developing Sediment TMDLs* (EPA 1999).

Baseline monitoring—identifies the environmental condition of the water body to determine if water quality standards are being met and identify temporal trends in water quality.

Implementation monitoring—tracks implementation of sediment reduction practices using BWSR's eLink or other tracking mechanisms.

Flow monitoring—is combined with water quality monitoring to allow for the calculation of pollutant loads.

Effectiveness monitoring—determines whether a practice or combination of practices are effective in improving water quality.

Trend monitoring—allows the statistical determination of whether water quality conditions are improving.

Validation monitoring—validates the source analysis and linkage methods in sediment source tracking to provide additional certainty regarding study findings. For instance monitoring above and below knickpoints rather than just at the watershed outlet to help constrain and identify sediment sources.

There are many monitoring efforts in place to address each of the six basic types of monitoring. Several key monitoring programs will provide the information to track trends in water quality and evaluate compliance with TMDLs:

- Intensive monitoring and assessment at the HUC 8 scale associated with Minnesota's watershed approach. This monitoring effort is conducted approximately every 10 years for each HUC 8. An outcome of this monitoring effort is the identification of waters that are impaired (i.e., do not meet standards and need restoration) and waters in need of protection to prevent impairment. Over time, condition monitoring can also identify trends in water quality. This helps determine whether water quality conditions are improving or declining, and it identifies how management actions are improving the state's waters overall.

- The MPCA's Watershed Pollutant Load Monitoring Network (WPLMN) measures and compares data on pollutant loads from Minnesota's rivers and streams and tracks water quality trends. WPLMN data will be used to assist with assessing impaired waters, watershed modeling, determining pollutant source contributions, developing watershed and water quality reports, and measuring the effectiveness of water quality restoration efforts. Data are collected along major river main stems, at major watershed (i.e., HUC 8) outlets to major rivers, and in several subwatersheds. In the MRSW, mainstream WPLMN sites are located at Royalton (site E15001002) and Sartell (site W15009003); the outlet site is located at Sauk Rapids (site W15009002), and a subwatershed site is located along the Platte River near Royalton (site H15030001). This long-term monitoring program began in 2007.
- Implementation monitoring is conducted by both BWSR (i.e., eLINK) and the United States Department of Agriculture. Both agencies track the locations of BMP installations. Tillage transects and crop residue data are collected periodically and reported through the Minnesota Tillage Transect Survey Data Center. BMP tracking information is readily available through the MPCA's "Healthier Watersheds" webpage.
- Discharges from permitted municipal and industrial wastewater sources are reported through discharge monitoring records (see Section 3.6.1); these records are used to evaluate compliance with NPDES/SDS permits. Summaries of discharge monitoring records are available through the MPCA's Wastewater Data Browser.

9. Implementation strategy summary

Minnesota's watershed approach to restoring and protecting water quality is based on a major watershed, or HUC8, scale. This watershed-level planning occurs on a 10-year cycle beginning with intensive watershed monitoring and culminates in local implementation (Figure 34). A WRAPS report is produced as part of this approach and addresses restoration of impaired subwatersheds and protection of unimpaired waters in each HUC8 watershed. These high-level reports are then used to inform watershed management plans that focus on local priorities and knowledge to identify prioritized, targeted, and measurable actions and locally based strategies. These plans further define specific actions, measures, roles, and financing for accomplishing water resource goals. Implementation activities in the MRSW WRAPS report will heavily influence and support implementation of this TMDL. The following sections provide an overview of potential implementation strategies to address the high priority pollutant sources including failing SSTSs and ITPHSs, AFOs, agricultural runoff, and stormwater runoff.

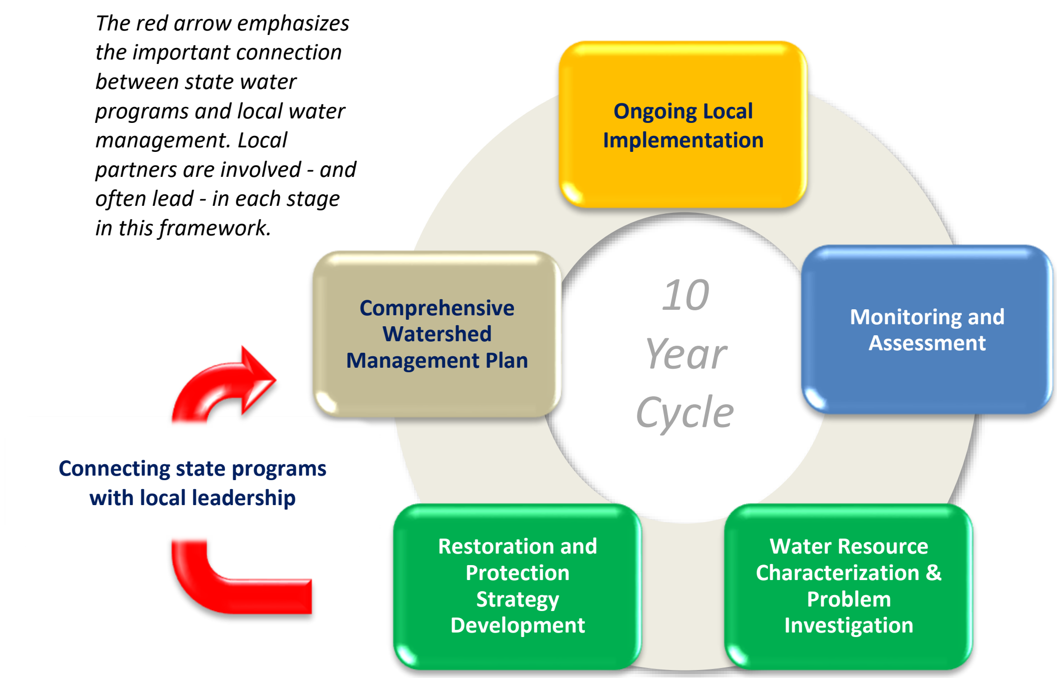

Figure 34. Minnesota's watershed approach.

9.1 Implementation strategies for non-permitted sources

Implementation of the MRSW TMDLs will require numerous BMPs that address priority sources of *E. coli* and phosphorus. This section provides an overview of example BMPs that may be used for implementation. The BMPs included in this section are not exhaustive, and the list may be amended. Priority sources of *E. coli* to target for implementation are livestock in AFOs, ITPHS, and stormwater runoff. Agricultural runoff is the priority source of phosphorus to target for implementation. SSTSs that are failing to protect groundwater are required by state law to be addressed and are therefore also considered a priority source of phosphorus. Table 74 summarizes example BMPs that can be implemented to achieve goals of the TMDL.

Table 74. Example BMPs for non-permitted sources of pollutants in the MRSW.

Strategy	BMP examples [a]	Targeted Pollutant	
		E. coli	**Phosphorus**
Agricultural runoff control and soil improvements	Conservation tillage		✓
	Cover crops		✓
	Filter strips and field borders	✓	✓
Feedlot runoff control	Feedlot runoff reduction and treatment	✓	✓
	Feedlot manure/storage addition	✓	✓
Nutrient management	Nutrient management	✓	✓
	Manure incorporation within 24 hours	✓	✓
Pasture management	Conventional pasture to prescribed rotational grazing		✓
	Livestock access control	✓	✓
Septic system improvements	Septic system improvement (maintenance and replacement)	✓	✓
Converting land to perennials	Conservation cover perennials		✓
Buffers and filters	Riparian buffers and field boarders	✓	✓
Urban stormwater runoff control	Green infrastructure practices	✓	✓
	Improved lawn/turf vegetation & soil practices	✓	✓
In-lake management	Curlyleaf pondweed management		✓

a. Descriptions of BMP examples can be found in the *Agricultural BMP Handbook for Minnesota* (Lenhart et al. 2017), the *Minnesota Stormwater Manual* (Minnesota Stormwater Manual contributors 2019), the MPCA's *Lake Protection and Management* website, and the University of Minnesota Extension's *Onsite Sewage Treatment Program* website.

9.2 Implementation strategies for permitted sources

Implementation of the MRSW TMDL for permitted sources will consist of permit compliance as explained below.

9.2.1 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 Appendix A of the Construction General Permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL. Construction activity must also meet all local government construction stormwater requirements.

9.2.2 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/SDS Industrial Stormwater Permit coverage is required, and the BMPs and other stormwater control measures that should be implemented at the sites to limit the discharge of pollutants of concern. The BMPs and other stormwater control measures that should be implemented at the industrial sites are defined in Minnesota's NPDES/SDS Industrial Stormwater Multi-Sector General Permit (MNR050000) or NPDES/SDS General Permit for Construction Sand and Gravel, Rock Quarrying and Hot Mix Asphalt Production facilities (MNG490000). If a facility owner/operator obtains stormwater coverage under the appropriate NPDES/SDS Permit and properly selects, installs, and maintains all BMPs required under the permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL. Industrial activity must also meet all local government industrial stormwater requirements.

9.2.3 MS4

For new development projects, MPCA's current phase II MS4 general permit requires no net increase from pre-project conditions (on an annual average basis) of stormwater discharge volume and stormwater discharges of TSS and phosphorus. For redevelopment projects, MPCA's current phase II MS4 general permit requires a net reduction from pre-project conditions (on an annual average basis) of stormwater discharge volume and stormwater discharges of TSS and phosphorus. These provisions in the MS4 permit will prevent increases in annual loading in TSS and phosphorus. In addition, because stormwater serves as a conveyance system for *E. coli* in the landscape to enter waterbodies, these stormwater volume provisions likely will reduce or prevent increases in annual *E. coli* loading. More information on stormwater BMPs can be found in the Minnesota Stormwater Manual.

The MS4 General Permit requires permittees to address all WLAs in TMDLs approved prior to the effective date of the permit. In doing so, they must determine if they are currently meeting their WLA(s). If the WLA is not achieved at the time of application, a compliance schedule is required that includes interim milestones, expressed as BMPs, that will be implemented over the current five-year permit term to reduce loading of the pollutant of concern in the TMDL. Additionally, a long-term implementation strategy and target date for fully meeting the WLA must be included.

The MS4 General Permit was placed on public notice in the fall of 2019 and is expected to be reissued in 2020. The draft permit contains specific requirements to address *E. coli* TMDLs; these pollutant-specific requirements are in the Minimum Control Measures sections of the draft permit. A compliance schedule will not be required for applicable *E. coli* WLAs. A compliance schedule *will* be required for applicable phosphorus WLAs. Volume control requirements for redevelopment in the draft permit will also lead to reductions in *E. coli* and phosphorus loading to impaired waterbodies.

9.2.4 Wastewater

NPDES/SDS permits for municipal wastewater include effluent limits designed to meet phosphorus and *E. coli* water quality standards along with monitoring and reporting requirements to ensure effluent limits are met. Three municipal wastewater treatment facilities receive *E. coli* WLAs in this TMDL report and one receives a phosphorus WLA. The wastewater WLAs are all consistent with existing permit limits.

9.3 Cost

9.3.1 Implementation cost

TMDLs are required to include an overall approximation of implementation costs (Minn. Stat. § 114D.25). The costs to implement the activities outlined in the strategy are approximately $12 to $18 million dollars over the next 20 years. This range reflects the level of uncertainty in the source assessment and addresses the likely sources identified in Section 3.6. The cost includes increasing local capacity to oversee implementation in the watershed and the voluntary actions needed to achieve necessary TMDL reductions. Costs for implementing the TMDL and achieving the required pollutant load reductions were estimated by developing an implementation scenario with cost effective and practical options. Actual implementation will likely differ.

The cost of required actions, such as the replacement of ITPHS systems and SSTS maintenance, were not considered in the overall cost calculation because their costs are already accounted for in existing programs. The expected pollutant reductions of these required actions, however, were accounted for in the implementation scenario to achieve required TMDL reductions.

9.3.2 Phosphorus reduction cost methodology

Costs for phosphorus reductions in Two Rivers Lake (73-0138-00) and Platte Lake (18-0088-00) were determined by estimating the level of BMPs necessary to meet the overall estimated percent reduction needed to meet the TMDL (Table 70 and Table 73). BMPs used in the phosphorus scenario calculation include:

- Conservation tillage
- Cover crops
- Nutrient management
- Field borders/buffers
- Rotational grazing and pasture management
- SSTS maintenance and ITPHS replacement
- Alum treatment

9.3.3 *E. coli* cost methodology

Costs to achieve the required *E. coli* reductions were calculated using the most likely sources (Table 18) and the overall estimated percent reductions needed to meet each TMDL (Section 5.1). This cost assessment accounts for the uncertainty of a qualitative *E. coli* source assessment. BMPs used in the *E. coli* scenario calculation include:

- Feedlot BMPs and livestock access control
- Nutrient management
- SSTS maintenance and ITPHS replacement

Feedlot BMPs include buffer strips around feedlots, nutrient management, and compost facilities and were applied to all *E. coli* impaired subwatersheds. A feedlot BMP cost of $235 per AU was calculated for the impaired subwatersheds based on AU data provided by the MPCA and the 2019 EQIP payments for Minnesota. It was assumed that approximately 60% of existing feedlots are already implementing feedlot BMPs and do not need improvements.

9.3.4 Cost references

BMP costs and removal efficiencies used in cost calculation were predominantly obtained from the suggested default reductions for the Scenario Application Manager tool (RESPEC 2017), Minnesota EQIP dollars for 2019, the Minnesota NRS (MPCA 2014b), and the Minnesota Agricultural BMP Handbook (Lenhart et al. 2017).

9.4 Adaptive management

The implementation strategy for this TMDL report and the detailed WRAPS report focuses on adaptive management. An adaptive management approach is an overall system of continuous improvements and feedback loops that allows for changes in the management strategy if environmental indicators suggest that the strategy is inadequate or ineffective. Continued monitoring and course corrections responding to monitoring results are the most appropriate strategy for attaining the water quality goals established in this TMDL.

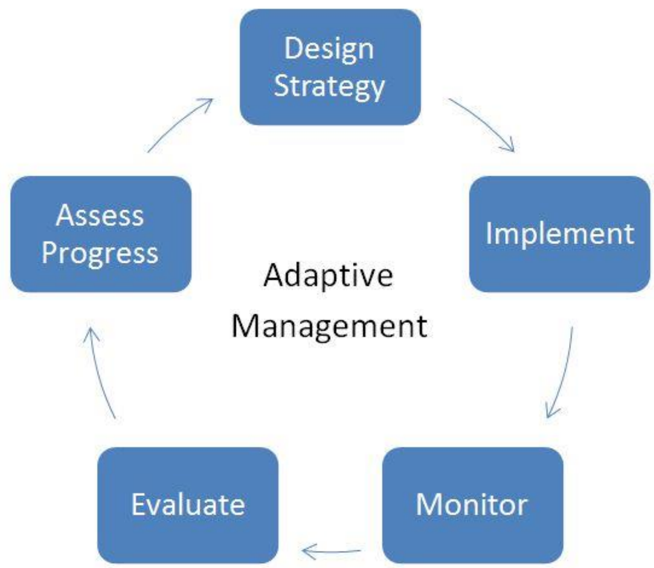

Figure 35. General adaptive management process.

Natural resource management involves a series of actions and associated feedback loops that help to inform next steps to achieve overarching goals. In the simplest of terms, adaptive management is a cyclical process or loop in which actions are implemented, monitored, evaluated, compared to anticipated progress, and redesigned if needed (Figure 35). In actuality, adaptive management in natural resource management consists of many of these feedback loops, all of which can occur at different speeds and durations. These loops or cycles can be large and programmatic in nature such as Minnesota's watershed approach, while others can be small and on a scale such as an individual field (Nelson et al. 2017). As a structured iterative implementation process, adaptive management offers the flexibility for responsible parties to monitor implementation actions, determine the success of such actions, and ultimately, base management decisions upon the measured results of completed implementation actions and the current state of the system. This process enhances the understanding and estimation of predicted outcomes and ensures refinement of necessary activities to better guarantee desirable results. In this way, understanding of the resource can be enhanced over time and management can be improved (Williams et al. 2009).

10. Public participation

Meetings and/or other informal communications with county and SWCD staff, MS4 representatives, other state agency staff, and other stakeholders were held at various points during the project. Opportunities were given to provide feedback on the TMDL methodology and review draft versions of the TMDL report. An opportunity for public comment on the draft TMDL report was provided via a public notice in the State Register from September 14, 2020 through October 14, 2020. There were two comment letters received and responded to as a result of the public comment period. In addition, the following civic engagement occurred.

Upper Mississippi–Brainerd/Sartell Watersheds Civic Engagement Cohort

An Upper Mississippi–Brainerd/Sartell (MBS) Watersheds Civic Engagement Cohort was sponsored by the MPCA in 2016–2017. This cohort was provided through a partnership with the University of Minnesota Extension, which provided the training. The cohort included partners from the Mississippi River–Brainerd Watershed and complements the efforts of the MRS WRAPS project through the professional training and development of interested watershed partners in becoming civic engagement leaders in their respective watersheds. While the regular cohort training sessions concluded in February 2017, the ongoing goal is to continue the communication among the cohort members to help sustain the system of civic engagement support and information that was developed through the cohort sessions.

The goals of the MBS Watersheds Civic Engagement Cohort included:

- Explore and apply civic engagement research, skills, and practices in watershed restoration and protection efforts.
- Expand leadership confidence, capacity, and connections.
- Build a system of support through fellow cohort participants.
- Learn from other cohort participants.
- Reflect and collaborate to further authentic community engagement in the watersheds.

Public participation during TMDL development

As part of implementing the communication plan for the watershed, two community outreach events were held in Rice, Minnesota during development of the TMDL. Educational materials developed for the TMDL project were made available to the local SWCDs at their offices and events held in the watershed such as county fairs. The communication plan will continue to be implemented during implementation of the TMDL and the development and implementation of the WRAPS report for the watershed.

Numerous Public Participation activities have occurred in connection with the Mississippi River WRAPS. See the Section 3.1 of the WRAPS report for additional detailed information.

11. Literature cited

Adhikari, H., D.L. Barnes, S. Schiewer, and D.M. White. 2007. Total Coliform Survival Characteristics in Frozen Soils. *Journal of Environmental Engineering* 133(12):1098–1105.

Alderisio, K.A. and N. DeLuca. 1999. Seasonal Enumeration of Fecal Coliform Bacteria from the Feces of Ring-Billed Gulls (*Larus Delawarensis*) and Canada Geese (*Branta Canadensis*). *Applied and Environmental Microbiology* 65 (12): 5628–30.

American Society of Agricultural Engineers (ASAE). 1998. *ASAE Standards, 45th Edition*. Standards, Engineering Practices, Data.

Barr Engineering. 2004. *Detailed Assessment of Phosphorus Sources to Minnesota Watersheds*. Prepared for Minnesota Pollution Control Agency, Saint Paul, MN.

Barr Engineering. 2007. *Detailed Assessment of Phosphorus Sources to Minnesota Watersheds—Atmospheric Deposition: 2007 Update*. Technical Memorandum prepared for Minnesota Pollution Control Agency, Saint Paul, MN.

Benton County. 2006. *2006 Benton County Comprehensive Plan*. Benton County, MN

Benton SWCD (Soil and Water Conservation District). 2011. *Little Rock Lake Nutrient TMDL*. Prepared for the Minnesota Pollution Control Agency in cooperation with W. Walker. Document #wq-iw8-31e.

Benton SWCD (Soil and Water Conservation District). 2015. *Little Rock Creek Watershed Total Maximum Daily Load Report: Dissolved Oxygen, Nitrate, Temperature and Fish Bioassessment Impairments*. Prepared by Barr Engineering. Document #wq-iw8-09e.

Benton SWCD (Soil and Water Conservation District). 2018. *Benton County Comprehensive Local Water Management Plan 2018–2028.* Available at: https://www.soilandwater.org/

Burns & McDonnell Engineering Company, Inc. 2017. *Minnehaha Creek Bacterial Source Identification Study Draft Report.* Prepared for City of Minneapolis, Department of Public Works. Project No. 92897. May 26, 2017.

BWSR (Board of Water and Soil Resources). 2016a. *Minnesota Excessive Soil Loss Program Implementation DRAFT Interim Guidance: Excessive Soil Loss Complaints for Agricultural Activities*. April 4, 2016

BWSR (Board of Water and Soil Resources). 2016b. *One Watershed, One Plan: Evolution of water planning in Minnesota*. Retrieved on 12/10/2018 from http://www.bwsr.state.mn.us/planning/1W1P/1W1P_Factsheet.pdf

City of Eden Prairie. 2008. *Canada Goose Management Plan*. June 11, 2008.

City of Sartell. 2016. *2016 Comprehensive Plan*. Available at: http://www.sartellmn.com/2016-comprehensive-plan-update

Chandrasekaran, R., M.J. Hamilton, P. Wang, C. Staley, S. Matteson, A. Birr, and M.J. Sadowsky. 2015. Geographic Isolation of *Escherichia Coli* Genotypes in Sediments and Water of the Seven Mile Creek — A Constructed Riverine Watershed. *Science of The Total Environment* 538: 78–85.

Crow Wing County. n.d. *Crow Wing County Local Comprehensive Water Plan 2013–2023.* Available at: http://crowwing.us

DNR (Minnesota Department of Natural Resources). In progress.

DNR (Minnesota Department of Natural Resources). 2003. Aquatic Vegetation of Platte Lake. Available at: http://files.dnr.state.mn.us/natural_resources/water/lakes/vegetation_reports/18008800.pdf.

Doyle, M.P., and M.C. Erickson. 2006. Closing the Door on the Fecal Coliform Assay. *Microbe* 1 (4): 162–63.

EPA (United States Environmental Protection Agency). 1991. *Guidance for Water Quality-based Decisions: The TMDL Process*. EPA-440/4-91-001. U.S. EPA, Office of Water (WH-553), Washington, DC. 62 pp.

EPA (U.S. Environmental Protection Agency). 1999. *Protocol for Developing Sediment TMDLs*. First Edition. EPA 841-B-99-004. EPA, Office of Water. Washington, DC. October 1999.

EPA (U.S. Environmental Protection Agency). 2002a. *National Recommended Water Quality Criteria: 2002.* EPA-822-R-02-047. Office of Water. Office of Science and Technology. Washington, D.C.

EPA (U.S. Environmental Protection Agency). 2013. *A Long-Term Vision for Assessment, Restoration, and Protection under the Clean Water Act Section 303(d) Program*. December 2013.

Farmland Wildlife Populations and Research Group. 2015. Monitoring Populations Trends of White-tailed Deer in Minnesota – 2015.

Ishii, S., W.B. Ksoll, R.E. Hicks, and M. Sadowsky. 2006. Presence and Growth of Naturalized *Escherichia Coli* in Temperate Soils from Lake Superior Watersheds. *Applied and Environmental Microbiology* 72: 612–21.

Ishii, S., T. Yan, H. Vu, D.L. Hansen, R.E. Hicks, and M.J. Sadowsky. 2010. Factors Controlling Long-Term Survival and Growth of Naturalized *Escherichia coli* Populations in Temperate Field Soils. *Microbes and Environments* 25(1):8−14.

Jiang, S.C., W. Chu, B.H. Olson, J. He, S. Choi, J. Zhang, J.Y. Le, and P.B. Gedalanga. 2007. Microbial Source Tracking in a Small Southern California Urban Watershed Indicates Wild Animals and Growth as the Source of Fecal Bacteria*. Applied Microbiology and Biotechnology* 76 (4): 927–34

Lenhart, C., B. Gordon, J. Peterson, W. Eshenaur, L. Gifford, B. Wilson, J. Stamper, L. Krider, and N. Utt. 2017. *Agricultural BMP Handbook for Minnesota, 2nd Edition*. St. Paul, MN: Minnesota Department of Agriculture.

Marino, R.P, and J.J. Gannon. 1991. Survival of Fecal Coliforms and Fecal Streptococci in Storm Drain Sediments. *Water Research* 25(9):1089–1098.

Metcalf and Eddy. 1991. *Wastewater Engineering: Treatment, Disposal, Reuse*. 3rd ed. McGraw-Hill, Inc., New York.

Mille Lacs SWCD (Soil and Water Conservation District) and the Mille Lacs County Local Water Planning Advisory Committee. 2012. *Mille Lacs County Local Water Resource Management Plan January 1, 2006 – December 31, 2016, 2012 Amendments*. Available at: https://www.millelacsswcd.org/

Minnesota Stormwater Manual contributors. 2018. "Construction activity by county," *Minnesota Stormwater Manual*, https://stormwater.pca.state.mn.us/index.php?title=Construction_activity_by_county&oldid=22583 (accessed September 25, 2018).

Minnesota Stormwater Manual contributors. 2019. "Green Infrastructure for stormwater management," *Minnesota Stormwater Manual,* https://stormwater.pca.state.mn.us/index.php?title=Green_Infrastructure_for_stormwater_management

Morrison County. 2016. *Morrison County Comprehensive Land Use Plan 2016–2036.* Morrison County, MN.

Morrison SWCD (Soil and Water Conservation District). 2017. *Morrison County Five Year Focus Plan, Comprehensive Local Water Plan 2017–2022.* Available at: http://morrisonswcd.org

MPCA (Minnesota Pollution Control Agency). 2005. *Minnesota Lake Water Quality Assessment Report: Developing Nutrient Criteria, 3rd Edition*. September 2005

MPCA (Minnesota Pollution Control Agency). 2007a. *Minnesota Statewide Mercury Total Maximum Daily Load*. Document #wq-iw4-01b.

MPCA (Minnesota Pollution Control Agency). 2007b. *Statement of Need and Reasonableness, Book III of III: In the Matter of Proposed Revisions of Minnesota Rules Chapter 7050, Relating to the Classification and Standards for Waters of the State; The Proposed Addition of a New Rule, Minnesota Rules Chapter 7053, Relating to Point and Nonpoint Source Treatment Requirements; and The Repeal of Minn. R. Chapters 7056 and 7065*. July 2007.

MPCA (Minnesota Pollution Control Agency). 2011a. *Guidance on What Discharges Should be Included in the TMDL Wasteload Allocation for MS4 Stormwater.* Document number wq-strm7-37a.

MPCA (Minnesota Pollution Control Agency). 2011b. *Recommendations and Planning for Statewide Inventories, Inspections of Subsurface Sewage Treatment Systems.* Document number lrwq-wwists-1sy11.

MPCA (Minnesota Pollution Control Agency). 2012. *Zumbro Watershed Total Maximum Daily Loads for Turbidity Impairments*. Document number wq-iw9-13e.

MPCA (Minnesota Pollution Control Agency). 2014a. *Upper Mississippi River Bacteria TMDL Study & Protection Plan*. Prepared by Emmons & Olivier Resources, Inc. for the Minnesota Pollution Control Agency and the Minnesota Department of Health. Document #wq-iw8-08e.

MPCA (Minnesota Pollution Control Agency). 2014b. *The Minnesota Nutrient Reduction Strategy*. St. Paul, MN. Document number wq-s1-80.

MPCA (Minnesota Pollution Control Agency). 2015. *Prioritization Plan for Minnesota 303(d) Listings to Total Maximum Daily Loads*. September 2015.

MPCA (Minnesota Pollution Control Agency). 2017. *Livestock and the Environment MPCA Feedlot Program Overview.* Document number wq-f1-01. November 2017.

MPCA (Minnesota Pollution Control Agency). 2018. Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 305(b) Report and 303(d) List. Available at: https://www.pca.state.mn.us/sites/default/files/wq-iw1-04j.pdf. March 2018.

MPCA (Minnesota Pollution Control Agency). 2019a. *Mississippi River–Sartell Monitoring and Assessment Report.* Document number wq-ws3-07010201b. May 2019.

MPCA (Minnesota Pollution Control Agency). 2019b. *Mississippi River–Sartell Stressor Identification.* Document number wq-xxx.

MPCA (Minnesota Pollution Control Agency). 2019c. *Water Quality and Bacteria Frequently Asked Questions*. Minnesota Pollution Control Agency. January 2019. Document number wq-s1-93.

Municipal Development Group, Inc. 2005. *St. Stephen Comprehensive Plan.*

Nelson, P., M.A. Davenport, and T. Kuphal. 2017. *Inspiring Action for Nonpoint Source Pollution Control: A Manual for Water Resource Protection.* Freshwater Society, Saint Paul, MN. https://freshwater.org/wp-content/uploads/2017/03/InspiringAction.pdf.

NRCS (Natural Resources Conservation Service). n.d. *Rapid Watershed Assessment Resource Profile Platte-Spunk (MN) HUC: 7010201.* Retrieved September 26, 2018 from https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_022050.pdf.

RESPEC. 2015. Two Rivers Targeted Conservation Practice Plan. Prepared for Stearns County Soil and Water Conservation District, Waite Park, MN. Topical Report RSI-2492. March 2015.

RESPEC. 2017. *Documentation of the Best Management Practice Database Available in the Scenario Application Manager.* Draft Topical Report RSI-2742. Prepared for the Minnesota Pollution Control Agency, Saint Paul, MN. October 2017.

RMB Environmental Laboratories, Inc. 2013. *Platte Lake Lake Water Quality*. Report available from the Crow Wing County website.

Sadowsky, M., S. Matteson, M. Hamilton, and R. Chandrasekaran. n.d. *Growth, Survival, and Genetic Structure of E. Coli Found in Ditch Sediments and Water at the Seven Mile Creek Watershed, 2008-2010*. Project report to Minnesota Department of Agriculture.

Stearns County. 2008. 2030 *Stearns County Comprehensive Plan*. Stearns County, MN.

Stearns County Environmental Services. 2017. *Stearns County Local Water Management Plan Amendment*. Addendum added September 19, 2017.

Tetra Tech. 2017. *Mississippi River–Sartell Watershed Communication Plan*. Prepared for Morrison Soil and Water Conservation District and Minnesota Pollution Control Agency.

Tetra Tech. 2019. *Upper Mississippi–Sartell Watershed HSPF Model Recalibration.* Memorandum to Chuck Regan and Mark Evenson, MPCA, from Michelle Schmidt and Jon Butcher. May 28, 2019.

Walker, W.W. 1987. *Empirical methods for predicting eutrophication in impoundments*. Report 4, Applications manual, Tech. Rep. E-81-9. Prepared for U.S. Army Corps of Engineers Waterways Exp. Sta. Vicksburg, MS.

Williams, B, R. Szaro, and C. Shapiro. 2009. *Adaptive Management: The U.S. Department of the Interior Technical Guide.* Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC.

Wu, J., P. Rees, and S. Dorner. 2011. Variability of *E. Coli* Density and Sources in an Urban Watershed. *Journal of Water and Health* 9 (1): 94.

Zeckoski, R., B. Benham, S. Shah, M. Wolfe, K. Branna, M. Al-Smadi, T. Dillaha, S. Mostaghimi, and D. Heatwole. 2005. BLSC: A Tool for Bacteria Source Characterization for Watershed Management. *Applied Engineering in Agriculture*. 21(5): 879-889.

Appendix A. Aquatic life impairment listings not addressed in this TMDL report

Table 75. Aquatic life impairment listings not addressed in this TMDL report.

HUC10 Watershed	Reach Name	AUID (07010201-xxx) or Lake ID	Designated Use	Basis for Aquatic Life Listing			Non-Pollutant Stressor(s)?	No Water Quality Standard for Identified Stressor(s)	Proposed Category	Notes
				MIBI Exceed Criteria?	FIBI Exceed Criteria?	DO Violates Criteria?				
Two River	South Two River (Schwinghammer Lk to Two River Lk)	532	AQL			Yes			5	Insufficient information to determine if low dissolved oxygen is linked to a pollutant. TMDL deferred.
	Two Rivers Lake	73-0138-00	AQL		Yes				5	Stressor(s) not yet identified; TMDL deferred.
	South Two River (River St. to Two R.)	643	AQL		Yes		Lack of habitat		4c	Non-pollutant stressor.
City of Sartell–Mississippi River	Hazel Creek (Unnamed ditch to Mississippi R)	569	AQL		Yes		Longitudinal connectivity Streamflow alteration		4c	Non-pollutant stressors.
Spunk Creek	Clear Lake	73-0172-00	AQL		Yes				5	Stressor(s) not yet identified; TMDL deferred.
Platte River	Unnamed Creek (Unnamed cr to Platte R)	634	AQL		Yes		Longitudinal connectivity Low dissolved oxygen		4c	Non-pollutant stressors.
	Big Mink Creek (235th Ave to Platte R)	647	AQL	Yes			Lack of habitat		5	Low dissolved oxygen is also a stressor, and phosphorus is an inconclusive, although suspected, cause of low dissolved oxygen. TMDL deferred.
	Little Mink Creek (-94.119 46.014 to Platte R)	645	AQL	Yes			Lack of habitat		5	Low dissolved oxygen is also a stressor. The most likely causes are oxygen-demanding substances, but data are inconclusive. TMDL deferred.
	Platte River (Headwaters (Platte Lk 18-0088-00) to Skunk R)	507	AQL		Yes		Longitudinal connectivity Lack of habitat		4c	Non-pollutant stressors.
	Unnamed Creek (-94.26 46.016 to Unnamed Cr)	651	AQL		Yes		Streamflow alteration Lack of habbitat		4c	Non-pollutant stressors.
	Rice Creek (Pelkey Lk to Rice Lk)	618	AQL	Yes			Low dissolved oxygen		4c	Non-pollutant stressor.
Little Rock Creek	Little Rock Creek (T39 R30W S22, south line to T38 R31W S23, west line)	652	AQL		Yes		Streamflow alteration, lack of habitat		4c	Non-pollutant stressors.

HUC10 Watershed	Reach Name	AUID (07010201-xxx) or Lake ID	Designated Use	Basis for Aquatic Life Listing			Non-Pollutant Stressor(s)?	No Water Quality Standard for Identified Stressor(s)	Proposed Category	Notes
				MIBI Exceed Criteria?	FIBI Exceed Criteria?	DO Violates Criteria?				
	Bunker Hill Creek (T38 R30W S6, north line to Little Rock Cr)	511	AQL	Yes	Yes		Temperature, longitudinal connectivity, streamflow alteration, lack of habitat	NOx toxicity	**5**	Approved nitrate TMDL for drinking water use. However, because there is not yet a numeric standard for nitrate toxicity to aquatic life, this TMDL is deferred.
	Little Rock Creek (T39 R31W S22, east line to T38 R31W S28, east line)	653	AQL	Yes	Yes		Temperature, longitudinal connectivity, streamflow alteration, lack of habitat		**4A**	Low dissolved oxygen is also a stressor. The oxygen demand TMDL for former AUID 07010201-548 Little Rock Creek (T39 R30W S22, south line to T38 R31W S28, east line) addresses the low DO stressor (Benton SWCD 2015).
	Zuleger Creek (Unnamed cr. to Unnamed cr.)	539	AQL	Yes	Yes		Longitudinal connectivity, streamflow alteration, lack of habitat		**4c**	Non-pollutant stressors.
	Watab River, South Fork (Little Watab Lk to Watab R)	554	AQL		Yes		Longitudinal connectivity, lack of habitat		**4c**	Non-pollutant stressors.
	County Ditch 13 (Bakers Lk to Watab R)	564	AQL			Yes			**5**	Insufficient information to determine if low dissolved oxygen is linked to a pollutant. TMDL deferred.
Watab River	Watab River (Rossier Lk to Mississippi R)	528	AQL		Yes		Streamflow alteration, lack of habitat		**4c**	Non-pollutant stressors.

Appendix B. Lake Modeling Documentation

Two Rivers Lake (73-0138-00)

Benchmark model

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.732	0.2
Evaporation (m)	0.732	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	27	0.50
Total N	0	0.50
Ortho P	0	0.50
Inorganic N	0	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	1	2ND ORDER, AVAIL P
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	TwoRivers	0	1	2.36	6.4	3.69	5.4	0.12	0	0	0	0.08	0	0	0	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	63.8	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Watershed	1	1	152.78	30.7	0	0	0	225.55	0	0	0	0	0	0	0
2	Septics	1	3	0	0.03193	0	0	0	2843.208	0	0	0	0	0	0	0
3	AlbanyWWTP	1	3	0	0.477	0	0	0	285	0	0	0	0	0	0	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.015	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

Segment Mass Balance Based Upon Predicted Concentrations

Component: TOTAL P **Segment:** 1 TwoRivers

Trib	Type	Location	Flow hm³/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m³
1	1	Watershed	30.700	93.2%	6924.4	96.0%	226
2	3	Septics	0.032	0.1%	90.8	1.3%	2843
3	3	AlbanyWWTP	0.477	1.4%	135.9	1.9%	285
PRECIPITATION			1.728	5.2%	63.7	0.9%	37
TRIBUTARY INFLOW			30.700	93.2%	6924.4	96.0%	226
POINT-SOURCE INFLOW			0.509	1.5%	226.7	3.1%	446
***TOTAL INFLOW			32.936	100.0%	7214.8	100.0%	219
ADVECTIVE OUTFLOW			31.209	94.8%	1993.2	27.6%	64
***TOTAL OUTFLOW			31.209	94.8%	1993.2	27.6%	64
***EVAPORATION			1.728	5.2%	0.0	0.0%	
***RETENTION			0.000	0.0%	5221.6	72.4%	

Hyd. Residence Time =	0.4840	yrs
Overflow Rate =	13.2	m/yr
Mean Depth =	6.4	m

TMDL Scenario

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.732	0.2
Evaporation (m)	0.732	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km²-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	27	0.50
Total N	0	0.50
Ortho P	0	0.50
Inorganic N	0	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	1	2ND ORDER, AVAIL P
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m⁻¹)		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km²	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	TwoRivers	0	1	2.36	6.4	3.69	5.4	0.12	0	0	0	0.08	0	0	0	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	63.8	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm³/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km²	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Watershed	1	1	152.78	30.7	0	0	0	95	0	0	0	0	0	0	0
2	Septics	1	3	0	0.03193	0	0	0	1250	0	0	0	0	0	0	0
3	AlbanyWWTP	1	3	0	0.763	0	0	0	360	0	0	0	0	0	0	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.015	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

Segment Mass Balance Based Upon Predicted Concentrations

Component: TOTAL P **Segment: 1 TwoRivers**

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
1	1	Watershed	30.700	92.4%	2916.5	88.5%	95
2	3	Septics	0.032	0.1%	39.9	1.2%	1250
3	3	AlbanyWWTP	0.763	2.3%	274.7	8.3%	360
PRECIPITATION			1.728	5.2%	63.7	1.9%	37
TRIBUTARY INFLOW			30.700	92.4%	2916.5	88.5%	95
POINT-SOURCE INFLOW			0.795	2.4%	314.6	9.5%	396
***TOTAL INFLOW			33.222	100.0%	3294.8	100.0%	99
ADVECTIVE OUTFLOW			31.495	94.8%	1254.5	38.1%	40
***TOTAL OUTFLOW			31.495	94.8%	1254.5	38.1%	40
***EVAPORATION			1.728	5.2%	0.0	0.0%	
***RETENTION			0.000	0.0%	2040.3	61.9%	

Hyd. Residence Time =	0.4796	yrs
Overflow Rate =	13.3	m/yr
Mean Depth =	6.4	m

Platte Lake (18-0088-00)

Benchmark model

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.781	0.2
Evaporation (m)	0.781	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	27	0.50
Total N	0	0.50
Ortho P	0	0.50
Inorganic N	0	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	8	CANF & BACH, LAKES
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Platte	0	1	6.72	2.44	3.24	2.44	0.12	0	0	0	0.08	0	0	0.04	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	48	0.12	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Watershed	1	1	85.63	16.8	0	0	0	92.8	0	0	0	0	0	0	0
2	Septics	1	3	0	0.02988	0	0	0	2727.787	0	0	0	0	0	0	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.015	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

Segment Mass Balance Based Upon Predicted Concentrations

Component: TOTAL P **Segment: 1 Platte**

Trib	Type	Location	Flow hm³/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m³
1	1	Watershed	16.800	76.1%	1559.0	81.2%	93
2	3	Septics	0.030	0.1%	81.5	4.2%	2728
PRECIPITATION			5.248	23.8%	181.4	9.4%	35
INTERNAL LOAD			0.000	0.0%	98.2	5.1%	
TRIBUTARY INFLOW			16.800	76.1%	1559.0	81.2%	93
POINT-SOURCE INFLOW			0.030	0.1%	81.5	4.2%	2728
***TOTAL INFLOW			22.078	100.0%	1920.2	100.0%	87
ADVECTIVE OUTFLOW			16.830	76.2%	800.6	41.7%	48
***TOTAL OUTFLOW			16.830	76.2%	800.6	41.7%	48
***EVAPORATION			5.248	23.8%	0.0	0.0%	
***RETENTION			0.000	0.0%	1119.5	58.3%	

Hyd. Residence Time =	0.9743	yrs
Overflow Rate =	2.5	m/yr
Mean Depth =	2.4	m

TMDL Scenario

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.781	0.2
Evaporation (m)	0.781	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km²-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	27	0.50
Total N	0	0.50
Ortho P	0	0.50
Inorganic N	0	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	8	CANF & BACH, LAKES
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m⁻¹)		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km²	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Platte	0	1	6.72	2.44	3.24	2.44	0.12	0	0	0	0.08	0	0	0.02	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	48	0.12	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm³/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km²	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Watershed	1	1	85.63	16.8	0	0	0	46.4	0	0	0	0	0	0	0
2	Septics	1	3	0	0.02988	0	0	0	1250	0	0	0	0	0	0	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.015	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

Segment Mass Balance Based Upon Predicted Concentrations

Component: TOTAL P **Segment: 1 Platte**

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
1	1	Watershed	16.800	76.1%	779.5	74.4%	46
2	3	Septics	0.030	0.1%	37.3	3.6%	1250
PRECIPITATION			5.248	23.8%	181.4	17.3%	35
INTERNAL LOAD			0.000	0.0%	49.1	4.7%	
TRIBUTARY INFLOW			16.800	76.1%	779.5	74.4%	46
POINT-SOURCE INFLOW			0.030	0.1%	37.3	3.6%	1250
***TOTAL INFLOW			22.078	100.0%	1047.4	100.0%	47
ADVECTIVE OUTFLOW			16.830	76.2%	508.6	48.6%	30
***TOTAL OUTFLOW			16.830	76.2%	508.6	48.6%	30
***EVAPORATION			5.248	23.8%	0.0	0.0%	
***RETENTION			0.000	0.0%	538.8	51.4%	