Minnesota River – Mankato Watershed Total Maximum Daily Load Study

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MINNESOTA POLLUTION CONTROL AGENCY

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Abbreviations

1W1P	One Watershed, One Plan
AFO	animal feeding operation
AU	animal unit
AGREETT	Agriculture Research, Education and Extension Technology Transfer Program
AUID	assessment unit ID
AWWDF	average wet weather design flow
BMP	best management practice
BWSR	Board of Water and Soil Resources
CAFO	concentrated animal feeding operation
chl-*a*	chlorophyll-*a*
CWA	Clean Water Act
DEM	digital elevation model
DMR	discharge monitoring report
DNR	Minnesota Department of Natural Resources
E. coli	*Escherichia coli*
EQuIS	Environmental Quality Information System
GIS	geographic information systems
HSPF	Hydrologic Simulation Program–Fortran
HUC	hydrologic unit code
IPHT	imminent public health threat
LA	load allocation
m	meters
mg/L	milligrams per liter
mL	milliliter
MnDOT	Minnesota Department of Transportation
MOS	margin of safety
MPCA	Minnesota Pollution Control Agency
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System

NRCS	Natural Resources Conservation Service
org/100 mL	organisms per 100 milliliters
SDS	State Disposal System
SIETF	Subsurface Sewage Treatment Systems Implementation and Enforcement Task Force
SSTS	subsurface sewage treatment system
SWCD	soil and water conservation district
SWPPP	Stormwater Pollution Prevention Program
TMDL	total maximum daily load
TP	total phosphorus
TSS	total suspended solids
EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WASCOB	water and sediment control basin
WLA	wasteload allocation
WPLMN	Watershed Pollutant Load Monitoring Network
WRAPS	watershed restoration and protection strategy
WWTP	wastewater treatment plant

Executive Summary

The 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. 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 stream and lake impairments in the Minnesota River–Mankato Watershed in south-central Minnesota. The causes of impairment in the watershed include high levels of *Escherichia coli* (*E. coli*), total suspended solids (TSS), nitrate, and total phosphorus (TP), affecting aquatic life, aquatic recreation, drinking water, and limited resource value designated uses. Forty-three stream TMDLs and eight lake TMDLs are provided: 34 *E. coli* TMDLs, 6 TSS TMDLs, 3 nitrate TMDLs, and 8 phosphorus lake TMDLs.

Land cover in the Minnesota River–Mankato Watershed is predominantly agricultural with the dominant crops being corn and soybeans; other crops include sugar beets and dry beans. Artificial drainage is common. Urban land use is the second major land use and is centralized near the city of Mankato and surrounding suburbs near the Minnesota River.

Potential sources of pollutants include watershed runoff (both regulated and unregulated), near-channel sources (e.g., bank failures and channel erosion), municipal and industrial wastewater, septic systems and untreated wastewater, livestock, atmospheric deposition, lake internal loading, and wildlife. High priority pollutant sources include human sources such as: septic systems with imminent threats to public health and safety (IPHTS); agricultural sources such as livestock, runoff from cropland, agricultural drainage, and agricultural groundwater; near channel erosion; and internal lake phosphorus loading.

The pollutant load capacity of the impaired streams was determined through the use of load duration curves for *E. coli*, TSS, and nitrate. 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 nutrient loading capacity for each 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. A 10% explicit margin of safety (MOS) was incorporated into all TMDLs to account for uncertainty. The estimated percent reductions needed to meet the TMDLs range from 12% to 96%.

The implementation strategy section highlights an adaptive management process to achieving water quality standards and restoring beneficial uses. Implementation strategies include: septic system upgrades, replacement, and maintenance; agricultural best management practices (BMP; e.g., filter strips, riparian buffers, drainage water management, and conservation cover); stream restoration; lake internal load management; and education and outreach. Public participation included meetings with watershed stakeholders to present watershed data. The TMDL study is supported by previous work including the *Minnesota River–Mankato Watershed Monitoring and Assessment Report* (MPCA 2016), *Minnesota River–Mankato Watershed Characterization Report* (DNR 2016), and the Minnesota River Watershed hydrology and water quality model (Tetra Tech 2015, Tetra Tech 2016). The farming community has been and continues to be a vital partner to conservation efforts in the Minnesota River Basin. Reducing sediment and nutrient impacts on water resources is important to Minnesota farmers who innovate new practices to improve the sustainability of their farms. Continued support from the

State, local governments, and farm organizations will be critical to finding and implementing solutions that work for individual farmers and help achieve the goal of clean water.

1. Project Overview

1.1 Purpose

The CWA and United States Environmental Protection Agency (EPA) regulations require that TMDLs be developed for waters that do not support their designated uses. In simple terms, a TMDL study determines what is needed in terms of pollution reductions 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 8 eutrophication (phosphorus), 34 *E. coli*, 6 TSS, and 3 nitrate impairments within the Minnesota River–Mankato Watershed (United States Geological Survey [USGS] Hydrologic Unit Code [HUC] 8 07020007). The project area covers the 1,347-square mile watershed in south-central Minnesota (Figure 1). This TMDL report addresses tributaries to the Minnesota River; *E. coli* and TSS TMDLs for the Minnesota River main stem reaches in this watershed are addressed in other reports.

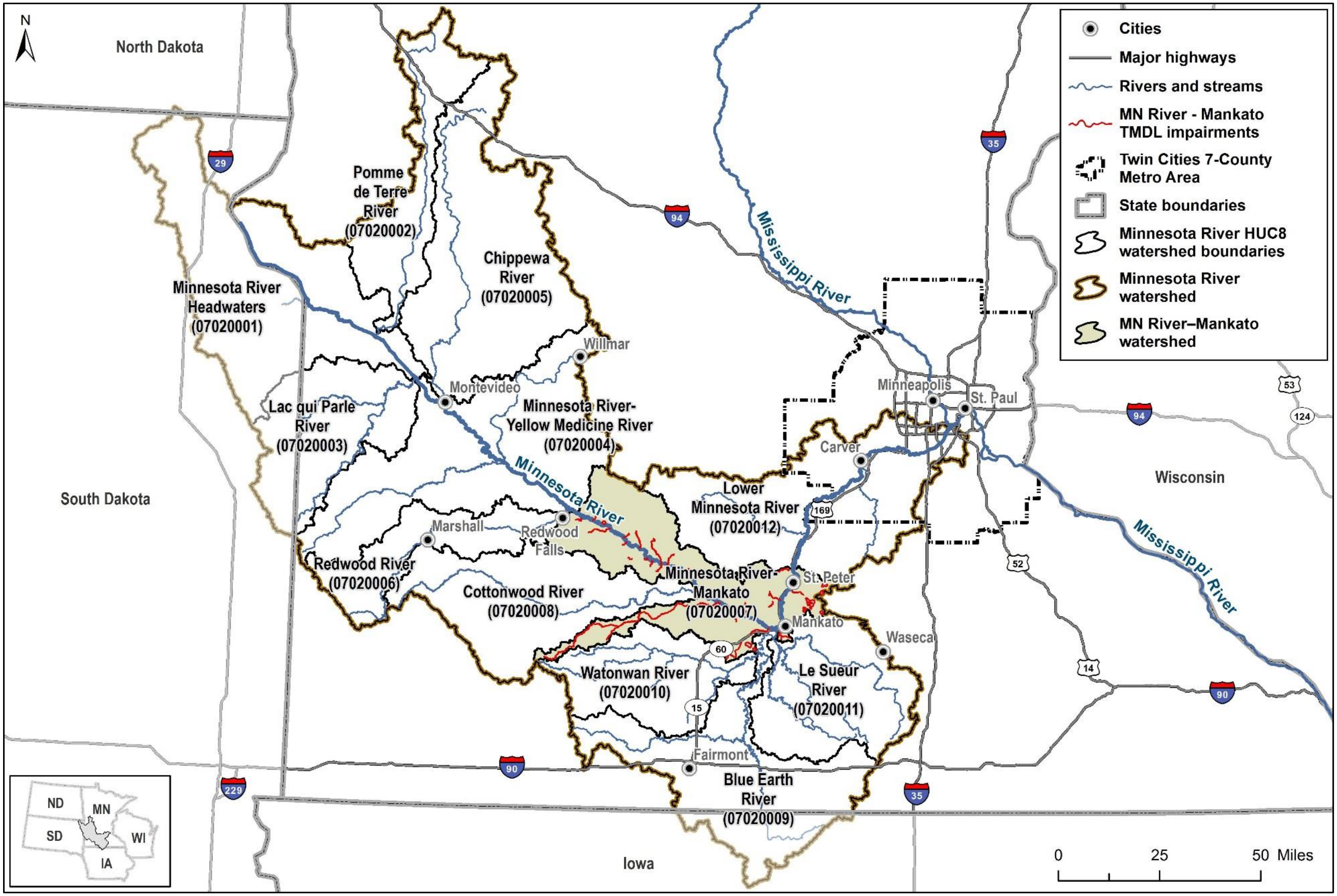


Figure 1. Minnesota River–Mankato Watershed.

1.2 Identification of Waterbodies

The Minnesota River–Mankato TMDL Report addresses 8 impaired lakes (Table 1) and 35 impaired stream reaches, or assessment units (Table 2). The lakes have aquatic recreation impairments as identified by eutrophication indicators, and the stream impairments affect aquatic life, aquatic recreation, drinking water, and/or limited resource value designated uses based on high levels of pathogens (fecal coliform or *E. coli*), turbidity or TSS, and/or nitrate. Aquatic consumption (fish tissue) impairments are not addressed in this report and therefore are not presented in Table 1 or Table 2. Impaired waterbodies are shown in Figure 3 and Figure 4. The MPCA includes any waters of the state that are impaired on the state's impaired waters list (MPCA 2018), including waters that border Indian reservations. None of the impairments addressed in this report are partially or wholly within the boundary of Native American tribal lands. The Lower Sioux Indian Community does have tribal land within the Minnesota River – Mankato Watershed (Figure 2). This land is adjacent to the Minnesota River mainstem (070200007-720) and as such does not constitute any of the watershed areas contributing to impairments in this TMDL study. This TMDL does not allocate pollutant load to any federally recognized Native American tribe.

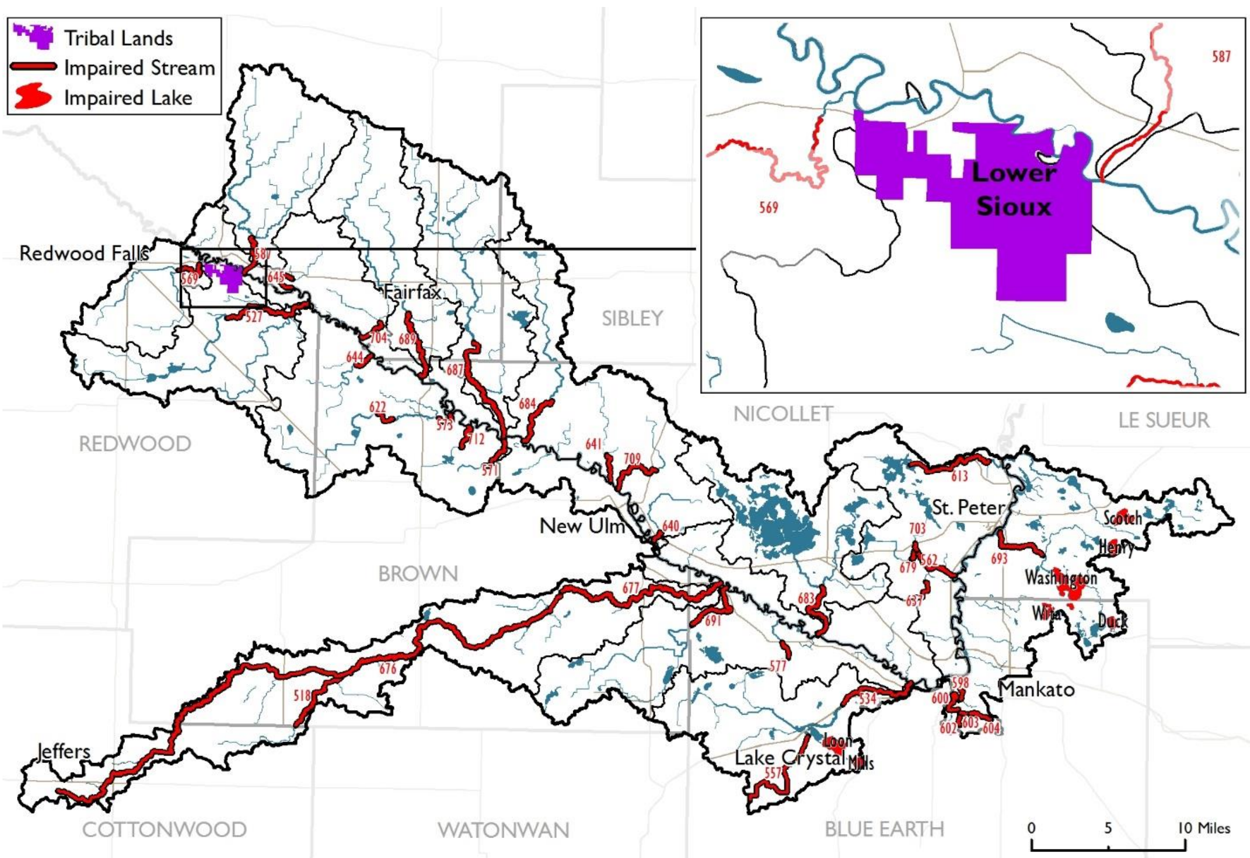


Figure 2. Map of Native American tribal lands within the Minnesota River - Mankato Watershed.

For this report, the impairments were divided into watershed groups and listed in tables ordered from upstream to downstream. All stream assessment unit identifications (AUIDs) for streams begin with 07020007, 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 07020007-569 is referred to as reach 569.

Table 1. Impaired lakes in the Minnesota River–Mankato Watershed
All lakes have aquatic recreation impairments as identified by eutrophication indicators.

Watershed Group	Lake Name	Lake ID	Use Class	Lake Type	Ecoregion	Year Listed
Little Cottonwood River–Nicollet	Mills	07-0097-00	2B	Shallow Lake	Western Corn Belt Plains	2016
	Loon	07-0096-00	2B	Shallow Lake		2010
Mankato–St. Peter	Wita	07-0077-00	2B	Shallow Lake	North Central Hardwood Forests	2016
	Duck	07-0053-00	2B	Lake		2008
	George	07-0047-00	2B	Lake		2016
	Washington	40-0117-00	2B	Lake		2008
	Henry	40-0104-00	2B	Shallow Lake		2016
	Scotch	40-0109-00	2B	Shallow Lake		2016

Table 2. Stream reach impairments in the Minnesota River–Mankato Watershed (HUC-8 07020007)

Watershed Group	Stream Name	Description	Assessment Unit ID (AUID) [a]	Use Class [b]	Affected Designated Use	Year listed for impairment(s)		
						E. coli/ Fecal Coliform [c]	TSS/ Turbidity [d]	Nitrate
Minnesota River–New Ulm	Crow Creek	CD 52 to T112 R35W S2, north line	569	2Bg	Aquatic Recreation	2016		
	Birch Coulee Creek	JD 12 to Minnesota R	587	2Bg	Aquatic Recreation	2016		
	Purgatory Creek	Unnamed cr to Minnesota R	645	2Bg	Aquatic Recreation	2016		
	Wabasha Creek	T112 R34W S19, west line to Minnesota R	527	2Bg	Aquatic Recreation	2016		
	Three-Mile Creek	CD 140 to Minnesota R	704	2Bg	Aquatic Recreation	2016		
	Unnamed creek	Unnamed cr to Minnesota R	644	2Bg	Aquatic Recreation	2016		
	Fort Ridgley Creek	T112 R33W S24, north line to Minnesota R	689	2Bg	Aquatic Recreation	2016		
	Spring Creek (Judicial Ditch 29)	T111 R33W S23, west line to T111 R33W S23, east line	622	2Bg	Aquatic Recreation	2016		
	Spring Creek	T111 R32W S21, west line to Minnesota R	573	2Bg	Aquatic Recreation	2016		
	County Ditch 13	245th Ave to Minnesota R	712	2Bg	Aquatic Recreation	2016		
	County Ditch 10 (John's Creek)	T110 R32W S1, west line to Minnesota R	571	1B, 2Ag	Aquatic Recreation and Drinking Water	2016		2012
	Little Rock Creek (Judicial Ditch 31)	Mud Lk to Minnesota R	687	2Bg	Aquatic Recreation	2016		
	Eight-Mile Creek	366th St/T-39 to Minnesota R	684	2Bg	Aquatic Recreation	2016		
	Huelskamp Creek	Unnamed cr to Minnesota R	641	2Bg	Aquatic Recreation	2016		
	Fritsche Creek (County Ditch 77)	-94.4172 44.3557 to Minnesota R	709	2Bg	Aquatic Recreation	2016		
	Heyman's Creek	Unnamed cr to Minnesota R	640	2Bg	Aquatic Recreation	2016		
Little Cottonwood River–Nicollet	Altermatts Creek	T108 R34W S35, south line to Little Cottonwood R	518	7	Limited Resource Value	2016		
	Little Cottonwood River	Headwaters to T109 R31W S22, north line	676	2Bg	Aquatic Recreation and Aquatic Life	2006	2006	
	Little Cottonwood River	T109 R31W S15, south line to Minnesota R	677	2Bg	Aquatic Recreation and Aquatic Life	2006	2006	
	Morgan Creek	T109 R29W S30, south line to Minnesota R	691	2Bg	Aquatic Recreation	2016		

Watershed Group	Stream Name	Description	Assessment Unit ID (AUID) [a]	Use Class [b]	Affected Designated Use	Year listed for impairment(s)		
						E. coli/ Fecal Coliform [c]	TSS/ Turbidity [d]	Nitrate
	Unnamed creek	T108 R28W S6, south line to T108 R28W S6, north line	577	1B, 2Ag	Drinking Water			2016
	Swan Lake Outlet (Nicollet Creek)	CD 39 to Minnesota R	683	2Bg	Aquatic Recreation	2016		
	County Ditch 56 (Lake Crystal Inlet)	Headwaters to Lk Crystal	557	2Bm	Aquatic Recreation	2010		
	Minneopa Creek	T108 R28W S23, south line to Minnesota R	534	2Bg	Aquatic Recreation and Aquatic Life	2016	2006	
Mankato–St. Peter	Unnamed creek	Headwaters to Unnamed cr	604	2Bg	Aquatic Recreation	2008		
	Unnamed creek	Unnamed cr to Unnamed cr	603	2Bg	Aquatic Recreation	2008		
	Unnamed creek	Headwaters to Unnamed cr	602	2Bg	Aquatic Recreation	2008		
	Unnamed creek	Unnamed cr to Unnamed cr	600	2Bg	Aquatic Recreation	2008		
	Unnamed ditch	Unnamed cr to underground pipe	598	2Bg	Aquatic Recreation	2008		
	County Ditch 46A	-94.0803 44.2762 to Seven-Mile Cr	679	2Bg	Aquatic Recreation and Aquatic Life	2006	2006	
	Seven-Mile Creek	MN Hwy 99 to CD 46A	703	2Bg	Aquatic Recreation and Aquatic Life	2006	2006	
	Unnamed creek (Seven-Mile Creek Tributary)	Headwaters to T109 R27W S15, north line	637	2Bg	Aquatic Recreation	2010		
	Seven-Mile Creek	T109 R27W S4, north line to Minnesota R	562	1B, 2Ag	Aquatic Recreation, Aquatic Life, and Drinking Water	2006	2010	2006
	Shanaska Creek	Shanaska Cr Rd to Minnesota R	693	2Bg	Aquatic Recreation	2016		
	Rogers Creek (County Ditch 78)	CD 21 to Unnamed cr	613	2Bg	Aquatic Recreation	2016		

a. The AUIDs begin with 07020007; the values in this column are the last 3 digits of the AUID.
b. 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); 2Bm: aquatic life and recreation—modified warm water habitat (streams); 7: limited resource value water.
c. *E. coli* / fecal coliform impairments listed in 2008 and earlier are fecal coliform impairments. Listings from 2010 and later are *E. coli* impairments.
d. TSS / turbidity impairments listed in 2014 and earlier are turbidity impairments. 2016 and 2018 listings are TSS impairments.

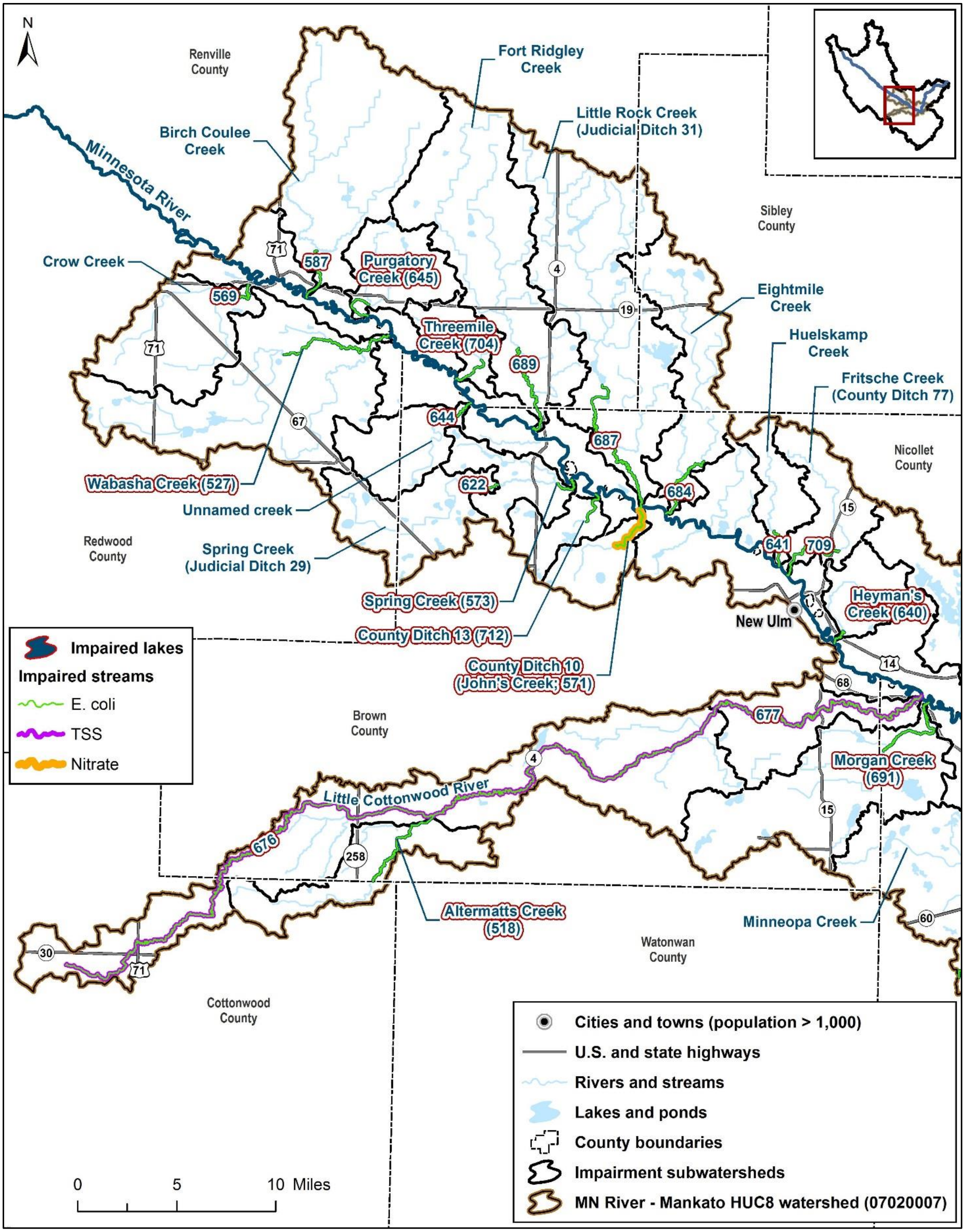


Figure 3. Impairments in the upstream reaches of the Minnesota River–Mankato Watershed.

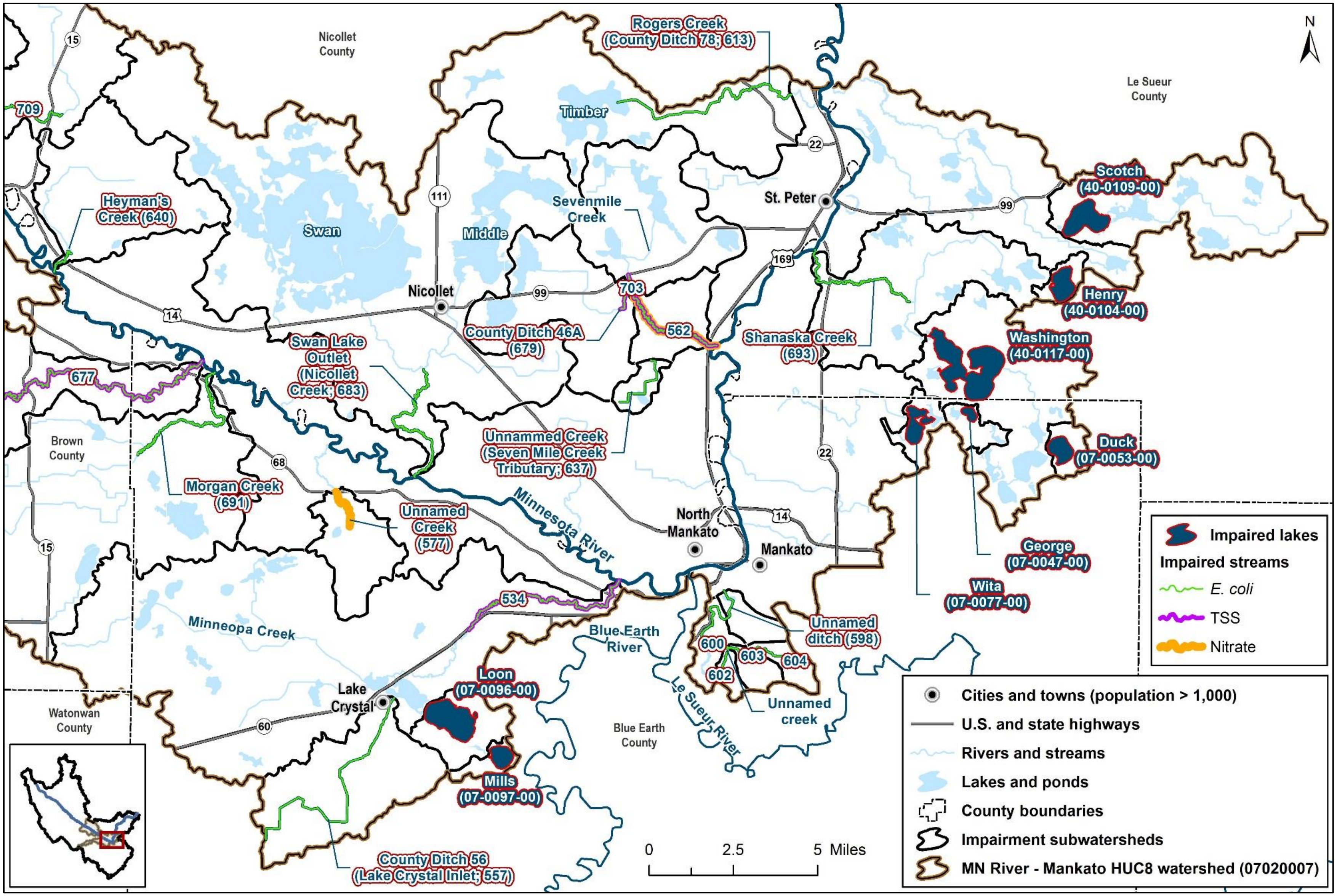


Figure 4. Impairments in the downstream reaches of the Minnesota River–Mankato Watershed.

1.3 Priority Ranking

The Minnesota Pollution Control Agency's (MPCA's) schedule for TMDL completions, as indicated on the 303(d) impaired waters list, reflects Minnesota's priority ranking of this TMDL. The MPCA has aligned TMDL priorities with the watershed approach and the watershed restoration and protection strategies (WRAPS) cycle. The MPCA developed a state plan Minnesota's TMDL Priority Framework Report to meet the needs of EPA's national measure (WQ-27) under EPA's Long-Term Vision for Assessment, Restoration and Protection under the CWA Section 303(d) Program. As part of these efforts, the MPCA identified water quality impaired segments that will be addressed by TMDLs by 2022. The Minnesota River–Mankato Watershed 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 antidegradation 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. 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, 2Bm, and/or 7 waters (Table 2). The three streams with nitrate impairments are designated coldwater streams, which are also protected as a source of drinking water (Minn. R. 7050.0222, subp. 2).

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, and the streams in this project fall into two categories—class 2Bg, which are general warm water habitat and class 2Bm, which are modified 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. The lakes addressed in this report are classified as class 2B waters (Table 1), which are protected for aquatic life and recreation.

2.2 Water Quality Standards

Water quality standards for class 1 waters are defined in Minn. R. 7050.0221, for class 2 waters are defined in Minn. R. 7050.0222, and for class 7 waters are defined in Minn. R. 7050.0227. Water quality standards for *E. coli*, TSS, nitrate, and eutrophication (phosphorus) are presented in able 3 and Table 4.

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 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 and 7 waters indicate 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 nitrate standard in streams indicate that a waterbody does not meet the drinking water standard. Exceedances of the TSS standard in streams indicate that a waterbody does not meet the aquatic life designated use. Exceedances of the eutrophication standard in lakes indicate that a waterbody does not meet the aquatic recreation designated use. The numeric water quality standards for these parameters (able 3 and Table 4), serve as targets for the applicable Minnesota River–Mankato TMDLs.

Minnesota River mainstem TSS TMDLs are in development at this time. Minnesota River mainstem *E. coli* TMDLs were completed in early 2019. The water quality standards applied to the Minnesota

River – Mankato Watershed TMDLs are the same as those applied to the Minnesota River TSS TMDLs and the Minnesota River Bacteria TMDLs (65 mg/L and 126 org/L respectively). Therefore, the loading capacities developed for the Minnesota River – Mankato Watershed TMDLs to achieve the stated standards will not violate downstream TMDL loading capacities.

The class 2B turbidity standard (Minn. R. ch. 7050.0222) that was in place at the time of the impairment assessment for many reaches in the project area was 25 NTUs. Impairment listings occurred when greater than 10% of data points collected within the previous 10-year period exceeded the 25 NTU standard (or equivalent values for TSS or the transparency tube). If sufficient turbidity data did not exist, transparency tube data were used to evaluate waters for turbidity impairments for the 2006 through 2014 303(d) lists of impaired waters. A transparency tube measurement less than 20 centimeters (cm) indicated a violation of the 25 NTU turbidity standard. A stream was considered impaired if more than 10% of the transparency tube measurements were less than 20 cm.

Due to weaknesses in the turbidity standards, the MPCA developed numeric TSS criteria to replace them. These TSS criteria are regional in scope and based on a combination of biotic sensitivity to the TSS concentrations and reference streams/least impacts streams as data allow. The results of the TSS criteria development were published by the MPCA in 2011. The new TSS standards were approved by EPA in January 2015. For the purpose of this TMDL report, the newly adopted 65 mg/L standard for class 2B waters is used to address the turbidity impairment listings in the Minnesota River – Mankato Watershed project area.

Chlorophyll-*a* (chl-*a*) and Secchi transparency standards must be met in lakes, in addition to meeting phosphorus limits. In developing the lake nutrient standards for Minnesota lakes (Minn. R. 7050), the MPCA evaluated data from a large cross-section of lakes within each of the state's ecoregions (MPCA 2005). Clear relationships were established between the causal factor TP and the response variables chl-*a* and Secchi transparency. Based on these relationships, it is expected that by meeting the phosphorus target in each lake, the chl-*a* and Secchi transparency standards (Table 4) will likewise be met.

able 3. Water quality standards for impaired streams

Parameter	Waterbody Type	Water Quality Standard	Numeric Standard/Target
E. coli	Class 2A and 2B streams	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 streams	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)
TSS	Class 2B streams in South River Nutrient Region	65 mg/L (milligrams per liter); TSS standards for class 2B may be exceeded for no more than 10% of the time. This standard applies April 1 through September 30.	≤ 65 mg/L
Nitrate	Class 1B streams	10 mg/L; 10mg/L is a federal safe drinking water standard and is incorporated by reference into Minnesota administrative rules (Minn. R.) chapter (ch.) 7050.0221.	≤ 10 mg/L

Table 4. Eutrophication standards for class 2B lakes, reservoirs, and shallow lakes

Parameter	Western Corn Belt Plains		North Central Hardwood Forests	
	Lakes and Reservoirs	Shallow Lakes	Lakes and Reservoirs	Shallow Lakes
Phosphorus, total (µg/L)	≤ 65	≤ 90	≤ 40	≤ 60
Chlorophyll-*a* (µg/L)	≤ 22	≤ 30	≤ 14	≤ 20
Secchi transparency (meters [m])	≥ 0.9	≥ 0.7	≥ 1.4	≥ 1.0

3. Watershed and Waterbody Characterization

The Minnesota River–Mankato Watershed is located in south central Minnesota. It covers around 862,000 and contains portions of Cottonwood, Brown, Redwood, Renville, Sibley, Nicollet, Blue Earth, and Le Sueur counties. The Minnesota River–Mankato Watershed consists of a portion of the mainstem Minnesota River and many small tributaries.

The watershed is located primarily in the Western Corn Belt Plains ecoregion, with the far eastern reaches stretching into the North Central Hardwood Forest ecoregion. There are about 1,564 stream miles in the Minnesota River–Mankato Watershed, and few large lakes, with only 6 exceeding 500 acres. The watershed is diverse in landscape, with flat cropland in the west and bluffs and lakes in the east. While the vast majority of the watershed is cropland, the city of Mankato is a regional urban center surrounded by several small cities along the main stem of the Minnesota River.

The *Minnesota River–Mankato Watershed Characterization Report* (DNR 2016) provides information on the bedrock and surficial geology, soils, land use, hydrology, connectivity, and geomorphology in the watershed.

3.1 Lakes

Impaired lakes range in surface area from 88 to 1,519 acres, with watershed area to surface area ratios from 2.4 to 17.9 (Table 5). The subwatershed area includes all drainage area to the impairment, including from upstream assessment units. The impaired lakes are shown in Figure 3 and Figure 4.

Table 5. Lake morphometry and watershed area

Watershed Group	Lake Name	Lake ID	Lake Type	Surface Area [a] (acres)	Mean Depth [b] (m)	Max Depth [b] (m)	Littoral Area [b] (% total area less than 15 feet deep, or 4.6 m)	Watershed Area [c] (incl. lake surface area; ac)	Watershed Area : Surface Area
Little Cottonwood River–Nicollet	Mills	07-0097-00	Shallow Lake	237	1.6	2.1	100%	774	3.3
	Loon [d]	07-0096-00	Shallow Lake	810	1.4	2.1	100%	3,693	4.6
Mankato–St. Peter	Wita	07-0077-00	Shallow Lake	338	1.2	1.8	100%	1,325	3.9
	Duck	07-0053-00	Lake	290	2.7	7.6	51%	1,018	3.5
	George	07-0047-00	Lake	88	2.8	8.5	35%	1,024	11.6
	Washington [e]	40-0117-00	Lake	1,519	3.4	12.5	66%	14,125	9.3
	Henry	40-0104-00	Shallow Lake	351	1.2	1.8	100%	838	2.4
	Scotch	40-0109-00	Shallow Lake	598	1.8	3.4	100%	10,694	17.9

a. Surface areas are from DNR's lake basin morphology shapefile except for Wita and Henry, which are from the MPCA's impaired waters shapefile.
b. Mean depth, maximum depth, and littoral areas are from the DNR's lake basin morphology shapefile. Mean depths for Wita and Henry are derived from the relationship between mean depth and maximum depth in the other impaired shallow lakes in this watershed and in the Minnesota River - Mankato Watershed.
c. See Section 3.3 for information on subwatershed boundaries.
d. The Loon Lake Watershed includes Mills Lake.
e. The Washington Lake Watershed includes George Lake and Duck Lake.

3.2 Streams

Subwatersheds that drain to impaired streams range from 501 to 108,297 acres (Table 6). The subwatershed area includes all drainage area to the impairment, including from upstream assessment units. The impairments are shown in Figure 3 and Figure 4**.**

Table 6. Watershed areas of impaired streams

Watershed Group	Reach Name	AUID	Watershed Area (acres) [a]
Minnesota River–New Ulm	Crow Creek	569	21,518
	Birch Coulee Creek	587	43,727
	Purgatory Creek	645	12,927
	Wabasha Creek	527	46,014
	Three-Mile Creek	704	7,636
	Unnamed creek	644	12,726
	Fort Ridgley Creek	689	44,785
	Spring Creek (Judicial Ditch 29)	622	18,324
	Spring Creek	573	28,506
	County Ditch 13	712	7,398
	County Ditch 10 (John's Creek)	571	8,481
	Little Rock Creek (Judicial Ditch 31)	687	53,937
	Eight-Mile Creek	684	23,631
	Huelskamp Creek	641	8147
	Fritsche Creek (County Ditch 77)	709	12,945
	Heyman's Creek	640	10,526
Little Cottonwood River–Nicollet	Altermatts Creek	518	16,781
	Little Cottonwood River	676	90,538
	Little Cottonwood River	677	108,297
	Morgan Creek	691	37,783
	Unnamed creek	577	3,976
	Swan Lake Outlet (Nicollet Creek)	683	50,537
	County Ditch 56 (Lake Crystal Inlet)	557	9,283
	Minneopa Creek	534	54,545
Mankato–St. Peter	Unnamed creek	604	977
	Unnamed creek	603	1,815
	Unnamed creek	602	501
	Unnamed creek	600	3,762
	Unnamed ditch	598	4,915
	County Ditch 46A	679	9,120
	Seven-Mile Creek	703	9,974
	Unnamed creek (Seven-Mile Creek Tributary)	637	970
	Seven-Mile Creek	562	23,244
	Shanaska Creek	693	26,753
	Rogers Creek (County Ditch 78)	613	16,798

a. Watershed area includes all drainage area to the impairment

3.3 Subwatersheds

The watershed boundaries of the impaired waterbodies (Figure 3 and Figure 4**Figure 4**) were developed using multiple data sources, starting with watershed delineations from the MPCA's Hydrologic Simulation Program–Fortran (HSPF) model application of the Minnesota River–Mankato Watershed (Tetra Tech 2015). The model watershed boundaries are based on Minnesota Department of Natural Resources (DNR) Level w8 watershed boundaries, and modified with a 30-meter digital elevation model (DEM). Where additional watershed breaks were needed to define the impairment watersheds, 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 (GIS) 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.

3.4 Land Cover

Land cover in the Minnesota River–Mankato Watershed is predominantly agricultural with the dominant crops being corn and soybeans (Table 7, Figure 5)**.** Other crops, including sugar beets and dry beans, are typically minor, but represent 5% or more of the watershed in the Crow Creek, Birch Coulee Creek, and Fort Ridgley Creek Watersheds. Artificial drainage is common in the watershed and is used to remove ponded water from flat or depressional areas (NRCS n.d.). Developed land use is the second major land use, and is centralized near the city of Mankato and surrounding suburbs.

Table 7. Land cover in impaired watersheds (2016 Cropland Data Layer)
Percentages rounded to the nearest whole number.

Watershed Group	Waterbody Name	Stream AUID / Lake ID	Percent of Watershed (%)							
			Urban	Corn	Soybeans	Other crops	Grassland/pasture	Forest	Wetlands	Open water
Minnesota River–New Ulm	Crow Creek	569	10	41	39	5	1	2	2	<1
	Birch Coulee Creek	587	4	48	32	9	1	3	3	<1
	Purgatory Creek	645	6	40	43	4	1	3	3	<1
	Wabasha Creek	527	6	43	40	2	3	2	4	<1
	Three-Mile Creek	704	6	45	35	4	1	4	5	<1
	Unnamed creek	644	6	42	43	2	2	2	3	<1
	Fort Ridgley Creek	689	6	49	32	6	2	2	3	<1
	Spring Creek (Judicial Ditch 29)	622	6	43	47	<1	1	1	2	<1
	Spring Creek	573	6	43	44	1	1	2	3	<1
	County Ditch 13	712	5	46	38	2	1	5	3	<1
	County Ditch 10 (John's Creek)	571	3	48	38	1	1	5	4	<1
	Little Rock Creek (Judicial Ditch 31)	687	5	54	28	3	2	3	3	2

Watershed Group	Waterbody Name	Stream AUID / Lake ID	Percent of Watershed (%)							
			Urban	Corn	Soybeans	Other crops	Grassland/pasture	Forest	Wetlands	Open water
Minnesota River–New Ulm, continued	Eight-Mile Creek	684	5	54	31	3	2	3	2	<1
	Huelskamp Creek	641	4	45	36	<1	2	7	5	1
	Fritsche Creek (County Ditch 77)	709	4	50	31	3	3	4	5	<1
	Heyman's Creek	640	3	57	31	1	2	2	4	<1
Little Cottonwood River–Nicollet	Altermatts Creek	518	5	37	39	3	4	<1	12	<1
	Little Cottonwood River	676	5	42	33	2	4	1	12	1
	Little Cottonwood River	677	5	41	33	2	4	2	12	1
	Morgan Creek	691	5	51	34	1	2	2	4	1
	Unnamed creek	577	5	54	37	<1	<1	1	3	<1
	Swan Lake Outlet (Nicollet Creek)	683	4	35	23	<1	2	4	11	21
	County Ditch 56 (Lake Crystal Inlet)	557	8	57	29	<1	1	<1	5	<1
	Mills	70-0097-00	3	13	31	<1	<1	3	18	32
	Loon	70-0096-00	4	32	18	<1	1	2	13	30
	Minneopa Creek	534	7	49	32	<1	1	2	5	4
Mankato–St. Peter	Unnamed creek	604	20	61	15	1	2	1	<1	0
	Unnamed creek	603	20	50	20	<1	4	4	2	<1
	Unnamed creek	602	18	51	9	<1	10	8	4	<1
	Unnamed creek	600	22	35	11	1	9	14	7	1
	Unnamed ditch	598	32	27	10	1	8	14	7	1
	Wita	70-0077-00	7	16	26	0	4	9	9	29
	County Ditch 46A	679	4	46	33	1	1	1	13	1
	Seven-Mile Creek	703	5	55	29	1	3	1	4	2
	Unnamed creek (Seven-Mile Creek Tributary)	637	4	46	42	<1	2	1	5	<1
	Seven-Mile Creek	562	5	48	31	1	2	4	8	1
	Duck	07-0053-00	8	30	17	<1	7	4	4	30
	George	07-0047-00	6	26	15	<1	16	13	10	14
	Washington	40-0117-00	5	27	20	<1	13	6	9	20
	Henry	40-0104-00	2	35	8	<1	4	3	3	45
	Shanaska Creek	693	6	30	24	<1	11	7	7	15
	Rogers Creek (County Ditch 78)	613	5	54	25	2	6	4	4	<1
	Scotch	40-0109-00	3	37	30	<1	8	5	10	7

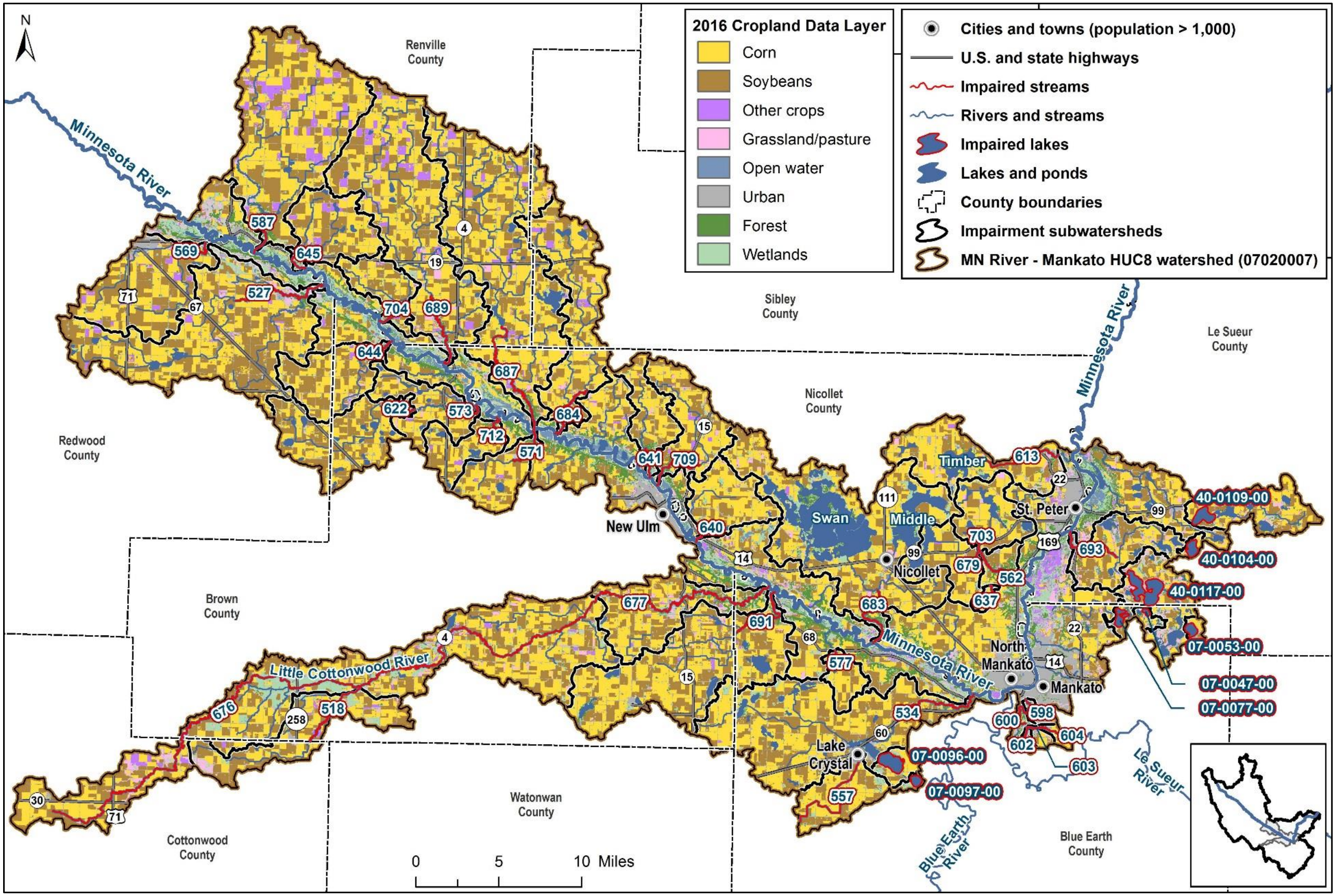


Figure 5. Land cover in the Minnesota River–Mankato Watershed.

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 years 2006 through 2015 were used in the water quality summary tables. If data from 2006 through 2015 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 Lakes

Water quality data from 2006 to 2015 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. Results are presented in Appendix A and are summarized in Figure 6 through Figure 8. Growing season mean phosphorus concentrations were highest in Henry Lake, with only one year of data. On average, Washington Lake has the lowest phosphorus concentrations and the most complete data record (Figure 6Figure 6); the chl-*a* concentration patterns are similar (Figure 7). More Secchi depth data are available than phosphorus and chl-*a*. Washington Lake has the highest clarity on average (1.5 meters), and Mills Lake, Loon Lake, and Wita Lake have the lowest clarity on average (0.2 to 0.3 meters; Figure 8).

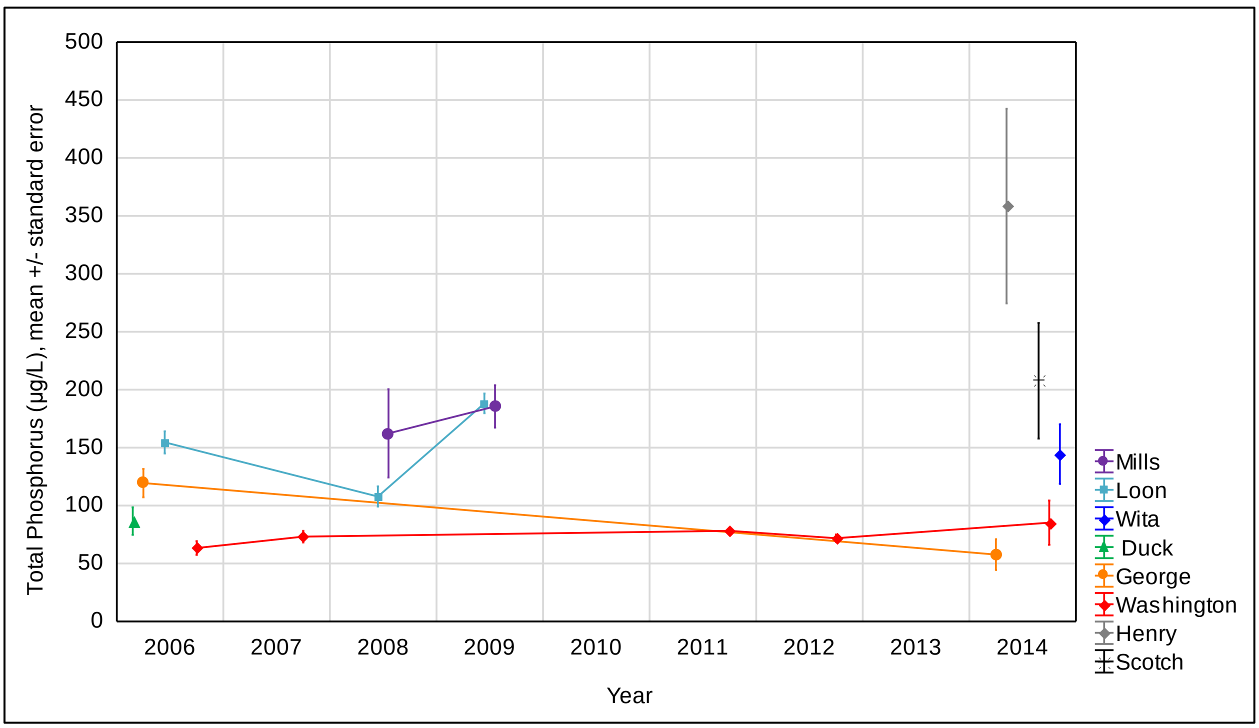


Figure 6. Growing season mean phosphorus concentrations by year for impaired lakes.

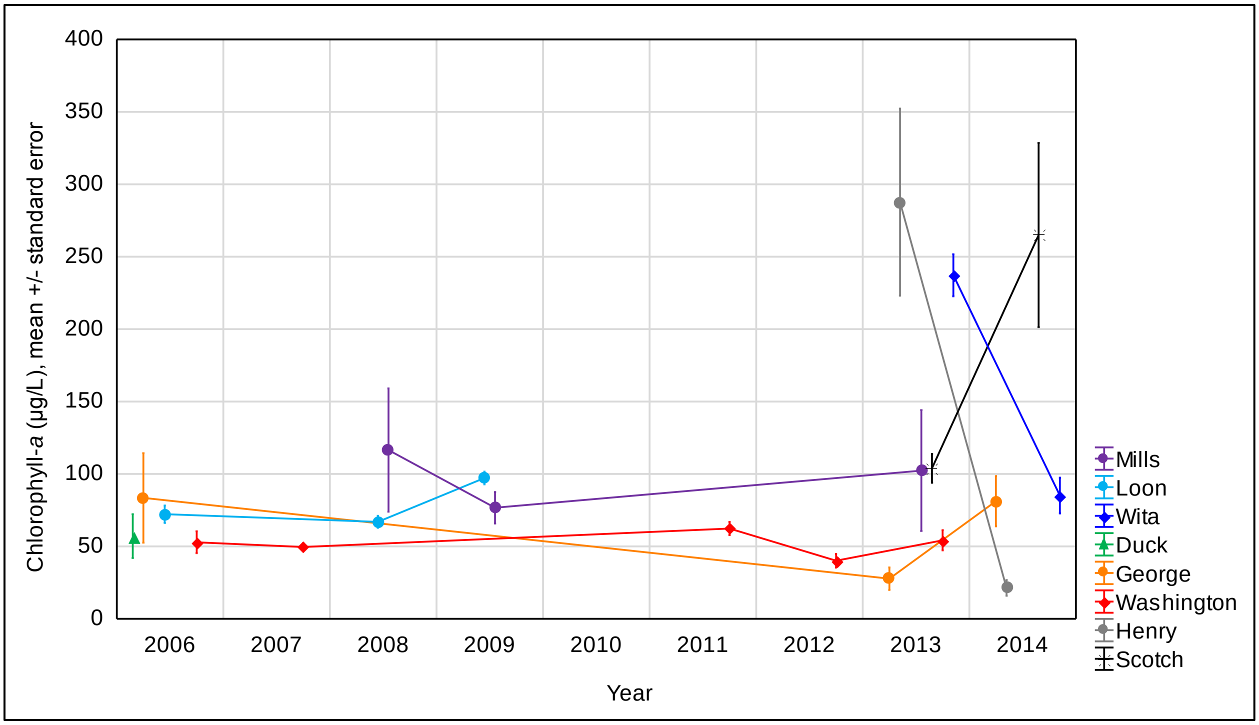


Figure 7. Growing season mean chlorophyll-*a* concentrations by year for impaired lakes.

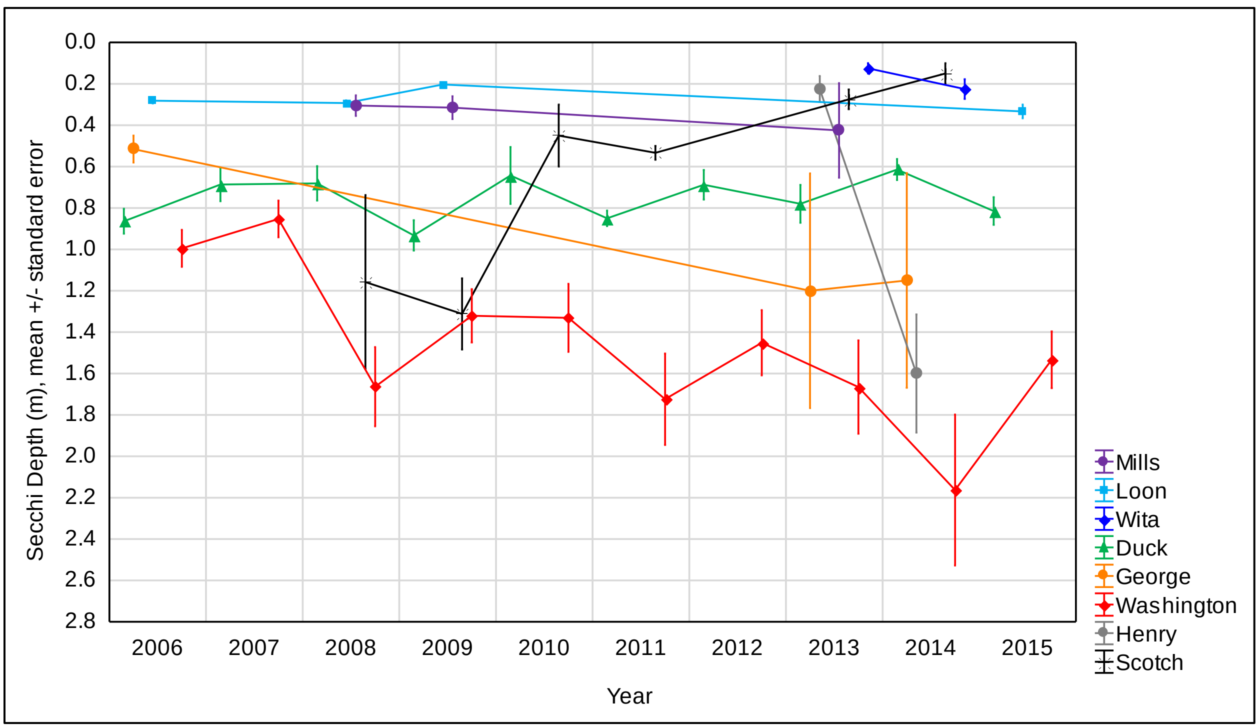


Figure 8. Growing season mean Secchi depths by year for impaired lakes.

3.5.2 Streams

Flow

The analyses used the following sources of flow data (Table 8):

- The MPCA provided flow data from Hydstra, a database that stores MPCA and DNR stream gauging data. Daily average flows from three gages were calculated and used in the analyses.

- Daily average flows were simulated with the MPCA's HSPF model application for the Minnesota River–Mankato Watershed (2016-02-18 version). Simulated flows are available at the downstream end of each model reach. The model reports (Tetra Tech 2015, Tetra Tech 2016) describe the framework and the data that were used to develop the model and include information on the calibration.

The flow records from the three monitoring gages were prioritized over simulated flows. The drainage area-ratio method was used to extrapolate gage flows to the locations of the segment outlets. For example, flows from MPCA/DNR gage 28057001 on the Little Cottonwood River collected from January 1, 1986, through December 31, 2015, were reduced by 16% to develop the flow duration curve for AUID 07020007-676, because the impaired segment drains 141.5 square miles and the MPCA/DNR gage drains 169 square miles (i.e., the impaired subwatershed is 84% of the gaged subwatershed).

For the remaining 32 impaired segments, daily average flow simulated in HSPF for the modeling period (January 1, 1995, through December 31, 2012) was used in the analyses. The outlets of 29 of the impaired segments were collocated with model output locations, and thus HSPF-simulated flows were used to develop flow duration curves. For the remaining three impairments, HSPF-simulated flows from nearby modeled reaches were drainage area-weighted to the impaired reach. For additional information regarding HSPF modeling, see the summary in Section 3.6.3 or modeling documentation (Tetra Tech 2015, Tetra Tech 2016).

Table 8. Stream flow data sources

Watershed Group	Stream Name	AUID	Flow Source	Period of Record
Minnesota River–New Ulm	Crow Creek	569	HSPF Reach 11, area-weighted	1/1/1995–12/31/2012
	Birch Coulee Creek	587	HSPF Reach 55	1/1/1995–12/31/2012
	Purgatory Creek	645	HSPF Reach 59	1/1/1995–12/31/2012
	Wabasha Creek	527	HSPF Reach 75	1/1/1995–12/31/2012
	Three-Mile Creek	704	HSPF Reach 131	1/1/1995–12/31/2012
	Unnamed creek	644	HSPF Reach 151	1/1/1995–12/31/2012
	Fort Ridgley Creek	689	HSPF Reach 179	1/1/1995–12/31/2012
	Spring Creek (Judicial Ditch 29)	622	HSPF Reach 191, area-weighted	1/1/1995–12/31/2012
	Spring Creek	573	HSPF Reach 191	1/1/1995–12/31/2012
	County Ditch 13	712	HSPF Reach 193	1/1/1995–12/31/2012
	County Ditch 10 (John's Creek)	571	HSPF Reach 211	1/1/1995–12/31/2012
	Little Rock Creek (Judicial Ditch 31)	687	HSPF Reach 223	1/1/1995–12/31/2012
	Eight-Mile Creek	684	HSPF Reach 231	1/1/1995–12/31/2012
	Huelskamp Creek	641	HSPF Reach 271	1/1/1995–12/31/2012
	Fritsche Creek (County Ditch 77)	709	HSPF Reach 291	1/1/1995–12/31/2012
	Heyman's Creek	640	HSPF Reach 311	1/1/1995–12/31/2012
Little Cottonwood River–Nicollet	Altermatts Creek	518	HSPF Reach 363	1/1/1995–12/31/2012
	Little Cottonwood River	676	MPCA/DNR station 28057001, area-weighted	1/1/1986–12/31/2015
	Little Cottonwood River	677	MPCA/DNR station 28057001, area-weighted	1/1/1986–12/31/2015
	Morgan Creek	691	HSPF Reach 381	1/1/1995–12/31/2012
	Unnamed creek	577	HSPF Reach 391, area-weighted	1/1/1995–12/31/2012
	Swan Lake Outlet (Nicollet Creek)	683	HSPF Reach 417	1/1/1995–12/31/2012
	County Ditch 56 (Lake Crystal Inlet)	557	HSPF Reach 475	1/1/1995–12/31/2012
	Minneopa Creek	534	HSPF Reach 485	1/1/1995–12/31/2012
Mankato–St. Peter	Unnamed creek	604	HSPF Reach 511	1/1/1995–12/31/2012
	Unnamed creek	603	HSPF Reach 513	1/1/1995–12/31/2012
	Unnamed creek	602	HSPF Reach 515	1/1/1995–12/31/2012
	Unnamed creek	600	HSPF Reach 519	1/1/1995–12/31/2012
	Unnamed ditch	598	HSPF Reach 523	1/1/1995–12/31/2012
	County Ditch 46A	679	HSPF Reach 577	1/1/1995–12/31/2012
	Seven-Mile Creek	703	HSPF Reach 573	1/1/1995–12/31/2012
	Unnamed creek (Seven-Mile Creek Tributary)	637	HSPF Reach 579	1/1/1995–12/31/2012
	Seven-Mile Creek	562	MPCA/DNR stations 28063001 and 28063003, area-weighted	4/3/2002–11/22/2013 and 3/16/2014–11/9/2015
	Shanaska Creek	693	HSPF Reach 603	1/1/1995–12/31/2012
	Rogers Creek (County Ditch 78)	613	HSPF Reach 611	1/1/1995–12/31/2012

Pollutants

Water quality data from 2006 to 2015 were summarized for the TMDL pollutants (*E. coli,* TSS, and nitrate). If impaired segments had little or no *E. coli* data, fecal coliform data were evaluated when available. Data collected in 2000 through 2005 were also evaluated when recent data (2006 through 2015) were unavailable. 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 *E. coli* [for class 2 and class 7 waters, respectively], April through September for TSS, and all months for nitrate). 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.

Load duration curves are provided 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, sediment concentrations typically increase with rising flows as a result of factors such as channel scour from higher velocities. 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 either daily average flow reported from continuously recording gages or daily average flow from HSPF modeling (Tetra Tech 2015, Tetra Tech 2016). Table 8 presents the modeled stream segment number or monitoring gage and period of record 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*, 65 mg/L TSS, and 10 mg/L nitrate), 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 or gaged flow (Table 8) on the day that the sample was taken. A nearby gage (MPCA/DNR gage 28063001/28063003) was used to estimate the flow exceedance to plot water quality samples from 2013, 2014, and 2015 from reaches for which the 1995 through 2012 HSPF simulated flow was used to develop the load duration curve. The flow exceedance was then used to determine the corresponding HSPF flow (at that flow exceedance) for which to calculate a load for the water quality sample. 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.

Where *E. coli* data do not exist or are limited, fecal coliform data were translated to *E. coli* concentrations and plotted on the load duration curves. *Ambient Water Quality Criteria for Bacteria* (EPA 1986) suggests that a fecal coliform concentration of 200 organisms per 100 mL and an *E. coli* concentration of 126 organisms per 100 mL are similar, in that they would both cause approximately 8 illnesses per 1,000 swimmers in fresh waters. The fecal coliform data were translated to *E. coli* using this ratio of 200 colonies of fecal coliform bacteria for every 126 organisms of *E. coli* bacteria.

To compare water quality data across all impaired reaches of one pollutant type, composite concentration duration curves were developed (Figure 9 through Figure 11). Concentration duration curves are similar to load duration curves, except that concentration instead of load is plotted on the y-axis. This provides a comparison of water quality conditions across multiple reaches with varying flows.

Water quality summary tables and load duration curves are presented for each impairment in Appendix A, and Table 9 summarizes the water quality data.

The number of *E. coli* samples per impaired reach ranges from zero (for five reaches) to 124. The impairments that do not have *E. coli* data were listed as impaired in 2008 based on fecal coliform data. The maximum recorded *E. coli* concentration per reach ranges from 613 to 35,000 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 31% (Table 9). There is not a strong relationship between *E. coli* concentrations and flow across all of the reaches with *E. coli* impairments, and exceedances of the single sample standard occur across all flow conditions (Figure 9).

The number of TSS samples per impaired reach ranges from 11 to 191, the maximum recorded TSS concentration per reach ranges from 160 to 5,970 mg/L, and the frequencies of exceedance range from 5% to 51% (Table 9). TSS concentrations on average are highest under high flow conditions and decrease with decreasing flow (Figure 10).

The number of nitrate samples per impaired reach ranges from 6 to 220, the maximum recorded nitrate concentration per reach ranges from 22 to 43 mg/L, and the frequencies of exceedance range from 65% to 83% (Table 9). Nitrate concentrations on average are highest under high flows with few exceedances under low flows (Figure 11).

Table 9. Summary of water quality data for impaired reaches

Summaries include data from months during which the standard applies (see section 2.2). *E. coli* units are org/100 mL, and TSS and nitrate units are mg/L.

Watershed Group	Stream Name (description)	AUID	Pollutant	Date Range	Sample Count	Mean [a]	Max-imum [b]	Number of Exceedances of Individual Standard	Frequency of Exceedance [c]
Minnesota River–New Ulm	Crow Creek (CD 52 to T112 R35W S2, north line)	569	*E. coli*	2006–2015	45	361	≥ 2,420	7	83% / 16%
	Birch Coulee Creek (JD 12 to Minnesota R)	587	*E. coli*	2006–2015	35	241	≥ 2,420	3	100% / 9%
	Purgatory Creek (Unnamed cr to Minnesota R)	645	*E. coli*	2006–2015	18	160	≥ 2,420	2	100% / 11%
	Wabasha Creek (T112 R34W S19, west line to Minnesota R)	527	*E. coli*	2006–2015	39	513	8,664	12	83% / 31%
	Three-Mile Creek (CD 140 to Minnesota R)	704	*E. coli*	2006–2015	20	70	613	0	50% / 0%
	Unnamed creek (Unnamed cr to Minnesota R)	644	*E. coli*	2006–2015	30	181	≥ 2,420	5	67% / 17%
	Fort Ridgley Creek (T112 R33W S24, north line to Minnesota R)	689	*E. coli*	2006–2015	35	105	≥ 2,420	1	100% / 3%
	Spring Creek (Judicial Ditch 29) (T111 R33W S23, west line to T111 R33W S23, east line)	622	*E. coli*	2006–2015	15	293	1,733	1	100% / 7%
	Spring Creek (T111 R32W S21, west line to Minnesota R)	573	*E. coli*	2006–2015	45	217	≥ 2,420	8	67% / 18%
	County Ditch 13 (245th Ave to Minnesota R)	712	*E. coli*	2006–2015	40	577	≥ 2,420	10	100% / 25%
	County Ditch 10 (John's Creek) (T110 R32W S1, west line to Minnesota R)	571	*E. coli*	2006–2015	29	335	3,609	9	80% / 31%
			Nitrate	2006–2015	29	14	22	24	83%
	Little Rock Creek (Judicial Ditch 31) (Mud Lk to Minnesota R)	687	*E. coli*	2006–2015	32	302	2,613	5	100% / 16%
	Eight-Mile Creek (366th St/T-39 to Minnesota R)	684	*E. coli*	2006–2015	34	305	≥ 2,420	4	100% / 12%
	Huelskamp Creek (Unnamed cr to Minnesota R)	641	*E. coli*	2006–2015	15	262	≥ 2,420	1	100% / 7%

Watershed Group	Stream Name (description)	AUID	Pollutant	Date Range	Sample Count	Mean [a]	Max-imum [b]	Number of Exceedances of Individual Standard	Frequency of Exceedance [c]
Minnesota River–New Ulm, continued	Fritsche Creek (County Ditch 77) (-94.4172 44.3557 to Minnesota R)	709	*E. coli*	2006–2015	18	290	≥ 2,420	1	100% / 6%
	Heyman's Creek (Unnamed cr to Minnesota R)	640	*E. coli*	2006–2015	20	293	≥ 2,420	2	100% / 10%
Little Cottonwood River–Nicollet	Altermatts Creek (T108 R34W S35, south line to Little Cottonwood R)	518	*E. coli*	2006–2015	15	457	≥ 2,420	2	33% / 13%
	Little Cottonwood River (Headwaters to T109 R31W S22, north line)	676	*E. coli*	2000–2005	5	550	1,722	1	– [d] / 20%
			Fecal coliform [e]	2000–2005	19	84	17,200	–	–
			TSS	2006–2016	14	58	160	4	29%
	Little Cottonwood River (T109 R31W S15, south line to Minnesota R)	677	*E. coli*	2006–2015	95	295	20,000	12	83% / 13%
			TSS	2006–2015	151	116	1,520	72	48%
	Morgan Creek (T109 R29W S30, south line to Minnesota R)	691	*E. coli*	2006–2015	36	259	4,400	1	100% / 3%
	Unnamed creek (T108 R28W S6, south line to T108 R28W S6, north line)	577	Nitrate	2006–2016	6	18	24	5	83%
	Swan Lake Outlet (Nicollet Creek) (CD 39 to Minnesota R)	683	*E. coli*	2006–2015	36	395	≥ 2,420	7	100% / 19%
	County Ditch 56 (Lake Crystal Inlet) (Headwaters to Lk Crystal)	557	*E. coli*	2006–2015	53	213	14,136	6	67% / 11%
	Minneopa Creek (T108 R28W S23, south line to Minnesota R)	534	*E. coli*	2006–2015	15	657	7,700	4	100% / 27%
			TSS	2006–2015	11	77	520	3	27%
Mankato–St. Peter	Unnamed creek (Headwaters to Unnamed cr)	604	Fecal coliform [e]	2000–2005	66	409	13,408	–	–
	Unnamed creek (Unnamed cr to Unnamed cr)	603	Fecal coliform [e]	2000–2005	54	287	9,957	–	–
	Unnamed creek (Headwaters to Unnamed cr)	602	Fecal coliform [e]	2000–2005	53	249	52,800	–	–
	Unnamed creek (Unnamed cr to Unnamed cr)	600	Fecal coliform [e]	2000–2005	54	487	8,083	–	–

Watershed Group	Stream Name (description)	AUID	Pollutant	Date Range	Sample Count	Mean [a]	Max-imum [b]	Number of Exceedances of Individual Standard	Frequency of Exceedance [c]
Mankato–St. Peter, continued	Unnamed ditch (Unnamed cr to underground pipe)	598	Fecal coliform [e]	2000–2005	66	1,059	77,394	–	–
	County Ditch 46A (-94.0803 44.2762 to Seven-Mile Cr)	679	*E. coli*	2006–2015	93	167	35,000	8	67% / 9%
			TSS	2006–2015	98	26	310	10	10%
	Seven-Mile Creek (MN Hwy 99 to CD 46A)	703	*E. coli*	2006–2015	89	155	≥ 2,420	7	50% / 8%
			TSS	2006–2015	96	16	160	5	5%
	Unnamed creek (Seven-Mile Creek Tributary) (Headwaters to T109 R27W S15, north line)	637	*E. coli*	2006–2015	53	209	14,000	10	83% / 19%
	Seven-Mile Creek (T109 R27W S4, north line to Minnesota R)	562	*E. coli*	2006–2015	124	125	15,000	12	57% / 10%
			TSS	2006–2015	191	140	5,970	98	51%
			Nitrate	2006–2015	220	16	43	142	65%
	Shanaska Creek (Shanaska Cr Rd to Minnesota R)	693	*E. coli*	2006–2015	18	226	≥ 2,420	3	100% / 17%
	Rogers Creek (County Ditch 78) (CD 21 to Unnamed cr)	613	*E. coli*	2006–2015	14	475	1,553	2	100% / 14%

a. Arithmetic means are provided for TSS and nitrate data; geometric means are provided for *E. coli* and fecal coliform data.

b. 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.

c. 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.

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

e. Fecal coliform data are summarized because *E. coli* data either do not exist or are limited. Fecal coliform data are not compared against a water quality standard.

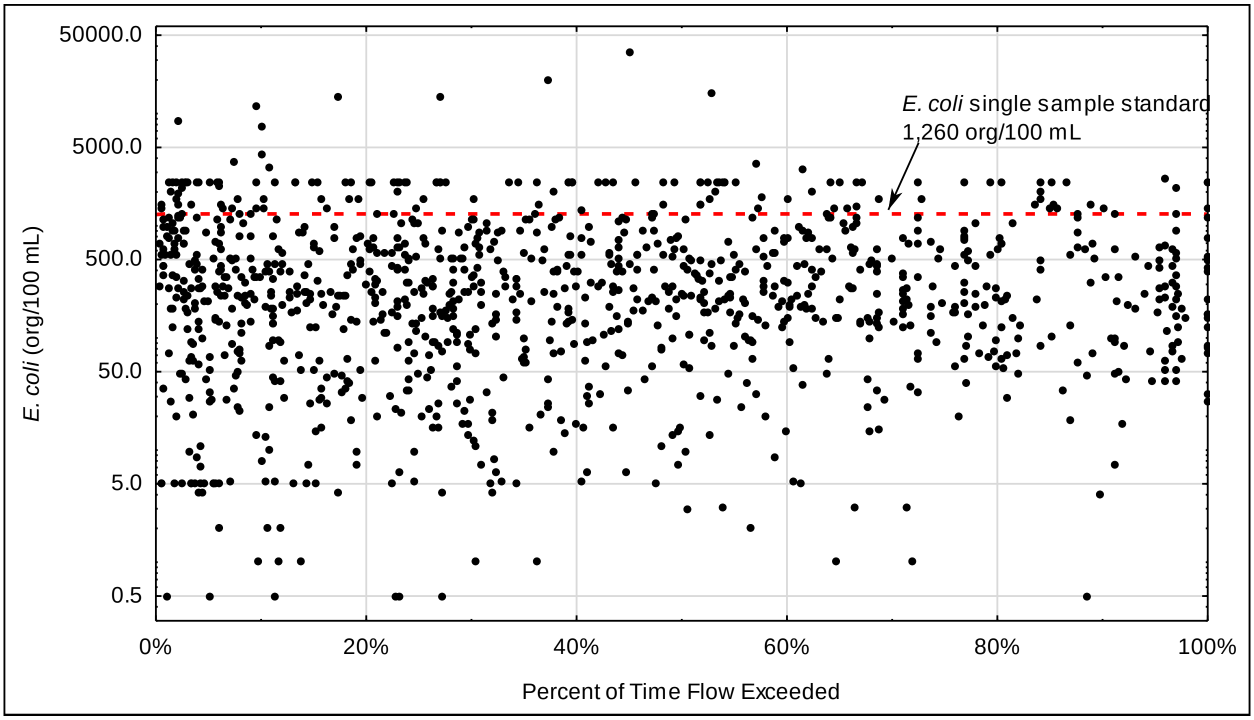


Figure 9. *E. coli* concentration duration curve for all reaches with *E. coli* impairments.

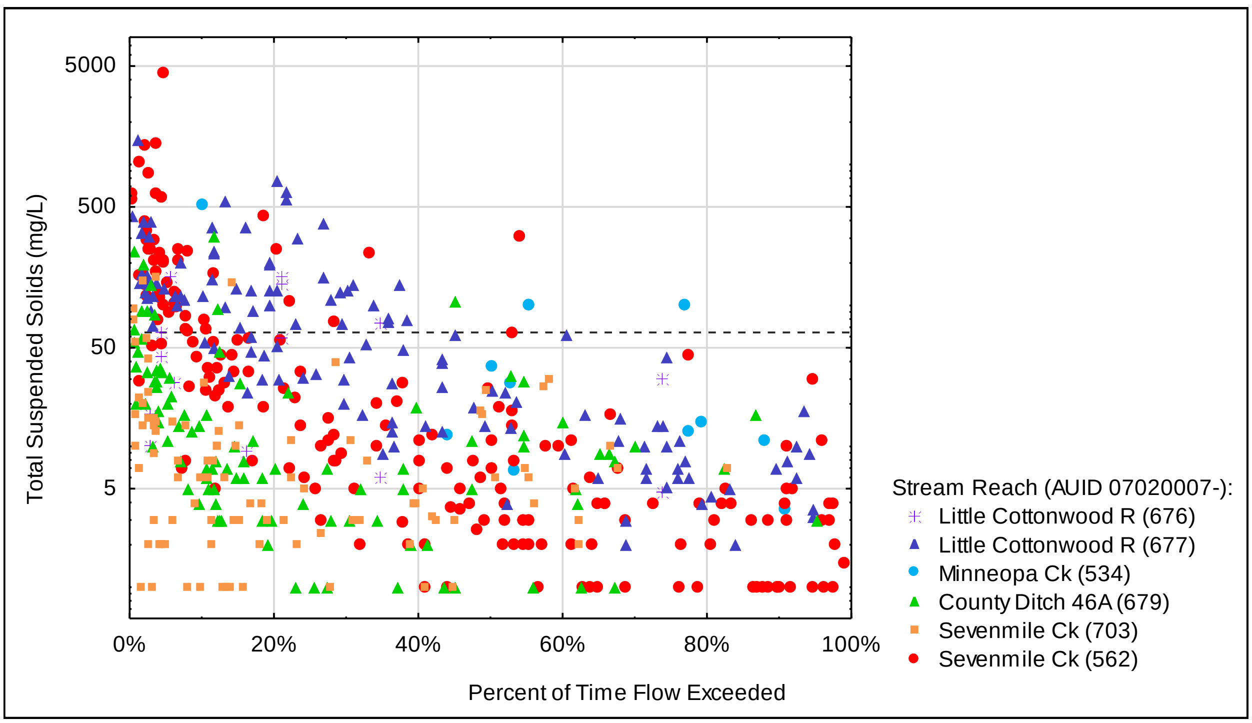


Figure 10. TSS concentration duration curve for all reaches with TSS impairments.

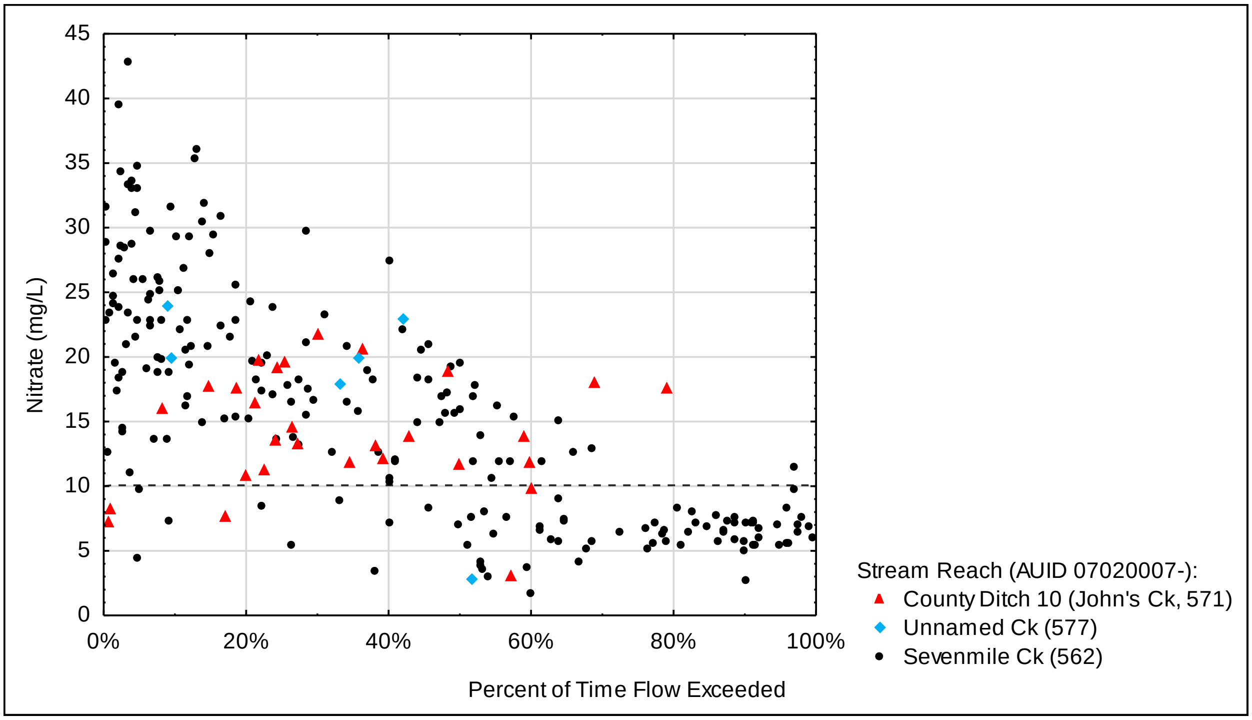


Figure 11. Nitrate concentration duration curve for all reaches with nitrate impairments.

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*, sediment, nitrate, and phosphorus in the watershed.

3.6.1 Pollutant Source Types

The pollutant sources evaluated in this report are permitted sources such as wastewater, stormwater, and permitted animal feeding operations (AFOs); and non-permitted sources such as watershed runoff, septic systems, near-channel sources, and internal loading. This section describes each of the pollutant source types in general. More details specific to pollutant type are provided in Sections 3.6.2 through 3.6.5.

Permitted Sources of Pollution

Point source pollution is defined by CWA Section 502(14) as “any discernible, confined and discrete conveyance, including any ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation (CAFO), or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agriculture stormwater discharges and return flow from irrigated agriculture.” Under the CWA, all point sources are regulated under the National Pollutant Discharge Elimination System (NPDES) program. Permitted sources in the Minnesota River–Mankato Watershed include regulated stormwater, industrial and municipal wastewater, and permitted CAFOs.

Regulated Stormwater

Regulated 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 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 regulated stormwater are permitted in the watershed:

- *Municipal Separate Storm Sewer Systems (MS4s)* are defined by the MPCA 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. 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 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.

  The Phase II General NPDES/State Disposal System (SDS) Municipal Stormwater Permit for MS4 communities has been issued to several cities, townships, and counties in the watershed. Whereas the MnDOT Outstate District is a permitted MS4, there are no roads or rights-of-way regulated through their permit in the TMDL watersheds.

Table 10. List of MS4s in the Minnesota River-Mankato Watershed given TMDL WLAs in this report

MS4 Permittee	Permit Number
Blue Earth County MS4	MS400276
Mankato City MS4	MS400226
Mankato Township MS4	MS400297
Minnesota State University –Mankato MS4	MS400279
Redwood Falls City MS4	MS400236
Skyline City MS4	MS400292
South Bend Township MS4	MS400299
St. Peter City MS4	MS400245

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 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 CWA. An annual report is submitted to the MPCA each year by the permittee documenting progress on implementation of the SWPPP.

In this report, entities such as cities and townships that are regulated through the MS4 permit are referred to as "permitted" entities, and the stormwater runoff and/or watershed areas that generate the runoff are referred to as being "regulated" through the MS4 permit. Permitted MS4s are mapped in Figure 12.

- *Construction stormwater* is runoff from a construction site. An NPDES Permit is required for construction activity that disturbs one or more acres of soil or for smaller sites if the activity is part of a larger development. A permit also might be required 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. Construction stormwater area percentages by county were obtained from the Minnesota Stormwater Construction Manual and area weighted to impaired subwatersheds. It is estimated that between 0.025% to 0.071% of the project area is regulated through the construction stormwater permit, so construction stormwater is not considered a significant source.
- *Industrial stormwater* is regulated through an NPDES permit when stormwater discharges have the potential to come into contact with materials and activities associated with the industrial activity.

Wastewater

Permitted wastewater (Figure 13) in the watershed includes industrial and municipal wastewater:

- *Industrial wastewater* is from industries, businesses, and other privately owned facilities that discharge treated wastewater to surface waters.
- *Municipal wastewater* is the domestic sewage and wastewater collected and treated by municipalities before being discharged to waterbodies as municipal wastewater effluent.

NPDES/SDS Permitted Animal Feeding Operations

In Minnesota, AFOs are required to register with their respective delegated county or the state if they are 1) an animal feedlot capable of holding 50 or more animal units (AU), or a manure storage area capable of holding the manure produced by 50 or more AUs outside of shoreland; or 2) an animal feedlot capable of holding 10 or more AUs, or a manure storage area capable of holding the manure produced by 10 or more AUs, that is located within shoreland. Further explanation of registration requirements can be found in Minn. R. 7020.0350.

Of the approximately 596 AFOs in the Minnesota River–Mankato Watershed, there are 106 CAFOs. CAFOs are defined by the EPA based on the number and type of animals (CAFOs, Figure 14). See

Appendix D for the complete list of CAFOs in the Minnesota River–Mankato Watershed. The MPCA currently uses the federal definition of a CAFO in its permit requirements of animal feedlots along with the definition of an AU. In Minnesota, the following types of livestock facilities are required to operate under a NPDES Permit or a state issued SDS Permit: a) all federally defined CAFOs that have had a discharge, some of which are under 1,000 AUs in size; and b) all CAFOs and non-CAFOs that have 1,000 or more AUs.

CAFOs and AFOs with 1,000 or more AUs must be designed to contain all manure and manure contaminated runoff from precipitation events of less than a 25-year - 24-hour storm event. Having and complying with an NPDES permit allows some enforcement protection if a facility discharges due to a 25-year - 24-hour precipitation event (approximately 5.3” in 24 hours) and the discharge does not contribute to a water quality impairment. Large CAFOs permitted with an SDS permit or those not covered by a permit must contain all runoff, regardless of the precipitation event. Therefore, many Large CAFOs in Minnesota have chosen to have an NPDES permit, even if discharges have not occurred in the past at the facility. A current manure management plan, which complies with Minn. R. 7020.2225, and the respective permit is required for all CAFOs and AFOs with 1,000 or more AUs.

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

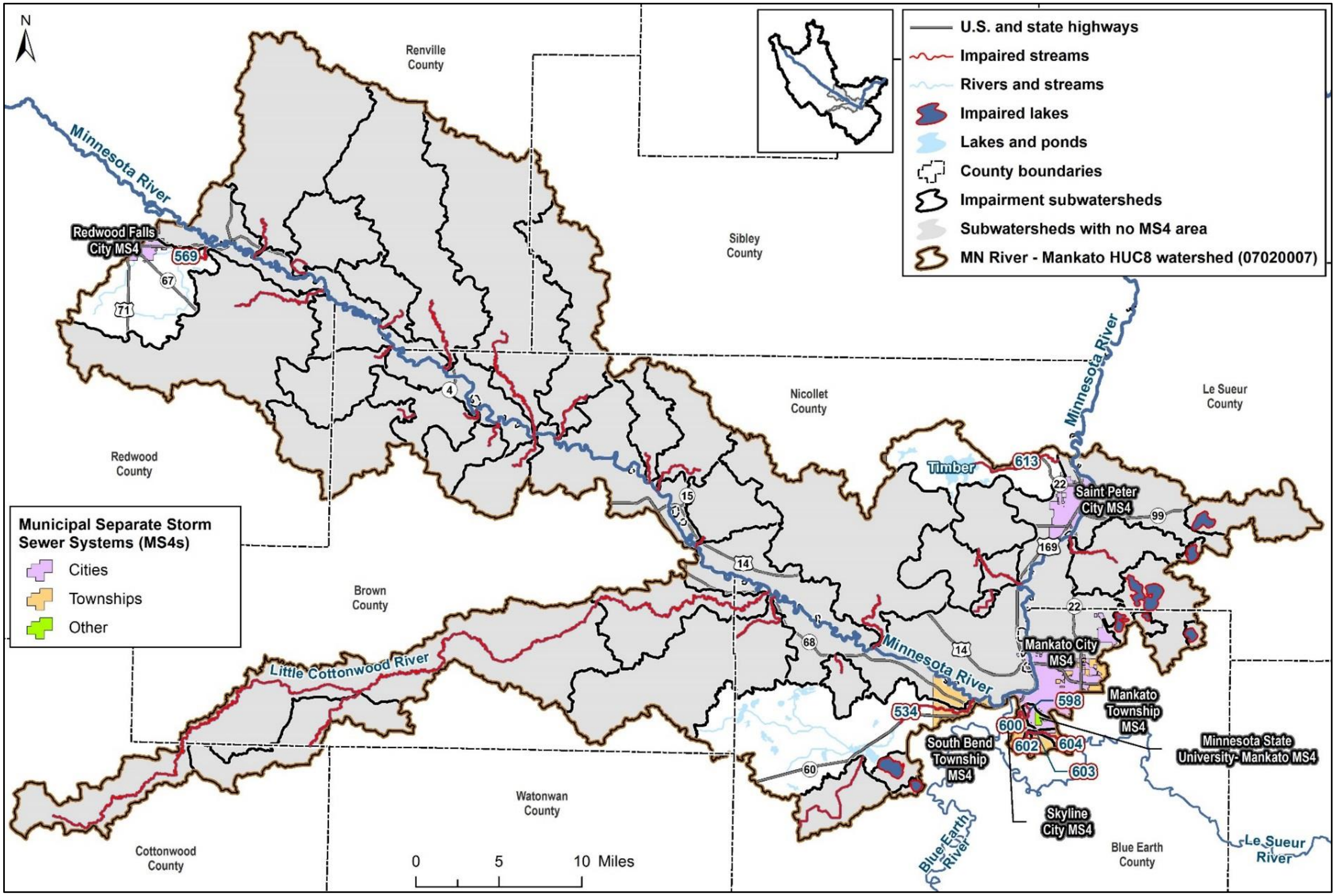


Figure 12. Permitted MS4s in the Minnesota River–Mankato Watershed.
In addition to the permitted MS4s depicted in the map, Blue Earth County is also a permitted MS4 in the project area.

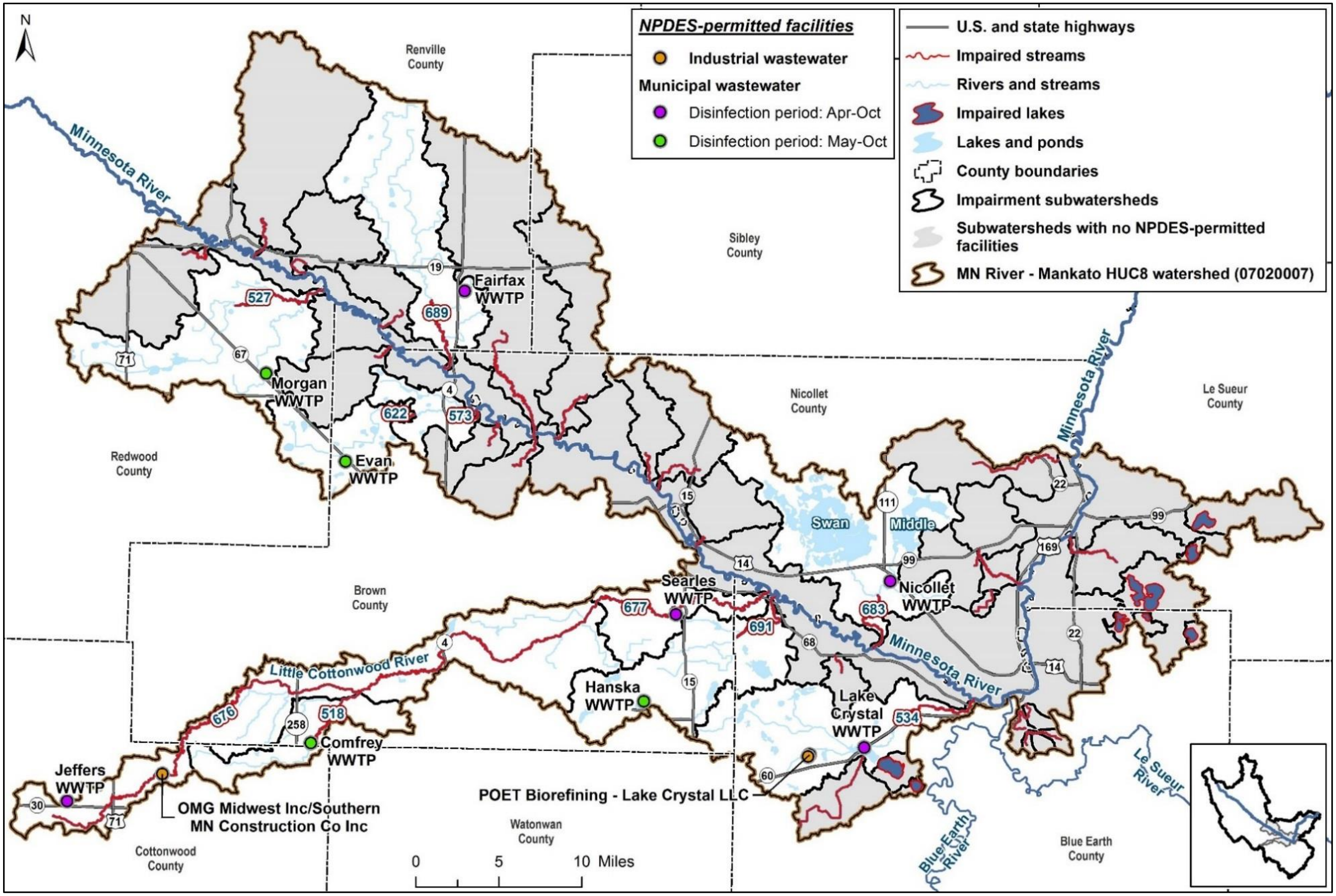


Figure 13. NPDES-permitted wastewater discharges in the Minnesota River–Mankato Watershed.

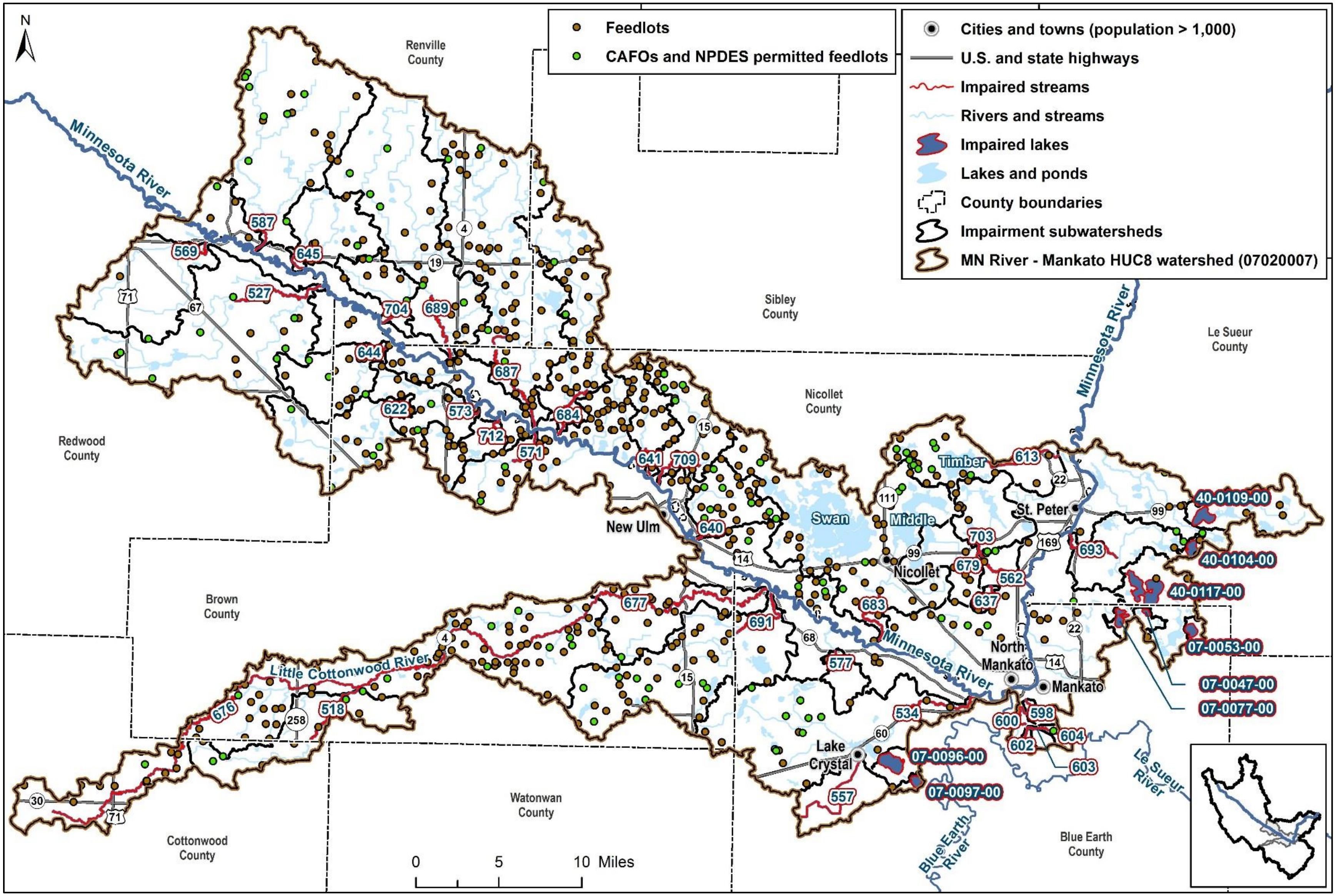


Figure 14. Feedlots in the Minnesota River–Mankato Watershed.
Data from the MPCA's registered feedlot database.

Non-Permitted Sources of Pollution

There are many non-permitted sources of pollution in the watershed. Non-permitted sources of pollution include unregulated watershed runoff, septic systems and straight pipes, non-NPDES/SDS permitted AFOs, and other pollutant-specific sources that are included in the pollutant-specific discussions (Sections 3.6.2 through 3.6.5), including agricultural drainage, agricultural groundwater, near channel erosion, and internal phosphorus loading in lakes.

Unregulated Watershed Runoff

Watershed runoff, which transports and delivers pollutants 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.), and domestic and wild animal waste.

Non-Permitted Wastewater

Human-derived sources of pollution include SSTSs, straight pipe systems, and earthen pit outhouses. 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. Straight pipes (i.e., unpermitted and illegal sewage disposal systems that transport raw or partially settled sewage directly to a lake, stream, drainage system, or the ground surface) and SSTSs that discharge untreated sewage to the land surface are considered IPHT. Straight pipe systems are required to be addressed 10 months after discovery (Minn. Stat. §§ 115.542, subd. 11).

Non-NPDES/SDS Permitted Animal Feeding Operations

AFOs under 1,000 AUs and those that are not federally defined as CAFOs do not operate with permits. In Minnesota, feedlots with greater than 50 AUs, or greater than 10 AUs in shoreland areas, are required to register with the state. Facilities with fewer AUs are not required to register with the state.

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. 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. Inadequately managed manure runoff from open lot feedlot facilities and improper application of manure can contaminate surface or groundwater. Registered feedlots in the Minnesota River–Mankato Watershed are mapped in Figure 14.

3.6.2 *E. coli* Source Summary

Sources of fecal bacteria are typically widespread and often intermittent. In the Minnesota River–Mankato Watershed, the *E. coli* standard is exceeded across all flow conditions, indicating a mix of source types (Figure 9). A qualitative approach was used to identify permitted and non-permitted sources of *E. coli* in the watershed. *E. coli* from livestock and SSTSs are the highest priority sources in the Minnesota–Mankato Watershed. Detailed explanation and rationale for the priority ranking is provided in the following subsections.

Permitted Sources of *E. coli*

Potential permitted sources of *E. coli* include regulated municipal stormwater, wastewater treatment plants (WWTP), and permitted AFOs.

Regulated Municipal Stormwater

Regulated stormwater from MS4s can be a source of *E. coli* to surface waters through the delivery of *E. coli* to surface waters. 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 surfaces. 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). Recent studies in Minneapolis using microbial markers show that birds are a primary source of the *E. coli* entering stormwater conveyances (Sadowsky et al. 2017). Growth and persistence of *E. coli* in soil and organic debris were also noted in the Minneapolis study. The Minnesota River–Mankato Watershed Watershed is predominantly rural; however, the small portion of permitted MS4 areas may be a possible source of *E. coli*.

Wastewater

There are nine permitted wastewater dischargers with fecal coliform permit limits in the Minnesota River–Mankato Watershed. Wastewater dischargers that operate under NPDES 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 bacteria 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 2007). 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, which is one month shorter than the time frame of the *E. coli* standard of the downstream impaired reaches. There are four dischargers to class 7 waters (Appendix B); these dischargers are a potential source of *E. coli* to downstream class 2 waters in April when disinfection is not required.

To determine the likelihood that dischargers to class 7 waters contribute to *E. coli* impairments in April, discharge volumes, surface water monitoring data, and the locations of the effluent discharge points were evaluated (Table 11). The facility design flows were compared to simulated low flows in the stream, because wastewater effluent is more likely to have an effect on stream water quality under low flow conditions. As the facility design flow relative to stream flow increases, there is a greater chance that the wastewater effluent could contribute to *E. coli* impairment.

Due to the low probability of low flows in April and bacteria die-off in surface waters, the wastewater effluent is not likely to be a significant source. However, there is the potential that discharge from these facilities could contribute to downstream *E. coli* impairments on class 2 waters in April.

Table 11. Design flows of WWTPs that are not required to disinfect in April as a percent of class 2 impaired reach flows

Wastewater Facility (NPDES Permit #)	Design Flow (cfs) [a]	Downstream Class 2 Impaired Reach	Approximate Distance to Impaired Class 2 Reach (miles)	April Exceedances Observed in Impaired Class 2 Reach	Impaired Reach Low Flow (cfs) [b]	Facility Design Flow as a Percent of Low Flows in Impaired Reach
Morgan WWTP (MN0020443)	3.583	07020007-527	7.5	NA	1.93	186%
Comfrey WWTP (MN0021687)	0.116	07020007-676	3.6	no data	8.20	1%
Hanska WWTP (MN0052663)	1.160	07020007-691	13.2	NA	5.35	22%
Evan WWTP (MNG580202)	0.224	07020007-622	7	no data	0.86	26%

a. Flow is either the average wet weather design flow (for Comfrey WWTP, which is a continuously discharging facility) or the maximum daily pond flow (for the remainder, which are controlled discharges).

b. 75^{th} percentile flow, simulated.

Monthly geometric means of effluent monitoring data are used to determine compliance with permits. Of the nine WWTPs in the Minnesota River–Mankato Watershed, two facilities have documented fecal coliform permit exceedances as provided in discharge monitoring reports (DMRs) for the time period between 2006 and 2015 (Table 12). Exceedances of wastewater fecal coliform permit limits could lead to exceedances of the instream *E. coli* standard at times. For the exceedances listed in Table 12, there are no surface water *E. coli* samples from the impaired reaches during the same month; therefore, it is difficult to determine if the permit exceedances led to exceedances of the surface water *E. coli* standard. However, because the wastewater effluent limit exceedances are infrequent, wastewater discharges are not considered a significant source of *E. coli* in the watershed.

Table 12. Wastewater treatment facilities with documented fecal coliform permit exceedances (2006–2015)

Wastewater Facility (NPDES Permit #)	*E. coli* Impairment AUID	Number of Permit Exceedances (2006–2015)	Reported Fecal Coliform Calendar Monthly Geometric Means that Exceed Permit Limit (org/100 mL)
Morgan WWTP (MN0020443)	07020007-527	1	523
Jeffers WWTP (MNG580111)	07020007-676	2	267 313

Permitted Animal Feeding Operations

There are 106 permitted AFOs and/or CAFOs in the impaired watersheds. Due to the requirement of these operations to completely contain runoff, facilities that are permit compliant are not expected to be a source of *E. coli* to surface waters.

Non-Permitted Sources of *E. coli*

Non-permitted sources evaluated as potential sources of *E. coli* in the Minnesota River–Mankato Watershed include waste from humans, livestock, and wildlife. Pet waste can be a source of *E. coli* and is considered to be part of watershed runoff from developed areas; 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 surfaces. Unregulated watershed runoff from developed areas, while not a direct source of *E. coli*, was evaluated for its role in the transport of *E. coli* across a watershed.

Human

SSTSs that function properly likely do not contribute *E. coli* to surface waters, but SSTSs that are considered IPHT (Section 3.6.1) can contribute *E. coli* to surface waters. The MPCA compiles the estimated percentage of septic systems that are IPHT as reported by counties. The approach to identifying IPHTs varies by county, and IPHTs typically include straight pipes, effluent ponding at ground surface, effluent backing up into homes, unsafe tank lids, electrical hazards, or any other unsafe condition deemed by a certified SSTS inspector. Therefore, not all of the IPHTs discharge pollutants directly to surface waters. In the Minnesota River–Mankato Watershed, percentages of IPHTs range from 3% in Le Sueur County to 39% in Cottonwood County (Table 13).

Table 13. Average septic system percent imminent threats to public health and safety by county

Data from MPCA. 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	2017 Estimated Percent IPHT
Blue Earth	9
Brown	24
Cottonwood	39
Le Sueur	3
Nicollet	22
Redwood	5
Renville	13
Sibley	26

Other human-derived sources of *E. coli* in the watershed include straight pipe discharges, earthen pit outhouses, and land application of septage. Straight pipe systems and earthen pit outhouses likely exist in the watershed, but their numbers and locations are unknown and were not quantified.

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

Livestock

Livestock are potential sources of fecal bacteria and nutrients to streams in the Minnesota River–Mankato Watershed, particularly when direct access is not restricted and/or where feeding structures are located adjacent to riparian areas.

Animal waste from non-permitted AFOs can be delivered to surface waters from failure of manure containment, runoff from the AFO itself, or runoff from nearby fields where the manure is applied. While a full accounting of the fate and transport of manure was not conducted for this project, a large portion of it is ultimately applied to the land surface and, therefore, this source is of concern. Minn. R. 7020.2225 contains several requirements for land application of manure; however, there are no explicit requirements for *E. coli* or bacteria treatment prior to land application. Manure practices that inject or incorporate manure pose lower risk to surface waters than surface application with little or no incorporation. In addition, manure application on frozen/snow covered ground in late winter months presents a high risk for runoff (Frame et al. 2012). Registered feedlots are mapped in Figure 14**.**

Wildlife

In the rural portions of the project area, deer, waterfowl, and other animals can be *E. coli* sources, with greater numbers in natural areas, wetlands and lakes, and river and stream corridors. Deer densities in the Minnesota River deer management zone range from 3 to 10 deer per square mile from the years 2010 through 2015 (Farmland and Wildlife Populations and Research Group 2015). Large geese populations near and within urban area waterbodies can also be of concern. Due to the relatively low density of deer compared to livestock in the watershed (over 175 AUs per square mile, based on data from the National Agricultural Statistics Service), wildlife is likely not a major contributor to *E. coli* in surface waters in the Minnesota River–Mankato Watershed.

Unregulated Watershed Runoff

Unregulated watershed runoff from developed areas has the same source types and mechanisms of delivery as regulated stormwater runoff, discussed under permitted sources of *E. coli*. The developed areas in the impairment watersheds that are not regulated through an NPDES permit can also be a source of *E. coli* to surface waters.

3.6.3 Sediment Source Summary

Sources of sediment to the impaired watersheds were quantified with the Minnesota River Basin HSPF model (2016-02-18 version; Tetra Tech 2015, Tetra Tech 2016), along with additional studies where available. The MPCA developed initial HSPF models for the Minnesota River basin in the 1990s and later expanded and refined the models (Tetra Tech 2015, Tetra Tech 2016). The HSPF models refined in 2016 were used to simulate phosphorus and TSS to support this TMDL effort. 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 2015, Tetra Tech 2016).

Within each subwatershed, the upland areas are separated into multiple land use categories. Simulated loads from upland areas represent the pollutant loads that reach the modeled stream or lake; the loading rates do not represent field-scale soil loss estimates. Note that modeled streams do not typically include ditches, ephemeral streams, or small perennial streams. The model evaluated both permitted and non-permitted sources including watershed runoff, near-channel, and wastewater point sources.

HSPF modeling results indicate that near-channel sources account for 72% of the TSS load in the Minnesota River–Mankato Watershed, and watershed runoff accounts for most of the remainder. Runoff from cropland areas was the dominant watershed runoff source at 27% of the total load. This is consistent with the observed TSS exceedances in the Minnesota River–Mankato Watershed, which typically occur during moderately high to high flow conditions when a high volume of water is running over cropland and through tile systems to waterways with higher erosive power than low flow conditions (Figure 10). Wastewater and permitted MS4 sources contributed negligible loads at 0.1% and less than 1%, respectively (Table 14). A detailed description of permitted and non-permitted sources of sediment is provided in the following sections.

Table 14. Summary of TSS sources in the Minnesota River–Mankato Watershed

Source	Percent Contribution of TSS Load [a]
Watershed runoff	**28%**
Cropland	27%
Feedlot	<1%
Pasture	<1%
Natural [b]	<1%
Urban runoff (permitted MS4)	<1%
Urban runoff (non-permitted)	1%
Near-channel	**72%**
Wastewater point sources	**0.1%**

a. Percentages are rounded to the nearest integer (except for wastewater point sources that were rounded to one-tenth of a percent). Percentages do not sum exactly due to rounding.
b. Forest, grassland, open water, and wetlands.

Permitted Sources of Sediment

Permitted pollutant sources evaluated as potential sources of sediment in the Minnesota River–Mankato Watershed include regulated stormwater and wastewater.

Regulated Stormwater

Permitted MS4s, industrial stormwater, and construction stormwater are potential sources of sediment to impaired streams. Untreated stormwater that runs off a construction site, an industrial site, or through a municipality is carried through stormwater pipes and discharged into surface waters. Along the way, it can pick up sediment and deliver it directly to a waterbody. Impervious areas (such as roads, driveways, and rooftops) can directly connect the location where sediment is deposited on the landscape to points where stormwater runoff carries sediment into surface waters. The watershed is predominantly rural; however, the small portion of permitted areas may be a source of sediment. TSS loading from permitted MS4 stormwater estimated with the HSPF model represents less than 1% of the total TSS load to the Minnesota River–Mankato Watershed (Table 14), and it is estimated that less than 0.1% of the project area is permitted through the construction stormwater permit.

Wastewater

Wastewater from municipal and industrial sources is a potential source of sediment to impaired waters in the watershed. NPDES permits limit the load or concentration of sediment, as TSS, that a municipal WWTP may discharge; the concentration limit is typically either 30 or 45 mg/L (as a calendar monthly average), which are protective of the 65 mg/L TSS stream standard.

Industrial wastewater often does not have a TSS concentration permit limit but is also expected to discharge at concentrations less than 65 mg/L TSS. Because the TSS concentration of wastewater effluent is typically below the stream standard, and because of its minimal TSS load contribution (Table 14), wastewater effluent is not considered a significant source of sediment to the impaired segments.

Non-Permitted Sources of Sediment

In the Minnesota River Basin, nonpoint sources are the largest sources of sediment (MPCA 2015a). Sediment in a stream is controlled by numerous, interrelated factors including hydrology, channel condition, and watershed land use. The primary non-permitted sources of sediment in the Minnesota River–Mankato Watershed are near-channel processes and watershed runoff from upland areas such as cropland (Table 14).

Near-Channel Sources

Near-channel sources of sediment are those in close proximity to the stream channel, including bluffs, banks, ravines, and the stream channel itself. Hydrologic changes in the landscape and altered precipitation patterns driven by climate change can lead to increased TSS in surface waters. Subsurface drainage tiling, channelization of waterways, land cover alteration, and increases in impervious surfaces all decrease detention time in the watershed and increase flows. Draining and tiling of wetland areas can decrease water storage on the landscape, which can lead to lower evapotranspiration and increased river flow (Schottler et al. 2014).

The straightening and ditching of natural rivers increases the slope of the original watercourse and moves water off the land at a higher velocity in a shorter amount of time. These changes to the way water moves through a watershed and how it makes its way into a river can lead to increases in water velocity, scouring of the river channel, and increased erosion of the river banks (Schottler et al. 2014, Lenhart et al. 2013).

Unregulated Watershed Runoff

Watershed runoff sources of sediment are largely the result of sheet, rill, and gully erosion occurring as water runs off over the land surface. High TSS levels can occur when heavy rains fall on unprotected soils, dislodging soil particles that are then transported by surface runoff into rivers and streams (MPCA and MSUM 2009). First-order streams, ephemeral streams, and gullies are typically higher up in the watershed and can flow intermittently, which makes them highly susceptible to disturbance. These sensitive areas have a very high erosion potential, which can be exacerbated by farming practices, but can also be protected by BMPs such as grassed waterways.

Agricultural activities such as livestock over-grazing and plowing or tilling crop fields can result in devegetated, exposed soil that is susceptible to erosion (EPA 2012). Cropland in the Minnesota River–Mankato Watershed ranges from 79% to 91% of the impaired subwatershed land cover. Thus, the majority of unprotected soil in the watershed is likely on agricultural fields. In certain locations, however, other land uses such as construction or insufficiently vegetated pastures can be the locally dominant source of TSS.

Tile drains with surface inlets can be direct sources of sediment load. Tile drains provide a pathway for water to be removed efficiently from the landscape. Without tile drains, snowmelt and/or stormwater would be held in the root zone for a longer period of time (weeks to months) than when tile drains are present. The water efficiently removed with tile drains also contains sediment from agricultural land that would otherwise potentially be trapped in vegetation. Tile drains also likely exacerbate sediment erosion from streambanks during both snowmelt and convective storms when flow is high. Sediment transport through tile drains is represented in the HSPF models, but is not well-constrained in the models by observations or explicit information on the density of surface inlets.

3.6.4 Nitrate Source Summary

In 2013, the MPCA conducted a statewide nitrogen study, *Nitrogen in Surface Waters* (MPCA 2013), which identified sources of nitrogen to surface waters in each major basin in Minnesota. The MPCA (2013) identified several potential sources of nitrogen to waterbodies on a statewide level:

- Livestock and poultry feedlots
- Municipal sewage effluents
- Industrial wastewater effluents
- Mineralization of soil organic matter
- Cultivation of nitrogen-fixing crop species (e.g., soybean, alfalfa, clover)
- Runoff/leaching/drainage of animal manure and inorganic nitrogen fertilizer
- Runoff from standing or burned forests and grasslands
- Urban and suburban runoff
- Septic system leachate and discharges from failed septic systems
- Emissions to the atmosphere from volatilization of manure and fertilizers and combustion of fossil fuels, and the subsequent atmospheric (wet and dry) deposition onto surface waters
- Activities that can mobilize nitrogen (e.g., biomass burning, land clearing and conversion, and wetland drainage)

The Minnesota River Basin, which contains the Minnesota River–Mankato Watershed, was one of the major basins evaluated in the report. Similar to the Minnesota River Basin as a whole, land use in the Minnesota River–Mankato Watershed is dominated by corn and soybean crops. In addition, both watersheds share similar topography and soils. As such, study results for the Minnesota River Basin were used to determine potential sources of nitrate to impaired waters in the Minnesota River–Mankato Watershed. Table 15 summarizes sources of nitrogen to the Minnesota River Basin during an average precipitation year. Agricultural drainage and agricultural groundwater contribute the majority of nitrogen loading in the Minnesota River Basin. Agricultural drainage overwhelmingly contributes the largest percentage. This is consistent with the observed nitrogen exceedances in the Minnesota River–Mankato Watershed, which typically occur during moderate to high flow conditions when tile drain volume is also typically high (Figure 11).

Nitrogen can be present in water bodies in several forms including ammonia, nitrite, and nitrate. The process in which nitrogen changes from one form to another is called the nitrogen cycle (Britannica 2019). Most nitrogen in waters starts as ammonia; ammonia is converted to nitrite, and then nitrite is converted to nitrate.

Table 15. Sources of nitrogen contributing to surface water loads in the Minnesota River Basin (MPCA 2013)

Source	Percent Contribution of Nitrogen Load
Agricultural groundwater	18%
Agricultural drainage	67%
Cropland runoff	4%
Point sources	5%
Atmospheric	3%
Nonpoint sources	2%
Forest	1%

Artificial agricultural drainage systems, such as tiling systems, are prevalent throughout the watershed due to the silt and loam soils of the area (MPCA 2016). Kronhom and Capel (2013), in a study throughout the Midwest, found that the highest nitrate yielding watersheds are those that have a dominant flow pathway of subsurface drainage. Soils in the Minnesota River–Mankato Watershed are typically loam or silt loam and actively drained. Considering the high agricultural land use in the Minnesota River–Mankato Watershed and high levels of nitrogen, agricultural drains are likely large contributors to nitrogen in surface water.

Agricultural groundwater is another source of nitrogen to surface waters in the watershed. Nitrogen can leach into groundwater from cropland where it then moves underground and can reach impaired streams through baseflow. The amount of time needed for groundwater nitrogen to reach surface water depends on the soil type and distance between the cropland and stream.

Nitrogen can also enter surface waters from cropland runoff. Fertilizers for crops contain high levels of phosphorus and nitrogen, which are both essential to crop production. Nutrients can be carried away with rainfall and erosion if applied in excess and not taken up by plant systems.

Atmospheric deposition and forest runoff also contribute small amounts of nitrogen to surface waters in the Minnesota River–Mankato Watershed. Nitrogen is bound to atmospheric particles that settle out of the atmosphere and are deposited directly onto surface water. Forested runoff is a potential contributor to nitrogen in impaired waters; however, forested land cover only accounts for 4% to 14% of land cover in the nitrate-impaired watersheds.

This source assessment identifies the potential priority nitrogen sources in the impaired watersheds. The HSPF model (Tetra Tech 2015, Tetra Tech 2016) could be used to further refine the estimates of nitrogen loading in the watershed.

3.6.5 Lake Phosphorus Source Summary

Phosphorus is an essential nutrient for aquatic and terrestrial life and is found naturally throughout a watershed. As such, there are several potential sources of phosphorus contributing excess amounts to impaired waterbodies. Where applicable, average annual phosphorus loads were estimated with the Minnesota River Basin HSPF model (see Section 3.6.1).

Because phosphorus has an affinity for sediment particles, TP is usually associated with suspended solids and/or contained in algal cells, whereas dissolved phosphorus generally is available for immediate uptake by aquatic organisms. This should be a consideration when assessing the mobility of phosphorus in the environment.

Permitted Sources of Phosphorus

Permitted sources of phosphorus include regulated stormwater and AFOs that either operate under NPDES/SDS permits and/or are federally defined CAFOs. There are no permitted wastewater facilities or regulated MS4s contributing to the impaired lakes.

Regulated Construction and Industrial Stormwater

Regulated construction and industrial stormwater is a potential source of phosphorus to impaired lakes. Untreated stormwater that runs off a construction or industrial site is carried through stormwater pipes and often discharged into surface waters. Along the way, it can pick up pollutants such as phosphorus and deliver them directly to a waterbody. Impervious areas (such as roads, rooftops, and airport runways) can directly connect the location where pollutants are deposited on the landscape to points where stormwater runoff carries them into surface waters.

Permitted Animal Feeding Operations

There is one NPDES permitted CAFO in the impaired lakes watersheds. Due to the requirement of permitted CAFOs to completely contain runoff, facilities that are permit compliant are not a source of phosphorus to surface waters. The phosphorus source assessment assumes that the permitted CAFO is in compliance.

Non-Permitted Sources of Phosphorus

Non-permitted pollutant sources to the impaired waterbodies include watershed runoff, tile drainage, septic systems, internal loading, upstream waterbodies, and atmospheric deposition.

Unregulated Watershed Runoff

Watershed runoff from non-permitted areas has the same source types and mechanisms of delivery as permitted stormwater runoff, discussed under point sources above. The developed areas in the impairment watersheds that are not regulated through an MS4 permit can be a source of phosphorus loads. In addition, animal waste is rich in nutrients such as phosphorus and nitrogen and may contribute to phosphorus loading to impaired lakes.

Phosphorus loads from watershed runoff were estimated with the Minnesota River Basin HSPF model (see Section 3.6.1). Modeled loading rates by land cover type were applied to the land covers based on area in each impaired lake watershed. The feedlot loading rate was applied to the total estimated feedlot area, based on the number of AUs in the MPCA's registered feedlot database.

Tile Drainage

Similar to sediment (Section 3.6.3), 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, but are implicitly included in the overall load estimates.

Septic Systems

Septic systems that function properly contribute less phosphorus than failing systems, which do not protect groundwater from contamination, or systems that are considered an IPHT. A conforming system is estimated to contribute on average 10% of the phosphorus that is found in the system, a failing system is estimated to contribute on average 30%, and an IPHT system is estimated to contribute on average 43% (assumptions from Barr Engineering 2004). The variety of reasons an SSTS may fail are provided in *Non-Permitted Sources of E. coli* in Section 3.6.2.

Phosphorus loads attributed to SSTSs were estimated for Washington Lake, Duck Lake, and Loon Lake. There are relatively few SSTSs along the shorelines of the other impaired lakes, and loading from SSTSs is expected to be insignificant relative to loading from watershed runoff to these lakes.

For Loon Lake, it was assumed that SSTSs within 1,000 feet of the lake's shoreline contribute phosphorus to the lakes. Households with SSTSs around Lake Washington and Duck Lake have been recently connected to municipal treatment plants, so SSTS loading is only be calculated to show past loading. The historical SSTSs sources for Washington and Duck Lakes (382, 126) were estimated from aerial imagery. Loon Lake has an estimated 31 SSTSs. The historical estimated percentages of failing systems for Washington Lake in Le Sueur County are based on 2000 through 2009 average percent failing (15%) and IPHT (14%) rates as reported in *Recommendations and Planning for Statewide Inventories, Inspections of Subsurface Sewage Treatment Systems* (MPCA 2011). Estimated failing (25%) and IPHT (20%) rates were reported by Blue Earth County in 2016 (Jesse Lee Anderson, Blue Earth County, personal communication) and were used for historical contributions to Duck Lake and current contributions to Loon Lake.

Phosphorus loads 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, an average of 2.55 people per household (Barr Engineering 2004), and an average value for phosphorus production per person per year (MPCA 2014).

Internal loading

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. 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 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 deeper lakes 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.
- Curly-leaf pondweed (*Potamogeton crispus*), which can reach nuisance levels in shallow lakes, decays in the early summer and releases phosphorus to the water column. It is not known if curly-leaf pondweed is present in the impaired lakes.
- 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 LakeFinder website indicate that carp and black bullhead are present in all lakes addressed in this TMDL report except for Wita Lake and Henry Lake; there are no fisheries data available for Wita and Henry 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 phosphorus budgets to calibrate the lake response models (see Section 4.9.1); these loads were attributed to internal loading. Internal loading rates are likely high in these lakes due to several factors, including shallow depths, lack of vegetation, bottom-feeding fish, and stagnant water conditions. However, a portion of the load that was attributed to internal loading in these lakes could be from watershed or septic system loads that were not quantified with the available data.

Upstream Waterbodies

Mills Lake is located in the Loon Lake Watershed, and Duck Lake and George Lake are located in the Washington Lake Watershed. Loads from Mills, Duck, and George Lakes were estimated as the average growing season lake phosphorus concentration (Appendix A) multiplied by the average flow at the lake outlet (Appendix C).

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 Minnesota River Basin (0.42 kilograms per hectare per year, Barr Engineering 2007).

Summary

The phosphorus source assessment results for the impaired lakes are presented in Table 16.

Table 16. Phosphorus source assessment for impaired lakes

Lake Name (ID)	Watershed Loading by Land Cover Type						SSTS [a]	Internal Loading [b]	Atmospheric Deposition	Up-stream Lakes [c]
	Forest	Crop	Grass/ Pasture	Wet-land	Feed-lots	Urban				
TP Load (lb/yr)										
George (07-0047-00)	5	358	11	4	–	24	–	64	33	–
Duck (07-0053-00)	2	450	6	6	–	37	159	400	109	–
Wita (07-0077-00)	4	474	4	9	–	42	–	1,047	127	–
Loon (07-0096-00)	2	1,337	2	17	–	46	39	2,850	304	173
Mills (07-0097-00)	1	299	<1	6	14	7	–	1,446	89	–
Henry (40-0104-00)	1	332	2	9	10	8	–	7,256	131	–
Scotch (40-0109-00)	19	6,551	67	36	5	139	–	5,359	224	–
Washington (40-0117-00)	24	5,070	109	64	17	234	390	297	569	254
TP Load (percent)										
George (07-0047-00)	1%	71%	2%	1%	–	5%	–	13%	7%	–
Duck (07-0053-00)	<1%	39%	<1%	1%	–	3%	14%	34%	9%	–
Wita (07-0077-00)	<1%	28%	<1%	1%	–	2%	–	62%	7%	–
Loon (07-0096-00)	<1%	28%	<1%	<1%	–	1%	1%	60%	6%	4%
Mills (07-0097-00)	<1%	16%	<1%	<1%	1%	<1%	–	78%	5%	–
Henry (40-0104-00)	<1%	4%	<1%	<1%	<1%	<1%	–	94%	2%	–
Scotch (40-0109-00)	<1%	54%	1%	<1%	<1%	1%	–	42%	2%	–
Washington (40-0117-00)	<1%	72%	2%	1%	<1%	3%	6%	4%	8%	4%

a. Loads from SSTSs from Loon Lake and historical SSTSs from Washington and Duck lakes were estimated only for lakes with a high density of shoreline residential properties.
b. 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.
c. The upstream lake in the Loon Lake Watershed is Mills Lake, and the upstream lakes in the Washington Lake Watershed are Duck Lake and George Lake.

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).

A summary of the allowable pollutant loads is presented in this section. The allocations for each of the various sources and parameters are provided in Appendix A.

4.1 Overall Approach

Streams: Assimilative loading capacities for the streams were developed using load duration curves (Cleland 2002). 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. 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 (Appendix A).

The TMDLs in this report present needed reductions differently depending on the parameter. Lake eutrophication TMDLs provide both an overall needed reduction and individual source (or source category) reductions. Other TMDLs provide only an “overall estimated percent reduction.” As the term implies, these overall reductions provide a rough approximation of the overall reduction needed for the waterbody to meet the TMDL. They should not be construed to mean that each of the separate sources listed within the TMDL table need to be reduced by that amount.

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 (Appendix A), 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.

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 United States 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 2016; 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 high quality of modeling, as described below.

The Minnesota River HSPF model was calibrated and validated using 57 stream flow gaging stations, with at least 3 gaging stations for each HUC-8 watershed; 11 of the stream flow gaging stations are in the Minnesota River–Mankato Watershed (Tetra Tech 2015). Of the stations in the Minnesota River–Mankato Watershed: three gaging stations have long-term, continuous flow records; three have long-term, seasonal flow records; and five have short-term, seasonal flow records. Sixty-three stream water quality stations were used for the Minnesota River Watershed sediment calibration and corroboration; all stations have at least 100 TSS samples from the simulation period. Of the 63 stations in the Minnesota River Watershed, eight are in the Minnesota River–Mankato Watershed (Tetra Tech 2016). 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 either HSPF-simulated daily flow data or long term monitoring data. Where monitoring data were used, the flow data consist of over 13 years of daily flow records.

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 C 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 stream 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. Using this approach, it has been determined that load reductions are needed for specific flow conditions.

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 2006 through 2015. The baseline year for implementation is 2010, the midpoint of the time period. 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 regulated through the Construction Stormwater General Permit MNR100001, and a single categorical WLA for construction stormwater is provided for each waterbody with a TSS, nitrate, or phosphorus impairment. The average annual percent area of each county that is regulated 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 regulated through the General Permit MNR050000 for Industrial Stormwater Multi-Sector. A single categorical WLA for industrial stormwater is provided for each impaired waterbody with a TSS, nitrate, or phosphorus impairment. Permitted industrial stormwater sources are not expected to be sources of *E. coli* and are not provided WLAs. The 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 watershed areas, and the industrial stormwater WLA for each impaired waterbody 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. In the allocation tables presented in Appendix A, these two categorical WLAs are combined into one line item and referred to as "WLA for Construction and Industrial Stormwater."

4.6 *E. coli*

4.6.1 Loading Capacity and Percent Reductions

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 class 7 streams). 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.

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. If *E. coli* data are not available from 2006 through 2015, the percent reduction was calculated based on *E. coli* data from 2000 through 2005 and/or fecal coliform data translated to *E. coli* concentration (see Section 3.5.2).

4.6.2 Wasteload Allocation Methodology

WLAs are provided for municipal WWTPs and for permitted MS4 communities. Because permitted AFOs and CAFOs are required to completely contain runoff, 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 facility's average wet weather design flow (AWWDF; Appendix B). For WWTPs with controlled discharge, the maximum daily discharge volume for each facility was used.

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 Appendix A and in the overall WLA table in Appendix B.

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 regulated as a point source and, therefore, must be included in the WLA portion of a TMDL. The 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.

Under phase II of the NPDES 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.

Under the NPDES stormwater program, MS4 entities are required to obtain a permit, then develop and implement an MS4 SWPPP, which outlines a plan to reduce pollutant discharges, protect water quality, and satisfy water quality requirements in the CWA. An annual report is submitted to the MPCA each year by the permittee documenting progress on implementation of the SWPPP. 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, and stormwater ponds.

The phase II general NPDES/SDS municipal stormwater permit for MS4 communities has been issued to cities, townships, and counties in the watershed. Stormwater conveyed from these systems is a regulated point source and, therefore, must be included in the WLA portion of the TMDL.

There are seven permitted MS4s in the *E. coli* impairment watersheds (Table 17). The regulated MS4 areas within each impairment watershed were determined using the following approaches:

- **City, Township, and Nontraditional MS4s:** Approximated using developed land within their jurisdictional boundaries. Developed land includes developed land cover classes in the 2011 National Land Cover Database: open space, low intensity, medium intensity, and high intensity.

- **County MS4s:** The MS4 permits for the permitted road authorities apply to roads within the U.S. Census Bureau 2010 urban area. The regulated roads and rights-of-way were approximated by the county road lengths (county and county state aid highways in the Minnesota Department of Transportation's [MnDOT's] STREETS_LOAD shapefile[1]) in the 2010 urban area multiplied by an average right-of-way width of 90 feet on either side of the centerline.

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

Table 17. Regulated MS4s that are part of the *E. coli* individual MS4 wasteload allocations

MS4 Permittee	Permit Number	Impaired Reach (AUID)							
		Crow Creek (569)	Minneopa Creek (534)	Unnamed Creek (604)	Unnamed Creek (603)	Unnamed Creek (602)	Unnamed Creek (600)	Unnamed Ditch (598)	Rogers Creek / County Ditch 78 (613)
Blue Earth County MS4	MS400276			✓	✓	✓	✓	✓	
Mankato City MS4	MS400226			✓	✓	✓	✓	✓	
Mankato Township MS4	MS400297			✓	✓	✓	✓	✓	
Minnesota State University –Mankato MS4	MS400279							✓	
Redwood Falls City MS4	MS400236	✓							
Skyline City MS4	MS400292						✓	✓	
South Bend Township MS4	MS400299		✓		✓	✓	✓	✓	
St. Peter City MS4	MS400245								✓

4.6.3 Load Allocation Methodology

Once the WLA and MOS were determined for each watershed and subtracted from the LC, the remaining pollutant load was allocated to the LA. The LA includes nonpoint pollution sources that are not subject to NPDES Permit requirements, as well as "natural background" sources. "Natural background" is defined in both Minnesota rule and statute: Minn. R. 7050.0150, subp. 4 "Natural causes" means the multiplicity of factors that determine the physical, chemical or biological conditions that would exist in the absence of measurable impacts from human activity or influence." The Clean Water Legacy Act (Minn. Stat. § 114D.10, subd. 10) defines natural background as "characteristics of the water body resulting from the multiplicity of factors in nature, including climate and ecosystem dynamics that affect the physical, chemical or biological conditions in a water body, but does not include measurable and distinguishable pollution that is attributable to human activity or influence."

[1] "Roads, Minnesota, 2012" downloaded from https://gisdata.mn.gov/dataset/trans-roads-mndot-tis,

Natural background sources of *E. coli* are inputs that would be expected under natural, undisturbed conditions. The relationship between bacterial sources and bacterial concentrations found in streams is complex, involving precipitation and flow, temperature, livestock management practices, wildlife activities, survival rates, land use practices, and other environmental factors. Two Minnesota studies described the potential for the presence of “naturalized or indigenous” *E. coli* in watershed soils (Ishii et al. 2006), ditch sediment, and water (Chandrasekaran et al. 2015). Chandrasekaran et al. (2015) conducted DNA fingerprinting of *E. coli* in sediment and water samples from Seven Mile Creek, located in Minnesota River – Mankato Watershed. They concluded that roughly 63.5% were represented by a single isolate, suggesting new or transient sources of *E. coli*. The remaining 36.5% of strains were represented by multiple isolates, suggesting persistence of specific *E. coli*. The study indicates that between the four sites sampled during the study period an average of 12% of all *E. coli* isolated were a “persistent strain”. However, for each impairment, natural background levels are implicitly incorporated in the water quality standards used by the MPCA to determine/assess impairment, and therefore natural background is accounted for and addressed through the MPCA’s waterbody assessment process. Natural background conditions were also evaluated as part of the source assessment. The source assessment exercises indicate that natural background inputs are generally low compared to livestock, cropland, and failing SSTSs.

Based on the MPCA’s waterbody assessment process and the TMDL source assessment exercises, there is no evidence at this time to suggest that natural background sources are a major driver of 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 Total Suspended Solids

4.7.1 Loading Capacity and Percent Reductions

The loading capacity was calculated as flow multiplied by the TSS standard (65 mg/L). The existing concentration for each impairment was calculated as the 90th percentile of observed TSS concentrations from the months that the standard applies (April through September). The 90th percentile was used because the TSS standard states that the numeric criterion (65 mg/L) may be exceeded for no more than 10% of the time. The overall estimated percent reduction needed to meet each TMDL was calculated as the existing concentration minus the TSS standard (65 mg/L) divided by the existing concentration. This calculation approximates the reduction in concentration needed to meet the standard. The percent reductions reported in the TMDL tables in Appendix A represent the overall reductions needed to meet the TMDLs but do not necessarily apply to each of the sources/allocations individually.

4.7.2 Wasteload Allocation Methodology

WLAs are provided for municipal and industrial wastewater, permitted MS4s, and permitted construction and industrial stormwater.

Wastewater

In the Minnesota River–Mankato Watershed, six wastewater facilities are authorized through NPDES permits to discharge TSS; these facilities received WLAs. These permitted facilities include municipal and industrial facilities. Individual WLAs were developed for each wastewater facility, and WLAs were calculated using information in the facilities' NPDES permits:

- **Load Limit:** When a permit defined a calendar monthly average TSS load limit, that limit was used as the WLA.
- **Design Flow and Concentration Limits:** When a permit did not define a TSS load limit but did define one or more design flows and TSS concentration limits, the WLA was calculated using a design flow and a concentration limit. If an AWWDF was defined, it was used to calculate the WLA; if the AWWDF was not defined, then the maximum design flow was used to calculate the WLA. If a monthly average TSS concentration limit was defined, then that limit was used to calculate the WLA; if only a daily maximum concentration limit was defined, then that limit was used to calculate the WLA.
- **No Design Flow and Concentration Limits:** If a permit did not define a design flow, the WLA was calculated using an estimated design flow and the TSS concentration limit. The design flow was estimated as the average reported flows for similar sites in the vicinity of the project area.

All the WLAs are based on TSS concentration limits less than or equal to the TSS standard of 65 mg/L. Therefore, facilities that discharge consistent with their WLAs are not a cause for in-stream exceedances of the TSS standard within their receiving water bodies. WLAs were calculated for any "surface discharge" outfall that discharged wastewater from a waste-stream that could contain TSS.

The total daily loading capacity in the low flow zone for some reaches is less than the permitted wastewater treatment facility design flows. 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 65 mg/L (or NPDES permit concentration)

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.

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. Background on permitted MS4s and the approach to determining the permitted MS4 boundaries can be found in the *E. coli* TMDL approach description in Section 4.6.1. There is one permitted MS4 in the TSS impairment watersheds—South Bend Township (MS400299), which is in the Minneopa Creek (07020007-534) Watershed. The WLA for the permitted MS4 was calculated as the percent area of each permitted MS4 multiplied by the loading capacity minus the MOS minus wastewater WLAs.

Construction and Industrial Stormwater WLAs

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

4.7.3 Load Allocation Methodology

After allocations to wastewater, regulated stormwater, and the MOS were determined for each reach and flow zone, the remaining loading capacity was allocated to the LA. The LA includes nonpoint pollution sources that are not subject to permit requirements, including near-channel sources and watershed runoff. The LA also includes natural background sources of sediment.

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; wildlife; and loading from grassland, forests, and other natural land covers. Refer back to Section 4.6.3 for the definition of natural background provided by the Clean Water Legacy Act (Minn. Stat. § 114D.10, subd. 10) and Minn. R. 7050.0150, subp. 4.

In a study of the Lake Pepin Watershed, Engstrom et al. (2009) found that sediment loads have increased about one order of magnitude since presettlement times. The MPCA uses the year 1830 as a reference point for measuring the beginning of anthropogenic effects on the TSS loads, based on estimates from Lake Pepin sediment cores. This period is prior to European settlement, which introduced dramatic changes to the landscape. These changes consisted primarily of converting more than 90% of native prairie and wetlands to agriculture through tillage and artificial drainage, along with the introduction of annual row crops. Schottler et al. (2010, p. 32) further explain that the land form that creates the potential for high erosion rates is natural, but today's high rates of erosion and sediment concentration are not natural:

> Because of geologic history, non-field sources such as bluffs and large ravines are natural and prevalent features in some watersheds. Consequently, these watersheds are predisposed to high erosion rates. However, it would be highly inaccurate to label this phenomenon as natural. Post-settlement increases in sediment accumulation rates in Lake Pepin, the Redwood Reservoir … and numerous lakes in agricultural watersheds … clearly show that rates of sediment erosion have increased substantially over the past 150 years. Coupling these observations with the non-field sediment yields determined in this study, demonstrates that the rate of non-field erosion must also have increased. The features and potential for non-field erosion may be natural, but the rate is not.

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

Based on the MPCA's waterbody assessment process and the TMDL source assessment exercises, there is no evidence at this time to suggest that natural background sources are a major driver of the impairments and/or affect their ability to meet state water quality standards. For all impairments addressed in this 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. Whereas the South Metro Mississippi River TSS TMDL (MPCA 2015a) provides explicit allocations for natural background conditions based on the order of magnitude increase in sedimentation since pre-European settlement times reported in Engstrom et al. (2009), the observed increase applies to the Minnesota River Basin as a whole. The method used to develop the natural background load for the Minnesota River Basin does not allow it to be extrapolated into the smaller watersheds of the individual impairments located throughout the basin.

4.8 Nitrate

4.8.1 Loading Capacity and Percent Reductions

The loading capacity was calculated as flow multiplied by the nitrate standard (10 mg/L). The MPCA's assessment procedure for nitrate impairment (MPCA 2017a) allows for one exceedance of the standard in three years. To allow this one exceedance, the existing concentration for each impairment was calculated as the second highest existing concentration relative to 10 mg/L. The overall estimated percent reduction needed to meet each TMDL was calculated as the existing concentration minus the nitrate standard (10 mg/L) divided by the existing concentration. This calculation approximates the reduction in concentration needed to meet the standard.

4.8.2 Wasteload Allocation Methodology

There are no permitted wastewater facilities or permitted MS4s discharging to nitrate-impaired segments; therefore, no WLAs are provided for these sources. A categorical WLA is provided for construction and industrial stormwater. See Section 4.5 for more details.

4.8.3 Load Allocation Methodology

The LA for each nitrate TMDL was calculated as the loading capacity minus the MOS minus the WLAs. The LA includes nonpoint pollution sources that are not subject to permit requirements, including agricultural drainage, agricultural groundwater, and watershed runoff. Refer back to Section 4.6.3 for the definition of natural background provided by the Clean Water Legacy Act (Minn. Stat. § 114D.10, subd. 10) and Minn. R. 7050.0150, subp. 4.

The LA also includes natural background sources of nitrate, which are primarily from soils that have not been impacted by human activities. For each impairment, natural background levels are implicitly incorporated in the water quality standards used by the MPCA to determine/assess impairment, and therefore natural background is accounted for and addressed through the MPCA's waterbody assessment process. Natural background conditions were also evaluated, where possible, within the source assessment portion of this study. The source assessment exercises indicate that natural background inputs are generally low compared to agricultural groundwater, agricultural drainage, and other anthropogenic sources.

Based on the MPCA's waterbody assessment process and the TMDL source assessment exercises, there is no evidence at this time to suggest that natural background sources are a major driver of 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.

4.9 Phosphorus

4.9.1 Loading Capacity and Load Reduction

The BATHTUB models were calibrated to the long term average phosphorus concentration, consisting of all data from 2006 through 2015 (see Appendix A for a summary of existing water quality data). Annual precipitation from HSPF was used as input to the BATHTUB models. The complete model inputs and outputs are presented in Appendix C.

The models within BATHTUB inherently include an internal load that is typical of lakes in the model development data set. The data suggest that internal loads are greater than the average rates inherent in BATHTUB, and additional internal loads were included during model calibration. After the model was calibrated, the TMDL scenario was developed by reducing phosphorus load inputs until the lake TP standard was met. The total load to the lake in the 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.

4.9.2 Wasteload Allocation Methodology

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. Background on permitted MS4s and the approach to determining the permitted MS4 boundaries can be found in the *E. coli* TMDL approach description in Section 4.6.1. There is one permitted MS4 in the impaired lake watersheds—the City of Mankato (MS400226). However, the portion of the city that is in an impaired lake watershed (Wita Lake) is regulated under the industrial stormwater permit for the Mankato Regional Airport (MNR0538PJ) and is therefore covered by the airport's WLA (see following paragraph). The City of Mankato does not own or operate any regulated conveyances in the Wita Lake Subwatershed, and does not have a benchmark monitoring requirement for phosphorus. The airport does not receive a WLA, and there are no WLAs for permitted MS4s in the lake TMDLs.

Construction and Industrial Stormwater WLAs

The Mankato Regional Airport (MNR0538PJ) is a permitted industrial stormwater site located in the Wita Lake Watershed. The airport falls under subsector S2 of the MPCA's industrial stormwater program: Airports that use less than 100,000 gallons of glycol-based deicing/anti-icing chemicals and/or less than 100 tons of urea on an average annual basis. Glycol-based deicing chemicals are a source of biochemical oxygen demand but are not expected to be a source of phosphorus. Urea is a nitrogen-based compound and also is not expected to be a phosphorus source. The facility has benchmark monitoring requirements for TSS, carbonaceous biochemical oxygen demand, chemical oxygen demand, and total ammonia; the facility does not have a benchmark monitoring requirement for phosphorus. Therefore, the airport does not have receive a WLA. However, the imperviousness associated with the airport is a concern regarding phosphorus loading to Wita Lake.

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

Feedlots

For the Minnesota River–Mankato Watershed TMDL, all NPDES and SDS permitted feedlots are designed to have zero discharge and as such, they do not receive a WLA. All other non-permitted feedlots and the land application of all manure are accounted for in the LA for nonpoint sources.

4.9.3 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 permit (e.g., unregulated watershed runoff, tile drainage, septic systems, and internal loading). The LA for each phosphorus TMDL was calculated as the loading capacity minus the MOS minus the WLAs.

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. Refer back to Section 4.6.3 for the definition of natural background provided by the Clean Water Legacy Act (Minn. Stat. § 114D.10, subd. 10) and Minn. R. 7050.0150, subp. 4.

For each impairment, natural background levels are implicitly incorporated in the lake phosphorus water quality standards used by the MPCA to determine/assess impairment and therefore natural background is accounted for and addressed through the MPCA's waterbody assessment process. Natural background conditions were also evaluated, where possible, within the modeling and source assessment portion of this study. The source assessment exercises indicate that natural background inputs are generally low compared to livestock, cropland, failing SSTSs, and other anthropogenic sources. Appendix C provides load estimates from the different TP sources for each lake, and could be referenced as a way to generally target implementation efforts for each lake.

Based on the MPCA's waterbody assessment process and the TMDL source assessment exercises, there is no evidence at this time to suggest that natural background sources are a major driver of 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.

5. TMDL Summaries

The estimated percent reductions needed to meet the TMDLs range from 12% to 96% (Table 18). Two reaches with TSS impairments (reaches 679 and 703) do not require TSS reductions to meet their TMDL; these reaches were originally listed in 2006 based on turbidity data. There is a lack of current data to delist waterbodies from the impaired waters list. The MPCA will reevaluate these reaches in the next impairment assessment for this watershed when more data is expected to be available. Appendix A includes the TMDL tables and load duration curves for all the impairments addressed in this report, organized by watershed group.

The load duration curves (Appendix A and Figure 9), when taken as a whole, indicate that exceedances of the *E. coli* standard occur across all flow regimes. Load reductions are needed to address multiple source types (see Section 3.6.2: *E. coli Source Summary*).

Most of the exceedances of the TSS standard occur during moderately high to high flow conditions (Figure 10). High TSS concentrations under high flows are typically due to upland runoff and near-channel sources and are associated with precipitation and/or snowmelt events (see Section 3.6.3: *Sediment Source Summary*).

Most of the exceedances of the nitrate standard also occur during moderate to high flows (Figure 11), indicating that the reductions will need to come from sources such as agricultural drainage (see Section 3.6.4: *Nitrate Source Summary*).

Reductions in phosphorus are presented on an average annual basis and will need to come primarily from cropland runoff and internal loading (see Section 3.6.5: *Phosphorus Source Summary*).

Table 18. Summary of load reductions per impaired waterbody

Watershed Group	Waterbody Name	AUID / Lake ID	Reduction (%)			
			E. coli	TSS	Nitrate	Phosphorus
Minnesota River–New Ulm	Crow Creek	569	91	–	–	–
	Birch Coulee Creek	587	66	–	–	–
	Purgatory Creek	645	87	–	–	–
	Wabasha Creek	527	90	–	–	–
	Three-Mile Creek	704	27	–	–	–
	Unnamed creek	644	81	–	–	–
	Fort Ridgley Creek	689	47	–	–	–
	Spring Creek (Judicial Ditch 29)	622	70	–	–	–
	Spring Creek	573	81	–	–	–
	County Ditch 13	712	83	–	–	–
	County Ditch 10 (John's Creek)	571	90	–	52	–
	Little Rock Creek (Judicial Ditch 31)	687	79	–	–	–
	Eight-Mile Creek	684	78	–	–	–
	Huelskamp Creek	641	69	–	–	–
	Fritsche Creek (County Ditch 77)	709	69	–	–	–
	Heyman's Creek	640	76	–	–	–

Watershed Group	Waterbody Name	AUID / Lake ID	Reduction (%)			
			E. coli	TSS	Nitrate	Phosphorus
Little Cottonwood River–Nicollet	Altermatts Creek	518	12	–	–	–
	Little Cottonwood River	676	80 [a]	58	–	–
	Little Cottonwood River	677	72	78	–	–
	Morgan Creek	691	66	–	–	–
	Unnamed creek	577	–	–	57	–
	Swan Lake Outlet (Nicollet Creek)	683	84	–	–	–
	County Ditch 56 (Lake Crystal Inlet)	557	80	–	–	–
	Mills Lake	07-0097-00	–	–	–	74
	Loon Lake	07-0096-00	–	–	–	56
	Minneopa Creek	534	87	35	–	–
Mankato–St. Peter	Unnamed creek	604	92 [a]	–	–	–
	Unnamed creek	603	75 [a]	–	–	–
	Unnamed creek	602	84 [a]	–	–	–
	Unnamed creek	600	88 [a]	–	–	–
	Unnamed ditch	598	95 [a]	–	–	–
	Wita Lake	07-0077-00	–	–	–	75
	County Ditch 46A	679	85	– [b]	–	–
	Seven-Mile Creek	703	73	– [b]	–	–
	Unnamed creek (Seven-Mile Creek Tributary)	637	88	–	–	–
	Seven-Mile Creek	562	40	96	75	–
	Duck Lake	07-0053-00	–	–	–	72
	George Lake	07-0047-00	–	–	–	69
	Washington Lake	40-0117-00	–	–	–	60
	Henry Lake	40-0104-00	–	–	–	91
	Shanaska Creek	693	60	–	–	–
	Rogers Creek (County Ditch 78)	613	71	–	–	–
	Scotch Lake	40-0109-00	–	–	–	82

a. *E. coli* data either do not exist or are limited. The percent reduction was calculated based on *E. coli* data from 2000–2005 and/or fecal coliform data translated to *E. coli* concentration (see section 3.5.2).

b. This impairment was originally listed in 2006 based on turbidity data; however, the TSS data presented in this report do not show impairment. The MPCA will reevaluate the reach in the next impairment assessment for this watershed.

– Waterbodies indicated with "–" are not impaired by the indicated pollutant.

6. Future Growth Considerations

6.1 New or Expanding Permitted MS4 WLA Transfer Process

Future transfer of watershed runoff loads in this TMDL might be necessary if any of the following scenarios occur within the project watershed boundaries:

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

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

6.2 New or Expanding Wastewater

The MPCA, in coordination with 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 applies to the TSS and *E. coli* TMDLs in this report, and will be used to update WLAs in approved TMDLs for new and expanding wastewater dischargers whose permitted effluent limits are at or below the in-stream 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 EPA input and involvement, 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 appropriate updates will be made to the TMDL WLA(s).

Additional reserve capacity was not added for phosphorus in municipal wastewater. There are no existing municipalities within the phosphorus impaired watersheds that are not already covered by a WLA for municipal wastewater. For more information on the overall process, visit the MPCA's TMDL Policy and Guidance web page.

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 Minnesota River–Mankato Watershed, 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 permit programs, as described in Section 3.6.

A considerable amount of implementation work has already been accomplished throughout the Minnesota River – Mankato Watershed. Since 2004, over $27 million dollars (Figure 15) has been spent in the watershed to address water quality concerns. The true amount spent may be significant higher as this amount only represents monies spent through some of the government programs of the USDA-NRCS, Minnesota Public Facilities Authority, BWSR, MDA and MPCA.

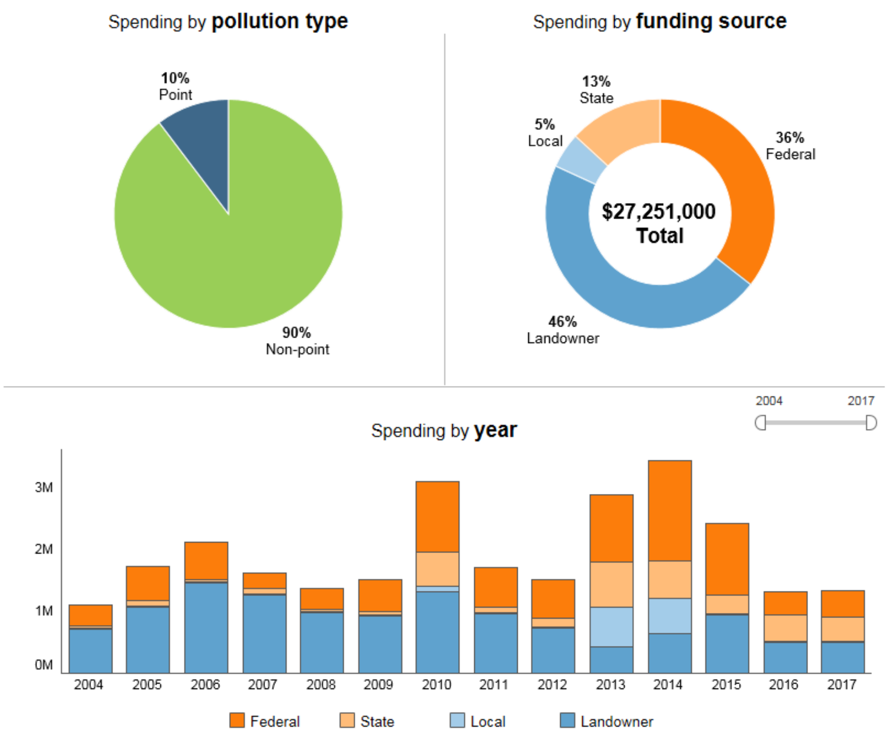


Figure 15. Pollution prevention spending in the Minnesota River – Mankato Watershed

7.1 Regulatory Approaches

MS4 Permitted Sources

The MPCA is responsible for applying federal and state regulations to protect and enhance water quality in the State of Minnesota. The MPCA oversees stormwater management accounting activities for all MS4 entities previously listed in this TMDL study. The Small MS4 General Permit requires regulated municipalities to implement BMPs that reduce pollutants in stormwater to the maximum extent practicable. A critical component of permit compliance is the requirement for the owners or operators of a regulated MS4 conveyance to develop a SWPPP. The SWPPP addresses all permit requirements, including the following six measures:

- Public education and outreach
- Public participation
- Illicit Discharge Detection and Elimination Program
- Construction site runoff controls
- Post-construction runoff controls
- Pollution prevention and municipal good housekeeping measures

A SWPPP is a management plan that describes the MS4 permittees' activities for managing stormwater within their regulated area. In the event of a completed TMDL study, MS4 permittees must document the WLA in their future NPDES/SDS Permit application, and provide an outline of the BMPs to be implemented that address any needed reductions. The MPCA requires MS4 owners or operators to submit their application and corresponding SWPPP document to the MPCA for their review. Once the application and SWPPP are deemed adequate by the MPCA, all application materials are placed on 30-day public notice, allowing the public an opportunity to review and comment on the prospective program. Once NPDES/SDS Permit coverage is granted, permittees must implement the activities described within their SWPPP, and submit an annual report to the MPCA documenting the implementation activities completed within the previous year, along with an estimate of the cumulative pollutant reduction achieved by those activities. For information on all requirements for annual reporting, please see the Minnesota Stormwater Manual.

This TMDL assigns TP, TSS, *E. coli*, and Nitrate WLAs to permitted MS4s in the study area (Section 4). The Small MS4 General Permit requires permittees to develop compliance schedules for EPA approved TMDL WLAs not already being met at the time of permit application. A compliance schedule includes BMPs that will be implemented over the permit term, a timeline for their implementation, and a long term strategy for continuing progress towards assigned WLAs. For WLAs being met at the time of permit application, the same level of treatment must be maintained in the future. Regardless of WLA attainment, all permitted MS4s are still required to reduce pollutant loadings to the maximum extent practicable.

The MPCA's stormwater program and its NPDES Permit program are regulatory activities providing reasonable assurance that implementation activities are initiated, maintained, and consistent with WLAs assigned in this study.

Regulated Construction Stormwater

Regulated construction stormwater was given a categorical TMDL is this study (combined with industrial stormwater). However, construction activities disturbing one acre or more in size are still required to obtain NPDES Permit coverage through the MPCA. Compliance with TMDL requirements are assumed when a construction site owner/operator meets the conditions of the Construction General Permit and properly selects, installs, and maintains all BMPs required under the permit, including any applicable additional BMPs required in Appendix A of the Construction General Permit for discharges to impaired waters, or compliance with local construction stormwater requirements if they are more restrictive than those in the State General Permit.

Regulated Industrial Stormwater

Industrial stormwater was combined into a categorical stormwater WLA in this study (combined with construction stormwater). Industrial activities still require permit coverage under the State's NPDES/SDS Industrial Stormwater Multi-Sector General Permit (MNR050000), or NPDES/SDS General Permit for Construction Sand & 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, their discharges are considered compliant with WLAs set in this study.

7.2 Example Non-Permitted Source Reduction Programs

Several non-permitted reduction programs exist to support implementation of nonpoint source reduction BMPs in the Minnesota River Basin. 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.

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 permitted in the state of Minnesota. While larger feedlots are permitted, there are numerous smaller lots in the watershed that are only registered by counties and do not have permits. The focus of the rule is on animal feedlots and manure storage areas that have the greatest potential for environmental impact.

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 2017b). All of the major counties within the Minnesota River–Mankato Watershed are delegated counties with the exception of Redwood and Sibley. In these counties, the MPCA is tasked with running the Feedlot Program. Since 2012, there has been 421 feedlot facility inspections in the Minnesota River - Mankato Watershed, with 315 of those inspection occurring at non-CAFO facilities and 106 at CAFO facilities. There has been an additional 76 manure application reviews within the watershed. Thirty-one of those inspections were conducted at CAFO facilities and 45 at non-CAFO facilities.

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 SSTS Implementation and Enforcement Task Force (SIETF). Members of the SIETF 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 IPHT and enforce all violation of the SSTS rules (See report to the legislature; MPCA 2011)
- Assisting MPCA in providing counties with enforcement protocols and inspection checklists

Each County within the Minnesota River – Mankato Watershed has ordinances establishing minimum requirements for regulation of SSTS for the treatment and dispersal of sewage within the applicable jurisdiction of the County to protect public health and safety, groundwater quality, and prevent or eliminate the development of public nuisances. Ordinances serve the best interests of the County's citizens by protecting its health, safety, general welfare, and natural resources. In addition, each county zoning ordinance prescribes the technical standards that on-site septic systems are required to meet for compliance and outlines the requirements for the upgrade of systems found not to be in compliance. This includes systems subject to inspection at transfer of property, upon the addition of living space that includes a bedroom and/or a bathroom, and at discovery of the failure of an existing system. Since 2002, the counties within Minnesota River - Mankato Watershed have, on average, upgraded/replaced 426 systems per year (Figure 16).

Currently, a system is in place in the state such that when a straight pipe system or other IPHTs location is confirmed, county health departments send notices of non-compliance. Upon doing do, a 10-month deadline is set for the system to be brought into compliance. All known IPHTs 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. Since 2014, the Clean Water Partnership Loan Program has awarded $1.07 million to local partners to provide low interest loans for SSTS upgrades. More information on SSTS financial assistance can be found at the following address: https://www.pca.state.mn.us/water/ssts-financial-assistance.

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. 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. ch. 103E, a 16.5-foot minimum width continuous buffer

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 allowed landowners to be granted a compliance waiver until July 1, 2018, when they 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 at https://bwsr.state.mn.us/where-can-i-find-buffer-maps.Table 19 summarizes the level of compliance for public waters estimates for counties located within the Minnesota River–Mankato Watershed as of January 2019

Table 19. Preliminary compliance with Minnesota Buffer Law as of January 2019 (BWSR)

County	Preliminary compliance with MN Buffer Law (%)
Blue Earth	90 - 94%
Brown	80 - 89%
Cottonwood	90 - 94%
Le Sueur	95 - 100%
Nicollet	70 - 79%
Redwood	80 - 89%
Renville	80 - 89%
Sibley	80 - 89%

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. Since the start of the program in 2014 through summer of 2019, the Ag Water Quality Certification Program has, statewide:

- Enrolled 476,433 acres;
- Included 720 producers;
- Added more than 1,466 new conservation practices;

In the Minnesota River – Mankato Watershed 6,236 acres have been enrolled by 13 different producers.

Groundwater Protection Rule

In June of 2019, the final Groundwater Protection Rule was finalized and published in the Minnesota State Register. This new rule will regulate nitrogen application in vulnerable groundwater areas. The rule will become effective January 1, 2020. The rule contains two parts and farmers may be subject to one part of the rule, both, or none at all depending on geographic location.

Part one restricts fall application of nitrogen fertilizer if a farm is located in a vulnerable groundwater area where at least 50% or more of a quarter section is designated as vulnerable or a public water drinking supply management area (DWSMA) with nitrate-nitrogen testing at least 5.4 mg/L in the previous 10 years. Once the rule is effective, fall application restrictions will being in the fall of 2020.

Part two will apply to farming operations in a DWSMA with elevated nitrate levels and farms will be subject to a sliding scale of voluntary and regulatory actions based on the concentration of nitrate in the well and the use of BMPs. In part two, no regulatory action will occur until after at least three growing seasons once a DWSMA is determined to meet the criteria for level two.

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 2016).

Agriculture Research, Education and Extension Technology Transfer Program (AGREETT)

The purpose of AGREETT is to support agricultural productivity growth through research, education and extension services. Since 2015, when the AGREETT program was established by the state legislature, significant progress has been made toward restoring and expanding capacity and research capabilities at the University of Minnesota in the College of Food, Agriculture and Natural Sciences, Extension and the College of Veterinary Medicine. As of February 2019, 21 faculty and extension educators have been hired along with needed infrastructure upgrades in the areas of crop and livestock productivity, soil fertility, water quality and pest resistance. Researchers who have been hired are pursuing work in the areas of manure management including strip till of liquid manure and precision application of manure based on nutrient content rather than volume, precision agriculture, agricultural practices to ensure good water quality under irrigation and promotion of BMPs for nitrogen and phosphorus management in row crop production. This addition of capacity at the University of Minnesota for public research covering several areas related to restoration and protection strategies will benefit water quality in the Minnesota River Basin long-term.

Drainage System Repair Cost Apportionment Option

Minnesota drainage law, Minn. R. ch. 103E, was updated in 2019 to add a voluntary, alternative method for cost apportionment that better utilizes technology to more equitably apportion drainage system repair costs, based on relative runoff and sediment contributions to the system, thus providing an incentive to reduce runoff and sediment contributions to the drainage system. This voluntary option is available for drainage authorities to use and is limited to repair costs only. The option also includes applicable due process hearings, findings, orders and appeal provisions consistent with other aspects of drainage law.

Minnesota Sediment Strategy

The MPCA has developed the *Sediment Reductio]n Strategy for the Minnesota River Basin and South Metro Mississippi River* (MPCA 2015b) to establish a foundation for local water planning to reach sediment reduction goals developed as part of TMDLs.

The *Sediment Reduction Strategy* outlines a milestone goal of reducing sediment in the Minnesota River by 25% by 2020 and by 50% by 2030, with a goal of meeting TMDL sediment reduction requirements by 2040 (MPCA 2015b). In addition to the sediment reduction goals, the *Sediment Reduction Strategy* also provides peak flow reduction goals to further address sediment reduction:

- Reduce two-year annual peak flow rates by 25% by 2030
- Decrease the number of days the two-year peak flow is exceeded by 25% by 2030

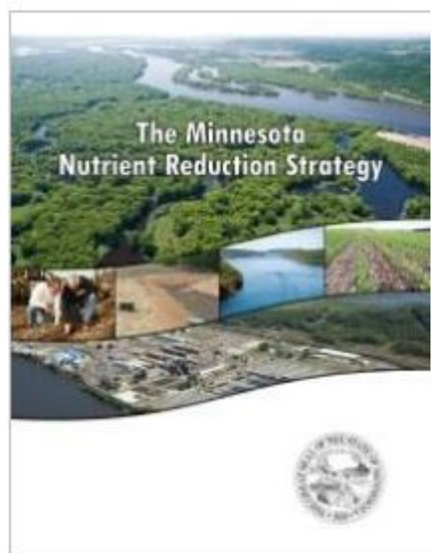
The MPCA expects that a combination of reduction strategies, simultaneously addressing reduction from upland and near-channel sources, will be most successful.

Management practices that reduce sediment loading in the Minnesota River Basin will also represent progress towards achieving the sediment load reductions in the Minnesota River–Mankato TMDL.

MN Nutrient Reduction Strategy

The *Minnesota Nutrient Reduction Strategy* (MPCA 2014) 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 Nutrient Reduction Strategy was developed by an interagency coordination team with help from public input. Fundamental elements of the Nutrient Reduction Strategy include:

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



Included within the strategy discussion are alternatives and tools for consideration by drainage authorities, 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 Nutrient Reduction Strategy 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, downstream of the Minnesota River–Mankato Watershed.

Successful implementation of the Nutrient Reduction Strategy 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:

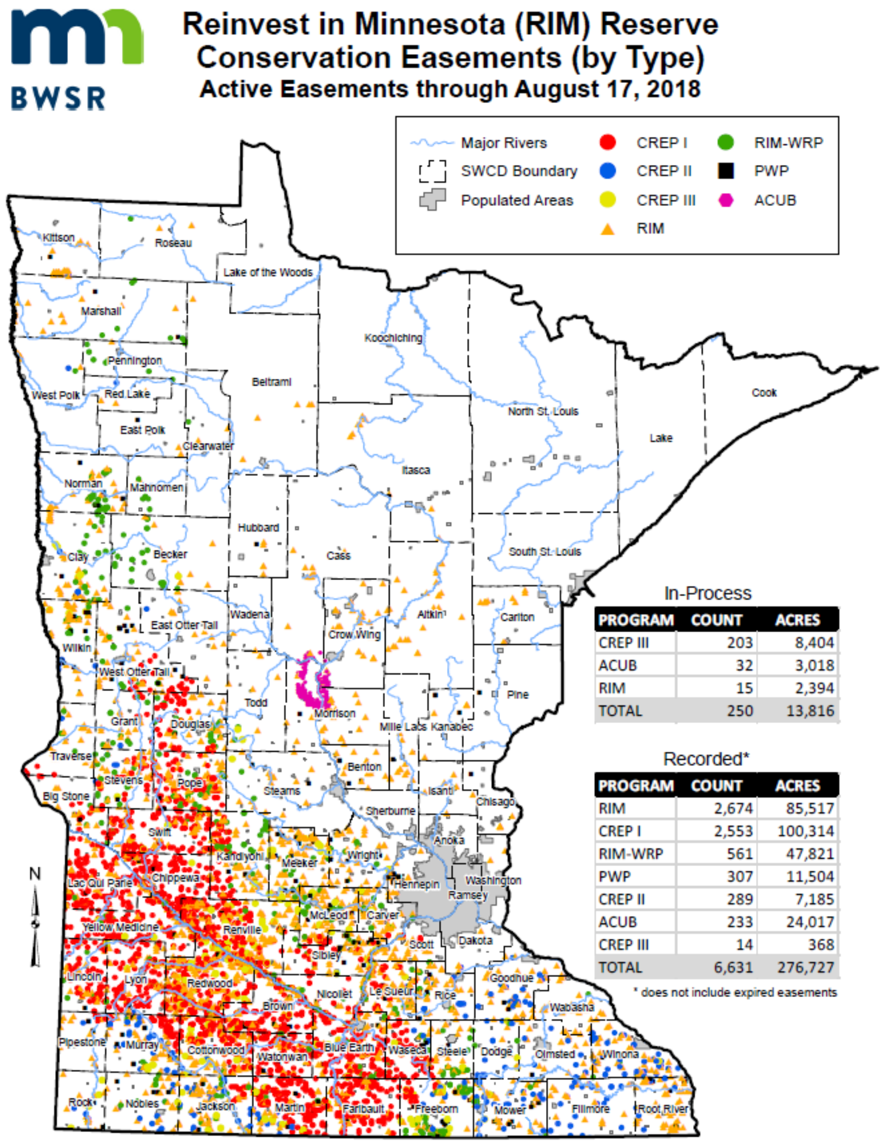
- Intensive watershed monitoring

- Assessment of watershed health
- Development of WRAPS reports
- Management of NPDES and other regulatory and assistance programs

This framework will result in nutrient reduction for the basin as a whole and the major watersheds within the basin. The Strategy is being updated in 2019-2020.

Conservation Easements.

Conservation easements are a critical component of the state's efforts to improve water quality by reducing soil erosion, phosphorus and nitrogen loading, and improving wildlife habitat and flood attenuation on private lands. Easements protect the state's water and soil resources by permanently restoring wetlands, adjacent native grassland wildlife habitat complexes and permanent riparian buffers. In cooperation with county SWCDs and the USDA Natural Resources Conservation Service (NRCS), BWSR's programs compensate landowners for granting conservation easements and establishing native vegetation habitat on economically marginal, flood-prone, environmentally sensitive or highly erodible lands. These easements vary in length of time from 10 years to permanent/perpetual easements. Types of conservation easements in Minnesota include: Conservation Reserve Program (CRP); Conservation Reserve Enhancement Program (CREP); Reinvest in Minnesota (RIM); and the Wetland Reserve Program (WRP) or Permanent Wetland Preserve (PWP). As of August 2018, in the eight counties that are located within the Minnesota River - Mankato Watershed, there was 93,410 acres of short term conservation easements such as CRP and 69,766 acres of long term or permanent easements (CREP, RIM, WRP) (Figure 16).



In-Process

PROGRAM	COUNT	ACRES
CREP III	203	8,404
ACUB	32	3,018
RIM	15	2,394
TOTAL	250	13,816

Recorded*

PROGRAM	COUNT	ACRES
RIM	2,674	85,517
CREP I	2,553	100,314
RIM-WRP	561	47,821
PWP	307	11,504
CREP II	289	7,185
ACUB	233	24,017
CREP III	14	368
TOTAL	6,631	276,727

* does not include expired easements

Figure 16. Statewide Conservation Easements

7.3 Summary of Local Plans

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.

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 “One Watershed, One Plan” (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 Minnesota River –Mankato Watershed. BWSR is committed to completing all 1W1Ps by 2025. The eventual Minnesota River–Mankato 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 Minnesota River–Mankato Watershed, water planning continues to be done on a county basis, per the Comprehensive Local Water Management Act (Minn. Stat. §103B.301) (see the 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.

The following is a list of local county water plans for major counties in the Minnesota River–Mankato Watershed; URL links are provided as well:

- Blue Earth County Water Management Plan (2017–2026)
- Brown County Comprehensive Local Water Management Plan (2008-–2018), Amended 2013
- Cottonwood County Comprehensive Local Water Management Plan (2017–2027)
- Le Sueur County Local Comprehensive County Water Management Plan (2016–2021)
- Nicollet County Local Water Management Plan (2008–2018, 2013 amendment)
- Redwood County Comprehensive Local Water Management Plan (2006–2016, 2016 Amendment 2016–2020)
- Renville County Comprehensive Water Management Plan (2013–2023)
- Sibley County Comprehensive Local Water Plan (2013–2023)

7.4 Partners, Organizations, and Events

Local SWCDs are active in the project area and impaired watersheds. 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 *E. coli,* sediment, nitrate, and phosphorus loading. From 2004 to 2017, at least 1616 BMPs were installed in the Minnesota River - Mankato Watershed by local partners. Figure 17 depicts the number of BMPs per subwatershed in the Minnesota River - Mankato Watershed. Additional information about the BMPs may be found on the MPCA's Healthier Watershed website: https://www.pca.state.mn.us/water/healthier-watersheds.

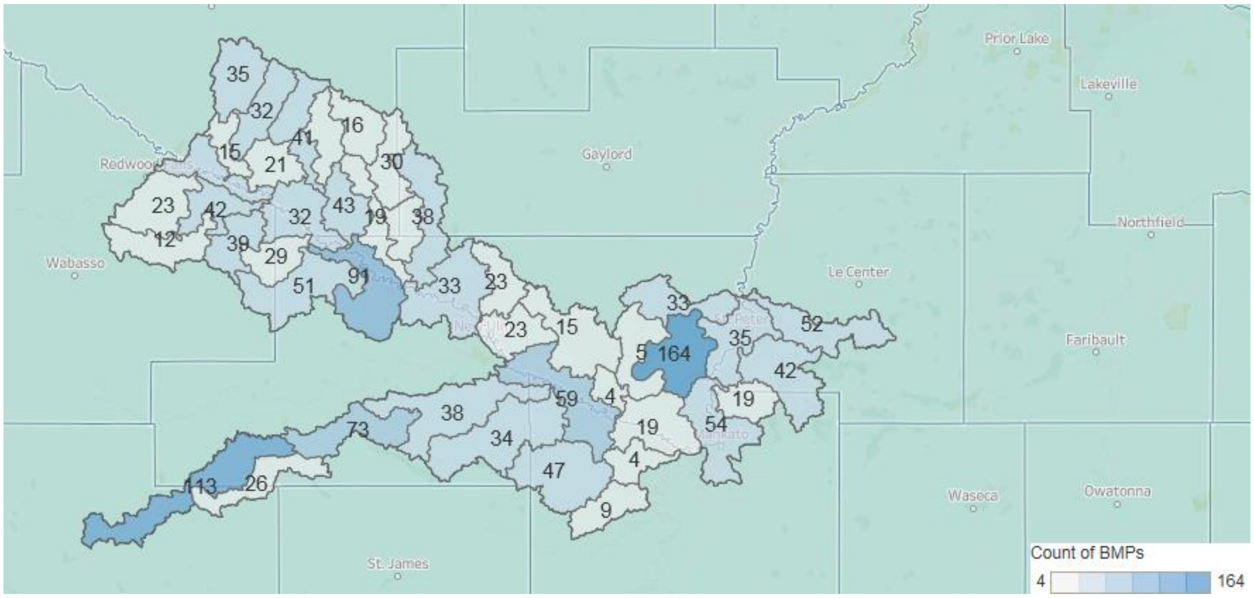


Figure 17. BMPs by HUC–12

Several SWCD projects have been completed in recent years that are located within the watershed or influence the watershed; the following are examples:

- Blue Earth, Nicollet, and Le Sueur SWCDs partnered together to receive a MnDOT grant for various erosion projects in the area
- Blue Earth SWCD received a grant in 2016 to reduce phosphorus in the Crystal Lake Watershed
- Blue Earth SWCD completed a county-wide tillage and erosion research project with the University of Minnesota
- Brown County SWCD conducted the civic engagement for the Minnesota River–Mankato Watershed WRAPS through a MPCA contract
- Nicollet SWCD completed the installation of a side inlet along a county ditch, grade stabilization, and native grass filter strips in the Seven Mile Creek Watershed
- Redwood SWCD installed nine grade stabilization structures, 32 water and sediment control basins (WASCOBs), and two streambank protection projects in 2017
- Approximately 50 conservation easements in Renville County and 152 easement inspections were completed in 2016

In addition to the SWCDs, several other groups are active in the Minnesota River–Mankato River Watershed and surrounding areas. These groups have different levels of organization and structure, but share a common goal to protect and improve water quality in the watershed. They typically conduct watershed outreach and education activities, monitoring, research, and project planning and implementation. They are often the link between landowners and planning initiatives set on a watershed, region, or basin-wide scale. The level of activity being conducted by these organizations and available funding mechanisms, such as the Clean Water Fund and Clean Water Act Section 319 grant programs, provide additional reasonable assurance that implementation will continue to occur to address nonpoint sources of pollution. Organizations in and surrounding the Minnesota River–Mankato Watershed that are supporting implementation include:

- **Coalition for a Clean Minnesota River** (http://www.ccmnriver.org/) is a grass-roots organization coordinating citizen and business interests in basinwide efforts including:
  - Storm sewer runoff education and awareness programs
  - River bank and curb side organic debris clean up
  - River and water quality related legislative initiatives, and
  - Various restoration projects
- **Seven Mile Creek Watershed Partnership** works to improve water quality in the Seven Mile Creek Watershed. Over the next five years, they aim to eliminate the bacteria impairment in Seven Mile Creek and reduce sediment by 40% and nitrates by 25%. Recent projects include:
  - One-on-one landowner outreach that has resulted in a 25% participation rate with local landowners thus far
  - Plantings of over 100 marginal acres of perennial vegetation
  - 65 conservation BMPS
- **The University of Minnesota** has been active in Seven Mile Creek within the Minnesota River–Mankato Watershed through multiple programs. The following are examples:
  - The New Agricultural Bioeconomy Project (NAMP) (http://newagbioeconomy.umn.edu/Seven-Milecreek/) is hosting and facilitating stakeholder meetings to identify opportunities to improve economic, environmental, and community conditions in the watershed
  - Numerous university studies conducted in the Seven Mile Creek Watershed that investigate topics including the growth, survival, and genetic structure of *E. coli* and the development of sediment erosion models
- **Minnesota River Basin Data Center,** Minnesota State University Mankato Water Resource Center (http://mrbdc.mnsu.edu/) provides basinwide data management and coordination
- **Minnesota River Watershed Alliance and Minnesota River Congress** (http://watershedalliance.blogspot.com/) coordinates basinwide governance and opportunities for stakeholders

Several other organizations within the Minnesota River–Mankato Watershed that are interested and/or connected to the watershed can be found in the Middle Minnesota River Directory. Organizations listed include businesses, organizations, individuals, and governmental units. The purpose of this directory is to increase public awareness of the Minnesota River–Mankato Watershed and its tributaries. The directory highlights key existing organizations, their work, resources they can offer, and their contact information to better facilitate implementation in the watershed.

In addition to the organizations and partners listed, events are hosted that work to promote water quality in and around the Minnesota River–Mankato Watershed:

- The Annual Nutrient Management Conference hosted in Mankato, Minnesota by the MDA Water Resource Center and University of Minnesota Extension. The 2018 conference covered trends in phosphorus and sulfur management, in-season nitrogen applications, and management options for phosphorus runoff losses from farmland

- Nitrogen Smart seminars hosted by the University of Minnesota Extension are held throughout Minnesota to help farmers become more efficient with their use of nitrogen containing fertilizers

Participation of farmers and landowners is essential to implementing nonpoint source BMPs and improving water quality in the watershed. Educational efforts and cost-share programs will likely increase participation to levels needed to protect water quality. Additional assurance can be achieved during implementation of the TMDLs through contracts, memorandums of understanding, and other similar agreements, especially for BMPs that receive outside funds and cost share.

8. Monitoring

This monitoring plan provides an overview of what is expected to occur at many scales in multiple watersheds within the Minnesota River–Mankato Watershed. The designated uses of aquatic life, aquatic recreation, limited resource value, and drinking water will be the ultimate measures of water quality. Improving 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 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 at the site 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 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. Ultimately, this monitoring can determine when waters have been restored and can be delisted from the impaired waters list.

- 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 mainstems, at major watershed (i.e., HUC-8) outlets to major rivers, and in several subwatersheds. This long-term monitoring program began in 2007.
- Discovery Farms Minnesota is a farmer-led program that collects farm- and field-scale monitoring data under real-world conditions. The program is coordinated by the Minnesota Agricultural Water Resource Center in partnership with the MDA and the University of Minnesota Extension. There is one Discovery Farms core farm located in Renville County and one core farm located in Redwood County.
- 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 Tillage Transect Survey Data Center.
- 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 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 HUC-8, scale. This watershed-level planning occurs on a 10-year cycle beginning with intensive watershed monitoring and culminates in local implementation (Figure 18). A WRAPS report is produced as part of this approach, and addresses the development of strategies for restoration of impaired waters and protection of unimpaired waters in each HUC-8 watershed. The WRAPS for each HUC-8 watershed includes elements such as implementation strategies, timelines, and interim milestones. These high-level reports are then used to inform watershed management plans that focus on local priorities and knowledge to identify locally-based prioritized, targeted, and measurable actions to implement the strategies. These plans further define specific actions, measures, roles, and financing for accomplishing water resource goals. Development of the WRAPS report for the Minnesota River–Mankato Watershed was done concurrently with this report, and implementation strategies in that 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 human wastewater sources such as SSTSs and IPHTs; agricultural sources such as livestock and runoff from cropland, agricultural drainage, and agricultural groundwater; near channel erosion; and internal lake phosphorus loading. These implementation strategies align and build upon the restoration and protection strategies in the previously developed *Minnesota River, Mankato Watershed Characterization Report* (DNR 2016).

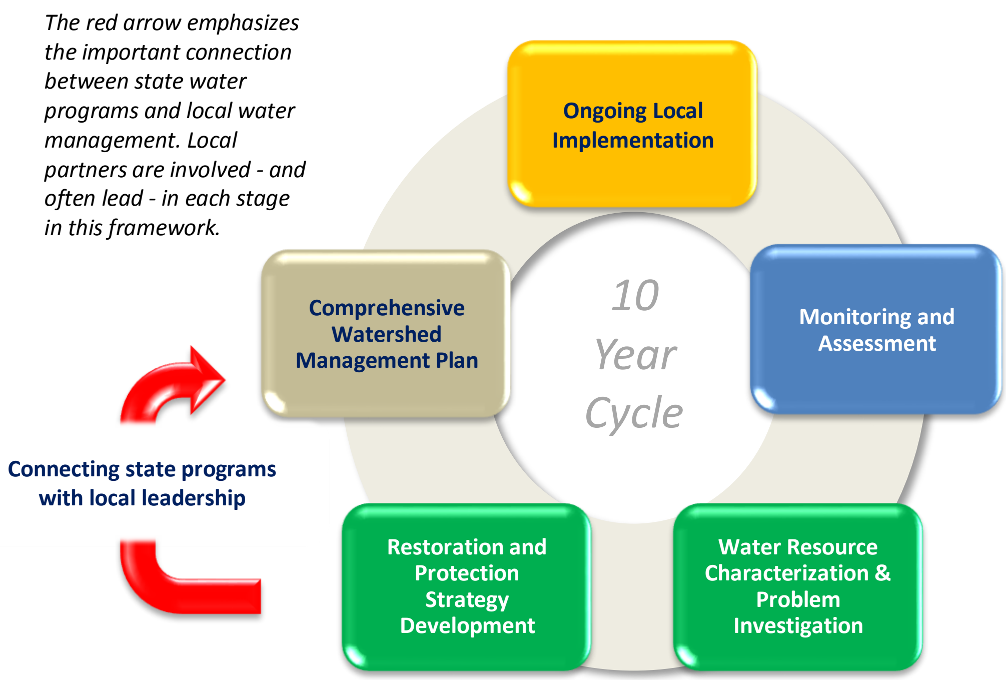


Figure 18. Minnesota's watershed approach.

9.1 Implementation Strategies for Permitted Sources

Permitted sources were not identified as priority sources in the pollutant source summary. Implementation of the Minnesota River–Mankato Watershed TMDL for permitted sources will consist of permit compliance as explained below.

9.1.1 Construction Stormwater

The WLA for stormwater discharges from sites where there is construction activity reflects the area of construction sites larger 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 the state'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. All local construction stormwater requirements must also be met.

9.1.2 Industrial Stormwater

The WLA for stormwater discharges from sites where there is industrial activity reflects the number of sites in the watershed for which NPDES industrial stormwater permit coverage is required, and the BMPs and other stormwater control measures that should be implemented at the sites to limit the discharge of pollutants of concern. The BMPs and other stormwater control measures that should be implemented at the industrial sites are defined in the state'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. All local stormwater management requirements must also be met.

9.1.3 MS4s

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 TP. For redevelopment projects, the 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 TP. These provisions in the MS4 permit will prevent increases in annual loading in TSS and TP. 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. Stormwater treatment practices such as bioretention, stormwater ponds and infiltration are able to remove from 35% to 100% of bacteria loads in stormwater (Minnesota Stormwater Manual contributors 2019). More information on stormwater BMPs can be found in the Minnesota Stormwater Manual.

9.1.4 Wastewater

Municipal and industrial wastewater treatment facilities are regulated through NPDES permits. These permits include effluent limits designed to meet water quality standards along with monitoring and reporting requirements to ensure effluent limits are met.

9.2 Implementation Strategies for Non-Permitted Sources

Implementation of the Minnesota River–Mankato Watershed TMDL will require BMPs that address the numerous pollutants in the watershed. This section provides an overview of example BMPs that may be used for implementation. The BMPs included in this section are not exhaustive.

Human wastewater sources such as SSTSs and IPHTs; agricultural sources such as livestock and runoff from cropland, agricultural drainage, and agricultural groundwater; near channel erosion; and internal lake phosphorus loading were identified as high priority pollutant sources.

9.2.1 Human Sources

Septic System upgrades/replacement

A watershed wide inventory of current systems and continuation of inspection programs in the area are necessary to help locate IPHTs. Once found, all known IPHTs must be brought into compliance within a 10-month period (see Section 3.6.1). The reductions in loading resulting from upgrading or replacing failing systems in the watershed depend on the level of failure present in the watershed. Upgrading or replacing IPHT systems will result in 100% reduction in fecal bacteria loading from that system. The State of Minnesota offers a no interest loan program for SSTS upgrades and compliance. See Section 7.2 for more information on the program.

Septic System maintenance

The most cost-effective BMP for managing loads from septic systems is regular maintenance. EPA recommends that septic tanks be pumped every three to five years depending on the tank size and number of residents in the household (EPA 2002b). When not maintained properly, septic systems can cause the release of pathogens and excess nutrients into surface water. Annual inspections, in addition to regular maintenance, ensure that systems function properly. Compliance with state and county code is essential to reducing *E. coli* and phosphorus loading from septic systems. Septic systems are regulated under Minn.Stat. §§ 115.55 and 115.56. Counties must enforce ordinances in Minn. R. ch. 7080 to 7083.

Public education

Education is another crucial component of reducing phosphorus and *E. coli* loading from septic systems. Education can occur through public meetings, mass mailings, and radio and television advertisements. An inspection program can also help with public education because inspectors can educate owners about proper operation and maintenance during inspections.

9.2.2 Agricultural Sources

Several different agricultural BMPs can be used to target priority sources and their associated pollutants. Table 20 provides a summary of agricultural BMPs, their NRCS code, and their targeted pollutants.

Descriptions of each BMP are provided below. More information on agricultural BMPs in the state of Minnesota can be found in the *Agricultural BMP Handbook for Minnesota* (Lenhart et al. 2017).

Table 20. Summary of agricultural BMPs for agricultural sources and their primary targeted pollutants

BMP (NRCS standard)	Targeted pollutant(s)			
	E. coli	**Sediment**	**Nitrate**	**Phosphorus**
Filter strips (636)	X	X		X
Riparian buffers (390)	X	X		X
Clean water diversion (362)	X			X
Access control/fencing (472 and 382)	X	X		X
Waste storage facilities (313) and nutrient management (590)	X		X	X
Drainage water management (554)			X	
Bioreactors (605)			X	
Grassed waterways (412)		X		X
Water and sediment control basins (638)		X		X
Conservation cover (327)		X	X	X
Conservation/reduced tillage (329 and 345)		X		X
Cover crops (340)		X	X	X

Filter strips (636) and riparian buffers (390)

Feedlot/wastewater filter strips are defined as “a strip or area of vegetation that receive and reduce sediment, nutrients, and pathogens in discharge from a setting basin or the feedlot itself. In Minnesota, there are five levels of runoff control, with Level 1 being the strictest and for the largest operations” (Lenhart et al. 2017). Riparian buffers are composed of a mix of grasses, forbs, sedges, and other vegetation that serves as an intermediate zone between upland and aquatic environments (Lenhart et al. 2017). The vegetation is tolerant of intermittent flooding and/or saturated soils that are prone to occur in intermediate zones.

Riparian buffers and filter strips that include perennial vegetation and trees can filter runoff from adjacent cropland, provide shade and habitat for wildlife, and reinforce streambanks to minimize erosion. The root structure of the vegetation uses enhanced infiltration of runoff and subsequent trapping of pollutants. Both; however, are only effective in this manner when the runoff enters the BMP as a slow moving, shallow “sheet”; concentrated flow in a ditch or gully will quickly pass through the vegetation offering minimal opportunity for retention and uptake of pollutants. Similarly, tile lines can often allow water to bypass a buffer or filter strip, thus reducing its effectiveness.

Clean water diversions (362)

Clean runoff water diversion “involves a channel constructed across the slope to prevent rainwater from entering the feedlot area or the farmstead to reduce water pollution” (Lenhart et al. 2017). Clean water diversions can take many forms including roof runoff management, grading, earthen berms, and other barriers that direct uncontaminated runoff from areas that may contain high levels of *E. coli* and nutrients.

Access control/fencing (472 and 382)

Fencing can be used with controlled stream crossings to allow livestock to cross a stream while minimizing disturbance to the stream channel and streambanks. Providing alternative water supplies for livestock allows animals to access drinking water away from the stream, thereby minimizing the impacts to the stream and riparian corridor. Some researchers have studied the impacts of providing alternative watering sites without structural exclusions and found that cattle spend 90% less time in the stream when alternative drinking water is furnished (EPA 2003).

Waste storage facilities (313) and nutrient management (590)

Manure management strategies depend on a variety of factors. A pasture or open lot system with a relatively low density of animals (one to two head of cattle per acre [EPA 2003]) may not produce manure in quantities that require management for the protection of water quality. For mid-size and large facilities, additional waste storage is needed. A waste storage facility is “an impoundment created by excavating earth or a structure constructed to hold and provide treatment to agricultural waste” (Lenhart et al. 2017). Waste storage facilities hold and treat waste directly from animal operations, process wastewater, or contaminated runoff.

Confined swine operations typically use liquid manure storage areas that are located under the confinement barn. Wash water used to clean the floors and remove manure buildup combines with the solid manure to form a liquid or slurry in the pit. The mixture is usually land applied in the spring and fall by injection/incorporation into the soil or transported offsite. Some facilities may have “open-air” liquid manure storage areas, which can pose a runoff risk if improperly managed.

Dairies that require either an NPDES or SDS operating permit in the Minnesota River–Mankato Watershed mainly store and handle manure in liquid form to be land applied at a later date. Other potential sources of wastewater include process wastewater such as parlor wash down water, milk-house wastewater, silage leachate, and runoff from outdoor silage feed storage areas. There are potential runoff problems associated with these wastewater sources if not properly managed. In addition, many small dairy operations have limited to no manure storage. Most poultry manure is handled as a dry solid in the state; liquid poultry manure handling and storage is rare. Improperly stockpiled poultry manure or improper land application can pose runoff issues.

Final disposal of waste usually involves land application on the farm or transportation to another site. Minn. R. 7020.2225 contains several requirements for land application of manure. These requirements vary depending on feedlot size and include provisions on manure nutrient testing, nutrient application rates (based on determination of crop needs and phosphorus soil testing), manure management plans, recordkeeping, and various limitations in certain areas or near environmentally-sensitive areas. Manure is typically applied to the land once or twice per year. To maximize the amount of nutrients and organic material retained in the soil, application should not occur on frozen ground or when precipitation is forecast during the next several days.

The Minnesota Department of Agriculture (MDA) has recently developed an interactive model to assist livestock producers to evaluate the potential runoff risk for manure applications, based on weather forecasts for temperature and precipitation along with soil moisture content. The model can be customized to specific locations. It is advised that all producers applying manure utilize the model to determine the runoff risk, and use caution when the risk is “medium” and avoid manure application during “high” risk times. For more information and to sign up for runoff risk alerts from the MDA Runoff Risk Advisory Forecast, please see the MDA website.

Drainage water management (554)

Drainage water management, or controlled drainage, is a BMP in which a water control structure such as stop logs or floating mechanisms are placed at or near the outlet of a drainage system to manage the water table beneath an agricultural field. Storing excess water through the use of a controlled drainage system reduces the volume of agricultural drainage flow to surface water and the nitrogen it carries.

Bioreactors (605)

Bioreactors are excavated pits that denitrify water from subsurface drainage by providing a carbon source (often wood chips) for denitrifying bacteria, which in turn convert nitrate to nitrogen.

Grassed waterways (412) and water and sediment control basins (WASCOB) (638)

Grassed waterways and WASCOBs are both agricultural BMPs that aim to slow water flow off agricultural fields. Grassed waterways are areas of vegetative cover that are placed in line with high flow areas on a field. WASCOBs are vegetative embankments that are placed perpendicular to water's flow path to pool and slowly release water. Both practices reduce erosion and sediment and phosphorus loss from agricultural fields.

Conservation cover (327), conversation/reduced tillage (329 and 345), and cover crops (340)

Conservation cover, conversation/reduced tillage, and cover crops are all on-field agricultural BMPs that aim to reduce erosion and nutrient loss by increasing and/or maintaining vegetative cover and root structure. Conservation cover is the process of converting previously row crop agricultural fields to permanent perennial vegetation. Conservation or reduced tillage can mean any tillage practice that leaves additional residue on the soil surface; 30% or more cover is typically considered conservation tillage. In addition to reducing erosion, conservation tillage preserves soil moisture. Cover crops refer to "the use of grasses, legumes, and forbs planted with annual cash crops to provide seasonal soil cover on cropland when the soil would otherwise be bare" (Lenhart et al. 2017).

9.2.3 Near Channel Sources of Sediment

Both direct and indirect controls for reducing near-channel sediment can be used in the Minnesota River–Mankato Watershed.

Direct sediment controls

Direct controls for near channel sediment sources include practices such as limiting ravine erosion with a drop structure or energy dissipater, or controlling streambank or bluff erosion through stream channel restoration**.**

Indirect controls

Indirect controls for sediment loss typically involve land management practices and structural practices designed to temporarily store water or shift runoff patterns by increasing evapotranspiration at critical times of the year. The temporary storage of water and a shift in runoff patterns are needed to reduce peak flows and extend the length of storm hydrographs, which in turn will reduce the erosive power of streamflow on streambanks and bluffs.

It is also expected that implementation of the Minnesota Sediment Reduction Strategy will reduce sediment in the Minnesota River–Mankato Watershed (see Section 7.2 Example Non-Permitted Source Reduction Programsfor more information on the strategy).

9.2.4 Internal Loading Lake Phosphorus Sources

Implementation strategies for internal loading reduction include water level drawdown, sediment phosphorus immobilization or chemical treatment (e.g., alum), and biomanipulation (e.g., carp management).

Sequencing of in-lake management strategies both relative to each other as well as relative to external load reduction is important to evaluate and consider. In general, external loading, if moderate to high, should be the initial priority for reduction efforts. Biomanipulation may also be an early priority. However, it is generally believed that further in-lake management efforts involving chemical treatment (e.g., alum) can follow after substantial external load reduction has occurred. The success of alum treatments depends on several factors including lake morphometry, water residence time, alum dose used, and presence of benthic-feeding fish (Huser et al. 2016).

The MPCA recommends feasibility studies for any lakes in which water level drawdown or chemical treatment is considered.

9.2.5 Education and Outreach

Education is a crucial component of reducing pollutant sources in the Minnesota River–Mankato Watershed and is important to increasing public buy-in of residents, businesses, and organizations. Education can occur through public events, mass mailings, and radio and television advertisements.

9.3 Cost

TMDLs are required to include an overall approximation of implementation costs (Minn. Stat. 2007, § 114D.25). The costs to implement the activities outlined in the strategy are approximately $25 to $45 million dollars over the next 20 years. This range reflects the level of uncertainty in the source assessment and addresses the high priority sources identified in Section 3.6. The cost includes increasing local capacity to oversee implementation in the watershed and the voluntary actions needed to achieve reductions. Required buffer installation and replacement of IPHT systems are not included.

9.4 Adaptive Management

The implementation strategy and the future detailed WRAPS report focus on adaptive management (Figure 19) to ensure management decisions are based on the most recent knowledge. An adaptive management approach 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.

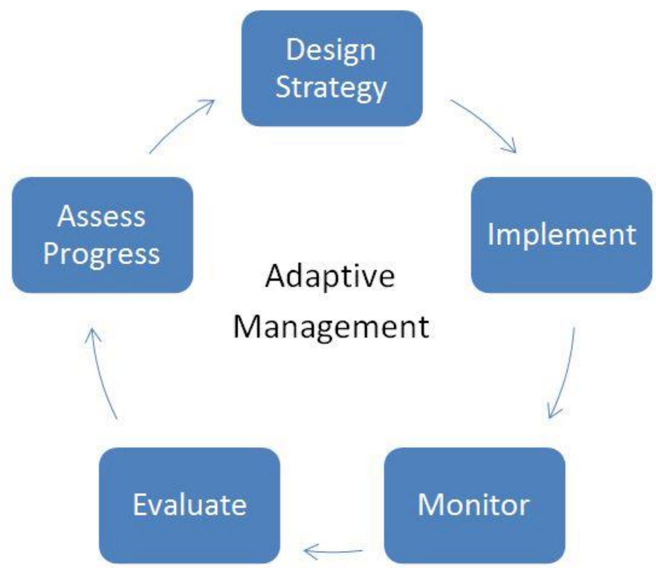


Figure 19. Adaptive management process.

Natural resource management involves a temporal sequence of decisions (or implementation actions), in which the best action at each decision point depends on the state of the managed system (Williams et al. 2009). 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 and Public Notice

Civic engagement and public participation was a major focus during the Middle Minnesota Watershed project related to WRAPS and the TMDL study. The MPCA worked with county and SWCD staff from eight counties in the watershed to promote water quality, survey and interview landowners, and create opportunities to explore the social dynamics in the watershed. Local partners, state agency staff and consultants worked on eight projects to promote civic engagement and collaboration related to WRAPS and TMDL work in the area.

The Middle Minnesota Watershed civic engagement projects were:

- Minnesota River at Mankato: Stakeholder Identification and Analysis
- Middle Minnesota Watershed Zonation Analysis
- Minneopa and Fort Ridgely Watershed Interpretive Signs
- Middle Minnesota Watershed SWCD WRAPS Strategy
- Middle Minnesota Watershed Renville County WRAPS Strategy
- Middle Minnesota Watershed Nicollet County WRAPS Strategy
- Middle Minnesota Watershed Lakes WRAPS Strategy
- Lake Hallett Civic Engagement Project

10.1 Opportunities and Constraints

Based on the efforts of the projects above, opportunities and constraints for water quality improvements were identified. The future opportunities include:

1. Future work by local partners should focus on strategic placement of BMPs including stormwater management, shoreland management, soil health, nutrient management, wetland restoration and enhancement.
2. There is interest to continue education efforts focused on water quality concerns and practices in both urban and rural areas targeting multiple age groups.
3. There is strong interest in the protection of the few unimpaired lakes in the watershed.
4. Revising stormwater management policies.
5. New commitment of landowners incorporating nutrient management, tillage management, and cover crops. Landowners are very interested in trying denitrifying bioreactors and phosphorus removal tank systems.
6. Encourage conservation success stories, demonstration sites, and field days highlighting the effectiveness of conservation practices in improving water resources.

Identified constraints to addressing water quality issues include:

1. Financial resources are lacking.
2. There is a lack of local leadership.

3. Programs are too complex and not flexible enough.
4. Programs should target smaller areas such as subwatersheds to build social networks and promote civic engagement in water quality and focus BMP efforts.
5. Face-to-face conversations between project staff and landowners are needed to make significant progress in the watershed.

For more information on public outreach and civic engagement related to the watershed approach see the Middle Minnesota River Watershed WRAPS.

An opportunity for public comment on the draft TMDL report was provided via a public notice in the *State Register* from July 22, 2019, to September 20, 2019. There were 10 comment letters received and responded to as a result of the public comment period.

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Appendices

Appendix A. Water Quality Summary Tables and Figures, Load Duration Curves, and TMDL Tables

Appendix B. Wastewater Wasteload Allocations

Appendix C. Lake Modeling Documentation

Appendix D. CAFOs in the Minnesota River- Mankato Watershed

Appendix A. Water Quality Summary Tables and Figures, Load Duration Curves, and TMDL Tables

This section provides the water quality summary tables, load duration curves for streams, water quality summary figures and source assessment tables for lakes, and TMDL tables. See sections 3.5 and 4 in the report for an explanation of the data analyses.

Tables

Figures

1. Minnesota River–New Ulm

A1.1 Crow Creek, CD 52 to T112 R35W S2, north line (07020007-569)

E. coli

Table A-1. Annual summary of *E. coli* data at Crow Creek (AUID 07020007-569; 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
2006	0	–	–	–	–	–
2007	0	–	–	–	–	–
2008	0	–	–	–	–	–
2009	13	331	36	≥ 2,420 [a]	2	15
2010	17	442	17	≥ 2,420 [a]	5	29
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	7	484	231	770	0	–
2014	8	211	33	762	0	–
2015	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

Table A-2. Monthly summary of *E. coli* data at Crow Creek (AUID 07020007-569; 2006–2015)

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 percent 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	5	43	17	93	0	0
May	5	147	36	291	0	0
Jun	10	347	33	≥ 2,420 [a]	2	20
Jul	10	551	158	866	0	–
Aug	10	581	186	≥ 2,420 [a]	2	20
Sep	5	1,331	548	≥ 2,420 [a]	3	60
Oct	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

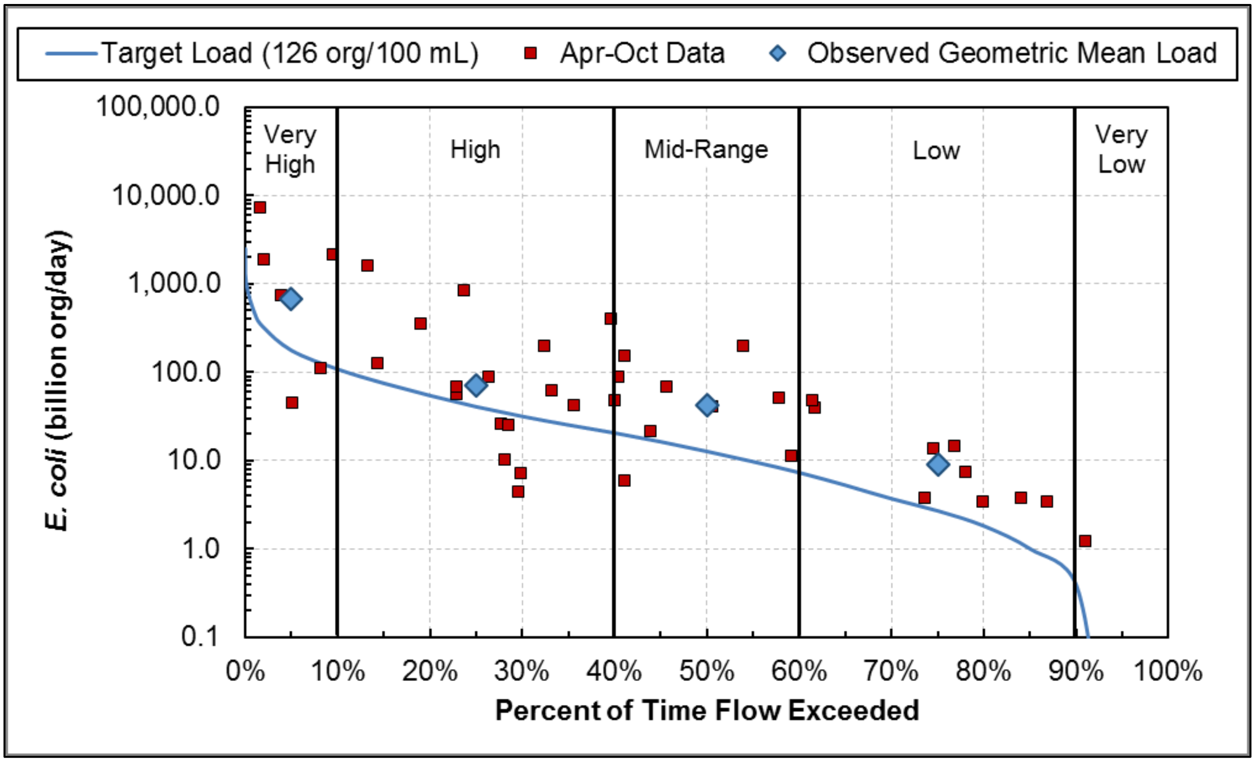

Figure A-20. *E. coli* load duration curve, Crow Creek (AUID 07020007-569).

Table A-3. *E. coli* TMDL summary, Crow Creek (AUID 07020007-569)

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	E. coli Load (billion org/d)				
WLA: Redwood Falls City MS4 (MS400236)	6.6	1.6	0.49	0.10	– [a]
Load Allocation	150	35	11	2.3	– [a]
Margin of Safety	18	4.1	1.3	0.27	– [a]
Loading Capacity	175	41	13	2.7	– [a]
Maximum Monthly Geometric Mean (org/100 mL)	1,331				
Estimated Percent Reduction	91%				

a. HSPF simulated flow of zero is likely an underestimate of actual flow conditions.

A1.2 Birch Coulee Creek, JD 12 to Minnesota R (07020007-587)

E. coli

Table A-4 Annual summary of *E. coli* data at Birch Coulee Creek (AUID 07020007-587; 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
2006	0	–	–	–	–	–
2007	0	–	–	–	–	–
2008	0	–	–	–	–	–
2009	10	132	16	461	0	–
2010	10	448	44	≥ 2,420 [a]	2	20
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	7	246	87	1,203	0	–
2014	8	231	51	1,918	1	13
2015	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

Table A-5 Monthly summary of *E. coli* data at Birch Coulee Creek (AUID 07020007-587; 2006–2015)

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 percent 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	3 [a]	26	16	44	0	–
May	2 [a]	99	77	127	0	–
Jun	10	376	51	1,918	1	10
Jul	11	291	111	1,300	1	9
Aug	9	298	87	≥ 2,420 [b]	1	11
Sep	0	–	–	–	–	–
Oct	0	–	–	–	–	–

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

b. 2,420 org/100mL is the method's maximum recordable value.

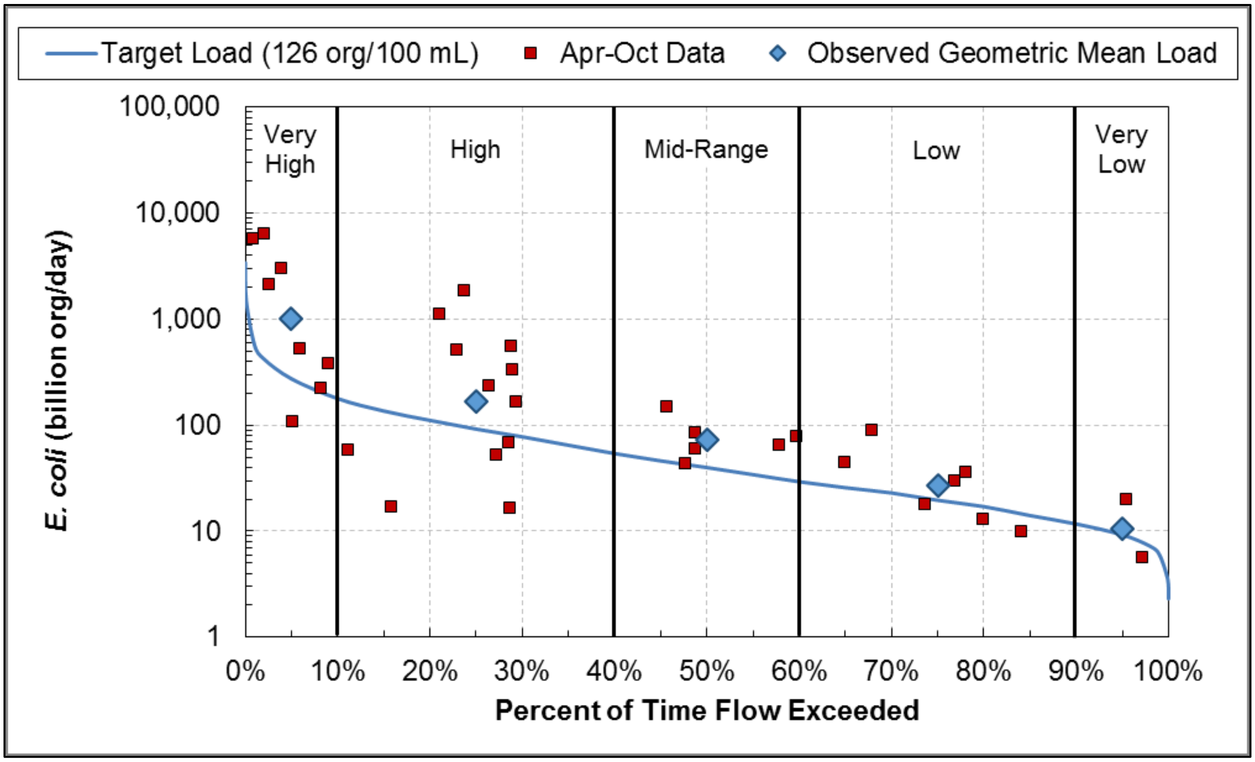

Figure A-21. ***E. coli*** **load duration curve, Birch Coulee Creek (AUID 07020007-587).**

Table A-6. ***E. coli*** **TMDL summary, Birch Coulee Creek (AUID 07020007-587)**

TMDL Parameter	Flow Zone				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	E. coli **Load (billion org/d)**				
Load Allocation	247	83	36	18	8.3
Margin of Safety	28	9.2	4.0	2.0	0.92
Loading Capacity	275	92	40	20	9.2
Maximum Monthly Geometric Mean (org/100 mL)	376				
Estimated Percent Reduction	66%				

A1.3 Purgatory Creek, Unnamed Cr to Minnesota R (07020007-645)

E. coli

Table A-7 Annual summary of *E. coli* data at Purgatory Creek (AUID 07020007-645; 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
2006	0	–	–	–	–	–
2007	0	–	–	–	–	–
2008	0	–	–	–	–	–
2009	8	64	1	770	0	–
2010	10	333	1	≥ 2,420 [a]	2	20
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

Table A-8 Monthly summary of *E. coli* data at Purgatory Creek (AUID 07020007-645; 2006–2015)

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 percent 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	3 [a]	1	1	3	0	–
May	2 [a]	72	52	99	0	–
Jun	5	365	77	1,120	0	–
Jul	5	959	488	≥ 2,420 [b]	1	20
Aug	3 [a]	485	109	≥ 2,420 [b]	1	33
Sep	0	–	–	–	–	–
Oct	0	–	–	–	–	–

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

b. 2,420 org/100mL is the method's maximum recordable value.

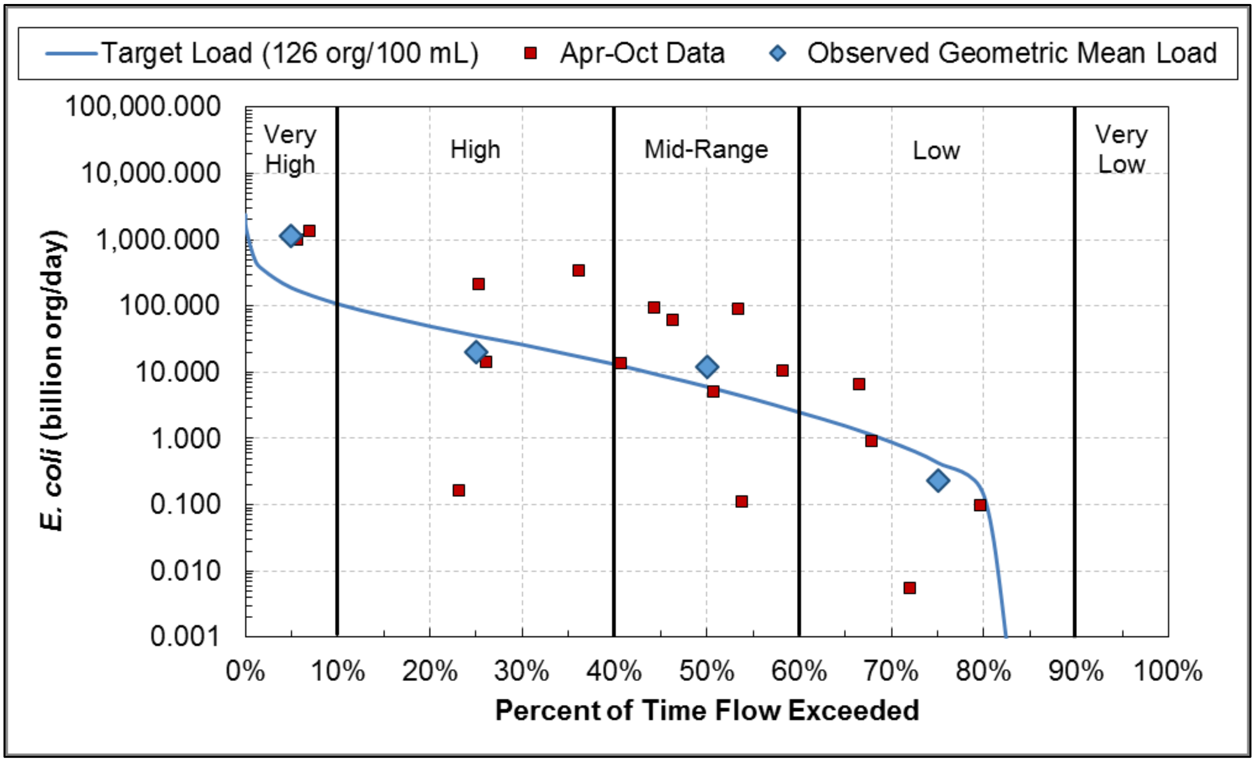

Figure A-22. *E. coli* load duration curve, Purgatory Creek (AUID 07020007-645).

Table A-9. *E. coli* TMDL summary, Purgatory Creek (AUID 07020007-645)

TMDL Parameter	Flow Zone				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	***E. coli* Load (billion org/d)**				
Load Allocation	170	32	5.5	0.39	– [a]
Margin of Safety	19	3.5	0.61	0.043	– [a]
Loading Capacity	189	36	6.1	0.43	– [a]
Maximum Monthly Geometric Mean (org/100 mL)	959				
Estimated Percent Reduction	87%				

a. HSPF simulated flow of zero is likely an underestimate of actual flow conditions.

A1.4 Wabasha Creek, T112 R34W S19, west line to Minnesota R (07020007-527)

E. coli

Table A-10. Annual summary of *E. coli* data at Wabasha Creek (AUID 07020007-527; 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
2006	0	–	–	–	–	–
2007	0	–	–	–	–	–
2008	0	–	–	–	–	–
2009	13	604	148	≥ 2,420 [a]	4	31
2010	17	340	1	≥ 2,420 [a]	5	29
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	6	716	276	1,986	1	17
2014	3	1,339	213	8,664	2	67
2015	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

Table A-11. Monthly summary of *E. coli* data at Wabasha Creek (AUID 07020007-527; 2006–2015)

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 percent 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	5	46	1	517	0	–
May	5	253	96	≥ 2,420 [a]	1	20
Jun	8	1,039	173	8,664	4	50
Jul	8	591	285	1,300	1	13
Aug	8	856	276	≥ 2,420 [a]	3	38
Sep	5	1,309	517	≥ 2,420 [a]	3	60
Oct	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

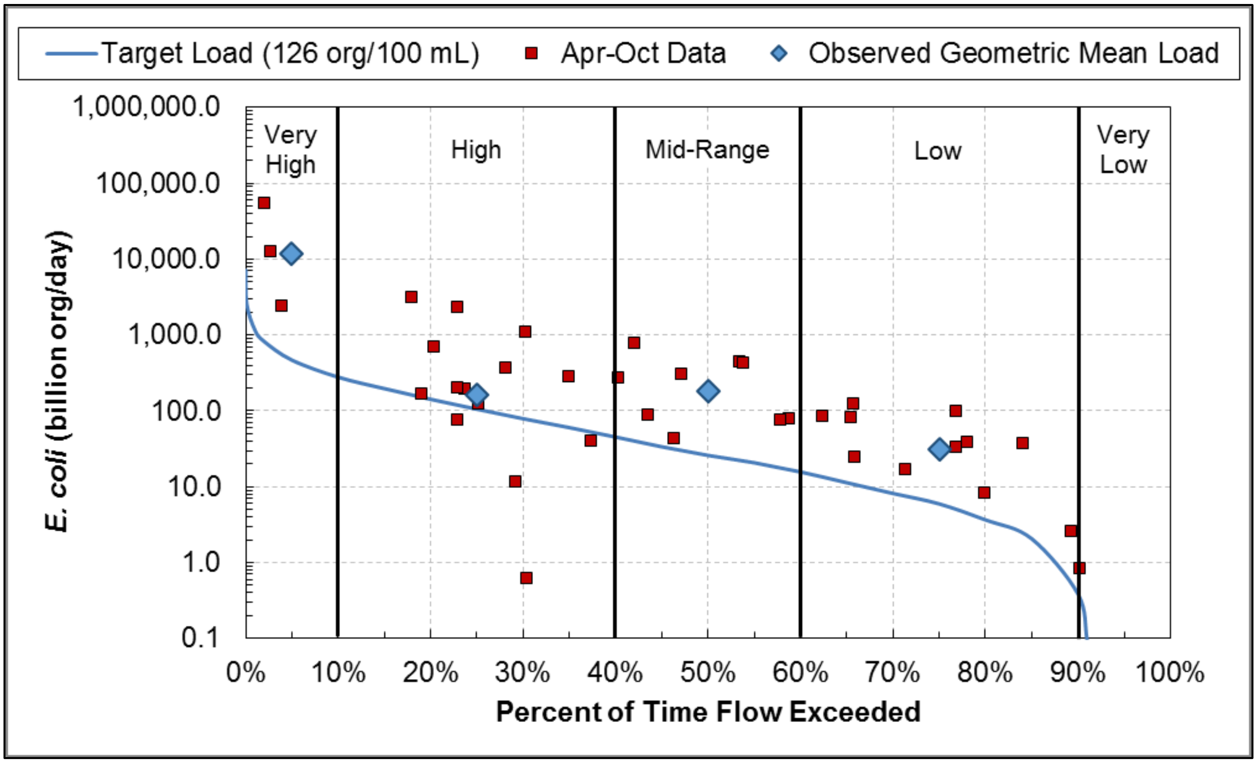

Figure A-23. *E. coli* load duration curve, Wabasha Creek (AUID 07020007-527).

Table A-12. *E. coli* TMDL summary, Wabasha Creek (AUID 07020007-527)

TMDL Parameter	**Flow Zone**				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	***E. coli* Load (billion org/d)**				
WLA: Morgan WWTP (MN0020443)	11	11	11	– [a]	– [b]
Load Allocation	410	84	12	– [a]	– [b]
Margin of Safety	47	11	2.6	0.60	– [b]
Loading Capacity	468	106	26	6.0	– [b]
Maximum Monthly Geometric Mean (org/100 mL)	1,309				
Estimated Percent Reduction	90%				

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 4.6.2 for more detail.

b. HSPF simulated flow of zero is likely an underestimate of actual flow conditions.

A1.5 Three-Mile Creek, CD 140 to Minnesota R (07020007-704)

E. coli

Table A-13. Annual summary of *E. coli* data at Three-Mile Creek (AUID 07020007-704; 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
2006	0	–	–	–	–	–
2007	0	–	–	–	–	–
2008	0	–	–	–	–	–
2009	10	41	3	420	0	–
2010	10	120	1	613	0	–
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–

Table A-14. Monthly summary of *E. coli* data at Three-Mile Creek (AUID 07020007-704; 2006–2015)

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 percent 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	3 [a]	3	1	25	0	–
May	2 [a]	21	16	27	0	–
Jun	5	93	32	179	0	–
Jul	6	173	28	613	0	–
Aug	4 [a]	227	150	461	0	–
Sep	0	–	–	–	–	–
Oct	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

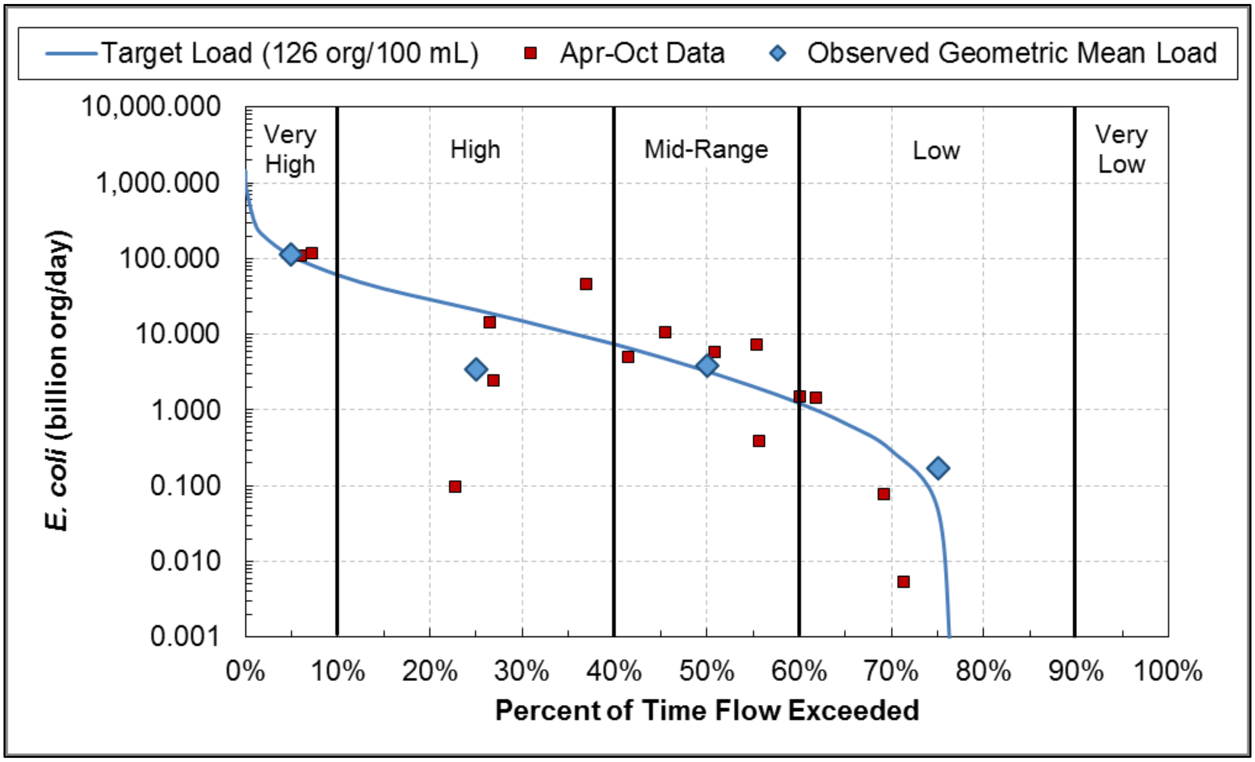

Figure A-24. *E. coli* load duration curve, Three-Mile Creek (AUID 07020007-704).

Table A-15. *E. coli* TMDL summary, Three-Mile Creek (AUID 07020007-704)

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	E. coli Load (billion org/d)				
Load Allocation	98	19	3.0	0.044	– [a]
Margin of Safety	11	2.1	0.33	0.0049	– [a]
Loading Capacity	109	21	3.3	0.049	– [a]
Maximum Monthly Geometric Mean (org/100 mL)	173				
Estimated Percent Reduction	27%				

a. HSPF simulated flow of zero is likely an underestimate of actual flow conditions.

A1.6 Unnamed creek, Unnamed Cr to Minnesota R (07020007-644)

E. coli

Table A-16. Annual summary of *E. coli* data at Unnamed Creek (AUID 07020007-644; 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
2006	0	–	–	–	–	–
2007	0	–	–	–	–	–
2008	0	–	–	–	–	–
2009	13	121	4	≥ 2,420 [a]	2	15
2010	17	246	5	≥ 2,420 [a]	3	18
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

Table A-17. Monthly summary of *E. coli* data at Unnamed Creek (AUID 07020007-644; 2006–2015)

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 percent 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	5	10	5	19	0	–
May	5	38	4	122	0	–
Jun	5	438	82	≥ 2,420 [a]	2	40
Jul	5	568	152	≥ 2,420 [a]	2	40
Aug	5	531	152	1,203	0	–
Sep	5	679	222	≥ 2,420 [a]	1	20
Oct	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

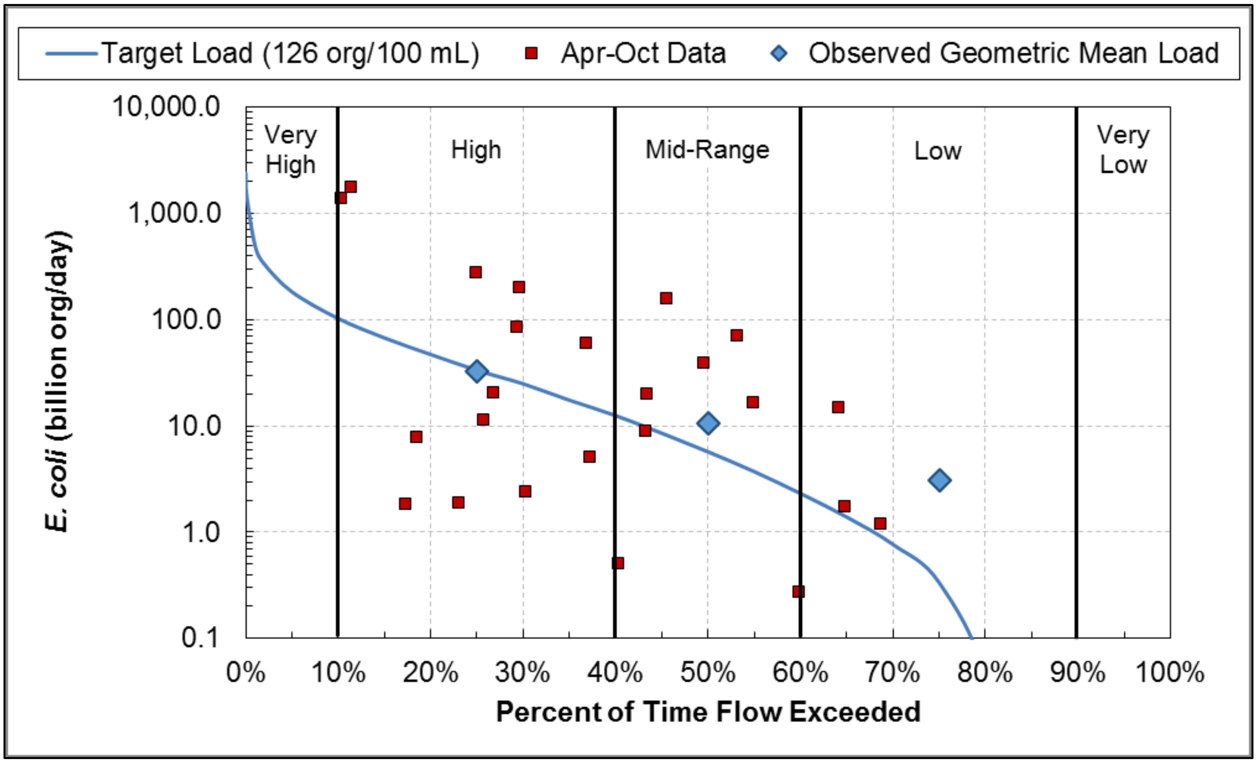

Figure A-25. ***E. coli*** **load duration curve, Unnamed Creek (AUID 07020007-644).**

Table A-18. ***E. coli*** **TMDL summary, Unnamed Creek (AUID 07020007-644)**

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	E. coli Load (billion org/d)				
Load Allocation	166	31	5.1	0.30	– [a]
Margin of Safety	18	3.4	0.57	0.033	– [a]
Loading Capacity	184	34	5.7	0.33	– [a]
Maximum Monthly Geometric Mean (org/100 mL)	679				
Estimated Percent Reduction	81%				

a. HSPF simulated flow of zero is likely an underestimate of actual flow conditions.

A1.7 Fort Ridgley Creek, T112 R33W S24, north line to Minnesota R (07020007-689)

E. coli

Table A-19. Annual summary of *E. coli* data at Fort Ridgley Creek (AUID 07020007-689; 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
2006	0	–	–	–	–	–
2007	0	–	–	–	–	–
2008	0	–	–	–	–	–
2009	10	42	3	613	0	–
2010	10	182	5	687	0	–
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	8	144	32	≥ 2,420 [a]	1	13
2014	7	123	41	369	0	–
2015	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

Table A-20. Monthly summary of *E. coli* data at Fort Ridgley Creek (AUID 07020007-689; 2006–2015)

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 percent 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	3 [a]	4	3	5	0	–
May	2 [a]	41	26	65	0	–
Jun	8	237	15	≥ 2,420 [b]	1	13
Jul	12	154	32	613	0	–
Aug	8	134	41	687	0	–
Sep	2 [a]	60	48	75	0	–
Oct	0	–	–	–	–	–

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

b. 2,420 org/100mL is the method's maximum recordable value.

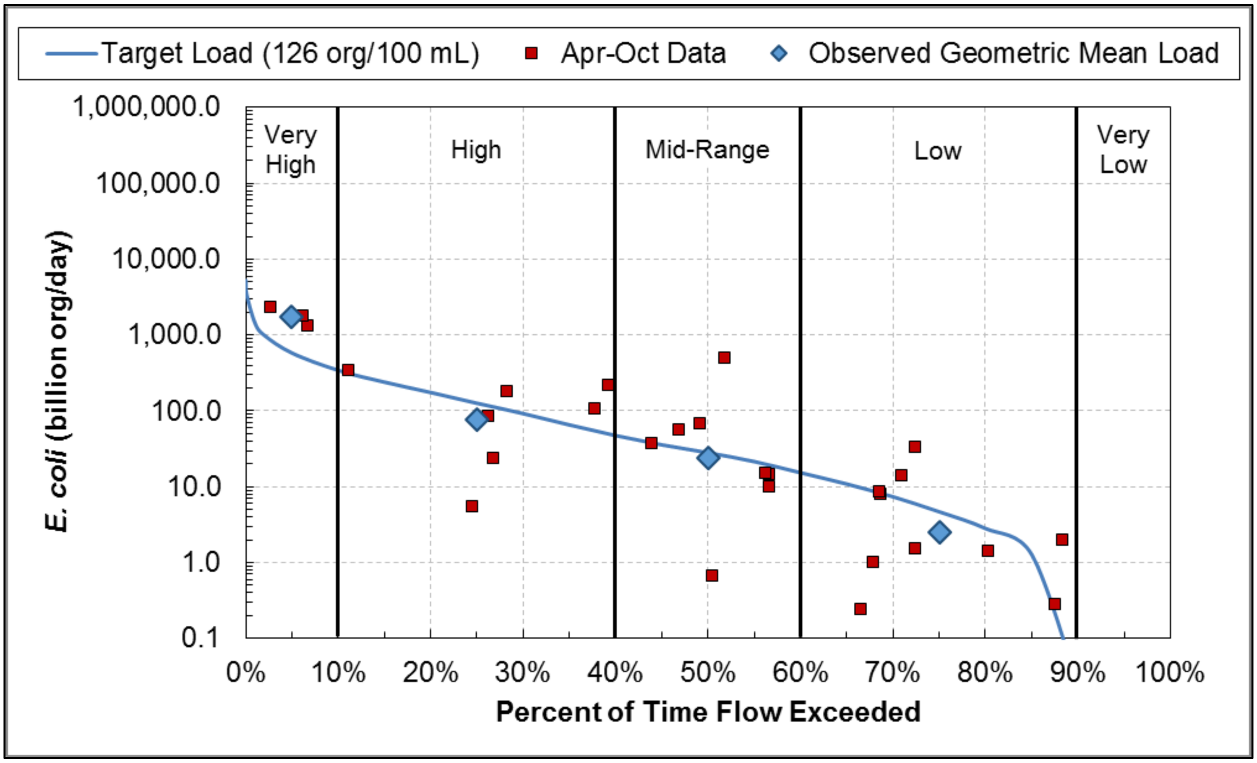

Figure A-26. *E. coli* load duration curve, Fort Ridgley Creek (AUID 07020007-689).

Table A-21. *E. coli* TMDL summary, Fort Ridgley Creek (AUID 07020007-689)

TMDL Parameter	Flow Zone				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	***E. coli* Load (billion org/d)**				
WLA: Fairfax WWTP (MNG580060)	20	20	20	– [a]	– [b]
Load Allocation	503	93	5.2	– [a]	– [b]
Margin of Safety	58	13	2.8	0.47	– [b]
Loading Capacity	581	126	28	4.7	– [b]
Maximum Monthly Geometric Mean (org/100 mL)	237				
Estimated Percent Reduction	47%				

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 4.6.2 for more detail.

b. HSPF simulated flow of zero is likely an underestimate of actual flow conditions.

A1.8 Spring Creek (Judicial Ditch 29), T111 R33W S23, west line to T111 R33W S23, east line (07020007-622)

E. coli

Table A-22. Annual summary of *E. coli* data at Spring Creek-Judicial Ditch 29 (AUID 07020007-622; 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
2006	0	–	–	–	–	–
2007	0	–	–	–	–	–
2008	0	–	–	–	–	–
2009	6	216	99	770	0	–
2010	9	359	167	1,733	1	11
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–

Table A-23. Monthly summary of *E. coli* data at Spring Creek-Judicial Ditch 29 (AUID 07020007-622; 2006–2015)

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 percent 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	423	111	1,733	1	20
Jul	5	295	225	548	0	–
Aug	5	201	99	517	0	–
Sep	0	–	–	–	–	–
Oct	0	–	–	–	–	–

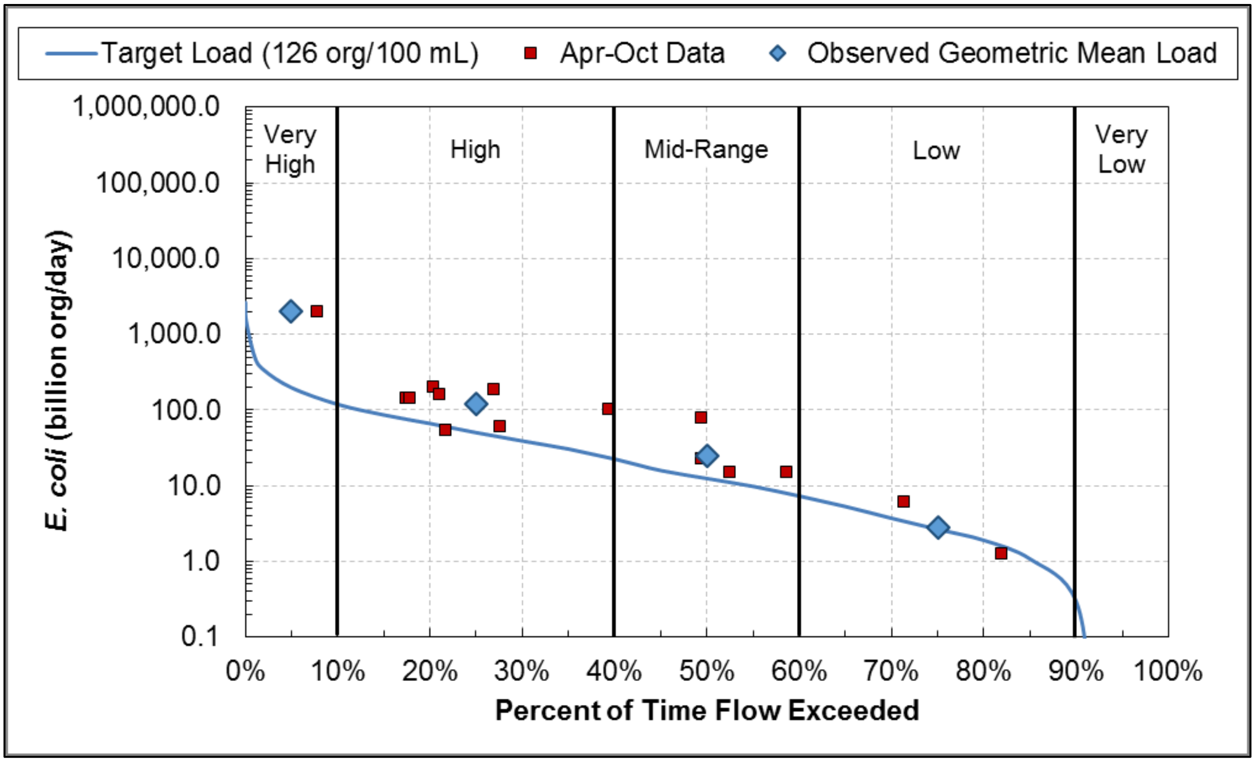

Figure A-27. ***E. coli*** **load duration curve, Spring Creek (Judicial Ditch 29; AUID 07020007-622).**

Table A-24. ***E. coli*** **TMDL summary, Spring Creek (Judicial Ditch 29; AUID 07020007-622)**

TMDL Parameter	Flow Zone				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	E. coli **Load (billion org/d)**				
WLA: Evan WWTP (MNG580202)	0.69	0.69	0.69	0.69	–[a]
Load Allocation	177	45	11	1.7	–[a]
Margin of Safety	20	5.1	1.3	0.27	–[a]
Loading Capacity	198	51	13	2.7	–[a]
Maximum Monthly Geometric Mean (org/100 mL)	423				
Estimated Percent Reduction	70%				

a. HSPF simulated flow of zero is likely an underestimate of actual flow conditions.

A1.9 Spring Creek, T111 R32W S21, west line to Minnesota R (07020007-573)

E. coli

Table A-25 Annual summary of *E. coli* data at Spring Creek (AUID 07020007-573; 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
2006	0	–	–	–	–	–
2007	0	–	–	–	–	–
2008	0	–	–	–	–	–
2009	13	110	4	≥ 2,420 [a]	2	15
2010	17	247	16	≥ 2,420 [a]	4	24
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	7	415	56	≥ 2,420 [a]	2	29
2014	8	281	68	1,223	0	–
2015	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

Table A-26 Monthly summary of *E. coli* data at Spring Creek (AUID 07020007-573; 2006–2015)

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 percent 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	5	12	4	25	0	–
May	5	45	4	160	0	–
Jun	10	502	68	≥ 2,420 [a]	3	30
Jul	10	344	147	727	0	–
Aug	10	315	56	1,789	3	30
Sep	5	655	211	≥ 2,420 [a]	2	40
Oct	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

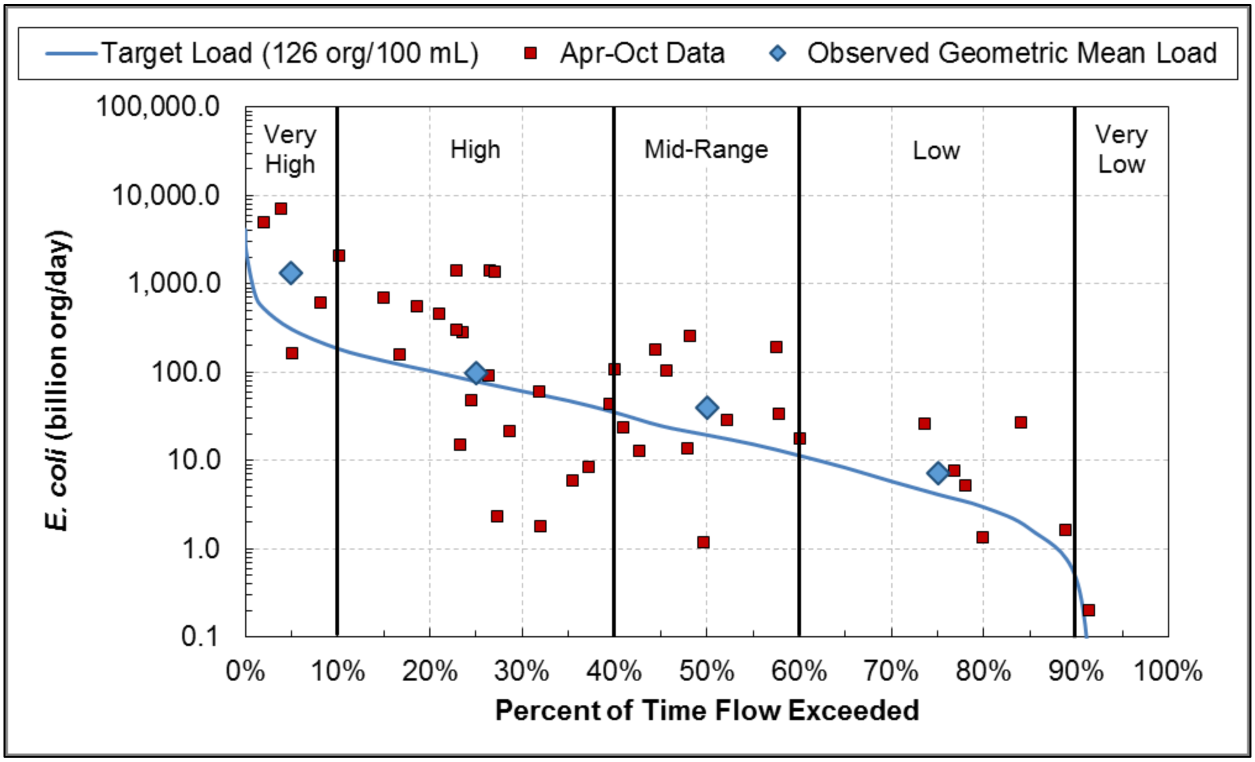

Figure A-28. ***E. coli*** **load duration curve, Spring Creek (AUID 07020007-573).**

Table A-27. ***E. coli*** **TMDL summary, Spring Creek (AUID 07020007-573)**

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	E. coli Load (billion org/d)				
WLA: Evan WWTP (MNG580202)	0.69	0.69	0.69	0.69	– [a]
Load Allocation	276	70	16	3.0	– [a]
Margin of Safety	31	7.9	1.9	0.41	– [a]
Loading Capacity	308	79	19	4.1	– [a]
Maximum Monthly Geometric Mean (org/100 mL)	655				
Estimated Percent Reduction	81%				

a. HSPF simulated flow of zero is likely an underestimate of actual flow conditions.

A1.10 County Ditch 13, 245th Ave to Minnesota R (07020007-712)

E. coli

Table A-28. Annual summary of *E. coli* data at County Ditch 13 (AUID 07020007-712; 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
2006	0	–	–	–	–	–
2007	0	–	–	–	–	–
2008	0	–	–	–	–	–
2009	22	573	99	≥ 2,420 [a]	5	23
2010	18	582	122	≥ 2,420 [a]	5	28
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

Table A-29. Monthly summary of *E. coli* data at County Ditch 13 (AUID 07020007-712; 2006–2015)

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 percent 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	7	656	249	≥ 2,420 [a]	2	29
May	7	434	99	≥ 2,420 [a]	1	14
Jun	7	611	122	≥ 2,420 [a]	2	29
Jul	8	722	345	≥ 2,420 [a]	2	25
Aug	6	486	219	1,553	1	17
Sep	5	568	105	≥ 2,420 [a]	2	40
Oct	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

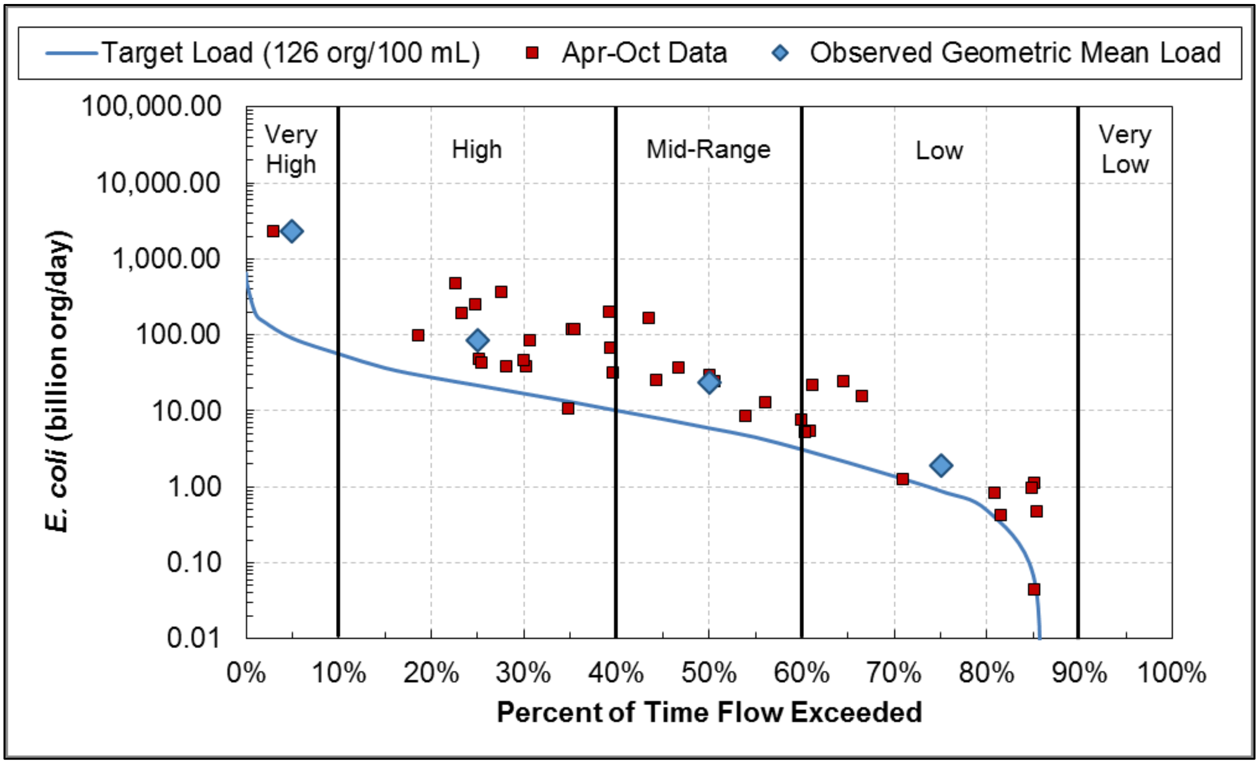

Figure A-29. *E. coli* load duration curve, County Ditch 13 (AUID 07020007-712).

Table A-30. *E. coli* TMDL summary, County Ditch 13 (AUID 07020007-712)

TMDL Parameter	Flow Zone				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	***E. coli* Load (billion org/d)**				
Load Allocation	82	20	5.4	0.79	– [a]
Margin of Safety	9.1	2.2	0.60	0.088	– [a]
Loading Capacity	91	22	6.0	0.88	– [a]
Maximum Monthly Geometric Mean (org/100 mL)	722				
Estimated Percent Reduction	83%				

a. HSPF simulated flow of zero is likely an underestimate of actual flow conditions.

A1.11 County Ditch 10 (John's Creek), T110 R32W S1, west line to Minnesota R (07020007-571)

E. coli

Table A-31. Annual summary of *E. coli* data at County Ditch 10-John's Creek (AUID 07020007-571; 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
2006	0	–	–	–	–	–
2007	0	–	–	–	–	–
2008	0	–	–	–	–	–
2009	10	240	15	3,609	1	10
2010	19	399	13	≥ 2,420 [a]	8	42
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

Table A-32. Monthly summary of *E. coli* data at County Ditch 10-John's Creek (AUID 07020007-571; 2006–2015)

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 percent 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	5	25	13	66	0	–
May	5	176	79	548	0	–
Jun	5	525	125	1,733	2	40
Jul	4 [a]	429	219	770	0	–
Aug	5	1,270	291	3,609	3	60
Sep	5	1,197	72	≥ 2,420 [b]	4	80
Oct	0	–	–	–	–	–

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

b. 2,420 org/100mL is the method's maximum recordable value.

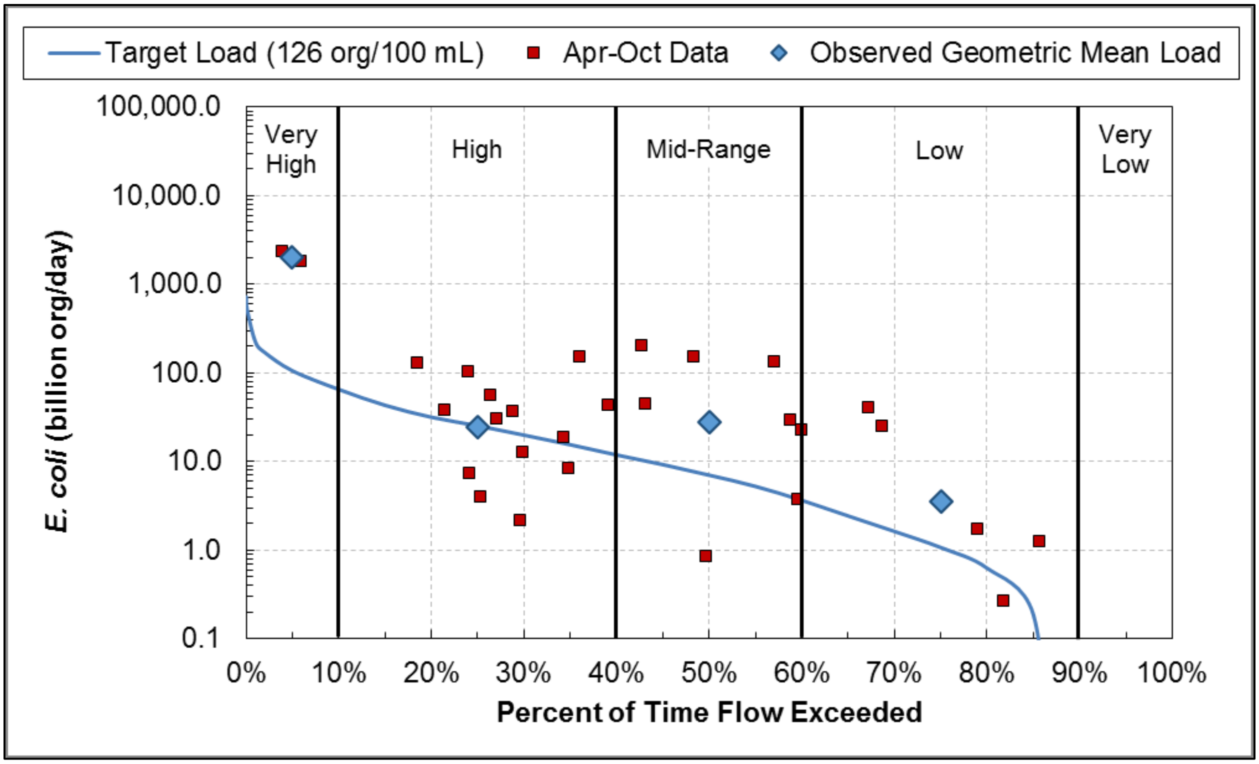

Figure A-30. *E. coli* load duration curve, County Ditch 10 (John's Creek; AUID 07020007-571).

Table A-33. *E. coli* TMDL summary, County Ditch 10 (John's Creek; AUID 07020007-571)

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	E. coli Load (billion org/d)				
Load Allocation	95	23	6.3	1.0	– [a]
Margin of Safety	11	2.5	0.70	0.11	– [a]
Loading Capacity	106	26	7.0	1.1	– [a]
Maximum Monthly Geometric Mean (org/100 mL)	1,270				
Estimated Percent Reduction	90%				

a. HSPF simulated flow of zero is likely an underestimate of actual flow conditions.

Nitrate

Table A-34. Annual summary of nitrate data at County Ditch 10-John's Creek (AUID 07020007-571; Jan–Dec)

Year	Sample count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
2006	0	–	–	–	–	–
2007	0	–	–	–	–	–
2008	0	–	–	–	–	–
2009	15	12	3	18	12	80%
2010	14	16	7	22	12	86%
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–

Table A-35. Monthly summary of nitrate data at County Ditch 10-John's Creek (AUID 07020007-571; 2006–2015)

Month	Sample count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
Jan	0	–	–	–	–	–
Feb	0	–	–	–	–	–
Mar	2	8	7	8	0	–
Apr	4	16	11	20	4	100%
May	4	17	12	22	4	100%
Jun	7	16	12	21	7	100%
Jul	3	13	10	18	2	67%
Aug	3	12	3	18	2	67%
Sep	2	17	14	19	2	100%
Oct	4	13	8	18	3	75%
Nov	0	–	–	–	–	–
Dec	0	–	–	–	–	–

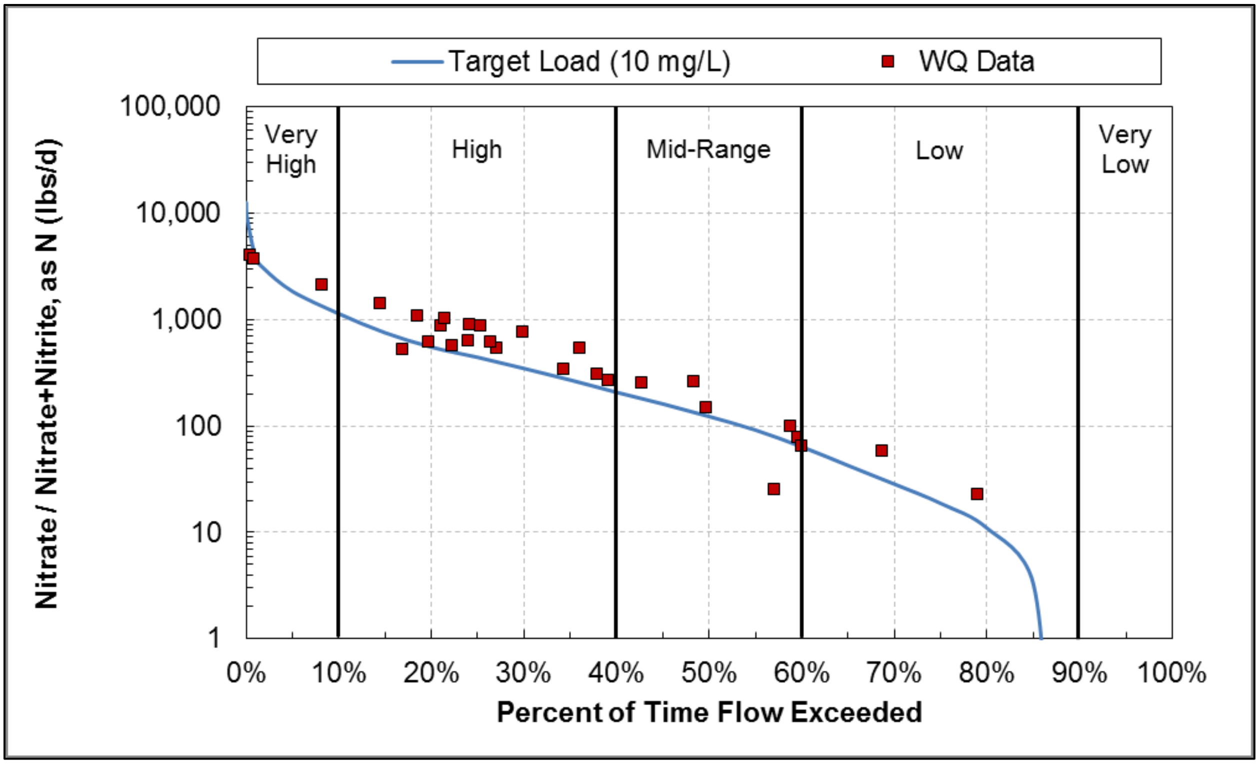

Figure A-31. Nitrate load duration curve, County Ditch 10 (John's Creek; AUID 07020007-571).

Table A-36. Nitrate TMDL summary, County Ditch 10 (John's Creek; AUID 07020007-571)

TMDL Parameter	Flow Zone				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	Inorganic N (Nitrate and Nitrite) Load (lb/d)				
WLA: Construction and Industrial Stormwater	0.90	0.22	0.060	0.0092	– [a]
Load Allocation	1,668	400	111	17	– [a]
Margin of Safety	185	45	12	1.9	– [a]
Loading Capacity	1,854	445	123	19	– [a]
2nd Highest Exceedance Concentration (mg/L)	21				
Estimated Percent Reduction	52%				

a. HSPF simulated flow of zero is likely an underestimate of actual flow conditions.

A1.12 Little Rock Creek (Judicial Ditch 31), Mud Lk to Minnesota R (07020007-687)

E. coli

Table A-37. Annual summary of *E. coli* data at Little Rock Creek-Judicial Ditch 31 (AUID 07020007-687; 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
2006	0	–	–	–	–	–
2007	0	–	–	–	–	–
2008	0	–	–	–	–	–
2009	5	26	5	118	0	–
2010	13	352	10	1,120	0	–
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	6	1,008	308	≥ 2,420 [a]	3	50
2014	8	441	75	2,613	2	25
2015	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

Table A-38. Monthly summary of *E. coli* data at Little Rock Creek-Judicial Ditch 31 (AUID 07020007-687; 2006–2015)

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 percent 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	3 [a]	8	5	10	0	–
May	2 [a]	44	21	91	0	–
Jun	9	449	118	1,553	1	11
Jul	11	544	179	≥ 2,420 [b]	2	18
Aug	7	592	75	2,613	2	29
Sep	0	–	–	–	–	–
Oct	0	–	–	–	–	–

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

b. 2,420 org/100mL is the method's maximum recordable value.

Figure A-32. *E. coli* load duration curve, Little Rock Creek (Judicial Ditch 31; AUID 07020007-687).

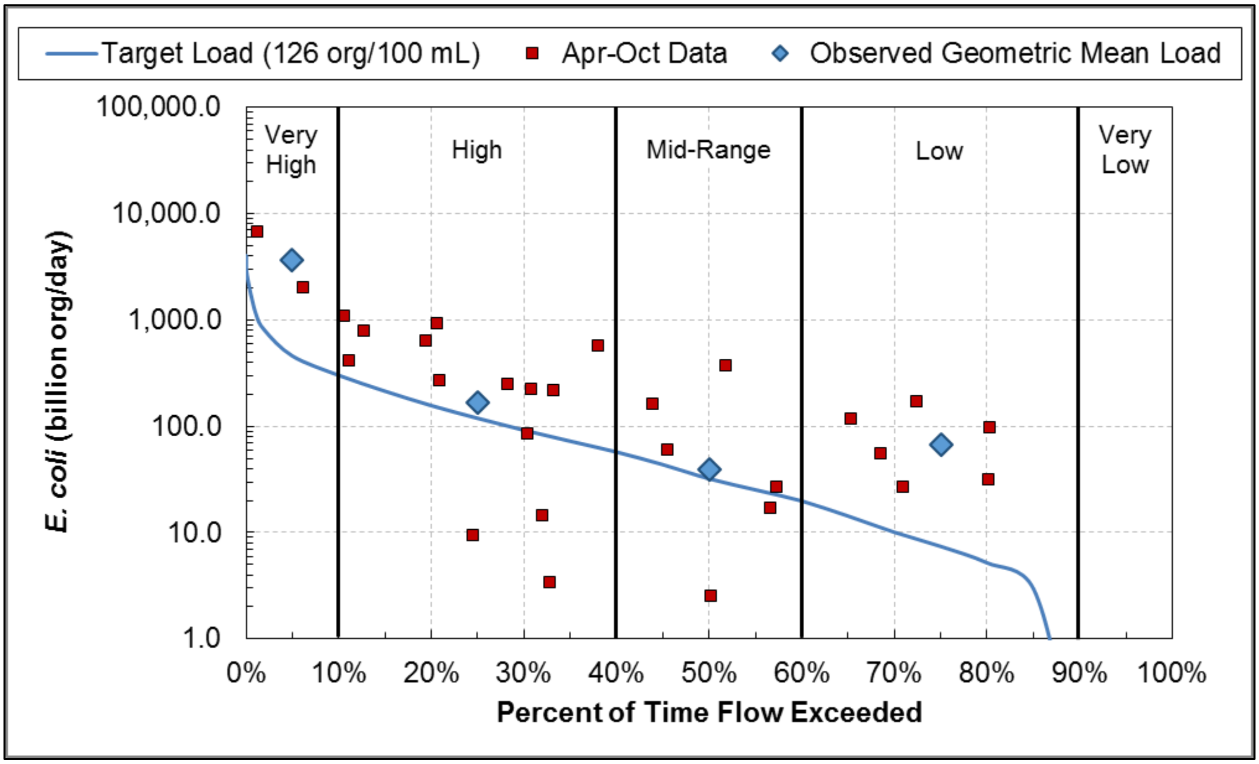

Table A-39. *E. coli* TMDL summary, Little Rock Creek (Judicial Ditch 31; AUID 07020007-687)

TMDL Parameter	Flow Zone				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	***E. coli* Load (billion org/d)**				
Load Allocation	414	107	29	6.7	– [a]
Margin of Safety	46	12.0	3.2	0.74	– [a]
Loading Capacity	460	119	32	7.4	– [a]
Maximum Monthly Geometric Mean (org/100 mL)	592				
Estimated Percent Reduction	79%				

a. HSPF simulated flow of zero is likely an underestimate of actual flow conditions.

A1.13 Eight-Mile Creek, 366th St/T-39 to Minnesota R (07020007-684)

E. coli

Table A-40. Annual summary of *E. coli* data at Eight-Mile Creek (AUID 07020007-684; 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
2006	0	–	–	–	–	–
2007	0	–	–	–	–	–
2008	0	–	–	–	–	–
2009	8	99	6	1,300	1	13
2010	10	438	11	1,553	2	20
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	8	535	91	≥ 2,420 [a]	1	13
2014	8	342	158	1,081	0	–
2015	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

Table A-41. Monthly summary of *E. coli* data at Eight-Mile Creek (AUID 07020007-684; 2006–2015)

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 percent 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	3 [a]	9	6	11	0	–
May	2 [a]	77	69	86	0	–
Jun	9	561	140	≥ 2,420 [b]	1	11
Jul	11	486	180	1,373	2	18
Aug	8	497	158	1,553	1	13
Sep	1 [a]	91	91	91	0	–
Oct	0	–	–	–	–	–

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

b. 2,420 org/100mL is the method's maximum recordable value.

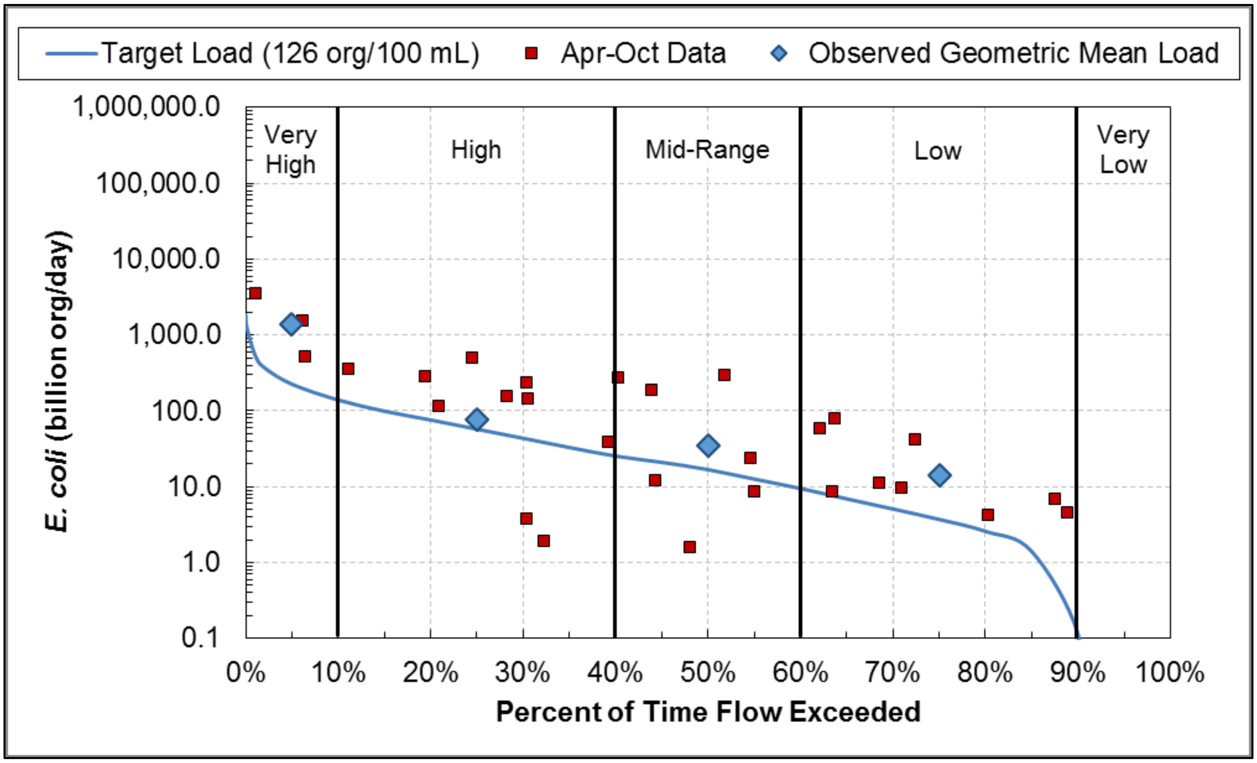

Figure A-33. ***E. coli*** **load duration curve, Eight-Mile Creek (AUID 07020007-684).**

Table A-42. ***E. coli*** **TMDL summary, Eight-Mile Creek (AUID 07020007-684)**

TMDL Parameter	Flow Zone				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	E. coli **Load (billion org/d)**				
Load Allocation	203	52	15	3.3	– [a]
Margin of Safety	23	5.8	1.7	0.37	– [a]
Loading Capacity	226	58	17	3.7	– [a]
Maximum Monthly Geometric Mean (org/100 mL)	561				
Estimated Percent Reduction	78%				

a. HSPF simulated flow of zero is likely an underestimate of actual flow conditions.

A1.14 Huelskamp Creek, Unnamed Cr to Minnesota R (07020007-641)

E. coli

Table A-43. Annual summary of *E. coli* data at Huelskamp Creek (AUID 07020007-641; 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
2006	0	–	–	–	–	–
2007	0	–	–	–	–	–
2008	0	–	–	–	–	–
2009	6	116	30	579	0	–
2010	9	452	9	≥ 2,420 [a]	1	11
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

Table A-44. Monthly summary of *E. coli* data at Huelskamp Creek (AUID 07020007-641; 2006–2015)

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 percent 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	3 [a]	21	9	34	0	–
May	2 [a]	119	62	228	0	–
Jun	5	411	260	921	0	–
Jul	4 [a]	858	649	1,046	0	–
Aug	0	–	–	–	–	–
Sep	1 [a]	≥ 2,420 [b]	≥ 2,420 [b]	≥ 2,420 [b]	1	100
Oct	0	–	–	–	–	–

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

b. 2,420 org/100mL is the method's maximum recordable value.

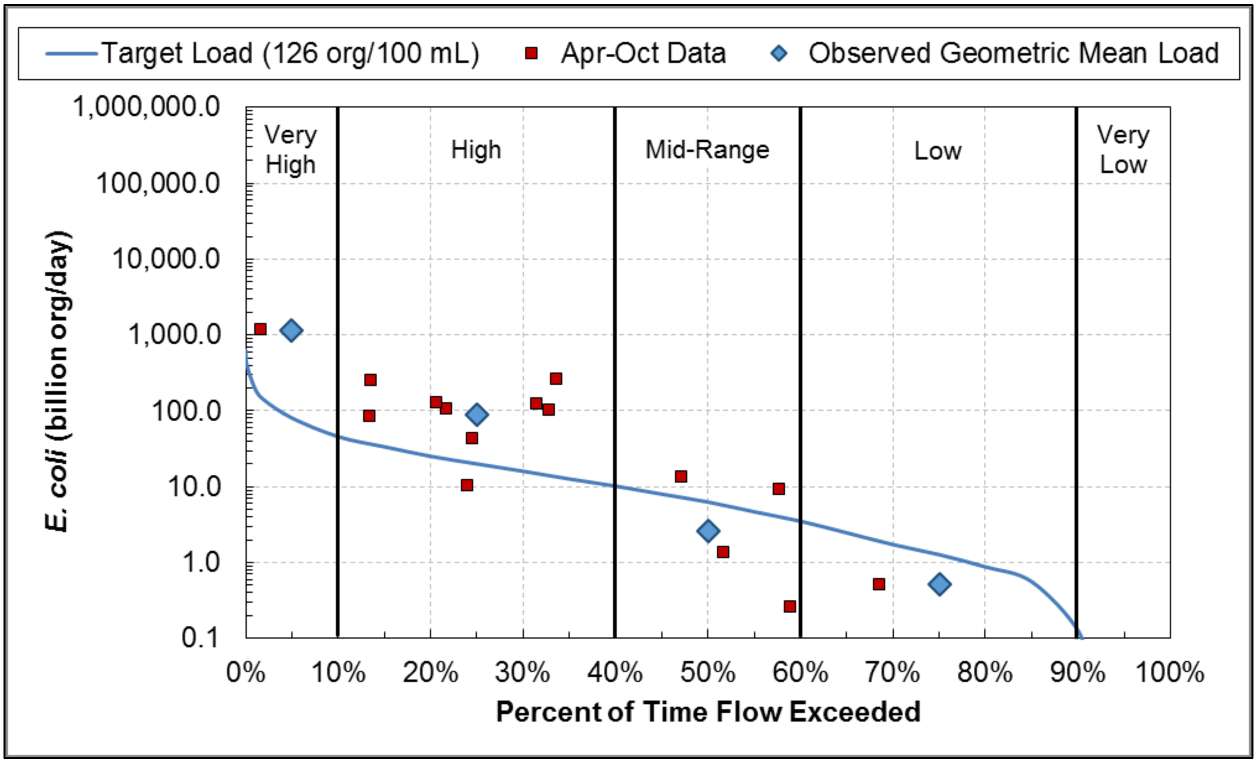

Figure A-34. ***E. coli*** **load duration curve, Huelskamp Creek (AUID 07020007-641).**

Table A-45. ***E. coli*** **TMDL summary, Huelskamp Creek (AUID 07020007-641)**

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	E. coli Load (billion org/d)				
Load Allocation	73	18.0	5.7	1.2	– [a]
Margin of Safety	8.1	2.0	0.63	0.13	– [a]
Loading Capacity	81	20	6.3	1.3	– [a]
Maximum Monthly Geometric Mean (org/100 mL)	411				
Estimated Percent Reduction	69%				

a. HSPF simulated flow of zero is likely an underestimate of actual flow conditions.

A1.15 Fritsche Creek (County Ditch 77), -94.4172 44.3557 to Minnesota R (07020007-709)

E. coli

Table A-46. Annual summary of *E. coli* data at Fritsche Creek-County Ditch 77 (AUID 07020007-709; 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
2006	0	–	–	–	–	–
2007	0	–	–	–	–	–
2008	0	–	–	–	–	–
2009	8	171	14	649	0	–
2010	10	442	31	≥ 2,420 [a]	1	10
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

Table A-47. Monthly summary of *E. coli* data at Fritsche Creek-County Ditch 77 (AUID 07020007-709; 2006–2015)

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 percent 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	3 [a]	39	14	140	0	–
May	2 [a]	119	105	135	0	–
Jun	5	408	261	579	0	–
Jul	5	370	170	921	0	–
Aug	3 [a]	1,483	1,120	≥ 2,420 [b]	1	33
Sep	0	–	–	–	–	–
Oct	0	–	–	–	–	–

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

b. 2,420 org/100mL is the method's maximum recordable value.

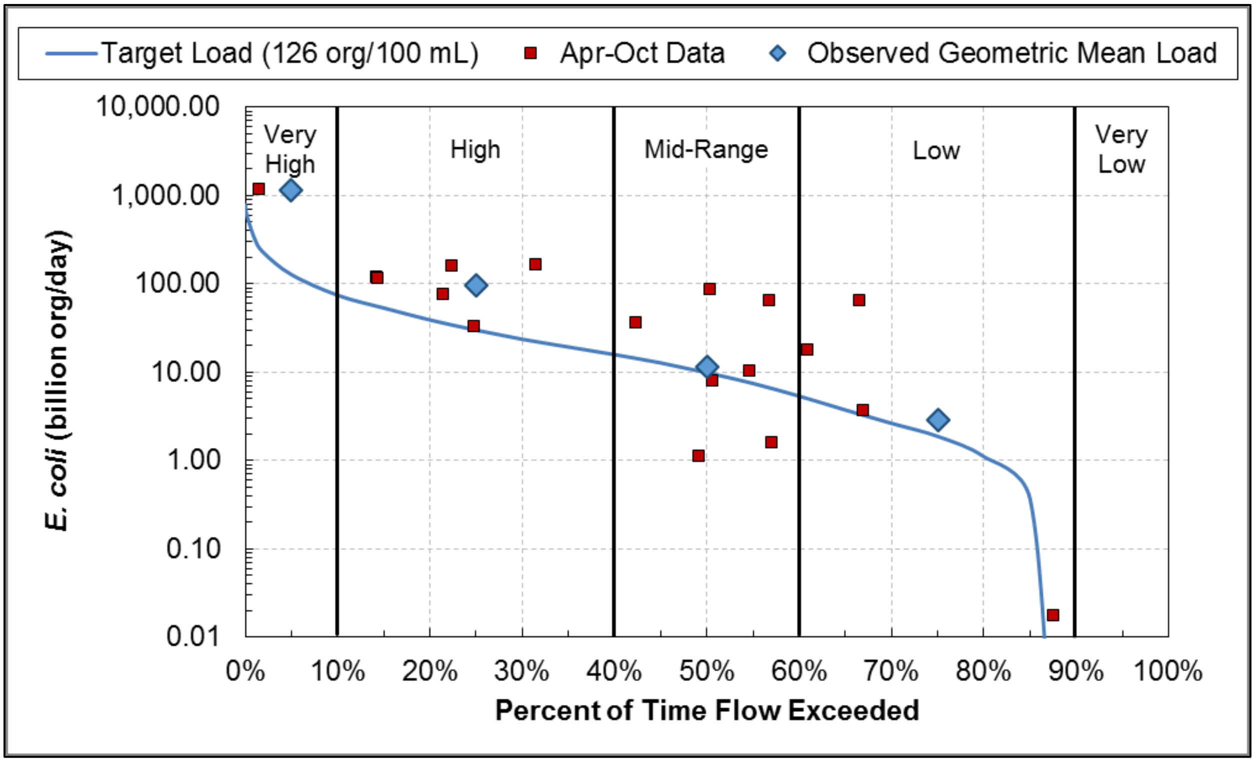

Figure A-35. ***E. coli*** **load duration curve, Fritsche Creek (County Ditch 77; AUID 07020007-709).**

Table A-48. ***E. coli*** **TMDL summary, Fritsche Creek (County Ditch 77; AUID 07020007-709)**

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	E. coli Load (billion org/d)				
Load Allocation	115	27	8.9	1.7	– [a]
Margin of Safety	13	3.0	1.0	0.19	– [a]
Loading Capacity	128	30	10	1.9	– [a]
Maximum Monthly Geometric Mean (org/100 mL)	408				
Estimated Percent Reduction	69%				

a. HSPF simulated flow of zero is likely an underestimate of actual flow conditions.

A1.16 Heyman’s Creek, Unnamed Cr to Minnesota R (07020007-640)

E. coli

Table A-49. Annual summary of *E. coli* data at Heyman's Creek (AUID 07020007-640; 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
2006	0	–	–	–	–	–
2007	0	–	–	–	–	–
2008	0	–	–	–	–	–
2009	10	230	20	≥ 2,420 [a]	1	10
2010	10	373	33	1,733	1	10
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–

a. 2,420 org/100mL is the method’s maximum recordable value.

Table A-50. Monthly summary of *E. coli* data at Heyman's Creek (AUID 07020007-640; 2006–2015)

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 percent 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	3 [a]	26	20	33	0	–
May	2 [a]	84	45	157	0	–
Jun	5	377	201	613	0	–
Jul	6	532	259	1,203	0	–
Aug	4 [a]	1,013	387	≥ 2,420 [b]	2	50
Sep	0	–	–	–	–	–
Oct	0	–	–	–	–	–

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

b. 2,420 org/100mL is the method’s maximum recordable value.

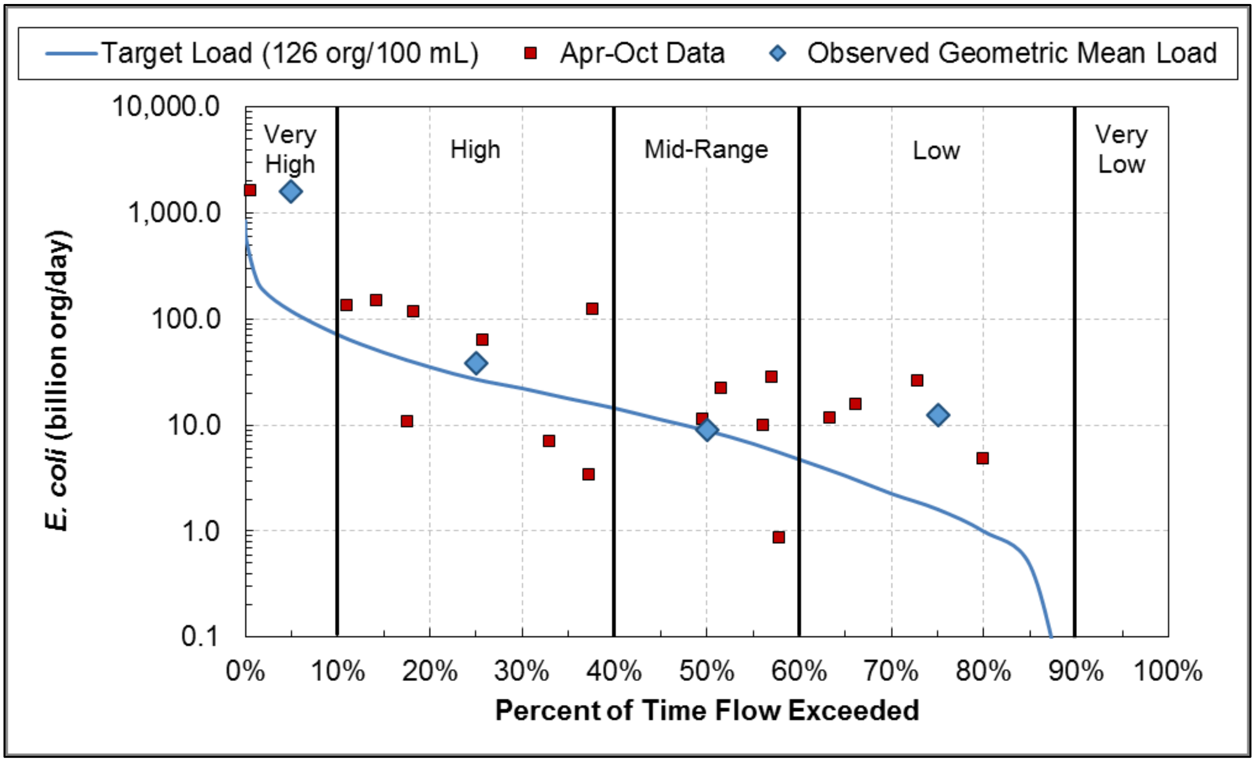

Figure A-36. ***E. coli*** **load duration curve, Heyman's Creek (AUID 07020007-640).**

Table A-51. ***E. coli*** **TMDL summary, Heyman's Creek (AUID 07020007-640)**

TMDL Parameter	**Flow Zone**				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	E. coli **Load (billion org/d)**				
Load Allocation	107	24	8.0	1.4	– [a]
Margin of Safety	12	2.7	0.89	0.16	– [a]
Loading Capacity	119	27	8.9	1.6	– [a]
Maximum Monthly Geometric Mean (org/100 mL)	532				
Estimated Percent Reduction	76%				

a. HSPF simulated flow of zero is likely an underestimate of actual flow conditions.

2. Little Cottonwood River–Nicollet

A2.1 Altermatts Creek, T108 R34W S35, south line to Little Cottonwood R (07020007-518)

E. coli

Table A-52. Annual summary of *E. coli* data at Altermatts Creek (AUID 07020007-518; 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
2006	0	–	–	–	–	–
2007	0	–	–	–	–	–
2008	0	–	–	–	–	–
2009	6	254	127	687	0	–
2010	9	676	326	≥ 2,420 [a]	2	22
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

Table A-53. Monthly summary of *E. coli* data at Altermatts Creek (AUID 07020007-518; 2006–2015)

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 percent 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	5	400	127	≥ 2,420 [a]	1	20
Jul	5	716	488	1,414	1	20
Aug	5	334	133	727	0	–
Sep	0	–	–	–	–	–
Oct	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

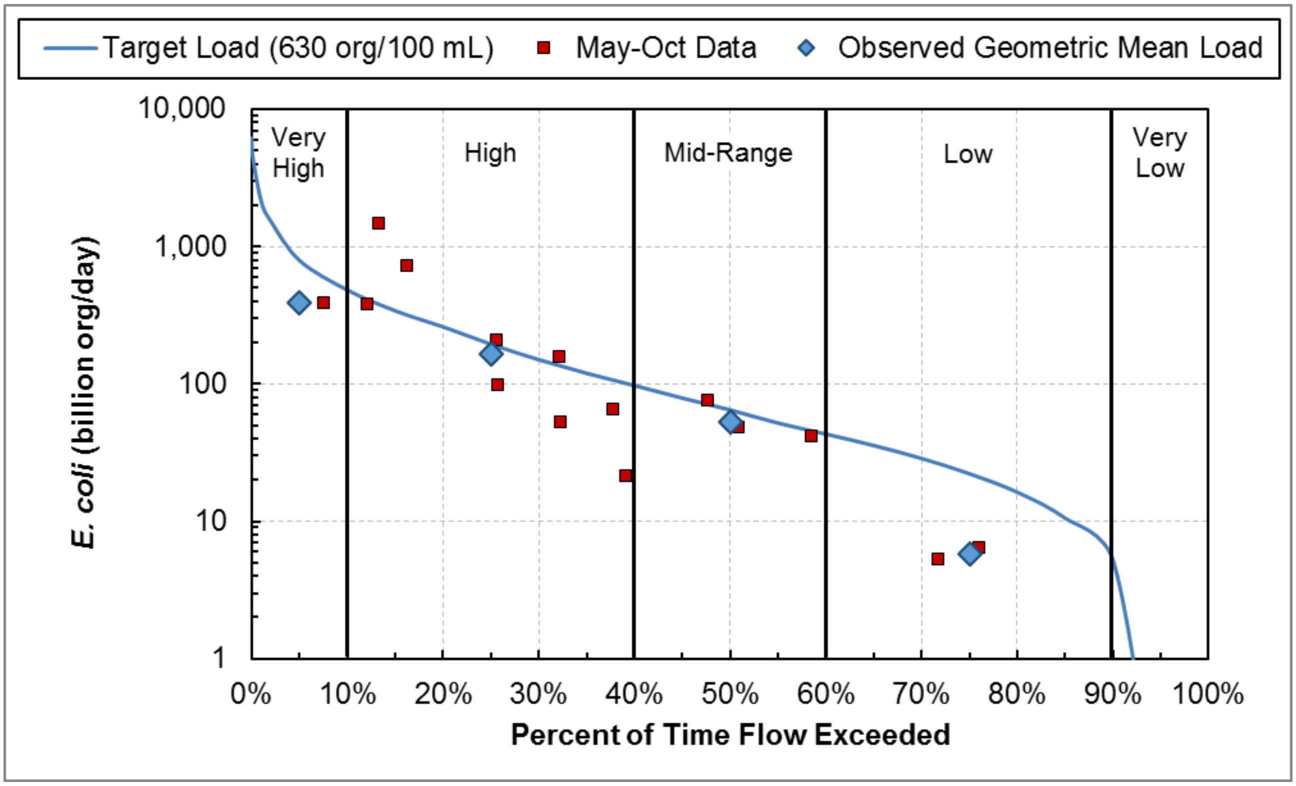

Figure A-37. *E. coli* load duration curve, Altermatts Creek (AUID 07020007-518).

Table A-54. *E. coli* TMDL summary, Altermatts Creek (AUID 07020007-518)

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	E. coli Load (billion org/d)				
WLA: Comfrey WWTP (MN0021687)	0.36	0.36	0.36	0.36	– [a]
Load Allocation	709	175	57	19	– [a]
Margin of Safety	79	19	6.4	2.2	0.0049
Loading Capacity	788	194	64	22	0.049
Maximum Monthly Geometric Mean (org/100 mL)	716				
Estimated Percent Reduction	12%				

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 (630 org per 100 mL) x conversion factors. See section 4.6.2 for more detail.

A2.2 Little Cottonwood River, Headwaters to T109 R31W S22, north line (07020007-676)

E. coli

There are no *E. coli* data available from 2006–2015.

Table A-55. Annual summary of *E. coli* data at Little Cottonwood River (AUID 07020007-676; 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
2000	0	–	–	–	–	–
2001	0	–	–	–	–	–
2002	5	550	60	1,722	1	20
2003	0	–	–	–	–	–
2004	0	–	–	–	–	–
2005	0	–	–	–	–	–

Table A-56. Monthly summary of *E. coli* data at Little Cottonwood River (AUID 07020007-676; 2000–2005)

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 percent 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	1 [a]	60	60	60	0	–
Jun	2 [a]	731	620	862	0	–
Jul	1 [a]	1,722	1,722	1,722	1	100
Aug	1 [a]	909	909	909	0	–
Sep	0	–	–	–	–	–
Oct	0	–	–	–	–	–

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

Table A-57. Annual summary of fecal coliform data at Little Cottonwood River (AUID 07020007-676; April–October)

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)
2000	18	585	10	17,200
2001	1	40	40	40
2002	0	–	–	–
2003	0	–	–	–
2004	0	–	–	–
2005	0	–	–	–

Table A-58. Monthly summary of fecal coliform data at Little Cottonwood River (AUID 07020007-676; 2000–2005)

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)
Apr	4	20	10	40
May	9	776	200	17,200
Jun	3	944	700	1,500
Jul	3	5,750	1,100	16,000
Aug	0	–	–	–
Sep	0	–	–	–
Oct	0	–	–	–

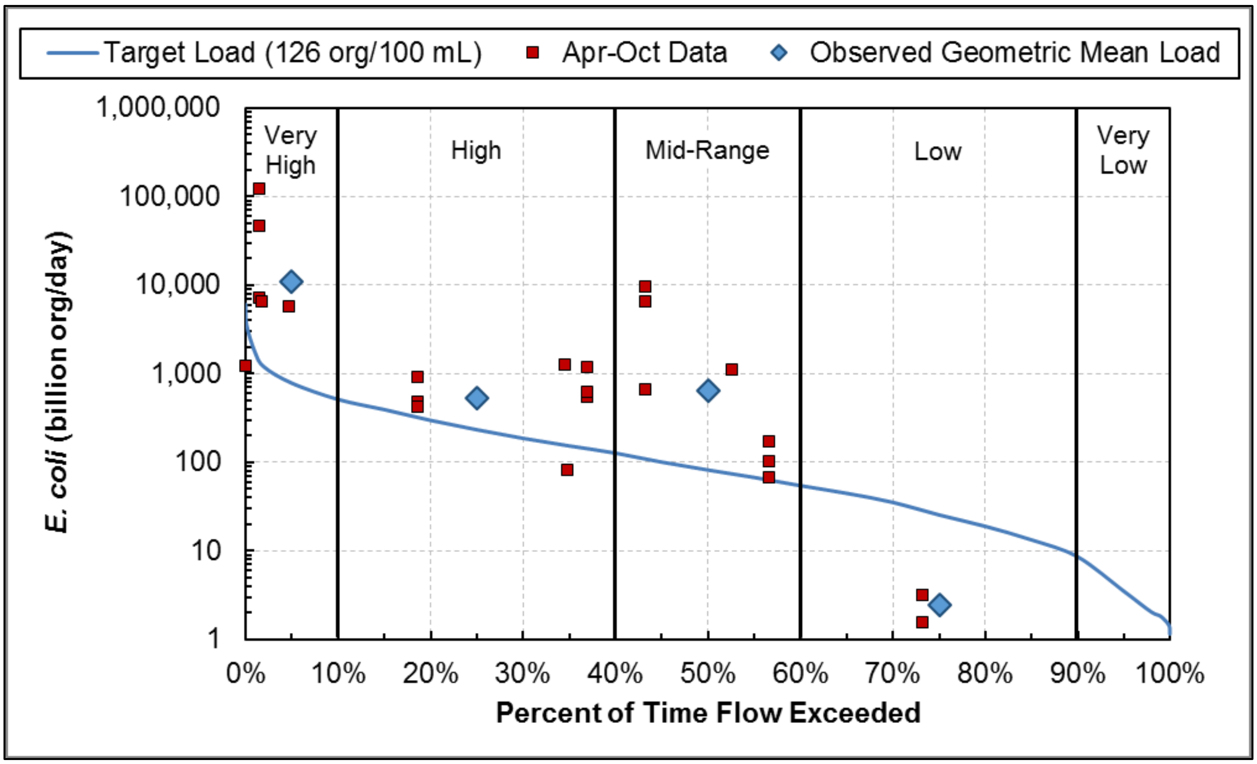

Figure A-38. ***E. coli*** **load duration curve, Little Cottonwood River (AUID 07020007-676).**

E. coli data are limited. The monitoring data are *E. coli* data from 2000–2005 and fecal coliform data translated to *E. coli* concentration.

Table A-59. *E. coli* TMDL summary, Little Cottonwood River (AUID 07020007-676)

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	E. coli Load (billion org/d)				
WLA: Jeffers WWTP (MNG580111)	1.6	1.6	1.6	1.6	1.6
WLA: Comfrey WWTP (MN0021687)	0.36	0.36	0.36	0.36	0.36
Load Allocation	700	207	72	21	1.2
Margin of Safety	78	23	8.2	2.5	0.35
Loading Capacity	780	232	82	25	3.5
Maximum Monthly Geometric Mean (org/100 mL)	646 [a]				
Estimated Percent Reduction	80% [a]				

a. *E. coli* data are limited. The percent reduction was calculated based on *E. coli* data from 2000–2005 and fecal coliform data translated to *E. coli* concentration.

TSS

Table A-60. Annual summary of TSS data at Little Cottonwood River (AUID 07020007-676; April–September)

2016 data are included due to the low sample size in the TMDL period (2006–2015). Values in red indicate years in which the individual standard of 65 mg/L was exceeded in greater than 10 percent of the samples.

Year	Sample count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
2006	0	–	–	–	–	–
2007	0	–	–	–	–	–
2008	0	–	–	–	–	–
2009	0	–	–	–	–	–
2010	0	–	–	–	–	–
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	7	68	5	160	3	43%
2016	7	47	9	160	1	14%

Table A-61. Monthly summary of TSS data at Little Cottonwood River (AUID 07020007-676; 2006–2016)

2016 data are included due to the low sample size in the TMDL period (2006–2015). Values in red indicate months in which the individual standard of 65 mg/L was exceeded in greater than 10 percent of the samples. Standard applies only to months April–September.

Month	Sample count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
Feb	1	24	24	24	NA	–
Mar	0	–	–	–	–	–
Apr	0	–	–	–	–	–
May	4	49	9	160	1	25%
Jun	8	72	6	160	3	38%
Jul	0	–	–	–	–	–
Aug	2	17	5	30	0	–
Sep	0	–	–	–	–	–

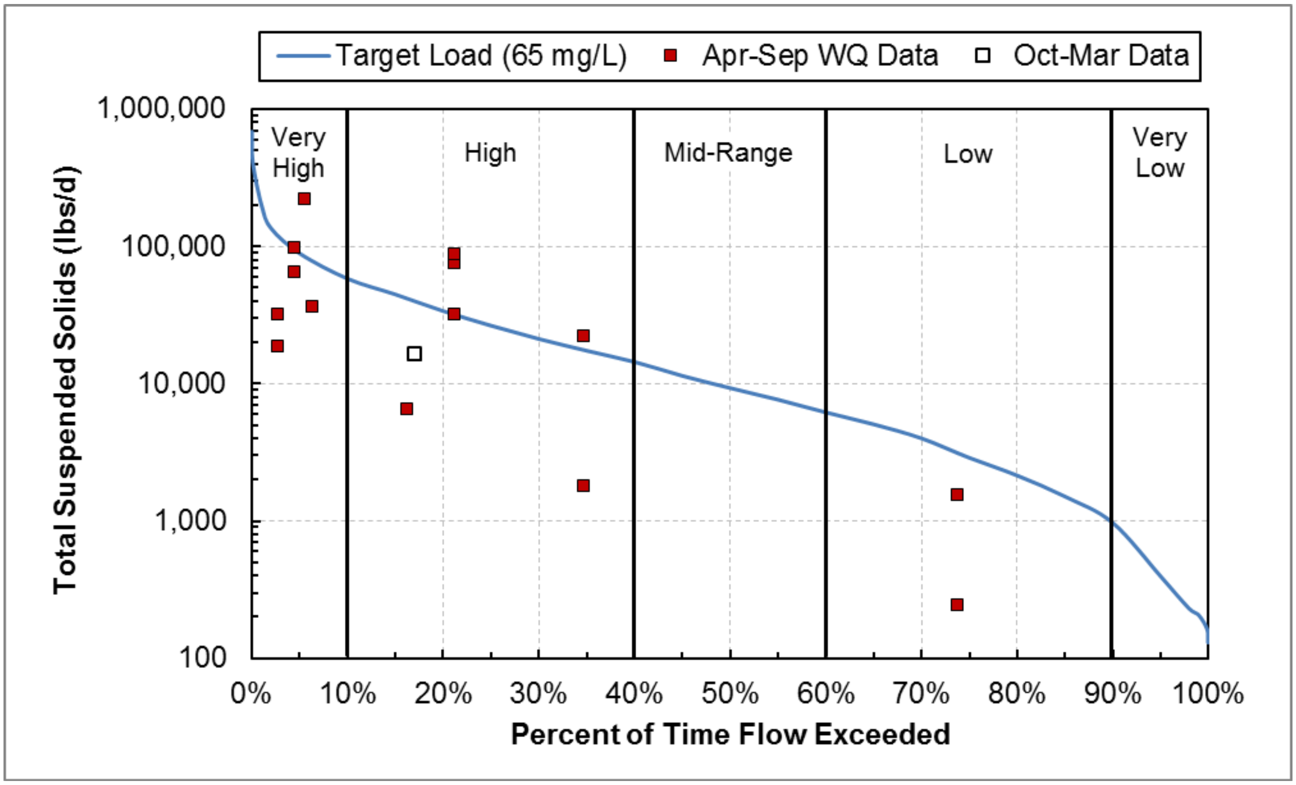

Figure A-39. TSS load duration curve, Little Cottonwood River (AUID 07020007-676).

2016 data are included due to the low sample size in the TMDL period (2006–2015).

Table A-62. TSS TMDL summary, Little Cottonwood River (AUID 07020007-676)

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	TSS Load (lb/d)				
WLA: Construction and Industrial Stormwater	61	18	6.2	1.9	– [a]
WLA: OMG Midwest Inc/Southern MN Construction Co Inc (MNG490131)	905	905	905	905	– [a]
WLA: Jeffers WWTP (MNG580111)	128	128	128	128	– [a]
WLA: Comfrey WWTP (MN0021687)	19	19	19	19	– [a]
Load Allocation	78,726	22,699	7,288	1,534	– [a]
Margin of Safety	8,871	2,641	927	288	40
Loading Capacity	88,710	26,410	9,273	2,876	395
90^{th} Percentile Existing Concentration (mg/L)	154				
Estimated Percent Reduction	58%				

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 65 mg/L (or NPDES permit concentration) x conversion factors. See section 4.6.2 for more detail.

A2.3 Little Cottonwood River, T109 R31W S15, south line to Minnesota R (07020007-677)

E. coli

Table A-63. Annual summary of *E. coli* data at Little Cottonwood River (AUID 07020007-677; 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
2006	18	205	5	20,000	4	22
2007	22	369	21	≥ 2,420 [a]	4	18
2008	23	173	1	≥ 2,420 [a]	3	13
2009	16	151	6	866	0	–
2010	0	–	–	–	–	–
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	10	401	53	4,600	1	10
2014	6	202	74	360	0	–
2015	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

Table A-64. Monthly summary of *E. coli* data at Little Cottonwood River (AUID 07020007-677; 2006–2015)

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 percent 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	9	131	1	2,300	NA	–
Apr	14	55	1	866	0	–
May	15	148	20	≥ 2,420 [b]	2	13
Jun	23	449	5	4,600	4	17
Jul	14	289	98	≥ 2,420 [b]	1	7
Aug	15	227	16	20,000	2	13
Sep	4 [a]	352	194	613	0	–
Oct	10	440	53	≥ 2,420 [b]	3	30

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

b. 2,420 org/100mL is the method's maximum recordable value.

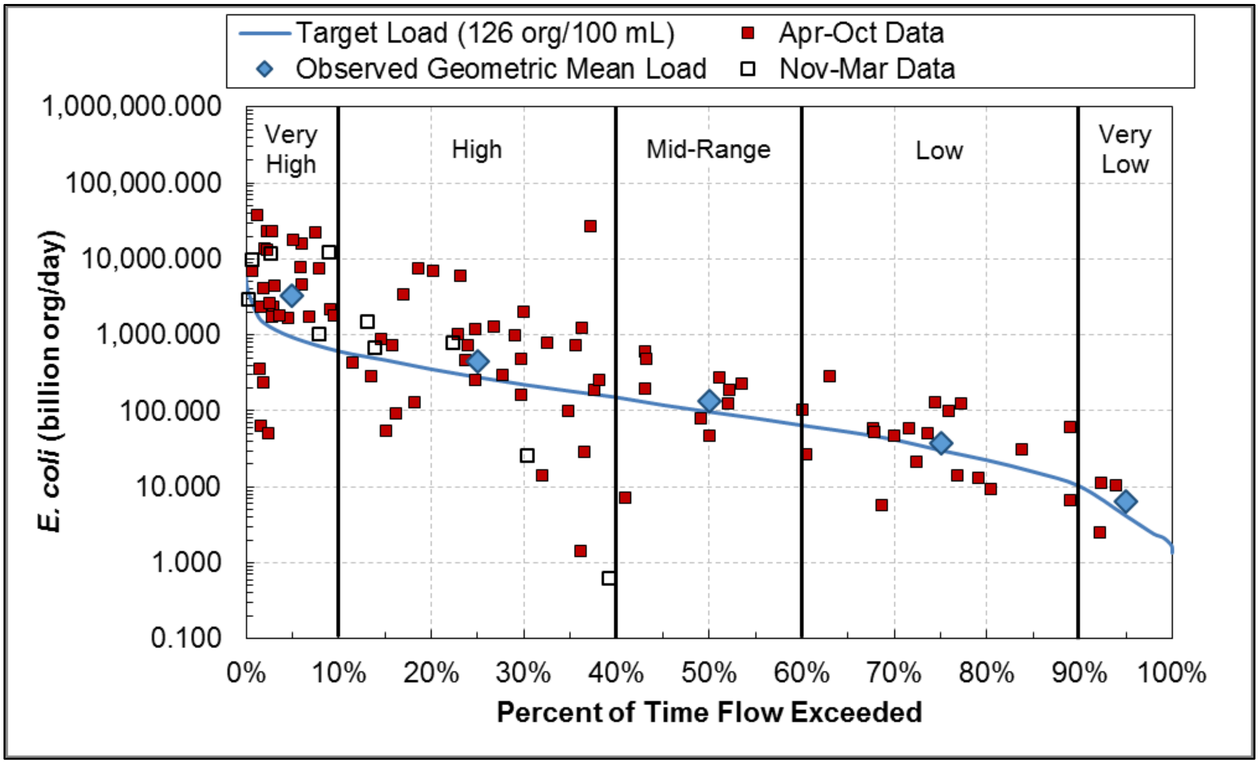

Figure A-40. *E. coli* load duration curve, Little Cottonwood River (AUID 07020007-677).

Table A-65. *E. coli* TMDL summary, Little Cottonwood River (AUID 07020007-677)

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	E. coli Load (billion org/d)				
WLA: Searles WWTP (MNG580080)	1.8	1.8	1.8	1.8	1.8
WLA: Jeffers WWTP (MNG580111)	1.6	1.6	1.6	1.6	1.6
WLA: Comfrey WWTP (MN0021687)	0.36	0.36	0.36	0.36	0.36
Load Allocation	836	246	84	23	0.020
Margin of Safety	93	28	9.8	3.0	0.42
Loading Capacity	933	278	98	30	4.2
Maximum Monthly Geometric Mean (org/100 mL)	449				
Estimated Percent Reduction	72%				

TSS

Table A-66. Annual summary of TSS data at Little Cottonwood River (AUID 07020007-677; April–September)

Values in red indicate years in which the individual standard of 65 mg/L was exceeded in greater than 10 percent of the samples.

Year	Sample count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
2006	20	124	6	392	13	65%
2007	16	81	6	305	8	50%
2008	23	148	2	778	13	57%
2009	15	17	4	62	0	–
2010	1	300	300	300	1	100%
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	34	84	3	630	13	38%
2014	22	183	5	1,520	12	55%
2015	20	147	3	644	12	60%

Table A-67. Monthly summary of TSS data at Little Cottonwood River (AUID 07020007-677; 2006–2015)

Values in red indicate months in which the individual standard of 65 mg/L was exceeded in greater than 10 percent of the samples. Standard applies only to months April–September.

Month	Sample count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
Jan	1	1	1	1	NA	–
Feb	2	3	3	4	NA	–
Mar	15	185	43	730	NA	–
Apr	25	93	3	368	13	52%
May	32	69	10	362	10	31%
Jun	43	217	4	1,520	39	91%
Jul	21	125	6	778	6	29%
Aug	20	48	2	305	4	20%
Sep	10	8	2	18	0	–
Oct	15	71	1	308	NA	–
Nov	2	13	3	22	NA	–
Dec	3	4	1	8	NA	–

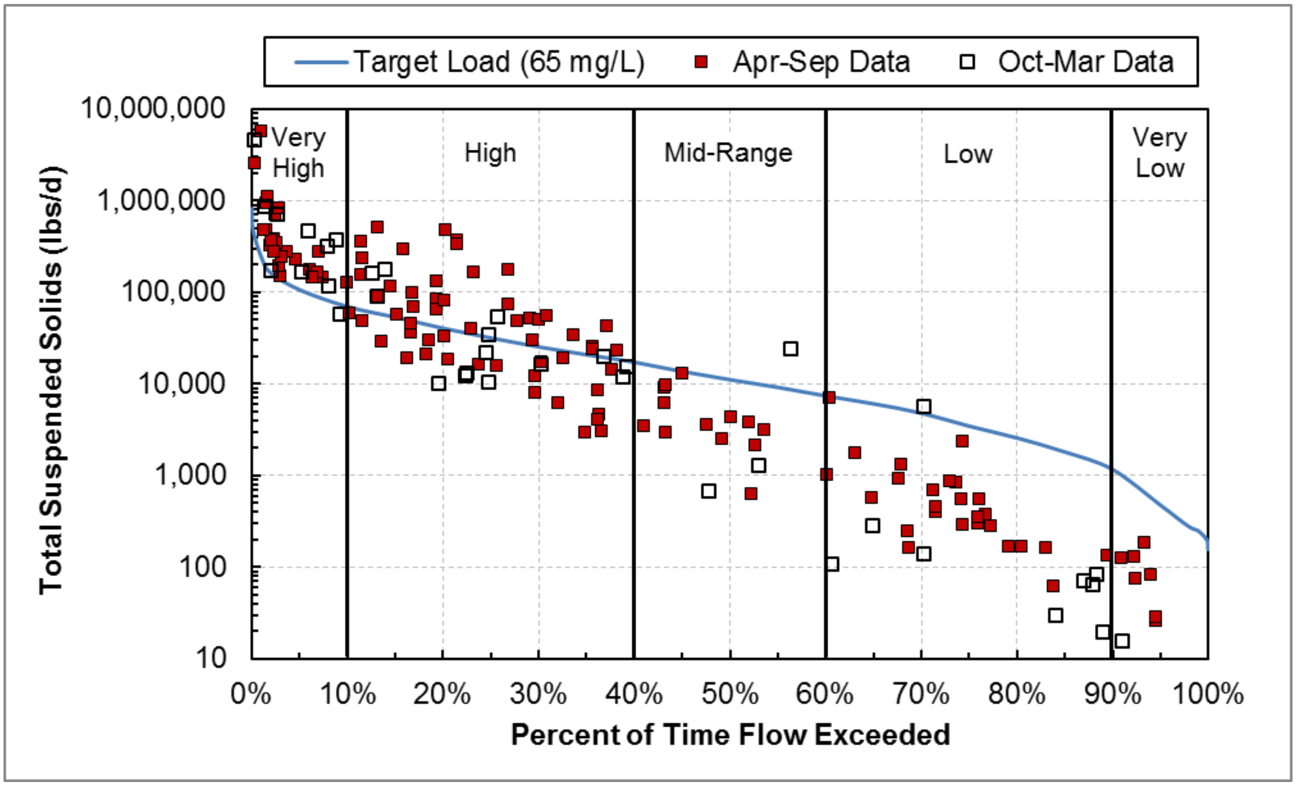

Figure A-41. TSS load duration curve, Little Cottonwood River (AUID 07020007-677).

Table A-68. TSS TMDL summary, Little Cottonwood River (AUID 07020007-677)

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	TSS Load (lb/d)				
WLA: Construction and Industrial Stormwater	70	20	6.5	1.4	– [a]
WLA: Searles WWTP (MNG580080)	144	144	144	144	– [a]
WLA: OMG Midwest Inc/Southern MN Construction Co Inc (MNG490131)	905	905	905	905	– [a]
WLA: Jeffers WWTP (MNG580111)	128	128	128	128	– [a]
WLA: Comfrey WWTP (MN0021687)	19	19	19	19	– [a]
Load Allocation	94,232	27,216	8,781	1,899	– [a]
Margin of Safety	10,611	3,159	1,109	344	47
Loading Capacity	106,109	31,591	11,093	3,440	473
90^{th} Percentile Existing Concentration (mg/L)	300				
Estimated Percent Reduction	78%				

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 65 mg/L (or NPDES permit concentration) x conversion factors. See section 4.6.2 for more detail.

A2.4 Morgan Creek, T109 R29W S30, south line to Minnesota R (07020007-691)

E. coli

Table A-69. Annual summary of *E. coli* data at Morgan Creek (AUID 07020007-691; 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
2006	0	–	–	–	–	–
2007	0	–	–	–	–	–
2008	0	–	–	–	–	–
2009	10	170	39	613	0	–
2010	10	229	5	921	0	–
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	10	477	160	4,400	1	10
2014	6	234	120	420	0	–
2015	0	–	–	–	–	–

Table A-70. Monthly summary of *E. coli* data at Morgan Creek (AUID 07020007-691; 2006–2015)

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 percent 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	3 [a]	21	5	43	0	–
May	2 [a]	547	488	613	0	–
Jun	11	307	39	4,400	1	9
Jul	11	287	140	580	0	–
Aug	9	368	160	921	0	–
Sep	0	–	–	–	–	–
Oct	0	–	–	–	–	–

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

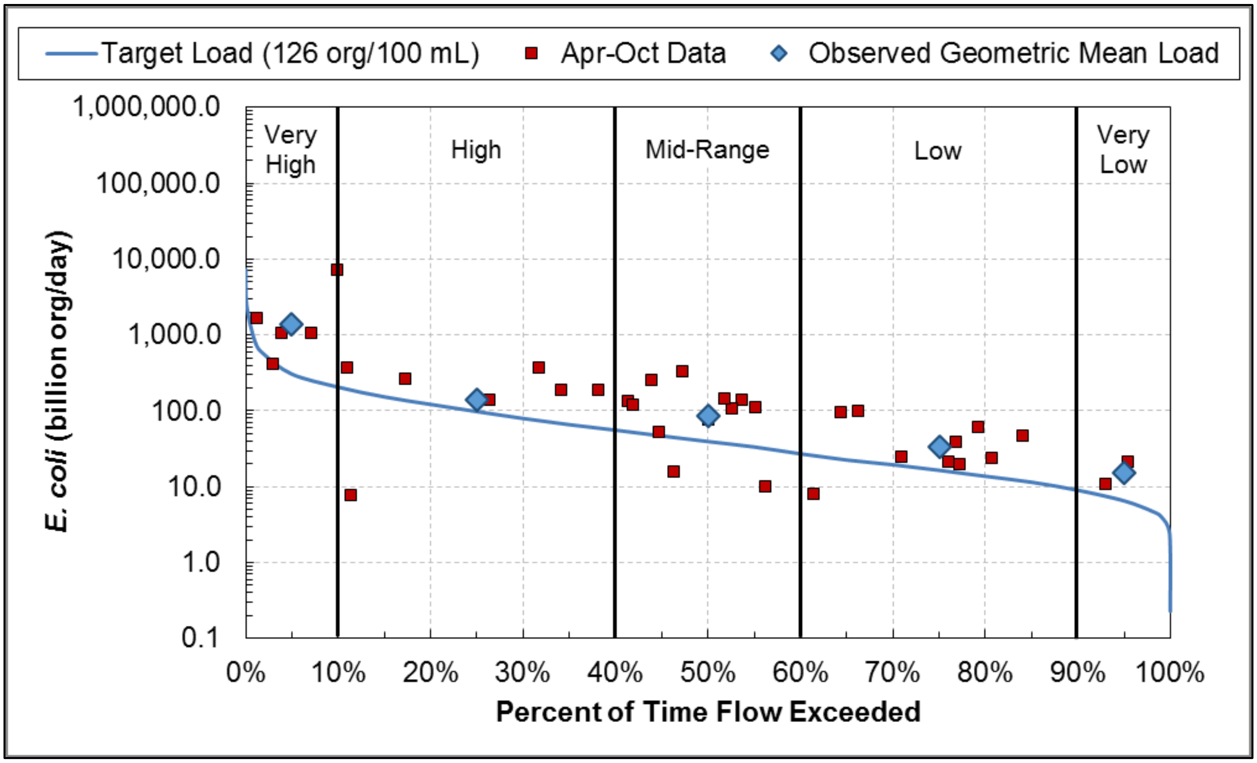

Figure A-42. ***E. coli*** **load duration curve, Morgan Creek (AUID 07020007-691).**

Table A-71. ***E. coli*** **TMDL summary, Morgan Creek (AUID 07020007-691)**

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	E. coli Load (billion org/d)				
WLA: Hanska WWTP (MN0052663)	3.6	3.6	3.6	3.6	3.6
Load Allocation	271	85	32	11	2.3
Margin of Safety	31	9.8	4.0	1.6	0.65
Loading Capacity	306	98	40	16.0	6.6
Maximum Monthly Geometric Mean (org/100 mL)	368				
Estimated Percent Reduction	66%				

A2.5 Unnamed Creek, T108 R28W S6, south line to T108 R28W S6, north line (07020007-577)

Nitrate

Table A-72. Annual summary of nitrate data at Unnamed Creek (AUID 07020007-577; Jan–Dec)

2016 data are included due to the low sample size in the TMDL period (2006–2015).

Year	Sample count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
2006	0	–	–	–	–	–
2007	0	–	–	–	–	–
2008	0	–	–	–	–	–
2009	0	–	–	–	–	–
2010	0	–	–	–	–	–
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	2	13	3	23	1	50%
2016	4	21	18	24	4	100%

Table A-73. Monthly summary of nitrate data at Unnamed Creek (AUID 07020007-577; 2006–2016)

2016 data are included due to the low sample size in the TMDL period (2006–2015).

Month	Sample count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
Jan	0	–	–	–	–	–
Feb	0	–	–	–	–	–
Mar	0	–	–	–	–	–
Apr	1	20	20	20	1	100%
May	1	20	20	20	1	100%
Jun	2	24	23	24	2	100%
Jul	0	–	–	–	–	–
Aug	1	18	18	18	1	100%
Sep	1	3	3	3	0	0%
Oct	0	–	–	–	–	–
Nov	0	–	–	–	–	–
Dec	0	–	–	–	–	–

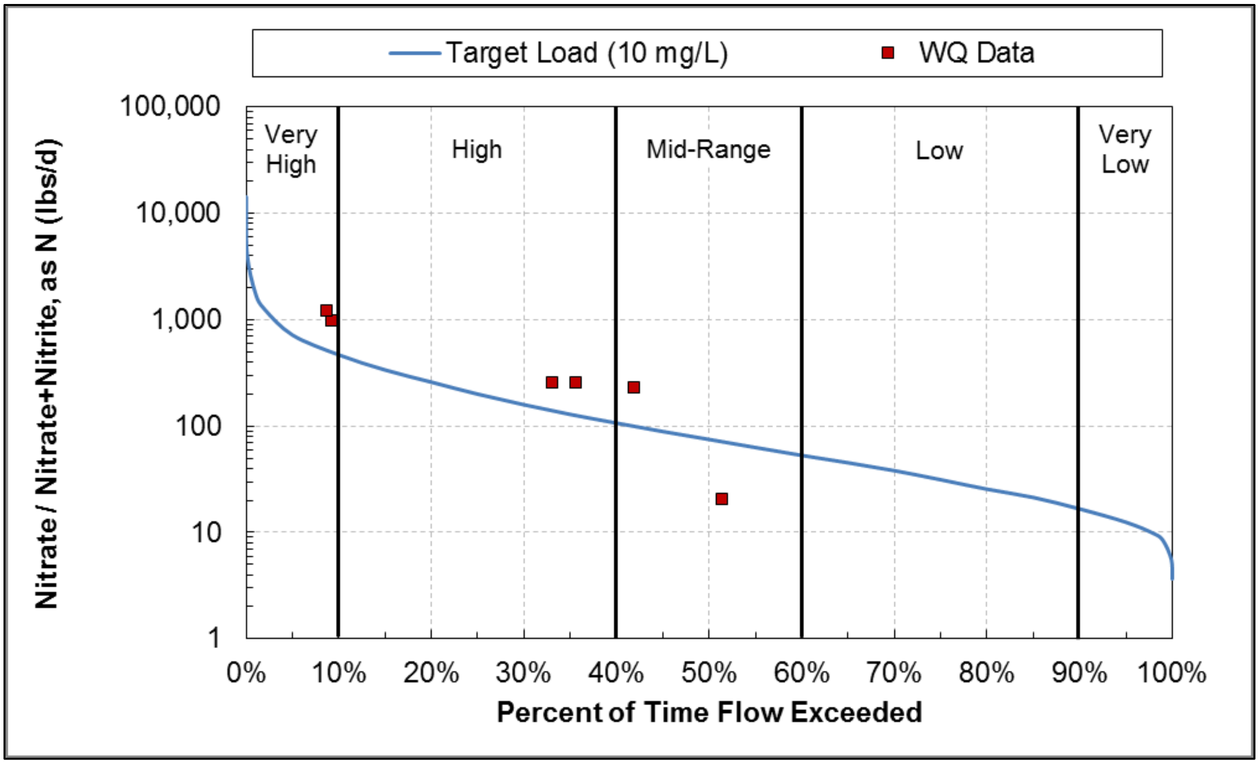

Figure A-43. Nitrate load duration curve, Unnamed Creek (AUID 07020007-577).

2016 data are included due to the low sample size in the TMDL period (2006–2015).

Table A-74. Nitrate TMDL summary, Unnamed Creek (AUID 07020007-577)

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	Inorganic N (Nitrate and Nitrite) Load (lb/d)				
WLA: Construction and Industrial Stormwater	0.92	0.26	0.10	0.040	0.015
Load Allocation	648	180	67	28	11
Margin of Safety	72	20	7.5	3.1	1.2
Loading Capacity	721	200	75	31	12
2nd Highest Exceedance Concentration (mg/L)	23				
Estimated Percent Reduction	57%				

A2.6 Swan Lake Outlet (Nicollet Creek), CD 39 to Minnesota R (07020007-683)

E. coli

Table A-75. Annual summary of *E. coli* data at Swan Lake Outlet-Nicollet Creek (AUID 07020007-683; 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
2006	0	–	–	–	–	–
2007	0	–	–	–	–	–
2008	0	–	–	–	–	–
2009	10	368	5	≥ 2,420 [a]	4	40
2010	10	393	32	1,733	2	20
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	8	566	228	1,300	1	13
2014	8	304	134	583	0	–
2015	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

Table A-76. Monthly summary of *E. coli* data at Swan Lake Outlet-Nicollet Creek (AUID 07020007-683; 2006–2015)

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 percent 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	3 [a]	17	5	32	0	–
May	2 [a]	327	219	488	0	–
Jun	9	779	228	≥ 2,420 [b]	3	33
Jul	12	452	134	≥ 2,420 [b]	2	17
Aug	9	437	189	1,733	1	11
Sep	1 [a]	1,300	1,300	1,300	1	100
Oct	0	–	–	–	–	–

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

b. 2,420 org/100mL is the method's maximum recordable value.

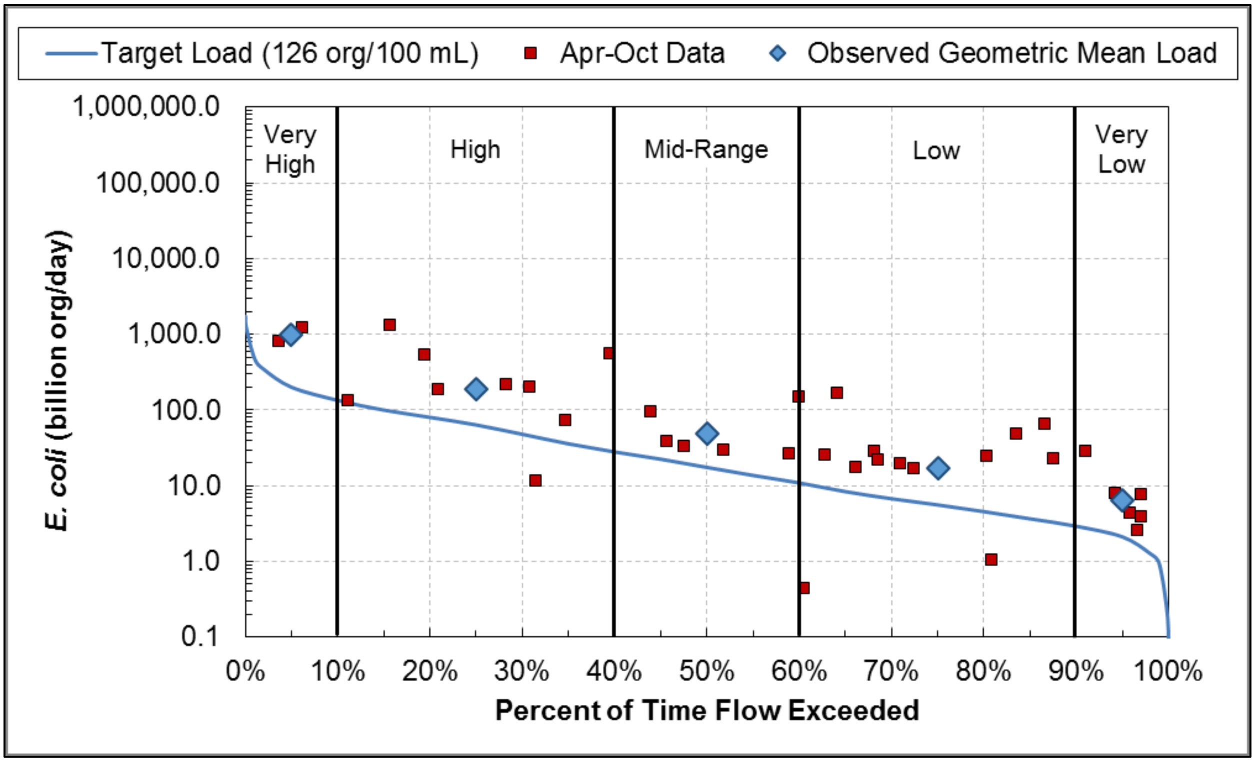

Figure A-44. ***E. coli*** **load duration curve, Swan Lake Outlet (Nicollet Creek; AUID 07020007-683).**

Table A-77. ***E. coli*** **TMDL summary, Swan Lake Outlet (Nicollet Creek; AUID 07020007-683)**

TMDL Parameter	Flow Zone				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	E. coli **Load (billion org/d)**				
WLA: Nicollet WWTP (MNG580037)	12	12	12	– [a]	– [a]
Load Allocation	169	46	4.2	– [a]	– [a]
Margin of Safety	20	6.4	1.8	0.56	0.21
Loading Capacity	201	64	18	5.6	2.1
Maximum Monthly Geometric Mean (org/100 mL)	779				
Estimated Percent Reduction	84%				

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 4.6.2 for more detail.

A2.7 County Ditch 56 (Lake Crystal Inlet), Headwaters to Lk Crystal (07020007-557)

E. coli

Table A-78. Annual summary of *E. coli* data at County Ditch 56-Lake Crystal Inlet (AUID 07020007-557; 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
2006	0	–	–	–	–	–
2007	11	243	1	3,255	1	9
2008	26	264	10	14,136	4	15
2009	16	137	8	≥ 2,420 [a]	1	6
2010	0	–	–	–	–	–
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

Table A-79 Monthly summary of *E. coli* data at County Ditch 56-Lake Crystal Inlet (AUID 07020007-557; 2006–2015)

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 percent 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	8	28	1	214	0	–
May	7	113	20	602	0	–
Jun	12	471	23	11,616	2	17
Jul	9	634	76	14,136	3	33
Aug	8	298	93	1,046	0	–
Sep	4 [a]	136	84	285	0	–
Oct	5	232	47	3,255	1	20

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

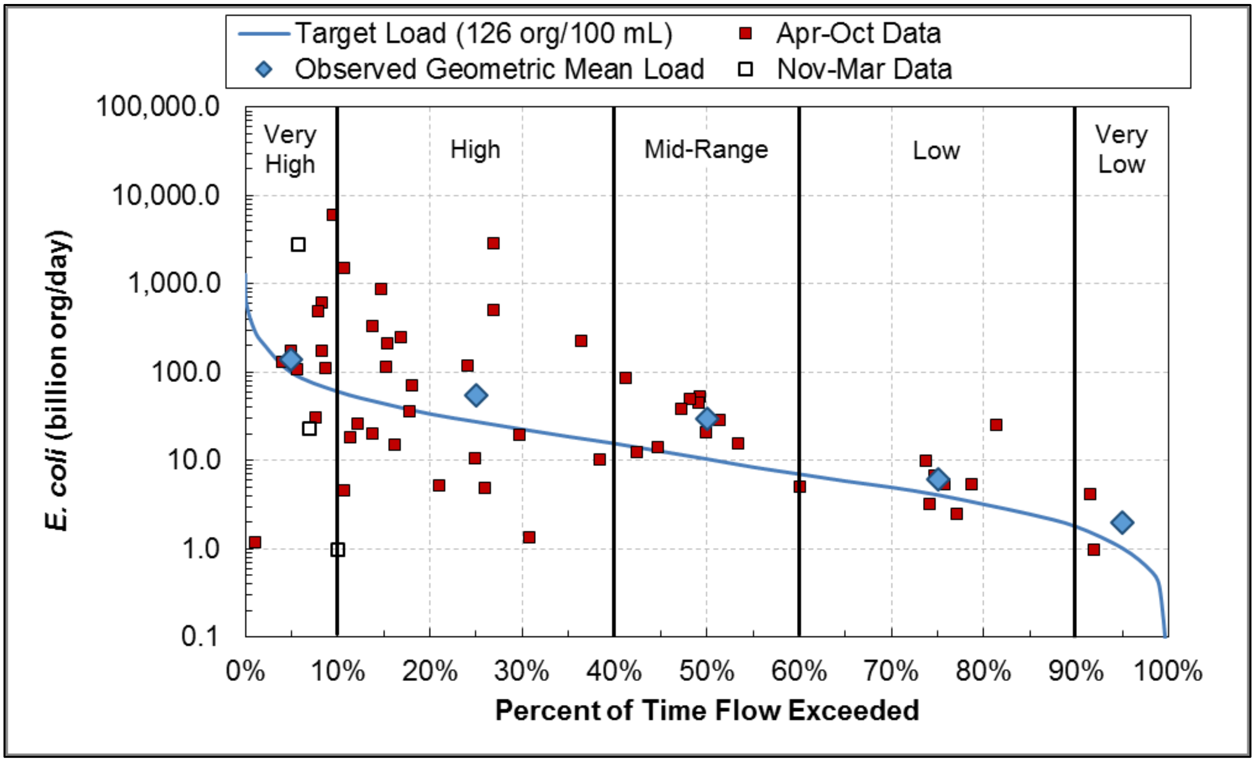

Figure A-45. ***E. coli*** **load duration curve, County Ditch 56 (Lake Crystal Inlet; AUID 07020007-557).**

Table A-80. ***E. coli*** **TMDL summary, County Ditch 56 (Lake Crystal Inlet; AUID 07020007-557)**

TMDL Parameter	Flow Zone				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	E. coli **Load (billion org/d)**				
Load Allocation	89	25	9.0	3.7	0.90
Margin of Safety	10	2.8	1.0	0.41	0.10
Loading Capacity	99	28	10	4.1	1.0
Maximum Monthly Geometric Mean (org/100 mL)	634				
Estimated Percent Reduction	80%				

A2.8 Mills Lake (07-0097-00)

Phosphorus

Table A-81. Mills Lake (07-0097-00) water quality data summary, 2005–2016

Values in red indicate violations of the standard.

Ecoregion	Shallow Lake	Parameter	Average of Annual Growing Season Means (Jun–Sep)	Water Quality Standard
Western Corn Belt Plains	Y	TP (µg/L)	174	≤ 90
		Chl-*a* (µg/L)	99	≤ 30
		Secchi (m)	0.3	≥ 0.7

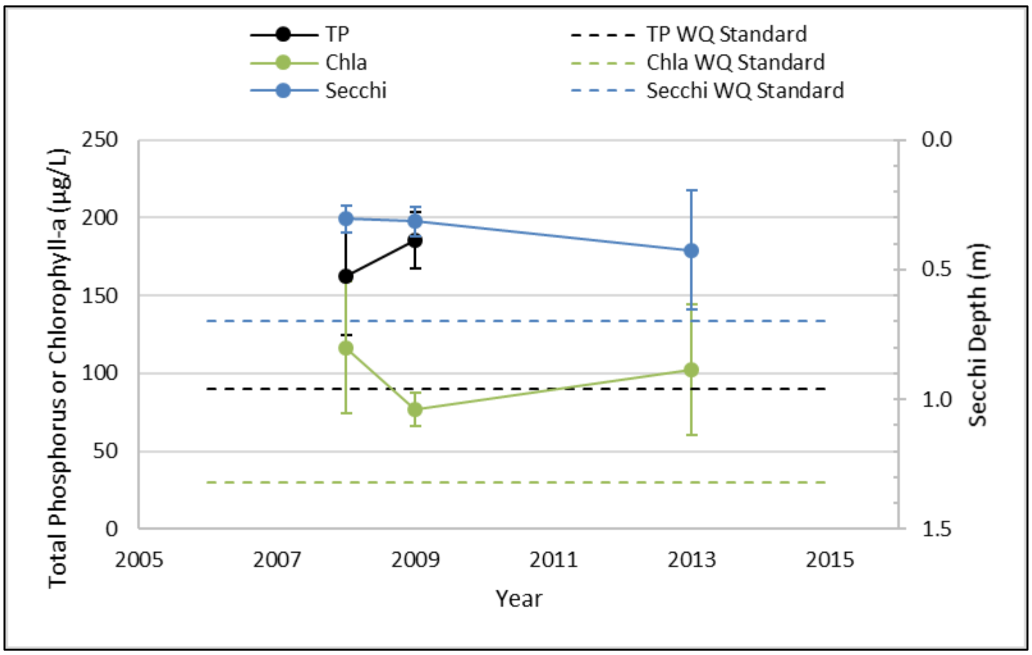

Figure A-46. Mills Lake water quality data

Growing season means + / - standard error.

Table A-82. Phosphorus source assessment, Mills Lake (07-0097-00)

Source		TP Load (lb/yr)	TP Load (%)
Watershed	Forest	1	<1%
	Crop	299	16%
	Grass/Pasture	<1	<1%
	Wetland	6	<1%
	Feedlots	14	0.01
	Urban	7	<1%
SSTS		–	–
Internal Loading		1,446	78%
Atmospheric Deposition		89	5%
Upstream Lakes		–	–
Total		*1,862*	*100%*

Table A-83. Phosphorus TMDL summary, Mills Lake (07-0097-00)

TMDL Parameter	TP Load (lb/yr)	TP Load (lb/day)
WLA for Construction and Industrial Stormwater	0.622	0.00170
Load Allocation	438	1.20
Margin of Safety	48.7	0.133
Loading Capacity	**487**	**1.33**
Existing Load	1,862	5.10
Percent Load Reduction	74%	74%

A2.9 Loon Lake (07-0096-00)

Phosphorus

Table A-84. Loon Lake (07-0096-00) water quality data summary, 2005–2016

Values in red indicate violations of the standard.

Ecoregion	Shallow Lake	Parameter	Average of Annual Growing Season Means (Jun–Sep)	Water Quality Standard
Western Corn Belt Plains	Y	TP (µg/L)	150	≤ 90
		Chl-*a* (µg/L)	79	≤ 30
		Secchi (m)	0.3	≥ 0.7

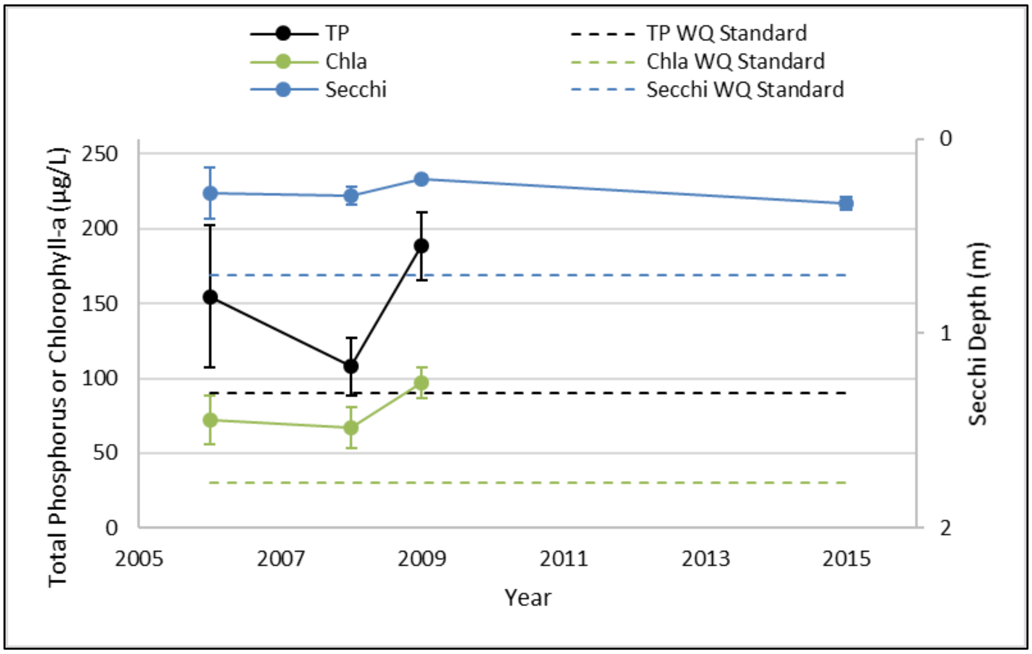

Figure A-47. Loon Lake water quality data

Growing season means + / - standard error.

Table A-85. Phosphorus source assessment, Loon Lake (07-0096-00)

Source		TP Load (lb/yr)	TP Load (%)
Watershed	Forest	2	<1%
	Crop	1,337	28%
	Grass/Pasture	2	<1%
	Wetland	17	<1%
	Feedlots	–	–
	Urban	46	1%
SSTS		39	1%
Internal Loading		2,850	60%
Atmospheric Deposition		304	6%
Upstream Lakes		173	4%
Total		*4,770*	*100%*

Table A-86. Phosphorus TMDL summary, Loon Lake (07-0096-00)

TMDL Parameter	TP Load (lb/yr)	TP Load (lb/day)
WLA for Construction and Industrial Stormwater	2.70	0.00740
Load Allocation	1,898	5.20
Margin of Safety	211	0.578
Loading Capacity	**2,112**	**5.79**
Existing Load	4,770	13.1
Percent Load Reduction	56%	56%

A2.10 Minneopa Creek, T108 R28W S23, south line to Minnesota R (07020007-534)

E. coli

Table A-87. Annual summary of *E. coli* data at Minneopa Creek (AUID 07020007-534; 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
2006	0	–	–	–	–	–
2007	0	–	–	–	–	–
2008	0	–	–	–	–	–
2009	0	–	–	–	–	–
2010	0	–	–	–	–	–
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	9	932	110	7,700	4	44
2014	6	389	170	790	0	–
2015	0	–	–	–	–	–

Table A-88. Monthly summary of *E. coli* data at Minneopa Creek (AUID 07020007-534; 2006–2015)

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 percent 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	446	110	7,700	1	20
Jul	5	670	280	2,400	1	20
Aug	5	947	490	2,400	2	40
Sep	0	–	–	–	–	–
Oct	0	–	–	–	–	–

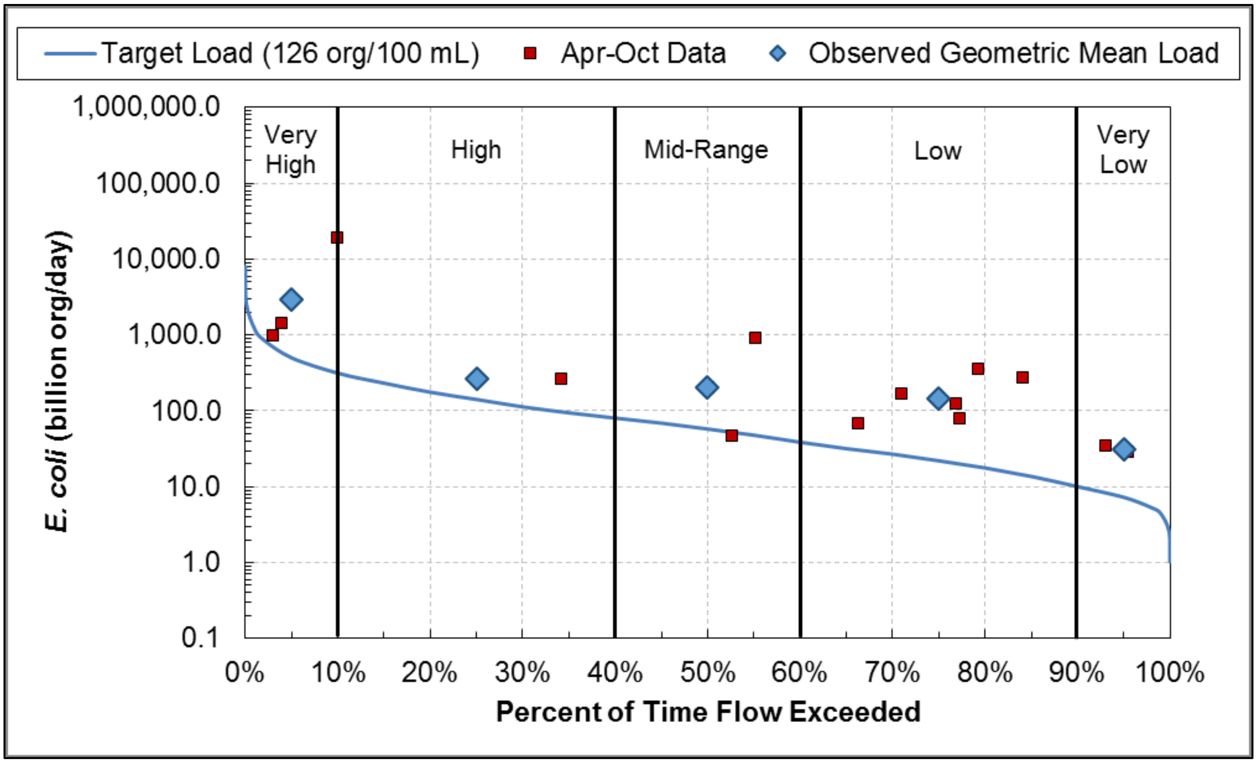

Figure A-48. *E. coli* load duration curve, Minneopa Creek (AUID 07020007-534).

Table A-89. *E. coli* TMDL summary, Minneopa Creek (AUID 07020007-534)

TMDL Parameter	Flow Zone				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	***E. coli* Load (billion org/d)**				
WLA: South Bend Township MS4 (MS400299)	1.8	0.50	0.20	0.068	0.015
WLA: Lake Crystal WWTP (MN0055981)	2.8	2.8	2.8	2.8	2.8
Load Allocation	448	125	49	17	3.8
Margin of Safety	50	14.0	5.8	2.2	0.73
Loading Capacity	503	142	58	22.0	7.3
Maximum Monthly Geometric Mean (org/100 mL)	947				
Estimated Percent Reduction	87%				

TSS

Table A-90. Annual summary of TSS data at Minneopa Creek (AUID 07020007-534; April–September)

Values in red indicate years in which the individual standard of 65 mg/L was exceeded in greater than 10 percent of the samples.

Year	Sample count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
2006	0	–	–	–	–	–
2007	0	–	–	–	–	–
2008	0	–	–	–	–	–
2009	0	–	–	–	–	–
2010	0	–	–	–	–	–
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	11	77	4	520	3	27%
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–

Table A-91. Monthly summary of TSS data at Minneopa Creek (AUID 07020007-534; 2006–2015)

Values in red indicate months in which the individual standard of 65 mg/L was exceeded in greater than 10 percent of the samples. Standard applies only to months April–September.

Month	Sample count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
Apr	0	–	–	–	–	–
May	2	9	7	12	0	–
Jun	3	195	28	520	1	33%
Jul	2	100	100	100	2	100%
Aug	2	14	13	15	0	–
Sep	2	7	4	11	0	–

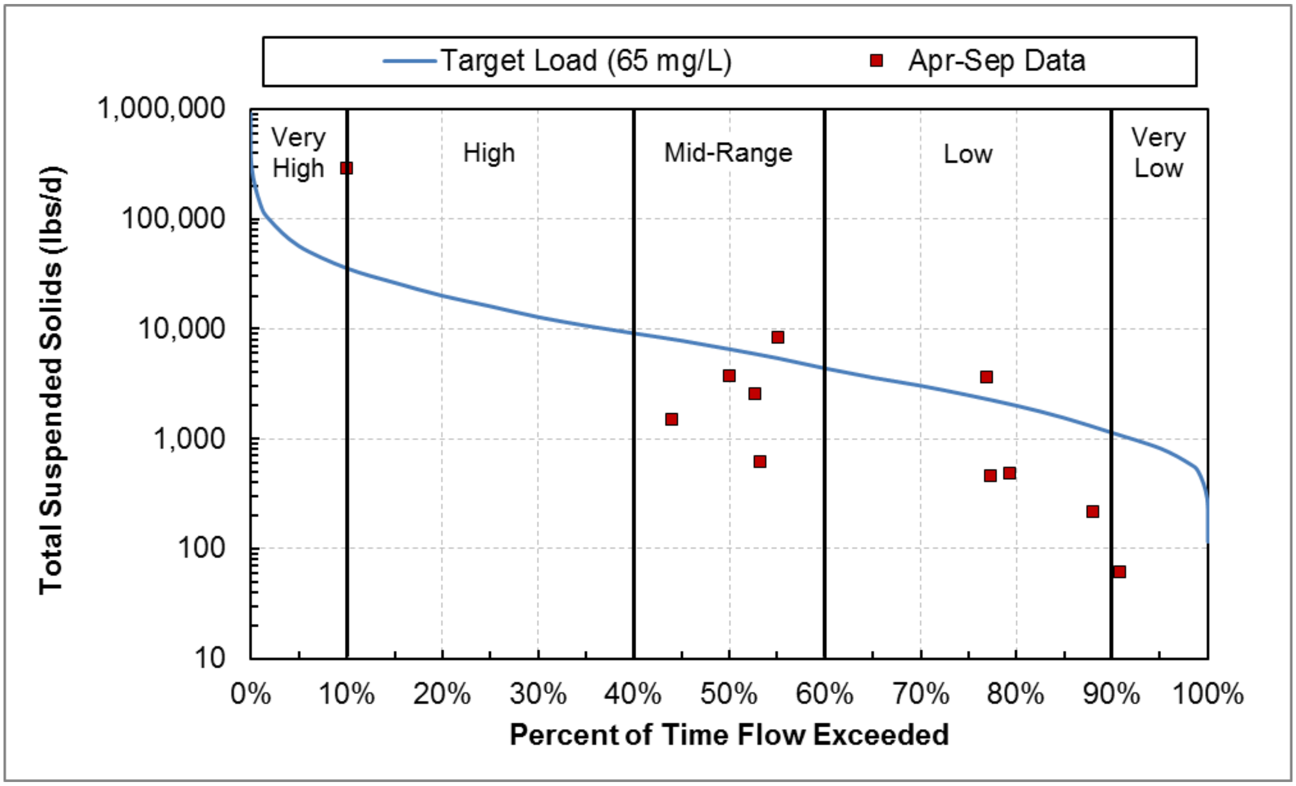

Figure A-49. TSS load duration curve, Minneopa Creek (AUID 07020007-534).

Table A-92. TSS TMDL summary, Minneopa Creek (AUID 07020007-534)

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	TSS Load (lb/d)				
WLA: Construction and Industrial Stormwater	34	10	3.8	1.4	0.38
WLA: South Bend Township MS4 (MS400299)	210	57	23	8.3	2.2
WLA: POET Biorefining- Lake Crystal LLC (MN0067172)	33	33	33	33	33
WLA: Lake Crystal WWTP (MN0055981)	148	148	148	148	148
Load Allocation	51,018	14,291	5,710	2,064	559
Margin of Safety	5,716	1,616	658	251	83
Loading Capacity	57,159	16,155	6,576	2,506	826
90th Percentile Existing Concentration (mg/L)	100				
Estimated Percent Reduction	35%				

3. Mankato–St. Peter

A3.1 Unnamed Creek, Headwaters to Unnamed Cr (07020007-604)

E. coli

E. coli data are not available along the impaired reach.

Table A-93. Annual summary of fecal coliform data at Unnamed Creek (AUID 07020007-604; April–October)

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)
2000	0	–	–	–
2001	0	–	–	–
2002	0	–	–	–
2003	24	717	50	13,408
2004	42	295	20	11,800
2005	0	–	–	–

Table A-94. Monthly summary of fecal coliform data at Unnamed Creek (AUID 07020007-604; 2000-2005)

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)
Apr	6	130	20	880
May	17	148	20	5,900
Jun	14	265	33	7,868
Jul	11	695	200	8,975
Aug	10	1,300	222	11,800
Sep	8	2,588	100	13,408
Oct	0	–	–	–

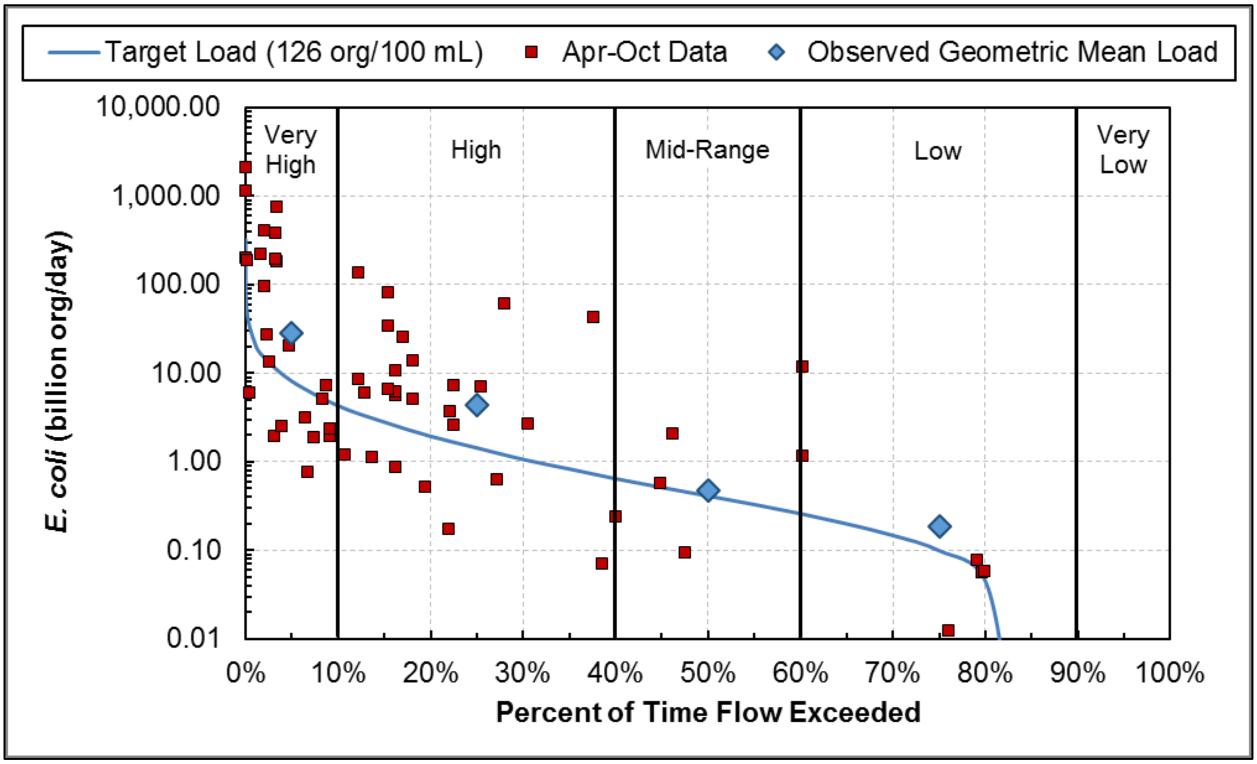

Figure A-50. *E. coli* load duration curve, Unnamed Creek (AUID 07020007-604).

E. coli data are not available; the monitoring data are fecal coliform data translated to *E. coli* concentration.

Table A-95. *E. coli* TMDL summary, Unnamed Creek (AUID 07020007-604)

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	E. coli Load (billion org/d)				
WLA: Blue Earth County MS4 (MS400276)	0.0797	0.0138	0.0041	0.0010	– [a]
WLA: Mankato City MS4 (MS400226)	1.0163	0.1762	0.0522	0.0129	– [a]
WLA: Mankato Township MS4 (MS400297)	0.4040	0.0700	0.0207	0.0051	– [a]
Load Allocation	5.8	1.0	0.29	0.07	– [a]
Margin of Safety	0.81	0.14	0.041	0.010	– [a]
Loading Capacity	8.1	1.4	0.41	0.10	– [a]
Maximum Monthly Geometric Mean (org/100 mL)	1,631 [b]				
Estimated Percent Reduction	92% [b]				

a. HSPF simulated flow of zero is likely an underestimate of actual flow conditions.
b. *E. coli* data are not available. The percent reduction was calculated based on fecal coliform data translated to *E. coli* concentration.

A3.2 Unnamed Creek, Unnamed Cr to Unnamed Cr (07020007-603)

E. coli

E. coli data are not available along the impaired reach.

Table A-96. Annual summary of fecal coliform data at Unnamed Creek (AUID 07020007-603; April–October)

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)
2000	0	–	–	–
2001	0	–	–	–
2002	0	–	–	–
2003	23	425	33	9,957
2004	31	214	1	4,000
2005	0	–	–	–

Table A-97. Monthly summary of fecal coliform data at Unnamed Creek (AUID 07020007-603; 2000-2005)

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)
Apr	6	17	1	260
May	16	193	20	1,564
Jun	15	496	73	4,000
Jul	10	812	253	2,050
Aug	4	174	42	775
Sep	3	2,541	324	9,957
Oct	0	–	–	–

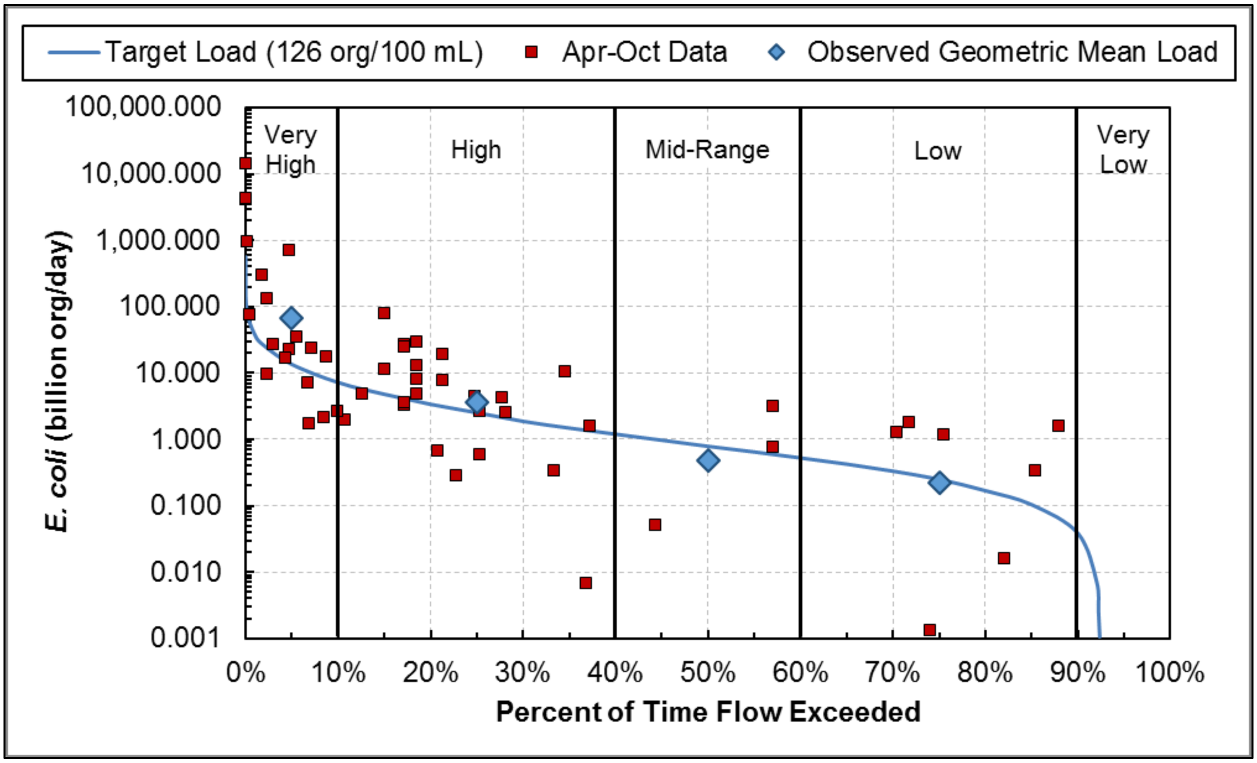

Figure A-51. *E. coli* load duration curve, Unnamed Creek (AUID 07020007-603).

E. coli data are not available; the monitoring data are fecal coliform data translated to *E. coli* concentration.

Table A-98. *E. coli* TMDL summary, Unnamed Creek (AUID 07020007-603)

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	E. coli Load (billion org/d)				
WLA: Blue Earth County MS4 (MS400276)	0.1711	0.0308	0.0096	0.0031	– [a]
WLA: Mankato City MS4 (MS400226)	1.0693	0.1925	0.0599	0.0192	– [a]
WLA: Mankato Township MS4 (MS400297)	1.2019	0.2163	0.0673	0.0216	– [a]
WLA: South Bend Township MS4 (MS400299)	0.0577	0.0104	0.0032	0.0010	– [a]
Load Allocation	10	1.8	0.56	0.18	– [a]
Margin of Safety	1.4	0.25	0.078	0.025	– [a]
Loading Capacity	14	2.5	0.78	0.25	– [a]
Maximum Monthly Geometric Mean (org/100 mL)	511 [b]				
Estimated Percent Reduction	75% [b]				

a. HSPF simulated flow of zero is likely an underestimate of actual flow conditions.
b. *E. coli* data are not available. The percent reduction was calculated based on fecal coliform data translated to *E. coli* concentration.

A3.3 Unnamed Creek, Headwaters to Unnamed Cr (07020007-602)

E. coli

E. coli data are not available along the impaired reach.

Table A-99. Annual summary of fecal coliform data at Unnamed Creek (AUID 07020007-602; April–October)

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)
2000	0	–	–	–
2001	0	–	–	–
2002	0	–	–	–
2003	16	226	4	2,408
2004	37	260	1	52,800
2005	0	–	–	–

Table A-100. Monthly summary of fecal coliform data at Unnamed Creek (AUID 07020007-602; 2000-2005)

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)
Apr	3	4	1	75
May	15	89	4	2,933
Jun	13	193	20	905
Jul	11	435	20	2,408
Aug	7	1,233	533	5,066
Sep	4	7,765	333	52,800
Oct	0	–	–	–

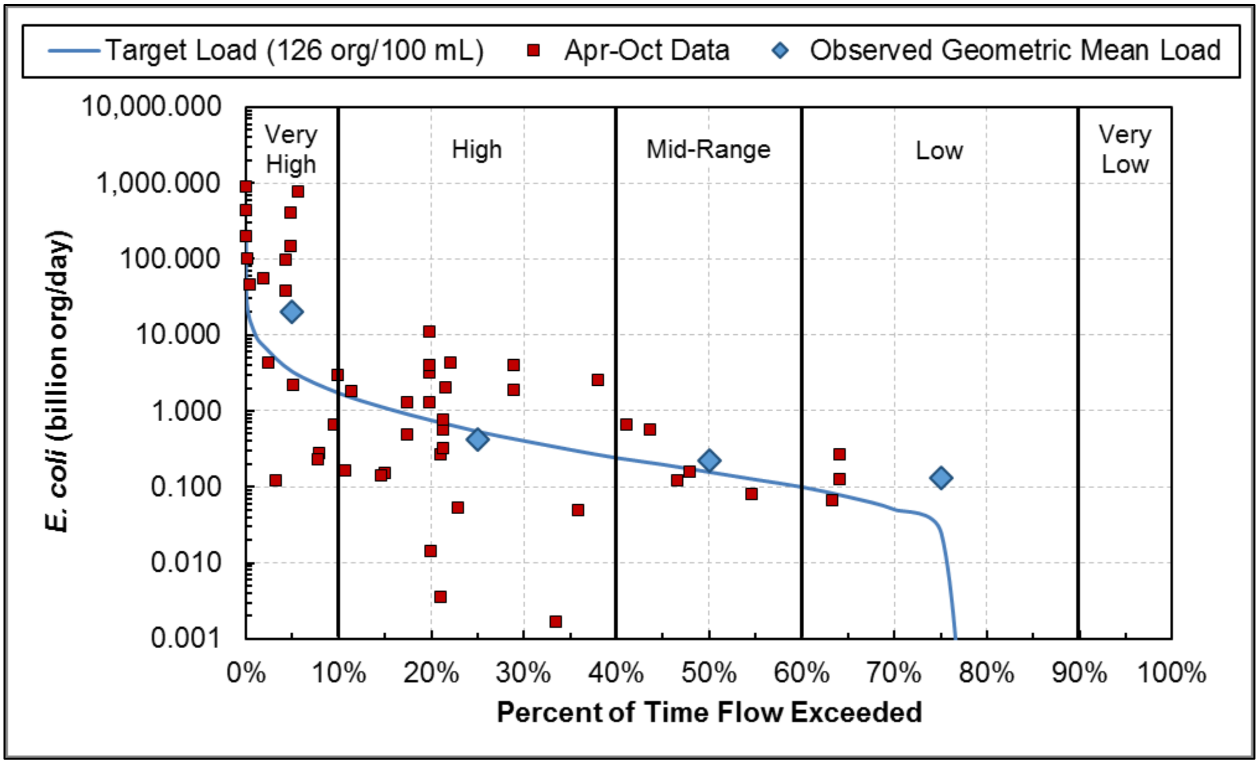

Figure A-52. *E. coli* load duration curve, Unnamed Creek (AUID 07020007-602).

E. coli data are not available; the monitoring data are fecal coliform data translated to *E. coli* concentration.

Table A-101. *E. coli* TMDL summary, Unnamed Creek (AUID 07020007-602)

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	E. coli Load (billion org/d)				
WLA: Blue Earth County MS4 (MS400276)	0.0448	0.0072	0.0022	0.0003	– [a]
WLA: Mankato City MS4 (MS400226)	0.0384	0.0062	0.0019	0.0003	– [a]
WLA: Mankato Township MS4 (MS400297)	0.1057	0.0169	0.0052	0.0008	– [a]
WLA: South Bend Township MS4 (MS400299)	0.3610	0.0578	0.0177	0.0026	– [a]
Load Allocation	2.4	0.39	0.12	0.018	– [a]
Margin of Safety	0.33	0.053	0.016	0.0024	– [a]
Loading Capacity	3.3	0.53	0.16	0.024	– [a]
Maximum Monthly Geometric Mean (org/100 mL)	777 [b]				
Estimated Percent Reduction	84% [b]				

a. HSPF simulated flow of zero is likely an underestimate of actual flow conditions.
b. *E. coli* data are not available. The percent reduction was calculated based on fecal coliform data translated to *E. coli* concentration.

A3.4 Unnamed Creek, Unnamed Cr to Unnamed Cr (07020007-600)

E. coli

E. coli data are not available along the impaired reach.

Table A-102. Annual summary of fecal coliform data at Unnamed Creek (AUID 07020007-600; April–October)

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)
2000	0	–	–	–
2001	0	–	–	–
2002	0	–	–	–
2003	18	489	22	8,083
2004	36	486	10	4,550
2005	0	–	–	–

Table A-103. Monthly summary of fecal coliform data at Unnamed Creek (AUID 07020007-600; 2000–2005)

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)
Apr	3	97	20	227
May	17	204	10	2,045
Jun	13	583	29	7,289
Jul	12	1,059	190	8,083
Aug	5	1,689	578	3,523
Sep	4	754	335	2,125
Oct	0	–	–	–

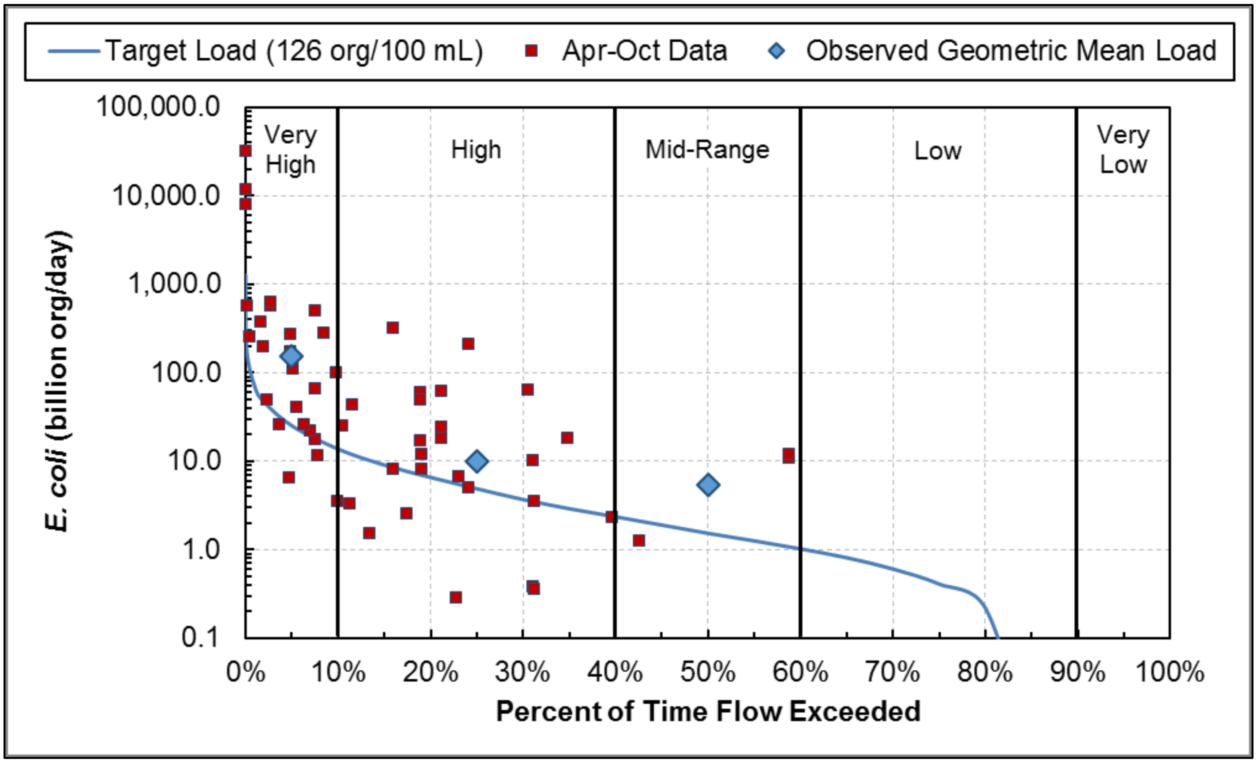

Figure A-53. *E. coli* load duration curve, Unnamed Creek (AUID 07020007-600).

E. coli data are not available; the monitoring data are fecal coliform data translated to *E. coli* concentration.

Table A-104. *E. coli* TMDL summary, Unnamed Creek (AUID 07020007-600)

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	E. coli Load (billion org/d)				
WLA: Blue Earth County MS4 (MS400276)	0.329	0.064	0.020	0.005	– [a]
WLA: Mankato City MS4 (MS400226)	1.547	0.303	0.093	0.025	– [a]
WLA: Mankato Township MS4 (MS400297)	1.213	0.238	0.073	0.020	– [a]
WLA: Skyline City MS4 (MS400292)	0.637	0.125	0.038	0.010	– [a]
WLA: South Bend Township MS4 (MS400299)	1.274	0.250	0.076	0.021	– [a]
Load Allocation	18	3.4	1.1	0.29	– [a]
Margin of Safety	2.5	0.49	0.15	0.041	– [a]
Loading Capacity	26	4.9	1.6	0.41	– [a]
Maximum Monthly Geometric Mean (org/100 mL)	1,064 [b]				
Estimated Percent Reduction	88% [b]				

a. HSPF simulated flow of zero is likely an underestimate of actual flow conditions.
b. *E. coli* data are not available. The percent reduction was calculated based on fecal coliform data translated to *E. coli* concentration.

A3.5 Unnamed Ditch, Unnamed Cr to underground pipe (07020007-598)

E. coli

E. coli data are not available along the impaired reach.

Table A-105. Annual summary of fecal coliform data at Unnamed Ditch (AUID 07020007-598; April–October)

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)
2000	0	–	–	–
2001	0	–	–	–
2002	0	–	–	–
2003	23	3,379	98	77,394
2004	43	569	3	11,600
2005	0	–	–	–

Table A-106. Monthly summary of fecal coliform data at Unnamed Ditch (AUID 07020007-598; 2000-2005)

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)
Apr	6	101	3	2,218
May	17	344	90	5,500
Jun	14	1,032	31	9,720
Jul	13	2,970	250	18,149
Aug	10	3,997	244	73,571
Sep	6	3,333	200	77,394
Oct	0	–	–	–

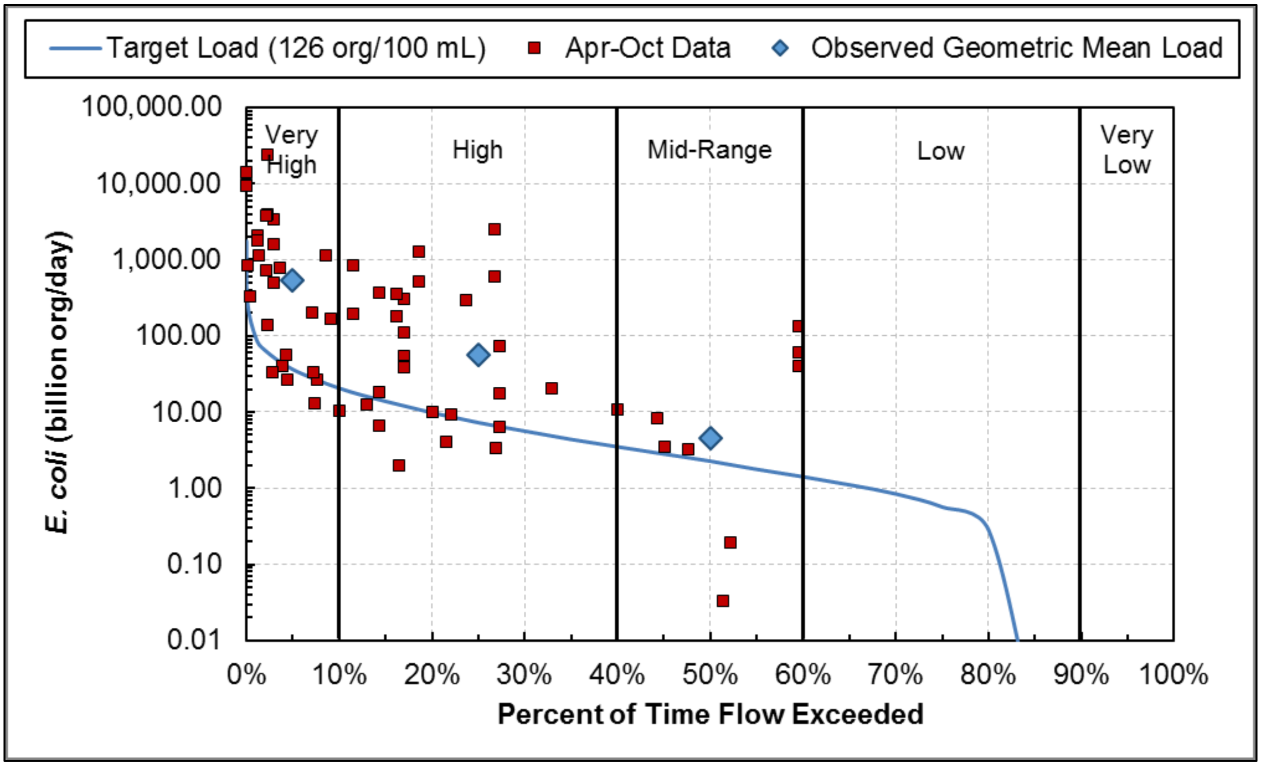

Figure A-54. *E. coli* load duration curve, Unnamed Ditch (AUID 07020007-598).

***E. coli* data are not available; the monitoring data are fecal coliform data translated to *E. coli* concentration.**

Table A-107. *E. coli* TMDL summary, Unnamed Ditch (AUID 07020007-598)

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	E. coli Load (billion org/d)				
WLA: Blue Earth County MS4 (MS400276)	0.89	0.18	0.05	0.01	– [a]
WLA: Mankato City MS4 (MS400226)	5.50	1.10	0.34	0.08	– [a]
WLA: Mankato Township MS4 (MS400297)	1.39	0.28	0.09	0.02	– [a]
WLA: Minnesota State University–Mankato MS4 (MS400279)	1.93	0.39	0.12	0.03	– [a]
WLA: Skyline City MS4 (MS400292)	0.25	0.05	0.02	0.0038	– [a]
WLA: South Bend Township MS4 (MS400299)	1.05	0.21	0.06	0.02	– [a]
Load Allocation	22	4.4	1.4	0.34	– [a]
Margin of Safety	3.7	0.73	0.23	0.057	– [a]
Loading Capacity	37	7.3	2.3	0.57	– [a]
Maximum Monthly Geometric Mean (org/100 mL)	2,518 [b]				
Estimated Percent Reduction	95% [b]				

a. HSPF simulated flow of zero is likely an underestimate of actual flow conditions.
b. *E. coli* data are not available. The percent reduction was calculated based on fecal coliform data translated to *E. coli* concentration.

A3.6 Wita Lake (07-0077-00)

Phosphorus

Table A-108. Wita Lake (07-0077-00) water quality data summary, 2005–2016

Values in red indicate violations of the standard.

Ecoregion	Shallow Lake	Parameter	Average of Annual Growing Season Means (Jun–Sep)	Water Quality Standard
North Central Hardwood Forests	Y	TP (µg/L)	145	≤ 60
		Chl-*a* (µg/L)	161	≤ 20
		Secchi (m)	0.2	≥ 1

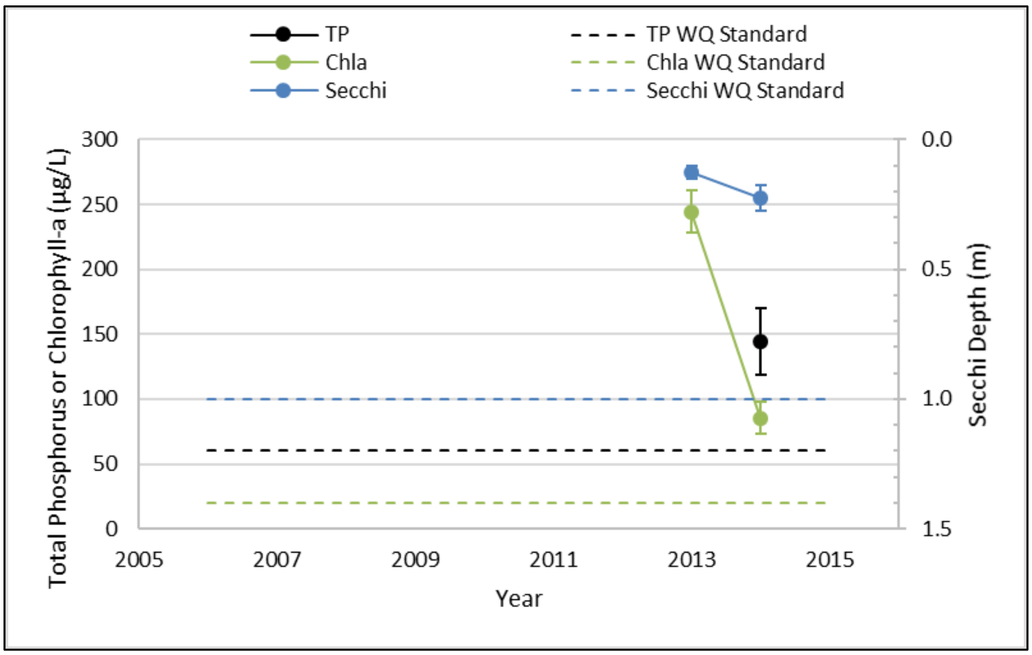

Figure A-55. Wita Lake water quality data.

Growing season means + / - standard error.

Table A-109. Phosphorus source assessment, Wita Lake (07-0077-00)

Source		TP Load (lb/yr)	TP Load (%)
Watershed	Forest	4	<1%
	Crop	474	28%
	Grass/Pasture	4	<1%
	Wetland	9	1%
	Feedlots	–	–
	Urban	42	2%
SSTS		–	–
Internal Loading		1,047	62%
Atmospheric Deposition		127	7%
Upstream Lakes		–	–
Total		*1,707*	*100%*

Table A-110. Phosphorus TMDL summary, Wita Lake (07-0077-00)

TMDL Parameter	TP Load (lb/yr)	TP Load (lb/day)
WLA for Construction and Industrial Stormwater	0.520	0.00142
Load Allocation	381.8	1.0405
Margin of Safety	42.5	0.116
Loading Capacity	**425**	**1.16**
Existing Load	1,707	4.68
Percent Load Reduction	75%	75%

A3.7 County Ditch 46A, -94.0803 44.2762 to Seven-Mile Cr (07020007-679)

E. coli

Table A-111. Annual summary of *E. coli* data at County Ditch 46A (AUID 07020007-679; 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
2006	14	52	5	35,000	1	7
2007	17	245	27	1,733	3	18
2008	20	73	1	≥ 2,420 [a]	1	5
2009	8	131	16	980	0	–
2010	2	18	10	34	0	–
2011	14	78	1	1,300	1	7
2012	18	390	13	≥ 2,420 [a]	2	11
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

Table A-112. Monthly summary of *E. coli* data at County Ditch 46A (AUID 07020007-679; 2006–2015)

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 percent 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	6	62	4	6,100	NA	–
Apr	18	18	1	387	0	–
May	31	89	2	1,414	1	3
Jun	21	196	5	1,414	1	5
Jul	9	714	219	≥ 2,420 [b]	2	22
Aug	8	860	131	35,000	4	50
Sep	1 [a]	166	166	166	0	–
Oct	5	240	47	649	0	–

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

b. 2,420 org/100mL is the method's maximum recordable value.

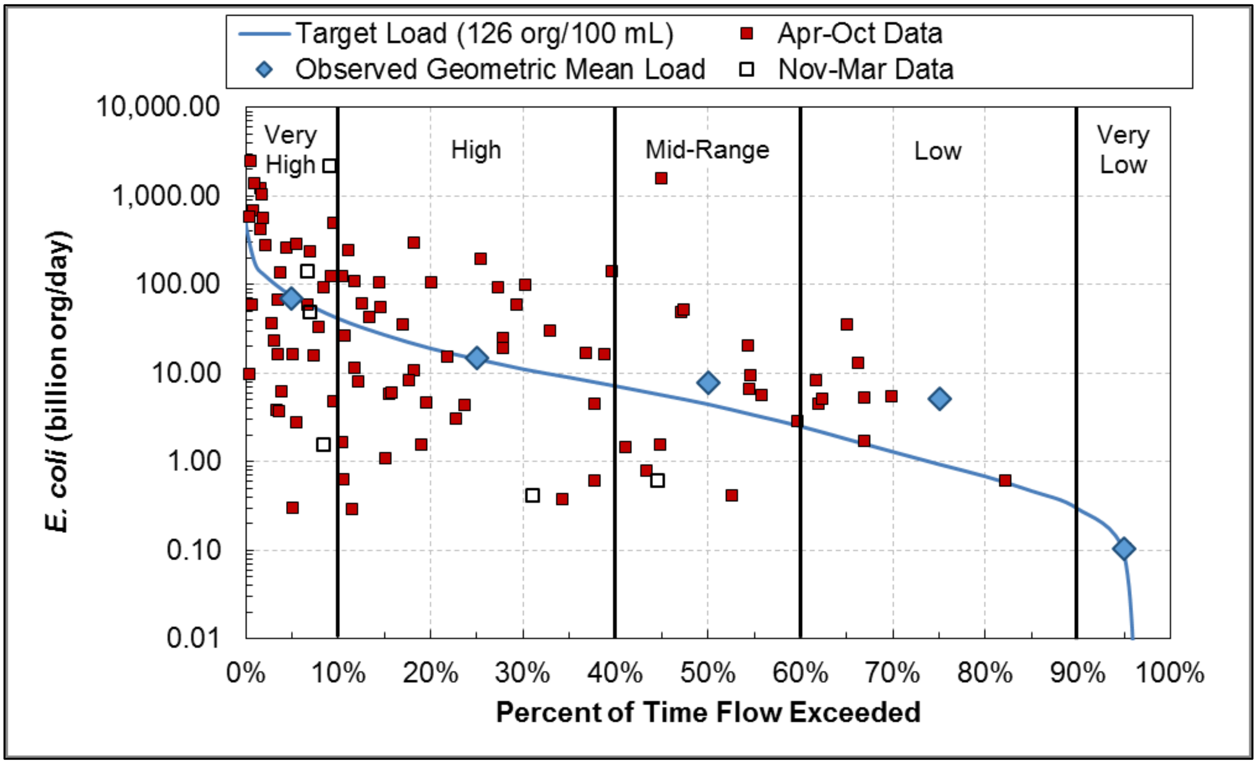

Figure A-56. *E. coli* load duration curve, County Ditch 46A (AUID 07020007-679).

Table A-113. *E. coli* TMDL summary, County Ditch 46A (AUID 07020007-679)

TMDL Parameter	**Flow Zone**				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	***E. coli* Load (billion org/d)**				
Load Allocation	68	13	4.1	0.85	0.079
Margin of Safety	7.5	1.4	0.45	0.094	0.0088
Loading Capacity	76	14	4.6	0.94	0.088
Maximum Monthly Geometric Mean (org/100 mL)	860				
Estimated Percent Reduction	85%				

TSS

Table A-114. Annual summary of TSS data at County Ditch 46A (AUID 07020007-679; April–September)

Values in red indicate years in which the individual standard of 65 mg/L was exceeded in greater than 10 percent of the samples.

Year	Sample count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
2006	14	38	3	107	4	29%
2007	12	10	1	29	0	–
2008	24	35	1	310	3	13%
2009	8	5	1	12	0	–
2010	8	9	1	36	0	–
2011	14	20	3	92	1	7%
2012	18	40	3	242	2	11%
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–

Table A-115. Monthly summary of TSS data at County Ditch 46A (AUID 07020007-679; 2006–2015)

Values in red indicate months in which the individual standard of 65 mg/L was exceeded in greater than 10 percent of the samples. Standard applies only to months April–September.

Month	Sample count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
Mar	8	47	2	161	NA	–
Apr	22	24	1	140	2	9%
May	32	31	1	242	4	13%
Jun	24	32	1	310	3	13%
Jul	10	10	1	29	0	–
Aug	9	19	1	107	1	11%
Sep	1	3	3	3	0	–
Oct	5	18	4	36	NA	–

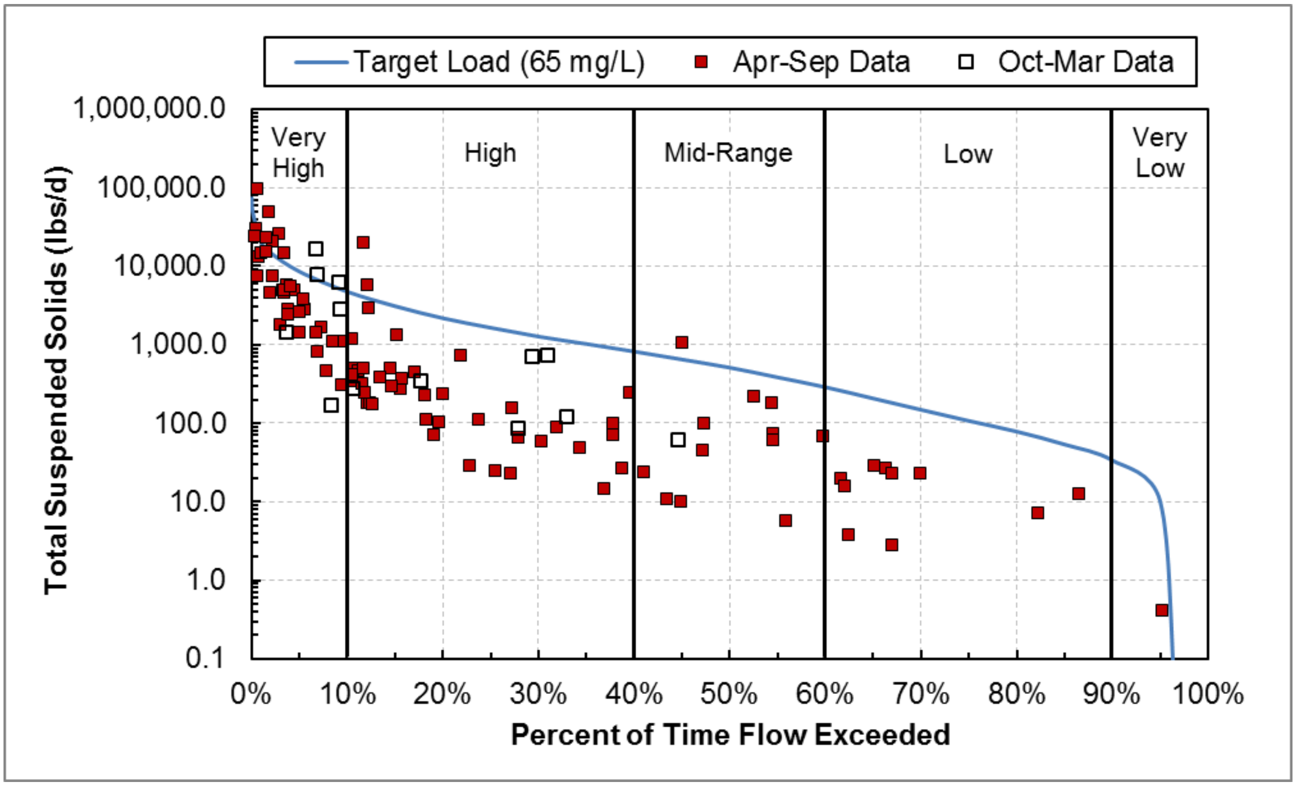

Figure A-57. TSS load duration curve, County Ditch 46A (AUID 07020007-679).

Table A-116. TSS TMDL summary, County Ditch 46A (AUID 07020007-679)

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	TSS Load (lb/d)				
WLA: Construction and Industrial Stormwater	10	1.9	0.59	0.12	0.012
Load Allocation	7,644	1,474	456	95	9.0
Margin of Safety	851	164	51	11	1.0
Loading Capacity	8,505	1,640	508	106	10
90th Percentile Existing Concentration (mg/L)	62				
Estimated Percent Reduction	–[a]				

c. This impairment was originally listed in 2006 based on turbidity data; however, the TSS data presented in this report do not show impairment. The MPCA will reevaluate the reach in the next impairment assessment for this watershed.

A3.8 Seven-Mile Creek, MN Hwy 99 to CD 46A (07020007-703)

E. coli

Table A-117. Annual summary of *E. coli* data at Seven-Mile Creek (AUID 07020007-703; 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
2006	14	58	5	2,400	1	7
2007	18	150	5	1,414	1	6
2008	19	69	1	≥ 2,420 [a]	2	11
2009	7	143	31	649	0	–
2010	2	10	6	14	0	–
2011	13	91	1	1,203	0	–
2012	16	263	55	1,986	3	19
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

Table A-118. Monthly summary of *E. coli* data at Seven-Mile Creek (AUID 07020007-703; 2006–2015)

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 percent 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	6	64	4	22,000	NA	–
Apr	18	27	1	1,553	1	6
May	31	87	1	1,986	3	10
Jun	21	191	5	≥ 2,420 [a]	1	5
Jul	6	386	104	1,414	1	17
Aug	7	469	130	2,400	1	14
Sep	0	–	–	–	–	–
Oct	6	103	36	488	0	–

a. 2,420 org/100mL is the method's maximum recordable value.

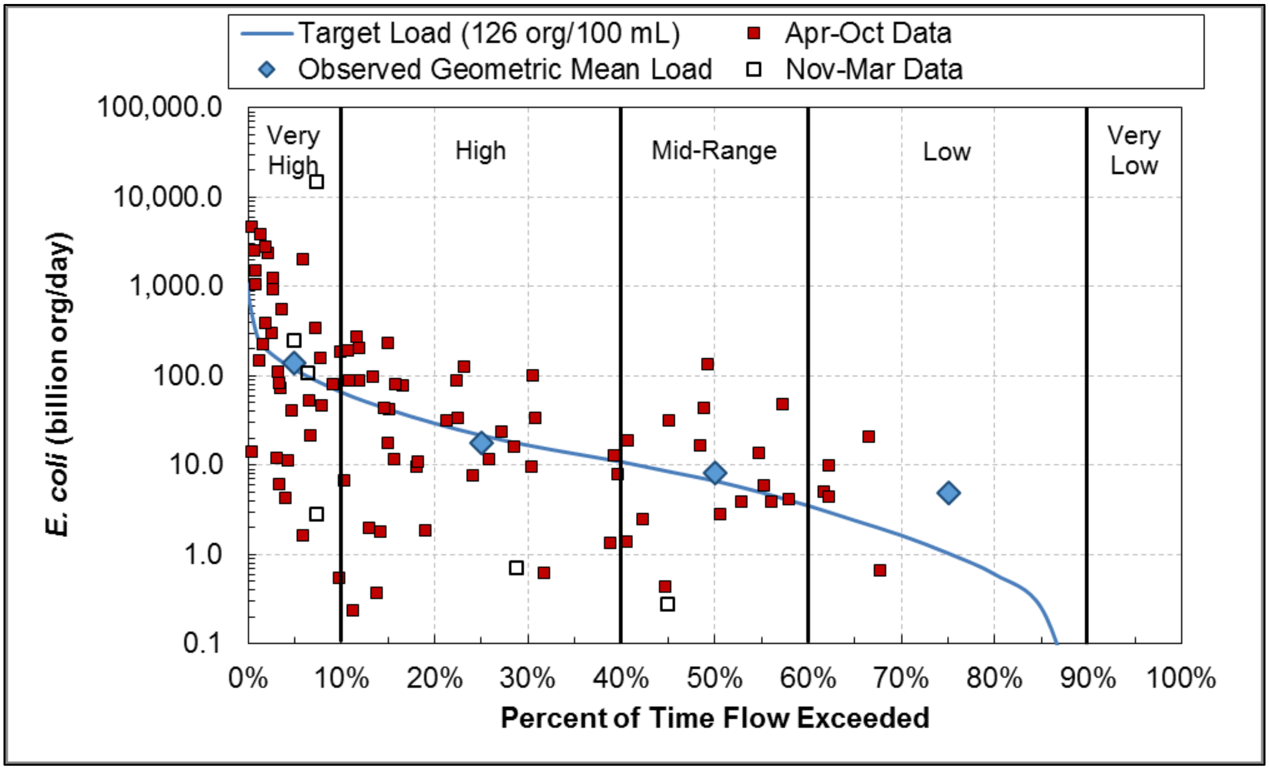

Figure A-58. *E. coli* load duration curve, Seven-Mile Creek (AUID 07020007-703).

Table A-119. *E. coli* TMDL summary, Seven-Mile Creek (AUID 07020007-703)

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	E. coli Load (billion org/d)				
Load Allocation	106	20	6.0	0.90	– [a]
Margin of Safety	12	2.2	0.67	0.10	– [a]
Loading Capacity	118	22	6.7	1.0	– [a]
Maximum Monthly Geometric Mean (org/100 mL)	469				
Estimated Percent Reduction	73%				

a. HSPF simulated flow of zero is likely an underestimate of actual flow conditions.

TSS

Table A-120. Annual summary of TSS data at Seven-Mile Creek (AUID 07020007-703; April–September)

Values in red indicate years in which the individual standard of 65 mg/L was exceeded in greater than 10 percent of the samples.

Year	Sample count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
2006	14	20	2	79	1	7%
2007	12	9	2	27	0	–
2008	23	14	1	144	1	4%
2009	7	4	1	7	0	–
2010	8	5	1	14	0	–
2011	13	13	1	56	0	–
2012	16	24	1	152	2	13%
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	3	55	2	160	1	33%

Table A-121. Monthly summary of TSS data at Seven-Mile Creek (AUID 07020007-703; 2006–2015)

Values in red indicate months in which the individual standard of 65 mg/L was exceeded in greater than 10 percent of the samples. Standard applies only to months April–September.

Month	Sample count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
Mar	8	12	1	24	NA	–
Apr	22	8	1	58	0	–
May	32	15	1	152	2	6%
Jun	25	19	1	144	2	8%
Jul	8	29	2	160	1	13%
Aug	8	15	3	30	0	–
Sep	1	2	2	2	0	–
Oct	6	18	1	58	NA	–

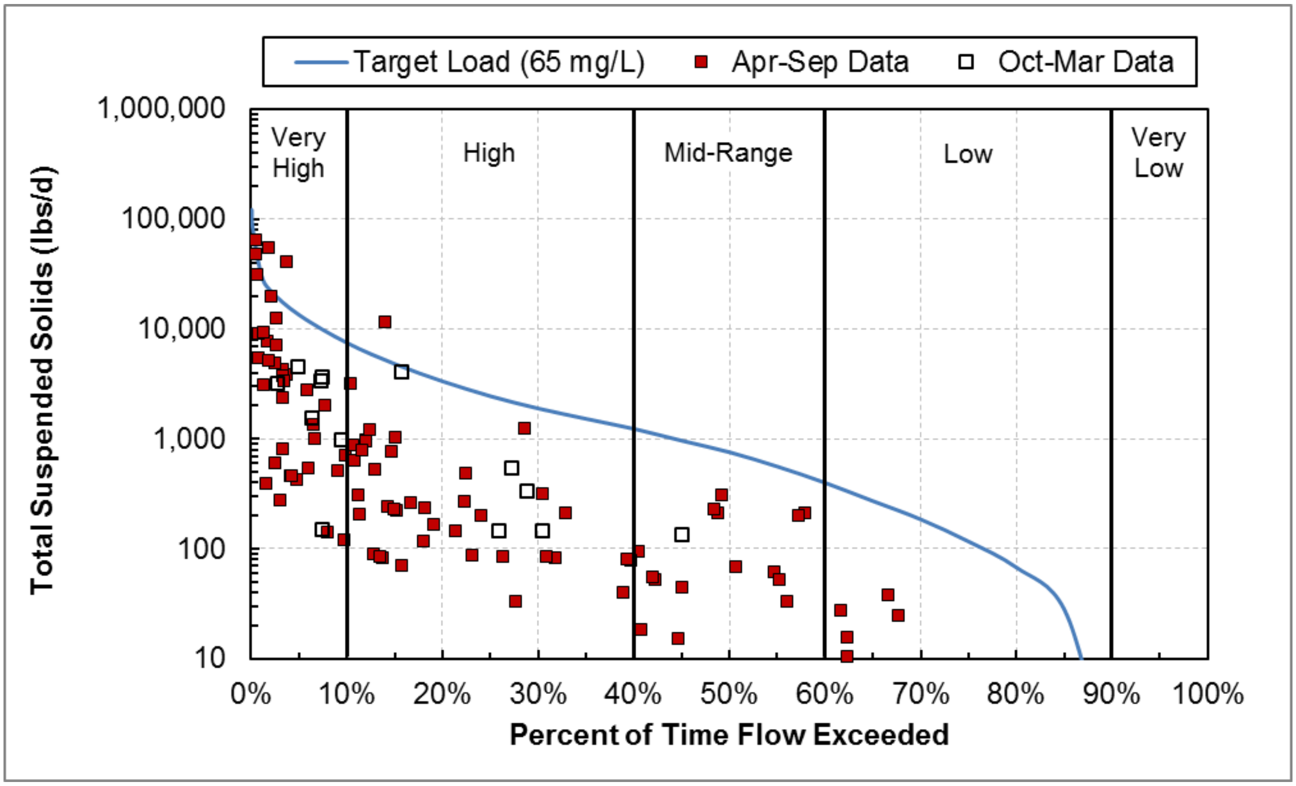

Figure A-59. TSS load duration curve, Seven-Mile Creek (AUID 07020007-703).

Table A-122. TSS TMDL summary, Seven-Mile Creek (AUID 07020007-703)

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	TSS Load (lb/d)				
WLA: Construction and Industrial Stormwater	16	2.9	0.89	0.14	– [a]
Load Allocation	12,029	2,207	684	105	– [a]
Margin of Safety	1,338	246	76	12	– [a]
Loading Capacity	13,383	2,456	761	117	– [a]
90th Percentile Existing Concentration (mg/L)	29				
Estimated Percent Reduction	– [b]				

a. HSPF simulated flow of zero is likely an underestimate of actual flow conditions.
b. This impairment was originally listed in 2006 based on turbidity data; however, the TSS data presented in this report do not show impairment. The MPCA will reevaluate the reach in the next impairment assessment for this watershed.

A3.9 Unnamed creek (Seven-Mile Creek Tributary), Headwaters to T109 R27W S15, north line (07020007-637)

E. coli

Table A-123. Annual summary of *E. coli* data at Unnamed Creek-Seven-Mile Creek Tributary (AUID 07020007-637; 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
2006	14	76	5	14,000	2	14
2007	17	372	5	≥ 2,420 [a]	3	18
2008	15	285	4	≥ 2,420 [a]	4	27
2009	7	202	1	1,414	1	14
2010	0	–	–	–	–	–
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

Table A-124. Monthly summary of *E. coli* data at Unnamed Creek-Seven-Mile Creek Tributary (AUID 07020007-637; 2006–2015)

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 percent 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	4	253	5	4,800	NA	–
Apr	9	14	1	205	0	–
May	15	246	7	3,200	4	27
Jun	13	316	5	≥ 2,420 [a]	3	23
Jul	5	1,060	548	≥ 2,420 [a]	2	40
Aug	5	830	96	14,000	1	20
Sep	0	–	–	–	–	–
Oct	6	279	133	1,120	0	–

a. 2,420 org/100mL is the method's maximum recordable value.

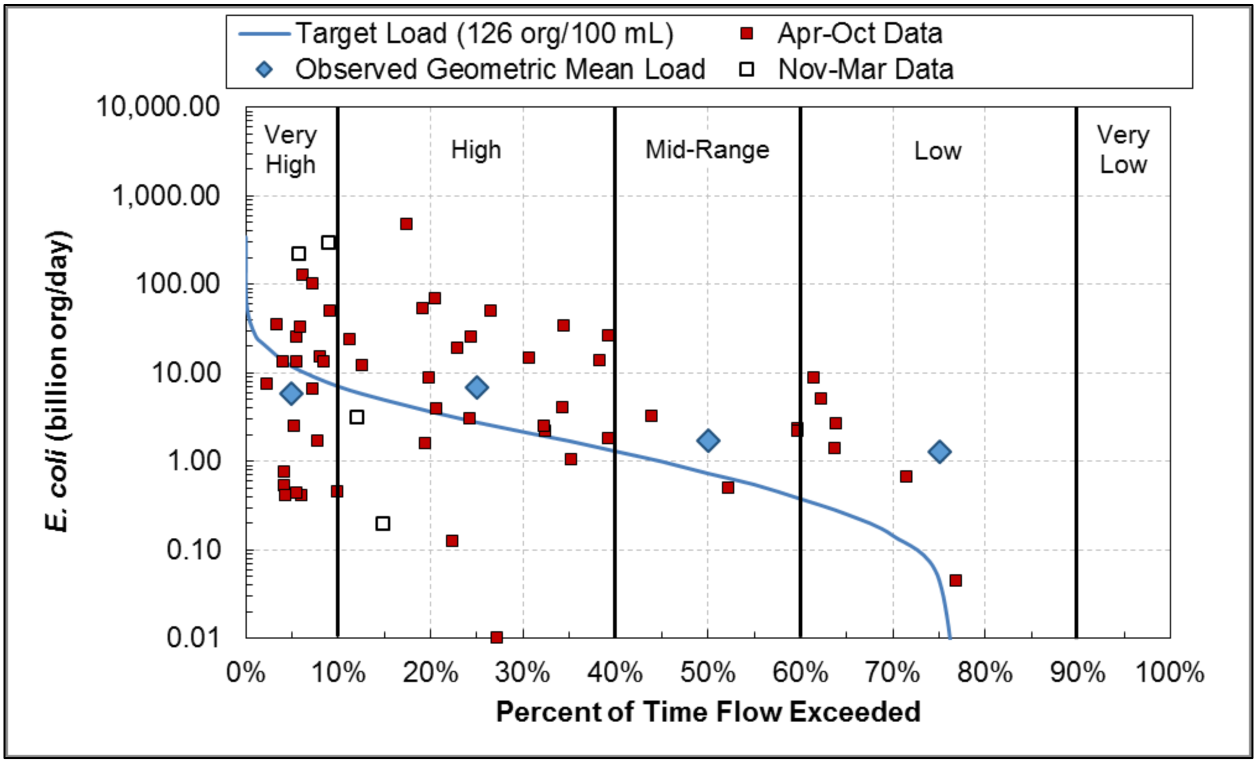

Figure A-60. ***E. coli*** **load duration curve, Unnamed Creek (Seven-Mile Creek Tributary; AUID 07020007-637).**

Table A-125. ***E. coli*** **TMDL summary, Unnamed Creek (Seven-Mile Creek Tributary; AUID 07020007-637)**

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	E. coli Load (billion org/d)				
Load Allocation	11	2.5	0.66	0.041	– [a]
Margin of Safety	1.2	0.28	0.073	0.0045	– [a]
Loading Capacity	12	2.8	0.73	0.046	– [a]
Maximum Monthly Geometric Mean (org/100 mL)	1,060				
Estimated Percent Reduction	88%				

a. HSPF simulated flow of zero is likely an underestimate of actual flow conditions.

A3.10 Seven-Mile Creek, T109 R27W S4, north line to Minnesota R (07020007-562)

E. coli

Table A-126. Annual summary of *E. coli* data at Seven-Mile Creek (AUID 07020007-562; 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
2006	14	99	5	15,000	2	14
2007	18	150	20	1,986	2	11
2008	22	85	1	≥ 2,420 [a]	2	9
2009	14	47	2	249	0	–
2010	4	31	18	91	0	–
2011	14	94	2	≥ 2,420 [a]	1	7
2012	22	121	1	≥ 2,420 [a]	4	18
2013	8	256	98	1,300	1	13
2014	8	103	41	309	0	–
2015	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

Table A-127. Monthly summary of *E. coli* data at Seven-Mile creek (AUID 07020007-562; 2006–2015)

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 percent 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	12	77	1	7,200	NA	–
Apr	20	17	1	249	0	–
May	31	102	2	≥ 2,420 [a]	3	10
Jun	25	209	5	≥ 2,420 [a]	2	8
Jul	15	143	5	≥ 2,420 [a]	2	13
Aug	18	190	17	15,000	4	22
Sep	7	65	46	102	0	–
Oct	8	132	19	1,300	1	13

a. 2,420 org/100mL is the method's maximum recordable value.

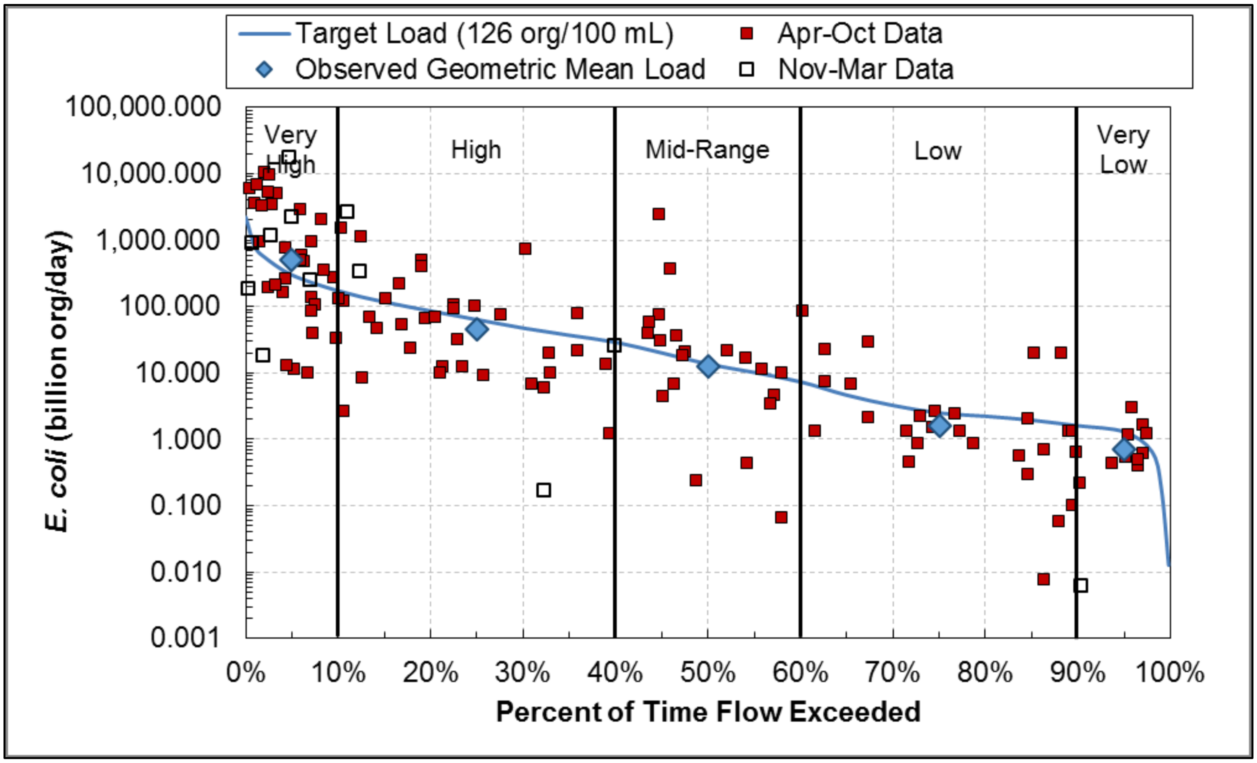

Figure A-61. ***E. coli*** **load duration curve, Seven-Mile creek (AUID 07020007-562).**

Table A-128. ***E. coli*** **TMDL summary, Seven-Mile creek (AUID 07020007-562)**

TMDL Parameter	Flow Zone				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	E. coli **Load (billion org/d)**				
Load Allocation	270	58	13	2.3	1.2
Margin of Safety	30	6.4	1.4	0.25	0.13
Loading Capacity	300	64	14	2.6	1.3
Maximum Monthly Geometric Mean (org/100 mL)	209				
Estimated Percent Reduction	40%				

TSS

Table A-129. Annual summary of TSS data Seven-Mile Creek (AUID 07020007-562; April–September)

Values in red indicate years in which the individual standard of 10 mg/L was exceeded in greater than 10 percent of the samples.

Year	Sample count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
2006	22	125	2	624	14	64%
2007	12	13	1	85	3	25%
2008	25	108	1	620	16	64%
2009	13	3	1	11	1	8%
2010	8	15	2	68	3	38%
2011	14	66	2	400	7	50%
2012	22	69	1	880	7	32%
2013	29	24	1	248	12	41%
2014	26	385	3	5,970	20	77%
2015	20	387	1	4,560	15	75%

Table A-130, Monthly summary of TSS data at Seven-Mile Creek (AUID 07020007-562; 2006–2015)

Values in red indicate months in which the individual standard of 65 mg/L was exceeded in greater than 10 percent of the samples. Standard applies only to months April–September.

Year	Sample count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
Mar	20	104	1	508	NA	–
Apr	37	105	1	1,390	22	59%
May	48	74	1	880	24	50%
Jun	47	244	1	5,970	31	66%
Jul	22	112	1	1,410	8	36%
Aug	25	207	1	4,560	9	36%
Sep	12	13	1	45	4	33%
Oct	11	55	1	385	NA	–

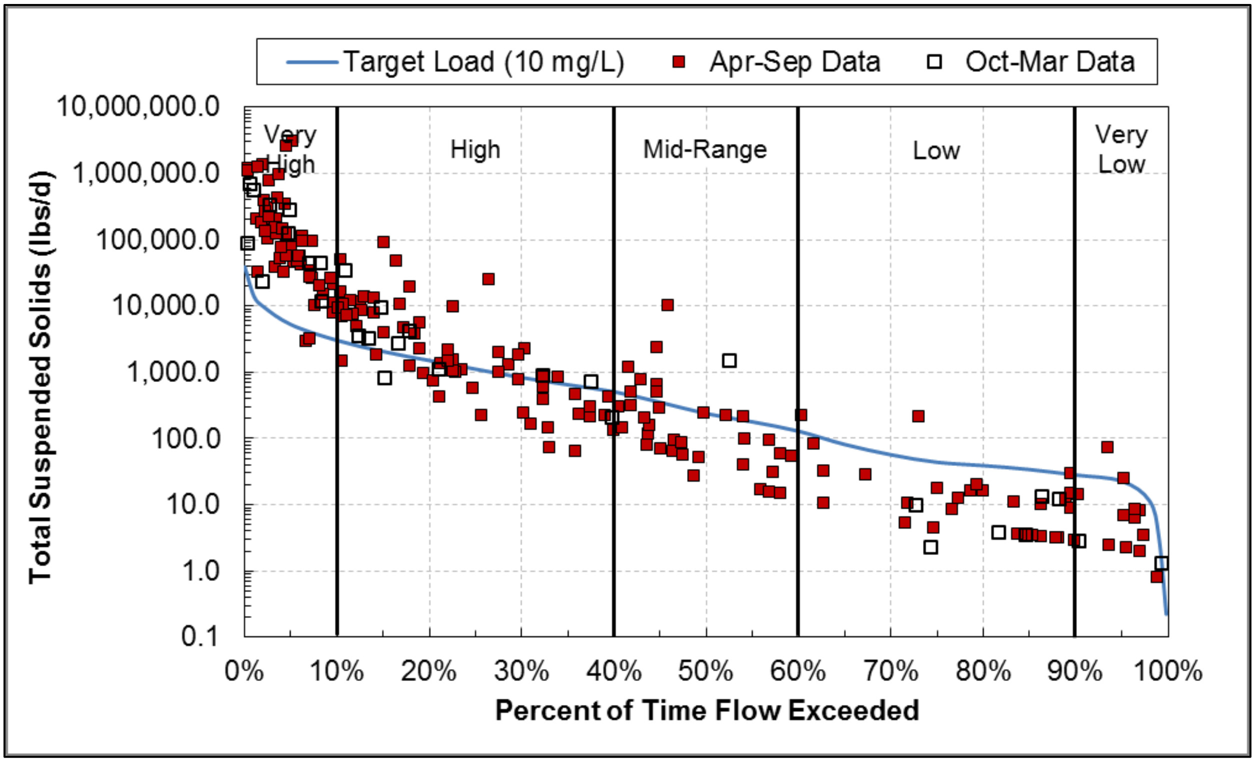

Figure A-62. TSS load duration curve, Seven-Mile Creek (AUID 07020007-562).

Table A-131. TSS TMDL summary, Seven-Mile Creek (AUID 07020007-562)

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	TSS Load (lb/d)				
WLA: Construction and Industrial Stormwater	6.1	1.3	0.28	0.051	0.027
Load Allocation	4,717	1,003	214	40	21
Margin of Safety	525	112	24	4.4	2.3
Loading Capacity	5,248	1,116	238	44	23
90th Percentile Existing Concentration (mg/L)	249				
Estimated Percent Reduction	96%				

Nitrate

Table A-132. Annual summary of nitrate data at Seven-Mile Creek (AUID 07020007-562; Jan–Dec)

Year	Sample count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
2006	23	22	4	35	19	83%
2007	22	14	3	30	15	68%
2008	25	15	3	26	16	64%
2009	15	6	4	16	1	7%
2010	12	15	7	25	10	83%
2011	14	17	6	25	11	79%
2012	23	14	4	32	11	48%
2013	31	17	5	36	21	68%
2014	31	20	6	43	22	71%
2015	24	14	2	29	16	67%

Table A-133. Monthly summary of nitrate data at Seven-Mile Creek (AUID 07020007-562; 2006–2015)

Month	Sample count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
Jan	0	–	–	–	–	–
Feb	0	–	–	–	–	–
Mar	20	10	2	23	8	40%
Apr	36	17	5	43	26	72%
May	47	20	4	35	41	87%
Jun	47	21	4	40	44	94%
Jul	22	12	3	29	11	50%
Aug	25	8	3	19	4	16%
Sep	12	9	5	21	2	17%
Oct	11	16	6	30	6	55%
Nov	0	–	–	–	–	–
Dec	0	–	–	–	–	–

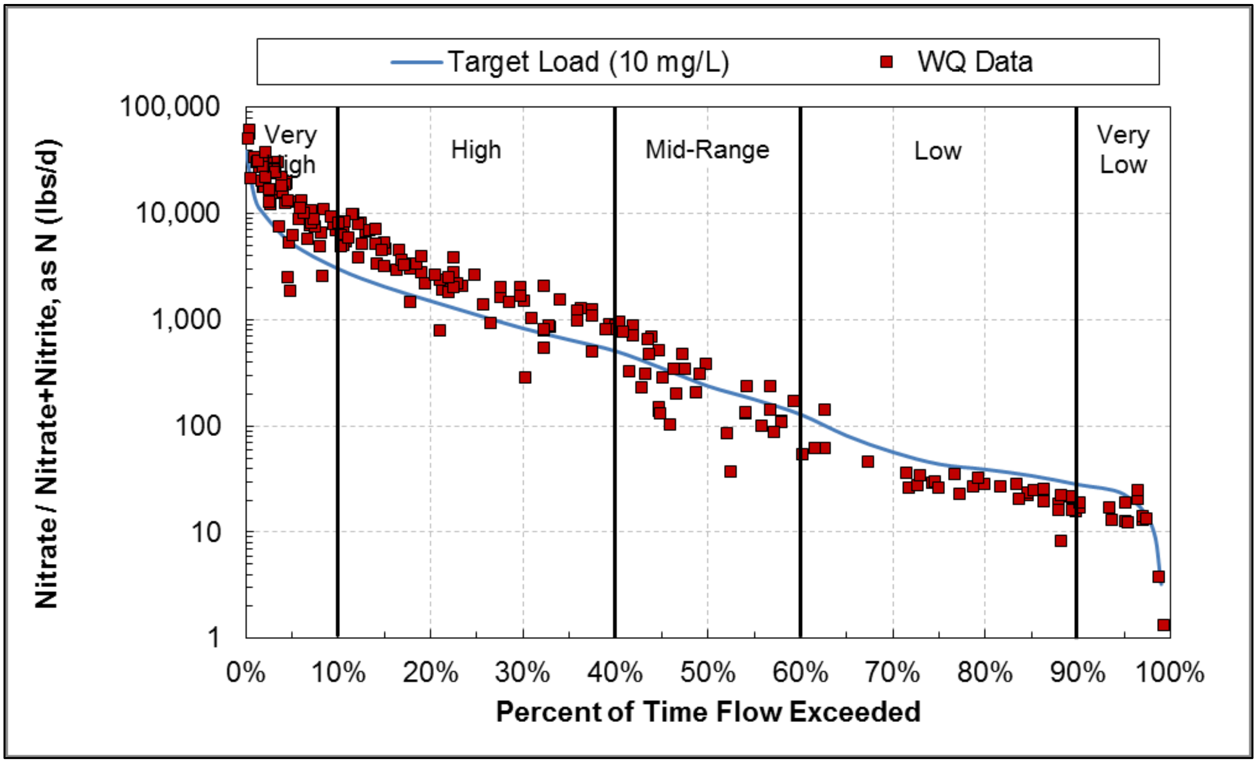

Figure A-63. Nitrate load duration curve, Seven-Mile Creek (AUID 07020007-562).

Table A-134. Nitrate TMDL summary, Seven-Mile Creek (AUID 07020007-562)

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	Inorganic N (Nitrate and Nitrite) Load (lb/d)				
WLA: Construction and Industrial Stormwater	6.1	1.3	0.28	0.051	0.027
Load Allocation	4,717	1,003	214	40	21
Margin of Safety	525	112	24	4.4	2.30
Loading Capacity	5,248	1,116	238	44	23
2nd Highest Exceedance Concentration (mg/L)	40				
Estimated Percent Reduction	75%				

A3.11 Duck Lake (07-0053-00)

Phosphorus

Table A-135. Duck Lake (07-0053-00) water quality data summary, 2005–2016

Values in red indicate violations of the standard.

Ecoregion	Shallow Lake	Parameter	Average of Annual Growing Season Means (Jun–Sep)	Water Quality Standard
North Central Hardwood Forests	N	TP (µg/L)	87	≤ 40
		Chl-*a* (µg/L)	57	≤ 14
		Secchi (m)	0.8	≥ 1.4

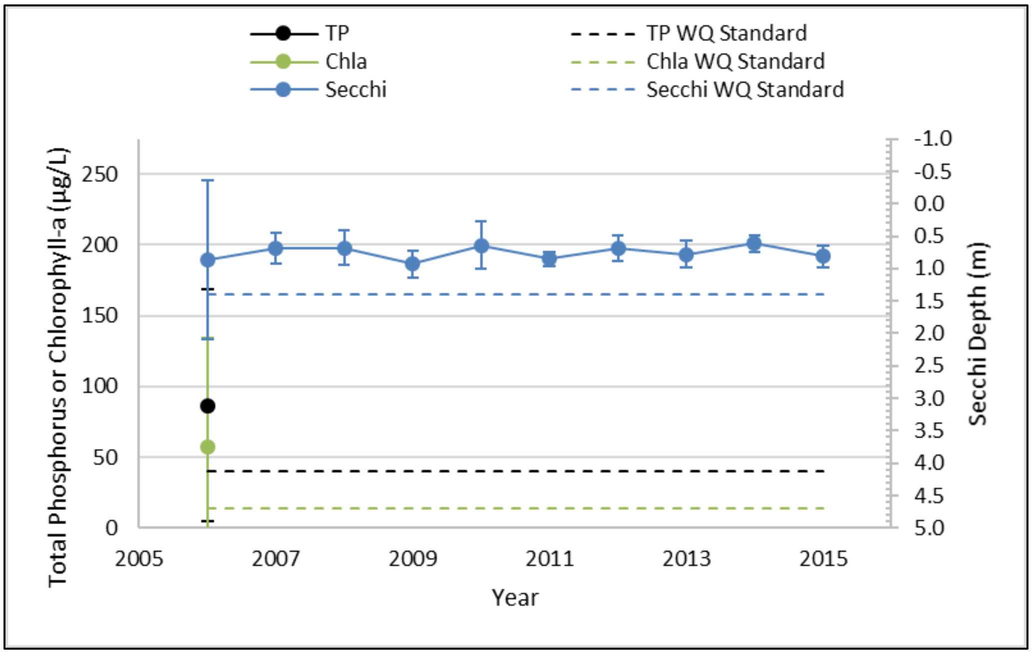

Figure A-64. Duck Lake water quality data.

Growing season means + / - standard error.

Table A-136. Phosphorus source assessment, Duck Lake (07-0053-00)

Source		TP Load (lb/yr)	TP Load (%)
Watershed	Forest	2	<1%
	Crop	450	39%
	Grass/Pasture	6	<1%
	Wetland	6	1%
	Feedlots	–	–
	Urban	37	3%
SSTS[a]		159	14%
Internal Loading		400	34%
Atmospheric Deposition		109	9%
Upstream Lakes		–	–
Total		*1,169*	*100%*

[a] Historical source based on recent development of connection to municipal wastewater facility

Table A-137. Phosphorus TMDL summary, Duck Lake (07-0053-00)

TMDL Parameter	TP Load (lb/yr)	TP Load (lb/day)
WLA for Construction and Industrial Stormwater	0.422	0.00116
Load Allocation	297	0.812
Margin of Safety	33.0	0.0904
Loading Capacity	**330**	**0.904**
Existing Load	1,169	3.20
Percent Load Reduction	72%	72%

A3.12 George Lake (07-0047-00)

Phosphorus

Table A-138. George Lake (07-0047-00) water quality data summary, 2005–2016

Values in red indicate violations of the standard.

Ecoregion	Shallow Lake	Parameter	Average of Annual Growing Season Means (Jun–Sep)	Water Quality Standard
North Central Hardwood Forests	N	TP (µg/L)	89	≤ 40
		Chl-*a* (µg/L)	64	≤ 14
		Secchi (m)	1.0	≥ 1.4

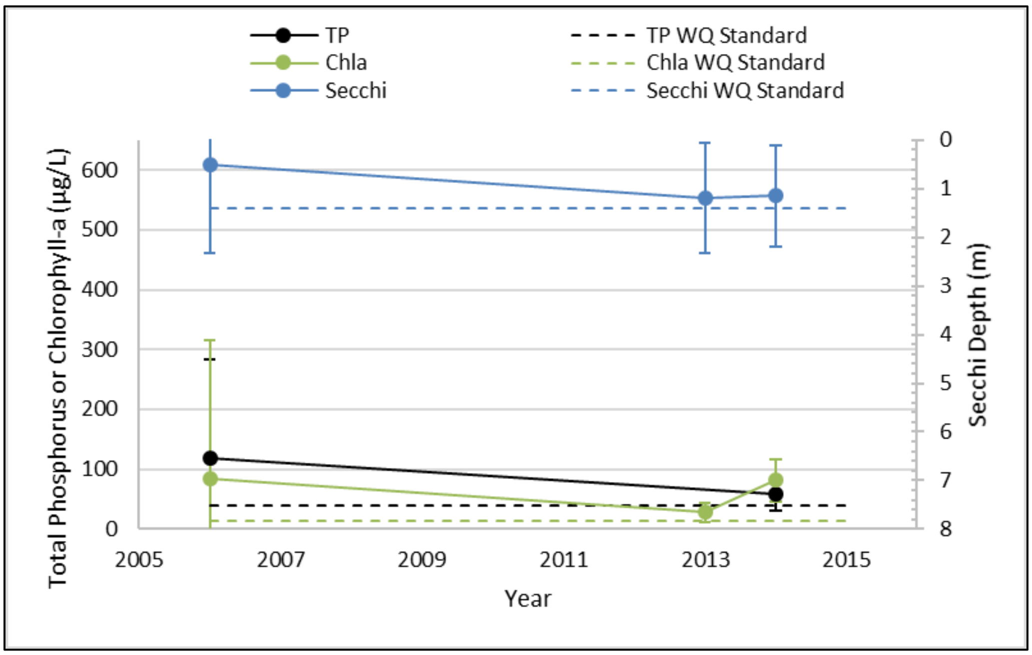

Figure A-65. George Lake water quality data.

Growing season means + / - standard error.

Table A-139. Phosphorus source assessment, George Lake (07-0047-00)

Source		TP Load (lb/yr)	TP Load (%)
Watershed	Forest	5	1%
	Crop	358	71%
	Grass/Pasture	11	2%
	Wetland	4	1%
	Feedlots	–	–
	Urban	24	5%
SSTS		–	–
Internal Loading		64	13%
Atmospheric Deposition		33	7%
Upstream Lakes		–	–
Total		*499*	*100%*

Table A-140. Phosphorus TMDL summary, George Lake (07-0047-00)

TMDL Parameter	TP Load (lb/yr)	TP Load (lb/day)
WLA for Construction and Industrial Stormwater	0.197	0.000540
Load Allocation	138	0.379
Margin of Safety	15.4	0.0422
Loading Capacity	**154**	**0.422**
Existing Load	499	1.37
Percent Load Reduction	69%	69%

A3.13 Washington Lake (40-0117-00)

Phosphorus

Table A-141. Washington Lake (40-0117-00) water quality data summary, 2005–2016

Values in red indicate violations of the standard.

Ecoregion	Shallow Lake	Parameter	Average of Annual Growing Season Means (Jun–Sep)	Water Quality Standard
North Central Hardwood Forests	N	TP (µg/L)	74	≤ 40
		Chl-*a* (µg/L)	52	≤ 14
		Secchi (m)	1.5	≥ 1.4

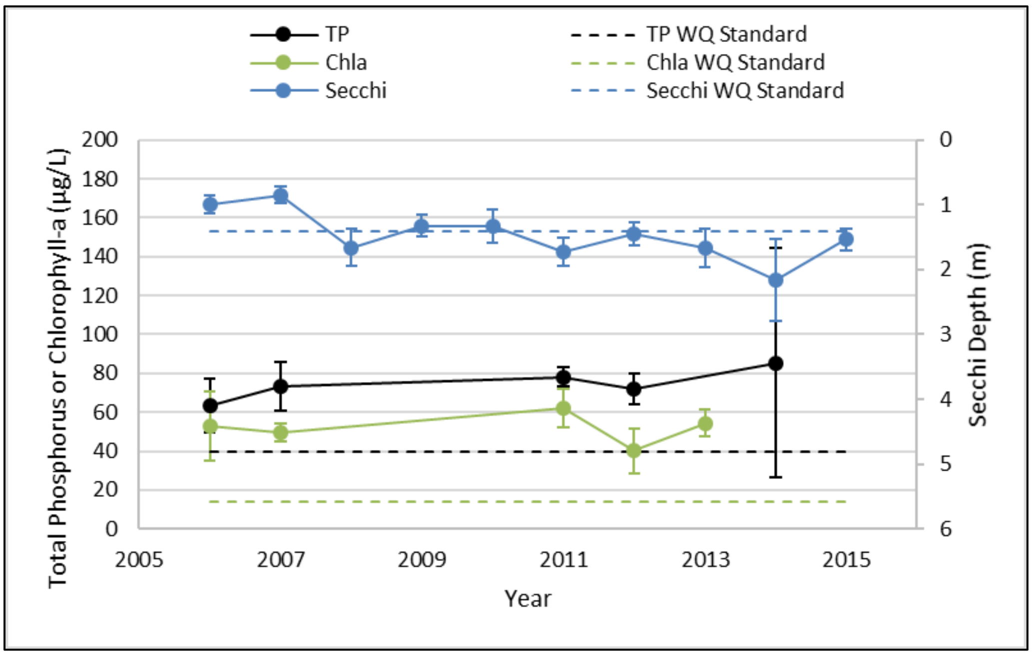

Figure A-66. Washington Lake water quality data.

Growing season means + / - standard error.

Table A-142. Phosphorus source assessment, Washington Lake (40-0117-00)

Source		TP Load (lb/yr)	TP Load (%)
Watershed	Forest	24	<1%
	Crop	5,070	72%
	Grass/Pasture	109	2%
	Wetland	64	1%
	Feedlots	17	<1%
	Urban	234	3%
SSTS[a]		390	6%
Internal Loading		297	4%
Atmospheric Deposition		569	8%
Upstream Lakes		254	4%
Total		*7,028*	*100%*

[a] Historical source based on recent development of connection to municipal wastewater facility

Table A-143. Phosphorus TMDL summary, Washington Lake (40-0117-00)

TMDL Parameter	TP Load (lb/yr)	TP Load (lb/day)
WLA for Construction and Industrial Stormwater	2.38	0.00652
Load Allocation	2,530	6.93
Margin of Safety	281	0.770
Loading Capacity	**2,813**	**7.71**
Existing Load	7,028	19.3
Percent Load Reduction	60%	60%

A3.14 Henry Lake (40-0104-00)

Phosphorus

Table A-144. Henry Lake (40-0104-00) water quality data summary, 2005–2016

Values in red indicate violations of the standard.

Ecoregion	Shallow Lake	Parameter	Average of Annual Growing Season Means (Jun–Sep)	Water Quality Standard
North Central Hardwood Forests	Y	TP (µg/L)	359	≤ 60
		Chl-*a* (µg/L)	155	≤ 20
		Secchi (m)	0.9	≥ 1

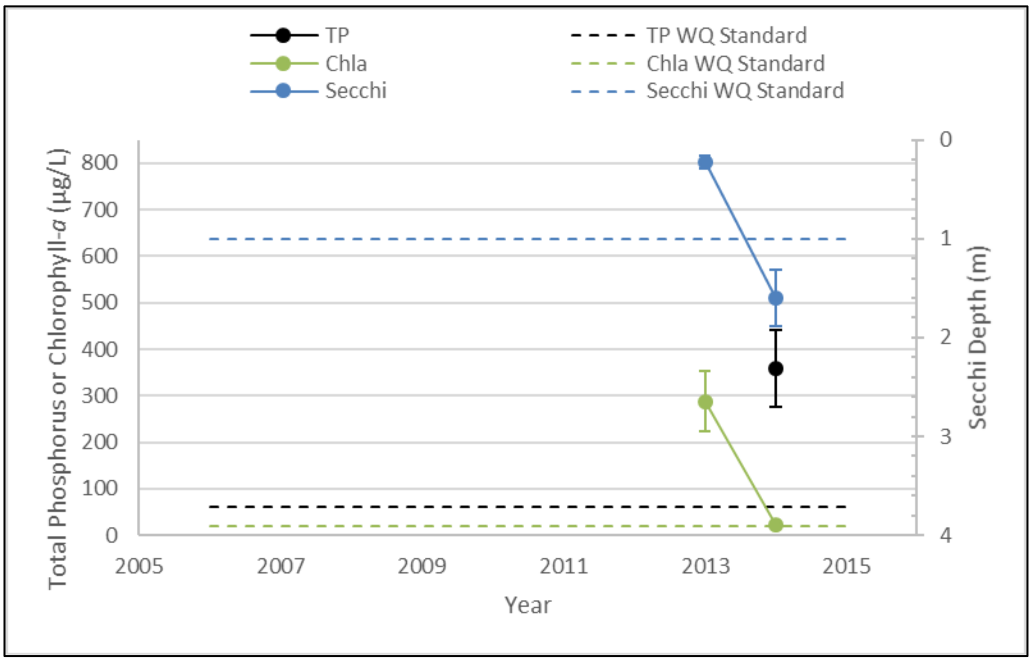

Figure A-67. Henry Lake water quality data.

Growing season means + / - standard error.

Table A-145. Phosphorus source assessment, Henry Lake (40-0104-00)

Source		TP Load (lb/yr)	TP Load (%)
Watershed	Forest	1	<1%
	Crop	332	4%
	Grass/Pasture	2	<1%
	Wetland	9	<1%
	Feedlots	10	<1%
	Urban	8	<1%
SSTS		–	–
Internal Loading		7,256	94%
Atmospheric Deposition		131	2%
Upstream Lakes		–	–
Total		*7,749*	*100%*

Table A-146. Phosphorus TMDL summary, Henry Lake (40-0104-00)

TMDL Parameter	TP Load (lb/yr)	TP Load (lb/day)
WLA for Construction and Industrial Stormwater	0.357	0.000978
Load Allocation	661	1.81
Margin of Safety	73.5	0.201
Loading Capacity	**735**	**2.01**
Existing Load	7,749	21.2
Percent Load Reduction	91%	91%

A3.15 Shanaska Creek, Shanaska Cr Rd to Minnesota R (07020007-693)

E. coli

Table A-147. Annual summary of *E. coli* data at Shanaska Creek (AUID 07020007-693; April–October)

Year	Sample count	Geomean (org/100mL)	Minimum (org/100mL)	Maximum (org/100mL)	# SSM exceedances	Perc. Freq. SSM Exceed.
2006	0	–	–	–	–	–
2007	0	–	–	–	–	–
2008	0	–	–	–	–	–
2009	7	72	16	219	0	–
2010	11	469	26	≥ 2,420 [a]	3	27
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	0	–	–	–	–	–
2014	0	–	–	–	–	–
2015	0	–	–	–	–	–

a. 2,420 org/100mL is the method's maximum recordable value.

Table A-148. Monthly summary of *E. coli* data at Shanaska Creek (AUID 07020007-693; 2006–2015)

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 percent 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	3 [a]	29	16	60	0	–
May	2 [a]	127	105	154	0	–
Jun	5	278	37	≥ 2,420 [b]	1	20
Jul	5	318	79	1,300	1	20
Aug	3 [a]	1,036	411	≥ 2,420 [b]	1	33
Sep	0	–	–	–	–	–
Oct	0	–	–	–	–	–

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

b. 2,420 org/100mL is the method's maximum recordable value.

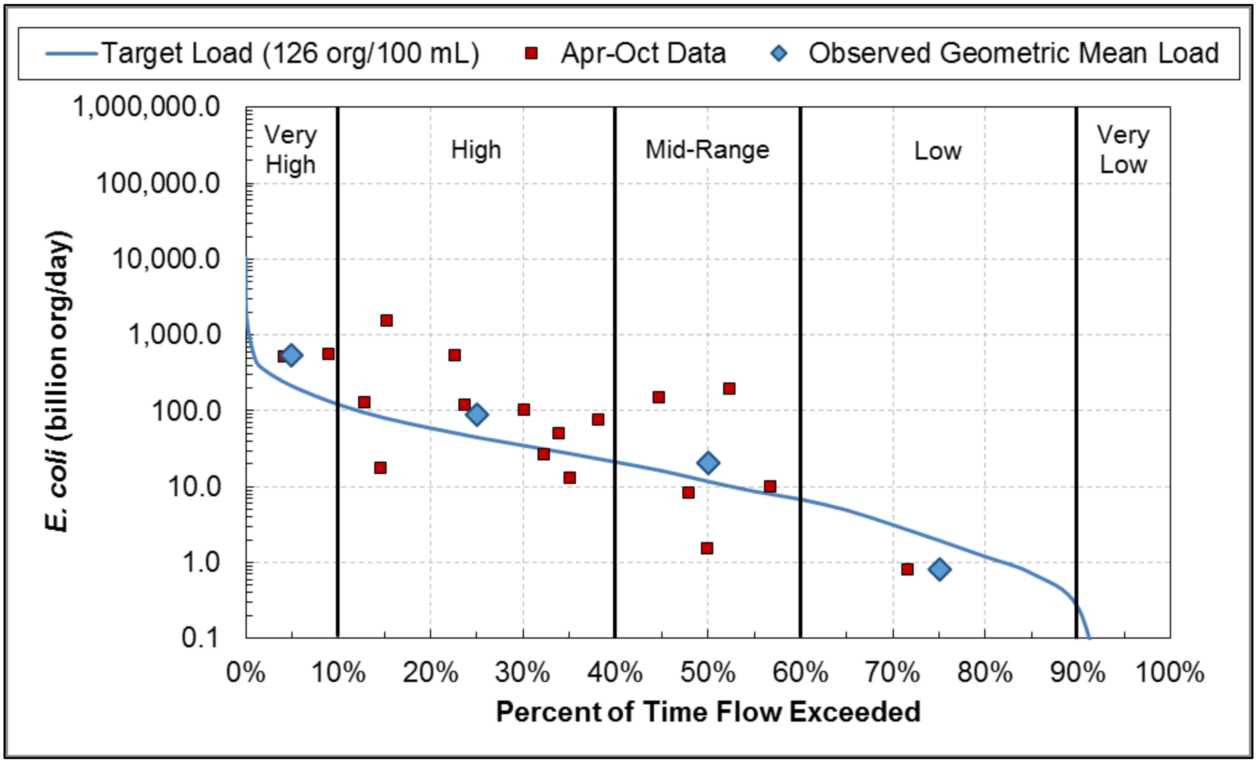

Figure A-68. *E. coli* load duration curve, Shanaska Creek (AUID 07020007-693).

Table A-149. *E. coli* TMDL summary, Shanaska Creek (AUID 07020007-693)

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	E. coli Load (billion org/d)				
Load Allocation	193	41	11	1.8	– [a]
Margin of Safety	21	4.5	1.2	0.20	– [a]
Loading Capacity	214	46	12	2.0	– [a]
Maximum Monthly Geometric Mean (org/100 mL)	318				
Estimated Percent Reduction	60%				

a. HSPF simulated flow of zero is likely an underestimate of actual flow conditions.

A3.16 Rogers Creek (County Ditch 78), CD 21 to Unnamed Cr (07020007-613)

E. coli

Table A-150. Annual summary of *E. coli* data at Rogers Creek-County Ditch 78 (AUID 07020007-613; 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
2006	0	–	–	–	–	–
2007	0	–	–	–	–	–
2008	0	–	–	–	–	–
2009	0	–	–	–	–	–
2010	0	–	–	–	–	–
2011	0	–	–	–	–	–
2012	0	–	–	–	–	–
2013	6	525	120	1,553	1	17
2014	8	440	156	1,274	1	13
2015	0	–	–	–	–	–

Table A-151. Monthly summary of *E. coli* data at Rogers Creek-County Ditch 78 (AUID 07020007-613; 2006–2015)

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 percent 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	4 [a]	400	120	1,553	1	25
Jul	6	436	156	921	0	–
Aug	4 [a]	640	233	1,274	1	25
Sep	0	–	–	–	–	–
Oct	0	–	–	–	–	–

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

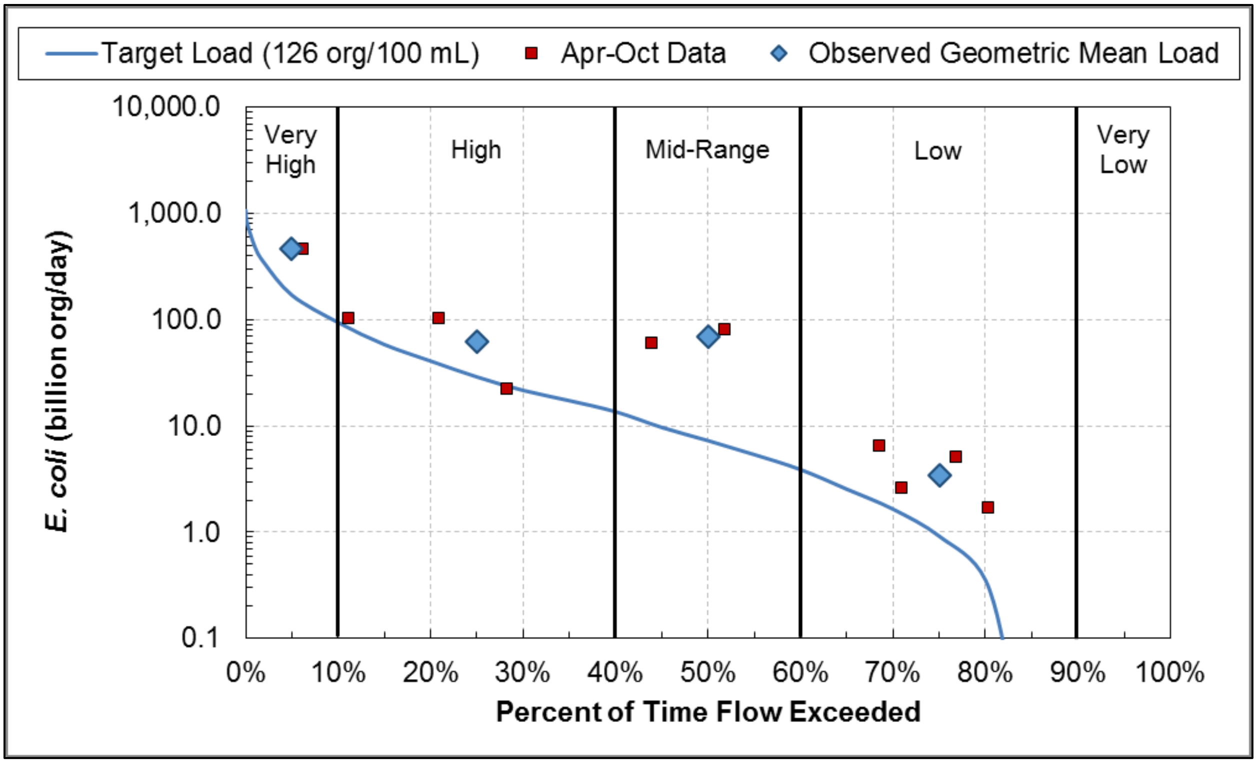

Figure A-69. ***E. coli*** **load duration curve, Rogers Creek (County Ditch 78; AUID 07020007-613).**

Table A-152. ***E. coli*** **TMDL summary, Rogers Creek (County Ditch 78; AUID 07020007-613)**

TMDL Parameter	Flow Zone				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	E. coli **Load (billion org/d)**				
WLA: St. Peter City MS4 (MS400245)	0.19	0.033	0.0082	0.0010	– [a]
Load Allocation	154	26	6.6	0.83	– [a]
Margin of Safety	17	2.9	0.73	0.092	– [a]
Loading Capacity	171	29	7.3	0.92	– [a]
Maximum Monthly Geometric Mean (org/100 mL)	436				
Estimated Percent Reduction	71%				

a. HSPF simulated flow of zero is likely an underestimate of actual flow conditions.

A3.17 Scotch Lake (40-0109-00)

Phosphorus

Table A-153. Scotch Lake (40-0109-00) water quality data summary, 2005–2016

Values in red indicate violations of the standard.

Ecoregion	Shallow Lake	Parameter	Average of Annual Growing Season Means (Jun–Sep)	Water Quality Standard
North Central Hardwood Forests	Y	TP (µg/L)	208	≤ 60
		Chl-*a* (µg/L)	184	≤ 20
		Secchi (m)	0.6	≥ 1

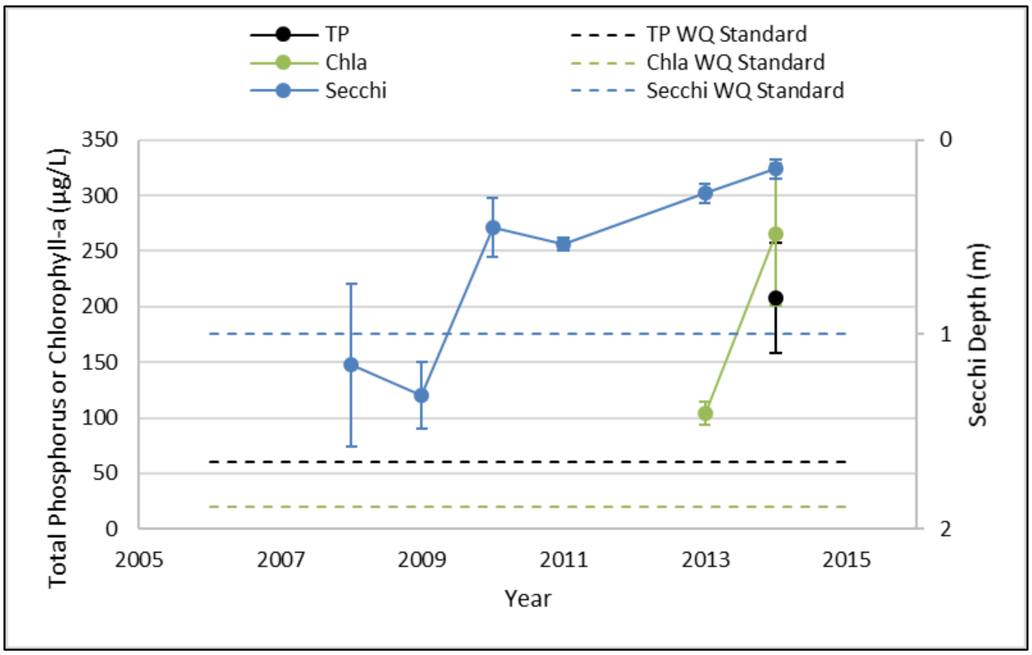

Figure A-70. Scotch Lake water quality data.

Growing season means + / - standard error.

Table A-154. Phosphorus TMDL summary, Scotch Lake (40-0109-00)

Source		TP Load (lb/yr)	TP Load (%)
Watershed	Forest	19	<1%
	Crop	6,551	54%
	Grass/Pasture	67	1%
	Wetland	36	<1%
	Feedlots	5	<1%
	Urban	139	1%
SSTS		–	–
Internal Loading		5,359	42%
Atmospheric Deposition		224	2%
Upstream Lakes		–	–
Total		*12,400*	*100%*

Table A-155. Phosphorus TMDL summary, Scotch Lake (40-0109-00)

TMDL Parameter	TP Load (lb/yr)	TP Load (lb/day)
WLA for Construction and Industrial Stormwater	1.07	0.00293
Load Allocation	1,977	5.41
Margin of Safety	220	0.603
Loading Capacity	**2,198**	**6.02**
Existing Load	12,400	34.0
Percent Load Reduction	82%	82%

Appendix B. Wastewater Wasteload Allocations

All wastewater WLAs are listed in the individual TMDL tables in Appendix A and are compiled in the following table.

Table B-21. Individual wastewater wasteload allocations

Facility	Permit Number	Design Flow (mgd) [a]	Wasteload Allocation [b]		Impairment AUID
			E. coli (billion organisms per day), Apr–Oct	TSS (lb/d), Apr–Sep	
Morgan WWTP	MN0020443	2.314	11.03 [c]	–	07020007-527
Comfrey WWTP	MN0021687	0.075	0.36 [c]	19 [d]	07020007-518, 676, 677
Hanska WWTP	MN0052663	0.749	3.57 [c]	–	07020007-691
Lake Crystal WWTP	MN0055981	0.590	2.81	148 [d]	07020007-534
POET Biorefining–Lake Crystal LLC	MN0067172	0.130	–	33	07020007-534
OMG Midwest Inc/Southern MN Construction Co Inc	MNG490131	3.614	–	905	07020007-676, 677
Nicollet WWTP	MNG580037	2.558	12.20	–	07020007-683
Fairfax WWTP	MNG580060	4.220	20.13	–	07020007-689
Searles WWTP	MNG580080	0.385	1.84	144 [d]	07020007-677
Jeffers WWTP	MNG580111	0.342	1.63	128 [d]	07020007-676, 677
Evan WWTP	MNG580202	0.145	0.69 [c]	–	07020007-622, 573

a. Average wet weather design flow or maximum daily pond flow for municipal wastewater and maximum design flow for industrial wastewater, in million gallons per day (mgd).

b. See sections 4.6.2 and 4.7.2 in the report for the approaches used to develop *E. coli* and TSS wastewater WLAs, respectively.

c. WLAs noted with footnote apply May–Oct; all others apply Apr–Oct.

d. WLA based on facility permitted load limit for TSS.

Appendix C. Lake Modeling Documentation

1. Mills Lake (07-0097-00)

Benchmark Model

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.81	0.2
Evaporation (m)	0.81	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	42	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	Mills	0	1	0.96	1.55	1.18	1.55	0.12	0	0	0	0.08	0	0	1.87	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	174	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	3.13	0.45	0	0	0	331.18	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 Mills

Trib	Type	Location	Flow hm³/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m³
1	1	Watershed	0.450	36.7%	149.0	17.6%	331
PRECIPITATION			0.778	63.3%	40.3	4.8%	52
INTERNAL LOAD			0.000	0.0%	655.7	77.6%	
TRIBUTARY INFLOW			0.450	36.7%	149.0	17.6%	331
***TOTAL INFLOW			1.228	100.0%	845.0	100.0%	688
ADVECTIVE OUTFLOW			0.450	36.7%	78.4	9.3%	174
***TOTAL OUTFLOW			0.450	36.7%	78.4	9.3%	174
***EVAPORATION			0.778	63.3%	0.0	0.0%	
***RETENTION			0.000	0.0%	766.7	90.7%	

Hyd. Residence Time =	3.3067	yrs
Overflow Rate =	0.5	m/yr
Mean Depth =	1.5	m

TMDL Scenario

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.81	0.2
Evaporation (m)	0.81	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km²-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	42	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	Mills	0	1	0.96	1.55	1.18	1.55	0.12	0	0	0	0.08	0	0	0.09	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	174	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	3.13	0.45	0	0	0	331.18	0	0	0	0	0	0	0

Segment Mass Balance Based Upon Predicted Concentrations

Component:		TOTAL P	Segment:		1	Mills	
			Flow	Flow	Load	Load	Conc
Trib	**Type**	**Location**	**hm³/yr**	**%Total**	**kg/yr**	**%Total**	**mg/m³**
1	1	Watershed	0.450	36.7%	149.0	67.5%	331
PRECIPITATION			0.778	63.3%	40.3	18.3%	52
INTERNAL LOAD			0.000	0.0%	31.6	14.3%	
TRIBUTARY INFLOW			0.450	36.7%	149.0	67.5%	331
***TOTAL INFLOW			1.228	100.0%	220.9	100.0%	180
ADVECTIVE OUTFLOW			0.450	36.7%	35.1	15.9%	78
***TOTAL OUTFLOW			0.450	36.7%	35.1	15.9%	78
***EVAPORATION			0.778	63.3%	0.0	0.0%	
***RETENTION			0.000	0.0%	185.8	84.1%	

Hyd. Residence Time =	3.3067	yrs
Overflow Rate =	0.5	m/yr
Mean Depth =	1.5	m

2. Loon Lake (07-0096-00)

Benchmark Model

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.79	0.2
Evaporation (m)	0.79	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km²-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	42	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	Loon	0	1	3.28	1.35	2.57	1.35	0.12	0	0	0	0.08	0	0	1.08	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	150.26	0.05	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	14.94	1.79	0	0	0	355.34	0	0	0	0	0	0	0
2	Septics	1	3	0	0.00655	0	0	0	2693	0	0	0	0	0	0	0
3	Mills Lake	1	3	0	0.45	0	0	0	174	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 Loon**

Trib	Type	Location	Flow hm³/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m³
1	1	Watershed	1.790	37.0%	636.1	29.4%	355
2	3	Septics	0.007	0.1%	17.6	0.8%	2693
3	3	Mills Lake	0.450	9.3%	78.3	3.6%	174
PRECIPITATION			2.591	53.6%	137.8	6.4%	53
INTERNAL LOAD			0.000	0.0%	1293.9	59.8%	
TRIBUTARY INFLOW			1.790	37.0%	636.1	29.4%	355
POINT-SOURCE INFLOW			0.457	9.4%	95.9	4.4%	210
***TOTAL INFLOW			4.838	100.0%	2163.6	100.0%	447
ADVECTIVE OUTFLOW			2.247	46.4%	335.9	15.5%	150
***TOTAL OUTFLOW			2.247	46.4%	335.9	15.5%	150
***EVAPORATION			2.591	53.6%	0.0	0.0%	
***RETENTION			0.000	0.0%	1827.8	84.5%	

Hyd. Residence Time =	1.9710	yrs
Overflow Rate =	0.7	m/yr
Mean Depth =	1.4	m

TMDL Scenario

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.79	0.2
Evaporation (m)	0.79	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	42	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	Loon	0	1	3.28	1.35	2.57	1.35	0.12	0	0	0	0.08	0	0	0.42	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	150.26	0.05	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	14.94	1.79	0	0	0	150	0	0	0	0	0	0	0
2	Septics	1	3	0	0.00655	0	0	0	1250	0	0	0	0	0	0	0
3	Mills Lake	1	3	0	0.45	0	0	0	90	0	0	0	0	0	0	0

Segment Mass Balance Based Upon Predicted Concentrations

Component: TOTAL P **Segment: 1 Loon**

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
1	1	Watershed	1.790	37.0%	268.5	28.0%	150
2	3	Septics	0.007	0.1%	8.2	0.9%	1250
3	3	Mills Lake	0.450	9.3%	40.5	4.2%	90
PRECIPITATION			2.591	53.6%	137.8	14.4%	53
INTERNAL LOAD			0.000	0.0%	503.2	52.5%	
TRIBUTARY INFLOW			1.790	37.0%	268.5	28.0%	150
POINT-SOURCE INFLOW			0.457	9.4%	48.7	5.1%	107
***TOTAL INFLOW			4.838	100.0%	958.1	100.0%	198
ADVECTIVE OUTFLOW			2.247	46.4%	201.8	21.1%	90
***TOTAL OUTFLOW			2.247	46.4%	201.8	21.1%	90
***EVAPORATION			2.591	53.6%	0.0	0.0%	
***RETENTION			0.000	0.0%	756.3	78.9%	

Hyd. Residence Time =	1.9710	yrs
Overflow Rate =	0.7	m/yr
Mean Depth =	1.4	m

3. Wita Lake (07-0077-00)

Benchmark Model

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.04	0.2
Evaporation (m)	0.04	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	42	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
1	Wita	0	1	1.37	1.23	1.3	1.23	0.12	0	0	0	0.08	0	0	0.95	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	144.5	0.18	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	5.36	0.8	0	0	0	302.02	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 Wita**

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
1	1	Watershed	0.800	93.6%	241.6	31.2%	302
PRECIPITATION			0.055	6.4%	57.5	7.4%	1050
INTERNAL LOAD			0.000	0.0%	475.4	61.4%	
TRIBUTARY INFLOW			0.800	93.6%	241.6	31.2%	302
***TOTAL INFLOW			0.855	100.0%	774.5	100.0%	906
ADVECTIVE OUTFLOW			0.800	93.6%	116.4	15.0%	145
***TOTAL OUTFLOW			0.800	93.6%	116.4	15.0%	145
***EVAPORATION			0.055	6.4%	0.0	0.0%	
***RETENTION			0.000	0.0%	658.1	85.0%	

Hyd. Residence Time =	2.1064	yrs
Overflow Rate =	0.6	m/yr
Mean Depth =	1.2	m

TMDL Scenario

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.04	0.2
Evaporation (m)	0.04	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	42	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	Wita	0	1	1.37	1.23	1.3	1.23	0.12	0	0	0	0.08	0	0	0.03	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	144.5	0.18	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	5.36	0.8	0	0	0	150	0	0	0	0	0	0	0

Segment Mass Balance Based Upon Predicted Concentrations

Component:	TOTAL P		Segment:	1	Wita		
			Flow	Flow	Load	Load	Conc
Trib	Type	Location	hm^3/yr	%Total	kg/yr	%Total	mg/m^3
1	1	Watershed	0.800	93.6%	120.0	62.3%	150
PRECIPITATION			0.055	6.4%	57.5	29.9%	1050
INTERNAL LOAD			0.000	0.0%	15.0	7.8%	
TRIBUTARY INFLOW			0.800	93.6%	120.0	62.3%	150
***TOTAL INFLOW			0.855	100.0%	192.6	100.0%	225
ADVECTIVE OUTFLOW			0.800	93.6%	48.3	25.1%	60
***TOTAL OUTFLOW			0.800	93.6%	48.3	25.1%	60
***EVAPORATION			0.055	6.4%	0.0	0.0%	
***RETENTION			0.000	0.0%	144.3	74.9%	

Hyd. Residence Time =	2.1064	yrs
Overflow Rate =	0.6	m/yr
Mean Depth =	1.2	m

4. Duck Lake (07-0053-00)

Benchmark Model

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.97	0.2
Evaporation (m)	0.97	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	42	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	Duck	0	1	1.18	2.73	1.3	2.73	0.12	0	0	0	0.08	0	0	0.42	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	86.63	0.14	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	4.12	0.67	0	0	0	339.97	0	0	0	0	0	0	0
2	Septics	1	3	0	0.02664	0	0	0	2703	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 Duck**

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
1	1	Watershed	0.670	36.4%	227.8	42.9%	340
2	3	Septics	0.027	1.4%	72.0	13.6%	2703
PRECIPITATION			1.145	62.2%	49.6	9.3%	43
INTERNAL LOAD			0.000	0.0%	181.0	34.1%	
TRIBUTARY INFLOW			0.670	36.4%	227.8	42.9%	340
POINT-SOURCE INFLOW			0.027	1.4%	72.0	13.6%	2703
***TOTAL INFLOW			1.841	100.0%	530.4	100.0%	288
ADVECTIVE OUTFLOW			0.697	37.8%	60.6	11.4%	87
***TOTAL OUTFLOW			0.697	37.8%	60.6	11.4%	87
***EVAPORATION			1.145	62.2%	0.0	0.0%	
***RETENTION			0.000	0.0%	469.8	88.6%	

Hyd. Residence Time =	4.6242	yrs
Overflow Rate =	0.6	m/yr
Mean Depth =	2.7	m

TMDL Scenario

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.97	0.2
Evaporation (m)	0.97	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	42	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	Duck	0	1	1.18	2.73	1.3	2.73	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	86.63	0.14	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	4.12	0.67	0	0	0	100	0	0	0	0	0	0	0
2	Septics	1	3	0	0.02664	0	0	0	1250	0	0	0	0	0	0	0

Segment Mass Balance Based Upon Predicted Concentrations

Component: TOTAL P **Segment: 1 Duck**

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
1	1	Watershed	0.670	36.4%	67.0	44.7%	100
2	3	Septics	0.027	1.4%	33.3	22.2%	1250
PRECIPITATION			1.145	62.2%	49.6	33.1%	43
TRIBUTARY INFLOW			0.670	36.4%	67.0	44.7%	100
POINT-SOURCE INFLOW			0.027	1.4%	33.3	22.2%	1250
***TOTAL INFLOW			1.841	100.0%	149.9	100.0%	81
ADVECTIVE OUTFLOW			0.697	37.8%	28.0	18.7%	40
***TOTAL OUTFLOW			0.697	37.8%	28.0	18.7%	40
***EVAPORATION			1.145	62.2%	0.0	0.0%	
***RETENTION			0.000	0.0%	121.8	81.3%	

Hyd. Residence Time = 4.6242 yrs

Overflow Rate = 0.6 m/yr

Mean Depth = 2.7 m

5. George Lake (07-0047-00)

Benchmark Model

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.76	0.2
Evaporation (m)	0.76	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	42	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	George	0	1	0.36	2.8	0.69	2.8	0.12	0	0	0	0.08	0	0	0.22	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	88.6	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	4.14	0.61	0	0	0	299.31	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 George**

Trib	Type	Location	Flow hm³/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m³
1	1	Watershed	0.610	69.0%	182.6	80.6%	299
PRECIPITATION			0.274	31.0%	15.1	6.7%	55
INTERNAL LOAD			0.000	0.0%	28.9	12.8%	
TRIBUTARY INFLOW			0.610	69.0%	182.6	80.6%	299
***TOTAL INFLOW			0.884	100.0%	226.6	100.0%	256
ADVECTIVE OUTFLOW			0.610	69.0%	54.0	23.8%	89
***TOTAL OUTFLOW			0.610	69.0%	54.0	23.8%	89
***EVAPORATION			0.274	31.0%	0.0	0.0%	
***RETENTION			0.000	0.0%	172.6	76.2%	

Hyd. Residence Time =	1.6525	yrs
Overflow Rate =	1.7	m/yr
Mean Depth =	2.8	m

TMDL Scenario

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.76	0.2
Evaporation (m)	0.76	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km²-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	42	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

Seg	Name	Outflow Segment	Group	Area km²	Depth m	Length km	Mixed Depth (m) Mean	Mixed Depth (m) CV	Hypol Depth Mean	Hypol Depth CV	Non-Algal Turb (m⁻¹) Mean	Non-Algal Turb CV	Internal Loads (mg/m2-day) Conserv. Mean	Conserv. CV	Total P Mean	Total P CV	Total N Mean	Total N CV
1	George	0	1	0.36	2.8	0.69	2.8	0.12	0	0	0	0.08	0	0	0	0	0	0

Segment Observed Water Quality

Seg	Conserv Mean	CV	Total P (ppb) Mean	CV	Total N (ppb) Mean	CV	Chl-a (ppb) Mean	CV	Secchi (m) Mean	CV	Organic N (ppb) Mean	CV	TP - Ortho P (ppb) Mean	CV	HOD (ppb/day) Mean	CV	MOD (ppb/day) Mean	CV
1	0	0	88.6	0.12	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

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

Tributary Data

Trib	Trib Name	Segment	Type	Dr Area km²	Flow (hm³/yr) Mean	CV	Conserv. Mean	CV	Total P (ppb) Mean	CV	Total N (ppb) Mean	CV	Ortho P (ppb) Mean	CV	Inorganic N (ppb) Mean	CV
1	Watershed	1	1	4.14	0.61	0	0	0	90	0	0	0	0	0	0	0

Segment Mass Balance Based Upon Predicted Concentrations

Component:	TOTAL P		Segment:	1	George	
		Flow	Flow	Load	Load	Conc
Trib / Type	Location	hm^3/yr	%Total	kg/yr	%Total	mg/m^3
1 / 1	Watershed	0.610	69.0%	54.9	78.4%	90
PRECIPITATION		0.274	31.0%	15.1	21.6%	55
TRIBUTARY INFLOW		0.610	69.0%	54.9	78.4%	90
***TOTAL INFLOW		0.884	100.0%	70.0	100.0%	79
ADVECTIVE OUTFLOW		0.610	69.0%	24.4	34.9%	40
***TOTAL OUTFLOW		0.610	69.0%	24.4	34.9%	40
***EVAPORATION		0.274	31.0%	0.0	0.0%	
***RETENTION		0.000	0.0%	45.6	65.1%	

Hyd. Residence Time =	1.6525	yrs
Overflow Rate =	1.7	m/yr
Mean Depth =	2.8	m

6. Washington Lake (07-0047-00)

Benchmark Model

Global Variables	Mean	CV	Model Options	Code	Description
Averaging Period (yrs)	1	0.0	Conservative Substance	0	NOT COMPUTED
Precipitation (m)	1.18	0.2	Phosphorus Balance	8	CANF & BACH, LAKES
Evaporation (m)	1.18	0.3	Nitrogen Balance	0	NOT COMPUTED
Storage Increase (m)	0	0.0	Chlorophyll-a	0	NOT COMPUTED
			Secchi Depth	0	NOT COMPUTED
Atmos. Loads (kg/km^2-yr	**Mean**	**CV**	Dispersion	1	FISCHER-NUMERIC
Conserv. Substance	0	0.00	Phosphorus Calibration	1	DECAY RATES
Total P	42	0.50	Nitrogen Calibration	1	DECAY RATES
Total N	0	0.50	Error Analysis	1	MODEL & DATA
Ortho P	0	0.50	Availability Factors	0	IGNORE
Inorganic N	0	0.50	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	Washington	0	1	6.15	3.39	4.5	3.39	0.12	0	0	0	0.08	0	0	0.06	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	74.43	0.04	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	57.16	7.72	0	0	0	324.2	0	0	0	0	0	0	0
2	Septics	1	3	0	0.08054	0	0	0	2197	0	0	0	0	0	0	0
3	George lake	1	3	0	0.61	0	0	0	89	0	0	0	0	0	0	0
4	Duck Lake	1	3	0	0.7	0	0	0	87	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 Washington

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
1	1	Watershed	7.720	47.2%	2502.8	78.5%	324
2	3	Septics	0.081	0.5%	176.9	5.6%	2197
3	3	George lake	0.610	3.7%	54.3	1.7%	89
4	3	Duck Lake	0.700	4.3%	60.9	1.9%	87
PRECIPITATION			7.257	44.3%	258.3	8.1%	36
INTERNAL LOAD			0.000	0.0%	134.8	4.2%	
TRIBUTARY INFLOW			7.720	47.2%	2502.8	78.5%	324
POINT-SOURCE INFLOW			1.391	8.5%	292.1	9.2%	210
***TOTAL INFLOW			16.368	100.0%	3188.0	100.0%	195
ADVECTIVE OUTFLOW			9.111	55.7%	676.7	21.2%	74
***TOTAL OUTFLOW			9.111	55.7%	676.7	21.2%	74
***EVAPORATION			7.257	44.3%	0.0	0.0%	
***RETENTION			0.000	0.0%	2511.4	78.8%	

Hyd. Residence Time =	2.2884	yrs
Overflow Rate =	1.5	m/yr
Mean Depth =	3.4	m

TMDL Scenario

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	1.18	0.2
Evaporation (m)	1.18	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	42	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	Washington	0	1	6.15	3.39	4.5	3.39	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	74.43	0.04	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	57.16	7.72	0	0	0	110	0	0	0	0	0	0	0
2	Septics	1	3	0	0.08054	0	0	0	1250	0	0	0	0	0	0	0
3	George lake	1	3	0	1	0	0	0	40	0	0	0	0	0	0	0
4	Duck Lake	1	3	0	0.7	0	0	0	40	0	0	0	0	0	0	0

Segment Mass Balance Based Upon Predicted Concentrations

Component: TOTAL P **Segment: 1 Washington**

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
1	1	Watershed	7.720	46.1%	849.2	66.5%	110
2	3	Septics	0.081	0.5%	100.7	7.9%	1250
3	3	George lake	1.000	6.0%	40.0	3.1%	40
4	3	Duck Lake	0.700	4.2%	28.0	2.2%	40
PRECIPITATION			7.257	43.3%	258.3	20.2%	36
TRIBUTARY INFLOW			7.720	46.1%	849.2	66.5%	110
POINT-SOURCE INFLOW			1.781	10.6%	168.7	13.2%	95
***TOTAL INFLOW			16.758	100.0%	1276.2	100.0%	76
ADVECTIVE OUTFLOW			9.501	56.7%	382.1	29.9%	40
***TOTAL OUTFLOW			9.501	56.7%	382.1	29.9%	40
***EVAPORATION			7.257	43.3%	0.0	0.0%	
***RETENTION			0.000	0.0%	894.1	70.1%	

Hyd. Residence Time =	2.1945	yrs
Overflow Rate =	1.5	m/yr
Mean Depth =	3.4	m

7. Henry Lake (40-0104-00)

Benchmark Model

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.22	0.2
Evaporation (m)	0.22	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	42	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	Henry	0	1	1.42	1.23	1.24	1.23	0.12	0	0	0	0.08	0	0	6.35	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	358.5	0.23	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	3.39	0.58	0	0	0	280.28	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 Henry**

Trib	Type	Location	Flow hm³/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m³
1	1	Watershed	0.580	65.0%	162.6	4.6%	280
PRECIPITATION			0.312	35.0%	59.6	1.7%	191
INTERNAL LOAD			0.000	0.0%	3293.5	93.7%	
TRIBUTARY INFLOW			0.580	65.0%	162.6	4.6%	280
***TOTAL INFLOW			0.892	100.0%	3515.7	100.0%	3940
ADVECTIVE OUTFLOW			0.580	65.0%	208.0	5.9%	359
***TOTAL OUTFLOW			0.580	65.0%	208.0	5.9%	359
***EVAPORATION			0.312	35.0%	0.0	0.0%	
***RETENTION			0.000	0.0%	3307.6	94.1%	

Hyd. Residence Time =	3.0114	yrs
Overflow Rate =	0.4	m/yr
Mean Depth =	1.2	m

TMDL Scenario

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.22	0.2
Evaporation (m)	0.22	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km²-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	42	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	Henry	0	1	1.42	1.23	1.24	1.23	0.12	0	0	0	0.08	0	0	0.36	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	358.5	0.23	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	3.39	0.58	0	0	0	150	0	0	0	0	0	0	0

Segment Mass Balance Based Upon Predicted Concentrations

Component:	**TOTAL P**		**Segment:**	**1**	**Henry**	

Trib	Type	Location	Flow hm³/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m³
1	1	Watershed	0.580	65.0%	87.0	26.1%	150
PRECIPITATION			0.312	35.0%	59.6	17.9%	191
INTERNAL LOAD			0.000	0.0%	186.7	56.0%	
TRIBUTARY INFLOW			0.580	65.0%	87.0	26.1%	150
***TOTAL INFLOW			0.892	100.0%	333.4	100.0%	374
ADVECTIVE OUTFLOW			0.580	65.0%	52.0	15.6%	90
***TOTAL OUTFLOW			0.580	65.0%	52.0	15.6%	90
***EVAPORATION			0.312	35.0%	0.0	0.0%	
***RETENTION			0.000	0.0%	281.3	84.4%	

Hyd. Residence Time =	3.0114	yrs
Overflow Rate =	0.4	m/yr
Mean Depth =	1.2	m

8. Scotch Lake (40-0109-00)

Benchmark Model

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.82	0.2
Evaporation (m)	0.82	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km²-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	42	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
1	Scotch	0	1	2.42	1.82	1.8	1.82	0.12	0	0	0	0.08	0	0	2.75	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	207.75	0.24	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	43.28	8.14	0	0	0	379.91	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 Scotch**

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
1	1	Watershed	8.140	80.4%	3092.5	55.0%	380
PRECIPITATION			1.984	19.6%	101.6	1.8%	51
INTERNAL LOAD			0.000	0.0%	2430.7	43.2%	
TRIBUTARY INFLOW			8.140	80.4%	3092.5	55.0%	380
***TOTAL INFLOW			10.124	100.0%	5624.8	100.0%	556
ADVECTIVE OUTFLOW			8.140	80.4%	1694.4	30.1%	208
***TOTAL OUTFLOW			8.140	80.4%	1694.4	30.1%	208
***EVAPORATION			1.984	19.6%	0.0	0.0%	
***RETENTION			0.000	0.0%	3930.5	69.9%	

Hyd. Residence Time = 0.5411 yrs
Overflow Rate = 3.4 m/yr
Mean Depth = 1.8 m

TMDL Scenario

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.82	0.2
Evaporation (m)	0.82	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	42	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	Scotch	0	1	2.42	1.82	1.8	1.82	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	207.75	0.24	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	43.28	8.14	0	0	0	110	0	0	0	0	0	0	0

Segment Mass Balance Based Upon Predicted Concentrations

Component: TOTAL P **Segment: 1 Scotch**

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
1	1	Watershed	8.140	80.4%	895.4	89.8%	110
PRECIPITATION			1.984	19.6%	101.6	10.2%	51
TRIBUTARY INFLOW			8.140	80.4%	895.4	89.8%	110
***TOTAL INFLOW			10.124	100.0%	997.0	100.0%	98
ADVECTIVE OUTFLOW			8.140	80.4%	486.3	48.8%	60
***TOTAL OUTFLOW			8.140	80.4%	486.3	48.8%	60
***EVAPORATION			1.984	19.6%	0.0	0.0%	
***RETENTION			0.000	0.0%	510.7	51.2%	

Hyd. Residence Time =	0.5411	yrs
Overflow Rate =	3.4	m/yr
Mean Depth =	1.8	m

Appendix D. CAFOs in the Minnesota River-Mankato Watershed

Table D-1: Registered CAFOs in the Minnesota River- Mankato Watershed

Registration Number	Site Name	Animal Unit Count	HUC 12 Code	HUC 12 Name
013-102624	Lantz Enterprise Inc - Site 2	1300	70200070901	Judicial Ditch No 48
013-111540	Jones Farms Facility #1	1440	70200070901	Judicial Ditch No 48
013-115756	Lantz Enterprises Inc - Site 3	750	70200070901	Judicial Ditch No 48
013-125563	Hoppe Finisher	990	70200071102	City of Mankato-Minnesota River
015-50001	Schieffert Finishing Old Site	1575	70200070406	Spring Creek
015-50003	Mark O Sletta Farm	1248	70200071001	Morgan Creek
015-50004	Patrick Krzmarzick Farm 1	1560	70200070407	County Ditch No 10-Minnesota River
015-50006	Rathman's Inc	1152	70200070703	Gilman Lake-Little Cottonwood River
015-50007	Christensen Farms Site C010	1108	70200071001	Morgan Creek
015-50011	Multi-Site - Christensen Farms Sites C002 & C006	1028	70200070406	Spring Creek
015-50015	Patrick Mohr Farm - Sec 27	1200	70200071001	Morgan Creek
015-60701	BayCon Society Inc	1200	70200071001	Morgan Creek
015-71676	Tom Byro Farm	900	70200071001	Morgan Creek
015-71682	TJ Turkeys LLP	1022	70200071001	Morgan Creek
015-71689	Tews Farms	1454.5	70200070701	Headwaters Little Cottonwood River
015-71991	John Hillesheim Site F024	936	70200070407	County Ditch No 10-Minnesota River
015-72105	Eric Helget Farm	936	70200070704	Little Cottonwood River
015-72119	MT - Finishers	1800	70200070704	Little Cottonwood River
015-72247	Larson Turkeys	830	70200071001	Morgan Creek
015-82448	Robert Goblirsch Farm 2	936	70200070704	Little Cottonwood River
015-82449	Krzmarzick Site 2	990	70200070407	County Ditch No 10-Minnesota River
015-95065	Helget Finisher	900	70200070703	Gilman Lake-Little Cottonwood River
015-95128	Craig Holm Farm	936	70200070704	Little Cottonwood River
015-100004	Dean Schneider Farm	1582.8	70200070704	Little Cottonwood River
015-108520	Schneider Farm 2	1560	70200070704	Little Cottonwood River
015-110520	Schwartz Farms Inc - Stately 27	900	70200070701	Headwaters Little Cottonwood River
015-116198	Richard Maurer Farm	1440	70200070406	Spring Creek
015-120235	Schwartz Farms Inc - Prairieville Site	990	70200070406	Spring Creek
015-123803	Eischen and Sons Farm	990	70200070702	County Ditch No 28-1
015-124026	Nelson Finisher	990	70200071001	Morgan Creek
015-124214	Clyde Larson Farm - Sec 19	900	70200071001	Morgan Creek
015-125912	Christensen Farms Site R002	840	70200070702	County Ditch No 28-1
033-50010	Christensen Farms Site C011	1200	70200070702	County Ditch No 28-1
033-99020	Christensen Farms Site F137	936	70200070702	County Ditch No 28-1
033-109280	Schwartz Farms Inc - Wolf	900	70200070701	Headwaters Little Cottonwood River
079-50003	Pheasant Run Great Plains Family Farms Inc	1384.6	70200071106	Cherry Creek
079-50004	Blue Sky Dairy LLC	1499.8	70200071104	Shanaska Creek
079-50004	Blue Sky Dairy LLC	1505.8	70200071104	Shanaska Creek
079-66307	Borgmeier Finisher Site	1062	70200071104	Shanaska Creek
079-99726	Hollerich Farms Inc #2	1400	70200071106	Cherry Creek

103-50001	Svin Hus Inc	1080	70200071102	City of Mankato-Minnesota River
103-50003	Waibel Pork Inc	1232.4	70200070801	Swan Lake
103-50006	Randy Reinhart Farm - Sec 21	1923	70200070604	City of New Ulm-Minnesota River
103-50009	Belgrade Pullets, LLC	960	70200071003	County Ditch No 3-Minnesota River
103-50010	Altmann Family Pork	2112	70200070604	City of New Ulm-Minnesota River
103-50011	Wendinger Bryan 2	1248	70200070603	Fritsche Creek
103-50012	Rebco Pork Inc	1130	70200071002	City of Courtland-Minnesota River
103-50015	Randy Reinhart Farm - Sec 26	1900.8	70200070604	City of New Ulm-Minnesota River
103-50016	Josie's Pork Farm - Site 1	1792.5	70200071105	Rogers Creek
103-50018	Peichel 2 - Nicollet	1560	70200070504	Little Rock Creek
103-60501	Northern Plains Dairy	3300	70200071103	Sevenmile Creek
103-61920	Timothy A. Waibel Farm	1650	70200071002	City of Courtland-Minnesota River
103-96920	Ryan Bode Farm	1200	70200070603	Fritsche Creek
103-97362	K & K Wenner Farms	1200	70200071105	Rogers Creek
103-97385	Mike Vogel Farm - Sec 34	1125	70200071103	Sevenmile Creek
103-97503	Martens Family Farm	1191.6	70200070604	City of New Ulm-Minnesota River
103-97541	Lakeview Pork LLC	900	70200070801	Swan Lake
103-97606	Duane Hacker Farm - Sec 16	900	70200070603	Fritsche Creek
103-97770	Wykson Growers LLC	975	70200071105	Rogers Creek
103-97781	Jason Enter - Site 1	900	70200070604	City of New Ulm-Minnesota River
103-97785	Michels Farms Inc - Sec 21	870	70200071103	Sevenmile Creek
103-97804	Courtland Dairy LLC	1680	70200071002	City of Courtland-Minnesota River
103-99440	PJM Pork	1500	70200070604	City of New Ulm-Minnesota River
103-99580	Tim Harmening Farm	1314	70200070604	City of New Ulm-Minnesota River
103-107140	Jonathan R Rewitzer Farm	923.1	70200070604	City of New Ulm-Minnesota River
103-107797	Jason Enter - Site 2	900	70200070604	City of New Ulm-Minnesota River
103-110501	New Sweden Dairy	4943.7	70200071105	Rogers Creek
103-110720	Daniel Mages Farm - Sec 17	900	70200070603	Fritsche Creek
103-114102	Rebco Run LLC	990	70200070803	Swan Lake Outlet
103-115695	Ryan Franta Farm	1800	70200070603	Fritsche Creek
103-116552	Granby Calf Ranch LLC	950.4	70200070802	Middle Lake
103-121268	Wayne Havemeier Farm - Sec 2	900	70200071105	Rogers Creek
103-124605	Rebco Pork II	1440	70200071002	City of Courtland-Minnesota River
103-126174	Jason Enter Site #3	900	70200070604	City of New Ulm-Minnesota River
103-126291	Jason and Michele Schroeder	900	70200071002	City of Courtland-Minnesota River
127-50053	Hacker Farms Inc	1560	70200070404	Judicial Ditch No 17
127-50064	Neitzel Pork Project	1200	70200070203	Wabasha Creek
127-50068	Jared Schiller Farm	1500	70200070201	County Ditch No 64
127-50070	Polesky Site 2	1440	70200070202	County Ditch No 109
127-50071	Polesky Site 3	1140	70200070404	Judicial Ditch No 17
127-105760	Kerkhoff Cattle Co Inc	3740	70200070203	Wabasha Creek
127-106960	R & J Feedlot	900	70200070401	Crow Creek
127-126307	Neitzel Pork Project - Site 2	990	70200070202	County Ditch No 109
129-50002	KNK Farms - Site 2 - N	1200	70200070301	County Ditch No 106A
129-50003	Lee Farms Inc	1300	70200070405	Threemile Creek-Minnesota River
129-50004	Jerry R Weldy Farm	768	70200070402	Purgatory Creek
129-50007	Erickson Brothers	1152	70200070101	County Ditch No 124
129-50009	Rieke Farms Inc	1200	70200070504	Little Rock Creek
129-50017	Willmar Poultry Farms Inc - Green	1150	70200070103	Birch Coulee Creek
129-50021	Revier Cattle Co Inc	10500	70200070101	County Ditch No 124
129-60147	Nosbush Dairy LLP	1631.6	70200070303	Fort Ridgely Creek
129-60161	Revier Feedlot Inc	4270	70200070101	County Ditch No 124
129-67909	KNK Farms - Site 1	936	70200070301	County Ditch No 106A
129-97220	Christensen Farms Site C042	1458	70200070101	County Ditch No 124
129-97241	Christensen Farms Site NF002 Finisher	2688	70200070101	County Ditch No 124
129-99963	Willmar Poultry Farms - Wilson	1190	70200070403	City of Morton-Minnesota River
129-104661	KNK Farms - Site 3	936	70200070301	County Ditch No 106A
129-107160	Tim Schweiss Farm	900	70200070501	County Ditch No 34
129-112598	RBS LLP Site F128	990	70200070402	Purgatory Creek
129-125569	JR Pork	900	70200070303	Fort Ridgely Creek
129-126298	F155 Greenslit	990	70200070402	Purgatory Creek
143-50006	Peichel 1 - Sibley	1298	70200070601	Eightmile Creek
143-89219	Twin Pine Farms LLP	1162	70200070502	Judicial Ditch No 8
143-89718	Bode Dairy and Feedlots Co - Sec 7	1611.4	70200070502	Judicial Ditch No 8
143-89746	Larry Baumgardt Farm - Sibley Site	1200	70200070502	Judicial Ditch No 8