Cannon River Watershed Total Maximum Daily Load

Minnesota Pollution Control Agency

LimnoTech

Water Environment | Scientists Engineers

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Acronyms

AUs	Animal Units
AUID	Assessment Unit ID
BMP	Best Management Practice
CAFO	Concentrated Animal Feeding Operation
cfu	Colony-forming unit
Chl-*a*	Chlorophyll-*a*
CRW	Cannon River Watershed
CV	Coefficients of variance
DNR	Minnesota Department of Natural Resources
EPA	U.S. Environmental Protection Agency
EQuIS	Environmental Quality Information System
FWMC	Flow weighted mean concentration
GW	Groundwater
HSPF	Hydrologic Simulation Program-Fortran
IBI	Index of Biotic Integrity
in/yr	Inches per year
IMW	Intensive Watershed Monitoring
km^2	Square kilometer
LA	Load Allocation
Lb	Pound
lb/day	Pounds per day
lb/yr	Pounds per year
LDCs	Load duration curves
LGU	Local Government Unit
m	Meter
MCL	Maximum contaminant level
mg/L	Milligrams per liter
mg/m^2-day	Milligram per square meter per day
mL	Milliliter
MOS	Margin of Safety
MPCA	Minnesota Pollution Control Agency
MS4	Municipal Separate Storm Sewer Systems

NCHF	North Central Hardwood Forests
NPDES	National Pollutant Discharge Elimination System
RES	River eutrophication standard
SDWA	Safe Drinking Water Act
SID	Stressor Identification
SONAR	Statement of Need and Reasonableness
SSTS	Subsurface Sewage Treatment Systems
SWPPP	Stormwater Pollution Prevention Plan
TMDL	Total Maximum Daily Load
TSS	Total suspended solid
TP	Total phosphorus
µg/L	Microgram per liter
WCBP	Western Cornbelt Plains
WLA	Wasteload Allocation
WRAPS	Watershed Restoration and Protection Strategy
WWTF	Wastewater treatment facility

Executive Summary

The Clean Water Act (1972) requires that each state develop a plan to identify and restore any waterbody that is deemed impaired by state regulations. A Total Maximum Daily Load Study (TMDL) is required by the U.S. Environmental Protection Agency (EPA) as a result of the federal Clean Water Act. A TMDL identifies the pollutant that is causing the impairment and how much of that pollutant can enter the waterbody and still meet water quality standards.

This TMDL study includes calculations for 30 lakes with phosphorus impairments as well as 41 stream reaches with bacteria, chloride, nitrate and/or total suspended solid (TSS) impairments located in the Cannon River Watershed (CRW) (HUC 07040002) in southeastern Minnesota. These listings are on the approved 2012 EPA 303(d) list of impaired waters and the draft 2014 EPA 303(d) list of impaired waters.

Information from multiple sources was used to evaluate the ecological health of each waterbody:

- All available water quality data over the past 10 years
- Published studies
- Stressor Identification (SID) investigations
- BATHTUB model
- Hydrologic Simulation Program-Fortran (HSPF) model
- Stakeholder input

The following pollutant sources were evaluated for each impaired lake and impaired stream: watershed runoff, loading from upstream waterbodies, atmospheric deposition, municipal and industrial wastewater facilities (WWTFs), Municipal Separate Storm Sewer Systems (MS4) communities, construction and industrial stormwater runoff, and feedlots. An inventory of pollutant sources was used to inform the lake response models and stream load duration curves (LDCs). These models were then used to determine the pollutant reductions for each lake and the allowed loads for each stream to meet state water quality standards.

The findings from this TMDL study will be used to aid the selection of implementation activities as part of the Cannon River Watershed Restoration and Protection Strategy (WRAPS) process. The purpose of the WRAPS report is to support local working groups and jointly develop scientifically-supported restoration and protection strategies to be used for subsequent implementation planning. Following completion, the WRAPS and TMDLs documents will be publically available on the Minnesota Pollution Control Agency (MPCA) CRW website: https://www.pca.state.mn.us/water/watersheds/cannon-river.

1. Project Overview

Purpose

The passage of Minnesota's Clean Water Legacy Act (CWLA) in 2006 provided a policy framework and resources to state and local governments to accelerate efforts to monitor, assess and restore impaired waters and to protect unimpaired waters. The result has been a comprehensive watershed approach that integrates water resource management efforts with local government and local stakeholders and develops restoration and protection studies for Minnesota's 80 major watersheds.

For the CRW, the approach began with intensive watershed monitoring (IMW) in 2011 and culminates in 2016 with completion of a Watershed Restoration and Protection Strategies (WRAPS) report and this TMDL study, which addresses aquatic recreation, aquatic life, and drinking water impairments on 41 stream Assessment Unit IDs (AUIDs) and 30 lake AUIDs in the CRW.

Completed studies for this watershed that are referenced in this TMDL report include:

- CRW Monitoring and Assessment Report (MPCA 2014c)
- CRW HSPF Model Development Project Phases I and II (LimnoTech 2015a & b)
- CRW SID Report (MPCA 2015b)
- CRW Management Strategy: 2011 through 2015 (Cannon River Watershed Partnership 2011)

More related information is summarized in the WRAPS report; those works listed above can be reviewed at the MPCA's CRW website: https://www.pca.state.mn.us/water/watersheds/cannon-river.

Given the accumulation of data and conclusions achieved throughout these component processes, the documents cross-reference frequently and should thus be considered a "package" of information that comprehensively addresses condition monitoring, restoration and protection in the CRW. For example, much of the substance that provides reasonable assurance for the TMDLs is described in detail in the WRAPS document.

The findings from this TMDL study can be used in conjunction with the WRAPS report and supporting information to guide management in the CRW. Together these works will support local projects in developing scientifically-supported restoration and protection strategies to be used for subsequent implementation planning.

The goal of this TMDL study was to quantify, where applicable, the pollutant reductions needed to meet State water quality standards for select waterbodies in the CRW. This CRW TMDL study was established in accordance with Section 303(d) of the Clean Water Act and provides wasteload allocations (WLAs) and load allocations (LAs) for the watershed areas as appropriate.

1.1 Identification of Waterbodies

This TMDL report addresses 76 water quality impairments on 41 stream AUIDs and 30 lake AUIDs through the CRW (Figure 1). In the case of the stream impairments, many of the use support decisions drew heavily on biota data, which require further examination (herein referred to as stressor identification) to determine whether or not pollutants are causing the impairments (Table 1). Pollutant stressors are addressed via TMDLs. Non-pollutant stressors are not subject to load quantification and therefore do not require TMDLs. If a non-pollutant stressor is linked to a pollutant (e.g. habitat issues driven by TSS or low dissolved oxygen caused by excess phosphorus) a TMDL is required. However, in many cases habitat stressors are not linked to pollutants. With respect to the few identified dissolved oxygen stressors in the CRW, there are insufficient means for conclusively linking the condition to a pollutant cause. Note that all aquatic life use impairments – not just those with associated TMDLs - are addressed in the WRAPS report. For example, many streams that are stressed by degraded habitat do not require TMDLs but may still be a focus in future planning or restoration work in the CRW.

The following tables and Appendix A (which includes notes regarding aquatic life impairments for which TMDLs are not computed) summarize CRW impairments and those addressed by TMDLs in this document. Impairments were categorized as follows:

- 59 AUIDs do not support aquatic recreation use
- 15 AUIDs do not support aquatic life use
- 5 AUIDs do not support drinking water use

More information regarding assessments of streams, rivers and lakes (e.g. how many were assessed, percentages of each that are impaired) is available in the CRW Monitoring and Assessment Report (MPCA 2014c).

1.2.1 Previously Completed TMDLs

The presence of fecal pathogens in surface water is a regional problem in southeast Minnesota. The issue was well-described in a stakeholder driven process that culminated in approval of 39 approved fecal coliform TMDLs for streams and rivers in the region. The *Revised Regional Total Maximum Daily Load Evaluation of Fecal Coliform Bacteria Impairments in the Lower Mississippi River Basin in Minnesota*, approved in 2006, can be reviewed at the MPCA web site: http://www.pca.state.mn.us/index.php/view-document.html?gid=8006. Subsequent to TMDL approval, stakeholders completed an implementation plan: http://www.pca.state.mn.us/index.php/view-document.html?gid=8013. According to the findings and strategies summarized in these documents, numerous projects have been executed in efforts to reduce pathogen loading to the region's surface waters. Feedlot runoff, unsewered communities and over-grazed pastures (among others) have all been addressed via grant funding. The *E. coli* TMDLs in the CRW should be considered (for planning purposes) an addendum to the regional TMDL work.

The TSS TMDLs for two AUIDs near the mouth of the Cannon River were approved in 2007 (https://www.pca.state.mn.us/sites/default/files/wq-iw9-04e.pdf). An implementation planning effort was coordinated by the CRW Partnership and completed in 2009 (https://www.pca.state.mn.us/sites/default/files/wq-iw9-04c.pdf). There are no additional TSS TMDLs in the Lower Cannon Watershed Lobe; the new TSS TMDLs in upstream lobes comport with those in the approved Lower Cannon TMDLs document.

The Byllesby Reservoir Phosphorus TMDL was public noticed from May 13 to July 15, 2013. The MPCA received 10 comment letters, 1 of which included a request for a contested case hearing. Over the months following the public notice period, staff worked with the petitioners and responded to comments. The contested case hearing request was withdrawn in March 2015. Given the timing of watershed work in the CRW, it was determined that the Byllesby Reservoir phosphorus TMDL would become part of the greater watershed TMDL report and as such would not be forwarded individually to the EPA for consideration for final approval. Other public comment suggested the Byllesby TMDL would be improved by pairing the BATHTUB modeling with a watershed model that would allow more detailed examination of point sources and phosphorus transport to the reservoir; this was accomplished as described in subsequent chapters of this document.

The BATHTUB modeling and the process of selecting the years in which to simulate in-lake goal attainment for Byllesby (1950 and 2003) are carried forward from the draft TMDL to the present document. Accordingly, the loading capacity for Byllesby is unchanged. The derivation of the WLAs for Faribault, Northfield and Owatonna marks the substantive change from previous draft to current: it now reflects the best available modeling of point source delivery and in-stream phosphorus dynamics in the CRW. This process culminated in an iterative application of the Hydrologic Simulation Program Fortran (HSPF) model that “stepped down” from permitted phosphorus loads to those that correspond to Cannon River inflow goal attainment. An important improvement provided by the model was an examination of the loading to Byllesby over a 17-year model simulation period; the WLAs were set according to an equitable reduction scenario (both point and nonpoint source reductions) that indicates goal attainment at the 80th percentile low flow for the entire simulation period. The resultant WLAs are 40% lower for June through September than those included in the previous draft of the Byllesby Reservoir Phosphorus TMDL. The modeling and calculations are described in detail in subsequent text (4.2).

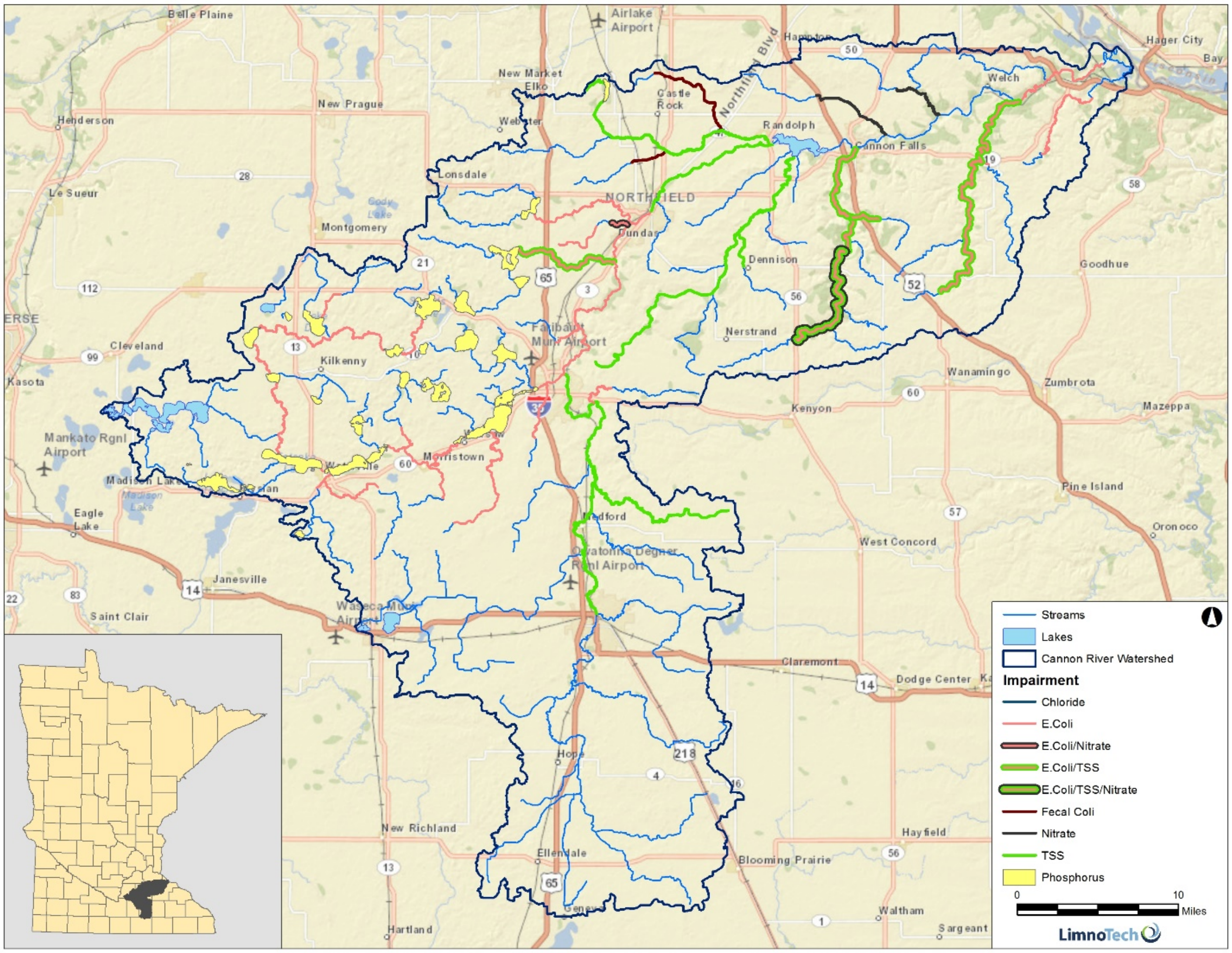


Figure 1. Map of the CRW and all impaired AUIDs that are addressed in this TMDL report.

The MPCA added these stream reaches to the state of Minnesota's 303(d) list of impaired waters between 2004 and 2014 (Table 2).

Table 1. List of 303(d) reaches in the Cannon River Watershed that are impaired for aquatic life use.

HUC-10 Watershed	Listed Waterbody Name	Location Description	Reach (AUID)	Basis for Aquatic Listing			Addressed in TMDL Report
				MIBI	FIBI	Turbidity	
Belle Creek	Belle Creek	Hwy 19 to Cannon River	07040002-734	Yes	Yes		Yes
Belle Creek	Belle Creek	Hwy 19 to Cannon River	07040002-735	Yes			Yes
Chub Creek	Chub Creek	Headwaters to Cannon River	07040002-528	Yes	Yes		Yes
Little Cannon River	Little Cannon River	T111 R17W S18, west line to Cannon River	07040002-526	Yes		Yes	Yes
Little Cannon River	Little Cannon River	T110 R18W S10, west line to T111 R18W S13, east line	07040002-589	Yes	Yes	Yes	Yes
Little Cannon River	Butler Creek	Unnamed Creek to Little Cannon River	07040002-590	Yes			Yes
Lower Cannon River	Cannon River	Byllesby Dam to Little Cannon R	07040002-539	YES			No
Lower Cannon River	Unnamed Creek (Trout Brook)	Unnamed Creek to Cannon River (trout stream portion)	07040002-567			Yes	No
Lower Cannon River	Unnamed creek (Trout Brook)	Unnamed cr to Unnamed cr	07040002-580	Yes			No
Middle Cannon River	Cannon River	Wolf Creek to Heath Creek	07040002-507	Yes		Yes	No
Middle Cannon River	Cannon River	Heath Creek to Northfield Dam	07040002-508			Yes	No
Middle Cannon River	Cannon River	Northfield Dam to Lake Byllesby	07040002-509	Yes	Yes		Yes
Middle Cannon River	Wolf Creek	Circle Lake to Cannon River	07040002-522			Yes	Yes
Middle Cannon River	Unnamed Ditch	T111 R22W S1, north line to Unnamed Creek	07040002-555	Yes	Yes		Yes
Middle Cannon River	Unnamed Creek (Spring Brook)	Unnamed Creek to Cannon River	07040002-557	Yes		Yes	No
Middle Cannon River	Spring Creek	T112 R15W S18, west line to T113 R15W S34, north line	07040002-569			Yes	No
Middle Cannon River	Spring Creek	T113 R15W S27, south line to Spring Creek Lk	07040002-571			Yes	No
Middle Cannon River	Cannon River	T110 R20W S19, NE 1/4 line to Wolf Creek	07040002-582	Yes			No
Middle Cannon River	Unnamed creek	Unnamed cr to Unnamed cr	07040002-587	Yes			No
Middle Cannon River	Spring Creek	Unnamed cr to Unnamed cr	07040002-591	Yes			No
Middle Cannon River	Unnamed creek	Unnamed cr to Prairie Cr	07040002-723	Yes			No
Prairie Creek	Prairie Creek	Headwaters to Lake Byllesby	07040002-504	Yes			Yes

HUC-10 Watershed	Listed Waterbody Name	Location Description	Reach (AUID)	Basis for Aquatic Listing			Addressed in TMDL Report
				MIBI	FIBI	Turbidity	
Prairie Creek	Unnamed Creek	Headwaters to Prairie Creek	07040002-512	Yes			Yes
Straight River	Straight River	Maple Creek to Crane Creek	07040002-503	Yes		Yes	Yes
Straight River	Rush Creek	Headwaters to Straight River	07040002-505			Yes	Yes
Straight River	Straight River	Rush Creek to Cannon River	07040002-515	Yes		Yes	Yes
Straight River	Straight River	Crane Creek to Rush Creek	07040002-536	Yes			Yes
Straight River	Medford Creek	Headwaters to Straight R	07040002-547	Yes	Yes		No
Straight River	Unnamed creek	Unnamed cr to Unnamed cr	07040002-731	Yes			No
Upper Cannon River	Cannon River	Headwaters to Cannon Lake	07040002-542	Yes			No
Upper Cannon River	Waterville Creek	Hands Marsh to Upper Sakatah Lake	07040002-560	Yes	Yes		No
Upper Cannon River	MacKenzie Creek	T108 R21W S7, west line to Cannon Lake	07040002-576	Yes			No
Upper Cannon River	Devils Creek	Unnamed Creek to Cannon River	07040002-577	Yes			No
Upper Cannon River	Unnamed creek	Unnamed cr to Cannon R	07040002-638	Yes			No
Upper Cannon River	Unnamed Creek	Unnamed Creek to Cannon River	07040002-705		Yes		No
Upper Cannon River	Whitewater Creek	Unnamed Creek to Waterville Creek	07040002-706	Yes			No

Table 2. List of 303(d) impaired lakes and stream reaches in the CRW grouped by HUC-10 watershed and their pollutant listing.

HUC-10 Watershed	Listed Waterbody Name	Location Description	Reach (AUID)	Impaired Use	Pollutant(s)	Listing Year	Target Start & Completion Dates
Belle Creek	Unnamed Creek	Unnamed Creek to Belle Creek	07040002-699	Aquatic Recreation	Escherichia coli	2014	2011 - 2016
Belle Creek	Belle Creek	Hwy 19 to Cannon River	07040002-734	Aquatic Recreation	Escherichia coli	2010	2011 - 2016
				Aquatic Life	TSS	2006	2011 - 2016
Belle Creek	Belle Creek	Hwy 19 to Cannon River	07040002-735	Aquatic Recreation	Escherichia coli	2010	2011 - 2016
				Aquatic Life	TSS	2006	2011 - 2016
Chub Creek	Chub Lake		19-0020-00	Aquatic Recreation	Phosphorus	2002	2011 - 2016
Chub Creek	Chub Creek	Headwaters to Cannon River	07040002-528	Aquatic Life	TSS	2014	2011 - 2016
Chub Creek	Mud Creek	Unnamed Creek to Chub Creek	07040002-558	Aquatic Recreation	Fecal Coliform	2006	2011 - 2016
Chub Creek	Chub Creek	T113 R19W S19, west line to Chub Creek	07040002-566	Aquatic Recreation	Fecal Coliform	2006	2011 - 2016
Crane Creek	Clear Lake		81-0014-01	Aquatic Recreation	Phosphorus	2004	2011 – 2016

HUC-10 Watershed	Listed Waterbody Name	Location Description	Reach (AUID)	Impaired Use	Pollutant(s)	Listing Year	Target Start & Completion Dates
Crane Creek	Loon Lake		81-0015-00	Aquatic Recreation	Phosphorus	2010	2011 - 2016
Little Cannon River	Little Cannon River	T111 R17W S18, west line to Cannon River	07040002-526	Aquatic Recreation	Escherichia coli	2010	2011 - 2016
				Aquatic Life	TSS	2006	2011 - 2016
Little Cannon River	Little Cannon River	T110 R18W S10, west line to T111 R18W S13, east line	07040002-589	Aquatic Recreation	Escherichia coli	2010	2011 - 2016
				Drinking Water	Nitrate	2010	2011 - 2016
				Aquatic Life	TSS	2006	2011 - 2016
Little Cannon River	Butler Creek	Unnamed Creek to Little Cannon River	07040002-590	Aquatic Recreation	Escherichia coli	2010	2011 - 2016
				Aquatic Life	TSS	2010	2011 - 2016
Lower Cannon River	Cannon River	Belle Creek to split near mouth	07040002-501	Aquatic Recreation	Escherichia coli	2010	2011 - 2016
Lower Cannon River	Pine Creek	T113 R18W S26, west line to Cannon River	07040002-520	Drinking Water	Nitrate	2010	2011 - 2016
Lower Cannon River	Unnamed Creek (Trout Brook)	Unnamed Creek to Cannon River (trout stream portion)	07040002-567	Drinking Water	Nitrate	2010	2011 - 2016
Lower Cannon River	Spring Creek	T112 R15W S18, west line to T113 R15W S34, north line	07040002-569	Aquatic Recreation	Escherichia coli	2014	2011 - 2016
Lower Cannon River	Unnamed Creek (Trout Brook)	T113 R17W S27, west line to Unnamed Creek	07040002-573	Drinking Water	Nitrate		2011 - 2016
Middle Cannon River	Byllesby Lake		19-0006-00	Aquatic Recreation	Phosphorus	2002	2002 - 2016
Middle Cannon River	Circle Lake		66-0027-00	Aquatic Recreation	Phosphorus	2006	2011 - 2016
Middle Cannon River	Fox Lake		66-0029-00	Aquatic Recreation	Phosphorus	2010	2011 - 2016
Middle Cannon River	Union Lake		66-0032-00	Aquatic Recreation	Phosphorus	2006	2011 - 2016
Middle Cannon River	Mazaska Lake		66-0039-00	Aquatic Recreation	Phosphorus	2006	1998 - 2025
Middle Cannon River	Cannon River	Wolf Creek to Heath Creek	07040002-507	Aquatic Recreation	Escherichia coli	2010	2011 - 2016
Middle Cannon River	Cannon River	Heath Creek to Northfield Dam	07040002-508	Aquatic Recreation	Escherichia coli	2010	2011 - 2016
Middle Cannon River	Cannon River	Northfield Dam to Lake Byllesby	07040002-509	Aquatic Life	TSS	2004	2011 - 2016
Middle Cannon River	Heath Creek	Union Lake to Cannon River	07040002-521	Aquatic Recreation	Escherichia coli	2010	2011 - 2016
Middle Cannon River	Wolf Creek	Circle Lake to Cannon River	07040002-522	Aquatic Recreation	Escherichia coli	2014	2011 - 2016
				Aquatic Life	TSS	2006	2011 - 2016
Middle Cannon River	Unnamed Ditch	T111 R22W S1, north line to Unnamed Creek	07040002-555	Aquatic Life	Chloride		2011 - 2016
Middle Cannon River		Unnamed Creek to Cannon River	07040002-557	Aquatic Recreation	Escherichia coli	2010	2011 - 2016

HUC-10 Watershed	Listed Waterbody Name	Location Description	Reach (AUID)	Impaired Use	Pollutant(s)	Listing Year	Target Start & Completion Dates
	Unnamed Creek (Spring Brook)			Drinking Water	Nitrate	2010	2011 - 2016
Middle Cannon River	Unnamed Creek (Spring Brook)	Headwaters to T111 R20W S9, north line	07040002-562	Aquatic Recreation	Escherichia coli	2010	2011 - 2016
Middle Cannon River	Cannon River	Straight River to T110 R20W S19, east line	07040002-581	Aquatic Recreation	Escherichia coli	2010	2011 - 2016
Middle Cannon River	Cannon River	T110 R20W S19, NE 1/4 line to Wolf Creek	07040002-582	Aquatic Recreation	Escherichia coli	2010	2011 - 2016
Middle Cannon River	Unnamed Creek	Unnamed Creek to Cannon River	07040002-703	Aquatic Recreation	Escherichia coli	2014	2011 - 2016
Prairie Creek	Prairie Creek	Headwaters to Lake Byllesby	07040002-504	Aquatic Life	TSS	2004	2011 - 2016
Prairie Creek	Unnamed Creek	Headwaters to Prairie Creek	07040002-512	Aquatic Life	TSS	2006	2011 - 2016
Straight River	Straight River	Maple Creek to Crane Creek	07040002-503	Aquatic Life	TSS	2004	2009 - 2016
Straight River	Rush Creek	Headwaters to Straight River	07040002-505	Aquatic Life	TSS	2006	2009 - 2016
Straight River	Straight River	Rush Creek to Cannon River	07040002-515	Aquatic Life	TSS	2004	2009 - 2016
Straight River	Straight River	Crane Creek to Rush Creek	07040002-536	Aquatic Life	TSS	2008	2009 - 2016
Straight River	Falls Creek	Unnamed Creek to Straight River	07040002-704	Aquatic Recreation	Escherichia coli	2014	2011 - 2016
Upper Cannon River	Horseshoe Lake		40-0001-00	Aquatic Recreation	Phosphorus	2010	2011 - 2016
Upper Cannon River	Upper Sakatah Lake		40-0002-00	Aquatic Recreation	Phosphorus	2006	2011 - 2016
Upper Cannon River	Sunfish Lake		40-0009-00	Aquatic Recreation	Phosphorus	2010	2011 - 2016
Upper Cannon River	Dora Lake		40-0010-00	Aquatic Recreation	Phosphorus	2010	2011 - 2016
Upper Cannon River	Mabel Lake		40-0011-00	Aquatic Recreation	Phosphorus	2010	2011 - 2016
Upper Cannon River	Sabre Lake		40-0014-00	Aquatic Recreation	Phosphorus	2010	2012 - 2025
Upper Cannon River	Tetonka Lake		40-0031-00	Aquatic Recreation	Phosphorus	2006	2011 - 2016
Upper Cannon River	Gorman Lake		40-0032-00	Aquatic Recreation	Phosphorus	2010	2011 - 2016
Upper Cannon River	Silver Lake		40-0048-00	Aquatic Recreation	Phosphorus	2014	2011 - 2016
Upper Cannon River	Frances Lake		40-0057-00	Aquatic Recreation	Phosphorus	2008	2011 - 2016
Upper Cannon River	Tustin Lake		40-0061-00	Aquatic Recreation	Phosphorus	2010	2011 - 2016
Upper Cannon River	Cannon Lake		66-0008-00	Aquatic Recreation	Phosphorus	2006	2011 - 2016
Upper Cannon River	Wells Lake		66-0010-00	Aquatic Recreation	Phosphorus	2010	2011 - 2016
Upper Cannon River	Roberds Lake		66-0018-00	Aquatic Recreation	Phosphorus	2006	2011 - 2016

HUC-10 Watershed	Listed Waterbody Name	Location Description	Reach (AUID)	Impaired Use	Pollutant(s)	Listing Year	Target Start & Completion Dates
Upper Cannon River	French Lake		66-0038-00	Aquatic Recreation	Phosphorus	2010	2011 - 2016
Upper Cannon River	Lower Sakatah Lake		66-0044-00	Aquatic Recreation	Phosphorus	2010	2011 - 2016
Upper Cannon River	Hunt Lake		66-0047-00	Aquatic Recreation	Phosphorus	2010	2011 - 2016
Upper Cannon River	Rice Lake		66-0048-00	Aquatic Recreation	Phosphorus	2010	2011 - 2016
Upper Cannon River	Caron Lake		66-0050-00	Aquatic Recreation	Phosphorus	2010	2011 - 2016
Upper Cannon River	Cedar Lake		66-0052-00	Aquatic Recreation	Phosphorus	2010	2011 - 2016
Upper Cannon River	Shields Lake		66-0055-00	Aquatic Recreation	Phosphorus	2010	2011 - 2016
Upper Cannon River	Toner's Lake		81-0058-00	Aquatic Recreation	Phosphorus	2014	2011 - 2016
Upper Cannon River	Cannon River	Cannon Lake to Straight River	07040002-540	Aquatic Recreation	Phosphorus	2010	2011 - 2016
Upper Cannon River	Cannon River	Headwaters to Cannon Lake	07040002-542	Aquatic Recreation	Escherichia coli	2014	2011 - 2016
Upper Cannon River	Waterville Creek	Hands Marsh to Upper Sakatah Lake	07040002-560	Aquatic Recreation	Escherichia coli	2010	2011 - 2016
Upper Cannon River	MacKenzie Creek	T108 R21W S7, west line to Cannon Lake	07040002-576	Aquatic Recreation	Escherichia coli	2014	2011 - 2016
Upper Cannon River	Devils Creek	Unnamed Creek to Cannon River	07040002-577	Aquatic Recreation	Escherichia coli	2014	2011 - 2016
Upper Cannon River	County Ditch 63	Unnamed Creek to Lake Dora	07040002-621	Aquatic Recreation	Escherichia coli	2014	2011 - 2016
Upper Cannon River	Unnamed Creek	Unnamed Creek to Cannon River	07040002-702	Aquatic Recreation	Escherichia coli	2010	2011 - 2016
Upper Cannon River	Unnamed Creek	Unnamed Creek to Cannon River	07040002-705	Aquatic Recreation	Escherichia coli	2014	2011 - 2016
Upper Cannon River	Whitewater Creek	Unnamed Creek to Waterville Creek	07040002-706	Aquatic Recreation	Escherichia coli	2010	2011 - 2016

*Note that for some of the aquatic life use impairments the pollutant listed was identified via SID and thus the 303(d) list notes macroinvertebrate and/or fisheries bioassessment as the listing type.

1.2 Priority Ranking

The MPCA’s projected schedule for TMDL completions, as indicated on the 303(d) impaired waters list, implicitly reflects Minnesota’s priority ranking of this TMDL. Ranking criteria for scheduling TMDL projects include, but are not limited to: impairment impacts on public health and aquatic life; public value of the impaired water resource; likelihood of completing the TMDL in an expedient manner, including a strong base of existing data and restorability of the waterbody; technical capability and willingness locally to assist with the TMDL; and appropriate sequencing of TMDLs within a watershed or basin.

1.3 Summary of the Impairments and Pollutant Stressors

The following section describes the lake and stream impairments and the pollutant stressors that are addressed by the 79 TMDLs in this study (Table 3). A total of 29 bacteria, 1 chloride, 5 nitrate, 14 TSS, and 30 phosphorus TMDLs were completed.

Table 3. Pollutants addressed in this TMDL report by AUID and use class.

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	Designated Use Class	Bacteria	Chloride	Nitrate	Phosphorus	TSS
Belle Creek	Unnamed Creek	07040002-699	2B, 3C	✓				
Belle Creek	Belle Creek	07040002-734	2B, 3C	✓				✓
Belle Creek	Belle Creek	07040002-735	2B, 3C	✓				✓
Chub Creek	Chub Lake	19-0020-00	2B, 3C				✓	
Chub Creek	Chub Creek	07040002-528	2B, 3C					✓
Chub Creek	Mud Creek	07040002-558	2B, 3C	✓				
Chub Creek	Chub Creek	07040002-566	2C	✓				
Crane Creek	Clear Lake	81-0014-01	2B, 3C				✓	
Crane Creek	Loon Lake	81-0015-00	2B, 3C				✓	
Little Cannon River	Little Cannon River	07040002-526	2B, 3C	✓				✓
Little Cannon River	Little Cannon River	07040002-589	1B, 2A, 3B	✓		✓		✓
Little Cannon River	Butler Creek	07040002-590	2B, 3C	✓				✓
Lower Cannon River	Cannon River	07040002-501	2B, 3C	✓				
Lower Cannon River	Pine Creek	07040002-520	1B, 2A, 3B			✓		
Lower Cannon River	Unnamed Creek (Trout Brook)	07040002-567	1B, 2A, 3B			✓		
Lower Cannon River	Spring Creek	07040002-569	1B, 2A, 3B	✓				
Lower Cannon River	Unnamed Creek (Trout Brook)	07040002-573	1B, 2A, 3B			✓		
Middle Cannon River	Byllesby Lake	19-0006-00	2B, 3C				✓	
Middle Cannon River	Circle Lake	66-0027-00	2B, 3C				✓	

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	Designated Use Class	Bacteria	Chloride	Nitrate	Phosphorus	TSS
Middle Cannon River	Fox Lake	66-0029-00	2B, 3C				✓	
Middle Cannon River	Union Lake	66-0032-00	2B, 3C				✓	
Middle Cannon River	Mazaska Lake	66-0039-00	2B, 3C				✓	
Middle Cannon River	Cannon River	07040002-507	2B, 3C	✓				
Middle Cannon River	Cannon River	07040002-508	2B, 3C	✓				
Middle Cannon River	Cannon River	07040002-509	2B, 3C					✓
Middle Cannon River	Heath Creek	07040002-521	2B, 3C	✓				
Middle Cannon River	Wolf Creek	07040002-522	2B, 3C	✓				✓
Middle Cannon River	Unnamed Ditch	07040002-555	2B, 3C		✓			
Middle Cannon River	Unnamed Creek (Spring Brook)	07040002-557	1B, 2A, 3B	✓		✓		
Middle Cannon River	Unnamed Creek (Spring Brook)	07040002-562	2B, 3C	✓				
Middle Cannon River	Cannon River	07040002-581	2B, 3C	✓				
Middle Cannon River	Cannon River	07040002-582	2B, 3C	✓				
Middle Cannon River	Unnamed Creek	07040002-703	2B, 3C	✓				
Prairie Creek	Prairie Creek	07040002-504	2C					✓
Prairie Creek	Unnamed Creek	07040002-512	2B, 3C					✓
Straight River	Straight River	07040002-503	2B, 3C					✓
Straight River	Rush Creek	07040002-505	2B, 3C					✓
Straight River	Straight River	07040002-515	2B, 3C					✓
Straight River	Straight River	07040002-536	2B, 3C					✓
Straight River	Falls Creek	07040002-704	2B, 3C	✓				
Upper Cannon River	Horseshoe Lake	40-0001-00	2B, 3C				✓	
Upper Cannon River	Upper Sakatah Lake	40-0002-00	2B, 3C				✓	
Upper Cannon River	Sunfish Lake	40-0009-00	2B, 3C				✓	
Upper Cannon River	Dora Lake	40-0010-00	2B, 3C				✓	
Upper Cannon River	Mabel Lake	40-0011-00	2B, 3C				✓	
Upper Cannon River	Sabre Lake	40-0014-00	2B, 3C				✓	
Upper Cannon River	Tetonka Lake	40-0031-00	2B, 3C				✓	
Upper Cannon River	Gorman Lake	40-0032-00	2B, 3C				✓	
Upper Cannon River	Silver Lake	40-0048-00	2B, 3C				✓	

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	Designated Use Class	Bacteria	Chloride	Nitrate	Phosphorus	TSS
Upper Cannon River	Frances Lake	40-0057-00	2B, 3C				✓	
Upper Cannon River	Tustin Lake	40-0061-00	2B, 3C				✓	
Upper Cannon River	Cannon Lake	66-0008-00	2B, 3C				✓	
Upper Cannon River	Wells Lake	66-0010-00	2B, 3C				✓	
Upper Cannon River	Roberds Lake	66-0018-00	2B, 3C				✓	
Upper Cannon River	French Lake	66-0038-00	2B, 3C				✓	
Upper Cannon River	Lower Sakatah Lake	66-0044-00	2B, 3C				✓	
Upper Cannon River	Hunt Lake	66-0047-00	2B, 3C				✓	
Upper Cannon River	Rice Lake	66-0048-00	2B, 3C				✓	
Upper Cannon River	Caron Lake	66-0050-00	2B, 3C				✓	
Upper Cannon River	Cedar Lake	66-0052-00	2B, 3C				✓	
Upper Cannon River	Shields Lake	66-0055-00	2B, 3C				✓	
Upper Cannon River	Toner's Lake	81-0058-00	2B, 3C				✓	
Upper Cannon River	Cannon River	07040002-540	2B, 3C	✓				
Upper Cannon River	Cannon River	07040002-542	2B, 3C	✓				
Upper Cannon River	Waterville Creek	07040002-560	2B, 3C	✓				
Upper Cannon River	MacKenzie Creek	07040002-576	2C	✓				
Upper Cannon River	Devils Creek	07040002-577	2B, 3C	✓				
Upper Cannon River	County Ditch 63	07040002-621	2B, 3C	✓				
Upper Cannon River	Unnamed Creek	07040002-702	2B, 3C	✓				
Upper Cannon River	Unnamed Creek	07040002-705	2B, 3C	✓				
Upper Cannon River	Whitewater Creek	07040002-706	2B, 3C	✓				

2. Applicable Water Quality Standards and Numeric Water Quality Targets

2.1 State of Minnesota Designated Uses

Each stream reach has a Designated Use Classification defined by Minn. R. 7050.1040, which sets the optimal purpose for that waterbody. The streams addressed by this TMDL fall into one of the following two designated use classifications:

> 1B, 2A, 3C – drinking water use after approved disinfectant; a healthy cold water aquatic community; industrial cooling and materials transport without a high level of treatment
>
> 2B, 3C – a healthy warm water aquatic community; industrial cooling and materials transport without a high level of treatment
>
> 2C – a healthy indigenous fish community

Class 1 waters are protected for domestic consumption, Class 2 waters are protected for aquatic life, aquatic consumption and aquatic recreation, and Class 3 waters are protected for industrial consumption as defined by Minn. R. 7050.0140. The most protective of these classes is 1B. These water bodies are currently assessed by the MPCA for the beneficial use of domestic consumption for the EPA's Safe Drinking Water Act (SDWA) nitrate primary standards. In the CRW, all class 1B waters are also class 2A waters.

The Minnesota narrative water quality standard for all Class 2 waters (Minn. R. 7050.0150, subp. 3) states that "the aquatic habitat, which includes the waters of the state and stream bed, shall not be degraded in any material manner, there shall be no material increase in undesirable slime growths or aquatic plants, including algae, nor shall there be any significant increase in harmful pesticide or other residues in the waters, sediments, and aquatic flora and fauna; the normal fishery and lower aquatic biota upon which it is dependent and the use thereof shall not be seriously impaired or endangered, the species composition shall not be altered materially, and the propagation or migration of the fish and other biota normally present shall not be prevented or hindered by the discharge of any sewage, industrial waste, or other wastes to the waters".

The impaired waters addressed in this TMDL are both Class 2B waters for which aquatic life and recreation are the protected beneficial uses and Class 1B/2A for which aquatic life, aquatic recreation and drinking water are the protected beneficial uses.

2.2 State of Minnesota Standards and Criteria for Listing

The state of Minnesota regulated water quality standards for the lake and stream impairments addressed in this TMDL are summarized in Table 4 and Table 5, respectively.

Table 4. Lake Eutrophication Standards in the North Central Hardwood Forest ecoregion.

Ecoregion	TP (µg/L)	Chlorophyll a (µg/L)	Secchi (m)
North Central Hardwood Forests: Shallow Lakes	60	20	not < 1
North Central Hardwood Forests: Deep Lakes	40	14	not < 1.4
Western Cornbelt Plains: Shallow Lakes	90	30	not < 0.7
Western Cornbelt Plains: Deep Lakes	65	22	not < 0.9

Table 5. Water quality standards applicable to impaired streams in the CRW.

Pollutant	Water Quality Standard	Notes
E. coli	126 org/100 mL	
Fecal coliform	200 org/100 mL	Equivalent to *E. coli* standard
Chloride	230 mg/L	
Nitrate nitrogen	10 mg/L	National drinking water standard
Turbidity & TSS	10 mg/L	Southern MN region - for coldwater streams
	65 mg/L	Southern MN region - for warmwater streams

2.2.1 Lake Eutrophication

The lake eutrophication impairments in the CRW were characterized by phosphorus and Chl-*a* concentrations that exceed state water quality standards and Secchi transparency depths below the state water quality standards. Excessive nutrient loads, in particular TP, lead to an increase in algae blooms and reduced transparency – both of which may significantly impair or prohibit the use of lakes for aquatic recreation.

TP is often the limiting factor controlling primary production in freshwater lakes: as in-lake phosphorus concentrations increase, algal growth increases resulting in higher Chl-*a* concentrations and lower water transparency. In addition to meeting phosphorus limits, Chl-*a* and Secchi transparency depth standards must also be met. 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 (Heiskary and Wilson 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 standards will likewise be met.

The impaired lakes within the CRW were assessed against the North Central Hardwood Forests (NCHF) and Western Cornbelt Plains (WCBP) Ecoregion water quality standards (see Figure 2). A separate water quality standard was developed for shallow lakes which tend to have poorer water quality than deeper lakes in this ecoregion. According to the MPCA definition of shallow lakes, a lake is considered shallow if its maximum depth is less than 15 feet, or if the littoral zone (area where depth is less than 15 feet) covers at least 80% of the lake's surface area.

To be listed as impaired (Minn. R. 7050.0150, subp. 5), the summer growing season (June through September) monitoring data must show that the standards for both TP (the causal factor) and either Chl-*a* or Secchi transparency (the response variables) were violated. If a lake is impaired with respect to only one of these criteria, it may be placed on a review list; a weight of evidence approach is then used to determine if it will be listed as impaired. For more details regarding the listing process, see the

Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 303(b) Report and 303(d) List (MPCA 2012).

2.2.1.1 Byllesby Reservoir Site Specific Criteria Development

The technical basis for Minnesota's lake nutrient criteria is found in a series of previously-published Minnesota Lake Water Quality Assessment reports. These reports provide the context for the nutrient, or eutrophic, criteria adopted by the Byllesby Reservoir TMDL Technical Committee for computation of load and WLAs. The WCBPs shallow lakes criteria serve as the primary basis for the Byllesby Reservoir site-specific criteria, and represent a significant reduction in TP and Chl-*a* as compared to data from recent monitoring efforts. Achieving these values should result in a measurable and perceptible reduction in the frequency and severity of nuisance algae blooms. Recommended water quality goals include the causal factor, TP, and two response criteria, Chl-*a* and Secchi disk depth measurements as follows:

- TP < 90 ppb as a summer-mean as measured in the combined transitional and near-dam segments. This value is equivalent to the criteria for shallow WCBP lakes. To achieve this in-lake concentration, Cannon River inflow on the order of 150 ppb may be required (see Appendix B). Relative to minimally impacted streams in the NCHF ecoregion this corresponds to about the 75th percentile and for WCBP streams this is below the 25th percentile.
- Viable Chl-*a* < 30 ppb as a summer-mean as measured in these two segments. This should keep maximum Chl-*a* below 60 ppb and reduce frequency of 30 ppb (severe nuisance blooms) from about 55-60% of the summer to about 30% of the summer. This value is also equivalent to the Chl-*a* criterion for shallow WCBP lakes.
- Secchi as a summer-mean of 0.8 m or greater as measured in these two segments. This value is close to the long-term mean for the lake and is intermediate between the criteria values for shallow and deep WCBP lakes (0.7 and 0.9 respectively). It also corresponds with the proposed TP and Chl-*a* criteria based on the MPCA regression equations.

These site specific water quality criteria were public noticed from May 26 to June 26, 2009, and approved by the EPA in August 2011. They should be attained in a range of flows from ~180 cfs (summer 122 day, 1 in 10-year recurrence, 10th percentile flow) up to ~940 cfs (~80th percentile). This range of flows corresponds to a residence time of about 8 to 10 days, which is generally associated with lake-like conditions.

In addition, to assess compliance with the TMDL, water quality must be monitored at consistent sites within each of the three segments. Data from the transitional and near dam segments will be area-weighted and the subsequent values will be used in follow-up assessments. There appears to be minimal difference in the trophic indicators between the transitional and near-dam segments, and intra-segment residence time is quite short. These two segments are the primary focus of recreational activities in the reservoir, so it would be reasonable to combine them for purposes of establishing site-specific criteria and evaluating compliance with the TMDL.

See Appendix C for details regarding site specific criteria development and approval.

Figure 2. CRW Ecoregions

2.2.2 Biotic Integrity

Minnesota's standard for biotic integrity is set forth in Minn. R. 7050.0150 (3) and (6). The standard uses an Index of Biotic Integrity (IBI), which evaluates and integrates multiple attributes of the aquatic community, or "metrics," to evaluate a complex biological system. Each metric is based upon a structural (e.g. species composition) or functional (e.g. feeding habits) aspect of the aquatic community that changes in a predictable way in response to human disturbance. Fish and macroinvertebrate IBIs are expressed as a score that ranges from 0-100, with 100 being the best score possible. The MPCA has evaluated fish and macroinvertebrate communities at numerous reference sites across Minnesota that have been minimally impacted by human activity, and has established IBI impairment thresholds based on stream drainage area, ecoregion, and major basin. A stream's biota is considered to be impaired when the IBI falls below the threshold established for that category of stream. The MPCA has two documents that further describe the development of fish and macroinvertebrate IBIs (MPCA 2014a and MPCA 2014b).

2.2.3 Bacteria (*Escherichia coli* (*E. coli*) and Fecal coliform)

E. coli

With the revisions of Minnesota's water quality rules in 2008, the State changed to an *E. coli* standard because it is a superior potential illness indicator and costs for lab analysis are less (CRWP and MPCA 2007). The revised standards now state:

> "*E. coli* concentrations are not to exceed **126** colony forming units per 100 milliliters (cfu/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** cfu/100 ml. The standard applies only between April 1 and October 31."

Fecal coliform

The fecal coliform standard contained in Minn. R. 7050.0222, subp. 5, states that fecal coliform concentrations shall "not exceed 200 organisms per 100 milliliters as a geometric mean of not less than five samples in any calendar month, nor shall more than 10% of all samples taken during any calendar month individually exceed 2000 organisms per 100 milliliters. The standard applies only between April 1 and October 31." Impairment assessment is based on the procedures contained in the Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment (MPCA 2012).

The *E. coli* concentration standard of 126 cfu/100 ml was considered reasonably equivalent to the fecal coliform standard of 200 cfu/100 ml from a public health protection standpoint. The SONAR (Statement of Need and Reasonableness) section that supports this rationale uses a log plot to show the relationship between these two parameters. The relationship has an R2 value of 0.69. The following regression equation was deemed reasonable to convert fecal coliform data to *E. coli* equivalents:

$$\textit{E. coli}\text{ concentration (equivalents)} = 1.80 \times (\text{Fecal Coliform Concentration})^{0.81}$$

Although surface water quality standards are now based on *E. coli*, wastewater treatment facilities (WWTF) are permitted based on fecal coliform concentrations.

2.2.4 Chloride

The chronic standard for chloride to protect for 2B uses is 230 mg/L. The chronic standard is defined in Minn. R. 7050.0218, subp. 3(L), as “the highest water concentration of a toxicant to which organisms can be exposed indefinitely without causing chronic toxicity.” The 230 mg/L value is based on a 4-day exposure of aquatic organisms to chloride. The maximum standard to protect for 2B uses is 860 mg/L. The maximum standard is defined in Minn. R. 7050.0218, subp. 3(T), as “the highest concentration of a toxicant in water to which organisms can be exposed for a brief time with zero to slight mortality.” The 860 mg/L value is based on a 24-hour exposure of aquatic organisms to chloride. These criteria are adopted from the EPA's recommended water quality criteria for chloride.

The MPCA’s approach to determining whether or not a stream, lake or wetland is impaired by chloride is outlined in the MPCA document Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 305(b) Report and 303(d) List (2014). Two or more exceedances of the chronic criterion within a 3-year period are considered an impairment. One exceedance of the acute criterion is considered an impairment. This TMDL has been developed with the goal of eliminating these exceedances. The chronic standard of 230 mg/L has been applied as the numeric water quality target for the chloride TMDLs for all impaired stream segments.

2.2.5 Nitrate nitrogen (nitrate-N)

The nitrogen (N) forms of primary concern for human health are nitrite and nitrate. The EPA established the SDWA standard, known as a maximum contaminant level (MCL), for nitrate in drinking water of **10 mg/l nitrate-N** (equivalent to 45 mg/l as nitrate) in 1975. The EPA adopted a nitrite MCL of 1 mg/L nitrite-N in 1991. MCLs are regulatory drinking water standards required to be met in finished drinking water provided by designated public drinking water facilities. Both standards were promulgated to protect infants against methemoglobinemia, based on the early case studies in the United States, including Minnesota, which found no cases of methemoglobinemia when drinking water nitrate-N levels were less than 10 mg/L. The nitrite MCL is lower than nitrate, because nitrite is the N form of greatest toxicity, and nitrate risk to infants is based on the level of internal conversion to nitrite. Because the impacts of methemoglobinemia can occur as quickly as a day or two of exposure, the MCLs are applied as acute standards, not to be exceeded on average in a 48-hour timeframe.

The MPCA incorporated the EPA MCLs as standards by reference in the State’s Water Quality Standards (Minn. R. ch. 7050.0221). The nitrate and nitrite MCLs are applied as Class 1 Domestic Consumption standards. Class 1 waters are protected as a source of drinking water. In Minnesota, all groundwater (GW) and selected surface waters are designated Class 1. The assessment of GW (Class 1A) for potential impairment of the drinking water use is outside the scope of this Guidance. The Minnesota Department of Health (MDH) monitors municipal finished water supplies for compliance with drinking water standards. The following applies to assessment of Class 1B and 1C listed surface waters for potential impairment by nitrate nitrogen.

Southeast Minnesota is particularly affected by nitrate contamination of its drinking water because of the prevailing karst geology and the region's rural character, including plentiful agriculture. Nitrate concentrations are higher during baseflow and diluted during precipitation in the coldwater streams in the watershed. Enhanced surface water - ground water interaction is a defining characteristic of karst that often contributes to drinking water quality problems. In recognition of the trend of increasing nitrate concentrations in Minnesota streams and the public health and economic impact arising from elevated nitrate concentrations in drinking water (a particular concern in Southeast Minnesota's karst region), the MPCA assesses Class 1B and 1C designated surface waters for potential impairment by nitrate nitrogen (MPCA 2008).

Data requirements and determination of impaired condition:

When assessing drinking water-protected surface waters Class 1B and 1C, the MPCA compares 24-hour average nitrate concentrations to the 10 mg/L standard. Two 24-hour averages exceeding 10 mg/L within a three-year period indicates impairment.

Single measurements of nitrate concentrations under relatively stable conditions are generally considered to be sufficiently representative of 24-hour average concentrations for the purpose of assessments. When concentrations are more variable, multiple samples or time-weighted composite samples may be necessary in order to calculate a sufficiently accurate average concentration. The necessary number and type of samples can vary considerably from one situation to another and the determination of adequacy for the purpose of assessment will necessarily involve considerable professional judgment (MPCA 2012).

2.2.6 Turbidity and TSS

Turbidity is a measure of reduced transparency that can increase due to suspended particles such as sediment, algae, and organic matter. The Minnesota turbidity standard is 10 Nephelometric Turbidity Units (NTU) for class 2A waters and 25 NTU for class 2B waters. The state of Minnesota, in 2014, amended state water quality standards and replaced stream water quality standards for turbidity with standards for TSS. One component of the rationale for this change is that that turbidity unit (NTUs) is not concentration-based and therefore not well-suited to load-based studies (Markus 2011).

The new TSS criteria are stratified by geographic region and stream class due to differences in natural background conditions resulting from the varied geology of the state and biological sensitivity. The assessment period for these samples is April through September; any TSS data collected outside of this period was not considered for assessment purposes. The TSS standard for all class 2A streams is 10 mg/L, and the TSS standard for class 2B streams in the South River Nutrient Region is 65 mg/L. For assessment, this concentration is not to be exceeded in more than 10% of samples within a 10-year period. The TSS results are available for the watershed from state-certified laboratories, and the existing data covers a large spatial and temporal scale in the watershed. The TSS LDCs and TMDLs were developed for all stream turbidity impairments (Heiskary et al. 2013).

3. Watershed and Waterbody Characterization

3.1 Cannon River Watershed Description

The CRW drains 946,440 acres (1460 mi^2) in southeastern Minnesota and consists of two river systems: the Cannon River and the Straight River. From west to east, the Cannon River travels 112 miles between Shields Lake and the Mississippi River north of Redwing. From south to north, the Straight River flows 56 miles through the cities of Owatonna and Medford before connecting with the Cannon River downstream of the dam in Faribault.

The CRW spans a portion of nine counties. The six counties with the largest land area in the watershed include Steele, Rice, Goodhue, Dakota, LeSueur, and Waseca while small portions of Scott, Blue Earth, and Freeborn dot the periphery of the watershed.

The waters of the watershed provide drinking water for households and industry, habitat for aquatic life, riparian corridors for wildlife, and many recreational opportunities. The Cannon River is designated as a Wild and Scenic River starting downstream of its confluence with the Straight River in Faribault. Both the Cannon and Straight River are managed by the Minnesota Department of Natural Resources (DNR) as state water courses that are navigable by canoe and kayak. These rivers pass through scenic landscapes of variable terrain, from the flat wooded floodplains along the Straight River to sandstone, limestone, and dolomite blufflands in the Driftless Area in the lower reaches of the Cannon River. The watershed has numerous lakes that are managed for game fish recreation and a number of trout streams with Brook, Brown, and Rainbow trout that bring local and many Twin Cities residents to the area for fly fishing. Other natural areas for recreational enjoyment include state parks such as Nerstrand Big Woods and Sakata Lake, scenic and natural areas, county parks, and bike trails which provide opportunities for fishing, hiking, cross-country skiing, biking, snowmobiling, birdwatching, geocaching, morel hunting, and viewing of rare and endemic plants such as the Minnesota Dwarf Trout-Lilly (*Erythronium popullans*) and Prairie Bush- Clover (*Lespedeza leptostachya*), among others.

The CRW is comprised of three Level III ecoregions: NCH, WCBP and Driftless Area (Omernik and Gallant 1988). The ecosystem framework attempts to characterize broad regional differences in geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology (Omernik 1995) and consequent ecosystem responses to disturbance (Bryce et al. 1999) in order to assist agencies and organizations in design and implementation of effective management strategies (Omernik et al. 2000).

The Level III ecoregions were recently further subdivided into Level IV ecoregions (EPA 2007). In the northwest corner of the watershed lies the southern extent of the NCH and includes the Big Woods (51i). This region was once hardwood forests covering rolling plains dotted with lakes. Today the hardwood forests have largely been removed and the region is dominated by row-crop agriculture and residential development. The northern lobe of the WCBP runs through the south and central regions of the watershed, which includes the headwaters of the Straight River and central portion of the Cannon River. The portion along the Straight River lies within the eastern Iowa and Minnesota Drift Plains (47c), which is described as an “older glacial till plain with mostly row crops and some pasture” while the

Cannon River portion falls within the Lower St. Croix and Vermillion Valleys (49j), which is described as a "dissected till plain and outwash valleys with a mix of row crops and pasture" (EPA 2007). On the eastern side lies the Blufflands and Coulees (51i) region of the Driftless Area. This region has steep hills and plateaus and was densely forested. For a time, these steep hills were intensely farmed; however, today, many acres are now managed as forest with cropland and pasture in the valleys.

Geology & Soils

Overall, the geology of the CRW has soil topped plateaus of loess that are deeply dissected by river valleys (NRCS 2007). Loess is very fine glacial material that is easily erodible. Loess thickness is variable across the watershed with deposits ranging from 30 feet thick on broad ridgetops, to less than a foot on valley walls (NRCS 2007) with less erodible sedimentary rock such as sandstone and limestone exposed along rivers and road cuts.

The CRW has three major land resource areas. The *Central Iowa and Minnesota Till Prairies* cover the largest portion of the western and southern extent of the watershed. Part of the Des Moines Lobe of the Wisconsin ice sheet, the land is mostly a rolling glaciated plain of sand and gravel with higher hills formed by glacial meltwaters with lake plains in some areas. Consequently, the geology is predominantly glacial till, outwash and glacial lake deposits with clay, silt, sand, and gravel fill the bottoms of most of the major river valleys (NRCS 2006). Soils are generally very deep, loamy, and range from well drained to very poorly drained. The *Eastern Iowa and Minnesota Till Prairies* encompass land near Northfield and Cannon Falls. The geology is a mix of glacial till and outwash deposits with clay, silt, sand, and gravel fills the major river valleys. Karst features exist in this area with shallow depth of soils and glacial material covering limestone. Soils are classified as well drained to very poorly drained. Subsurface drain tile is commonly used to lower water tables and increase crop production (NRCS 2006). The *Northern Mississippi Valley Loess Hills* lies on the far eastern extent of the watershed. This region is part of what is known as the "Driftless Area" because it underwent limited landscape formation by glacial ice. The resulting landscape is mostly gently sloping to rolling summits that create scenic landscapes of deep valleys, abundant rock outcrops, high bluffs, caves, crevices, and sinkholes (NRCS 2006). Limestone and sandstone outcrops are observed along some streams and rivers in the area. Loess deposits cover bedrock in many areas. Some karst areas exist where carbonate rocks are near the surface. Soils are generally moderately deep to very deep, loamy, and well drained to moderately well drained.

3.2 Lakes

Morphometric information of the impaired lakes are listed in Table 6.

Table 6. Morphometric characteristics of impaired lakes.

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	Watershed Area (ac)	Surface Area (ac)	Mean Depth (m)	Max Depth (m)
Chub Creek	Chub Lake	19-0020-00	1487.0	301.0	1*	2.9
Crane Creek	Clear Lake	81-0014-01	1,956	648	3.0	7.6
Crane Creek	Loon Lake	81-0015-00	459	119	1.5	2.4
Middle Cannon River	Byllesby Reservoir	19-0006-00	733,393	1,380	3.2	15.2
Middle Cannon River	Circle Lake	66-0027-00	20430.7	837.7	1.6	4.3
Middle Cannon River	Fox Lake	66-0029-00	8349.7	311.4	5.9	14
Middle Cannon River	Union Lake	66-0032-00	19009.0	437.0	1	no data
Middle Cannon River	Mazaska Lake	66-0039-00	2844.2	672.1	5.1	15.2
Upper Cannon River	Horseshoe Lake	40-0001-00	2893.6	400.0	3.1	7.9
Upper Cannon River	Upper Sakatah Lake	40-0002-00	131907.0	881.0	1.9	3
Upper Cannon River	Sunfish Lake	40-0009-00	449.7	116.0	3.4	9.1
Upper Cannon River	Dora Lake	40-0010-00	11245.8	760.0	1	1.8
Upper Cannon River	Mabel Lake	40-0011-00	795.7	103.0	1*	2.4*
Upper Cannon River	Sabre Lake	40-0014-00	53587.3	253.0	1*	4
Upper Cannon River	Tetonka Lake	40-0031-00	105585.0	1336.0	5	9.5
Upper Cannon River	Gorman Lake	40-0032-00	42007.9	590.0	2.1	4.3
Upper Cannon River	Silver Lake	40-0048-00	125.0	17.0	1*	no data
Upper Cannon River	Frances Lake	40-0057-00	4107.0	870.0	5	no data
Upper Cannon River	Tustin Lake	40-0061-00	4868.0	153.0	1*	1.5
Upper Cannon River	Cannon Lake	66-0008-00	189163.0	1476.0	2.5	4.6
Upper Cannon River	Wells Lake	66-0010-00	205160.0	634.0	1*	1.2
Upper Cannon River	Roberds Lake	66-0018-00	9125.6	654.0	3.1	11.6
Upper Cannon River	French Lake	66-0038-00	4101.9	842.0	5	15.4
Upper Cannon River	Lower Sakatah Lake	66-0044-00	139383.0	341.0	1*	2.1
Upper Cannon River	Hunt Lake	66-0047-00	615.3	190.0	3	8.2
Upper Cannon River	Rice Lake	66-0048-00	12305.8	330.0	1*	2
Upper Cannon River	Caron Lake	66-0050-00	8095.2	406.0	1*	1.2
Upper Cannon River	Cedar Lake	66-0052-00	4504.7	927.0	2.8	12.8
Upper Cannon River	Shields Lake	66-0055-00	6864.6	877.0	3.1	9.4
Upper Cannon River	Toner's Lake	81-0058-00	298.0	127.0	1*	no data

* Value estimated by MPCA (MPCA 2014c)

3.3 Streams

The total watershed areas of the impaired stream reaches are listed in Table 7Table 7. Total watershed and areas were delineated from CRW HSPF model subbasins.

Table 7. Watershed area of impaired stream reaches.

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	AUID Length (Miles)	Watershed Area (sq. mile)	Designated Trout Stream
Belle Creek	Unnamed Creek	07040002-699	0.55	13.25	No
Belle Creek	Belle Creek	07040002-734	7.85	78.13	No
Belle Creek	Belle Creek	07040002-735	18.63	69.35	No
Chub Creek	Chub Creek	07040002-528	24.74	84.61	No
Chub Creek	Mud Creek	07040002-558	2.46	9.87	No
Chub Creek	Chub Creek	07040002-566	7.06	19.39	No
Little Cannon River	Little Cannon River	07040002-526	11.87	94.69	Yes
Little Cannon River	Little Cannon River	07040002-589	12.05	57.32	Yes
Little Cannon River	Butler Creek	07040002-590	2.11	9.99	No
Lower Cannon River	Cannon River	07040002-501	8.64	1398.53	No
Lower Cannon River	Pine Creek	07040002-520	6.03	22.47	Yes
Lower Cannon River	Unnamed Creek (Trout Brook)	07040002-567	3.02	28.26	No
Lower Cannon River	Spring Creek	07040002-569	8.87	22.51	Yes
Lower Cannon River	Unnamed Creek (Trout Brook)	07040002-573	1.56	15.22	Yes
Middle Cannon River	Cannon River	07040002-507	2.99	851.01	No
Middle Cannon River	Cannon River	07040002-508	1.59	892.95	No
Middle Cannon River	Cannon River	07040002-509	10.53	920.98	No
Middle Cannon River	Heath Creek	07040002-521	13.39	39.89	No
Middle Cannon River	Wolf Creek	07040002-522	10.1	39.41	No
Middle Cannon River	Unnamed Ditch	07040002-555	0.57	3.35	No
Middle Cannon River	Unnamed Creek (Spring Brook)	07040002-557	1.9	6.51	Yes
Middle Cannon River	Unnamed Creek (Spring Brook)	07040002-562	3.71	3.98	No
Middle Cannon River	Cannon River	07040002-581	0.85	765.45	No
Middle Cannon River	Cannon River	07040002-582	11.23	800.48	No
Middle Cannon River	Unnamed Creek	07040002-703	2.18	8.26	No
Prairie Creek	Prairie Creek	07040002-504	28.76	79.29	No
Prairie Creek	Unnamed Creek	07040002-512	2.95	16.86	No
Straight River	Straight River	07040002-503	5.77	249.00	No
Straight River	Rush Creek	07040002-505	15.22	22.31	No
Straight River	Straight River	07040002-515	13.33	456.71	No
Straight River	Straight River	07040002-536	6.73	385.00	No
Straight River	Falls Creek	07040002-704	3.8	12.68	No
Upper Cannon River	Cannon River	07040002-540	4.97	307.14	No
Upper Cannon River	Cannon River	07040002-542	52.04	239.37	No
Upper Cannon River	Waterville Creek	07040002-560	6.44	19.44	No
Upper Cannon River	MacKenzie Creek	07040002-576	12.39	23.94	No
Upper Cannon River	Devils Creek	07040002-577	2.48	19.58	No
Upper Cannon River	County Ditch 63	07040002-621	2.39	6.51	No
Upper Cannon River	Unnamed Creek	07040002-702	4.18	9.71	No
Upper Cannon River	Unnamed Creek	07040002-705	2.91	7.69	No
Upper Cannon River	Whitewater Creek	07040002-706	0.73	15.54	No

3.4 Subwatersheds

The HUC-8 CRW is divided into nine HUC-10 subwatersheds. The subwatersheds in Figure 3 were obtained from the DNR Watershed Suite dataset downloaded from the Minnesota Geospatial Commons website.

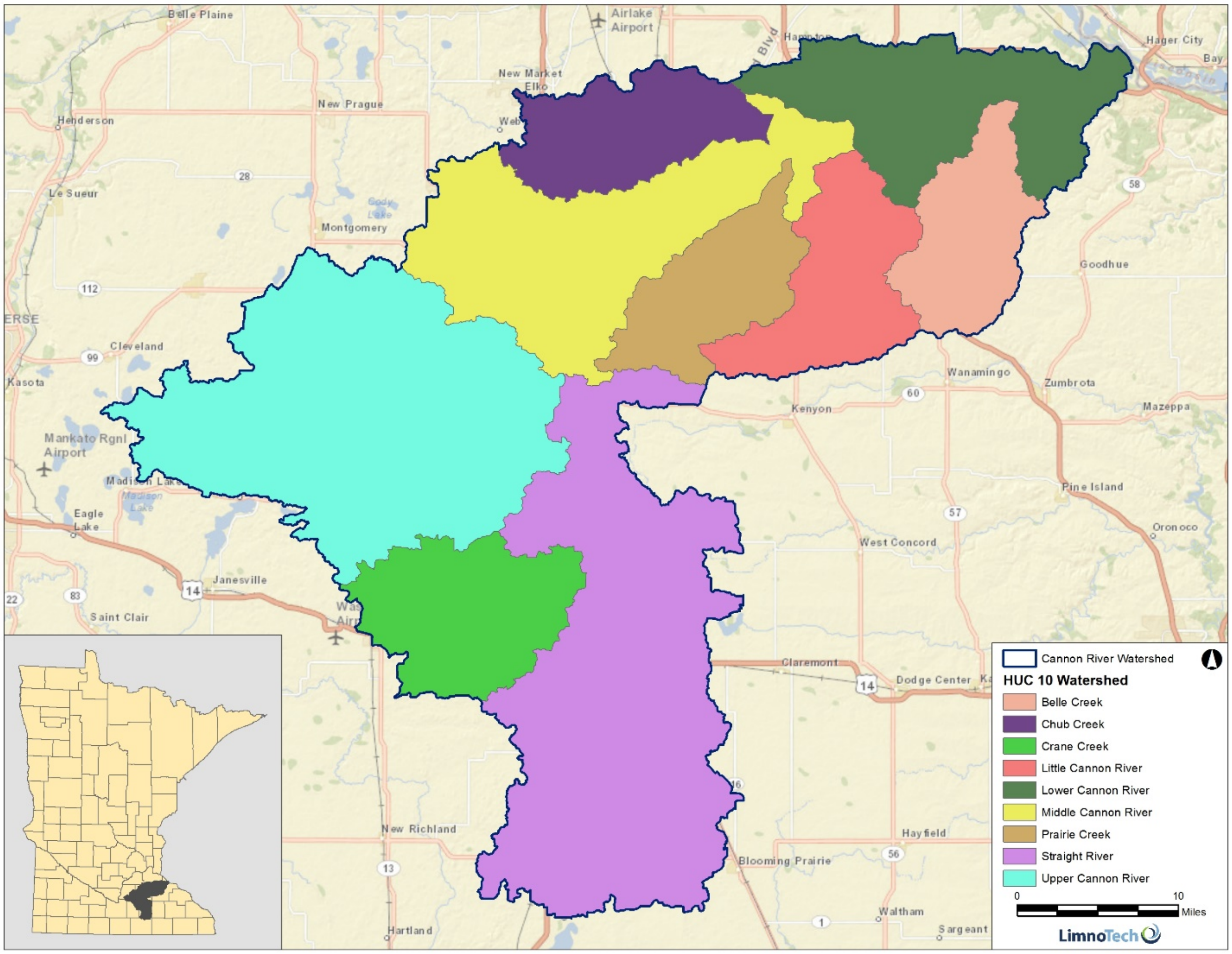


Figure 3. HUC-10 divisions within the CRW.

3.5 Land Use

Historically, the Cannon River was used as a navigation corridor by the Oneota, a tribe of Native Americans who lived in large villages along the Cannon River (DNR 1979), and by fur traders who traveled between the Mississippi River and inland. When French fur traders arrived in the area, they saw a great number of canoes along the river banks and so named the river “La Riviere aux Canots” meaning “the river of canoes”. As new immigrants moved westward, they saw great opportunities in logging the hardwood forests. Dams were built along the Cannon River to harvest the energy of flowing water to operate saw mills that were springing up along the railroad corridor and along the Mississippi River. As the woodlands fell to the ax, the fertile soils brought another wave of newcomers to area that planted wheat and converted the timber mills to grist mills (DNR 1979). By 1887, there were 15 flour mills along the Cannon River between Faribault and Northfield alone (http://www.dnr.state.mn.us/watertrails/cannonriver/more.html). During this early era of farming, horses were used to pull plows up and down the newly denuded and steep hills of the Driftless Area, and as a consequence heavy rains washed the fine loess soil down to streams where deep layers of soil buried streams, including the Little Cannon River and Belle Creek. During the 1930s, an era of conservation farming began, and various strategies were adopted to limit soil loss from uplands and greatly reduce excess sedimentation in streams (Trimble and Lund 1982). However, during the same time period, canning operations discharged directly into the Straight and Cannon Rivers causing fish kills (CRWP and MSU 2011), while untreated sewage polluted these rivers as well as many other streams in the watershed.

Also since the early 1900s, many wetlands were drained, stream courses were straightened, and tile lines were laid in order to increase the amount of land that could be cultivated. However, these actions also greatly changed the hydrology (amount and speed of water moving through land to waterbodies) of the watershed, which has led to increased bank erosion, turbidity impairments, excess sedimentation, and reduced habitat quality in many streams throughout the watershed, but especially in the Middle and Lower Cannon River lobes.

Today, the CRW is comprised of a variable mix of agriculture, forest, and developed land (Figure 4). Agricultural cropland, pasture and forage acreage account for approximately 75% of the watershed. Cropland is used predominantly for growing corn and soybeans. Forest (approximately 10%) and wetland together comprise 12.5%. Developed land (e.g. industrial land use, urban and rural housing, roads) is approximately 8%.

The total watershed population is approximately 194,000 people (NRCS 2007). The three largest cities stretch along the banks of the Straight and Cannon Rivers: Owatonna, Faribault, and Northfield. Smaller cities line the river banks and are scattered throughout agricultural areas: Waseca, Ellendale, Medford, Waterville, Morristown, Kilkenny, Lonsdale, Dundas, Cannon Falls, New Trier, Miesville, Randolph, Dennison, Nerstrand, and Welch. Several unincorporated communities dot the watershed as well.

For additional information regarding watershed background and characteristics, see the Monitoring and Assessment Report (MPCA 2014c) and the WRAPS report.

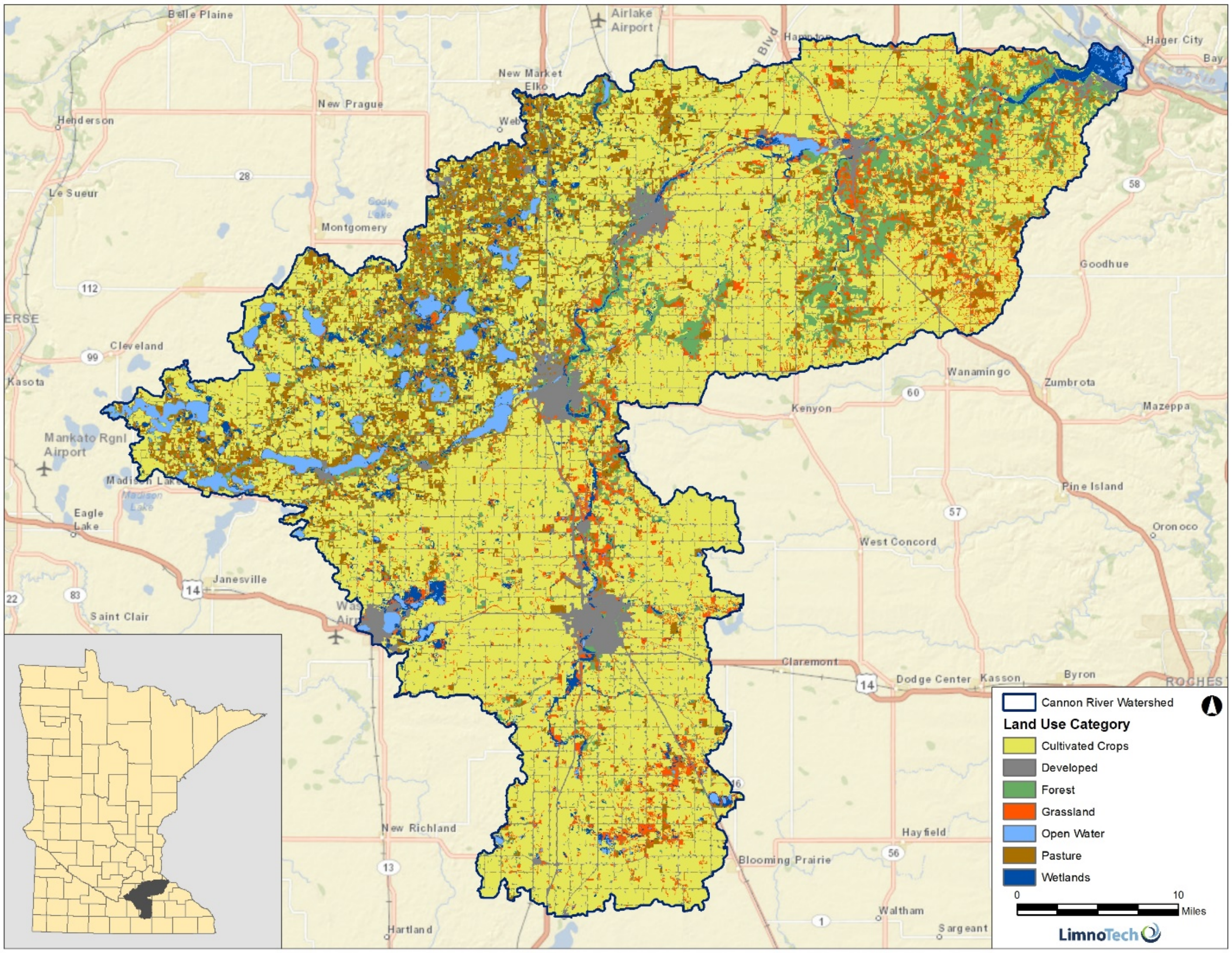


Figure 4. Current National Land Cover Dataset land use coverage in the CRW.

3.6 Current/Historic Water Quality

The existing stream water quality conditions were quantified using data downloaded from the MPCA Environmental Quality Information System (EQuIS) database and available for the 16-year modeling period (1996 through 2012) to identify impairments in the CRW. *E. coli*, chloride, nitrate, and TSS data for streams were summarized based on the TMDLs identified to address the assessed impairments. HUC-10 level summaries of the impaired AUIDs are in the following sections. For aquatic life use impairments in streams, the tables include summary information regarding the pollutant stressors of biota for which TMDLs were computed. The purpose of this brief summary is to illustrate the frequency of exceedances. Additional monitoring and assessment data, including indices of biological integrity for each stream, can be examined in the CRW Monitoring and Assessment Report (https://www.pca.state.mn.us/sites/default/files/wq-ws3-0704002b.pdf). Identified stressors beyond those for which TMDLs were computed can be examined in the SID and WRAP reports.

3.6.1 Belle Creek HUC-10

The Belle Creek Subwatershed has three impaired AUIDs; one for aquatic recreation and two for both aquatic recreation and aquatic life.

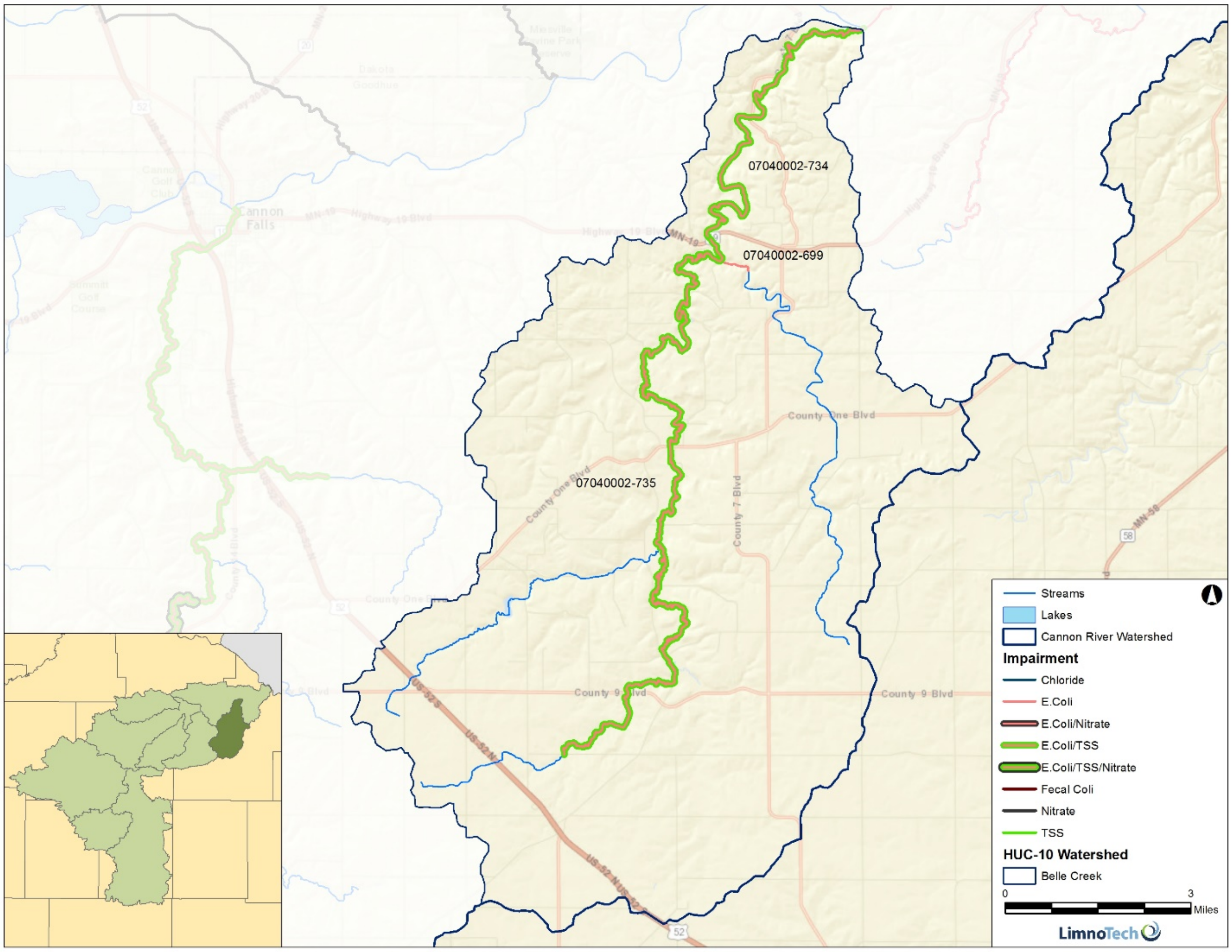


Figure 5. Impaired stream reaches in the Belle Creek HUC-10 Watershed.

Table 8. Aquatic Recreation Impairments in the Belle Creek HUC-10 Watershed.

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	# Samples Above 126 MPN/100 mL	*E. coli* Geomean (MPN/100 mL)	Sample Date
Belle Creek	Unnamed Creek	07040002-699	23/33	253.72	2008-2009
Belle Creek	Belle Creek	07040002-734	28/67	151.05	2007-2008; 2011-2012
Belle Creek	Belle Creek	07040002-735	43/52	461.80	2007-2008

Table 9. Aquatic Life Impairments in the Belle Creek HUC-10 Watershed.

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	# TSS Samples Above 65 mg/L	Sample Date
Belle Creek	Belle Creek	07040002-734	8/14 (used 10 mg/L)	2004
Belle Creek	Belle Creek	07040002-735	2/8	2012

3.6.2 Chub Creek HUC-10

The Chub Creek Subwatershed has three impaired AUIDs; two for aquatic recreation and one for aquatic life.

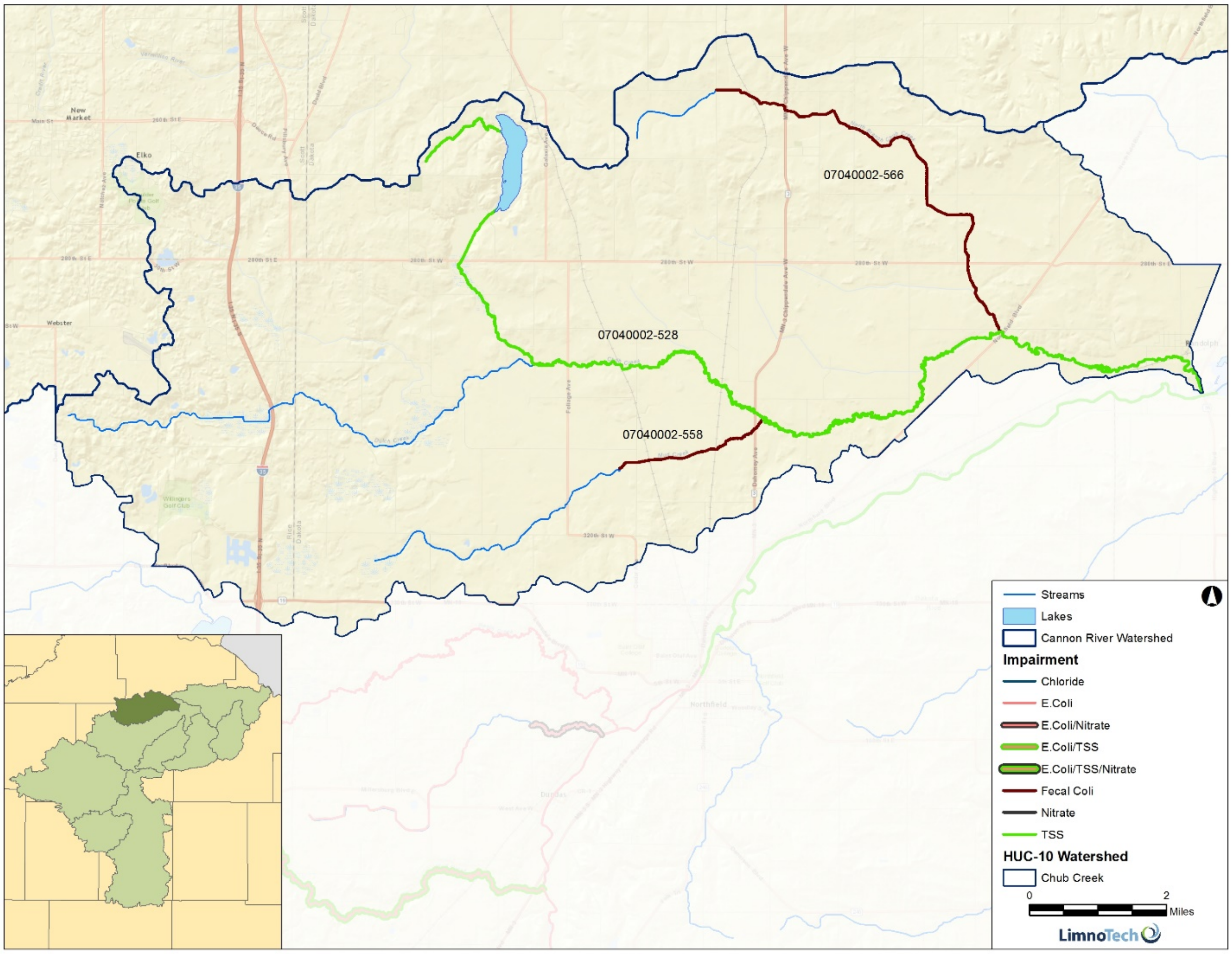


Figure 6. Impaired stream reaches in the Chub Creek HUC-10 Watershed.

Table 10. Aquatic Recreation Impairments in the Chub Creek HUC-10 Watershed.

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	# Samples Above 126 MPN/100 mL	*E. coli* Geomean (MPN/100 mL)	Sample Date
Chub Creek	Mud Creek	07040002-558	36/45	345.65	1999-2000; 2004-2005
Chub Creek	Chub Creek	07040002-566	31/49	237.41	1999-2000; 2004-2005

Table 11. Aquatic Life Impairments in the Chub Creek HUC-10 Watershed.

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	# TSS Samples Above 65 mg/L	Sample Date
Chub Creek	Chub Creek	07040002-528	9/53	2004-2008; 2011-2012

3.6.3 Crane Creek HUC-10

The Crane Creek Subwatershed has no impaired stream AUIDs.

3.6.4 Little Cannon River HUC-10

The Little Cannon River Subwatershed has three impaired AUIDs all of which are impaired for both aquatic recreation and aquatic life; one of which is impaired for drinking water.

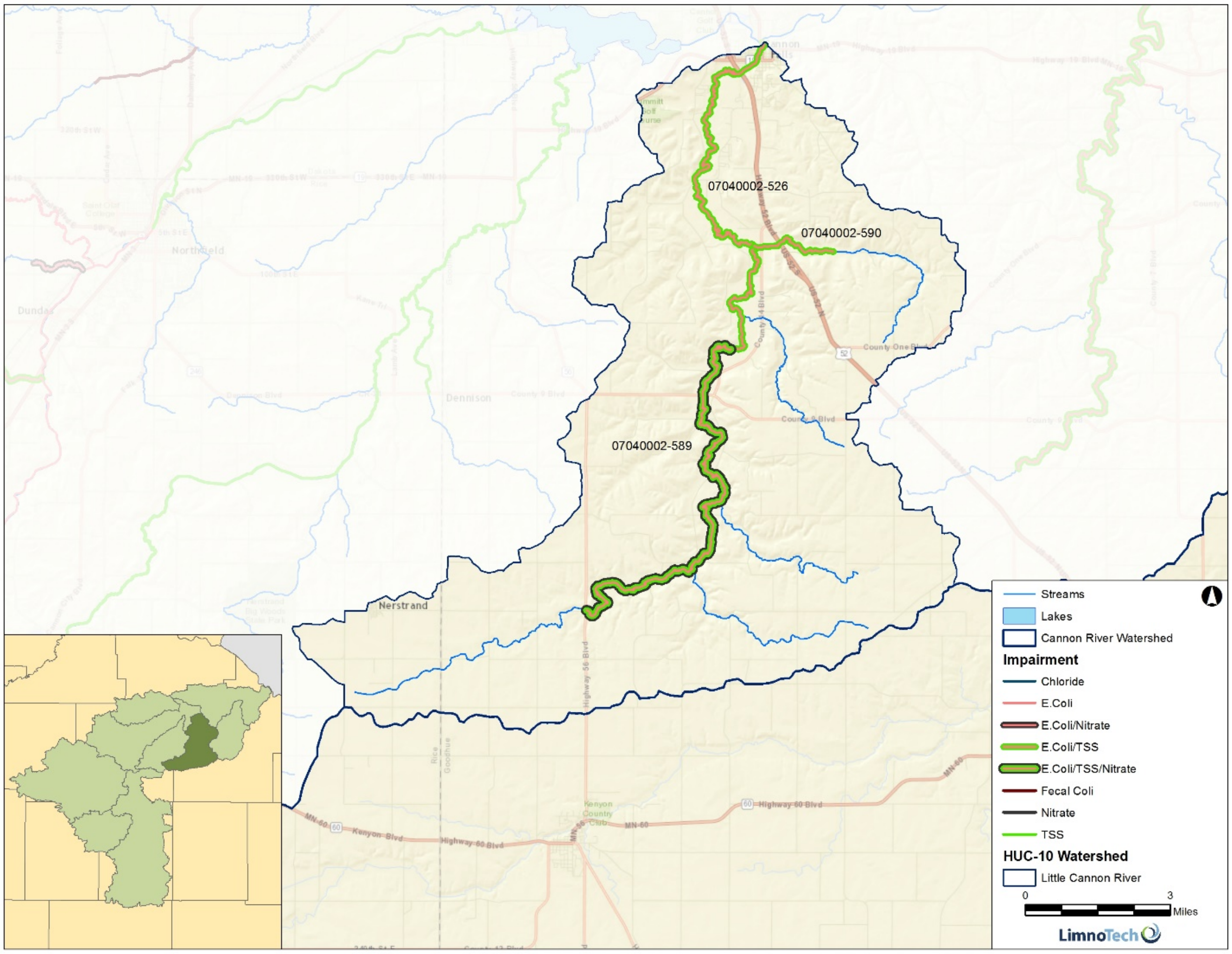


Figure 7. Impaired stream reaches in the Little Cannon River HUC-10 Watershed

Table 12. Aquatic Recreation Impairments in the Little Cannon River HUC-10 Watershed.

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	# Samples Above 126 MPN/100 mL	*E. coli* Geomean (MPN/100 mL)	Sample Date
Little Cannon River	Little Cannon River	07040002-526	37/53	215.73	2007-2008
Little Cannon River	Little Cannon River	07040002-589	21/23	491.78	2007
Little Cannon River	Butler Creek	07040002-590	21/33	289.38	2008-2009

Table 13. Aquatic Life Impairments in the Little Cannon River HUC-10 Watershed.

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	# TSS Samples Above 65 mg/L	Sample Date
Little Cannon River	Little Cannon River	07040002-526	7/13	2004
Little Cannon River	Little Cannon River	07040002-589	51/65 (used 10 mg/L)	2007-2010
Little Cannon River	Butler Creek	07040002-590	3/33	2008-2009

Table 14. Drinking Water Impairments in the Little Cannon River HUC-10 Watershed.

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	# NO_3-N Samples Above 10 mg/L	Sample Date
Little Cannon River	Little Cannon River	07040002-589	3/65	2007-2010

3.6.5 Lower Cannon River HUC-10

The Lower Cannon River Subwatershed has five impaired AUIDs; two for aquatic recreation and three for drinking water.

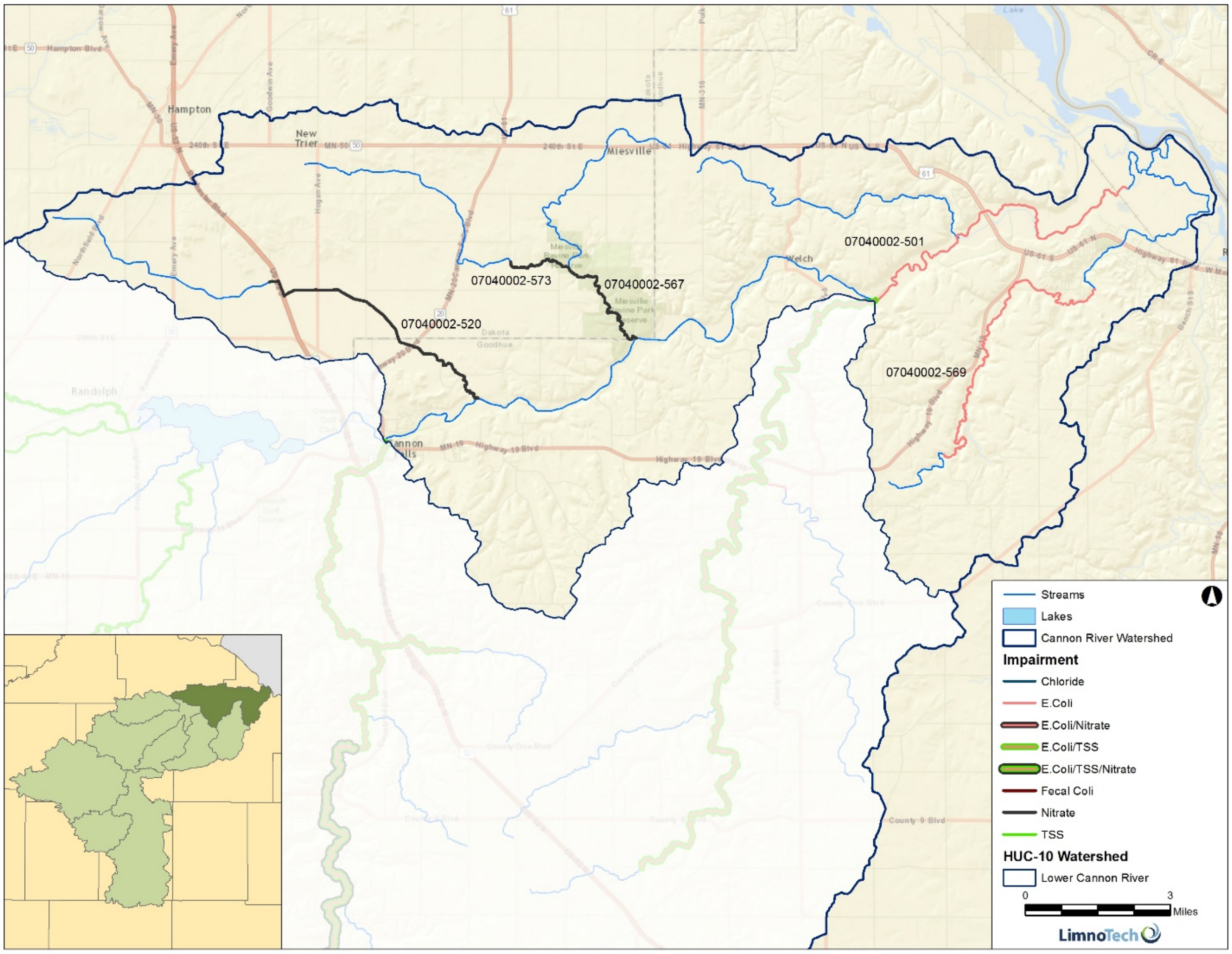


Figure 8. Impaired stream reaches in the Lower Cannon River HUC-10 Watershed.

Table 15. Aquatic Recreation Impairments in the Lower Cannon River HUC-10 Watershed.

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	# Samples Above 126 MPN/100 mL	*E. coli* Geomean (MPN/100 mL)	Sample Date
Lower Cannon River	Cannon River	07040002-501	23/71	86.76	2007-2008; 2011-2012
Lower Cannon River	Spring Creek	07040002-569	28/36	306.27	2008-2009

Table 16. Drinking Water Impairments in the Lower Cannon River HUC-10 Watershed.

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	# NO_3-N Samples Above 10 mg/L	Sample Date
Lower Cannon River	Pine Creek	07040002-520	5/16	2005-2008
Lower Cannon River	Unnamed Creek (Trout Brook)	07040002-567	12/12	2005-2007
Lower Cannon River	Unnamed Creek (Trout Brook)	07040002-573*	17/19	2006; 2010

* AUID not on 2014 303(d) list, but it will be subjected to an “opt-in assessment” with construction of the 2018 303(d) list

3.6.6 Middle Cannon River HUC-10

The Middle Cannon River Subwatershed has 11 impaired AUIDs; 7 for aquatic recreation, 1 for both aquatic recreation and aquatic life, 1 for both aquatic recreation and drinking water, and 2 for aquatic life.

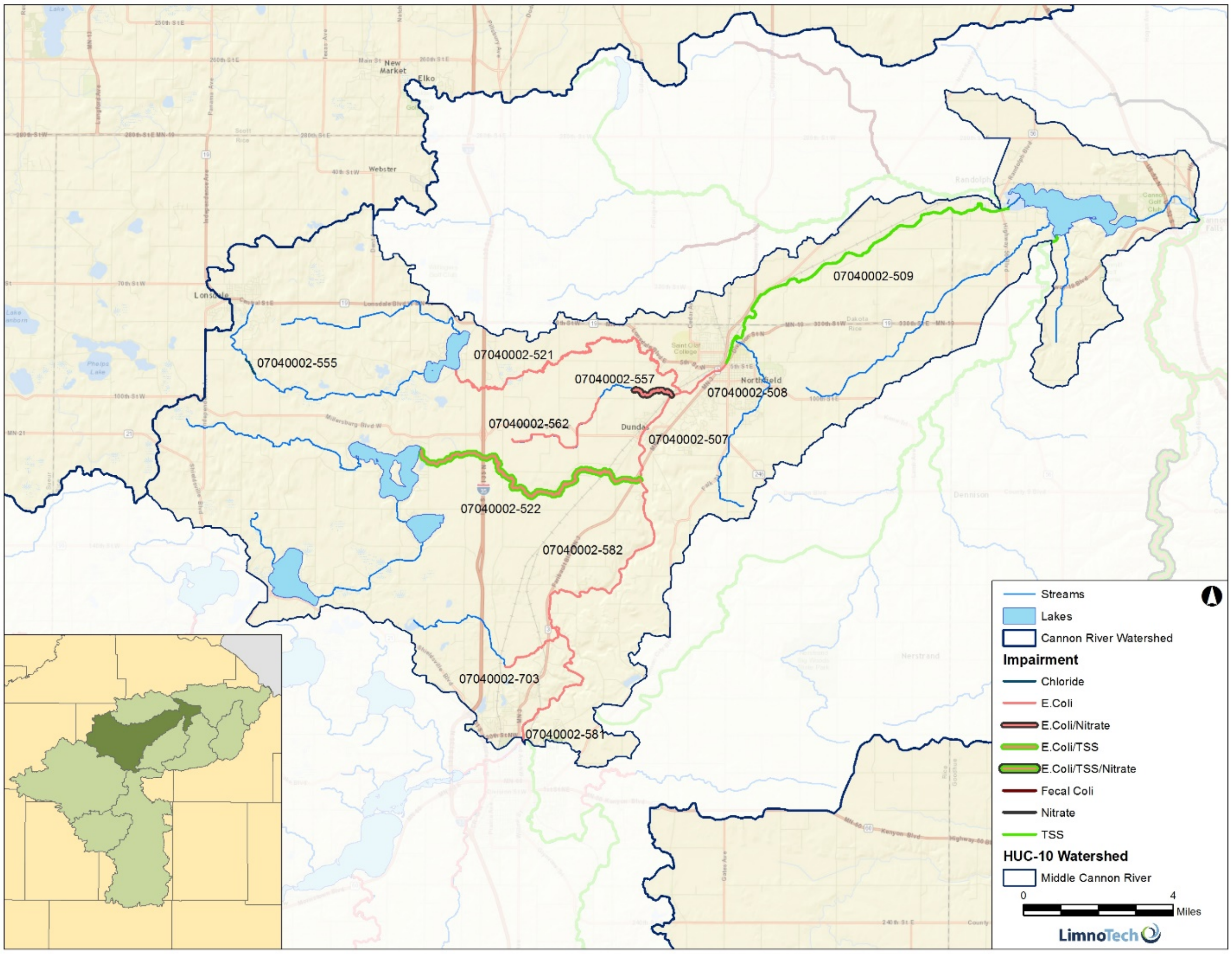


Figure 9. Impaired stream reaches in the Middle Cannon River HUC-10 Watershed.

Table 17. Aquatic Recreation Impairments in the Middle Cannon River HUC-10 Watershed.

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	# Samples Above 126 MPN/100 mL	*E. coli* Geomean (MPN/100 mL)	Sample Date
Middle Cannon River	Cannon River	07040002-507	22/53	99.47	2007-2008
Middle Cannon River	Cannon River	07040002-508	29/55	133.89	2007-2008
Middle Cannon River	Heath Creek	07040002-521	36/57	137.49	2007-2008; 2011-2012
Middle Cannon River	Wolf Creek	07040002-522	14/15	451.80	2011-2012
Middle Cannon River	Unnamed Creek (Spring Brook)	07040002-557	50/59	376.08	2007-2008
Middle Cannon River	Unnamed Creek (Spring Brook)	07040002-562	22/47	62.85	2007-2008
Middle Cannon River	Cannon River	07040002-581	25/53	112.14	2007-2008
Middle Cannon River	Cannon River	07040002-582	42/75	178.09	2007-2009
Middle Cannon River	Unnamed Creek	07040002-703	25/51	105.37	2008-2009

Table 18. Aquatic Life Impairments in the Middle Cannon River HUC-10 Watershed.

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	# TSS Samples Above 65 mg/L	Sample Date
Middle Cannon River	Cannon River	07040002-509	11/61	2001-2004
Middle Cannon River	Wolf Creek	07040002-522	2/10	2011

Table 19. Aquatic Recreation Impairments in the Middle Cannon River HUC-10 Watershed.

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	# Chloride Samples Above 230 mg/L	Sample Date
Middle Cannon River	Unnamed Ditch	07040002-555	No chloride monitoring data*	-

*Available chloride data do not intersect the assessment or modeling periods; data collected during SID are summarized in Chapter 4.4.

Table 20. Drinking Water Impairments in the Middle Cannon River HUC-10 Watershed.

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	# NO_3-N Samples Above 10 mg/L	Sample Date
Middle Cannon River	Unnamed Creek (Spring Brook)	07040002-557	21/32	2008; 2011

3.6.7 Prairie Creek HUC-10

The Prairie Creek Subwatershed has two AUIDs with aquatic life use impairments.

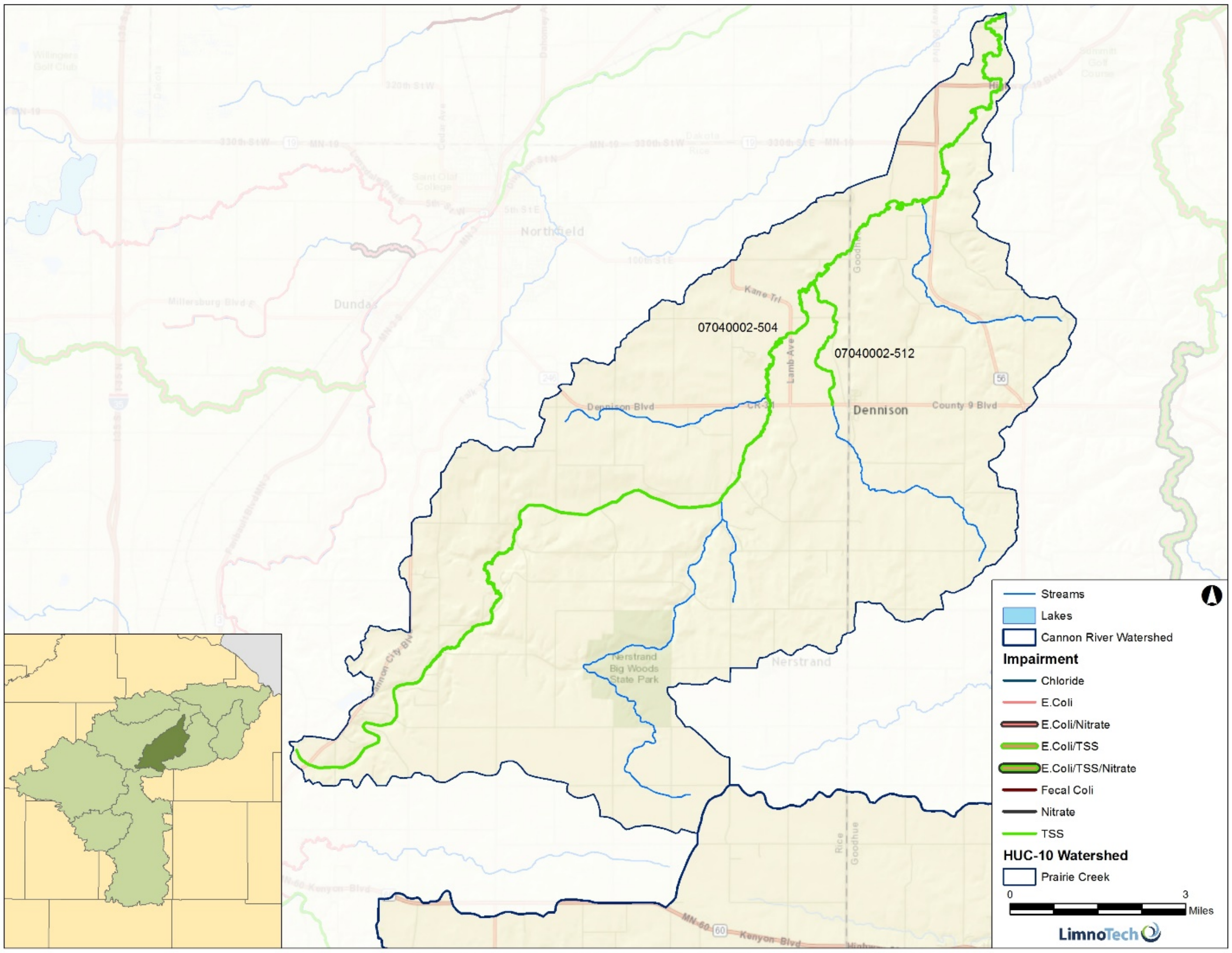


Figure 10. Impaired stream reaches in the Prairie Creek HUC-10 Watershed.

Table 21. Aquatic Life Impairments in the Prairie Creek HUC-10 Watershed.

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	# TSS Samples Above 65 mg/L	Sample Date
Prairie Creek	Prairie Creek	07040002-504	11/31	2001-2004; 2011
Prairie Creek	Unnamed Creek	07040002-512	No TSS monitoring data	-

3.6.8 Straight River HUC-10

The Straight River Subwatershed has five impaired AUIDs; one for aquatic recreation and four for aquatic life.

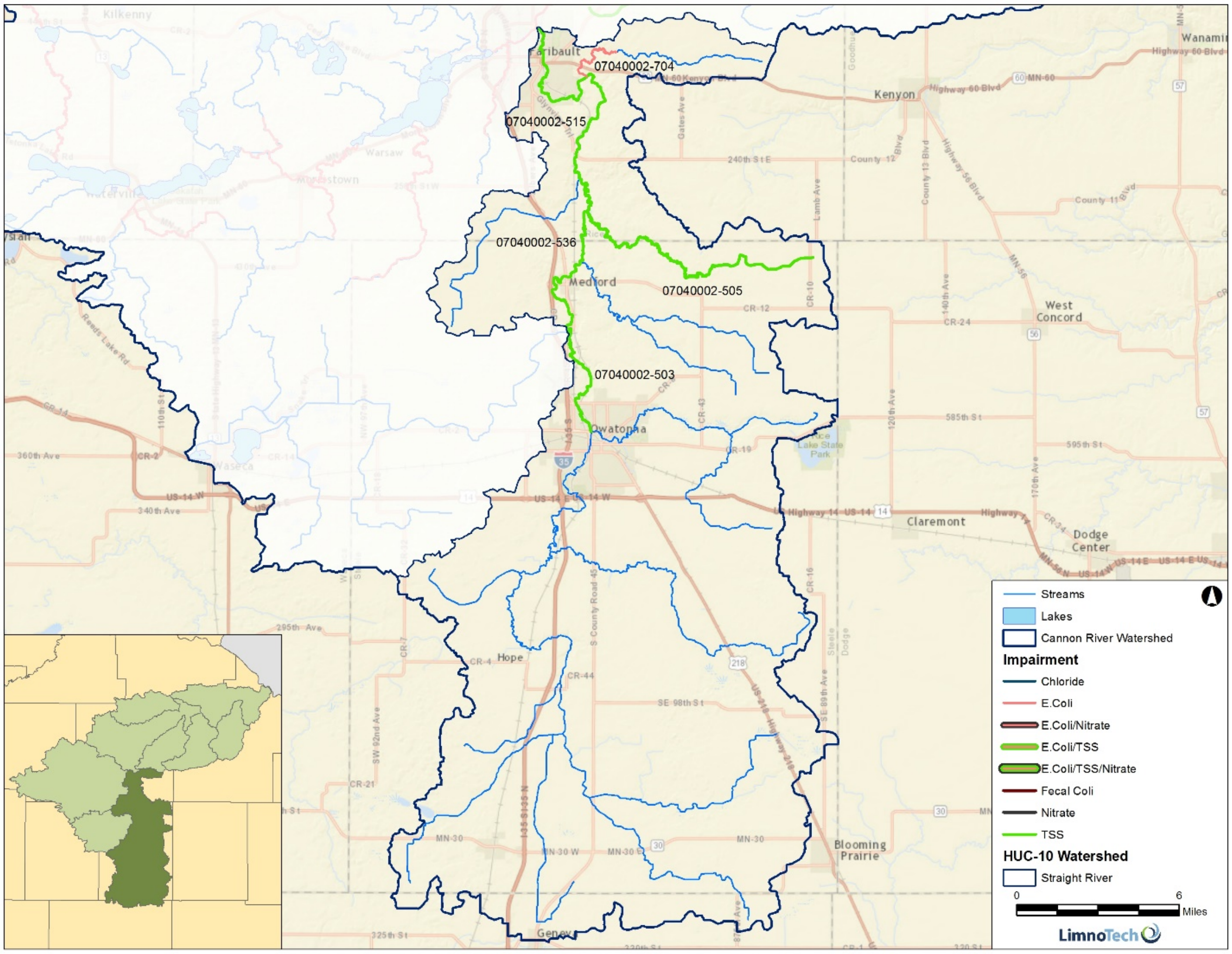


Figure 11. Impaired stream reaches in the Straight River HUC-10 Watershed.

Table 22. Aquatic Recreation Impairments in the Straight River HUC-10 Watershed.

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	# Samples Above 126 MPN/100 mL	*E. coli* Geomean (MPN/100 mL)	Sample Date
Straight River	Falls Creek	07040002-704	26/49	111.06	2008-2009

Table 23. Aquatic Life Impairments in the Straight River HUC-10 Watershed.

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	# TSS Samples Above 65 mg/L	Sample Date
Straight River	Straight River	07040002-503	12/165	1998-2011
Straight River	Rush Creek	07040002-505	2/30	1999; 2008-2009
Straight River	Straight River	07040002-515	21/80	2001-2004; 2009-2010
Straight River	Straight River	07040002-536	No TSS monitoring data for simulation period 1996-2012	-

3.6.9 Upper Cannon River HUC-10

The Upper Cannon River Subwatershed has nine impaired AUIDs all for aquatic recreation.

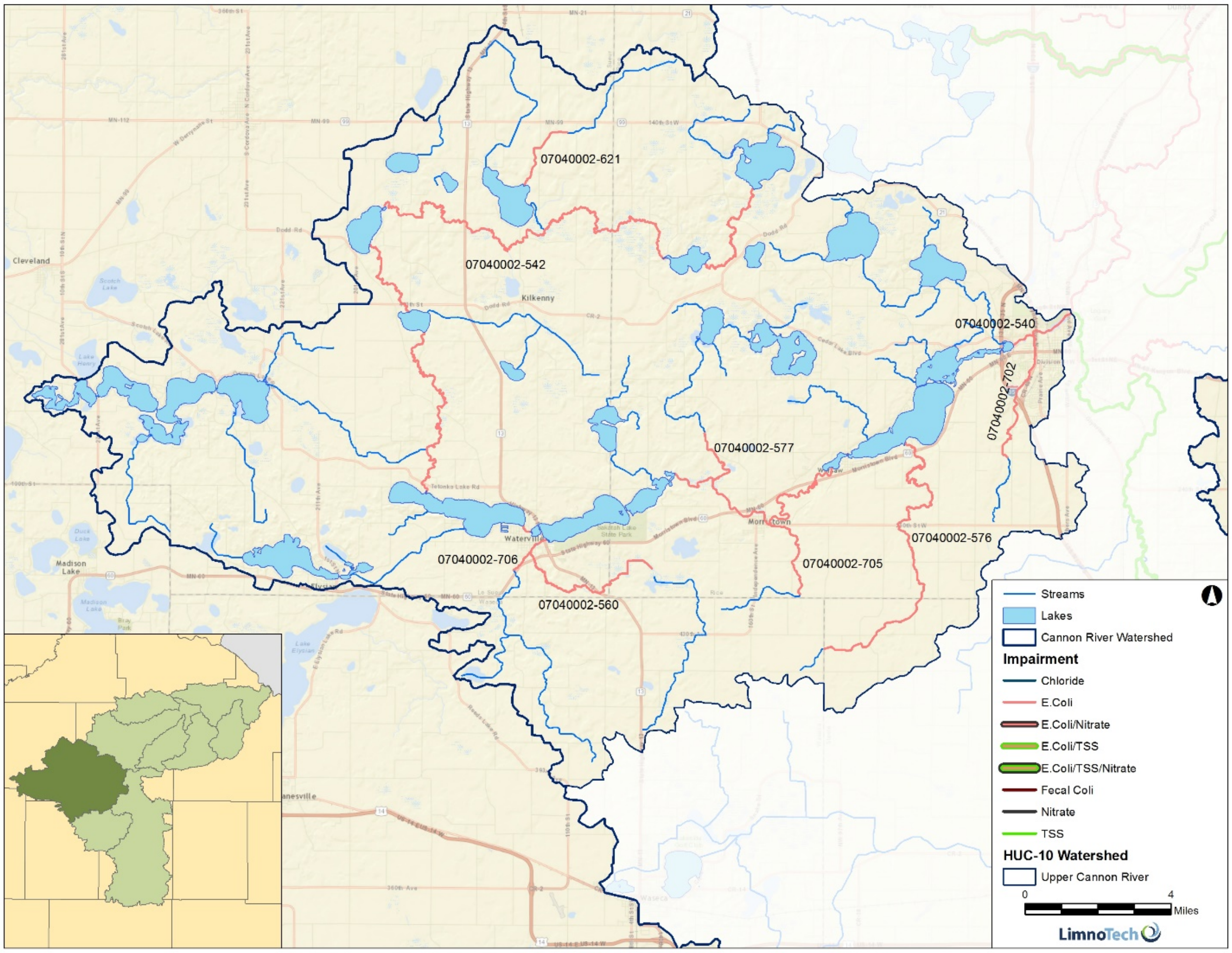


Figure 12. Impaired stream reaches in the Upper Cannon River HUC-10 Watershed.

Table 24. Aquatic Recreation Impairments in the Upper Cannon River HUC-10 Watershed.

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	# Samples Above 126 MPN/100 mL	*E. coli* Geomean (MPN/100 mL)	Sample Date
Upper Cannon River	Cannon River	07040002-540	15/47	58.73	2007-2008
Upper Cannon River	Cannon River	07040002-542	8/15	178.00	2011-2012
Upper Cannon River	Waterville Creek	07040002-560	27/43	172.19	2008-2009
Upper Cannon River	MacKenzie Creek	07040002-576	20/31	149.03	2008-2009
Upper Cannon River	Devils Creek	07040002-577	13/34	97.06	2008-2009
Upper Cannon River	County Ditch 63	07040002-621	12/31	51.51	2008-2009
Upper Cannon River	Unnamed Creek	07040002-702	36/51	331.20	2008-2009
Upper Cannon River	Unnamed Creek	07040002-705	28/38	246.60	2008-2009
Upper Cannon River	Whitewater Creek	07040002-706	23/43	121.44	2008-2009

3.7 Pollutant Source Summary

3.7.1 Point Sources

Permitted point sources are included in Table 25 below and mapped in Figure 13. Given that the CRW is a predominately rural landscape, point sources account for a relatively small component of pollutant loads. However, at lower flows, point sources can play a significant role in pollutant loading and water quality conditions.

In total, there are 33 permitted facilities that were used to develop this TMDL report and they include city WWTFs, industrial dewatering pits, and operational cooling water that discharge either directly to impaired waterbodies or to upstream subwatersheds within the CRW. These facilities discharged during the HSPF model simulation period and were built into the HSPF model as point sources.

Point sources of phosphorus can be further examined using the MPCA's interactive tool regarding phosphorus in wastewater: https://www.pca.state.mn.us/water/phosphorus-wastewater.

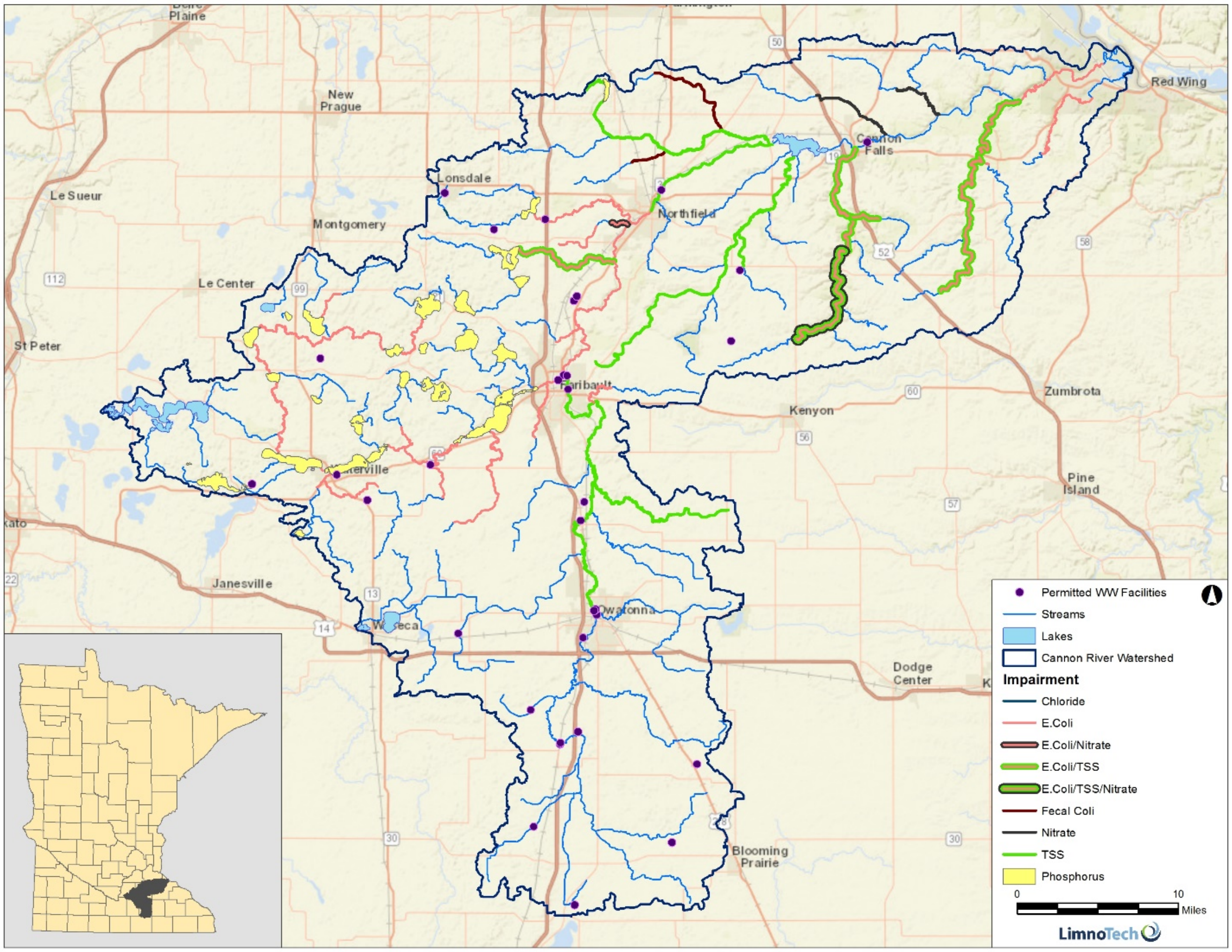


Figure 13. Location of active permitted wastewater facilities in the CRW that were also active during the HSPF model simulation period and used in this TMDL report to develop WLAs.

Table 25. List of active permitted wastewater facilities in the CRW that were also active during the HSPF model simulation period and used in this TMDL report to develop WLAs.

Facility Name	NPDES Permit #
Cannon Falls WWTF	MN0022993
CenterPoint Energy - WWTS	MN0063967
Dennison WWTP	MN0022195
Ellendale WWTP	MNG580014
Elysian WWTP	MN0041114
Faribault Dairy Co Inc - Faribault	MNG255092
Faribault Foods - Faribault Division	MN0050491
Faribault WWTP	MN0030121
Geneva WWTP	MN0021008
Genova-Minnesota Inc	MN0046957
Hope - Somerset Township WWTP	MN0068802
Hope Creamery	MN0001317
Kilkenny WWTP	MNG580084
Lakeside Foods Inc - Owatonna Plant	MN0001571
Lonsdale WWTP	MN0031241
Mathiowetz Construction	MNG490137
Mathy Construction – Aggregate; Milestone Materials: Spinler Quarry	MNG490081
Medford WWTP	MN0024112
Meriden Township WWTP	MN0068713
MNDOT - Heath Creek Rest Area	MN0069639
MNDOT Straight River Rest Area	MN0049514
Morristown WWTP	MN0025895
Nerstrand WWTP	MN0065668
Northfield WWTP	MN0024368
OMG Midwest Inc/Southern MN Construction (Dundas Wash Plant S&G, Rice)	MNG490131
OMG Midwest Inc/Southern MN Construction (Owatonna Quarry, Steele County)	MNG490131
OMG Midwest Inc/Southern MN Construction (Thomas S&G, Rice)	MNG490131
Owatonna WWTP	MN0051284
Sanders North (Medford North S&G)	MNG490273
Sanders North (Millersburg S&G)	MNG490273
Viracon	MNG255078
Waterville WWTP	MN0025208
Wondra Pit	MNG490130

3.7.2 Phosphorus & Sediment

This section provides a brief description of the potential sources in the watershed contributing to excess nutrients in the impaired lakes. Phosphorus in lakes often originates on land. Phosphorus from sources such as phosphorus-containing fertilizer, manure, and the decay of organic matter can adsorb to soil particles. Wind and water action erode the soil, detaching particles and conveying them in stormwater runoff to nearby waterbodies where the phosphorus becomes available for algal growth. Organic material such as leaves and grass clippings can leach dissolved phosphorus into standing water and runoff or be conveyed directly to waterbodies where biological action breaks down the organic matter and releases phosphorus.

3.7.2.1 Permitted

The regulated sources of phosphorus within the watersheds of the eutrophication impairments addressed in this TMDL study include National Pollutant Discharge Elimination System (NPDES) permitted WWTF effluent, MS4 stormwater, construction sites, and industrial sites. See Figure 13 and Table 25.

3.7.2.2 Non-permitted

Several investigations related to sediment source apportionment have been conducted within the past 5 to 15 years for watershed areas in southeast Minnesota and for Lake Pepin. These studies have generally involved sediment "fingerprinting" through the geochemical analysis of sediments and the representation of distinct sediment sources within HSPF models developed for the MPCA (LimnoTech 2013). Because phosphorus, given the nature of the CRW, shares many general sources and pathways with those of sediment, these investigations are useful in considering both pollutants. In a literature review conducted in 2013, LimnoTech examined the following:

- Sediment fingerprinting for Lake Pepin and its tributary systems (Kelly and Nater 2000, Schottler et al. 2010);
- Minnesota River HSPF model development and calibration (TetraTech 2009);
- Sediment fingerprinting for the LeSueur Watershed (Belmont 2012);
- Sediment fingerprinting for source and transport pathways in the Root River (Belmont 2011, Stout 2012); and
- Root River HSPF model development and calibration (TetraTech 2013).

A summary of general findings of the literature review:

- Overall sediment delivery from tributaries to the Upper Mississippi River in southeast Minnesota has increased substantially since European settlement and the onset of agricultural activities in the tributary watersheds;
- The relative contributions of "non-field" sources of sediment to the overall watershed sediment yield appears to be increasing over time, with a likely link to the "flashier" hydrology (i.e. rapidly

increasing and decreasing flow volumes) resulting from agricultural land use and associated drainage and urban development (LimnoTech 2013).

Regarding phosphorus, the Minnesota NRS summary findings are included below:

- The primary sources of phosphorus transported to surface waters are cropland runoff, atmospheric deposition, permitted wastewater, and streambank erosion. These four sources combined are 71%, 76%, and 83% of the statewide phosphorus load under dry, average, and wet years, respectively.
- During dry conditions, NPDES permitted wastewater discharges and atmospheric deposition becomes more prominent sources of phosphorus.
- The most significant phosphorus sources by major basin during an average precipitation year include cropland runoff, wastewater point sources, and streambank erosion in the Mississippi River Major Basin (MPCA 2014d).

Other resources useful in examining sediment and phosphorus sources in the CRW include the Lower Mississippi River Basin Regional Sediment Data Evaluation Project (Barr Engineering 2004, http://www.pca.state.mn.us/index.php/view-document.html?gid=5983), Detailed Assessments of Phosphorus Sources to Minnesota Watersheds (Barr Engineering 2004 and 2007, https://www.pca.state.mn.us/water/detailed-assessments-phosphorus-sources-minnesota-watersheds) and Minnesota's NRS (https://www.pca.state.mn.us/water/nutrient-reduction-strategy).

Sediment Source Apportionment from CRW HSPF Model Development

The calibrated CRW HSPF model simulates that upland sources contribute 41% of the sediment load for the entire watershed. This is consistent with the observation that a larger upland source percentage may be appropriate for the Cannon River given the predominance of type "C" or highly erodible/unstable soils. The highest simulated sediment source is bed and bank erosion at 48% and the third-largest contributor is gully and ravine erosion at 10%. Point sources, tile drainage, and GW outflow pathways each contribute less than 1% to the overall sediment delivery. A breakdown of the sediment sources can be found in the CRW WRAPS document (MPCA 2016a).

Feedlots

While feedlots are not considered one of the major sources of phosphorus to the Mississippi River (MPCA 2014d), local impacts to water resources in the CRW could in some cases be significant. Heiskary and Martin (2015) used feedlot inventories in the context of BATHTUB modeling to examine potential feedlot phosphorus loads to the upper Cannon lakes. This analysis can be paired with working knowledge of local government units (LGUs) to identify and address feedlot pollution hazards. See 3.7.3 for more information regarding feedlots.

Tributary Load

The calibrated HSPF model was used to determine inflowing volumes and loads to the lakes. The HSPF predicted loads include permitted and non-permitted sources.

Atmospheric Deposition

Atmospheric deposition represents the phosphorus that is bound to particulates in the atmosphere and is deposited directly onto surface waters. The BATHTUB default average phosphorus atmospheric deposition loading rates were 30 lb/km^2 of TP per year for an average rainfall year. This rate was applied to the lake surface area to determine the total atmospheric deposition load per year to the impaired lakes.

Internal Phosphorus Loads in Lakes and Reservoirs

Internal cycling of phosphorus can be an important nutrient source for phytoplankton growth. The phosphorus loads to the lakes and reservoirs in the CRW include both watershed and internal components. Approximating both is important in understanding how watershed work to reduce phosphorus loads may (or may not) impact water quality for a given lake. For example, in 2004 Chesapeake Biogeochemical Associates examined sediment release of phosphorus at four stations in the Byllesby Reservoir. They estimated that on average, internal recycling accounts for approximately 7% of the TP loading and 16% of the soluble reactive phosphorus loading to the reservoir.

Heiskary and Martin describe the difficulty in estimating internal loads for the lakes of the CRW:

> *Several of the lakes demonstrate factors that can allow for excessive internal loading: shallowness, wind mixing, high temperatures, high pH, and/or abundant sediment disturbing carp. If external loads were calculated with a high degree of confidence, it might be reasonable to assign the "unaccounted for" portion of the estimated P budget to internal recycling -- but that was not the case for most of the modeled lakes. Absent that, we need to make estimates based on literature values and best professional judgment.*

One possible source for unaccounted for internal TP loads is re-suspension via carp activity. The lakes modeled in Heiskary and Martin (2015) summarized general carp concentrations. In a number of the shallow lakes there is an abundance of carp.

More accurate phosphorus budgeting for the Upper Cannon Lakes would benefit from the collection of sediment cores and determination of phosphorus release through laboratory incubation and measurement. Lakes could be grouped according to size, morphometry, mixing status (to help describe potential for phosphorus release from sediments during anoxic conditions) and residence time and representative members of each group could be subjected to further study of phosphorus budget and cycling.

Low Flow Phosphorus Load in Upper Straight River

High phosphorous concentrations in the Upper Straight River (upstream of Owatonna) have been well documented by Steele County Environmental Services monitoring. The concentration in the river at low flows is often greater than the inflow water quality goal for the Byllesby Reservoir (0.150 mg/l). Decreasing this low flow load is critical to downstream goal attainment. At this time the geographic confine of the Upper Straight River Watershed is understood to be a "source" of high phosphorus during the critical condition for aquatic recreation (late summer, low flows) but the sources of the pollutant mass and the dynamics that deliver the mass to surface waters must be further studied before specific restoration strategies can be developed. See the CRW WRAPS document (MPCA 2016a) for more detail. The MPCA staff has begun to communicate with local partners in developing further investigative monitoring in the watershed.

3.7.3 Escherichia coli/Fecal Coliform

Water-borne pathogens pose a potential health risk to those who come into contact with inoculated surface water. These pathogens – bacteria, protozoa, viruses and others – come from a variety of sources, including agricultural runoff, inadequately treated domestic sewage, and wildlife. Some of these pathogens may cause disease. The following discussion addresses probable point and nonpoint sources of fecal pathogens and the associated indicators: fecal coliform and *E. coli*, the latter being the indicator currently used in Minnesota's water quality standard.

3.7.3.1 Permitted

Wastewater Treatment Facilities

Fecal pathogen loading can occur from both permitted and non-permitted sources. Permitted sources of bacteria include industrial wastewater effluent, municipal WWTF effluent, and municipal/industrial stormwater runoff. See Figure 13 and Table 25.

Livestock Feedlots

Animal waste containing fecal bacteria can be transported in watershed runoff to surface waters. The MPCA regulates animal feedlots in Minnesota though counties may be delegated by the MPCA to administer the program for feedlots that are not under federal regulation. The primary goal of the state program for AFO is to ensure that surface waters are not contaminated by the runoff from feeding facilities, manure storage or stockpiles, and cropland with improperly applied manure. Livestock also occur at hobby farms, small-scale farms that are not large enough to require registration, but may have small-scale feeding operations and associated manure application or stockpiles.

Livestock manure is often either surface applied or incorporated into farm fields as a fertilizer and soil amendment. This land application of manure has the potential to be a substantial source of fecal contamination, entering waterways from overland runoff and drain tile intakes. Research being conducted in southern Minnesota shows high concentrations of fecal bacteria leaving fields with incorporated manure and open tile intakes (Scott Matteson, personal communication). Minn. R. ch. 7020 contains manure application setback requirements based on research related to phosphorus transport, and not bacterial transport, and the effectiveness of these current setbacks on bacterial transport to surface waters is not known.

All feedlots in Minnesota are regulated by Minn. R. ch. 7020. The MPCA has regulatory authority of feedlots but counties may choose to participate in a delegation of the feedlot regulatory authority to the local unit of government. Delegated counties are then able to enforce Minn. R. ch. 7020 (along with any other local rules and regulations) within their respective counties for facilities that are under the CAFO threshold. In the CRW, the counties of Goodhue, Le Sueur, Steele, Rice and Waseca counties are delegated the feedlot regulatory authority.

Of the approximately of 2,150 feedlots in the CRW, there are 46 active NPDES permitted operations, 38 of which are Concentrated Animal Feeding Operation (CAFOs) (Figure 14). In Minnesota, NPDES Permits are issued to facilities with over 1,000 animal units (AUs), most of which are CAFOs (an EPA definition that implies not only a certain number of AUs but also specific animal types e.g. 2500 swine is a CAFO, 1000 cattle is a CAFO but a site with 2499 swine and 999 cattle is not a CAFO according to the EPA definition). The MPCA currently uses the federal definition of a CAFO in its regulation of animal feedlots.

In Minnesota, the following types of livestock facilities are issued, and must operate under, a NPDES Permit: a) all federally defined CAFOs, some of which are under 1000 AUs in size; and b) all CAFOs and non-CAFOs that have 1000 or more AUs. These feedlots must be designed to totally contain runoff, and manure management planning requirements are more stringent than for smaller feedlots. In accordance with the state of Minnesota's agreement with EPA, CAFOs with state-issued General NPDES Permits must be inspected twice during every five year permitting cycle and CAFOs with state issued Individual NPDES Permits are inspected annually. The number of AUs by animal type registered with the MPCA feedlot database (November 2014) is summarized in Table 26**.**

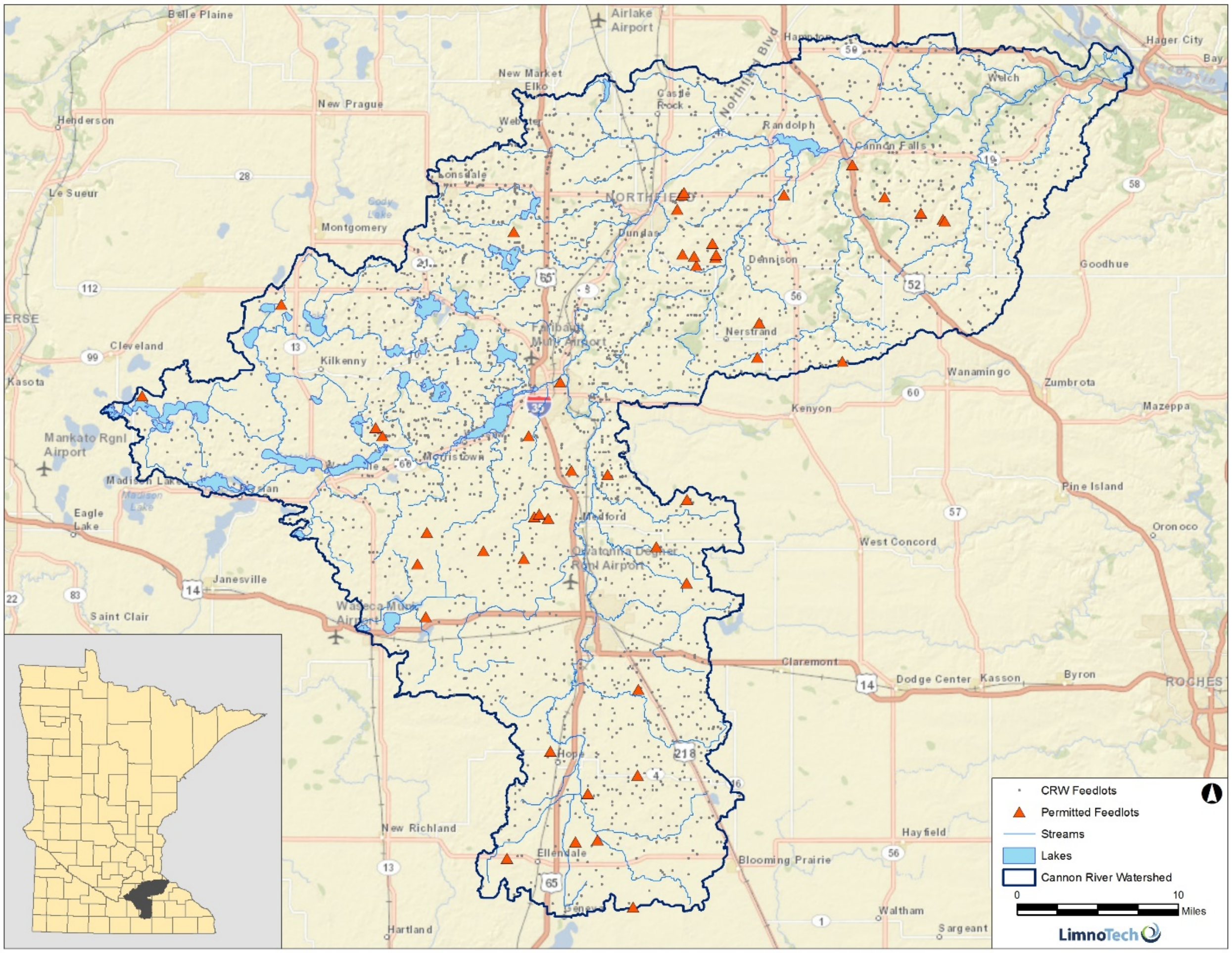


Figure 14. Location of all feedlots within the CRW. Feedlots with an NPDES Permit are identified in orange.

Table 26. The number of AUs registered in the MPCA feedlot database (November 2014).

Facility Name	NPDES Permit #	Livestock	Total AU
Ahlman Hog Farm Sec 11	MNG440092	Swine	1200
Borchert Swine Farms	MNG441187	Swine	1440
Brian Dobberstein Farm Sect. 20	MNG441188	Swine	1440
Brian J Kosel Farm - Sec 23	MNG440672	Swine	816
Brian Waage Farm	MNG440091	Swine	1200
Cary Berg Farm - Sec 1	MNG440971	Swine	1500
Chad Johnson Farm	MNG440615	Swine	936
Eastgate Farms - Sec 32	MNG440513	Poultry	1380
Eastgate Farms - Sec 32 - North	MNG440513	Poultry	450
Eastgate Farms Inc Hwy 19 Farm - C. Holden	MNG440513	Poultry	575
Gustafson Farms LLC	MNG440306	Swine	1332
Heers Family Farm	MNG440090	Swine	1200
Holden Farms Inc - Fallingbrook Facility	MNG440165	Swine & Poultry	1197
Holden Farms Inc - Pine Grove Facility	MNG440165	Swine	499
Holden Farms Inc - Spring Hill Facility	MNG440165	Swine	930
Holden Farms Inc - Triagra	MNG441135	Swine	1045
Hovel Farms - Site 1	MNG440785	Swine	720
Hovel Farms - Site 2	MNG440785	Swine	960
Jeff & Cheryl Ptacek	MNG440008	Swine	1200
Jennie-O Turkey Store - Blooming Grove	MNG441022	Poultry	569
Jennie-O Turkey Store - Deerfield Farm	MNG440131	Poultry	1968
Jennie-O Turkey Store - Hillcrest Farm	MNG440133	Poultry	1968
Jennie-O Turkey Store - Medford Farm	MNG440810	Poultry	335
Jennie-O Turkey Store - Merton Farm	MNG440132	Poultry	1968
Jennie-O Turkey Store - Valleyview	MNG440134	Poultry	390
JK Farms LLC - Sec 25	MNG440624	Swine	1440
Jon Keller Farm	MNG440073	Swine	867
Koppelman Farms Inc	MNG440088	Swine	1140
Legacy Family Farms	MNG440454	Swine	1200
Matt Holland Farm Sec.27	MNG441160	Swine	1464
Matthew & JoEllen Voxland Farm	MNG440644	Swine	1561
Our Farm Henkensief - Jones	MNG440095	Swine	1260
P & J Products Co - Site I	MNG440166	Poultry	180
P & J Products Co - Site II	MNG440166	Poultry	53
P & J Products Co - Site III	MNG440166	Poultry	1025
R & D Systems Goat Farm	MNG440075	Goats	117
R&D Systems Inc - Farm	MNG440075	Cows	1134
Richard & Jane Peterson Farm	MNG440573	Poultry	1150
Saemrow Dairy	MNG441143	Cows	1289
Saemrow Dairy Heifer Facility	MNG441143	Cows	56
Sammon-Acres LLC - Sec 11	MNG440532	Swine	798
Steven Jaster Farm	MNG440094	Swine	1200
Thomas Dressel	MNG441189	Swine	1470
Tim Donkers Farm	MNG441128	Swine	833
Wingspan LLP	MNG440196	Swine	2880
Woodville Pork	MNG440199	Swine	1093

3.7.3.2 Non-permitted

The following text, which provides an overview of nonpoint sources of fecal coliform and *E. coli* bacteria and associated pathogens, is excerpted and adapted from the *Revised Regional Total Maximum Daily Load Evaluation of Fecal Coliform Bacteria Impairments in the Lower Mississippi River Basin in Minnesota* (MPCA 2006) (*Note: refer to 2006 report for references in this section*). At the time, Minnesota's water quality standard was described in terms of fecal coliform colonies as indicators of fecal pathogens; it has since changed to make use of *E. coli* counts (the water quality standard used in these TMDLs) for the same purpose. While the specific indicator has changed, the discussion of likely pathogen sources at a southeast Minnesota regional scale applies to the CRW; specific source information was inserted where appropriate.

The relationship between land use and fecal coliform concentrations found in streams is complex, involving both pollutant transport and rate of survival in different types of aquatic environments. Intensive sampling at numerous sites in southeastern Minnesota shows a strong positive correlation between stream flow, precipitation, and fecal coliform bacteria concentrations. In the Vermillion River Watershed, storm-event samples often showed concentrations in the thousands of organisms per 100 milliliters, far above non-storm-event samples. A study of the Straight River Watershed divided sources into continuous (failing individual sewage treatment systems, unsewered communities, industrial and institutional sources, WWTFs) and weather-driven (feedlot runoff, manured fields, urban stormwater categories). The study hypothesized that when precipitation and stream flows are high; the influence of continuous sources is overshadowed by weather-driven sources, which generate extremely high fecal coliform concentrations. However, during drought, low-flow conditions continuous sources can generate high concentrations of fecal coliform, the study indicated. Besides precipitation and flow, factors such as temperature, livestock management practices, wildlife activity, fecal deposit age, and channel and bank storage also affect bacterial concentrations in runoff (Baxter-Potter and Gilliland, 1988). Fine sediment particles in the streambed can serve as a substrate harboring fecal coliform bacteria. "Extended survival of fecal bacteria in sediment can obscure the source and extent of fecal contamination in agricultural settings," (Howell et. al. 1996). Sadowsky et al. studied growth and survival of *E. coli* in ditch sediments and water in the Seven Mile Creek Watershed; their work concluded that while cattle are likely major contributors to fecal pollution in the sediments of Seven Mile Creek, it is also likely that some *E. coli* strains grow in the sediments and thus some sites probably contain a mixture of newly acquired and resident strains (Sadowsky et. al. 2008 through 2010).

Hydrogeologic features in southeastern Minnesota may favor the survival of fecal coliform bacteria. Cold GW, shaded streams, and sinkholes may protect fecal coliform from light, heat, drying, and predation. Sampling in the South Branch of the Root River showed concentrations of up to 2,000 organisms/100 ml coming from springs, pointing to a strong connection between surface water and ground water (Fillmore County 1999 and 2000). The presence of fecal coliform bacteria has been detected in private well water in southeastern Minnesota. However, many have been traced to problems of well construction, wellhead management, or flooding, not from widespread contamination of the deeper aquifers used for drinking water. Finally, fecal coliform survival appears to be shortened through exposure to sunlight. This is purported to be the reason why, at several sampling sites downstream of reservoirs, fecal coliform concentrations were markedly lower than at monitoring sites upstream of the reservoirs. This has been demonstrated at the Byllesby Reservoir on the Cannon River. Despite the complexity of the relationship between sources and in-stream concentrations of fecal coliform, the following can be considered major source categories:

Urban and Rural Stormwater

Untreated stormwater from cities, small towns, and rural residential or commercial areas can be a source for many pollutants including fecal coliform bacteria and associated pathogens. Fecal coliform concentrations in urban runoff can be as great as or greater than those found in cropland runoff, and feedlot runoff (EPA 2001). Sources of fecal coliform in urban and residential stormwater include pet and wildlife waste that can be directly conveyed to streams and rivers via impervious surfaces and storm sewer systems. Newer urban development often includes stormwater treatment in the form of such practices as sedimentation basins, infiltration areas, and vegetated filter strips. Smaller communities or even rural residences not covered by MS4 permits may be sources of stormwater and associated pollutants. There are five permitted MS4 communities in the CRW: Faribault (MS400233), Northfield (MS400271), Owatonna (MS400244), Red Wing (MS400235), and Waseca (MS400258) (Figure 15). There are many small communities with unknown impacts to bacteria levels in neighboring streams.

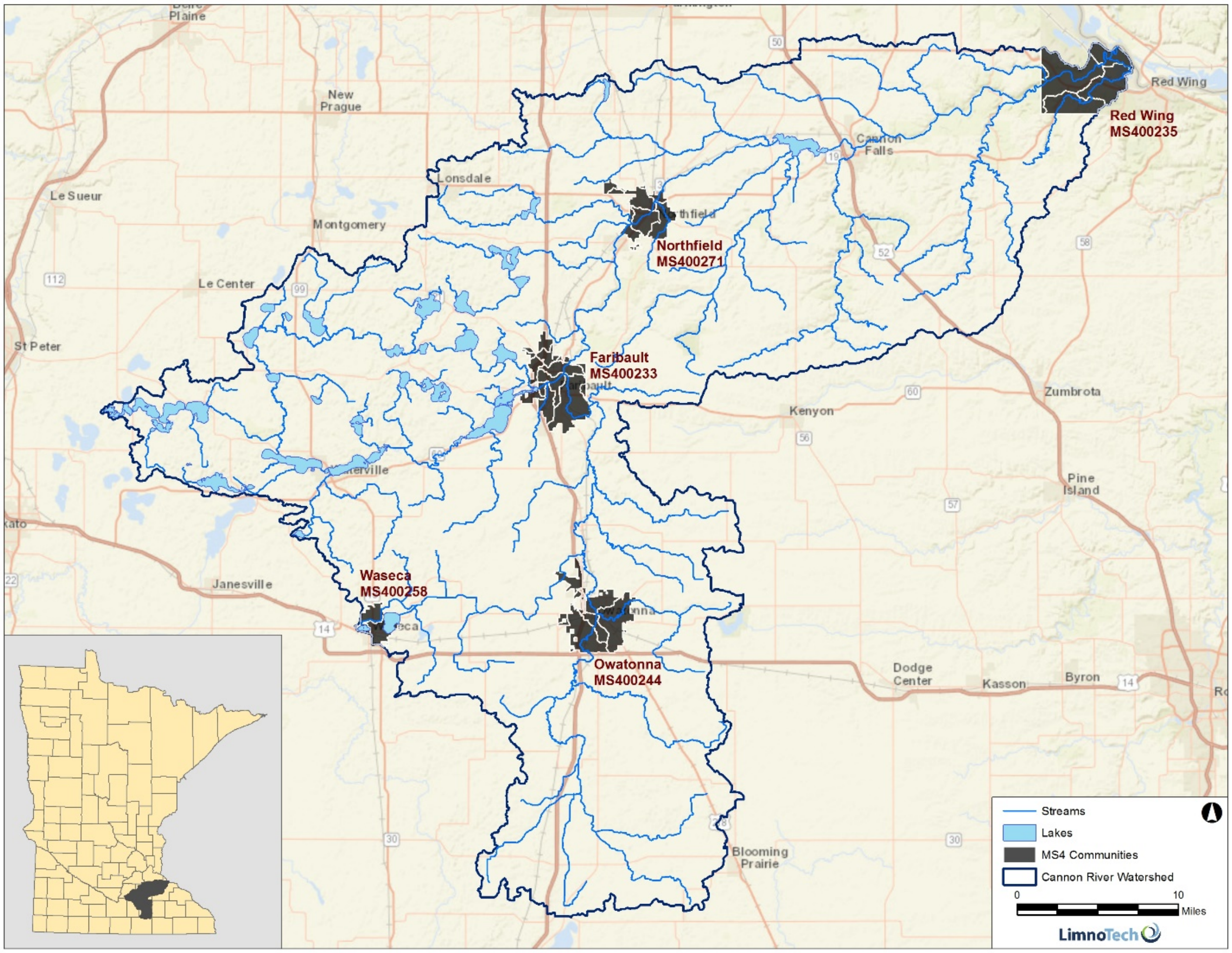


Figure 15. Permitted MS4 communities in the CRW.

Table 27. Permitted MS4 communities in the CRW.

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	List of MS4 Communities	Watershed Area (ac)	MS4 Area (ac)	% MS4 Area	Phosphorus Period of Record	*E. coli* Period of Record	TSS Period of Record	Baseline Year
Chub Creek	Chub Creek	07040002-528	Northfield	54,153.30	355.43	0.66%	-	-	2004-2005; 2008; 2011-2012	2008
Chub Creek	Mud Creek	07040002-558	Northfield	6,318.68	355.43	5.63%	-	1999-2000; 2004-2005	-	2002
Lower Cannon River	Cannon River	07040002-501	Faribault, Northfield, Owatonna, Red Wing, Waseca	895,058.97	37,743.11	4.22%	-	2007-2008; 2011-2012	-	2010
Lower Cannon River	Spring Creek	07040002-569	Red Wing	14,405.18	2,537.64	17.62%	-	2008-2009	-	2009
Middle Cannon River	Cannon River	07040002-507	Faribault, Northfield, Owatonna, Waseca	544,649.40	22,282.22	4.09%	-	2007-2008	-	2008
Middle Cannon River	Byllesby Lake	19-0006-00	Faribault, Northfield, Owatonna, Waseca	733,393	27,317.39	3.72	2001-2004			2003
Middle Cannon River	Cannon River	07040002-508	Faribault, Northfield, Owatonna, Waseca	571,487.24	23,969.17	4.19%	-	2007-2008	-	2008
Middle Cannon River	Cannon River	07040002-509	Northfield	589,428.17	26,961.97	4.57%	-	-	2001-2004	2003
Middle Cannon River	Heath Creek	07040002-521	Northfield	25,528.70	342.95	1.34%	-	2007-2008; 2011-2012	-	2010
Middle Cannon River	Unnamed Creek (Spring Brook)	07040002-557	Faribault, Owatonna, Waseca	4,169.56	9.36	0.22%	-	2007-2008	-	2008

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	List of MS4 Communities	Watershed Area (ac)	MS4 Area (ac)	% MS4 Area	Phosphorus Period of Record	*E. coli* Period of Record	TSS Period of Record	Baseline Year
Middle Cannon River	Cannon River	07040002-581	Faribault, Owatonna, Waseca	489,889.12	20,250.19	4.13%	-	2007-2008	-	2008
Middle Cannon River	Cannon River	07040002-582	Faribault	512,305.78	21,745.86	4.24%	-	2007-2009	-	2008
Middle Cannon River	Unnamed Creek	07040002-703	Owatonna	5,285.13	1,188.05	22.48%	-	2008-2009	-	2009
Straight River	Straight River	07040002-503	Faribault, Owatonna, Waseca	159,359.17	7,928.55	4.98%	-	-	1998-2012	2006
Straight River	Straight River	07040002-515	Owatonna, Waseca	292,291.84	15,665.23	5.36%	-	-	2001-2004; 2009-2010	These AUIDs adjacent; one baseline applies: 2006
Straight River	Straight River	07040002-536	Faribault	246,402.16	11,929.54	4.84%	-	-	No data within simulation period	
Straight River	Falls Creek	07040002-704	Faribault	8,116.52	156.12	1.92%	-	2008-2009	-	2009
Straight River	Clear Lake	81-0014-00	Waseca	1956	783	40%	1996-1999	-	-	1998
Straight River	Loon Lake	81-0014-00	Waseca	459	427	93%	1999-2008	-	-	2004
Upper Cannon River	Cannon River	07040002-540	Faribault	196,569.46	3,515.97	1.79%	-	2007-2008	-	2008
Upper Cannon River	Unnamed Creek	07040002-702		6,216.76	1,004.69	16.16%	-	2008-2009	-	2009

*MS4 Permit numbers: Faribault (MS400233), Northfield (MS400271), Owatonna (MS400244), Red Wing (MS400235), and Waseca (MS400258).

Individual Sewer Treatment Systems

Nonconforming septic systems are an important source of fecal coliform bacteria, particularly during periods of low precipitation and runoff when this continuous source may dominate fecal coliform loads. Unsewered or under sewered communities include older individual systems that are generally failing, and/or collection systems that discharge directly to surface water. This may result in locally high concentrations of wastewater contaminants in surface water, including fecal coliform bacteria, in locations close to population centers where risk of exposure is relatively high. The subsurface sewage treatment systems (SSTS) program at the MPCA keeps records of estimated non-compliant systems and imminent public health threats (IPHT); a sample of these data is provided below (note that the numbers pertain to counties and not watersheds; Steele County however approximates very closely the Straight River Watershed).

Table 28. Subsurface sewage treatment system estimates for four watershed counties.

County	Total SSTS	Non-compliant SSTS	Imminent Public Health Threats
Goodhue	5204	1040	1665
Rice	7177	1363	1363
Steele	3054	763	300
Waseca	2364	543	326

As of 2008, there were 20 small communities in the watershed identified as needing wastewater management improvements. The wastewater treatment concerns ranged from outdated septic systems to individual and community straight pipe connections to lakes and streams. Since that time, many communities (e.g. Hope, Bixby, Beaver Lake, Meriden) have completed several types of wastewater management improvements, including installation of new individual and cluster SSTS, connection to existing treatment facilities, and construction of new community wide WWTFs. County ordinances, inspections, and enforcement actions continue to make significant progress toward resolving wastewater issues.

3.7.4 Nitrates

Minnesota recently initiated two state-level efforts related to nitrogen in surface waters. The MPCA is developing water quality standards to protect aquatic life from the toxic effects of high nitrate concentrations. The standards development effort, which is required under a 2010 Legislative directive, draws upon recent scientific studies that identify the concentrations of nitrate harmful to fish and other aquatic life (MPCA 2013).

Minnesota's NRS, as called for in the 2008 Gulf of Mexico Hypoxia Action Plan, was completed in 2014 (https://www.pca.state.mn.us/sites/default/files/wq-s1-80.pdf). Minnesota contributes the 6th highest N load to the Gulf and is 1 of 12 member states serving on the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force. The cumulative N and phosphorus (P) contributions from several states are largely the cause of a hypoxic (low oxygen) zone in the Gulf of Mexico. This hypoxic zone affects commercial and recreational fishing and the overall health of the Gulf, since fish and other aquatic life cannot survive with low oxygen levels. Minnesota developed a strategy that examines nitrogen loads, sources, trends in surface waters and identifies how further progress can be made to reduce N and P entering both in-state and downstream waters (MPCA 2014d).

The scientific foundation of information for the nitrogen component of the NRS is represented in the 2013 report, *Nitrogen in Minnesota Surface Waters* ("Nitrogen Study" MPCA 2013, http://www.pca.state.mn.us/index.php/view-document.html?gid=19622). This document will be useful as the MPCA and other state and federal organizations further their nitrogen-related work, and also as local governments consider how high N levels might be reduced in their watersheds.

The Nitrogen Study and the NRS state that cropland nitrogen losses through agricultural tile drainage and agricultural GW (leaching loss from cropland to local GW) make up the majority of nitrogen sources in Minnesota, contributing 51%, 68%, and 73% of the nitrogen load under dry, average, and wet years, respectively. In the Lower Mississippi River Basin, agricultural GW is the greatest source of nitrogen to surface waters (MPCA 2014d). Less than 10% of the region's nitrogen load to streams and rivers is delivered via erosion/runoff transport mechanisms (Figure 16). This finding is important in considering tools for targeting and strategies for addressing nitrogen (in contrast to those applied when addressing phosphorus). The two nutrient pollutants are transported to surface waters via distinctly different pathways.

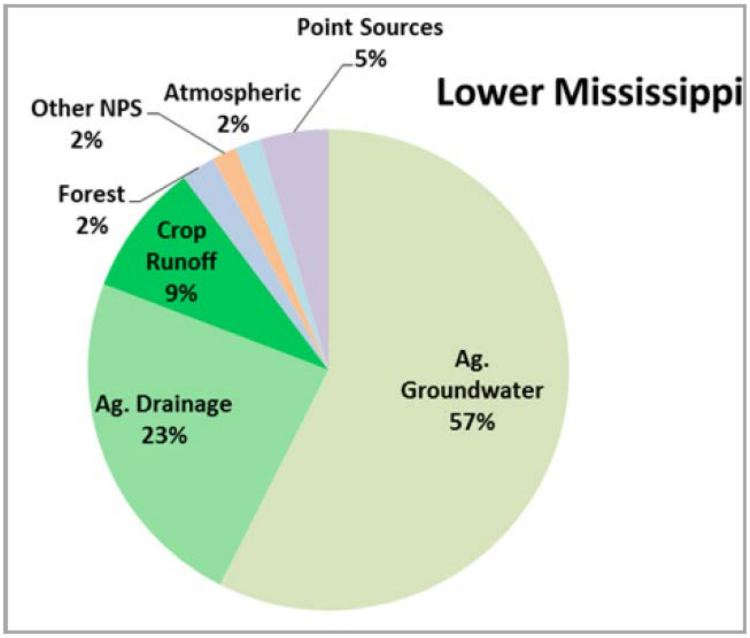


Figure 16. Estimated nitrogen sources from surface waters from the Minnesota contributing areas of the Lower Mississippi River Basin (average precipitation year) (MPCA 2013).

3.7.4.1 Permitted

According to the Nitrogen in Minnesota Surface Waters (MPCA 2013), point sources only contribute 5% of the nitrogen in the Lower Mississippi River Basin. According to the MPCA document titled *Minnesota NPDES Wastewater Permit Nitrogen Monitoring Implementation Plan* the frequency of nitrogen series monitoring requirements in Minnesota's industrial and municipal wastewater NPDES Permits increased, beginning with permits issued in 2014. This was done in order to develop a more complete understanding of the magnitude and dynamics of nitrogen sources and discharges from wastewater sources. On a statewide scale, it has been determined that a majority of point source nitrogen is from the 10 largest municipal facilities (MPCA 2014d).

The regulated sources of nitrate within the watersheds of the nitrate impairments addressed in this TMDL study include NPDES permitted WWTF effluent, construction stormwater, and industrial stormwater. The watersheds of the trout streams in the CRW that are impaired due to high nitrates are not impacted by MS4 regulated areas.

WWTFs tend to discharge high concentrations of nitrate, which is produced from the conversion of ammonia in waste. One very small WWTF in the CRW discharges to the Little Cannon River, which is listed for nitrates: Nerstrand WWTP (MN0065668). The load of nitrates from this WWTF is less than 1% of the loading capacity for the receiving water.

For industrial stormwater, some permitted industrial sectors have benchmark monitoring requirements for total nitrogen as nitrite plus nitrate-nitrogen. If one of these industrial sectors is currently in the watershed or comes into the watershed in the future, it would have the potential to be a source of nitrate.

For construction stormwater, nitrate is not currently covered in the construction permit, but if it becomes more prevalent in stormwater it could be. It was included to avoid potential need for transfers in the future. While sediment itself generally is not associated with nitrate, particulate nitrogen can be 30% to 40% of total nitrogen loads during urban runoff events. Therefore, indirectly, sediment could transport total nitrogen that could later transform to nitrate.

3.7.4.2 Non-permitted

Leaching loss from Agricultural Land Use

In the case of nitrate nitrogen, research has established a correlation between the dominant land use – row crop agriculture – and concentrations in the receiving water. At the largest scale, Goolsby et al examined nitrogen sources in 42 “small basin sites” in the Mississippi-Atchafalaya River Basin. These 42 basins range in size but in general would be viewed as “big rivers” (for example: Raccoon River in Iowa, Upper Mississippi River in Twin Cities metro area). A correlation of watershed row crop land use and nitrate concentration at the 42 river sites found that *“…high nitrate concentrations are associated with basins having either a high percentage of land in row crops (corn, soybeans, or sorghum) or a high population density (people per km2), or both*.” (Goolsby et al. 1999). More locally, Schilling & Libra published in 2000 *The Relationship of Nitrate Concentrations in Streams to Row Crop Land Use in Iowa*. This study correlated long-term mean nitrate concentrations with row crop land use for 15 watersheds (387 to 1,071 square miles) across the state of Iowa. The primary conclusion was that “*In Iowa, nitrate concentrations in surface water show a strong linear relationship to watershed row crop intensity.*”

Stream baseflow is the critical condition with respect to nitrate concentration and loading in heavily karsted watersheds (which contain most of southeast Minnesota’s trout streams). In such settings, unlike sediment and phosphorus, baseflow conducts the majority of the nitrate load, as nutrients readily move vertically from land surface to underlying aquifers. Masarik et al found that baseflow NO_3 alone account[s] for 80% of the annual N loss in the Fever River, which drains an agriculturally dominated watershed in the Northern Mississippi Valley Loess Hills region (Masarik, K.C., G.J. Kraft, D.J. Mechenich, and B.A. Browne. 2007). Jordan, Correll & Weller documented a strong relationship between nitrate concentration and row crop density for 27 study sites in the Chesapeake Bay Watershed and noted that *“…annual flow-weighted mean NO_3 concentrations increase as the proportion of cropland in the watershed increases, but in the Piedmont* [the baseflow dominated streams] *the rate of increase is much* *greater. At any given percentage of cropland, NO_3 concentrations for Piedmont watersheds were generally more than double those for Coastal Plain Watersheds* (Jordan, Correll & Weller, 1997). Schilling and Libra noted that, regarding the Driftless Area watersheds in their study area *"…the three next least-intensively row-cropped watersheds fall above the overall relationship. These are the Upper Iowa, Volga, and Maquoketa, all located in the high-relief, shallow fractured- bedrock terrain of northeast Iowa. This geologic setting allows for the relatively efficient leaching of nitrate-N from the soil, and for the rapid transport of groundwater and nitrate to these "high baseflow" rivers…"*

An analysis of the relationship between base flow nitrate concentrations in southeast Minnesota trout streams and percentage of row crop land in the watersheds of these streams produced a statistically significantly regression. The one hundred trout stream sites examined included six in the CRW. Specific conclusions of this work include:

- Potential Source Linkage: Nitrate concentrations in Southeast Minnesota's trout streams show a strong linear relationship to row crop land use. A linear regression showed a slope of 0.16, suggesting that the average base flow nitrate concentration in the trout stream watersheds of Southeast Minnesota can be approximated by multiplying a watershed's row crop percentage by 0.16. This regression analysis indicates that a watershed of approximately 60% corn and soybean acres corresponds to exceedances of Minnesota's drinking water nitrate-nitrogen standard of 10 mg/L at the point of sample in the stream (trout streams in Minnesota are protected as drinking water sources). This conclusion is supported by the findings of Nitrogen in Minnesota Surface Waters, which describe similar relationships between nitrogen in surface waters and "leaky soils below row crops," which include areas of shallow depth to bedrock such as the trout stream region of Southeast Minnesota (MPCA 2013).
- Potential Natural Background: The natural background level of nitrate in streams appears to be very low given that the base flow concentrations of streams with undisturbed (very little row crop land use and little or no other human impact) watersheds were less than 1 mg/L. Statistical analysis also suggested that in the absence of human disturbance in a watershed, the base flow nitrate concentration at the point of sample in the stream approaches a value that is in general agreement with recent work by the USGS that concluded human impacts are the primary reason for elevated nitrogen in United States surface waters; background concentrations of nitrate were 0.24 mg/L in watersheds dominated by non-urban and non-agricultural land uses (Dubrovsky et al. 2010) (Watkins, Rasmussen, Streitz et al. 2013).

In Figure 17 below, the six CRW points include three in Trout Brook Watershed, two in Rice Creek Watershed and one in the Spring Creek (Goodhue County) Watershed.

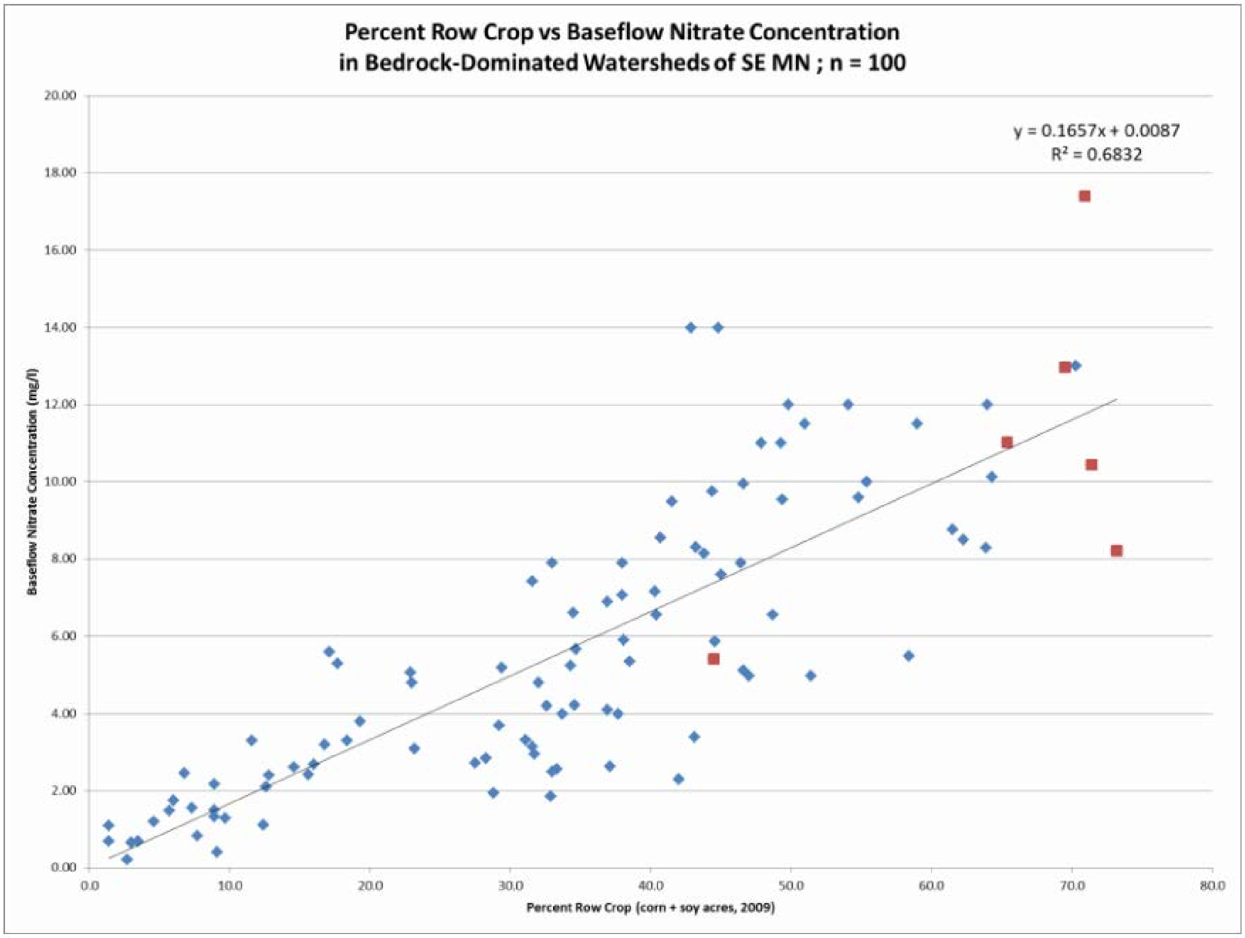
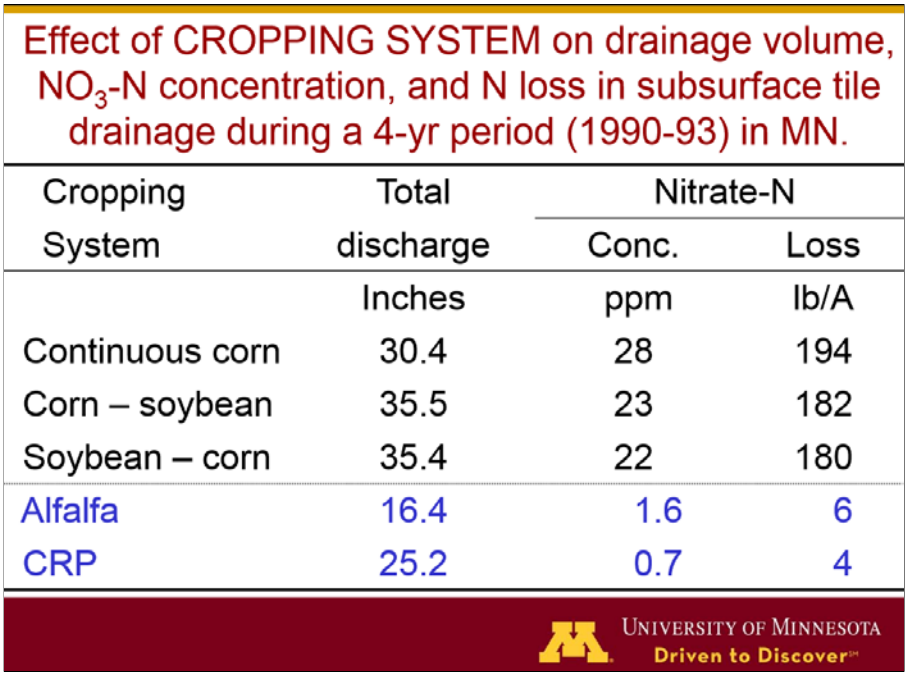


Figure 17. **Baseflow nitrate and row crop acres regression (Watkins, Rasmussen, Streitz et al. 2013.)**

Variable leaching loss across different land uses and within the Cropland N Source

Field and plot-scale work by the University of Minnesota has documented nitrate-nitrogen loading rates (measured via sampling of subsurface tiles) for various cropping systems and other land covers. Over the course of four years of monitoring continuous corn showed the highest loading rate and perennial cover (CRP) showed the lowest loading rate – approximately 50 times less than that of continuous corn (Figure 18).



Effect of CROPPING SYSTEM on drainage volume, NO_3-N concentration, and N loss in subsurface tile drainage during a 4-yr period (1990-93) in MN.

Cropping System	Total discharge	Nitrate-N Conc.	Nitrate-N Loss
	Inches	ppm	lb/A
Continuous corn	30.4	28	194
Corn – soybean	35.5	23	182
Soybean – corn	35.4	22	180
Alfalfa	16.4	1.6	6
CRP	25.2	0.7	4

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Figure 18. Effect of cropping system on nitrogen loss (slide from Gyles Randall, fstU of MN).

In 2010, a nitrate consortium that met in Rochester, Minnesota concluded that monitoring nitrate concentrations in soil water would provide significant support to such efforts to understand and manage nitrogen leaching loss from various land uses and crop management settings in southeast Minnesota. Randall noted that "Nitrate-N concentrations in the soil water at five feet (below the root zone) provide a good basis upon which to compare the environmental risks associated with various N management systems (Randall). For information regarding soil water monitoring of nitrates in southeast Minnesota see the Cannon WRAPS document (MPCA 2016a).

3.7.5 Total Suspended Solids

3.7.5.1 Permitted

The regulated sources of TSSs within the watersheds of the TSSs impairments addressed in this TMDL study include NPDES permitted WWTF effluent, MS4 stormwater, construction stormwater, and industrial stormwater.

3.7.5.2 Non-permitted

This section is addressed in Section 3.7.1.2 with the non-point source phosphorus loads. These two parameters share many of the same sources and are therefore addressed together in discussion of pollutant sources in this document and the WRAPS report.

4 TMDL Development

4.1 Watershed TMDLs Overview

Impaired Stream Reaches

The approach used in calculating the TMDLs for each impaired reach was consistent with the methods used in the Root River Watershed TMDL Report drafted by the MPCA. The TMDL, which is represented as the total loading capacity (TLC), is calculated using the following equation:

$$\mathrm{TLC} = \mathrm{WLA} + \mathrm{LA} + \mathrm{MOS} + \mathrm{RC}$$

Where:

Total Loading Capacity (TLC): the maximum allowed pollutant load calculated at the downstream end of a waterbody such that it does not exceed water quality standards

Wasteload Allocation (WLA): the sum of all point source pollutant loads within the waterbody's drainage area, which includes NPDES permitted industrial and municipal WWTFs, regulated construction and industrial stormwater, and MS4 communities (both present and future)

Load Allocation (LA): remaining pollutant load that is allocated to non-point source loads that do not require a NPDES permit

Margin of Safety (MOS): expressed as a percent of the TLC and accounts for any uncertainty in the calculations of WLA and LA components

Reserve Capacity (RC): accounts for any potential future loading sources that need to be included in the TLC

4.2 Phosphorus

4.2.1 Loading Capacity

Lake Response Model

The modeling software BATHTUB (Version 6.1) was selected to link phosphorus loads with in-lake water quality. A publicly available model, BATHTUB was developed by William W. Walker for the U.S. Army Corps of Engineers (Walker 1999). It has been used successfully in many lake studies in Minnesota and throughout the United States. BATHTUB is a steady-state annual or seasonal model that predicts a lake's summer (June through September) mean surface water quality. BATHTUB's time-scales are appropriate because watershed phosphorus loads are determined on an annual or seasonal basis, and the summer season is critical for lake use and ecological health. BATHTUB has built-in statistical calculations that account for data variability and provide a means for estimating confidence in model predictions. The heart of BATHTUB is a mass-balance phosphorus model that accounts for water and phosphorus inputs from tributaries, watershed runoff, the atmosphere, sources internal to the lake, and GW; and outputs through the lake outlet, water loss via evaporation, and phosphorus sedimentation and retention in the lake sediments.

Model Representation and Inputs

In typical applications of BATHTUB, lake and reservoir systems are represented by a set of segments and tributaries. Segments are the basins (lakes, reservoirs, etc.) or portions of basins for which water quality parameters are being estimated, and tributaries are the defined inputs of flow and pollutant loading to a particular segment. For the 15 lakes shown in bold italics in Table 29, detailed information regarding model inputs and representation can be found in Heiskary and Martin 2015. Model cases for Byllesby Reservoir, Tustin Lake, Union Lake and Upper Sakatah Lake were built by the MPCA staff prior to 2015 and cases for Clear and Loon lakes were built by Mankato State University (MSU Mankato 2016). These BATHTUB modeling results and memos were used to describe loading capacities, LAs and WLAs for these six lakes/reservoir. For the remaining nine lakes, new BATHTUB models were constructed by LimnoTech and represented as single segments with watershed inflow loads estimated using HSPF simulated flows and water quality (see below). Together the BATHTUB models built by the MPCA, MSU Mankato and LimnoTech provided modeling for each of the 30 lakes/reservoir listed in Table 29.

BATHTUB models were developed using available data downloaded from the EQuIS database, and morphometry information found in the CRW Monitoring and Assessment Report (MPCA 2014c). The CRW HSPF (CRWHSPF) model was used to develop flow and TP as boundary inputs for the BATHTUB models (LimnoTech 2015a). The available monitoring data were matched with the CRWHSPF outputs for the 16-year simulation period (1996 through 2012) to determine the averaging period in the BATHTUB models. The BATHTUB models were applied using the *Canfield-Bachman Lakes* option for simulation.

Model Calibration

The BATHTUB models were calibrated using the most recent available water quality data (Table 29). For many of the lakes, the predicted water quality was much better than observed. As described in Heiskary and Martin (2015), in many cases (especially for shallow lakes and those with varying rough fish populations and wind fetches) it is difficult to fully account for the differences in observed and predicted water quality. A component of the BATHTUB model inputs is internal loading. For most lakes this value was adjusted to provide a match between the predicted TP concentration and the observed TP concentration. In many cases, the internal loading rate used to calibrate the model was very high. Heiskary and Martin (2015) note (see 3.7.1) that s*everal of the lakes demonstrate factors that can allow for excessive internal loading: shallowness, wind mixing, high temperatures, high pH, and/or abundant sediment disturbing carp. If external loads were calculated with a high degree of confidence, it might be reasonable to assign the "unaccounted for" portion of the estimated P budget to internal recycling -- but that was not the case for most of the modeled lakes.* As such the loads of phosphorus added to the simulations should be considered "unaccounted for phosphorus" and not definitively described as internal loads. More detailed examination of the phosphorus budgets for the upper Cannon lakes would be useful for lake management planning. Table 29 summarizes the unaccounted for TP load used to calibrate the current conditions model.

Table 29. Calibrated Bathtub results for current conditions. Detailed information for the lakes in bold italics can be found in Heiskary and Martin (2015).

Lake	Total Phosphorus (ug/L)		Unaccounted for TP Load (mg/m²/day)*
	Predicted	Observed	
Byllesby Reservoir	See appendices		
Cannon	310.4	310.4	28.16
Caron	345.1	340.0	8
Cedar	47.5	50.0	0
Chub	172.8	172.8	1.454
Circle	315.5	330.0	9
Clear	80	80	0.517
Dora	328.9	351.0	3
Fox	63.6	59.0	0
Frances	84.5	84.5	1.512
French	157.5	157.0	5
Gorman	761.6	790.0	20
Horseshoe	87.4	87.4	0.94
Hunt	99.2	90.0	1
Loon	210	210	1.45
Lower Sakatah	375.4	375.3	67.9
Mabel	105.8	100.0	0
Mazaska	119.6	110.0	3
Rice	405.1	423.0	11
Roberds	246.6	266.0	8
Sabre	803.2	1000.0	20
Shields	255.4	293.0	8
Silver	113.7	113.7	0.341
Sunfish	72.4	63.0	0
Tetonka	346.6	346.6	36.52
Toners	178.0	178.0	1.153
Tustin	179.0	178.0	6
Union	450	228	19.986
Upper Sakatah	265	242	19.9856
Wells	330.4	330.4	49.45

*Note: Internal phosphorus sedimentation rate was adjusted to match the predicted load to the observed load

Once the model was calibrated, the internal load and tributary inflow values were adjusted by equal amounts to match the water quality standard after applying the MOS. Target TMDL concentrations and predicted TMDL concentration are summarized in Table 30. In addition to meeting P limits, Chl-*a* and Secchi transparency standards must also be met. 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 P target in each lake, the Chl-*a* and Secchi standards will likewise be met.

Clear Lake was modeled to attain the WCBP goal of 65 ug/l TP. Loon Lake was modeled to attain the shallow lakes goal for the WCBP of 90 ug/l phosphorus. See MSU Mankato (draft 2016) for more details regarding derivation of loading capacities for these lakes which are included in subsequent tables. The Byllesby Reservoir was modeled to attain a site specific standard (see 2.2.1.1); this BATHTUB application is discussed in text following Table 30.

Table 30. TMDL Bathtub predictions. Corresponding loading capacities summarized in TMDL summary tables in Section 4.2.6.

Lake	Total Phosphorus (ug/L)		
	Predicted	Goal*	NCHF Ecoregion Lake Eutrophication Standard Shallow lakes: 60 Deep lakes: 40
Byllesby Reservoir	88.5	90	90 (site specific standard)
Cannon	54	54	60
Caron	54	54	60
Cedar	36	36	40
Chub	54	54	60
Circle	54	54	60
Clear**	65	65	Western Corn Belt Plains Eutrophication Standard: 65
Dora	54	54	60
Fox	36	36	40
Frances	36	36	40
French	36	36	40
Gorman	54	54	60
Horseshoe	54	54	60
Hunt	36	36	40
Lower Sakatah	54	54	60
Loon**	90	90	Western Corn Belt Plains Shallow Lakes Eutrophication Standard: 90
Mabel	54	54	60
Mazaska	36	36	40
Rice	54	54	60
Roberds	36	36	40
Sabre	54	54	60
Shields	36	36	40
Silver	54	54	60
Sunfish	36	36	40
Tetonka	36	36	40
Toners	54	54	60
Tustin**	55	60	60
Union**	57	60	60
Upper Sakatah**	60	60	60
Wells	54	54	60

*Note: TMDL loads calibrated for value 10% of Standard to incorporate MOS.

**Note: TMDL loads for these lakes calibrated at or near standard; 10% MOS subtracted from loading capacity.

Application of BATHTUB for the Byllesby Reservoir

The Byllesby Reservoir is unique in the CRW in that there have been over the years data accumulated with the intention of estimating the load of phosphorus from the Cannon River to the reservoir inflow. None of the other lakes in the watershed are supported by such data and thus no others made use of modeled inflow phosphorus loads.

For Byllesby, a second model or program, FLUX, provided input data to the BATHTUB model. FLUX was used to analyze empirical water monitoring data collected on the in-flows (i.e. Cannon River and other tributaries) to the Byllesby Reservoir and produce phosphorus loads and flow-weighted concentrations. In summary, FLUX provides the phosphorus inputs to the Byllesby Reservoir, and the BATHTUB model processes these inputs to give the lake water quality response to the inputs. Further details on the BATHTUB and FLUX modeling, including the predicted and observed values, are included in Appendices B and D.

Model selection:

- The default models in BATHUB were selected (Table 31).
- Set model variables secchi/Chl-*a* slope to 0.01 due to bloom forming species. The model was not calibrated (calibration is useful for situations in which the reservoir of interest is quite different than the reservoirs that were used to establish the model. The Byllesby Reservoir is a "typical" reservoir).

Table 31. Selected models in BATHTUB for Byllesby Reservoir modeling.

Parameter	Model selection
Total Phosphorus	01 2ND ORDER, AVAIL P
Total Nitrogen	00 NOT COMPUTED
Chl-*a*	02 P, LIGHT, T
Transparency	VS. CHLA & TURBIDITY

A Study of Sediment Phosphorus Release from Lake Byllesby (Cornwell and Owens 2004) found that the recycling of sediment phosphorus to the water column varies from year to year, but averages approximately 7% of TP and 16% of soluble reactive phosphorus inputs to the reservoir (Cornwell and Owens 2004). This report is included in its entirety as Appendix E.

Loading Capacity Determination for Byllesby Reservoir

Analysis of Flow Conditions

A key consideration for establishing a phosphorus loading capacity for a lake, and especially a reservoir, is deciding on the flow conditions under which the concentration-based goals should apply. The MPCA has typically applied a 1 in 10 year recurrence probability to establish the low flow. This is simply the lowest flow that is likely to occur once every 10 years on average. The other end of the flow spectrum for Byllesby and other reservoirs is determined by water residence time. During higher flows in the Cannon River, the entire volume of the reservoir can be flushed in a matter of two weeks or less. Under these conditions, the reservoir is functioning more like a river system, and the lake concentration-based goals are not appropriate.

The approach taken for Byllesby was to identify actual years that most represent both the low flow condition and the higher flow conditions. The real flow records from those years were used in the BATHTUB model to predict the loading capacity consistent with the attainment of the goals described in the site specific standard documentation. As will be described further, 1950 and 2003 were selected as representing low flow conditions; and 2002 was selected as representing higher flow (but still lake-like) conditions.

The major in-flow to the Byllesby Reservoir is the Cannon River. Approximately 15 miles downstream of the reservoir at Welch, Minnesota is long-term U.S. Geologic Survey flow gauging station. Average daily flow values are available from this station dating back to 1910, although gaps in the record do exist from 1914 to 1929, and 1972 to 1990. These flow data provide the basis for prediction of the 1 in 10 year low flow. With such predictions, it is often the case that the entire flow record would be analyzed. During technical committee discussion, however, questions were raised about whether historic flow conditions (including such dry periods as the 1930s) were the appropriate basis for predicting future flow conditions. As indicated in Figure 19, it does appear that average annual flows at Welch have been higher in recent years. An additional issue for analyzing this flow record is the 1972 to 1990 gap in data at Welch. To provide a more complete picture of flows in this more recent period, this gap was “filled” by extrapolating flows from the nearby gauging station on the Straight River just south of Faribault, Minnesota. These two stations have 21 years of overlapping flow records. Figure 20 shows the relationship between the May through September average flows for these stations of the 21 years. Based on the strong R-squared value (0.85), Cannon River flows for 1972 to 1990 were estimated based on the regression equation shown.

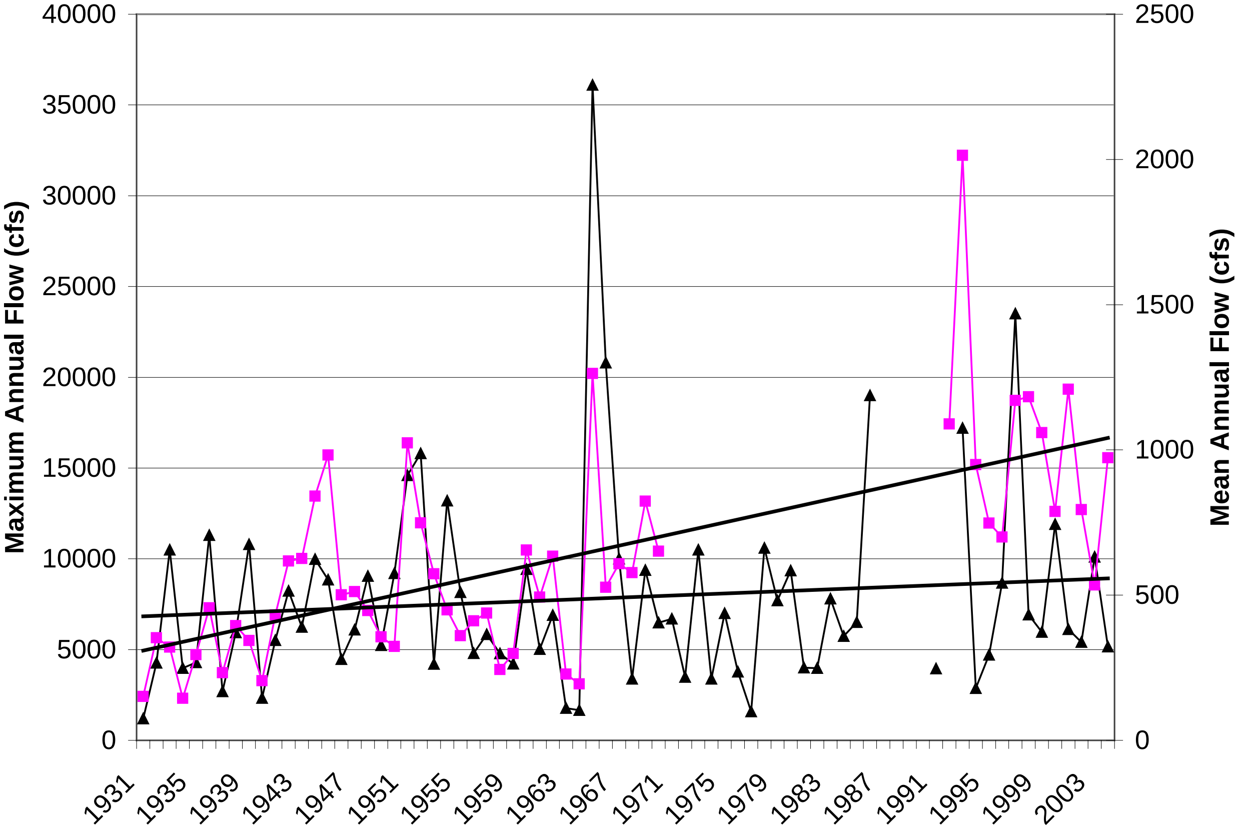


Figure 19. Average Annual (boxes; upward trending line; right axis) and Maximum Annual (triangles; flatter line; left axis) Flow at Welch.

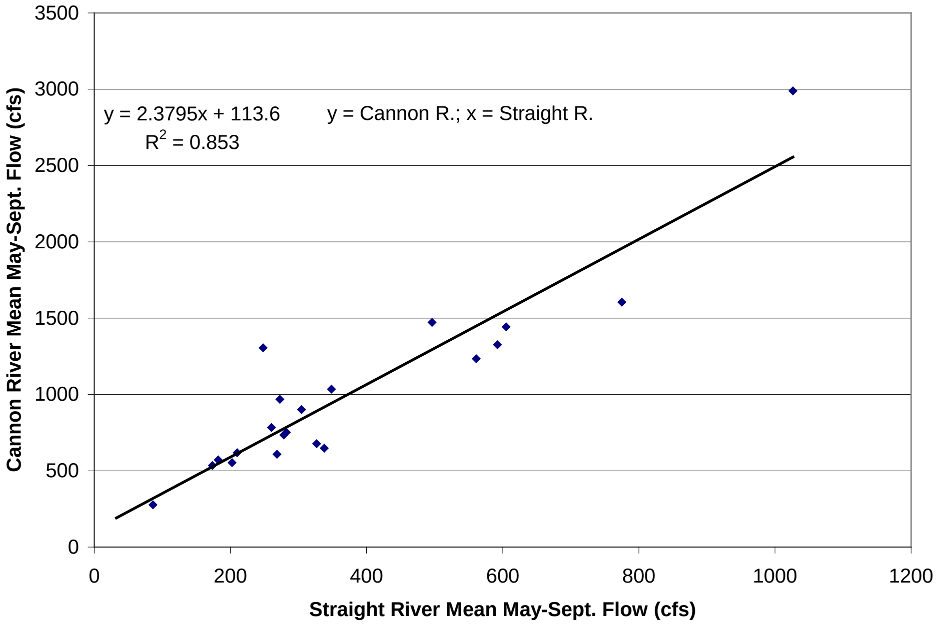


Figure 20. Straight and Cannon River Flows (1966-1971; 1992-2006).

With the inclusion of the 1972 to 1990 predicted flow values for the Cannon River, flow percentiles were analyzed using different periods of record. Table 32 shows those flow percentiles for the years 1950, 2002, and 2003. The full flow percentile analysis is shown in Appendix F.

Table 32. Cannon River Flow Percentiles for Different Years and Periods of Record.

	Flow Percentiles **(0% = lowest flow; 10% = 1 in 10 year low flow)**		
Flow Record	**1950**	**2002**	**2003**
Full: 1910-1913; 1930-2006	6%	73%	60%
30-year: 1977-2006	N/A	48%	27%
16-year: 1991-2006	N/A	40%	13%

Based on this analysis, it was confirmed that both 1950 and 2003 would be used in the FLUX and BATHTUB modeling to predict phosphorus loading capacity for low flow conditions in the Byllesby Reservoir. Within the more recent periods of record 2003 is representative of low flow conditions (in that year, there was a significant rain event in May, followed by very little precipitation and very low flows through September). To err on the conservative side and thus strengthen the MOS, a low flow year from the full period of record (1950) was paired with 2003 to arrive at a representative low flow year. Using these two years gives equal weight to both long-term flow conditions, and what appears to be a trend of higher flow in more recent years. The flow percentiles for 2002 suggest that lake-like flow conditions occur in 40% to 73% of years. In the other years, flows are such that the reservoir is functioning more like a river system, and the lake concentration-based goals are not appropriate.

Estimated Phosphorus Loading and Loading Capacities

Table 33 presents estimated TP loading to the Byllesby Reservoir for lower flow conditions (1950 and 2003), and for higher flow (but still lake-like) conditions (2002). For 2002 and 2003, the estimates are fully grounded in empirical phosphorus and flow monitoring data. For 1950, where there are only flow data available, the estimate is based on phosphorus dynamics observed in more recent years. Stated another way, the phosphorus load for 1950 should be viewed as the phosphorus load that would likely occur today if there were a year with flow conditions identical to those observed in 1950. The HSPF modeling documents provide estimates of phosphorus loads to the reservoir through 2012 (LimnoTech 2015 a & b).

Table 33. Estimated TP Loading to Byllesby Reservoir.

	Lower flow		**Higher flow**
	1950	**2003**	**2002**
Total phosphorus (kg/yr)	48,640	142,700	227,930

* 1950/2003 average = 95,670 kg/yr

Table 34 presents TP loading capacities for lower flow, and higher flow lake-like, conditions in the Byllesby Reservoir. These capacities were derived by reducing the BATHTUB loading input values (i.e. the values shown in Table 33) to the point where BATHTUB predicted that the reservoir would meet summer mean TP and Chl-*a* concentrations less than 90 µg/l and 30 µg/l, respectively, and a summer-mean Secchi transparency of greater than 0.8 meters. The loading capacities for 1950 and 2003 are averaged to arrive at a single lower flow loading capacity value that will serve as the basis for subsequent TMDL allocations.

Table 34. TP Loading Capacities for Byllesby Reservoir.

	Lower flow	**Higher flow**
Reference Year(s)	**1950/2003**	**2002**
Total phosphorus (kg/yr)	54,190	91,520

A key outcome of the BATHTUB modeling and derivation of loading capacities for the reservoir is that as noted in the site specific standard documentation (Appendix C), to achieve water quality goals in Byllesby a Cannon River flow weighted mean concentration (FWMC) of approximately 0.150 mg/l will be required. This value coincides with the river eutrophication standard (RES) for the Cannon River at Byllesby and was the inflow goal used in the derivation of the WLAs for upstream NPDES Permits (described in subsequent text below).

4.2.2 Load Allocation Methodology

The LA is the portion of the total loading capacity assigned to nonpoint and natural background sources of nutrient loading. These sources include the atmospheric loading and nearly all of the loading from watershed runoff, or in this case tributary inflow. The only portion of the watershed runoff not included in the LA is the small loading set aside for regulated stormwater runoff from construction and industrial sites. The LA includes nonpoint sources that are not subject to NPDES Permit requirements, as well as “natural background” sources. These include sources of phosphorus such as soil erosion or nutrient leaching from cropland, phosphorus-laden runoff from communities not covered by NPDES Permits, and streambed and streambank erosion resulting from human-induced hydrologic changes and disturbance of stream channels and riparian areas. In addition, some phosphorus may leach into the reservoir or its upstream tributaries from poorly functioning septic systems. Natural background sources of phosphorus include atmospheric deposition, as the relatively low levels of soil erosion from both stream channels and upland areas that would occur even under “natural conditions.” The LAs expressed in Tables 37 through 66 are the loading capacity that remains after the WLA and MOS have been subtracted.

4.2.3 Wasteload Allocation Methodology

4.2.3.1 Permitted Industrial and Municipal Wastewater Facilities

Within the CRW, there are 31 NPDES permitted Industrial and Municipal WWTFs upstream of the Byllesby Reservoir (the downstream-most phosphorus impaired waterbody). Each facility is permitted for specific water quality limits at their discharge. Listed below are the methods used to determine WLAs for a majority of the NDPES facilities:

- For cases in which dischargers have been given limits based on lakes more local than Byllesby, those limits were used to calculate the WLAs included in Appendix G: Elysian (Tustin Lake), Lonsdale (Union Lake) and Waterville (Upper Sakatah Lake). Morristown and Medford also have existing phosphorus limits which were used to calculate their WLAs.
- Stabilization pond WWTP WLAs were calculated using design flows and phosphorus concentrations of 2 mg/l, which is consistent with the approach in the draft Lake Pepin Phosphorus TMDL WLA derivations.
- Pit dewatering (quarries) WLAs were calculated using design flows and the Byllesby Reservoir in-lake TP goal of 0.090 mg/l. This is a conservative measure in that GW is generally low in phosphorus.
- Absent any monitoring data, non-contact cooling water discharge WLAs were calculated using design flows and the Byllesby Reservoir in-lake TP goal of 0.090 mg/l.
- The contact cooling water discharge WLAs for Lakeside Foods and Faribault Foods were calculated using design flows and available monitoring data.
- The non-contact cooling water discharge WLA for Viracon was calculated using design flows and a concentration of 0.5 mg/l TP to account for polyphosphate additives in the Owatonna municipal well water. This best available estimate (not based on monitoring data) was provided by Owatonna Public Works (personal communication).

The TP concentrations used to derive the WLAs for the pit dewatering, non-contact and contact cooling water dischargers should be verified at time of permit reissuance. It should be noted that in sum these dischargers comprise approximately 13% of the total WLA for the Byllesby Reservoir.

For the Byllesby Reservoir a method described in detail below was used to determine the WLAs for Faribault WWTP, Northfield WWTP, and Owatonna WWTP.

The CRWHSPF model was used to determine TP WLAs for the Faribault, Owatonna, and Northfield WWTPs that would result in goal attainment for the Byllesby Reservoir as measured at the Cannon River inflow. An average TP concentration of ≤0.150 mg-P/L at the 80th percentile flow during the June through September period served as the goal attainment threshold (MPCA 2015). The TP ≤0.150 mg-P/L target is also the RES, although the RES is measured as a long-term summer average (MPCA 2015). Complete documentation of the CRWHSPF model, including development, calibration, and validation is provided in the "CRWHSPF Model Development Project" final report (LimnoTech 2015a).

A series of six simulations were conducted using the CRWHSPF model in which the June through September effluent TP concentrations for the Faribault, Owatonna, and Northfield WWTPs were reduced downward from the permitted limit of 1.0 mg-P/L in increments of 0.10 mg-P/L while maintaining design flows for the entire year. The June through September major WWTP effluent TP loads for the six simulations are shown in Table 35. TP concentrations for the major WWTPs remained at the permitted limit of 1.0 mg P/L for the October through May period under all simulations. TP WLAs for all other point sources remained constant across all six simulations using values provided by the MPCA (Appendix G). All simulations assumed the following nonpoint source actions:

- Cover crops applied to approximately 12.4% of cropland acres with the highest sediment yields in the Byllesby Watershed;
- Conversion of all cropland acres classified as "marginal lands" and all cropland acres falling within a 50 feet buffer of rivers/streams to perennial vegetation;
- Reduction in the low flow TP concentrations in the Straight River upstream of the Owatonna WWTF, and elsewhere in the Straight River lobe, to approximately 0.10 mg-P/L.

Additional descriptions of the above-listed nonpoint source actions are provided in the "CRWHSPF Model Development Project-Phase II" Task 1 technical memorandum (LimnoTech 2015b). The TP load reductions resulting from these nonpoint source management actions are considered necessary for achieving goal attainment for the Byllesby Reservoir. As specified in Minn. R. 7053.0205, subp. 7(c), and the MPCA procedures for implementing RES in NPDES Wastewater Permits, reductions in TP loads from sources such as nonpoint shall be considered when setting point source effluent limits (MPCA 2015).

Table 35: June-September effluent TP concentrations and loads assumed for the Faribault, Owatonna, and Northfield WWTPs for six simulations conducted using the CRWHSPF model

Simulation	Jun.-Sep. Effluent TP conc. (mg/L)	Faribault WWTP TP Load (kg/day) at 7.0 MGD	Owatonna WWTP TP Load (kg/day) at 5.0 MGD	Northfield WWTP TP Load (kg/day) at 5.2 MGD	Combined Jun.-Sep. TP Load (kg/day)
1	1.0	26.50	18.93	19.68	65.11
2	0.9	23.85	17.03	17.72	58.60
3	0.8	21.20	15.14	15.75	52.09
4	0.7	18.55	13.25	13.78	45.58
5	0.6	15.90	11.36	11.81	39.07
6	0.5	13.25	9.46	9.84	32.55

Results from the six CRWHSPF model simulations suggest the following seasonal (June through September) WLAs would result in TP concentration goal attainment for the Byllesby Reservoir as measured at the Cannon River inflow: 15.90 kg-P/day for Faribault, 11.36 kg-P/day for Owatonna, and 11.81 kg-P/day for Northfield (Simulation #5 in Table 35). These TP WLAs were arrived upon by examining the load-response relationship shown in Figure 21. The independent variable on the load-response curve is the combined June through September TP load from the three major WWTPs. The dependent variable is the average TP concentration at the 80th percentile flow during the June through September period at the Cannon River inflow to Byllesby Reservoir. The TP load from the three major WWTPs greater than approximately 40 kg/day resulted in instream average TP concentrations at the 80th percentile flow above the goal attainment threshold of less than 0.15 mg-P/L. Therefore, assuming the specified TP WLAs from other point sources (Appendix G) and implementation of the nonpoint source actions described above, the CRWHSPF model suggests that if the combined June through September. The TP load from the three major WWTPs is less than 40 kg/day goal attainment for Byllesby Reservoir will be achieved. Table 36 presents seasonal and annual TP WLAs for the three major WWTPs and the combined WLA for all other permitted point sources.

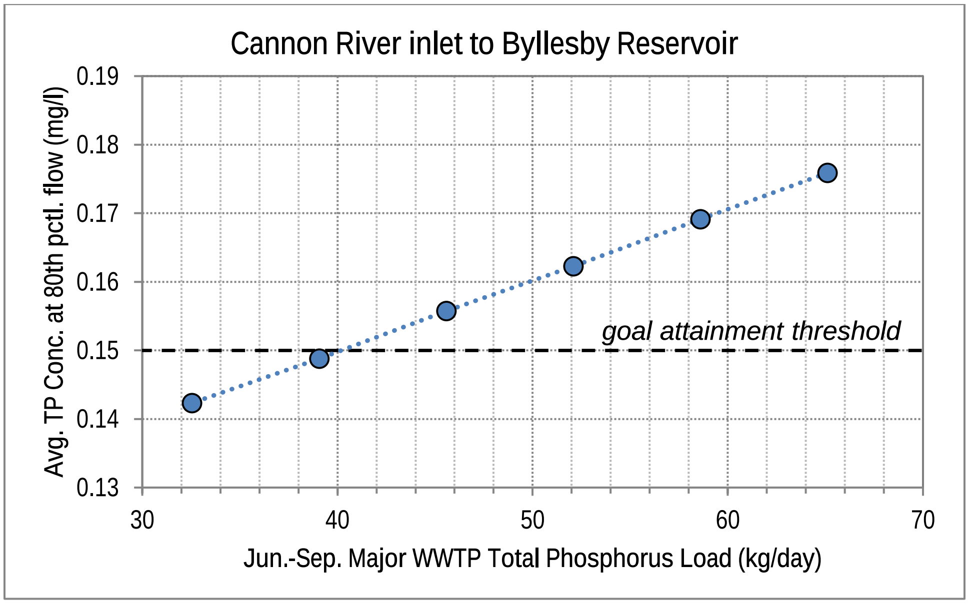


Figure 21: Simulated TP concentration at the 80th percentile flow (June through September) at the Cannon River inlet to Byllesby Reservoir for six CRWHSPF model simulations (1996 – 2012).

Table 36: Seasonal and annual TP WLAs for the Faribault, Owatonna, and Northfield WWTPs and the combined WLA for all other permitted point sources.

Wasteload Allocation	Jun.-Sep. (kg/day)[1]	Oct - May. (kg/day)	Annual (kg/yr)
City of Faribault WWTP	15.90	26.50	8,379
City of Owatonna WWTP	11.36	18.93	5,985
City of Northfield WWTP	11.81	19.68	6,224
All other WWTF & Industrial Permits (see Appendix G)[2]	41.31	41.31	5,588
SUBTOTAL	80.36	106.42	26,173

[1] June-September assumes TP=0.60 mg/l and design flow for major WWTPs
[2] June-September and Dec-Mar. value assumes no pond discharge

4.2.3.2 Permitted Industrial Stormwater Facilities

There was no individual permitted industrial stormwater facilities that required a WLA. Impaired AUIDs were not assigned a “0” WLA, but rather listed as NA (Not Applicable).

4.2.3.3 Regulated Construction and Industrial Stormwater

A permit is required for any construction activities disturbing: one acre or more of soil; less than one acre of soil if that activity is part of a “larger common plan of development or sale” that is greater than one acre; or less than one acre of soil, but the MPCA determines that the activity poses a risk to water resources. A construction stormwater runoff WLA is needed to account for pollutant loading (TP, TSS and nitrate) from ongoing construction activity in the watershed. The Minnesota Stormwater Manual average of construction activity for the six counties in the watershed (Le Sueur, Waseca, Steele, Rice, Dakota, and Goodhue) is approximately 0.075% (http://stormwater.pca.state.mn.us/index.php/Construction_activity_by_county). Thus a generally appropriate estimate of the WLA for construction stormwater is 0.1% of the TMDL watershed load. This estimate was used in CRW TMDL computations. Note that in the TMDL tables, some of the daily construction and industrial stormwater WLAs are very small values and are expressed as “0.00” due to rounding and displayed decimal places. This does not constitute a “0” WLA; the daily WLAs are simply the annual WLAs divided by 365 (days).

4.2.3.4 Regulated MS4 Stormwater

MS4 systems are designed to convey stormwater into a receiving waterbody and are permitted under the NPDES Permit.

All MS4 communities are existing communities and are included in the WLA. No future communities are planned that need to be included in this portion of the WLA.

MS4 allocations were calculated using the following equation:

$$\mathrm{MS4\ Allocation} = \%\mathrm{MS4\ Area} * (\mathrm{TLC} - \mathrm{MOS} - \mathrm{Permitted\ WW\ Facitilies})$$

Where:

%MS4 Area: the ratio of the total MS4 area to the total drainage area for the given AUID. Areas were obtained using ArcMap.

Permitted WW Facilities: the total WLA for all permitted industrial and municipal WWTFs that discharge into the AUID’s drainage area.

4.2.4 Margin of Safety

The FLUX computations and BATHTUB model for the Byllesby Reservoir provide the basis for a 10% MOS used in the TMDL computations for Byllesby and the lakes upstream. The output from these tools includes coefficients of variance (CV) statistics that describe the error or uncertainty associated with the loading and in-lake water quality estimates. A review of the CV’s for the major in-flow phosphorus loading estimates for 1950, 2002, and 2003 show values ranging from 0.039 (3.9%) to 0.084 (8.4%). Given that there are other points of uncertainty, and to be conservative, an explicit MOS was of 10% was selected. The use of FLUX CVs is cited in the Lake TMDL Protocol and Submittal Requirements as an acceptable means of arriving at a MOS (MPCA).

The MOS was incorporated in most of the lake TMDLs by modeling to an end point that is 10% beyond goal attainment. For Clear, Loon, Tustin, Union, Upper Sakatah lakes and the Byllesby Reservoir the 10% was subtracted from the loading capacity that corresponds to modeled goal attainment.

The MOS for the Byllesby Reservoir also includes two implicit components: (1) a conservative measure was used in computational processes: in defining a representative low flow year, a year (1950) outside the typically-used 30-year period of record was incorporated (averaged with the year 2003); 1950 was a 6% low flow year; using it in this analysis thus reduces the allowable load required to meet the water quality goals modeled in BATHTUB, and (2) some of the quarry dewatering discharges for which water quantity and quality details are not available were not included in the model simulations; this is a conservative measure in that quarry dewatering is typically a dilution for receiving waters in southeast Minnesota (total phosphorus concentrations in groundwater are relatively low).

4.2.5 Seasonal Variation

In-lake water quality varies seasonally. In Minnesota lakes, the majority of the watershed phosphorus load often enters the lake during the spring. During the growing season months (June through September), phosphorus concentrations may not change drastically if major runoff events do not occur. However, Chl-*a* concentration may still increase throughout the growing season due to warmer temperatures fostering higher algal growth rates. In shallow lakes, the phosphorus concentration more frequently increases throughout the growing season due to the additional phosphorus load from internal sources. This can lead to even greater increases in Chl-*a* since not only is there more phosphorus but temperatures are also higher. This seasonal variation is taken into account in the TMDL by using the eutrophication standards (which are based on growing season averages) as the TMDL goals. The eutrophication standards were set with seasonal variability in mind. The load reductions are designed so that the lakes and streams will meet the water quality standards over the course of the growing season (June through September).

Critical conditions in these lakes occur during the growing season, which is when the lakes are used for aquatic recreation. Similar to the manner in which the standards take into account seasonal variation, since the TMDL is based on growing season averages, the critical condition is addressed by the TMDL.

4.2.6 Reserve Capacity

For the Byllesby Reservoir phosphorus TMDL, a small Reserve Capacity (RC) is available to establish WLAs for the conversion of existing phosphorus loads; it is not intended to provide WLAs for new and expanding industrial or municipal discharges. Reserve Capacity will support projects that address failing or nonconforming septic systems and “unsewered” communities and will be made available only to new WWTPs or existing WWTPs that provide service to existing populations with failing or nonconforming systems. The RC mass was calculated using a kilograms of phosphorus per person per year multiplier of 0.16, which was the value applied in the Lake St. Croix Nutrient TMDL (MPCA & WDNR 2012). An examination of unsewered communities in the CRW provided a population estimate of 1703; the resultant RC mass is 272 kg/yr as indicated in Table 41.

4.2.7 TMDL Summaries

Table 37. CHUB CREEK HUC-10: Chub Lake – 19-0020-00

Chub Lake 19-0020-00 TMDL Summary		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		kg/yr	kg/day	kg/yr	kg/day	kg/yr	%
Phosphorus Loading Capacity (TMDL)		**764.27**	**2.09**	**123.50**	**0.34**	**640.77**	**83.84**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial WWTFs*	NA	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.25	0.00	0.25	0.00	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	**0.25**	**0.00**	**0.25**	**0.00**	**0.00**	**NA**
Total LA		**764.03**	**2.09**	**123.26**	**0.34**	**640.77**	**83.87**
10% Margin of Safety^		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

* No permitted wastewater facilities within lake drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

^ 10% MOS was taken off of WQ target concentration and is implicit in the TMDL loading capacity

Table 38. MIDDLE CANNON RIVER HUC-10: Circle Lake – 66-0027-00

Circle Lake 66-0027-00 TMDL Summary		**Existing TP Load**		**Allowable TP Load**		**Estimated Load Reduction**	
		kg/yr	**kg/day**	**kg/yr**	**kg/day**	**kg/yr**	**%**
Phosphorus Loading Capacity (TMDL)		**15071.17**	**41.26**	**1389.66**	**3.80**	**13681.51**	**90.78**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	2.78	0.01	2.78	0.01	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	**2.78**	**0.01**	**2.78**	**0.01**	**NA**	**NA**
Total LA		**15068.39**	**41.25**	**1386.88**	**3.80**	**13681.51**	**90.80**
10% Margin of Safety^		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

* No permitted wastewater facilities within lake drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

^ 10% MOS was taken off of WQ target concentration and is implicit in the TMDL loading capacity

Table 39. CRANE CREEK HUC-10: Clear Lake – 81-0014-00

Clear Lake 81-0014-00 TMDL Summary		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		kg/yr	kg/day	kg/yr	kg/day	kg/yr	%
Phosphorus Loading Capacity (TMDL)		998.00	2.73	683.00	1.87	383.3	38.41
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	1.23	0.00	1.23	0.00	0.00	0.00
	Waseca MS4 (40%)	399.20	1.09	245.88	0.67	153.32	NA
	Total WLA	400.43	1.10	247.11	0.68	153.32	NA
Load Allocation		597.57	1.64	367.59	1.01	229.98	NA
10% Margin of Safety		NA	NA	68.30	0.19	NA	NA

* No permitted wastewater facilities within lake drainage area

** No permitted individual stormwater facilities in the Cannon River Watershed

Table 40. CRANE CREEK HUC-10: Loon Lake – 81-0015-00

Loon Lake 81-0015-00 TMDL Summary		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		kg/yr	kg/day	kg/yr	kg/day	kg/yr	%
Phosphorus Loading Capacity (TMDL)		364.00	1.00	112.00	0.31	263.20	72.31
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.20	0.00	0.20	0.00	0.00	0.00
	Waseca MS4 (93%)	338.52	0.93	93.74	0.26	244.78	NA
	Total WLA	338.72	0.93	93.95	0.26	244.78	NA
Load Allocation		25.28	0.07	6.85	0.02	18.42	NA
10% Margin of Safety		NA	NA	11.20	0.03	NA	NA

* No permitted wastewater facilities within lake drainage area

** No permitted individual stormwater facilities in the Cannon River Watershed

Table 41. MIDDLE CANNON RIVER HUC-10: Byllesby Reservoir – 19-0006-00

Byllesby Reservoir 19-0006-00 TMDL Summary		Low Flow TP Load		High Flow TP Load	
		kg/yr	kg/day	kg/yr	kg/day
Phosphorus Loading Capacity (TMDL)		**54190.00**	**148.36**	**91520.00**	**250.57**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities* (Faribault, Northfield, Owatonna)	20585.00	39.06	20585.00	39.06
	All Other Permitted Municipal and Industrial Wastewater Facilities*	6217.00	44.63	6217.00	44.63
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA
	Construction and Industrial Stormwater	97.54	0.27	164.74	0.45
	MS4 Faribault (1.3%)	366.42	1.23	803.18	2.42
	MS4 Northfield (0.7%)	197.30	0.66	432.48	1.31
	MS4 Owatonna (1.2%)	338.23	1.13	741.40	2.24
	MS4 Waseca (0.3%)	84.56	0.28	185.35	0.56
	Total WLA	**27886.05**	**87.26**	**29129.14**	**90.67**
Load Allocation		**20612.95**	**45.52**	**52966.86**	**134.10**
Reserve Capacity		**272.00**	**0.74**	**272.00**	**0.74**
10% Margin of Safety		**5419.00**	**14.84**	**9152.00**	**25.06**

*All daily permitted wastewater facility WLAs, including Faribault, Northfield, and Owatonna for June - September are included in Table 41; see Appendix G for October - May.

** No permitted individual stormwater facilities in the Cannon River Watershed

Table 42. MIDDLE CANNON RIVER HUC-10: Fox Lake – 66-0029-00

Fox Lake 66-0029-00 TMDL Summary		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		kg/yr	kg/day	kg/yr	kg/day	kg/yr	%
Phosphorus Loading Capacity (TMDL)		**1779.25**	**4.87**	**742.10**	**2.03**	**1037.15**	**58.29**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	1.48	0.00	1.48	0.00	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	**1.48**	**0.00**	**1.48**	**0.00**	**NA**	**NA**
Total LA		**1777.77**	**4.87**	**740.62**	**2.03**	**1037.15**	**58.34**
10% Margin of Safety^		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

* No permitted wastewater facilities within lake drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

^ 10% MOS was taken off of WQ target concentration and is implicit in the TMDL loading capacity

Table 43. **MIDDLE CANNON RIVER HUC-10: Union Lake – 66-0032-00**

Union Lake 66-0032-00 TMDL Summary		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		kg/yr	kg/day	kg/yr	kg/day	kg/yr	%
Phosphorus Loading Capacity (TMDL)		**18322.00**	**50.16**	**1987.00**	**5.44**	**16533.70**	**90.24**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	202.93	0.66	359.93	2.91	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	3.58	0.01	3.58	0.01	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	**206.51**	**0.67**	**363.51**	**2.92**	**NA**	**NA**
Total LA		**18115.49**	**49.50**	**1424.79**	**2.52**	**16690.70**	**92.13**
10% Margin of Safety		**NA**	**NA**	**198.70**	**0.54**	**NA**	**NA**

* See Table 117 in Appendix H for complete facility list

** No permitted individual stormwater facilities in the Cannon River Watershed

*** No current MS4 communities within reach drainage area

Table 44. **MIDDLE CANNON RIVER HUC-10: Mazaska Lake – 66-0039-00**

Mazaska Lake 66-0039-00 TMDL Summary		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		kg/yr	kg/day	kg/yr	kg/day	kg/yr	%
Phosphorus Loading Capacity (TMDL)		**3581.33**	**9.81**	**444.31**	**1.22**	**3137.02**	**87.59**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.89	0.00	0.89	0.00	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	**0.89**	**0.00**	**0.89**	**0.00**	**NA**	**NA**
Total LA		**3580.44**	**9.80**	**443.42**	**1.21**	**3137.02**	**87.62**
10% Margin of Safety^		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

* No permitted wastewater facilities within lake drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

^ 10% MOS was taken off of WQ target concentration and is implicit in the TMDL loading capacity

Table 45. UPPER CANNON RIVER HUC-10: Horseshoe Lake – 40-0001-00

Horseshoe Lake 40-0001-00 TMDL Summary		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		kg/yr	kg/day	kg/yr	kg/day	kg/yr	%
Phosphorus Loading Capacity (TMDL)		939.26	2.57	438.69	1.20	500.57	53.29
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.88	0.00	0.88	0.00	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	0.88	0.00	0.88	0.00	NA	NA
Total LA		938.39	2.57	437.82	1.20	500.57	53.34
10% Margin of Safety^		NA	NA	NA	NA	NA	NA

* No permitted wastewater facilities within lake drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

^ 10% MOS was taken off of WQ target concentration and is implicit in the TMDL loading capacity

Table 46. **UPPER CANNON RIVER HUC-10: Upper Sakatah Lake – 40-0002-00**

Upper Sakatah Lake 40-0002-00 TMDL Summary		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		kg/yr	kg/day	kg/yr	kg/day	kg/yr	%
Phosphorus Loading Capacity (TMDL)		**56836.00**	**155.61**	**8924.00**	**24.43**	**48804.40**	**85.87**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	232.00	0.64	389.49	1.07	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	16.06	0.04	16.06	0.04	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	**248.06**	**0.68**	**405.55**	**1.11**	**NA**	**NA**
Total LA		**56587.94**	**154.93**	**7626.05**	**23.32**	**48961.89**	**86.52**
10% Margin of Safety		**NA**	**NA**	**892.40**	**2.44**	**NA**	**NA**

* See Table 118 in Appendix H for complete facility list; only includes Center Point Energy WWTS and Waterville WWTP, upstream facilities accounted for in inflow per discussion with MPCA

** No permitted individual stormwater facilities in the Cannon River Watershed

*** No current MS4 communities within reach drainage area

Table 47. **UPPER CANNON RIVER HUC-10: Sunfish Lake – 40-0009-00**

Sunfish Lake 40-0009-00 TMDL Summary		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		kg/yr	kg/day	kg/yr	kg/day	kg/yr	%
Phosphorus Loading Capacity (TMDL)		**840.95**	**2.30**	**287.27**	**0.79**	**553.68**	**65.84**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.57	0.00	0.57	0.00	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	**0.57**	**0.00**	**0.57**	**0.00**	**NA**	**NA**
Total LA		**840.38**	**2.30**	**286.69**	**0.78**	**553.68**	**65.89**
10% Margin of Safety^		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

* No permitted wastewater facilities within lake drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

^ 10% MOS was taken off of WQ target concentration and is implicit in the TMDL loading capacity

Table 48. **UPPER CANNON RIVER HUC-10: Dora Lake – 40-0010-00**

Dora Lake 40-0010-00 TMDL Summary		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		kg/yr	kg/day	kg/yr	kg/day	kg/yr	%
Phosphorus Loading Capacity (TMDL)		**9374.96**	**25.67**	**841.37**	**2.30**	**8533.59**	**91.03**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	1.68	0.00	1.68	0.00	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	**1.68**	**0.00**	**1.68**	**0.00**	**NA**	**NA**
Total LA		**9373.27**	**25.66**	**839.69**	**2.30**	**8533.59**	**91.04**
10% Margin of Safety^		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

* No permitted wastewater facilities within lake drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

^ 10% MOS was taken off of WQ target concentration and is implicit in the TMDL loading capacity

Table 49. **UPPER CANNON RIVER HUC-10: Mabel Lake – 40-0011-00**

Mabel Lake 40-0011-00 TMDL Summary		**Existing TP Load**		**Allowable TP Load**		**Estimated Load Reduction**	
		kg/yr	**kg/day**	**kg/yr**	**kg/day**	**kg/yr**	**%**
Phosphorus Loading Capacity (TMDL)		**368.13**	**1.01**	**127.51**	**0.35**	**240.62**	**65.36**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.26	0.00	0.26	0.00	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	**0.26**	**0.00**	**0.26**	**0.00**	**NA**	**NA**
Total LA		**367.87**	**1.01**	**127.25**	**0.35**	**240.62**	**65.41**
10% Margin of Safety^		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

* No permitted wastewater facilities within lake drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

^ 10% MOS was taken off of WQ target concentration and is implicit in the TMDL loading capacity

Table 50. **UPPER CANNON RIVER HUC-10: Sabre Lake – 40-0014-00**

Sabre Lake 40-0014-00 TMDL Summary		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		kg/yr	kg/day	kg/yr	kg/day	kg/yr	%
Phosphorus Loading Capacity (TMDL)		**35476.85**	**97.13**	**2306.06**	**6.31**	**33170.79**	**93.50**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	31.00	1.21	31.00	1.21	0.00	0.00
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	4.61	0.01	4.61	0.01	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	**35.61**	**1.22**	**35.61**	**1.22**	**NA**	**NA**
Total LA		**35441.24**	**95.91**	**2270.45**	**5.09**	**33170.79**	**93.59**
10% Margin of Safety^		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

* See Table 119 in Appendix H for complete facility list

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

^ 10% MOS was taken off of WQ target concentration and is implicit in the TMDL loading capacity

Table 51. **UPPER CANNON RIVER HUC-10: Tetonka Lake – 40-0031-00**

Tetonka Lake 40-0031-00 TMDL Summary		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		kg/yr	kg/day	kg/yr	kg/day	kg/yr	%
Phosphorus Loading Capacity (TMDL)		**82779.44**	**226.64**	**3913.00**	**10.71**	**78866.45**	**95.27**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	85.00	3.48	165.79	6.40	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	7.83	0.02	7.83	0.02	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	**92.83**	**3.50**	**173.62**	**6.42**	**NA**	**NA**
Total LA		**82686.62**	**223.14**	**3739.38**	**4.30**	**78947.24**	**95.48**
10% Margin of Safety^		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

* See Table 120 in Appendix H for complete facility list; Elysian WWTP daily load not 1/365th, calculated using 1.0 mg/L * 1.37 MGD * 3.785

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

^ 10% MOS was taken off of WQ target concentration and is implicit in the TMDL loading capacity

Table 52. UPPER CANNON RIVER HUC-10: Gorman Lake – 40-0032-00

Gorman Lake 40-0032-00 TMDL Summary		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		kg/yr	kg/day	kg/yr	kg/day	kg/yr	%
Phosphorus Loading Capacity (TMDL)		**27028.82**	**74.00**	**1760.75**	**4.82**	**25268.06**	**93.49**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	31.00	1.21	31.00	1.21	0.00	0.00
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	3.52	0.01	3.52	0.01	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	**34.52**	**1.22**	**34.52**	**1.22**	**NA**	**NA**
Total LA		**26994.30**	**72.78**	**1726.23**	**3.60**	**25268.06**	**93.61**
10% Margin of Safety^		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

* See Table 121 in Appendix H for complete facility list

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

^ 10% MOS was taken off of WQ target concentration and is implicit in the TMDL loading capacity

Table 53. UPPER CANNON RIVER HUC-10: Silver Lake – 40-0048-00

Silver Lake 40-0048-00 TMDL Summary		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		kg/yr	kg/day	kg/yr	kg/day	kg/yr	%
Phosphorus Loading Capacity (TMDL)		**33.73**	**0.09**	**12.20**	**0.03**	**21.53**	**63.83**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.02	0.00	0.02	0.00	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	**0.02**	**0.00**	**0.02**	**0.00**	**NA**	**NA**
Total LA		**33.70**	**0.09**	**12.18**	**0.03**	**21.53**	**63.87**
10% Margin of Safety^		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

* No permitted wastewater facilities within lake drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

^ 10% MOS was taken off of WQ target concentration and is implicit in the TMDL loading capacity

Table 54. UPPER CANNON RIVER HUC-10: Frances Lake – 40-0057-00

Frances Lake 40-0057-00 TMDL Summary		**Existing TP Load**		**Allowable TP Load**		**Estimated Load Reduction**	
		kg/yr	**kg/day**	**kg/yr**	**kg/day**	**kg/yr**	**%**
Phosphorus Loading Capacity (TMDL)		**2280.82**	**6.24**	**490.61**	**1.34**	**1790.21**	**78.49**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.98	0.00	0.98	0.00	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	**0.98**	**0.00**	**0.98**	**0.00**	**NA**	**NA**
Total LA		**2279.84**	**6.24**	**489.63**	**1.34**	**1790.21**	**78.52**
10% Margin of Safety^		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

* No permitted wastewater facilities within lake drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

^ 10% MOS was taken off of WQ target concentration and is implicit in the TMDL loading capacity

Table 55. UPPER CANNON RIVER HUC-10: Tustin Lake – 40-0061-00

Tustin Lake 40-0061-00 TMDL Summary		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		kg/yr	kg/day	kg/yr	kg/day	kg/yr	%
Phosphorus Loading Capacity (TMDL)		**932.40**	**2.55**	**200.70**	**0.55**	**751.77**	**80.63**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	54.00	2.27	134.79	5.19	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.36	0.00	0.36	0.00	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	**54.36**	**2.27**	**135.15**	**5.19**	**NA**	**NA**
Total LA^		**878.04**	**0.28**	**45.48**	**0.12**	**832.56**	**NA**
10% Margin of Safety		**NA**	**NA**	**20.07**	**0.05**	**NA**	**NA**

* See Table 122 in Appendix H for complete facility list; Elysian WWTP daily load not 1/365th, calculated using 1.0 mg/L * 1.37 MGD * 3.785

** No permitted individual stormwater facilities in the Cannon River Watershed

*** No current MS4 communities within reach drainage area

^Total Allowable Daily LA is calculated as 1/365.25 of Allowable Annual LA

Table 56. UPPER CANNON RIVER HUC-10: Cannon Lake – 66-0008-00

Cannon Lake 66-0008-00 TMDL Summary		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		kg/yr	kg/day	kg/yr	kg/day	kg/yr	%
Phosphorus Loading Capacity (TMDL)		**78706.60**	**215.49**	**9602.48**	**26.29**	**69104.12**	**87.80**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	463.69	4.91	700.28	8.25	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	19.20	0.05	19.20	0.05	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	**482.89**	**4.96**	**719.48**	**8.30**	**NA**	**NA**
Total LA		**78223.71**	**210.53**	**8883.00**	**17.99**	**69340.71**	**88.64**
10% Margin of Safety^		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

* See Table 123 in Appendix H for complete facility list; Elysian WWTP daily load not 1/365th, calculated using 1.0 mg/L * 1.37 MGD * 3.785

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

^ 10% MOS was taken off of WQ target concentration and is implicit in the TMDL loading capacity

Table 57. UPPER CANNON RIVER HUC-10: Wells Lake – 66-0010-00

Wells Lake 66-0010-00 TMDL Summary		**Existing TP Load**		**Allowable TP Load**		**Estimated Load Reduction**	
		kg/yr	**kg/day**	**kg/yr**	**kg/day**	**kg/yr**	**%**
Phosphorus Loading Capacity (TMDL)		**59957.64**	**164.16**	**8460.27**	**23.16**	**51497.37**	**85.89**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	463.69	4.91	700.28	8.25	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	16.92	0.05	16.92	0.05	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	**480.61**	**4.95**	**717.20**	**8.30**	**NA**	**NA**
Total LA		**59477.03**	**159.20**	**7743.07**	**14.86**	**51733.95**	**86.98**
10% Margin of Safety^		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

* See Table 124 in Appendix H for complete facility list; Elysian WWTP daily load not 1/365th, calculated using 1.0 mg/L * 1.37 MGD * 3.785

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

^ 10% MOS was taken off of WQ target concentration and is implicit in the TMDL loading capacity

Table 58. **UPPER CANNON RIVER HUC-10: Roberds Lake – 66-0018-00**

Roberds Lake 66-0018-00 TMDL Summary		**Existing TP Load**		**Allowable TP Load**		**Estimated Load Reduction**	
		kg/yr	**kg/day**	**kg/yr**	**kg/day**	**kg/yr**	**%**
Phosphorus Loading Capacity (TMDL)		**9529.11**	**26.09**	**496.72**	**1.36**	**9032.39**	**94.79**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.99	0.00	0.99	0.00	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	**0.99**	**0.00**	**0.99**	**0.00**	**NA**	**NA**
Total LA		**9528.12**	**26.09**	**495.72**	**1.36**	**9032.39**	**94.80**
10% Margin of Safety^		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

* No permitted wastewater facilities within lake drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

^ 10% MOS was taken off of WQ target concentration and is implicit in the TMDL loading capacity

Table 59. UPPER CANNON RIVER HUC-10: French Lake – 66-0038-00

French Lake 66-0038-00 TMDL Summary		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		kg/yr	kg/day	kg/yr	kg/day	kg/yr	%
Phosphorus Loading Capacity (TMDL)		**7619.83**	**20.86**	**580.19**	**1.59**	**7039.64**	**92.39**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	1.16	0.00	1.16	0.00	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	**1.16**	**0.00**	**1.16**	**0.00**	**NA**	**NA**
Total LA		**7618.67**	**20.86**	**579.03**	**1.59**	**7039.64**	**92.40**
10% Margin of Safety^		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

* No permitted wastewater facilities within lake drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

^ 10% MOS was taken off of WQ target concentration and is implicit in the TMDL loading capacity

Table 60. UPPER CANNON RIVER HUC-10: Lower Sakatah Lake – 66-0044-00

Lower Sakatah Lake 66-0044-00 TMDL Summary		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		kg/yr	kg/day	kg/yr	kg/day	kg/yr	%
Phosphorus Loading Capacity (TMDL)		**46184.76**	**126.45**	**5763.18**	**15.78**	**40421.57**	**87.52**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	318.69	4.12	555.28	7.46	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	11.53	0.03	11.53	0.03	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	**330.22**	**4.15**	**566.81**	**7.49**	**NA**	**NA**
Total LA		**45854.54**	**122.30**	**5196.38**	**8.29**	**40658.16**	**88.67**
10% Margin of Safety^		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

* See Table 125 in Appendix H for complete facility list; Elysian WWTP daily load not 1/365th, calculated using 1.0 mg/L * 1.37 MGD * 3.785

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

^ 10% MOS was taken off of WQ target concentration and is implicit in the TMDL loading capacity

Table 61. **UPPER CANNON RIVER HUC-10: Hunt Lake – 66-0047-00**

Hunt Lake 66-0047-00 TMDL Summary		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		kg/yr	kg/day	kg/yr	kg/day	kg/yr	%
Phosphorus Loading Capacity (TMDL)		408.18	1.12	72.75	0.20	335.43	82.18
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.15	0.00	0.15	0.00	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	0.15	0.00	0.15	0.00	NA	NA
Total LA		408.03	1.12	72.60	0.20	335.43	82.21
10% Margin of Safety^		NA	NA	NA	NA	NA	NA

* No permitted wastewater facilities within lake drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

^ 10% MOS was taken off of WQ target concentration and is implicit in the TMDL loading capacity

Table 62. **UPPER CANNON RIVER HUC-10: Rice Lake – 66-0048-00**

Rice Lake 66-0048-00 TMDL Summary		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		kg/yr	kg/day	kg/yr	kg/day	kg/yr	%
Phosphorus Loading Capacity (TMDL)		**7637.40**	**20.91**	**591.88**	**1.62**	**7045.52**	**92.25**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	1.18	0.00	1.18	0.00	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	**1.18**	**0.00**	**1.18**	**0.00**	**NA**	**NA**
Total LA		**7636.22**	**20.91**	**590.70**	**1.62**	**7045.52**	**92.26**
10% Margin of Safety^		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

* No permitted wastewater facilities within lake drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

^ 10% MOS was taken off of WQ target concentration and is implicit in the TMDL loading capacity

Table 63. UPPER CANNON RIVER HUC-10: Caron Lake – 66-0050-00

Caron Lake 66-0050-00 TMDL Summary		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		kg/yr	kg/day	kg/yr	kg/day	kg/yr	%
Phosphorus Loading Capacity (TMDL)		**4779.51**	**13.09**	**421.35**	**1.15**	**4358.16**	**91.18**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.84	0.00	0.84	0.00	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	**0.84**	**0.00**	**0.84**	**0.00**	**NA**	**NA**
Total LA		**4778.66**	**13.08**	**420.50**	**1.15**	**4358.16**	**91.20**
10% Margin of Safety^		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

* No permitted wastewater facilities within lake drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

^ 10% MOS was taken off of WQ target concentration and is implicit in the TMDL loading capacity

Table 64. UPPER CANNON RIVER HUC-10: Cedar Lake – 66-0052-00

Cedar Lake 66-0052-00 TMDL Summary		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		kg/yr	kg/day	kg/yr	kg/day	kg/yr	%
Phosphorus Loading Capacity (TMDL)		1123.80	3.08	701.72	1.92	422.08	37.56
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	1.40	0.00	1.40	0.00	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	1.40	0.00	1.40	0.00	NA	NA
Total LA		1122.40	3.07	700.32	1.92	422.08	37.61
10% Margin of Safety^		NA	NA	NA	NA	NA	NA

* No permitted wastewater facilities within lake drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

^ 10% MOS was taken off of WQ target concentration and is implicit in the TMDL loading capacity

Table 65. UPPER CANNON RIVER HUC-10: Shields Lake – 66-0055-00

Shields Lake 66-0055-00 TMDL Summary		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		kg/yr	kg/day	kg/yr	kg/day	kg/yr	%
Phosphorus Loading Capacity (TMDL)		13536.45	37.06	571.99	1.57	12964.46	95.77
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	1.14	0.00	1.14	0.00	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	1.14	0.00	1.14	0.00	NA	NA
Total LA		13535.31	37.06	570.85	1.56	12964.46	95.78
10% Margin of Safety^		NA	NA	NA	NA	NA	NA

* No permitted wastewater facilities within lake drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

^ 10% MOS was taken off of WQ target concentration and is implicit in the TMDL loading capacity

Table 66. UPPER CANNON RIVER HUC-10: Toner's Lake – 81-0058-00

Toners Lake 81-0051-00 TMDL Summary		**Existing TP Load**		**Allowable TP Load**		**Estimated Load Reduction**	
		kg/yr	**kg/day**	**kg/yr**	**kg/day**	**kg/yr**	**%**
Phosphorus Loading Capacity (TMDL)		**291.12**	**0.80**	**39.02**	**0.11**	**252.10**	**86.60**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.08	0.00	0.08	0.00	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	**0.08**	**0.00**	**0.08**	**0.00**	**NA**	**NA**
Total LA		**291.05**	**0.80**	**38.94**	**0.11**	**252.10**	**86.62**
10% Margin of Safety^		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

* No permitted wastewater facilities within lake drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

^ 10% MOS was taken off of WQ target concentration and is implicit in the TMDL loading capacity

4.3 Bacteria

4.3.1 Loading Capacity

A total loading capacity was assigned to each impaired reach identified in Table 2 under the following flow regimes: Very High, High, Mid, Low, and Very Low. The flow data used to develop the flow and LDCs for the *E. coli* TMDLs (and all subsequent stream TMDLs in this document) were simulated by a calibrated HSPF model. HSPF models combine land surface data, hydrographic boundaries, meteorological inputs, and water quality and quantity data to simulate watershed processes. For the Cannon River Watershed HSPF (CRWHSPF) these data were collected from federal, state, and local organizations and government entities. The two primary hydrologic calibration points in the model are USGS Station 05353800 (Straight River at Faribault) and USGS Station 05355200 (Cannon River at Welch). The CRWHSPF was completed by LimnoTech, Inc. in 2015 and model output data are maintained by the MPCA modeling staff.

Because of limited data availability, a modeling period from 1995 through 2012 was selected. Data used to develop TMDLs were limited to *1996* through 2012 because the first simulated year allows model parameters to "normalize," or meet observed conditions. Based on strong calibration for hydrology and water quality parameters (such as TSS, total nitrogen, and TP), the model is well suited for both point source and non-point source nutrient reduction and hydrologic investigations.

A total loading capacity was assigned for each flow regime – Very High, High, Mid, Low, and Very Low – by multiplying the median flow of each regime by the Minnesota water quality standard for *E. coli*.

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 of this report (Tables 67 through 94), only five points on the entire loading capacity curve are depicted (the midpoints of the designated flow zones). However, it should be understood that the entire curve represents the TMDL and is what is ultimately approved by the EPA.

4.3.2 Load Allocation Methodology

As stated in the governing TMDL equation, the LA is comprised of the non-point source load that is allocated to an impaired AUID after the MOS and WLA are subtracted from the total loading capacity for each flow regime. This residual load is meant to represent all non-regulated sources of *E. coli* upstream of the impaired reach, which are summarized in Section 3.7.2.

4.3.3 Wasteload Allocation Methodology

4.3.3.1 Permitted Industrial and Municipal Wastewater Facilities

Within the CRW, there are 33 NPDES permitted Industrial and Municipal WWTFs. Each facility is permitted for specific water quality limits at their discharge. A list of facilities discharging to each AUID is accompanied in Appendix H. The WLAs for permitted facilities were calculated using the design flow and permit limit for *E. coli*.

4.3.3.2 Permitted Industrial Stormwater Facilities

There was no individual permitted Industrial Stormwater Facilities that required a WLA. Impaired AUIDs were not assigned a “0” WLA, but rather listed as NA (Not Applicable).

4.3.3.3 Regulated Construction and Industrial Stormwater

For this TMDL, it was assumed that *E. coli* and Fecal coliform were not pollutants of stormwater runoff from construction and industrial sites. AUIDs impaired for bacteria were not assigned a “0” WLA, but rather are not applicable and therefore are not included in the following *E. coli* TMDL summary tables.

4.3.3.4 Regulated MS4 Stormwater

The MS4 systems are designed to convey stormwater into a receiving waterbody and are permitted under the NPDES Permit.

All MS4 communities are existing communities and are included in the WLA. No future communities are planned that need to be included in this portion of the WLA.

MS4 allocations were calculated using the following equation:

$$\text{MS4 Allocation} = \%\text{MS4 Area} * (\text{TLC} - \text{MOS} - \text{Permitted WW Facitilies})$$

Where:

%MS4 Area: the ratio of the total MS4 area to the total drainage area for the given AUID. Areas were obtained using ArcMap.

Permitted WW Facilities: the total WLA for all permitted industrial and municipal WWFs that discharge into the AUID’s drainage area.

Note that in the TMDL tables, some of the MS4 WLAs are very small values and are expressed as “0.00” due to rounding and displayed decimal places. This does not constitute a “0” WLA; the daily WLAs are simply the annual WLAs divided by 365 (days).

4.3.4 Margin of Safety

An explicit MOS equal to 10% of the loading capacity was used for the stream TMDLs based on the following considerations:

- Most of the uncertainty in flow is a result of extrapolating flows from the hydrologically-nearest stream gage. The explicit MOS, in part, accounts for this.
- Allocations are a function of flow, which varies from high to low flows. This variability is accounted for through the development of a TMDL for each of five flow regimes.
- With respect to the *E. coli* TMDLs, the load duration analysis does not address bacteria re-growth in sediments, die-off, and natural background levels. The MOS helps to account for the variability associated with these conditions.

4.3.5 Seasonal Variation

Use of these water bodies for aquatic recreation occurs from April through October, which includes all or portions of the spring, summer and fall seasons. *E. coli* loading varies with the flow regime and season. Spring is associated with large flows from snowmelt, the summer is associated with the growing season as well as periodic storm events and receding streamflows, and the fall brings increasing precipitation and rapidly changing agricultural landscapes.

4.3.6 TMDL Summaries

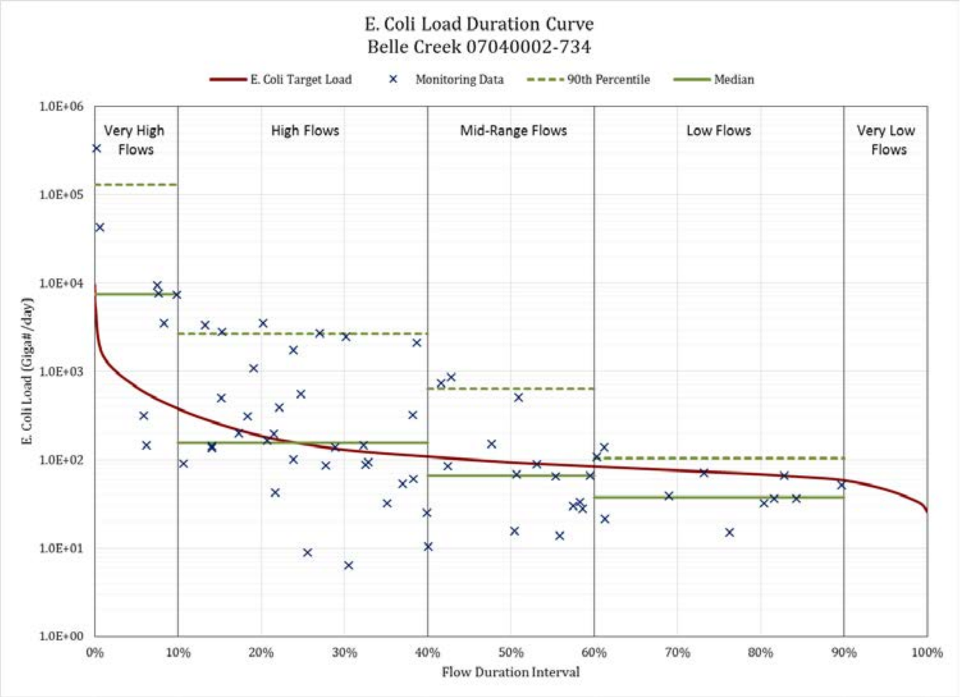


Figure 22. BELLE CREEK HUC-10: Belle Creek – 07040002-734

Table 67. BELLE CREEK HUC-10: Belle Creek – 07040002-734

Belle Creek 07040002-734 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		Billions of Organisms/day				
E. coli Loading Capacity (TMDL)		666.22	151.16	93.51	72.13	46.16
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	MS4***	NA	NA	NA	NA	NA
	Total WLA	NA	NA	NA	NA	NA
Load Allocation		599.60	136.04	84.16	64.92	41.54
10% Margin of Safety		66.62	15.12	9.35	7.21	4.62

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

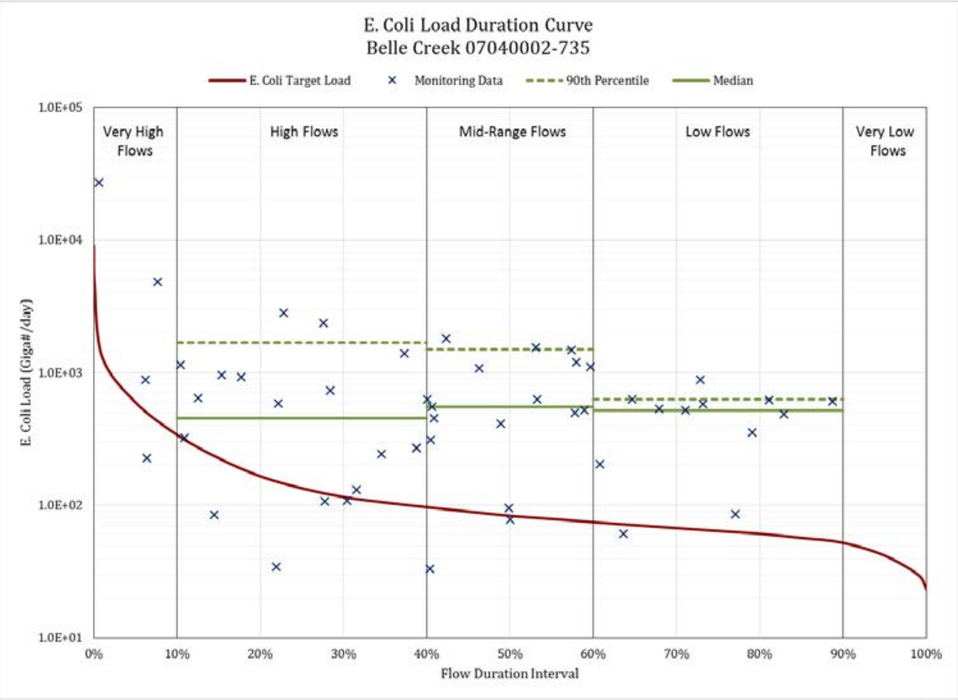


Figure 23. BELLE CREEK HUC-10: Belle Creek – 07040002-735

Table 68. BELLE CREEK HUC-10: Belle Creek – 07040002-735

Belle Creek 07040002-735 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		Billions of Organisms/day				
E. coli Loading Capacity (TMDL)		599.38	134.35	83.31	64.07	41.82
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	MS4***	NA	NA	NA	NA	NA
	Total WLA	NA	NA	NA	NA	NA
Load Allocation		539.45	120.92	74.98	57.66	37.64
10% Margin of Safety		59.94	13.44	8.33	6.41	4.18

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

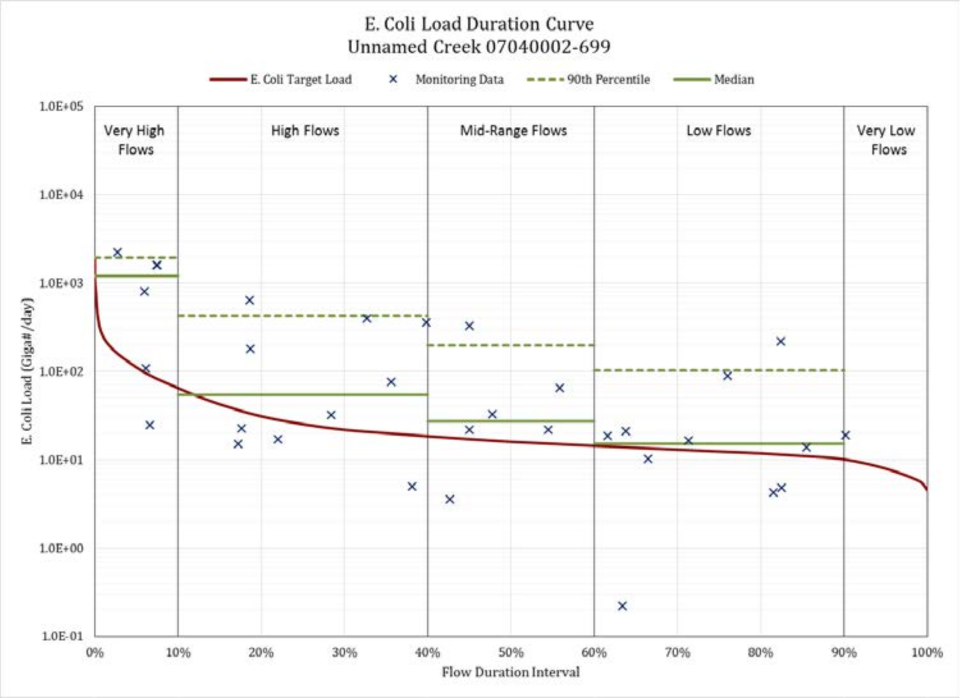


Figure 24. BELLE CREEK HUC-10: Unnamed Creek – 07040002-699

Table 69. BELLE CREEK HUC-10: Unnamed Creek – 07040002-699

Unnamed Creek 07040002-699 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		Billions of Organisms/day				
E. coli Loading Capacity (TMDL)		111.37	25.27	16.01	12.40	7.96
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	MS4***	NA	NA	NA	NA	NA
	Total WLA	NA	NA	NA	NA	NA
Load Allocation		100.23	22.74	14.41	11.16	7.16
10% Margin of Safety		11.14	2.53	1.60	1.24	0.80

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

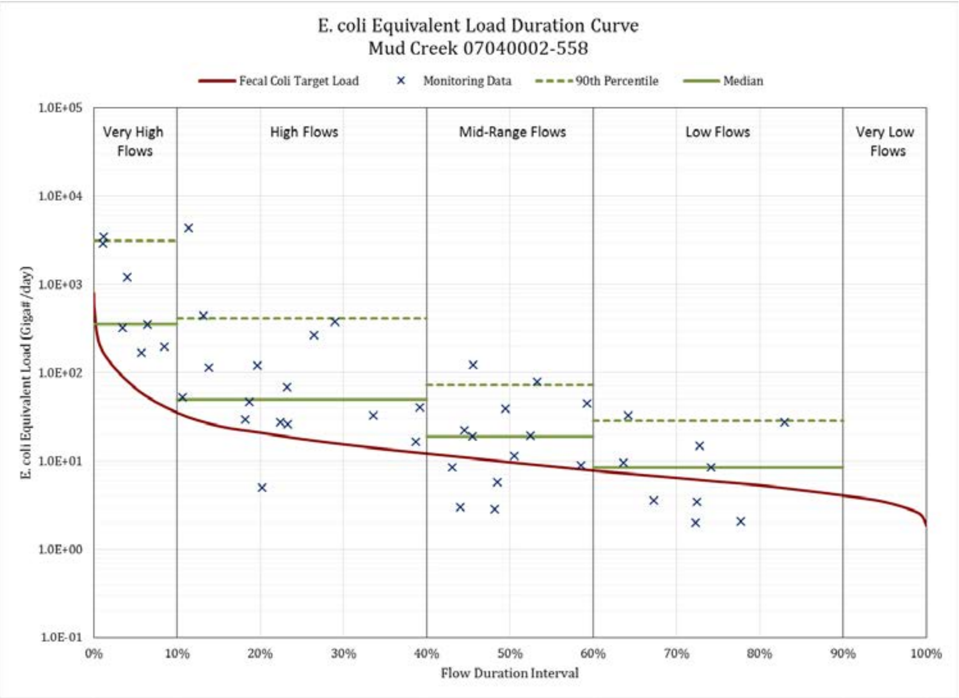


Figure 25. CHUB CREEK HUC-10: Mud Creek – 07040002-558

Table 70. CHUB CREEK HUC-10: Mud Creek – 07040002-558

Mud Creek 07040002-558 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		Billions of Organisms/day				
E. coli Equivalent Loading Capacity (TMDL)		66.82	17.72	9.67	5.82	3.44
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Northfield MS4 (5.6%)	3.38	0.90	0.49	0.29	0.17
	Total WLA	3.38	0.90	0.49	0.29	0.17
Load Allocation		56.75	15.05	8.21	4.94	2.92
10% Margin of Safety		6.68	1.77	0.97	0.58	0.34

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

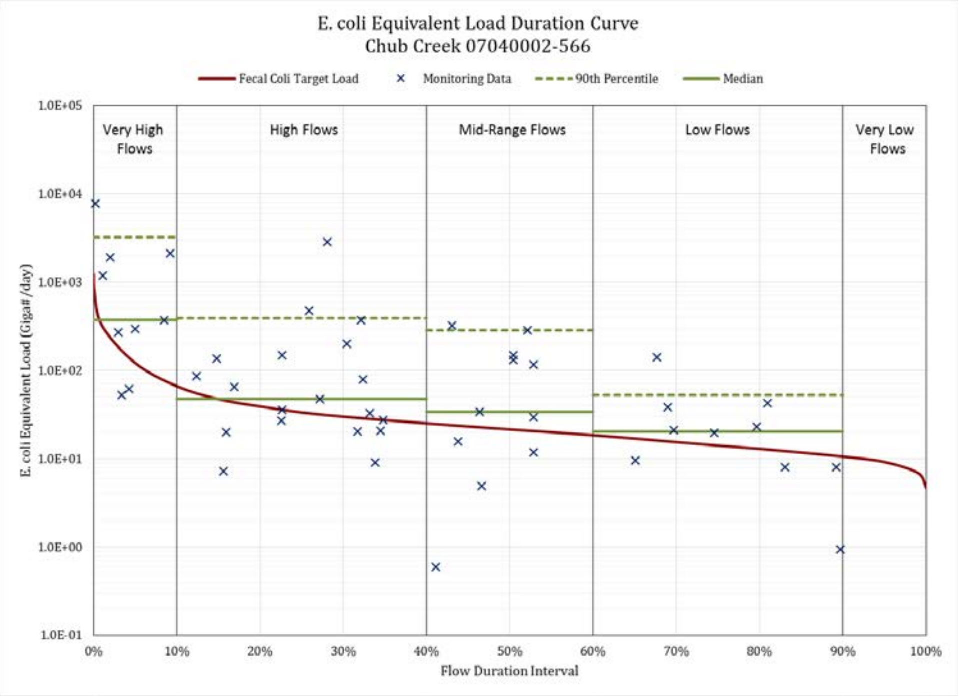


Figure 26. CHUB CREEK HUC-10: Chub Creek – 07040005-566

Table 71. CHUB CREEK HUC-10: Chub Creek – 07040005-566

Chub Creek 07040002-566 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		Billions of Organisms/day				
E. coli Equivalent Loading Capacity (TMDL)		121.56	33.47	21.48	14.09	9.19
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	MS4***	NA	NA	NA	NA	NA
	Total WLA	NA	NA	NA	NA	NA
Load Allocation		109.40	30.12	19.34	12.68	8.27
10% Margin of Safety		12.16	3.35	2.15	1.41	0.92

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

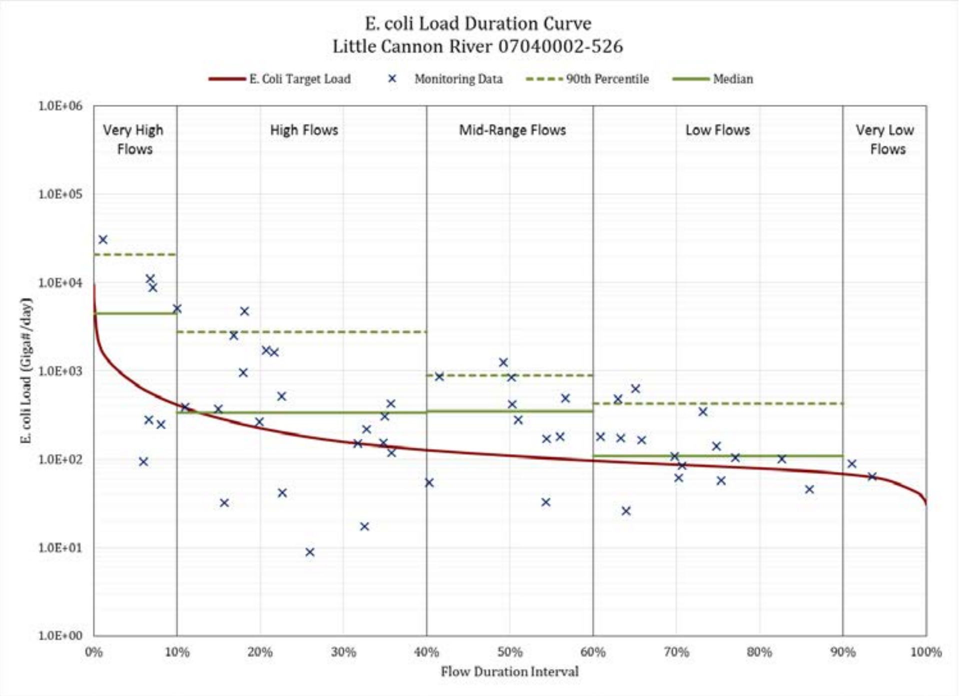


Figure 27. LITTLE CANNON RIVER HUC-10: Little Cannon River – 07040002-526

Table 72. LITTLE CANNON RIVER HUC-10: Little Cannon River – 07040002-526

Little Cannon River 07040002-526 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		Billions of Organisms/day				
E. coli Loading Capacity (TMDL)		710.55	183.97	109.38	82.84	58.92
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	0.20	0.20	0.20	0.20	0.20
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	MS4***	NA	NA	NA	NA	NA
	Total WLA	0.20	0.20	0.20	0.20	0.20
Load Allocation		639.30	165.37	98.24	74.36	52.83
10% Margin of Safety		71.06	18.40	10.94	8.28	5.89

* See Table 126 in Appendix H for complete facility list

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

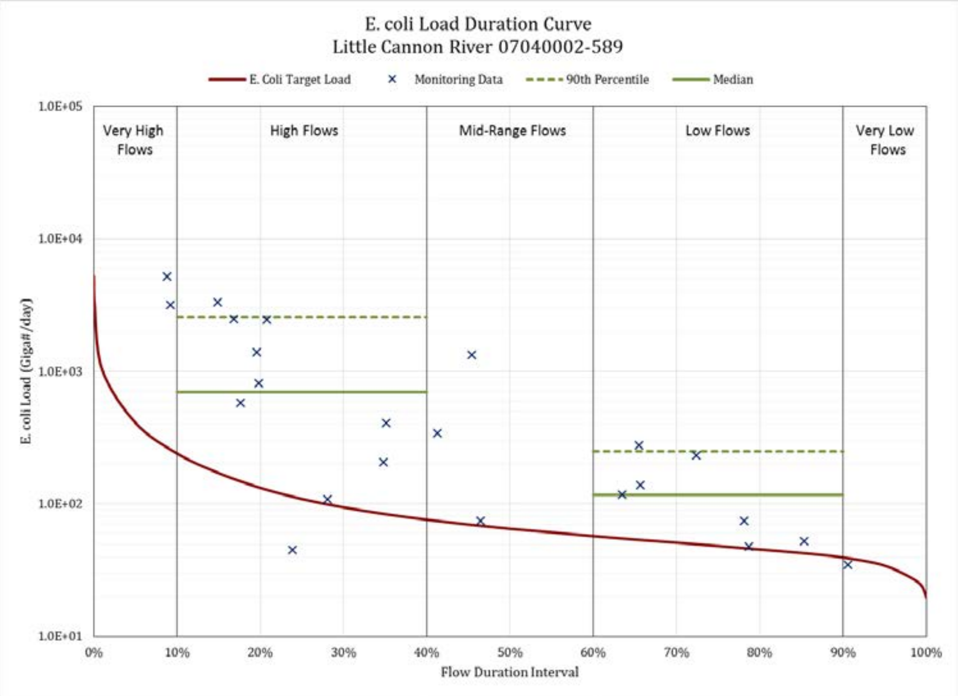


Figure 28. LITTLE CANNON RIVER HUC-10: Little Cannon River – 07040002-589

Table 73. LITTLE CANNON RIVER HUC-10: Little Cannon River – 07040002-589

Little Cannon River 07040002-589 TMDL Summary		**Flow Regime**				
		VHigh	**High**	**Mid**	**Low**	**VLow**
		Billions of Organisms/day				
***E. coli* Loading Capacity (TMDL)**		**410.45**	**109.01**	**64.97**	**48.21**	**34.24**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	0.20	0.20	0.20	0.20	0.20
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	MS4***	NA	NA	NA	NA	NA
	Total WLA	**0.20**	**0.20**	**0.20**	**0.20**	**0.20**
Load Allocation		**369.20**	**97.91**	**58.28**	**43.19**	**30.62**
10% Margin of Safety		**41.04**	**10.90**	**6.50**	**4.82**	**3.42**

* See Table 127 in Appendix H for complete facility list

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

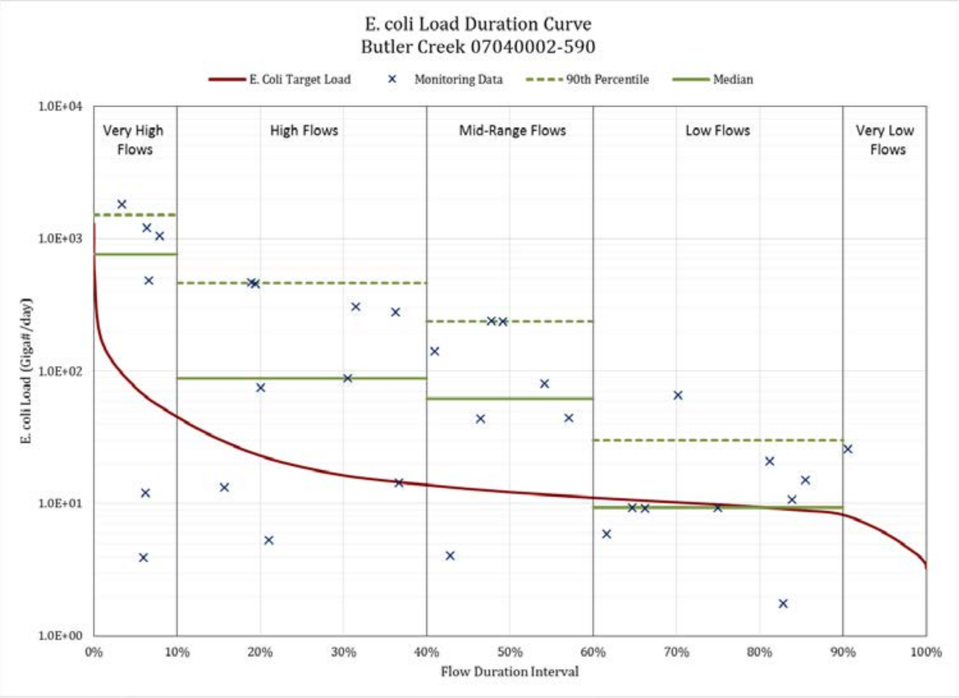


Figure 29. LITTLE CANNON RIVER HUC-10: Butler Creek – 07040002-590

Table 74. LITTLE CANNON RIVER HUC-10: Butler Creek – 07040002-590

Butler Creek 07040002-590 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		Billions of Organisms/day				
E. coli Loading Capacity (TMDL)		75.36	18.87	12.18	9.83	6.03
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	MS4***	NA	NA	NA	NA	NA
	Total WLA	NA	NA	NA	NA	NA
Load Allocation		67.82	16.98	10.96	8.84	5.42
10% Margin of Safety		7.54	1.89	1.22	0.98	0.60

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

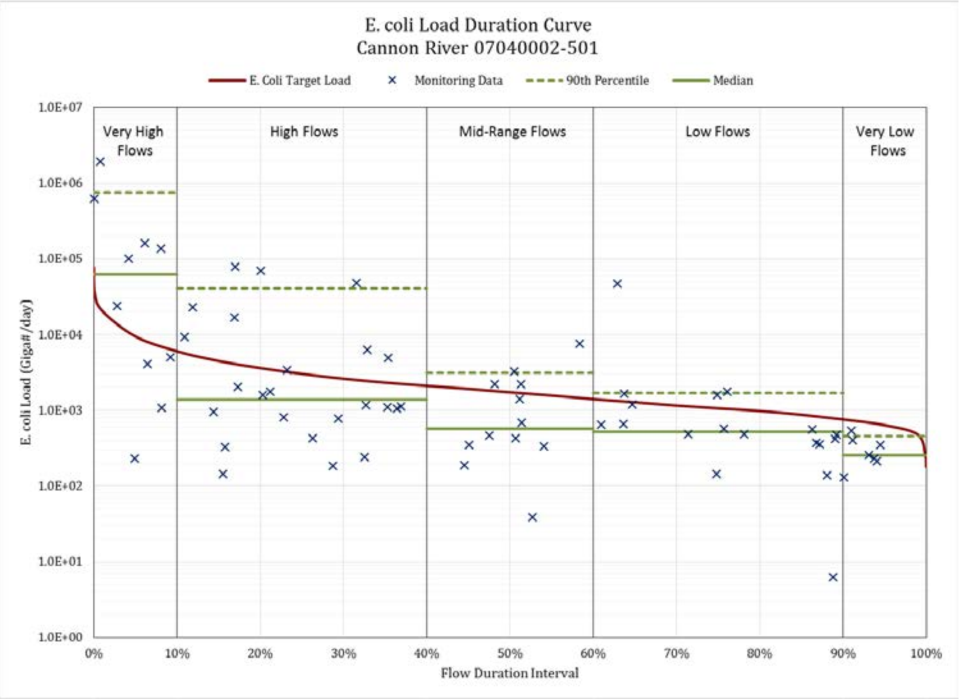


Figure 30. LOWER CANNON RIVER HUC-10: Cannon River – 07040002-501

Table 75. LOWER CANNON RIVER HUC-10: Cannon River – 07040002-501

Cannon River 07040002-501 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		Billions of Organisms/day				
***E. coli* Loading Capacity (TMDL)**		**9455.80**	**3029.74**	**1731.50**	**1062.38**	**636.53**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	114.48	114.48	114.48	114.48	114.48
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Faribault MS4 (1.1%)	92.35	28.74	15.88	9.26	5.04
	Northfield MS4 (0.62%)	52.05	16.20	8.95	5.22	2.84
	Owatonna MS4 (1.03%	86.48	26.91	14.87	8.67	4.72
	Red Wing MS4 (0.53%)	44.50	13.85	7.65	4.46	2.43
	Waseca MS4 (0.3%)	25.19	7.84	4.33	2.52	1.38
	Total WLA	**415.05**	**208.00**	**166.17**	**144.61**	**130.89**
Load Allocation		**8095.17**	**2518.77**	**1392.18**	**811.53**	**441.99**
10% Margin of Safety		**945.58**	**302.97**	**173.15**	**106.24**	**63.65**

* See Table 128 Appendix H for complete facility list

** No permitted individual stormwater facilities in the CRW

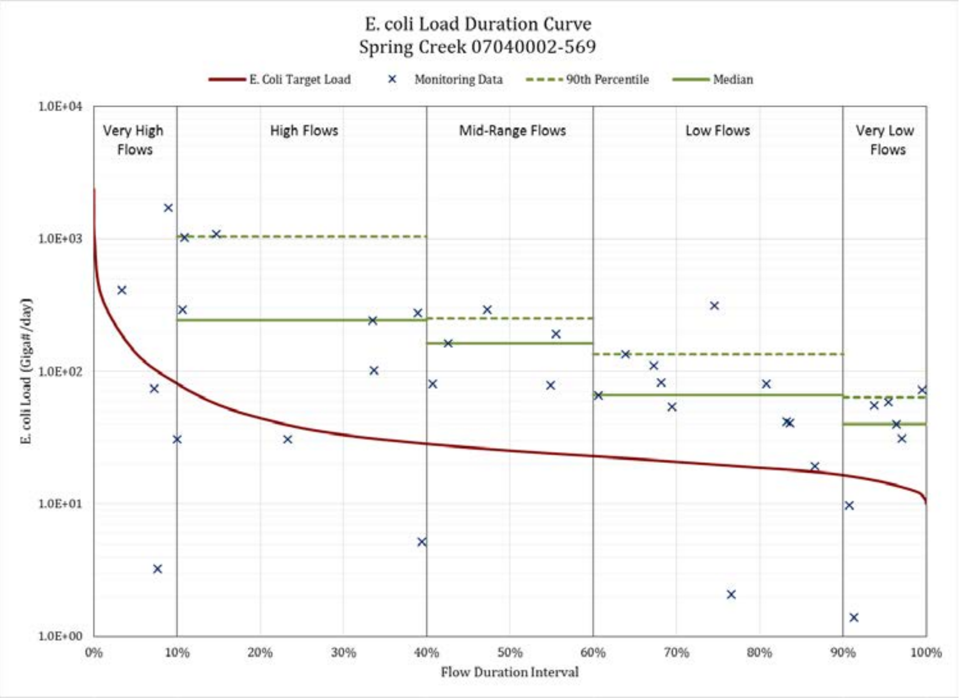


Figure 31. LOWER CANNON RIVER HUC-10: Spring Creek – 07040002-569

Table 76. LOWER CANNON RIVER HUC-10: Spring Creek – 07040002-569

Spring Creek 07040002-569 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		Billions of Organisms/day				
E. coli Loading Capacity (TMDL)		139.00	37.37	25.27	19.74	14.50
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Red Wing MS4 (17.62%)	22.04	5.93	4.01	3.13	2.30
	Total WLA	22.04	5.93	4.01	3.13	2.30
Load Allocation		103.06	27.71	18.74	14.64	10.75
10% Margin of Safety		13.90	3.74	2.53	1.97	1.45

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

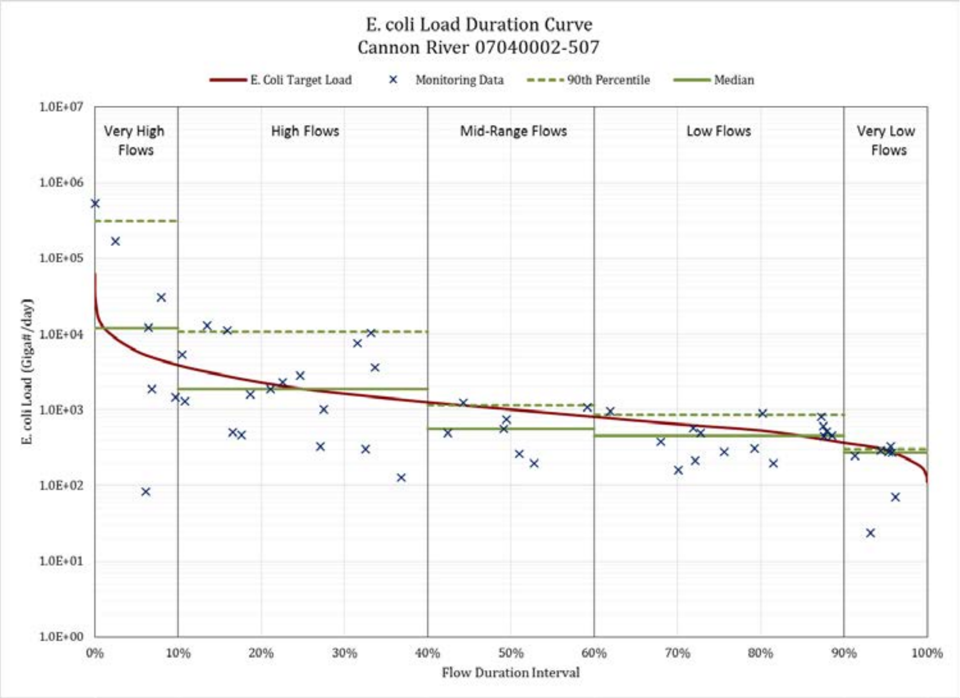


Figure 32. MIDDLE CANNON RIVER HUC-10: Cannon River – 07040002-507

Table 77. MIDDLE CANNON RIVER HUC-10: Cannon River – 07040002-507

Cannon River 07040002-507 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		Billions of Organisms/day				
***E. coli* Loading Capacity (TMDL)**		**5981.52**	**1889.43**	**1009.06**	**589.64**	**295.89**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	80.36	80.36	80.36	80.36	80.36
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Faribault MS4 (1.8%)	95.45	29.16	14.90	8.11	3.35
	Northfield MS4 (0.1%)	5.30	1.62	0.83	0.45	0.19
	Owatonna MS4 (1.69%)	89.62	27.38	13.99	7.61	3.14
	Waseca MS4 (0.5%)	26.52	8.10	4.14	2.25	0.93
	Total WLA	**297.25**	**146.62**	**114.22**	**98.78**	**87.96**
Load Allocation		**5086.11**	**1553.86**	**793.94**	**431.90**	**178.34**
10% Margin of Safety		**598.15**	**188.94**	**100.91**	**58.96**	**29.59**

* See Table 129 in Appendix H for complete facility list

** No permitted individual stormwater facilities in the CRW

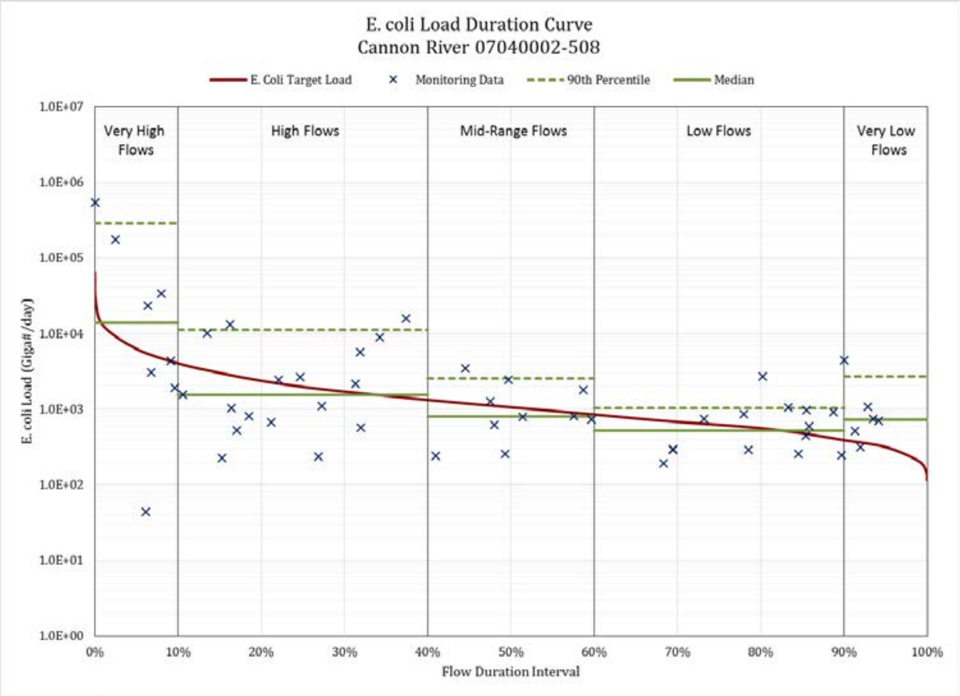


Figure 33. MIDDLE CANNON RIVER HUC-10: Cannon River – 07040002-508

Table 78. MIDDLE CANNON RIVER HUC-10: Cannon River – 07040002-508

Cannon River 07040002-508 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		Billions of Organisms/day				
E. coli **Loading Capacity (TMDL)**		**6280.15**	**1972.86**	**1061.80**	**622.03**	**316.15**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	83.85	83.85	83.85	83.85	83.85
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Faribault MS4 (1.72%)	95.77	29.10	14.99	8.19	3.45
	Northfield MS4 (0.39%)	21.72	6.60	3.40	1.86	0.78
	Owatonna MS4 (1.61%)	89.65	27.24	14.04	7.66	3.23
	Waseca MS4 (0.48%)	26.73	8.12	4.18	2.28	0.96
	Total WLA	**317.72**	**154.90**	**120.47**	**103.84**	**92.28**
Load Allocation		**5334.42**	**1620.67**	**835.16**	**455.99**	**192.25**
10% Margin of Safety		**628.01**	**197.29**	**106.18**	**62.20**	**31.61**

* See Table 130 in Appendix H for complete facility list

** No permitted individual stormwater facilities in the CRW

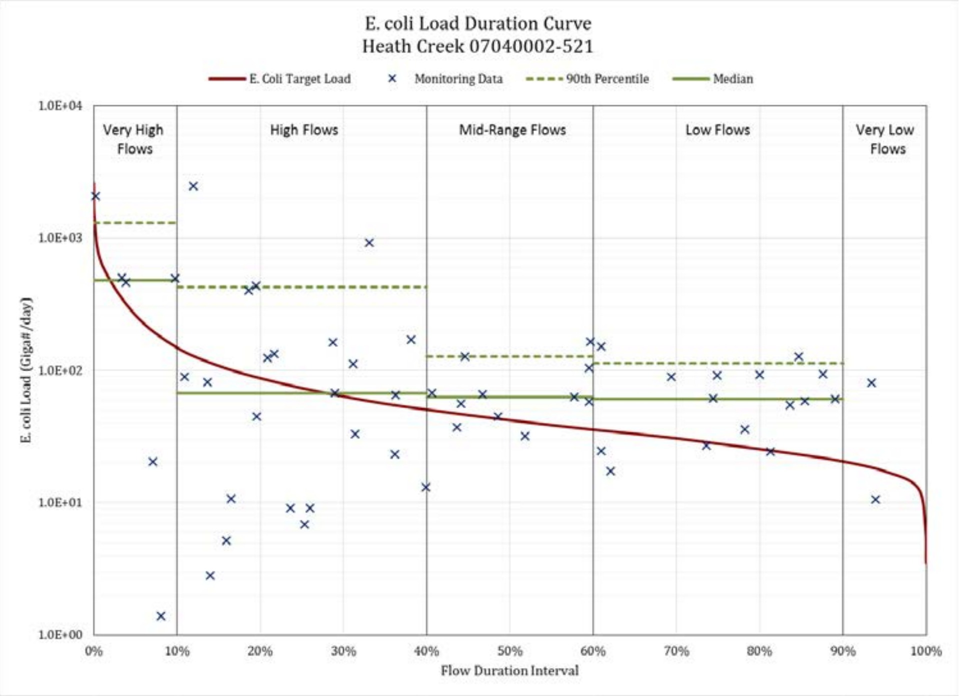


Figure 34. MIDDLE CANNON RIVER HUC-10: Heath Creek – 07040002-521

Table 79. MIDDLE CANNON RIVER HUC-10: Heath Creek – 07040002-521

Heath Creek 07040002-521 TMDL Summary		**Flow Regime**				
		VHigh	**High**	**Mid**	**Low**	**VLow**
		Billions of Organisms/day				
***E. coli* Loading Capacity (TMDL)**		**261.69**	**73.48**	**42.02**	**27.93**	**17.30**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	3.49	3.49	3.49	3.49	3.49
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Northfield MS4 (1.34%)	3.12	0.84	0.46	0.29	0.16
	Total WLA	**6.61**	**4.33**	**3.95**	**3.78**	**3.65**
Load Allocation		**228.91**	**61.80**	**33.86**	**21.35**	**11.92**
10% Margin of Safety		**26.17**	**7.35**	**4.20**	**2.79**	**1.73**

*See Table 132 in Appendix H for complete facility list

** No permitted individual stormwater facilities in the CRW

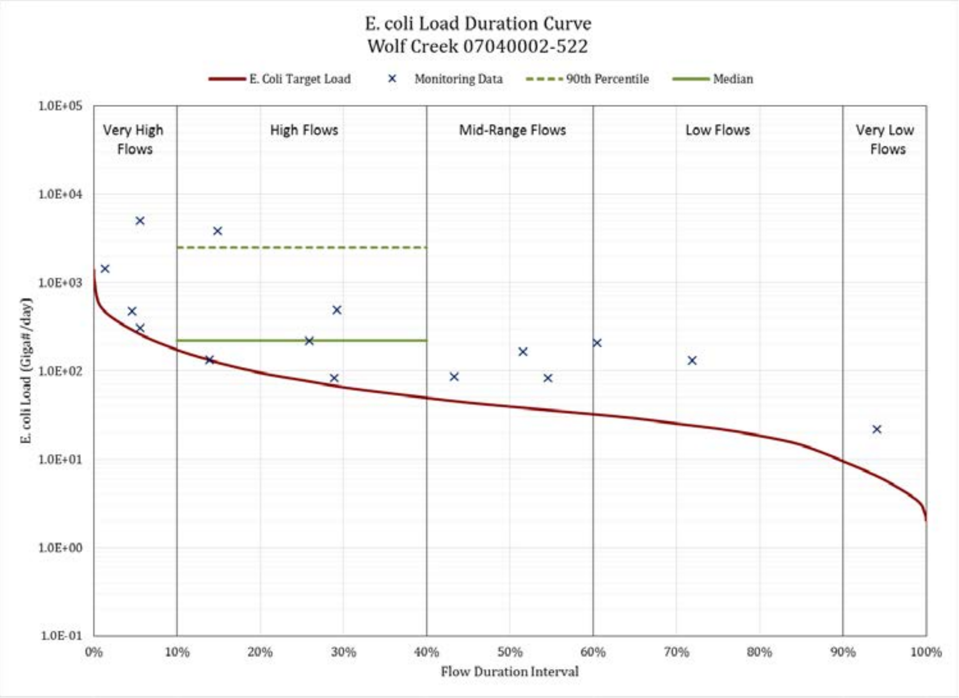


Figure 35. MIDDLE CANNON RIVER HUC-10: Wolf Creek – 07040002-522

Table 80. MIDDLE CANNON RIVER HUC-10: Wolf Creek – 07040002-522

Wolf Creek 07040002-522 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		Billions of Organisms/day				
E. coli Loading Capacity (TMDL)		277.35	78.67	39.44	22.18	5.83
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	MS4***	NA	NA	NA	NA	NA
	Total WLA	NA	NA	NA	NA	NA
Load Allocation		249.62	70.80	35.49	19.96	5.25
10% Margin of Safety		27.74	7.87	3.94	2.22	0.58

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

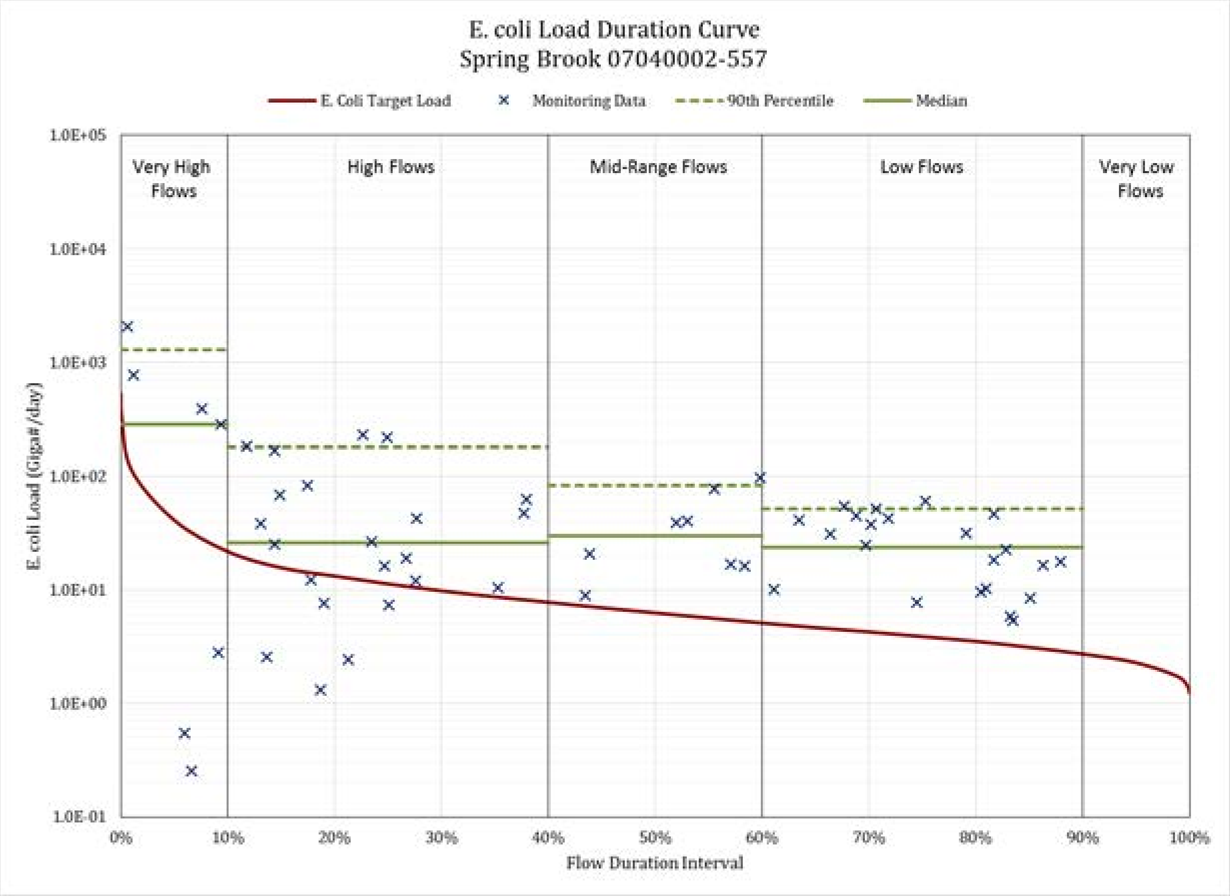


Figure 36. MIDDLE CANNON RIVER HUC-10: Rice Creek (Spring Brook) – 07040002-557

Table 81. MIDDLE CANNON RIVER HUC-10: Rice Creek (Spring Brook) – 07040002-557

Spring Brook 07040002-557 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		Billions of Organisms/day				
E. coli Loading Capacity (TMDL)		41.17	11.28	6.27	3.87	2.28
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Northfield MS4 (0.22%)	0.08	0.02	0.01	0.01	0.00
	Total WLA	0.08	0.02	0.01	0.01	0.00
Load Allocation		36.97	10.13	5.63	3.47	2.04
10% Margin of Safety		4.12	1.13	0.63	0.39	0.23

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

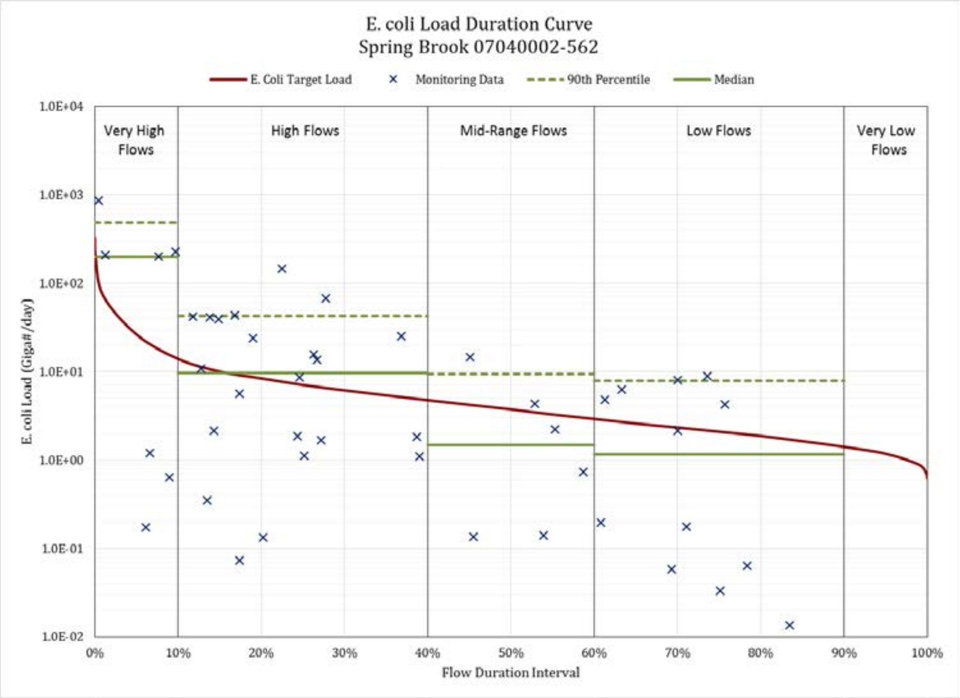


Figure 37. MIDDLE CANNON RIVER HUC-10: (Rice Creek) Spring Brook – 07040002-562

Table 82. MIDDLE CANNON RIVER HUC-10: (Rice Creek) Spring Brook – 07040002-562

Spring Brook 07040002-562 TMDL Summary		**Flow Regime**				
		VHigh	**High**	**Mid**	**Low**	**VLow**
		Billions of Organisms/day				
***E. coli* Loading Capacity (TMDL)**		**26.45**	**7.08**	**3.75**	**2.10**	**1.18**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	MS4***	NA	NA	NA	NA	NA
	Total WLA	**NA**	**NA**	**NA**	**NA**	**NA**
Load Allocation		**23.80**	**6.37**	**3.37**	**1.89**	**1.06**
10% Margin of Safety		**2.64**	**0.71**	**0.37**	**0.21**	**0.12**

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

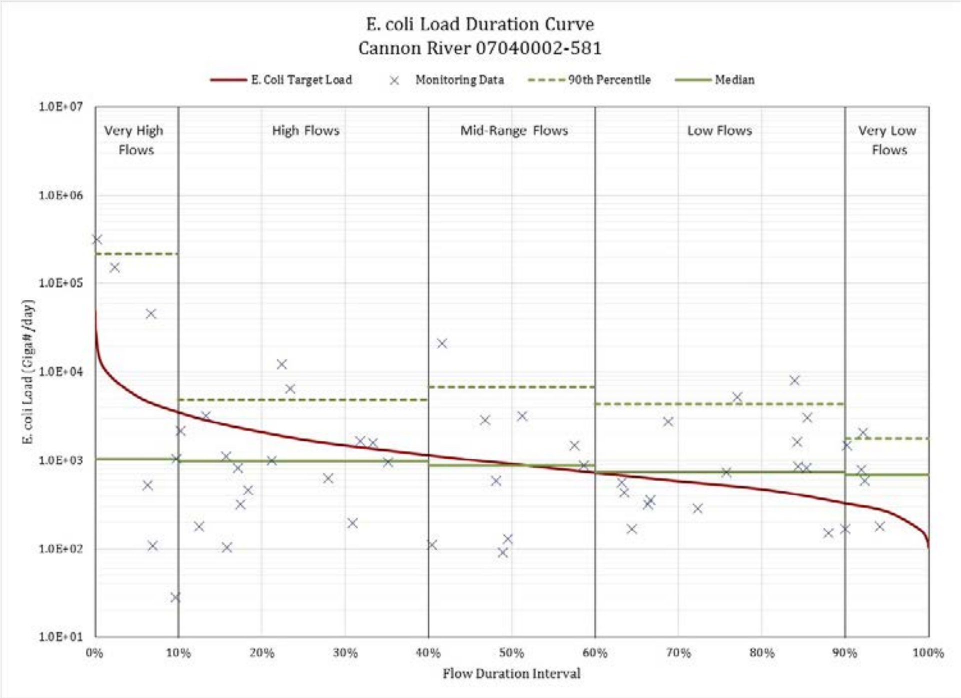


Figure 38. MIDDLE CANNON RIVER HUC-10: Cannon River – 07040002-581

Table 83. MIDDLE CANNON RIVER HUC-10: Cannon River – 07040002-581

Cannon River 07040002-581 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		Billions of Organisms/day				
E. coli Loading Capacity (TMDL)		5327.90	1713.49	914.40	528.23	264.05
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	80.36	80.36	80.36	80.36	80.36
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Faribault MS4 (1.7%)	80.15	24.85	12.62	6.72	2.67
	Owatonna MS4 (1.88%)	88.64	27.48	13.96	7.43	2.96
	Waseca MS4 (0.55%)	25.93	8.04	4.08	2.17	0.87
	Total WLA	275.08	140.73	111.03	96.67	86.86
Load Allocation		4520.03	1401.41	711.93	378.73	150.79
10% Margin of Safety		532.79	171.35	91.44	52.82	26.41

* See Table 134 in Appendix H for complete facility list

** No permitted individual stormwater facilities in the CRW

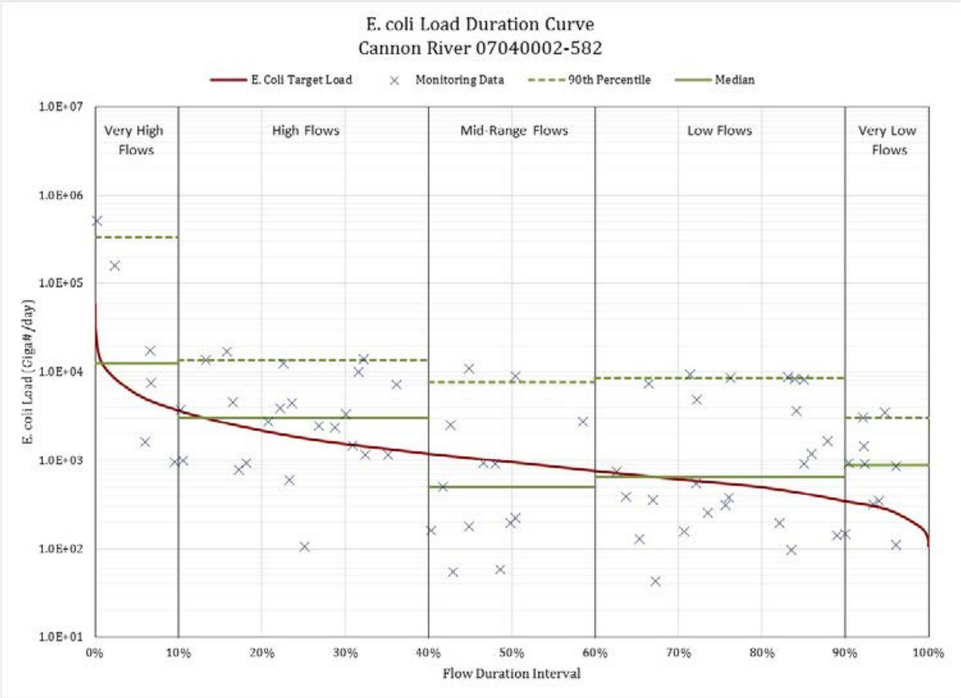


Figure 39. MIDDLE CANNON RIVER HUC-10: Cannon River – 07040002-582

Table 84. MIDDLE CANNON RIVER HUC-10: Cannon River – 07040002-582

Cannon River 07040002-582 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		Billions of Organisms/day				
E. coli Loading Capacity (TMDL)		5591.06	1787.32	956.80	556.33	279.51
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	80.36	80.36	80.36	80.36	80.36
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Faribault MS4 (1.92%)	95.07	29.34	14.99	8.07	3.29
	Owatonna MS4 (1.8%)	89.13	27.51	14.05	7.57	3.08
	Waseca MS4 (0.53%)	26.24	8.10	4.14	2.23	0.91
	Total WLA	290.80	145.31	113.54	98.22	87.64
Load Allocation		4741.15	1463.28	747.58	402.47	163.92
10% Margin of Safety		559.11	178.73	95.68	55.63	27.95

* See Table 135 in Appendix H for complete facility list

** No permitted individual stormwater facilities in the CRW

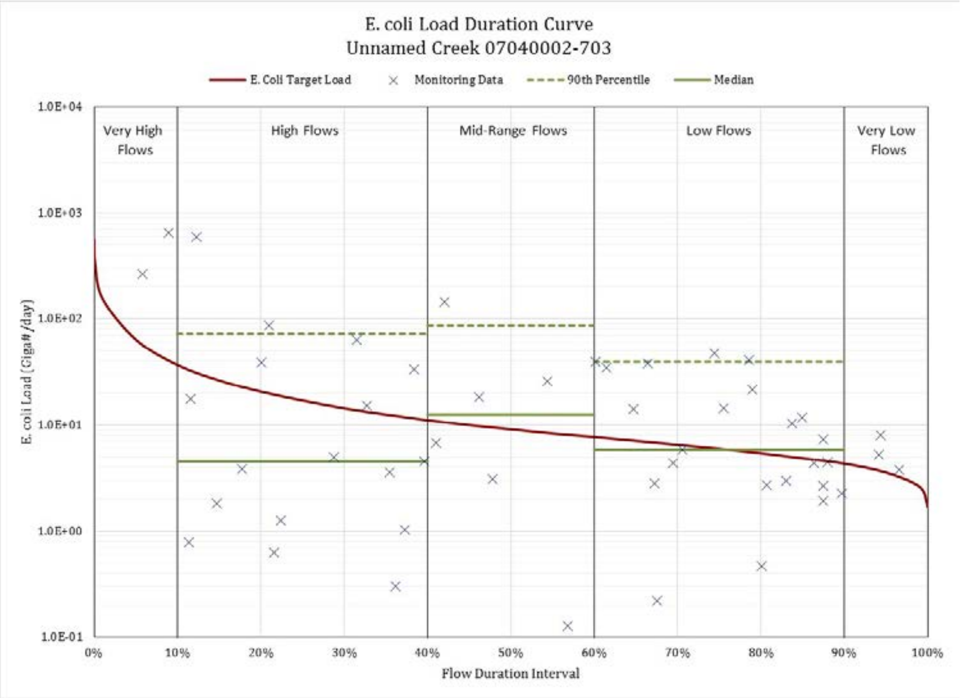


Figure 40. MIDDLE CANNON RIVER HUC-10: Unnamed Creek – 07040002-703

Table 85. MIDDLE CANNON RIVER HUC-10: Unnamed Creek – 07040002-703

Unnamed Creek 07040002-703 TMDL Summary		**Flow Regime**				
		VHigh	**High**	**Mid**	**Low**	**VLow**
		Billions of Organisms/day				
***E. coli* Loading Capacity (TMDL)**		**63.98**	**17.06**	**9.13**	**5.99**	**3.58**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Faribault MS4 (22.48%)	12.94	3.45	1.85	1.21	0.72
	Total WLA	**12.94**	**3.45**	**1.85**	**1.21**	**0.72**
Load Allocation		**44.64**	**11.90**	**6.37**	**4.18**	**2.50**
10% Margin of Safety		**6.40**	**1.71**	**0.91**	**0.60**	**0.36**

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

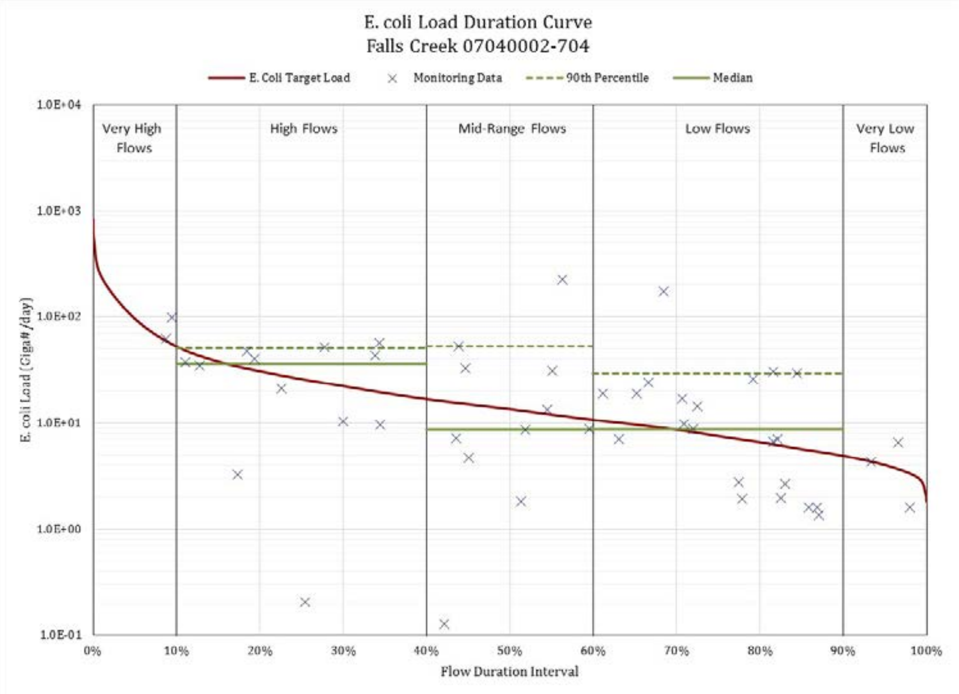


Figure 41. STRAIGHT RIVER HUC-10: Falls Creek – 07040002-704

Table 86. STRAIGHT RIVER HUC-10: Falls Creek – 07040002-704

Falls Creek 07040002-704 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		Billions of Organisms/day				
E. coli Loading Capacity (TMDL)		96.14	25.94	13.58	7.55	4.02
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Faribault MS4 (1.92%)	1.66	0.45	0.24	0.13	0.07
	Total WLA	1.66	0.45	0.24	0.13	0.07
Load Allocation		84.86	22.89	11.99	6.67	3.55
10% Margin of Safety		9.61	2.59	1.36	0.76	0.40

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

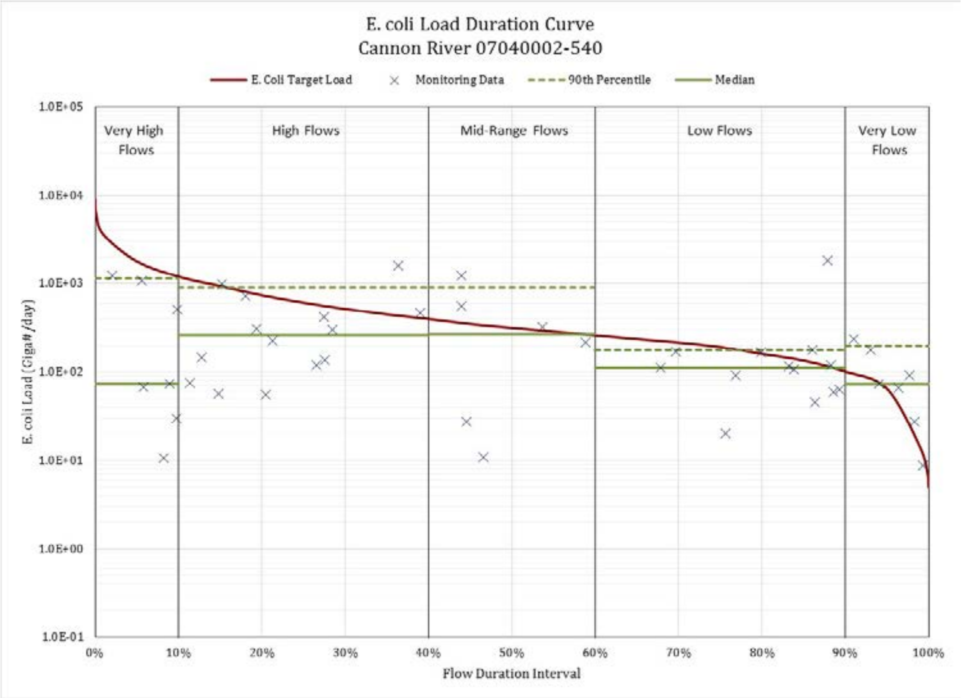


Figure 42. UPPER CANNON RIVER HUC-10: Cannon River – 07040002-540

Table 87. UPPER CANNON RIVER HUC-10: Cannon River – 07040002-540

Cannon River 07040002-540 TMDL Summary		**Flow Regime**				
		VHigh	**High**	**Mid**	**Low**	**VLow**
		Billions of Organisms/day				
***E. coli* Loading Capacity (TMDL)**		**1784.59**	**609.36**	**315.58**	**191.93**	**64.83**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	11.84	11.84	11.84	11.84	11.84
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Faribault MS4 (1.79%)	28.52	9.60	4.87	2.88	0.83
	Total WLA	**40.35**	**21.44**	**16.71**	**14.72**	**12.67**
Load Allocation		**1565.77**	**526.99**	**267.32**	**158.02**	**45.68**
10% Margin of Safety		**178.46**	**60.94**	**31.56**	**19.19**	**6.48**

* See Table 141 in Appendix H for complete facility list

** No permitted individual stormwater facilities in the CRW

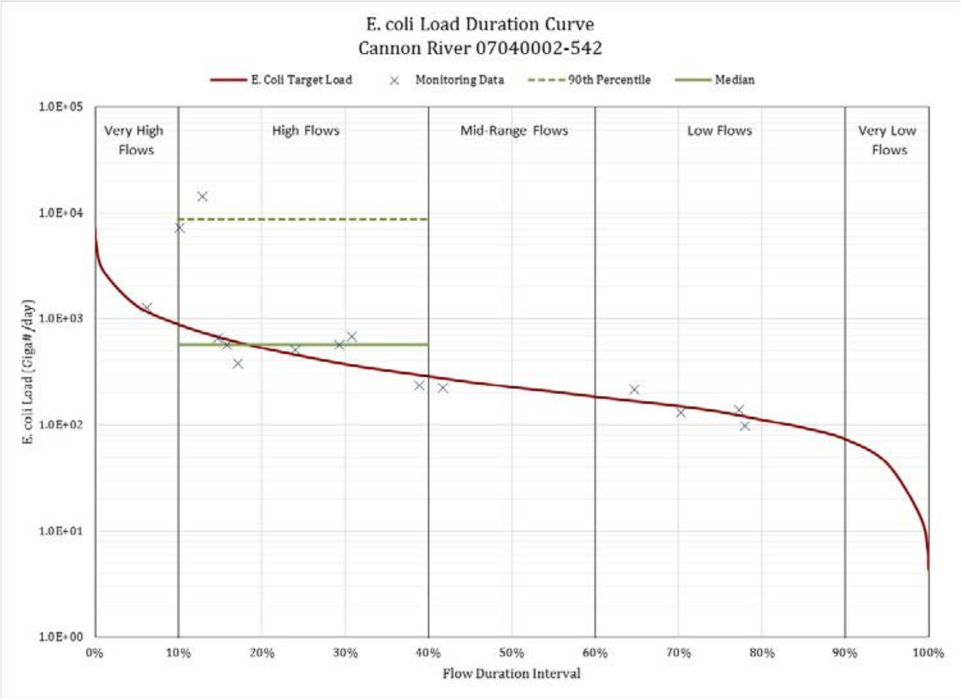


Figure 43. UPPER CANNON RIVER HUC-10: Cannon River – 07040002-542

Table 88. UPPER CANNON RIVER HUC-10: Cannon River – 07040002-542

Cannon River 07040002-542 TMDL Summary		**Flow Regime**				
		VHigh	**High**	**Mid**	**Low**	**VLow**
		Billions of Organisms/day				
***E. coli* Loading Capacity (TMDL)**		**1332.00**	**444.31**	**227.69**	**133.78**	**43.76**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	11.84	11.84	11.84	11.84	11.84
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	MS4***	NA	NA	NA	NA	NA
	Total WLA	**11.84**	**11.84**	**11.84**	**11.84**	**11.84**
Load Allocation		**1186.96**	**388.04**	**193.08**	**108.56**	**27.54**
10% Margin of Safety		**133.20**	**44.43**	**22.77**	**13.38**	**4.38**

* See Table 142 in Appendix H for complete facility list

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

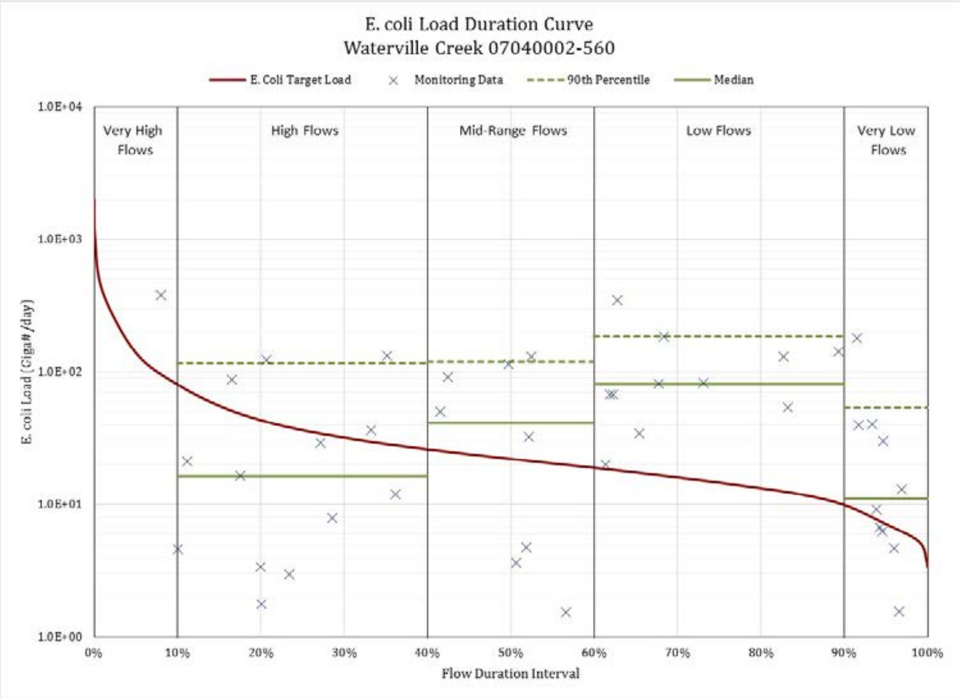


Figure 44. UPPER CANNON RIVER HUC-10: Waterville Creek – 07040002-560

Table 89. UPPER CANNON RIVER HUC-10: Waterville Creek – 07040002-560

Waterville Creek 07040002-560 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		Billions of Organisms/day				
E. coli Loading Capacity (TMDL)		139.62	36.44	22.12	14.70	7.15
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	MS4***	NA	NA	NA	NA	NA
	Total WLA	NA	NA	NA	NA	NA
Load Allocation		125.66	32.79	19.91	13.23	6.43
10% Margin of Safety		13.96	3.64	2.21	1.47	0.71

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

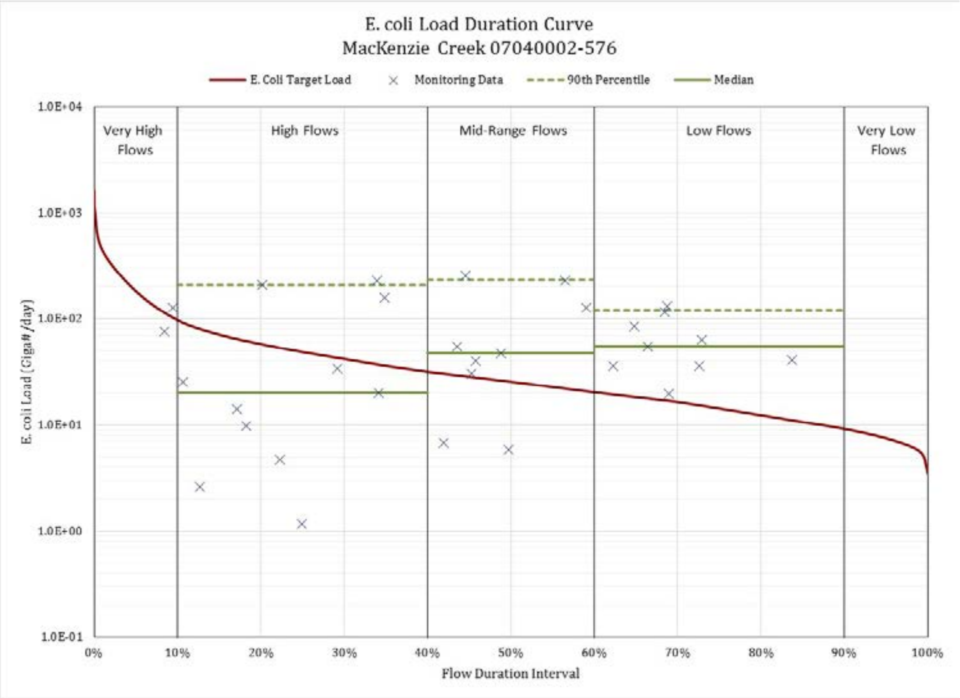


Figure 45. UPPER CANNON RIVER HUC-10: MacKenzie Creek – 07040002-576

Table 90. UPPER CANNON RIVER HUC-10: MacKenzie Creek – 07040002-576

MacKenzie Creek 07040002-576 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		Billions of Organisms/day				
E. coli Loading Capacity (TMDL)		182.89	48.88	25.60	14.36	7.51
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	MS4***	NA	NA	NA	NA	NA
	Total WLA	NA	NA	NA	NA	NA
Load Allocation		164.60	43.99	23.04	12.92	6.76
10% Margin of Safety		18.29	4.89	2.56	1.44	0.75

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

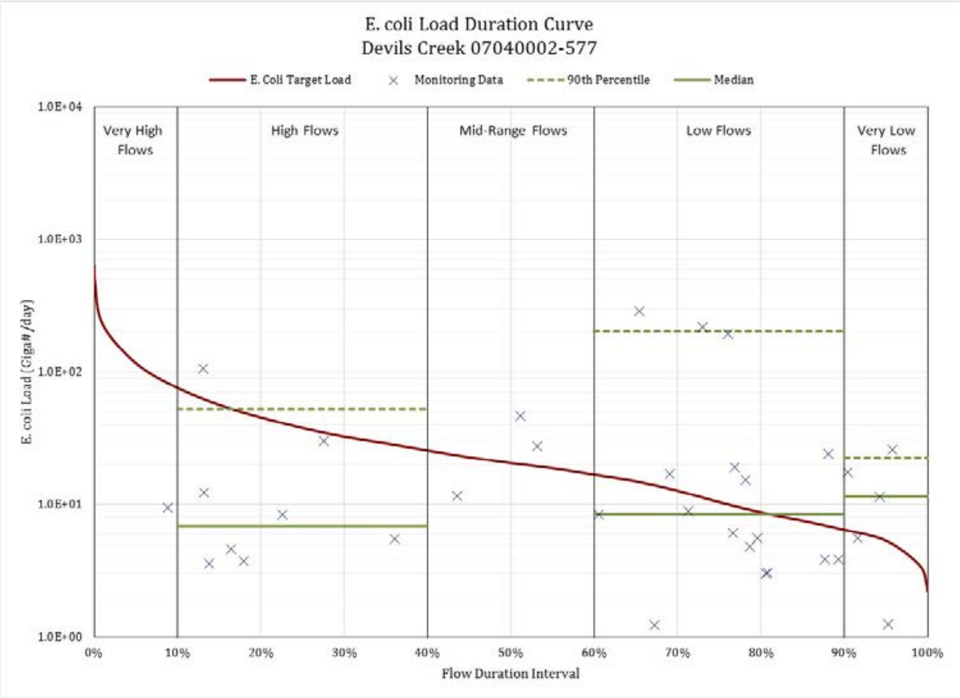


Figure 46. UPPER CANNON RIVER HUC-10: Devil's Creek – 07040002-577

Table 91. UPPER CANNON RIVER HUC-10: Devil's Creek – 07040002-577

Devils Creek 07040002-577 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		Billions of Organisms/day				
E. coli Loading Capacity (TMDL)		116.60	37.84	20.60	10.44	5.35
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	MS4***	NA	NA	NA	NA	NA
	Total WLA	NA	NA	NA	NA	NA
Load Allocation		104.94	34.05	18.54	9.39	4.82
10% Margin of Safety		11.66	3.78	2.06	1.04	0.54

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

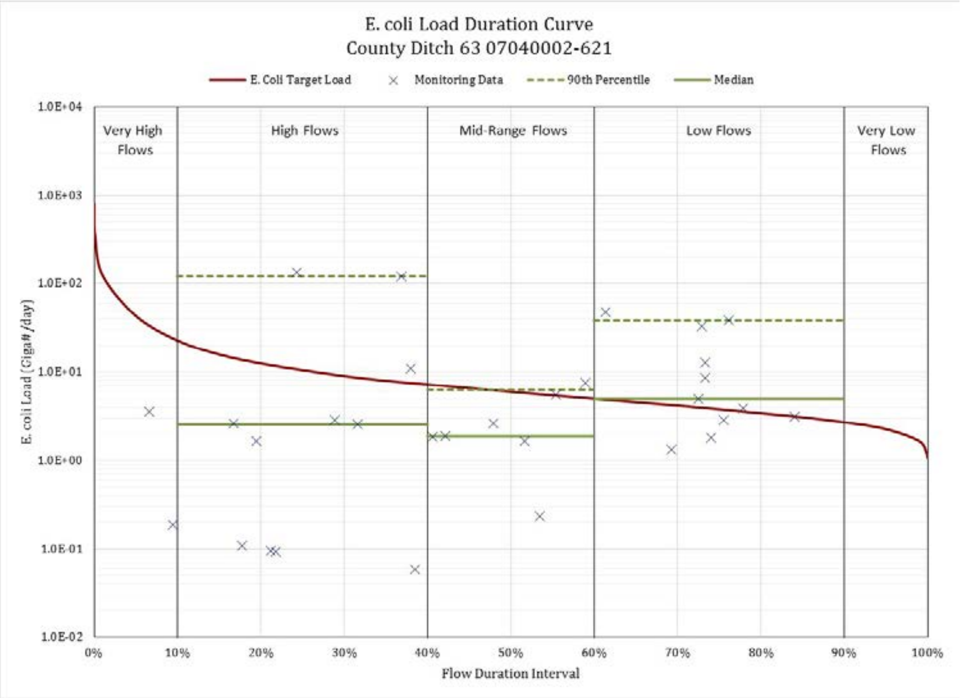


Figure 47. UPPER CANNON RIVER HUC-10: County Ditch 63 – 07040002-621

Table 92. UPPER CANNON RIVER HUC-10: County Ditch 63 – 07040002-621

County Ditch 63 07040002-621 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		Billions of Organisms/day				
E. coli Loading Capacity (TMDL)		43.13	10.52	5.99	3.80	2.27
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	MS4***	NA	NA	NA	NA	NA
	Total WLA	NA	NA	NA	NA	NA
Load Allocation		38.81	9.47	5.40	3.42	2.04
10% Margin of Safety		4.31	1.05	0.60	0.38	0.23

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

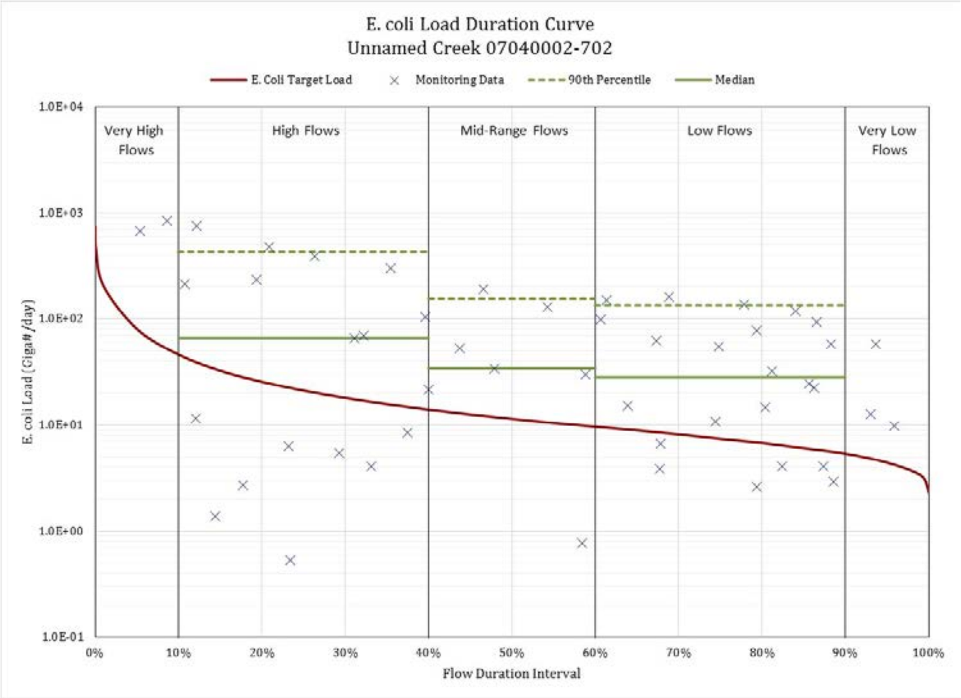


Figure 48. UPPER CANNON RIVER HUC-10: Unnamed Creek – 07040002-702

Table 93. UPPER CANNON RIVER HUC-10: Unnamed Creek – 07040002-702

Unnamed Creek 07040002-702 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		Billions of Organisms/day				
E. coli Loading Capacity (TMDL)		80.66	21.15	11.46	7.43	4.44
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Faribault MS4 (16.16%)	11.73	3.08	1.67	1.08	0.65
	Total WLA	11.73	3.08	1.67	1.08	0.65
Load Allocation		60.86	15.96	8.65	5.60	3.35
10% Margin of Safety		8.07	2.12	1.15	0.74	0.44

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

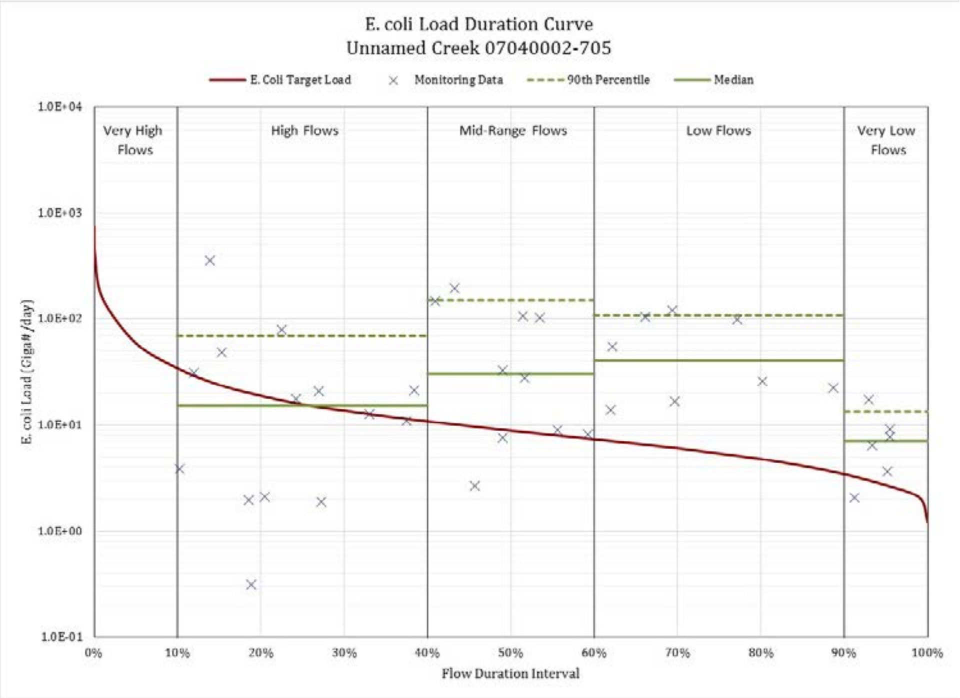


Figure 49. UPPER CANNON RIVER HUC-10: Unnamed Creek – 07040002-705

Table 94. UPPER CANNON RIVER HUC-10: Unnamed Creek – 07040002-705

Unnamed Creek 07040002-705 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		Billions of Organisms/day				
E. coli Loading Capacity (TMDL)		59.33	15.63	8.85	5.39	2.71
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities	NA	NA	NA	NA	NA
	MS4***	NA	NA	NA	NA	NA
	Total WLA	NA	NA	NA	NA	NA
Load Allocation		53.40	14.07	7.97	4.86	2.44
10% Margin of Safety		5.93	1.56	0.89	0.54	0.27

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

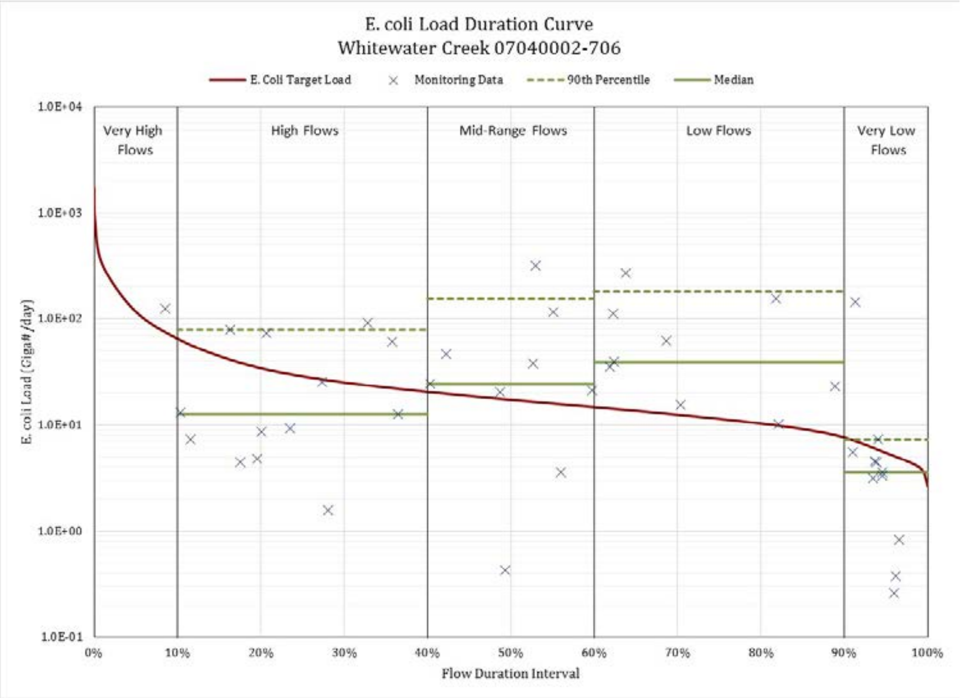


Figure 50. UPPER CANNON RIVER HUC-10: Unnamed Creek – 07040002-705

Table 95. UPPER CANNON RIVER HUC-10: Unnamed Creek – 07040002-705

Whitewater Creek 07040002-706 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		Billions of Organisms/day				
E. coli Loading Capacity (TMDL)		117.07	28.85	17.30	11.46	5.48
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	MS4***	NA	NA	NA	NA	NA
	Total WLA	NA	NA	NA	NA	NA
Load Allocation		105.37	25.97	15.57	10.31	4.93
10% Margin of Safety		11.71	2.89	1.73	1.15	0.55

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

4.4 Chloride

4.4.1 Loading Capacity Methodology

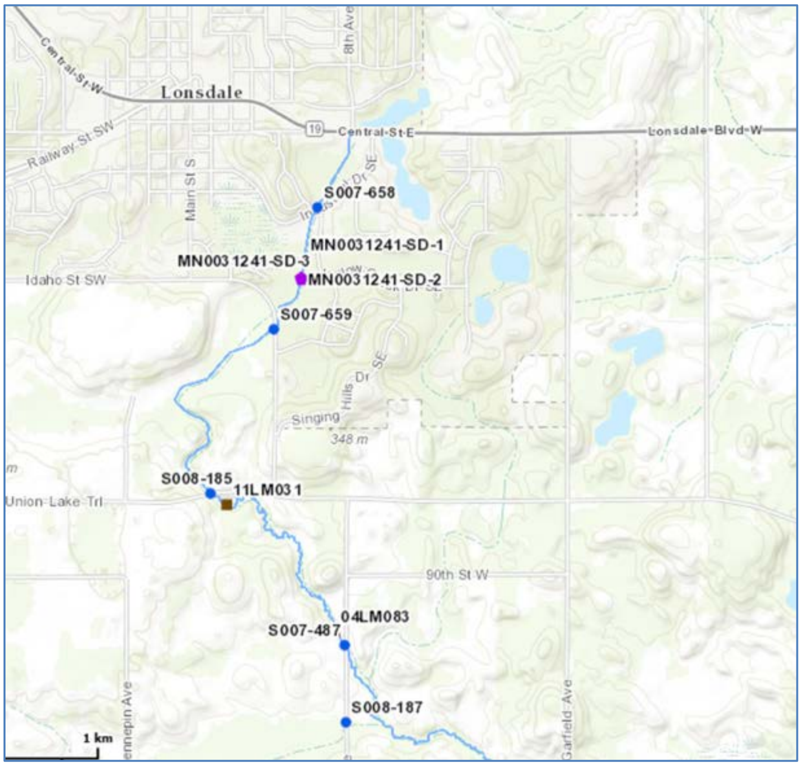
A total loading capacity was assigned to the impaired reach identified in Table 2 under the following flow regimes: Very High, High, Mid, Low, and Very Low. In 2014, LimnoTech developed a calibrated HSPF model for the simulation period covering 1996 through 2012, which was used as the baseline flow for all TMDLs. From these results, a total loading capacity was assigned for each flow regime – Very High, High, Mid, Low, and Very Low – by multiplying the median flow of each regime by the Minnesota water quality standard for chloride.

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 table of this report (Table 96) only five points on the entire loading capacity curve are depicted (the midpoints of the designated flow zones). However, it should be understood that the entire curve represents the TMDL and is what is ultimately approved by the EPA. In the load duration curve, there are no monitored data points plotted, because none of the samples collected fell within the HSPF simulation period.

During baseflow sampling in August of 2013, elevated levels of specific conductance were measured at the co-located stations of 04LM083 and S007-487. Follow-up monitoring longitudinally began September 9, 2013, and continued into 2014 under a variety of flow conditions. The stations that were monitored for chloride were stations S007-658, S007-659, and S007-487 (upstream to downstream). Stations S007-658 and S007-659 are on the upstream AUID (07040002-530) and station S007-487 is on the impaired AUID (07040002-555). Elevated chloride levels have been found at station S007-487 as high as 417 mg/L, well over the chronic standard of 230 mg/L (Figure 52). During times of increased stream flow, the chloride concentration is not as high, but during baseflow or lower flow times the two downstream stations exhibit elevated chloride concentrations.

Field measurements only were collected at additional stations downstream to follow the elevated specific conductivity measurements (Figure 53). During longitudinal surveys of conductivity, the highest conductivity was found at station S007-659 on July 24, 2014. The elevated conductivity may not be caused by the elevated chloride alone, but is a surrogate for issues such as chloride. Note that the chloride data collected during stressor identification work (which confirm the stressor and exceedances of the water quality standard) do not overlap the HSPF model simulation period and therefore are not plotted on the load duration curve in Figure 54. They are summarized in Figure 52.

Figure 51. Chloride data collection sites.



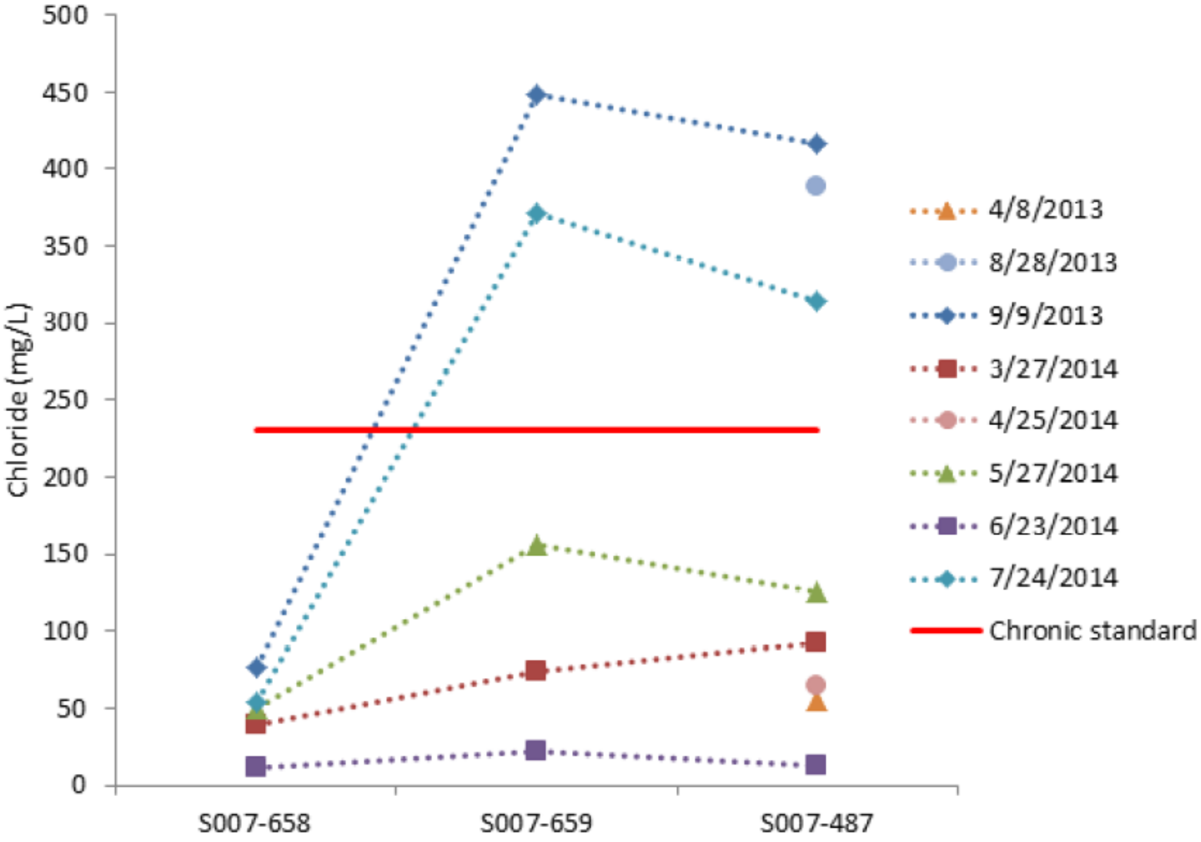


Figure 52. Chloride concentrations at three stations along Unnamed Ditch (MPCA 2015b)

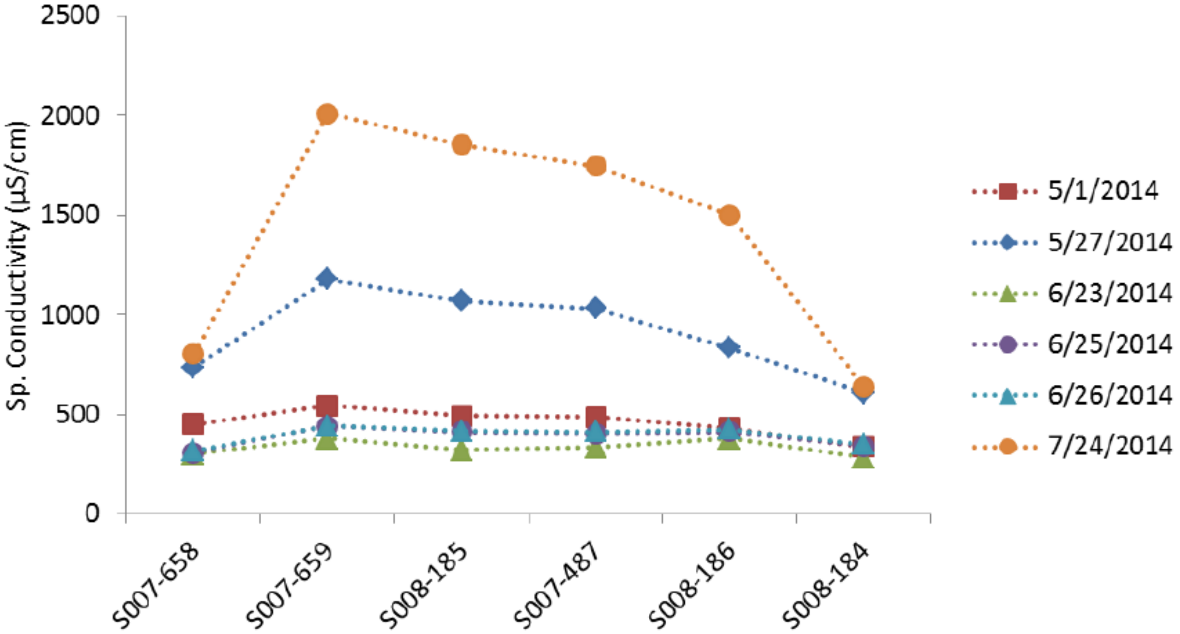


Figure 53. Specific conductivity readings longitudinally in Unnamed Ditch on selected dates in 2014 (MPCA, 2015b)

4.4.2 Load Allocation Methodology

The LA is comprised of the non-point source load that is allocated to an impaired AUID after the MOS and WLA are subtracted from the total loading capacity for each flow regime. This residual load is meant to represent all non-regulated sources of chloride upstream of the impaired reach.

4.4.3 Wasteload Allocation Methodology

4.4.3.1 Permitted Industrial and Municipal Wastewater Facilities

Within the CRW, there are 33 NPDES permitted industrial and municipal WWTFs. Each facility is permitted for specific water quality limits at their discharge. Only the Lonsdale WWTP discharges into an AUID impaired for chloride. The WLA for this facility was calculated using design flow and the state water quality standard for chloride.

4.4.3.2 Permitted Industrial Stormwater Facilities

There was no individual permitted industrial stormwater facilities that required a WLA. Impaired AUIDs were not assigned a “0” WLA, but rather listed as NA (Not Applicable).

4.4.3.3 Regulated Construction and Industrial Stormwater

WLAs for regulated construction stormwater (MNR10001) were not developed since chloride is not a typical pollutant from construction sites.

The WLAs for regulated industrial stormwater were also not developed. Industrial stormwater must receive a WLA only if the pollutant is part of benchmark monitoring for an industrial site in the watershed of an impaired waterbody.

4.4.3.4 Regulated MS4 Stormwater

The MS4 systems are designed to convey stormwater into a receiving waterbody and are permitted under the NPDES Permit.

There are no MS4 communities in the chloride impaired AUID watershed and thus none are included in the WLA. No future MS4 communities are planned that need to be included in the WLA.

4.4.4 Margin of Safety

An explicit MOS equal to 10% of the loading capacity was used for the stream TMDLs based on the following considerations:

- Most of the uncertainty in flow is a result of extrapolating flows from the hydrologically-nearest stream gage. The explicit MOS, in part, accounts for this.
- Allocations are a function of flow, which varies from high to low flows. This variability is accounted for through the development of a TMDL for each of five flow regimes.

4.4.5 Season Variation

In urbanized watersheds, seasonal variation is important given that a primary source of chloride is road deicing agents. However, the chloride causing impairments in the streams in the outlying areas of the metro is largely effluent from the WWTPs, rather than deicing salt (MPCA 2016b).

Residential water softener use is also a significant source of chloride. Residential water softeners use chloride to remove hardness, which is typically caused by high levels of calcium and/or magnesium. In areas with hard water, residential water softeners that use salt are common. The chloride from water softeners makes its way to the environment either through discharge to a septic system or by delivery to a municipal WWTP. Chloride is not removed from wastewater using conventional treatment methods. However, chloride can be removed from wastewater by using reverse osmosis (RO) technology, which is considered cost-prohibitive for an issue of this scale (MPCA 2016b).

4.4.6 TMDL Summary

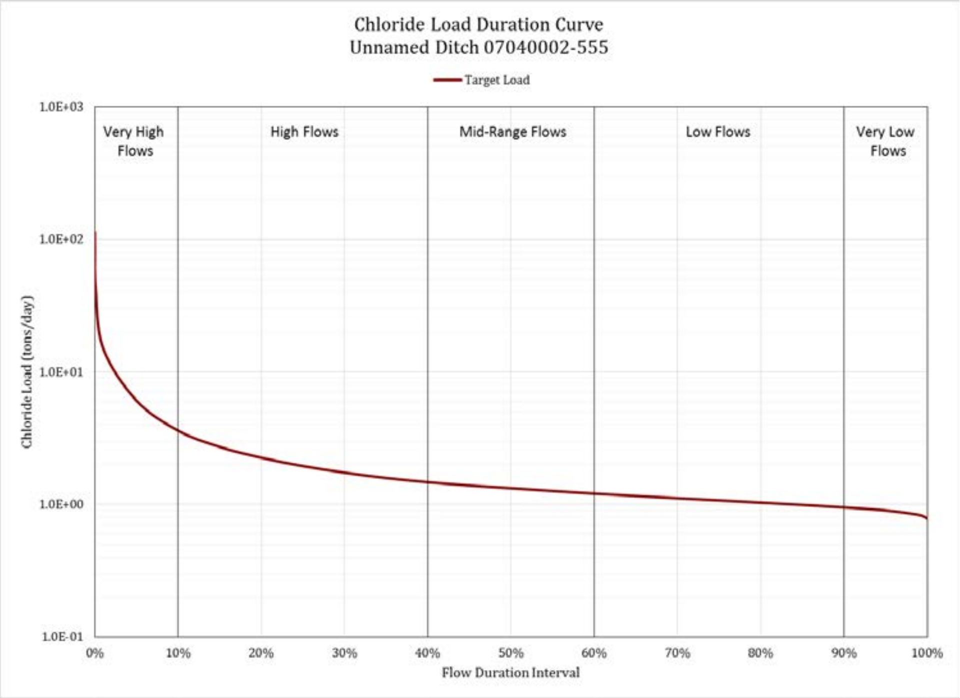


Figure 54. MIDDLE CANNON RIVER HUC-10: Unnamed Ditch – 07040002-555

Table 96. MIDDLE CANNON RIVER HUC-10: Unnamed Ditch – 07040002-555

Unnamed Ditch 07040002-555 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		tons/day				
Chloride Loading Capacity (TMDL)		6.10	1.95	1.33	1.07	0.90
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	0.66	0.66	0.66	0.66	0.66
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	MS4***	NA	NA	NA	NA	NA
	Total WLA	0.66	0.66	0.66	0.66	0.66
Load Allocation		4.83	1.09	0.53	0.31	0.15
10% Margin of Safety		0.61	0.19	0.13	0.11	0.09

* See Table 133 in Appendix H for complete facility list

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

4.5 Nitrate

4.5.1 Loading Capacity Methodology

A total loading capacity was assigned to each impaired reach identified in Table 2 under the following flow regimes: Very High, High, Mid, Low, and Very Low. In 2014, LimnoTech developed a calibrated HSPF model for the simulation period covering 1996 through 2012, which was used as the baseline flow for all TMDLs. From these results, a total loading capacity was assigned for each flow regime – Very High, High, Mid, Low, and Very Low – by multiplying the median flow of each regime by the national drinking water quality standard for nitrate.

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 of this report (Tables 95 through 99) only five points on the entire loading capacity curve are depicted (the midpoints of the designated flow zones). However, it should be understood that the entire curve represents the TMDL and is what is ultimately approved by EPA

4.5.2 Load Allocation Methodology

As stated in the above equation, the LA is comprised of the non-point source load that is allocated to an impaired AUID after the MOS and WLA are subtracted from the total loading capacity for each flow regime. This residual load is meant to represent all non-regulated sources of nitrates upstream of the impaired reach, which are summarized in Section 3.7.3.

4.5.3 Wasteload Allocation Methodology

4.5.3.1 Permitted Industrial and Municipal Wastewater Facilities

Within the CRW, there are 33 NPDES permitted industrial and municipal WWTFs. Each facility is permitted for specific water quality limits at their discharge. There is only one permitted facility (Nerstand WWTP) that discharges to a nitrate impaired AUID; the WLA is included in the table for the Little Cannon River (07040002-589).

4.5.3.2 Permitted Industrial Stormwater Facilities

There was no individual permitted industrial stormwater facilities that required a WLA. Impaired AUIDs were not assigned a "0" WLA, but rather listed as NA (Not Applicable).

4.5.3.3 Regulated Construction and Industrial Stormwater

A permit is required for any construction activities disturbing: one acre or more of soil; less than one acre of soil if that activity is part of a "larger common plan of development or sale" that is greater than one acre; or less than one acre of soil, but the MPCA determines that the activity poses a risk to water resources. A construction stormwater runoff WLA is needed to account for pollutant loading (TP, TSS and nitrate) from ongoing construction activity in the watershed. The Minnesota Stormwater Manual average of construction activity for the six counties in the watershed (Le Sueur, Waseca, Steele, Rice, Dakota, and Goodhue) is approximately 0.075%. (http://stormwater.pca.state.mn.us/index.php/Construction_activity_by_county). Thus a generally appropriate estimate of the WLA for construction stormwater is 0.1% of the TMDL watershed load. This estimate was used in CRW TMDL computations. Note that in the TMDL tables, some of the daily construction and industrial stormwater WLAs are very small values and are expressed as “0.00” due to rounding and displayed decimal places. This does not constitute a “0” WLA; the daily WLAs are simply the annual WLAs divided by 365 (days).

4.5.3.4 Regulated MS4 Stormwater

The MS4 systems are designed to convey stormwater into a receiving waterbody and are permitted under the NPDES Permit.

All MS4 communities are existing communities and are included in the WLA. No future communities are planned that need to be included in this portion of the WLA.

The MS4 allocations were calculated using the following equation:

$$\text{MS4 Allocation} = \%\text{MS4 Area} * (\text{TLC} - \text{MOS} - \text{Permitted WW Facitilies})$$

Where:

%MS4 Area: the ratio of the total MS4 area to the total drainage area for the given AUID. Areas were obtained using ArcMap.

Permitted WW Facilities: the total WLA for all permitted industrial and municipal WWTFs that discharge into the AUID’s drainage area.

4.5.4 Margin of Safety

An explicit MOS equal to 10% of the loading capacity was used for the stream TMDLs based on the following considerations:

- Most of the uncertainty in flow is a result of extrapolating flows from the hydrologically-nearest stream gage. The explicit MOS, in part, accounts for this.
- Allocations are a function of flow, which varies from high to low flows. This variability is accounted for through the development of a TMDL for each of five flow regimes.

4.5.5 Season Variation

Critical conditions and seasonal variation are addressed in this TMDL through several mechanisms. The nitrate standard applies year-round, and data was collected throughout this period. The water quality analysis conducted on these data evaluated variability in flow through the use of five flow regimes: from high flows, such as flood events, to low flows, such as baseflow. Through the use of LDCs, nitrate loading was evaluated at actual flow conditions at the time of sampling.

4.5.6 TMDL Summaries

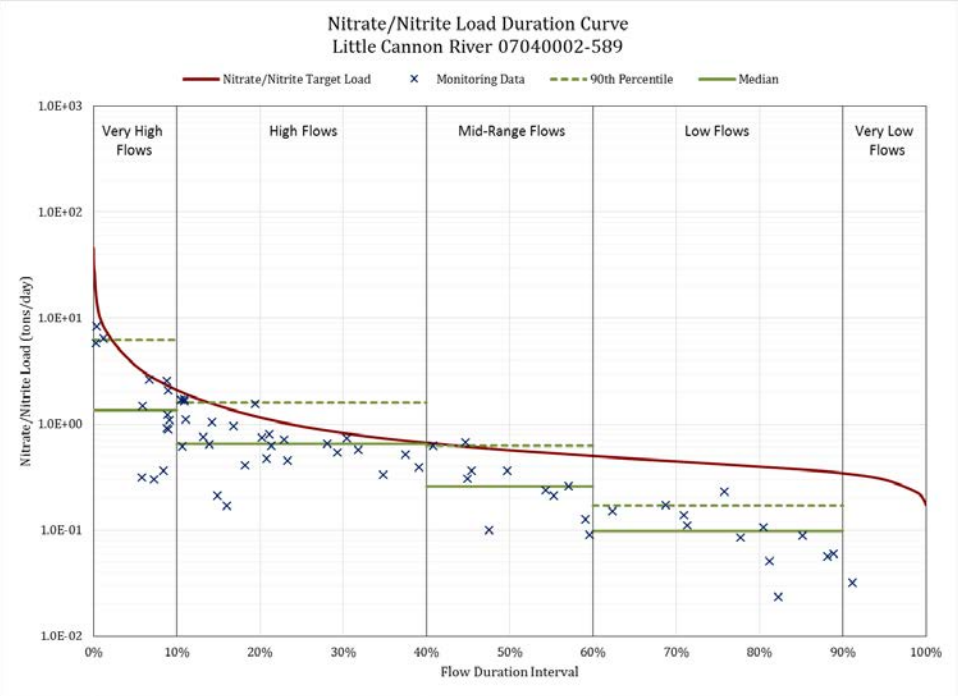


Figure 55. LITTLE CANNON RIVER HUC-10: Little Cannon River – 07040002-589

Table 97. LITTLE CANNON RIVER HUC-10: Little Cannon River – 07040002-589

Little Cannon River 07040002-589 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		kg/day				
Nitrate Loading Capacity (TMDL)		3258.43	865.38	515.80	382.76	271.85
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	4.00	4.00	4.00	4.00	4.00
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	2.93	0.78	0.46	0.34	0.24
	MS4***	NA	NA	NA	NA	NA
	Total WLA	6.93	4.78	4.46	4.34	4.24
Load Allocation		2925.65	774.07	459.76	340.14	240.42
10% Margin of Safety		325.84	86.54	51.58	38.28	27.18

* See Table 127 in Appendix H for facility list

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

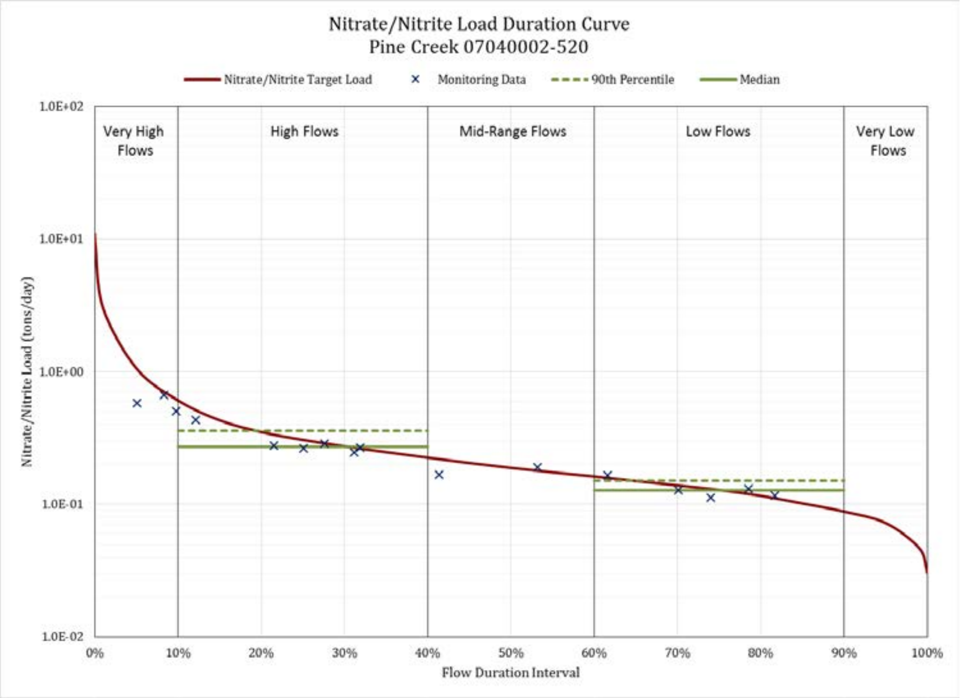


Figure 56. LOWER CANNON RIVER HUC-10: Pine Creek – 07040002-520

Table 98. LOWER CANNON RIVER HUC-10: Pine Creek – 07040002-520

Pine Creek 07040002-520 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		kg/day				
Nitrate Loading Capacity (TMDL)		**962.10**	**277.94**	**170.99**	**116.49**	**65.69**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.87	0.25	0.15	0.10	0.06
	MS4***	NA	NA	NA	NA	NA
	Total WLA	**0.87**	**0.25**	**0.15**	**0.10**	**0.06**
Load Allocation		**865.02**	**249.89**	**153.74**	**104.74**	**59.06**
10% Margin of Safety		**96.21**	**27.79**	**17.10**	**11.65**	**6.57**

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

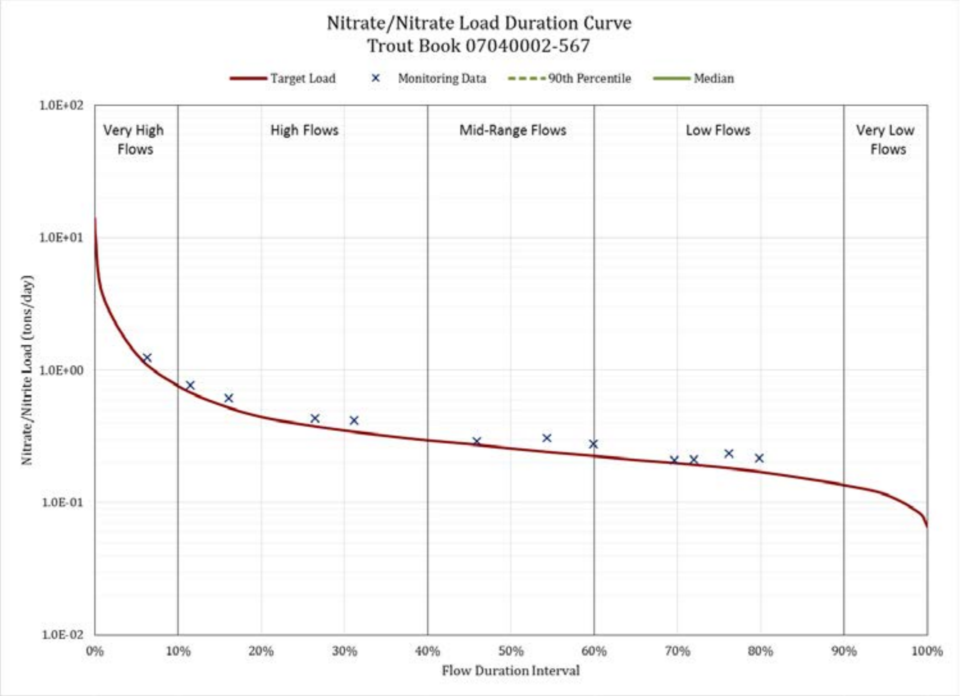


Figure 57. LOWER CANNON RIVER HUC-10: Trout Brook – 07040002-567

Table 99. LOWER CANNON RIVER HUC-10: Trout Brook – 07040002-567

Trout Book 07040002-567 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		tons/day				
Nitrate Loading Capacity (TMDL)		1201.60	353.34	232.93	168.07	104.48
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	1.08	0.32	0.21	0.15	0.09
	MS4***	NA	NA	NA	NA	NA
	Total WLA	1.08	0.32	0.21	0.15	0.09
Load Allocation		1080.35	317.69	209.43	151.11	93.94
10% Margin of Safety		120.16	35.33	23.29	16.81	10.45

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

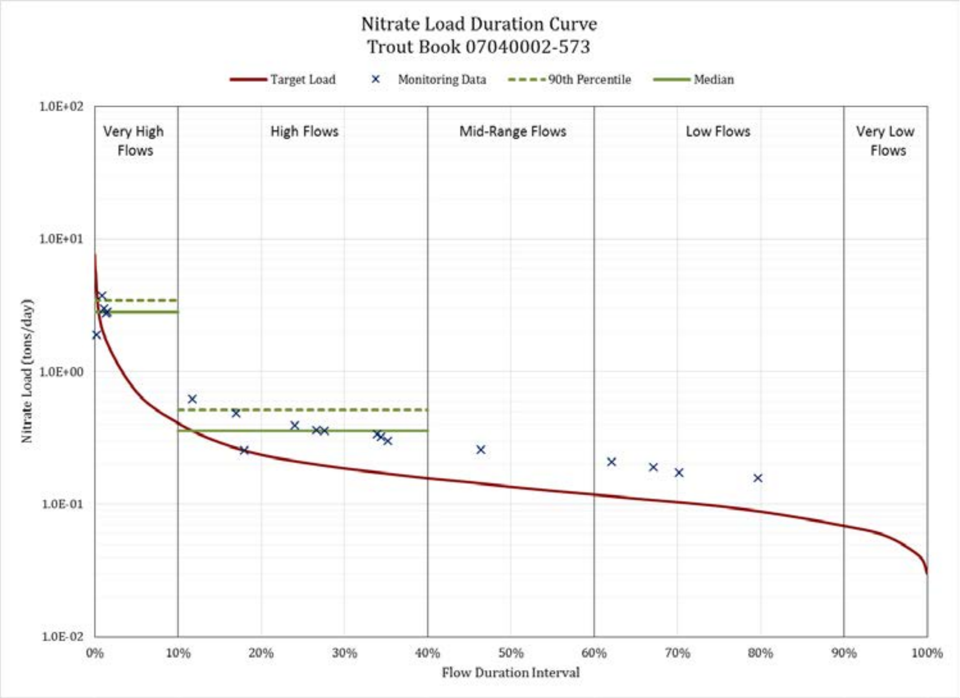


Figure 58. LOWER CANNON RIVER HUC-10: Trout Brook – 07040002-573

Table 100. LOWER CANNON RIVER HUC-10: Trout Brook – 07040002-573

Trout Book 07040002-573 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		kg/day				
Nitrate Loading Capacity (TMDL)		640.18	188.00	122.95	87.70	52.61
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.58	0.17	0.11	0.08	0.05
	MS4***	NA	NA	NA	NA	NA
	Total WLA	0.58	0.17	0.11	0.08	0.05
Load Allocation		575.59	169.03	110.55	78.85	47.30
10% Margin of Safety		64.02	18.80	12.30	8.77	5.26

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

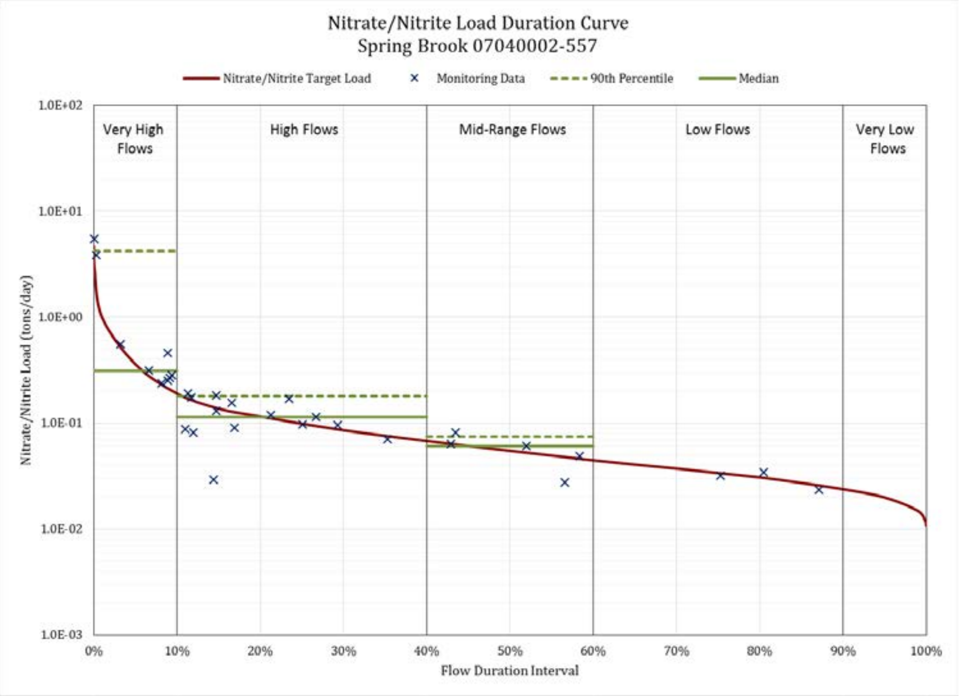


Figure 59. MIDDLE CANNON RIVER HIC-10: Spring Brook – 07040002-557

Table 101. MIDDLE CANNON RIVER HUC-10: Spring Brook – 07040002-557

Spring Brook 07040002-557 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		kg/day				
Nitrate Loading Capacity (TMDL)		326.85	89.57	49.75	30.72	18.07
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.29	0.08	0.04	0.03	0.02
	Northfield MS4 (0.22%)	0.65	0.18	0.10	0.06	0.04
	Total WLA	0.94	0.26	0.14	0.09	0.05
Load Allocation		293.22	80.36	44.63	27.56	16.21
10% Margin of Safety		32.69	8.96	4.97	3.07	1.81

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

4.6 Total Suspended Solids

4.6.1 Loading Capacity Methodology

A total loading capacity was assigned to each impaired reach identified in Table 2 under the following flow regimes: Very High, High, Mid, Low, and Very Low. In 2014, LimnoTech developed a calibrated HSPF model for the simulation period covering 1996 through 2012, which was used as the baseline flow for all TMDLs. From these results, a total loading capacity was assigned for each flow regime – Very High, High, Mid, Low, and Very Low – by multiplying the median flow of each regime by the Minnesota water quality standard for TSS.

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 of this report (Tables 100 through 113) only five points on the entire loading capacity curve are depicted (the midpoints of the designated flow zones). However, it should be understood that the entire curve represents the TMDL and is what is ultimately approved by the EPA. Two reaches did not have any monitoring data that fell within the HSPF simulation period, so HSPF predicted TSS loads were used (Figure 69 and Figure 73)

4.6.2 Load Allocation Methodology

As stated in the above equation, the LA is comprised of the non-point source load contributions that are allocated to an impaired AUID after the MOS and WLA are subtracted from the total loading capacity for each flow regime. This residual load is meant to represent all non-regulated sources of nitrates upstream of the impaired reach, which are summarized in Section 3.7.4.

4.6.3 Wasteload Allocation Methodology

4.6.3.1 Permitted Industrial and Municipal Wastewater Facilities

Within the CRW, there are 33 NPDES permitted industrial and municipal WWTFs. Each facility is permitted for specific water quality limits at their discharge. A list of facilities discharging to each AUID is accompanied in Appendix H. The WLAs for permitted facilities were calculated using design flow and the state water quality standard. Two different standards were used depending in the AUID was designated as a coldwater or warmwater reach.

4.6.3.2 Permitted Industrial Stormwater Facilities

There was no individual permitted industrial stormwater facilities that required a WLA. Impaired AUIDs were not assigned a "0" WLA, but rather listed as NA (Not Applicable).

4.6.3.3 Regulated Construction and Industrial Stormwater

A permit is required for any construction activities disturbing: one acre or more of soil; less than one acre of soil if that activity is part of a "larger common plan of development or sale" that is greater than one acre; or less than one acre of soil, but the MPCA determines that the activity poses a risk to water resources. A construction stormwater runoff WLA is needed to account for pollutant loading (TP, TSS and nitrate) from ongoing construction activity in the watershed. The Minnesota Stormwater Manual average of construction activity for the six counties in the watershed (Le Sueur, Waseca, Steele, Rice, Dakota, and Goodhue) is approximately 0.075%. (http://stormwater.pca.state.mn.us/index.php/Construction_activity_by_county). Thus a generally appropriate estimate of the WLA for construction stormwater is 0.1% of the TMDL watershed load. This estimate was used in CRW TMDL computations. Note that in the TMDL tables, some of the daily construction and industrial stormwater WLAs are very small values and are expressed as "0.00" due to rounding and displayed decimal places. This does not constitute a "0" WLA; the daily WLAs are simply the annual WLAs divided by 365 (days).

4.6.3.4 Regulated MS4 Stormwater

The MS4 systems are designed to convey stormwater into a receiving waterbody and are permitted under the NPDES Permit.

All MS4 communities are existing communities and are included in the WLA. No future communities are planned that need to be included in this portion of the WLA.

The MS4 allocations were calculated using the following equation:

$$\text{MS4 Allocation} = \%\text{MS4 Area} * (\text{TLC} - \text{MOS} - \text{Permitted WW Facitilies})$$

Where:

%MS4 Area: the ratio of the total MS4 area to the total drainage area for the given AUID. Areas were obtained using ArcMap.

Permitted WW Facilities: the total WLA for all permitted industrial and municipal WWTFs that discharge into the AUID's drainage area.

4.6.4 Margin of Safety

An explicit MOS equal to 10% of the loading capacity was used for the stream TMDLs based on the following considerations:

- Most of the uncertainty in flow is a result of extrapolating flows from the hydrologically-nearest stream gage. The explicit MOS, in part, accounts for this.
- Allocations are a function of flow, which varies from high to low flows. This variability is accounted for through the development of a TMDL for each of five flow regimes.

4.6.5 Season Variation

The TSS water quality standard applies for the period April through September which corresponds to the open water season when aquatic organisms are most active and when high stream TSS concentrations generally occur. TSS loading varies with the flow regime and season. Spring is associated with large flows from snowmelt, the summer is associated with the growing season as well as periodic storm events and receding streamflows, and the fall brings increasing precipitation and rapidly changing agricultural landscapes.

Critical conditions and seasonal variation are addressed in this TMDL through several mechanisms. The TSS standard applies during the open water months, and data was collected throughout this period. The water quality analysis conducted on these data evaluated variability in flow through the use of five flow regimes: from high flows, such as flood events, to low flows, such as baseflow. Through the use of LDCs, TSS loading was evaluated at actual flow conditions at the time of sampling.

4.6.6 TMDL Summaries

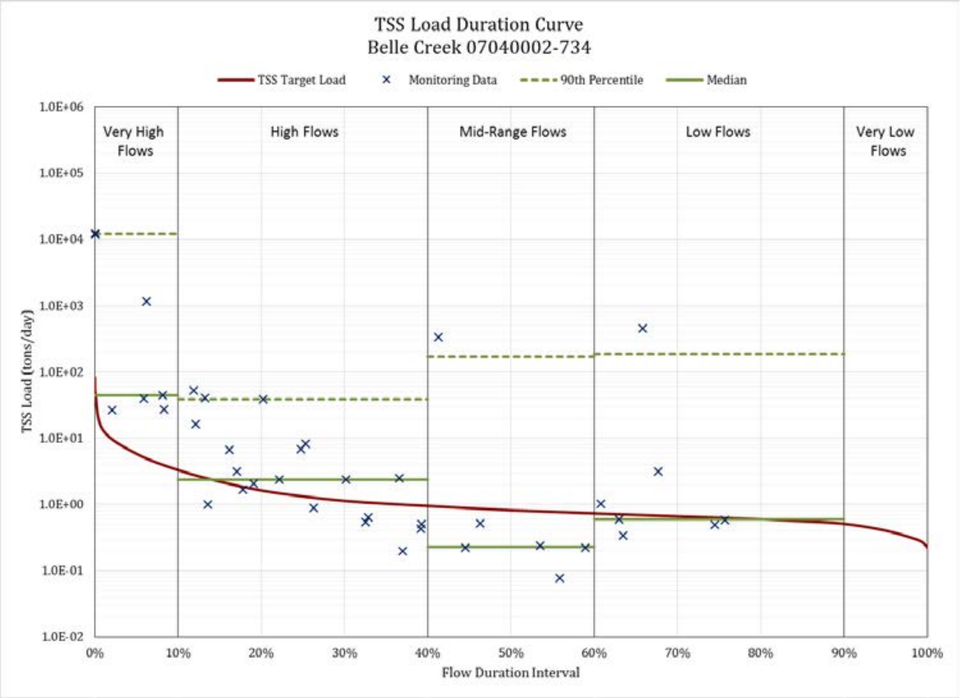


Figure 60. BELLE CREEK HUC-10: Belle Creek – 07040002-734

Table 102. BELLE CREEK HUC-10: Belle Creek – 07040002-734

Belle Creek 07040002-734 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		tons/day				
TSS Loading Capacity (TMDL)		5.83	1.32	0.82	0.63	0.40
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.01	0.00	0.00	0.00	0.00
	MS4***	NA	NA	NA	NA	NA
	Total WLA	0.01	0.00	0.00	0.00	0.00
Load Allocation		5.24	1.19	0.74	0.57	0.36
10% Margin of Safety		0.58	0.13	0.08	0.06	0.04

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

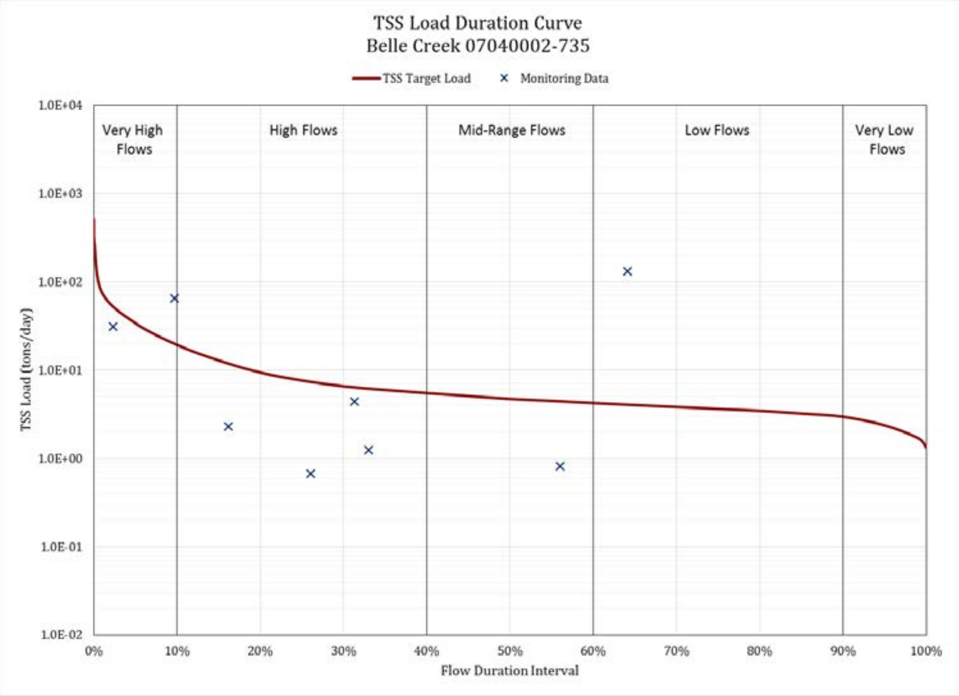


Figure 61. BELLE CREEK HUC-10: Belle Creek – 07040005-735

Table 103. BELLE CREEK HUC-10: Belle Creek – 07040005-735

Belle Creek 07040002-735 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		tons/day				
TSS Loading Capacity (TMDL)		34.08	7.64	4.74	3.64	2.38
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.03	0.01	0.00	0.00	0.00
	MS4***	NA	NA	NA	NA	NA
	Total WLA	0.03	0.01	0.00	0.00	0.00
Load Allocation		30.65	6.87	4.26	3.28	2.14
10% Margin of Safety		3.41	0.76	0.47	0.36	0.24

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

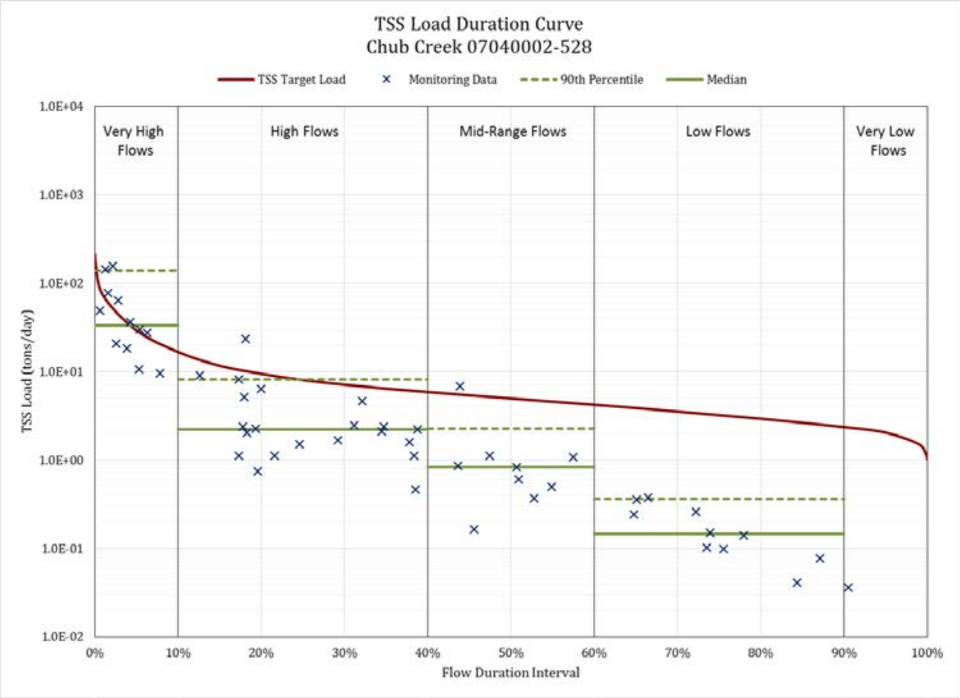


Figure 62. CHUB CREEK HUC-10: Chub Creek – 07040002-528

Table 104. CHUB CREEK HUC-10: Chub Creek – 07040002-528

Chub Creek 07040002-528 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		tons/day				
TSS Loading Capacity (TMDL)		29.44	8.04	4.99	3.23	2.05
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.03	0.01	0.00	0.00	0.00
	Northfield MS4 (0.66%)	0.17	0.05	0.03	0.02	0.01
	Total WLA	0.20	0.05	0.03	0.02	0.01
Load Allocation		26.30	7.19	4.46	2.88	1.83
10% Margin of Safety		2.94	0.80	0.50	0.32	0.21

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

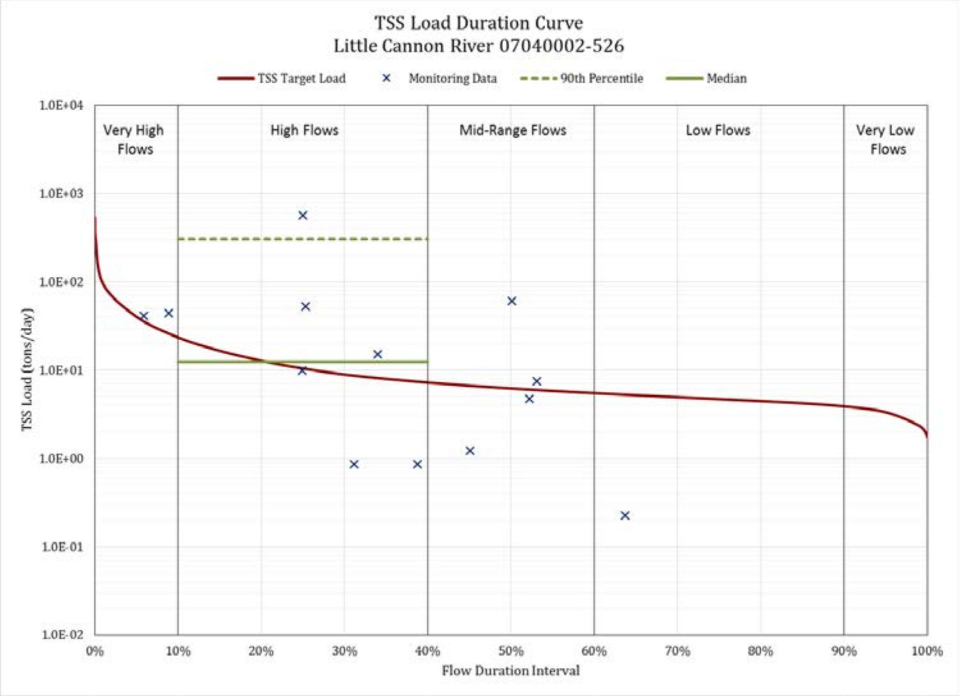


Figure 63. LITTLE CANNON RIVER HUC-10: Little Cannon River – 07040002-526

Table 105. LITTLE CANNON RIVER HUC-10: Little Cannon River – 07040002-526

Little Cannon River 07040002-526 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		tons/day				
TSS Loading Capacity (TMDL)		40.41	10.46	6.22	4.71	3.35
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	0.01	0.01	0.01	0.01	0.01
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.04	0.01	0.01	0.00	0.00
	MS4***	NA	NA	NA	NA	NA
	Total WLA	0.04	0.01	0.01	0.01	0.01
Load Allocation		36.32	9.40	5.59	4.23	3.01
10% Margin of Safety		4.04	1.05	0.62	0.47	0.34

* See Table 126Table 126 in Appendix H for complete facility list

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

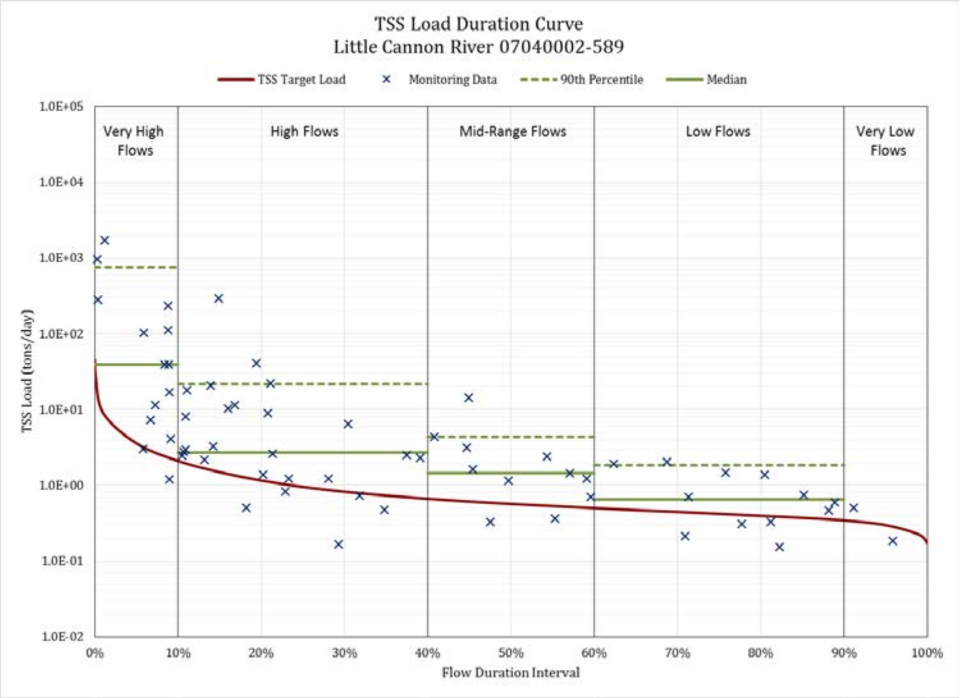


Figure 64. LITTLE CANNON RIVER HUC-10: Little Cannon River – 07040002-589

Table 106. LITTLE CANNON RIVER HUC-10: Little Cannon River – 07040002-589

Little Cannon River 07040002-589 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		tons/day				
TSS Loading Capacity (TMDL)		3.59	0.95	0.57	0.42	0.30
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	0.01	0.01	0.01	0.01	0.01
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.00	0.00	0.00	0.00	0.00
	MS4***	NA	NA	NA	NA	NA
	Total WLA	0.01	0.01	0.01	0.01	0.01
Load Allocation		3.22	0.85	0.51	0.37	0.26
10% Margin of Safety		0.36	0.10	0.06	0.04	0.03

* See Table 127 in Appendix H for complete facility list

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

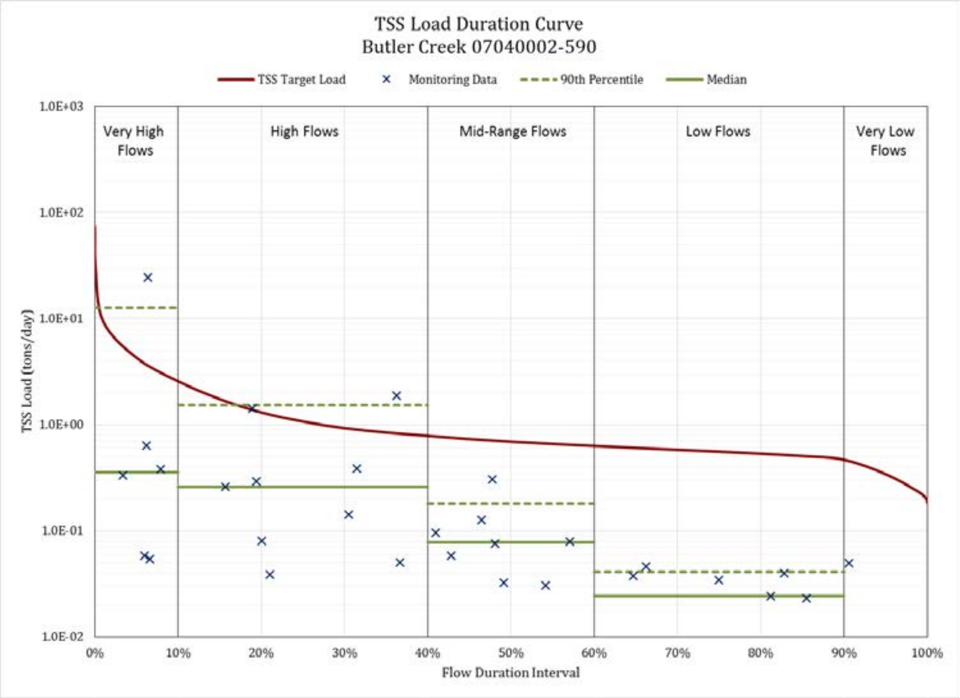


Figure 65. LITTLE CANNON RIVER HUC-10: Butler – 07040002-590

Table 107. LITTLE CANNON RIVER HUC-10: Butler – 07040002-590

Butler Creek 07040002-590 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		tons/day				
TSS Loading Capacity (TMDL)		**4.29**	**1.07**	**0.69**	**0.56**	**0.34**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.00	0.00	0.00	0.00	0.00
	MS4***	NA	NA	NA	NA	NA
	Total WLA	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Load Allocation		**3.85**	**0.96**	**0.62**	**0.50**	**0.31**
10% Margin of Safety		**0.43**	**0.11**	**0.07**	**0.06**	**0.03**

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

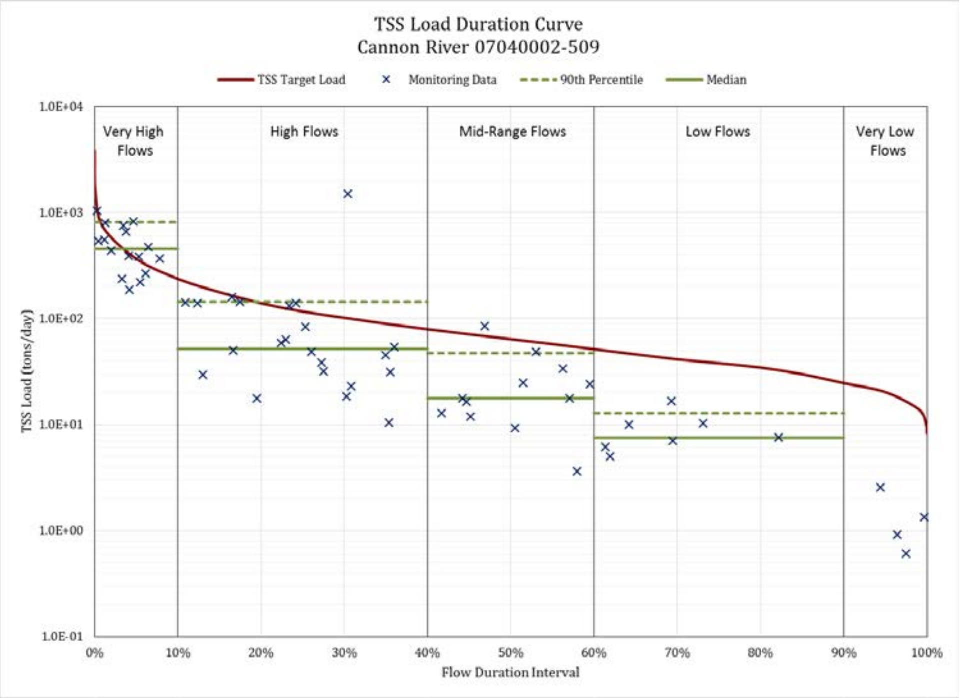


Figure 66. MIDDLE CANNON RIVER HUC-10: Cannon River – 07040002-509

Table 108. MIDDLE CANNON RIVER HUC-10: Cannon River – 07040002-509

Cannon River 07040002-509 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		tons/day				
TSS Loading Capacity (TMDL)		368.34	116.99	64.17	38.02	20.30
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	6.65	6.65	6.65	6.65	6.65
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.33	0.11	0.06	0.03	0.02
	Faribault MS4 (1.67%)	5.43	1.65	0.85	0.46	0.19
	Northfield MS4 (0.88%)	2.86	0.87	0.45	0.24	0.10
	Owatonna MS4 (1.56%)	5.07	1.54	0.80	0.43	0.18
	Waseca MS4 (0.46%)	1.49	0.45	0.24	0.13	0.05
	Total WLA	21.83	11.26	9.04	7.94	7.20
Load Allocation		309.68	94.03	48.71	26.27	11.07
10% Margin of Safety		36.83	11.70	6.42	3.80	2.03

* See Table 131 in Appendix H for complete facility list

** No permitted individual stormwater facilities in the CRW

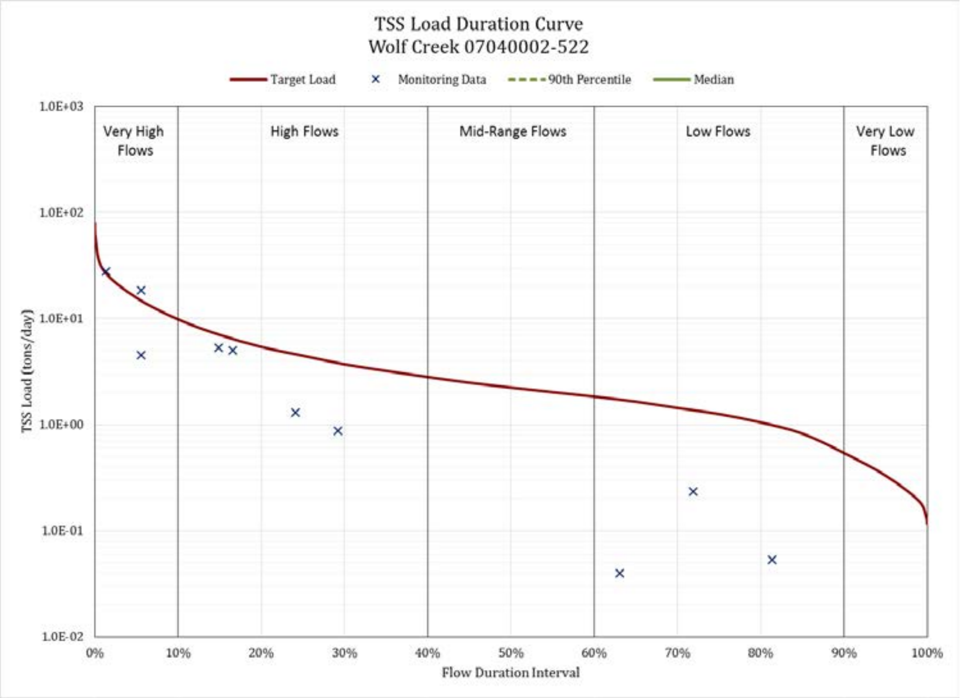


Figure 67. MIDDLE CANNON RIVER HUC-10: Wolf Creek – 07040002-522

Table 109. MIDDLE CANNON RIVER HUC-10: Wolf Creek – 07040002-522

Wolf Creek 07040002-522 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		tons/day				
TSS Loading Capacity (TMDL)		15.77	4.47	2.24	1.26	0.33
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.01	0.00	0.00	0.00	0.00
	MS4***	NA	NA	NA	NA	NA
	Total WLA	0.01	0.00	0.00	0.00	0.00
Load Allocation		14.18	4.02	2.02	1.13	0.30
10% Margin of Safety		1.58	0.45	0.22	0.13	0.03

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

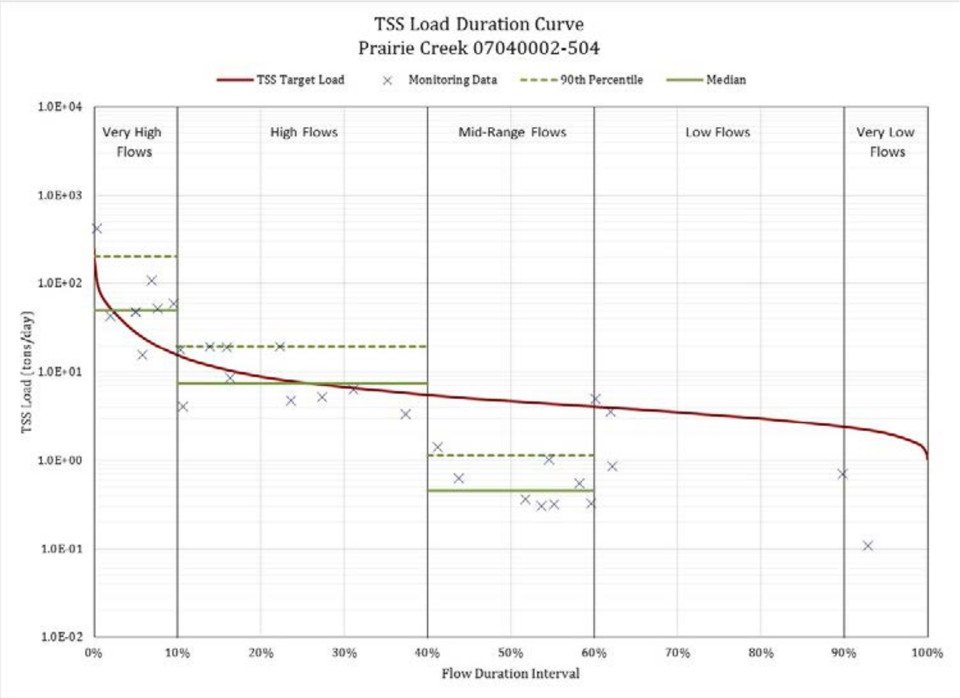


Figure 68. PRAIRIE CREEK HUC-10: Prairie Creek – 07040002-504

Table 110. PRAIRIE CREEK HUC-10: Prairie Creek – 07040002-504

Prairie Creek 07040002-504 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		tons/day				
TSS Loading Capacity (TMDL)		27.99	7.63	4.69	3.23	2.03
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	0.05	0.05	0.05	0.05	0.05
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.03	0.01	0.00	0.00	0.00
	MS4	NA	NA	NA	NA	NA
	Total WLA	0.07	0.06	0.05	0.05	0.05
Load Allocation		25.11	6.81	4.17	2.86	1.78
10% Margin of Safety		2.80	0.76	0.47	0.32	0.20

* See Table 136 in Appendix H for complete facility list

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

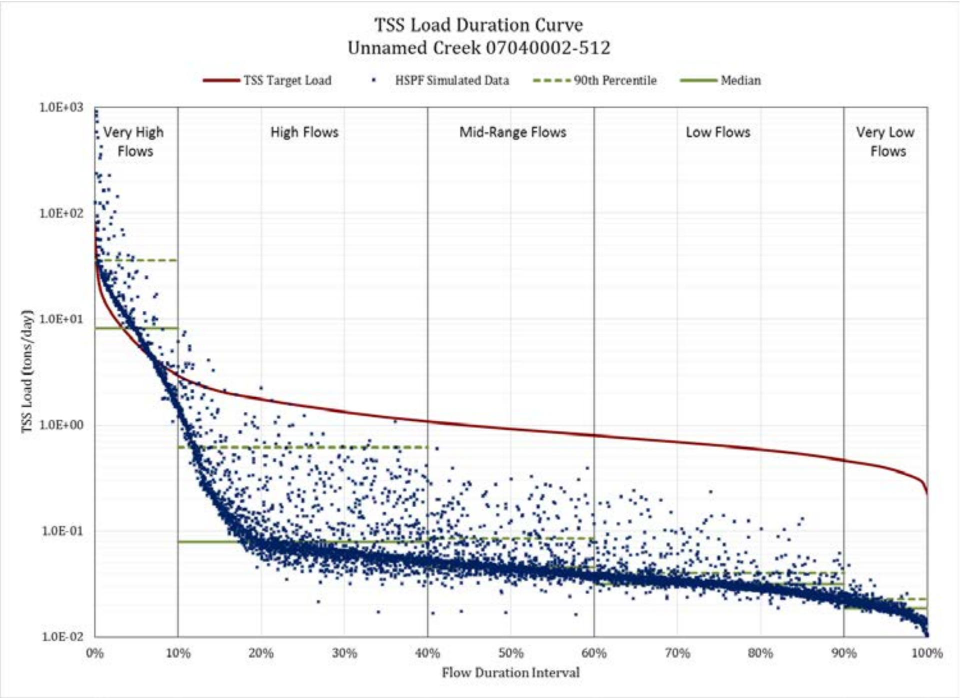


Figure 69. PRAIRIE CREEK HUC-10: Unnamed Creek – 07040002-512

Table 111. PRAIRIE CREEK HUC-10: Unnamed Creek – 07040002-512

Unnamed Creek 07040002-512 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		tons/day				
TSS Loading Capacity (TMDL)		**5.90**	**1.52**	**0.92**	**0.64**	**0.40**
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	0.05	0.05	0.05	0.05	0.05
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.01	0.00	0.00	0.00	0.00
	MS4***	NA	NA	NA	NA	NA
	Total WLA	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
Load Allocation		**5.26**	**1.31**	**0.78**	**0.53**	**0.31**
10% Margin of Safety		**0.59**	**0.15**	**0.09**	**0.06**	**0.04**

* See Table 137 in Appendix H for complete facility list
** No permitted individual stormwater facilities in the CRW
*** No current MS4 communities within reach drainage area

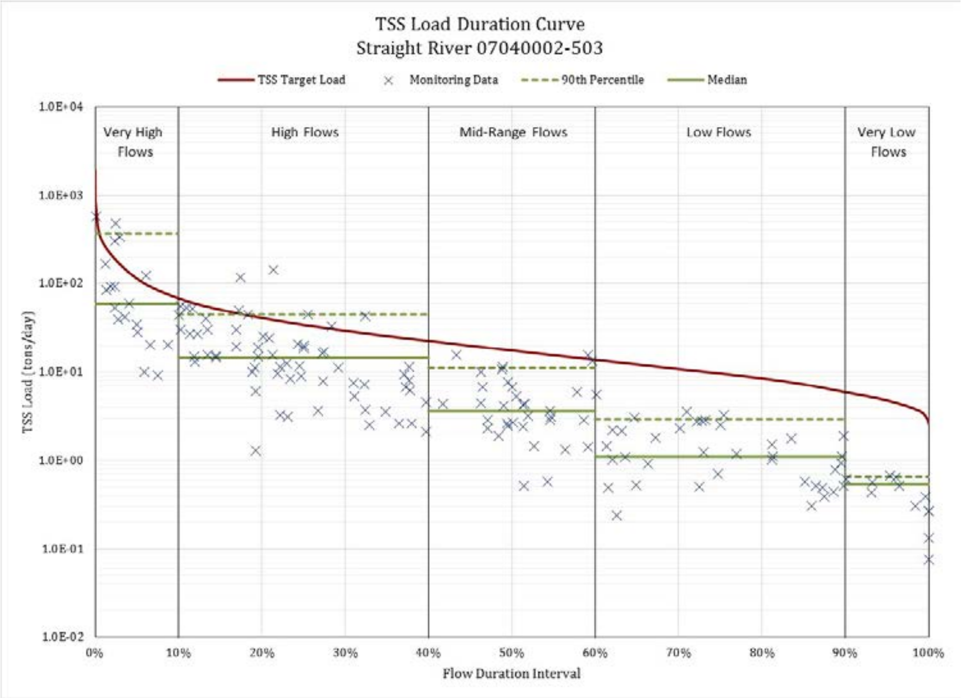


Figure 70. STRAIGHT RIVER HUC-10: Straight River – 07040002-503

Table 112. STRAIGHT RIVER HUC-10: Straight River – 07040002-503

Straight River 07040002-503 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		tons/day				
TSS Loading Capacity (TMDL)		113.72	34.15	17.56	9.64	4.78
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	3.18	3.18	3.18	3.18	3.18
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.10	0.03	0.02	0.01	0.00
	Owatonna MS4 (4.98%)	4.93	1.37	0.63	0.27	0.06
	Total WLA	8.22	4.58	3.82	3.46	3.24
Load Allocation		94.13	26.15	11.98	5.21	1.06
10% Margin of Safety		11.37	3.42	1.76	0.96	0.48

* See Table 138 in Appendix H for list of permitted facilities

** No permitted individual stormwater facilities in the Cannon River Watershed

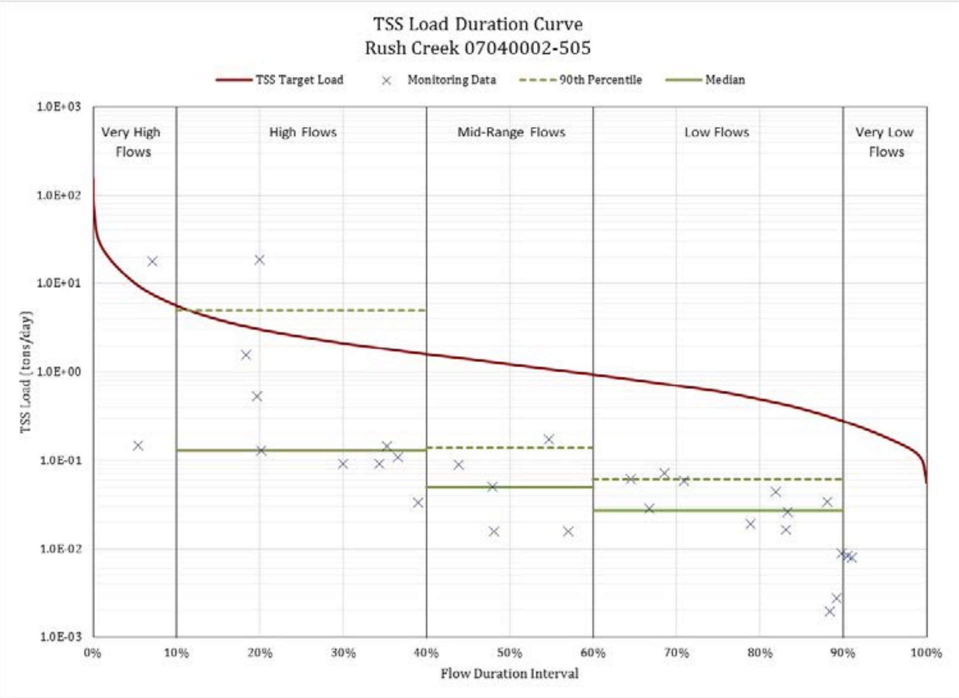


Figure 71. STRAIGHT RIVER HUC-10: Rush Creek – 07040002-505

Table 113. STRAIGHT RIVER HUC-10: Rush Creek – 07040002-505

Rush Creek 07040002-505 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		tons/day				
TSS Loading Capacity (TMDL)		10.11	2.50	1.22	0.61	0.18
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.01	0.00	0.00	0.00	0.00
	MS4***	NA	NA	NA	NA	NA
	Total WLA	0.01	0.00	0.00	0.00	0.00
Load Allocation		9.09	2.25	1.10	0.54	0.17
10% Margin of Safety		1.01	0.25	0.12	0.06	0.02

* No permitted wastewater facilities within reach drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

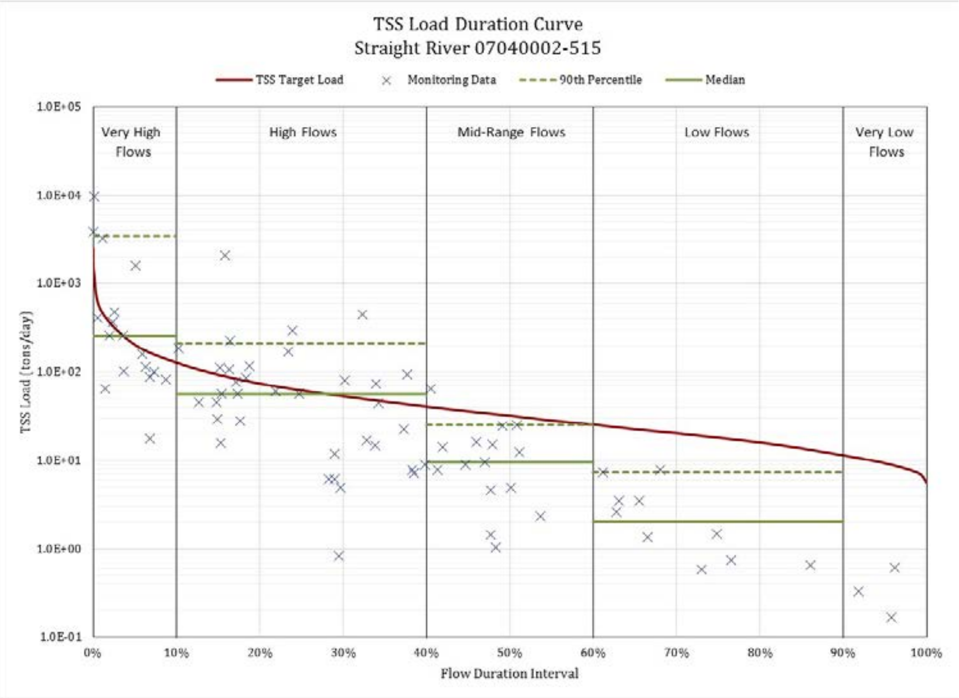


Figure 72. STRAIGHT RIVER HUC-10: Straight River – 07040002-515

Table 114. STRAIGHT RIVER HUC-10: Straight River – 07040002-515

Straight River 07040002-515 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		tons/day				
TSS Loading Capacity (TMDL)		203.99	61.93	32.11	18.11	9.31
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	4.12	4.12	4.12	4.12	4.12
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.18	0.06	0.03	0.02	0.01
	Faribault MS4 (1.28%)	2.30	0.66	0.32	0.16	0.05
	Owatonna MS4 (3.15%)	5.65	1.63	0.78	0.38	0.13
	Waseca MS4 (1.1%)	1.97	0.57	0.27	0.13	0.05
	Total WLA	14.23	7.03	5.52	4.81	4.37
Load Allocation		169.36	48.70	23.38	11.48	4.01
10% Margin of Safety		20.40	6.19	3.21	1.81	0.93

* See Table 139 in Appendix H for list of permitted facilities

** No permitted individual stormwater facilities in the Cannon River Watershed

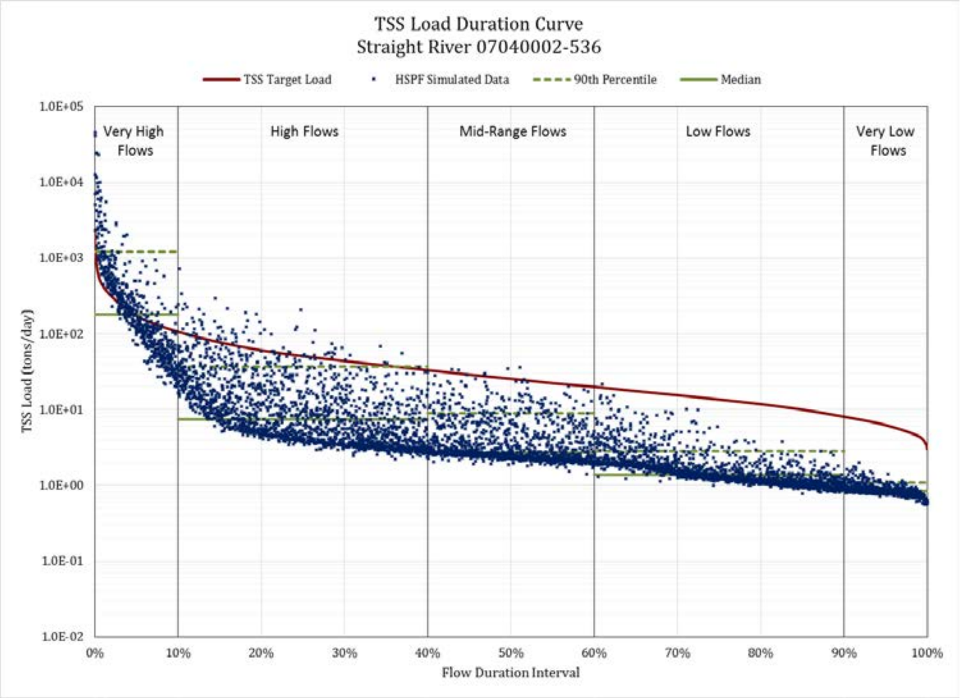


Figure 73. STRAIGHT RIVER HUC-10: Straight River – 07040002-536

Table 115. STRAIGHT RIVER HUC-10: Straight River – 07040002-536

Straight River 07040002-536 TMDL Summary		Flow Regime				
		VHigh	High	Mid	Low	VLow
		tons/day				
TSS Loading Capacity (TMDL)		173.82	50.84	25.54	13.60	6.25
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial Wastewater Facilities*	3.24	3.24	3.24	3.24	3.24
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.16	0.05	0.02	0.01	0.01
	Owatonna MS4 (3.74%)	5.73	1.59	0.74	0.34	0.09
	Waseca MS4 (1.1%)	1.69	0.47	0.22	0.10	0.03
	Total WLA	10.81	5.34	4.21	3.68	3.36
Load Allocation		145.63	40.42	18.77	8.55	2.27
10% Margin of Safety		17.38	5.08	2.55	1.36	0.63

* See Table 140 in Appendix H for list of permitted facilities

** No permitted individual stormwater facilities in the Cannon River Watershed

5 Future Growth Considerations

5.1 New or Expanding Permitted MS4 WLA Transfer Process

Currently, there are no new or expanding permitted MS4 communities planned in the CRW. However, future transfer of watershed runoff loads in this TMDL may be necessary if any of the following scenarios occur within the project watershed boundaries:

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

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

5.2 New or Expanding Wastewater (TSS and *E. coli* TMDLs only)

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

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

6 Reasonable Assurance

Reasonable assurance that water quality in the CRW will be improved is formulated on the following points:

1. Availability of reliable means of addressing pollutant loads (i.e. best management practices (BMPs), NPDES permits);
2. A means of prioritizing and focusing management;
3. Development of a strategy for implementation;
4. Availability of funding to execute projects;
5. A system of tracking progress and monitoring water quality response.

Accordingly, the following summary provides reasonable assurance that implementation will occur and result in pollutant load reductions in the CRW.

- **Regarding Availability of reliable means of addressing pollutant loads:** reliable means of addressing nonpoint source pollutant loads are fully addressed in the CRW WRAPS Report, a document that is written to be companion to the TMDLs. As described in the WRAPS text, the BMPS (for both phosphorus and nitrogen reduction) included there have all been demonstrated to be effective in reducing transport of pollutants to surface water. The combinations of BMPS discussed throughout the WRAPS process were derived from Minnesota's NRS and related tools. As such, they were vetted by a statewide engagement process prior to being applied in the CRW. They are practices that are supported by the basic programs administered by the SWCDs and the NRCS. Local resource managers are well-trained in promoting, placing and installing these BMPs. Some watershed counties have shown significant levels of adoption of these practices. Throughout the course of WRAPS and TMDL meetings local stakeholders endorsed these BMPs which constitute the standard means of addressing reductions in both runoff pollutant loads (i.e. phosphorus, sediment and even pathogens, which all share many sources and transport mechanisms) and pollutant loads delivered via vertical leaching to tiles or groundwater (e.g. nitrates). The WRAPS also takes great care in describing example scales of adoption that will attain pollutant reduction goals and entities with primary responsibility for implementation of strategies and programs.

  Southeast Minnesota has proven to be a leader in addressing unsewered communities, which can be sources of nutrients and pathogens to surface waters. The Southeast Minnesota Wastewater Initiative (http://crwp.net/sewersquad/) has helped twenty-two small communities upgrade their sewer systems, eliminating 317,290 gallons of untreated sewage per day (115 million gallons per year) from entering the lakes, streams, and rivers of Southeast Minnesota (CRWP website, 2016). This work was recognized by an award from the Bush Foundation in 2014.

  All municipal and industrial NPDES Wastewater Permits in the watershed will reflect limits derived from WLAs described herein. The MPCA's MS4 General Permit requires MS4 permittees to provide reasonable assurances that progress is being made toward achieving all WLAs in TMDLs approved by EPA prior to the effective date of the permit. In doing so, they must determine if they are currently meeting their WLA(s). If the WLA is not being achieved at the time of application, a compliance schedule is required that includes interim milestones, expressed as BMPs, that will be implemented over the current 5-year permit term to reduce loading of the pollutant of concern in the TMDL. Additionally, a long-term implementation strategy and target date for fully meeting the WLA must be included.

Water Quality Trends for Minnesota Rivers and Streams at Milestone Sites notes that sites across Minnesota, including those on the Cannon River and Straight River, show significant reductions over the period of record for TSS, phosphorus, ammonia and biochemical oxygen demand (MPCA 2014e). *The Minnesota NRS* documented a 33% reduction of the phosphorus load leaving the state via the Mississippi River from the pre-2000 baseline to current (MPCA 2014d). These reports generally agree that while further reductions are needed (e.g. for lake goals and for Byllesby Reservoir), municipal and industrial phosphorus loads as well as loads of runoff-driven pollutants (i.e. TSS and TP) are decreasing; a conclusion that lends assurance that the CRW WRAPS and TMDL phosphorus goals and strategies are reasonable and that long-term, enduring efforts to decrease erosion and nutrient loading to surface waters have the potential for positive impacts.

- **Regarding means of prioritizing and focusing management:** the WRAPS details a number of tools that provide means for identifying priority pollutant sources and focusing implementation work in the watershed. These include but are not limited to the HSPF model, SWAT model and terrain analysis. Further, LGUs in the CRW often employ their own local analysis for determining priorities for work:
    - The state of Minnesota funded a shoreland mapping project to inventory land use in riparian areas in southeast Minnesota. This information will be used in the implementation planning process to examine riparian land use in the CRW, and prioritize potential buffer installation.
    - Light Detection and Ranging (LIDAR) data are available for all of southeast Minnesota, and being increasingly used by LGUs to examine landscapes, understand water flow and dynamics, and accordingly prioritize BMP targeting.
- **Regarding a strategy for implementation**: the WRAPS, TMDLs and all supporting work provides a foundation for planning the CRW. Subsequent planning (e.g. local water planning or development of a “One Water-One Plan” for the CRW) will draw on the goals, technical information and built tools to describe in detail strategies for implementation. For the purposes of reasonable assurance, the WRAPS document is sufficient in that it provides strategies that in combination show examples of pollutant reduction goal attainment.
- **Regarding availability of funding to execute projects**: on November 4, 2008, Minnesota voters approved the Clean Water, Land & Legacy Amendment to the constitution to:
    - protect drinking water sources;
    - protect, enhance, and restore wetlands, prairies, forests, and fish, game, and wildlife habitat;
    - preserve arts and cultural heritage;
    - support parks and trails; and
    - protect, enhance, and restore lakes, rivers, streams, and GW.

  This is a secure funding mechanism with the explicit purpose of supporting water quality improvement projects. Additionally, there are many other funding sources for nonpoint pollutant reduction work; they include but are not limited to EPA 319 and the various NRCS programs.

- **Regarding a system of tracking progress and monitoring water quality response**: Monitoring components in the CRW are diverse and constitute a sufficient means for tracking progress and supporting adaptive management. See Chapter 7.

7 Monitoring Plan

Future monitoring in the CRW will be according to the watershed approach framework. The IWM strategy utilizes a nested watershed design allowing the aggregation of watersheds from a course to a fine scale. The foundation of this comprehensive approach is the 80 major watersheds within Minnesota. Streams are segmented by HUC. IWM occurs in each major watershed once every 10 years (MPCA 2012). The *Cannon River Watershed Monitoring and Assessment Report* provides detailed discussion of IWM and how it will be applied going forward (it will be repeated in CRW in 2021).

Load monitoring at Welch (S000-003) and at three intermediate sites is on-going and will be used to track reductions in nitrogen and phosphorus loads in the CRW; these sites are instrumented and gauged to track flow volumes, and are intensively monitored by the MPCA staff and partners.

Further, the *Revised Regional Total Maximum Daily Load Evaluation of Fecal Coliform Bacteria Impairments in the Lower Mississippi River Basin in Minnesota* includes a monitoring section that describes activities and responsibilities pertaining to the greater regional examination of pathogens in surface water, of which CRW is a part.

Local monitoring efforts (e.g. Steele County Environmental Services) have provided valuable data for use in model calibration. Lake associations in the CRW conduct monitoring to support further understanding at local lakeshed scales. Volunteer monitoring of water clarity in lakes and streams (i.e. Citizen Lake Monitoring and Citizen Stream Monitoring Programs) provides on-going records useful in trend analysis (see WRAPS document).

Focused Monitoring & Research Needs

In addition to monitoring for both assessment and effectiveness purposes, there are research needs to better understand pollutant loads and dynamics in the CRW. Primary amongst these are (1) low flow phosphorus loading in the upper Straight River Watershed (2) internal loading in the lakes of the watershed and (3) streamflow monitoring, GW level monitoring, and aquifer tests in the Pine Creek and Trout Brook Watersheds to further form the basis for activities that are needed to protect the health of Pine Creek and Trout Brook. Regarding pathogens, the *Revised Regional Total Maximum Daily Load Evaluation of Fecal Coliform Bacteria Impairments In the Lower Mississippi River Basin in Minnesota Implementation Plan* notes that research needs include, but are not limited to:

- Study of sources of pathogens in cities and urban areas;
- Better understanding of load reduction capabilities for applicable structural and non-structural BMPs;
- Models to evaluate loading sources and track load reductions;
- Methods to evaluate pollutant migration pathways and delivery mechanisms from pathogen sources to surface waters, both generally and in karsted landscapes; DNA “fingerprinting” to identify pathogen sources.

8 Implementation Strategy Summary

8.1 Permitted Sources

8.1.1 Construction Stormwater

The WLA for stormwater discharges from sites where there is construction activity reflects the number of construction sites greater than one acre expected to be active in the watershed at any one time, and the BMPs and other stormwater control measures that should be implemented at the sites to limit the discharge of pollutants of concern. The BMPs and other stormwater control measures that should be implemented at construction sites are defined in 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. It should be noted that all local construction stormwater requirements must also be met.

8.1.2 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 & 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. It should be noted that all local stormwater management requirements must also be met.

8.1.3 MS4

The MPCA oversees all regulated MS4 entities in stormwater management accounting activities. All regulated MS4s in the watershed fall under the category of Phase II. The MS4 NPDES/SDS Permits require regulated municipalities to implement BMPs to reduce pollutants in stormwater runoff to the MEP.

All owners or operators of regulated MS4s (also referred to as “permittees”) are required to satisfy the requirements of the MS4 general permit. The MS4 general permit requires the permittee to develop a Stormwater Pollution Prevention Program (SWPPP) that addresses all permit requirements, including the following six minimum control measures:

- Public education and outreach;
- Public participation;

- Illicit Discharge Detection and Elimination (IDDE) Program;
- Construction-site runoff controls;
- Post-construction runoff controls; and
- Pollution prevention and municipal good housekeeping measures

A SWPPP is a management plan that describes the MS4 permittee's activities for managing stormwater within their jurisdiction or regulated area. In the event a TMDL study has been completed, approved by EPA prior to the effective date of the general permit, and assigns a WLA to an MS4 permittee, that permittee must document the WLA in their application and provide an outline of the BMPs to be implemented in the current permit term to address any needed reduction in loading from the MS4.

The MPCA requires applicants submit their application materials and SWPPP document to the MPCA for review. Prior to extension of coverage under the general permit, all application materials are placed on 30-day public notice by the MPCA, to ensure adequate opportunity for the public to comment on each permittee's stormwater management program. Upon extension of coverage by the MPCA, the permittees are to implement the activities described within their SWPPP, and submit annual reports to the MPCA by June 30 of each year. These reports document the implementation activities which have been completed within the previous year, analyze implementation activities already installed, and outline any changes within the SWPPP from the previous year.

8.1.4 Wastewater

The MPCA issues permits for WWTFs that discharge into waters of the state. The permits have site specific limits that are based on water quality standards. Permits regulate discharges with the goals of 1) protecting public health and aquatic life, and 2) assuring that every facility treats wastewater. In addition, SDS Permits set limits and establish controls for land application of sewage.

8.2 Non-Permitted Sources

8.2.1 Adaptive Management

The response of the lakes and streams will be evaluated as management practices are implemented. This evaluation will occur every five years after the commencement of implementation actions; for the next 25 years. Data will be evaluated and decisions will be made as to how to proceed for the next five years. The management approach to achieving the goals should be adapted as new information is collected and evaluated.

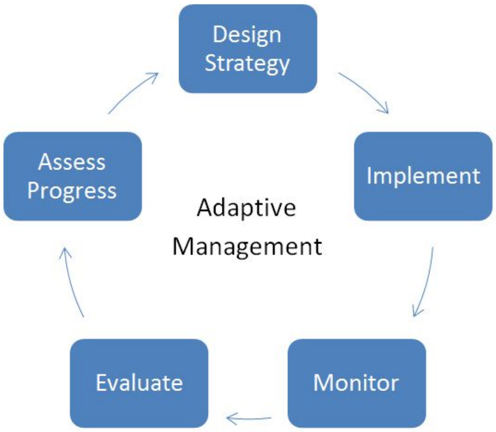


Figure 74. Adaptive Management

8.2.2 Best Management Practices

A variety of BMPs to restore and protect the lakes and streams within the CRW are outlined in the WRAPS report.

8.2.3 Education and Outreach

A crucial part in the success of the WRAPS report that will be designed to clean up the impaired lakes and streams and protect the non-impaired water bodies will be participation from local citizens. In order to gain support from these citizens, education and civic engagement opportunities will be necessary. A variety of educational avenues can and will be used throughout the watershed (see Public Participation section). These include (but are not limited to): press releases, meetings, workshops, focus groups, trainings, websites, etc. Local staff (SWCD, county, etc.) and board members work to educate the residents of the watersheds about ways to clean up their streams on a regular basis. Education and engagement will continue throughout the watershed.

8.2.4 Technical Assistance

The counties and SWCDs within the watershed provide assistance to landowners for a variety of projects that benefit water quality. Assistance provided to landowners varies from agricultural to rural to urban BMPs. This technical assistance includes education and one-on-one training. It is important that outreach opportunities for watershed residents continue. Marketing is necessary to motivate landowners to participate in voluntary cost-share assistance programs.

Programs such as state cost share, Clean Water Legacy funding, Environmental Quality Incentives Program (EQIP), and Conservation Reserve Program (CRP) are available to help implement the best conservation practices that each parcel of land is eligible for to target the best conservation practices per site. Conservation practices may include, but are not limited to: stormwater bioretention, septic system upgrades, feedlot improvements, invasive species control, wastewater treatment practices, as well as agricultural and rural BMPs. More information about types of practices and implementation of BMPs will be discussed in the Root River WRAPS Report.

8.2.5 Partnerships

Partnerships with counties, cities, townships, citizens, businesses, and CRW Partnership are mechanisms through which watershed partners will protect and improve water quality. Strong partnerships with state and local government to protect and improve water resources and to bring waters within the CRW into compliance with State standards will continue. A partnership with LGUs and regulatory agencies such as cities, townships and counties may be formed to develop and update ordinances to protect the area's water resources.

8.3 Cost

The CWLA requires that a TMDL include an overall approximation of the cost to implement a TMDL [Minn. Stat. 2007 § 114D.25]. At the direction of the *Group of 16* (G16), an interagency work group (BWSR, MDA, MPCA, MN SWCD, Minnesota Association of Watershed Districts, and NRCS) assessed restoration costs for several TMDLs. The initial estimate for implementing the Byllesby Reservoir Phosphorus TMDL ranged from approximately $170 to $180 million. The three most significant municipal point source dischargers of phosphorus (Faribault, Northfield and Owatonna) have completed capital improvements and taken on further maintenance costs to address phosphorus removal. For example, the Faribault WWTF invested approximately $27 million (low interest loans and other funding) for improved treatment (Henry Morgan, Superintendent of Faribault Wastewater Reclamation Facility, personal communication).

Because the Byllesby Reservoir Watershed includes approximately 730,000 acres (1.3% of the state of Minnesota) the G16 effort describes a cost estimate not only for point source load reductions of phosphorus but for large scale reductions in runoff pollutant loads (i.e. phosphorus, sediment and even pathogens, which all share many sources and transport mechanisms).

The CRW WRAPS Report includes cost estimates for achieving 12% reductions of phosphorus loading and 20% reductions of nitrogen loading for numerous HUC-10 subwatersheds. These nutrient reduction goals are consistent with Minnesota's NRS and include nonpoint source measures only. The cost of the phosphorus BMPS at the HUC-10 scale range from $60,000 to $1.73 million to achieve 12% reduction goal; the costs vary because suitable acres for different BMPs vary across the CRW and stakeholders described different combinations of BMPs that achieve the reduction goal.

Regarding nitrogen, the BMP spreadsheets indicate that to achieve a 20% reduction of loading at the HUC-10 scale the costs range from $160,000 to $1.52 million. This magnitude of nonpoint source reduction would reduce the baseflow concentration (allowing for "lag time" per groundwater transport) in the impaired coldwater streams in the CRW to less than 10 mg/l nitrate thus attaining the TMDL goals.

Applying the BMP spreadsheets (see WRAPS document for more detail) at the HUC-8 scale indicates that a 12% reduction of phosphorus loading would cost approximately $6 million and a 20% reduction of nitrogen loading would cost approximately $7 million; both estimates generally agree with the sums of the respective HUC-10 estimates.

Regarding chloride, the Twin Cities Metropolitan Area Chloride TMDL Study includes a discussion of the costs associated with removing chloride from municipal wastewater (see 8.4.1 of the TMDL: https://www.pca.state.mn.us/sites/default/files/wq-iw11-06e.pdf). The analysis concludes that the most feasible option for addressing chloride in wastewater is upstream source reduction. The two primary sources of chloride to WWTPs are residential water softeners and industrial users. If a facility has a chloride limit or wants to voluntarily reduce chloride WWTPs should work through their Industrial Pretreatment Programs (IPP) to identify significant users who may be contributing chloride. The WWTPs can review existing data from industrial users or can require industrial users to collect chloride data to assist in the assessment. If industrial users are identified as a significant source of chloride, the WWTP can work with the industrial user through the IPP to develop and implement a plan to reduce chloride loads (MPCA 2016c).

During the permit issuance or reissuance process, wastewater discharges will be evaluated for the potential to cause or contribute to violations of chloride water quality standards. Water Quality Based Effluent Limits (WQBELs) will be developed for facilities whose discharges are found to have a reasonable potential to cause or contribute to excursions above the water quality standards. The WQBELs will be calculated based on low flow conditions, may vary slightly from the TMDL WLAs and will include concentration based effluent limitations (MPCA 2016c).

9 Public Participation

9.1 Byllesby Reservoir TMDL Development

The available record of citizen involvement in addressing the eutrophication of the reservoir includes a request by the Lake Byllesby Improvement Association (LBIA) to conduct a lake assessment in 1996. The MPCA's Lake Assessment Program is "designed to assist lake associations or municipalities in their collection and analysis of baseline water quality in order to assess the trophic status of their lake." Participation by the lake association in MPCA's Citizen Lake Monitoring Program was included in the Byllesby Reservoir Lake Assessment in 1996, and has been ongoing since that time.

Outreach and education were components of "Byllesby Reservoir 319/CWP Project: An Examination of the Reservoir's Water, Sediment and Nutrient Budgets," conducted by CRWP and the MPCA from October, 1999 through July, 2004. The final report of that project states, "Throughout the course of the project information was shared with interested entities and the general public. The outreach mechanisms were: (1) newsletter articles, (2) newspaper articles, (3) presentations at meetings and gatherings, (4) world wide web articles, maps, and figures, (5) radio spots, (6) project-specific publications."

The CRWP coordinated most of the Technical Committee meetings and conducted all of the education and outreach activities specific to this TMDL study. There were multiple technical committees, public and stakeholder meetings held at various locations in the Byllesby Reservoir Watershed. The most recent public forums were November 12, 2012, at a CRW Partnership Board of Directors meeting and May 13, 2013, at the Phillippo Scout Reservation (on the Byllesby Reservoir) preceding the CRW Partnership Board of Directors meeting.

A draft Byllesby Reservoir Phosphorus TMDL was public noticed from May 13 to July 15, 2013. The MPCA received 10 comment letters, 1 of which included a request for a contested case hearing. Over the months following the public notice period, staff worked with the petitioners and responded to comments. The contested case hearing request was withdrawn in March 2015. Given the timing of watershed work in the CRW, it was determined that the Byllesby Reservoir phosphorus TMDL would become part of the greater watershed TMDL report and as such would not be forwarded individually to the EPA for consideration for final approval. Other public comment suggested the Byllesby TMDL would be improved by pairing the BATHTUB modeling with a watershed model that would allow more detailed examination of point sources and phosphorus transport to the reservoir; this was accomplished as described in previous chapters of this document.

9.2 WRAPS and Watershed TMDLs Development

Chapter 3.2 of the WRAPS document describes in detail the civic engagement and public participation that were integral to development of the CRW strategies for both restoration and protection.

The excerpt below describes outreach efforts and meetings that were held regarding TMDLs and WRAPS.

Stakeholder Outreach

The following articles described the watershed approach in the CRW and the WRAPS processes and substance:

WRAPS working to help keep our water safe, newspaper guest column by Beth Kallestad, CRWP Executive Director, May 20, 2015 (Faribault Daily News, also ran in Northfield News, Waseca County News, Owatonna People's Press, Red Wing Republican Eagle, Cannon Falls Beacon).

CRWP Electronic Newsletter - *Cannon Currents*:

- July 2015 - Summary of WRAPS kickoff meeting
- September 2015 - WRAPS Round 2 Lobe Worksession announcement
- October 2015 - *WRAPS Process* (link to website with meeting notes and agendas)
- January 2016 - WRAPS final watershed meeting in February

CRWP Print Newsletter - *The Watershed Watcher* (last published in May 2014)

- May 2011 - *Watershed Report Card on the Way* - by the MPCA staff, summary of IWM process
- November 2011 - *Health of the Cannon River Watershed* - by CRWP staff, summary of Surface Water Assessment Grant water chemistry and stream condition samples collected by CRWP staff and volunteers
- May 2012 - *Byllesby Reservoir Update: New Standard Adopted, Phosphorus Load Decreasing* - by Justin Watkins, MPCA, Byllesby Site Specific Standard and recent monitoring results
- May 2013 - *CRWP Partners with the University of Minnesota* - by CRWP staff, summary of surveys to assess citizen knowledge, behavior
- November 2013 - *The Current* -by CRWP Exec Director, update on survey project
- February 2014 - *2014 Minnesota 303(d) Impaired Waters List* - by CRWP staff, information about the draft list

During the WRAPS process, the CRWP website served as a repository of meeting announcements, notes and information. In addition, there is a watershed "library" on the CRWP website that is a repository for past studies and reports about the rivers, lakes and streams of the watershed.

Meetings

The CRWP hosted a series of meetings (Table 116) to provide information, receive feedback and input from a range of stakeholders in order to develop a WRAPS document that reflected local values and needs and summarized the current realities and possibilities for moving forward. The broad spectrum of stakeholders included local units of government, elected officials and staff, conservation professionals, urban residents, lakeshore owners, farmers, academics and others.

Public Notice

An opportunity for public comment on the draft WRAPS and TMDLs reports was provided via a public notice in the State Register from May 23 to June 23, 2016.

Table 116. WRAPS and TMDL meeting summaries

Date	Title/Topic	Attendees
March 19, 2015	Nutrient Management and the Nutrient BMP Tool	County and SWCD staff, MPCA Staff, CRWP staff
June 9, 2015	CRW WRAPS Kick-Off Meeting: Overview of watershed monitoring and assessment, biological stressor identification, TMDLs, HSPF , SWAT, and BATHTUB water quality models results/science, process overview, introduction to Zonation values-based and survey, plan for future meetings.	County, City and SWCD staff, state agency staff, elected officials, urban residents, lakeshore residents, farmers, commodity group representatives, academics, CRWP Board members, CRWP staff, college students, The Nature Conservancy, The Trust for Public Land
July 14 & 15, 2015	Round 1 - Lobe Work Sessions: Review of lobe characteristics/impairments/stressors Sources of pollution, HSPF modeling – 1st wave of scenarios, results from Zonation survey – lobe specific analysis, N/P BMP Tool introduction	County, City and SWCD staff, state agency staff, elected officials, urban residents, lakeshore residents, farmers, commodity group representatives, academics, CRWP Board members, college student, The Nature Conservancy, The Trust for Public Land
September 29 & 30, 2015	Round 2 - Lobe Work Sessions: nutrient and sediment reduction goals, application of N/P BMP Tool at the HUC 8 and 10 scale, Review HSPF modeling and intro 2nd wave of scenarios	County, City and SWCD staff, state agency staff, elected officials, urban residents, lakeshore residents, farmers, commodity group representatives, CRWP Board members, The Nature Conservancy, The Trust for Public Land
October 23, and December 14	Meetings with individual and groups of SWCDs/Counties to apply the N/PBMP Tool at the HUC 10 scale	CRWP and MPCA Staff met with staff from Rice, Le Sueur, Waseca, Dakota, and Steele Counties. Goodhue County submitted written scenarios for application of the Tool.
November 23, 2015	Municipalities Meeting covering TMDLs (focus on Byllesby), wastewater permitting, source water protection, storm water issues	City Wastewater Treatment, Drinking Water, Engineering and Stormwater staff, state agency staff, CRWP staff
December 2 & 3, 2015	Round 3 - Lobe Work Sessions: Zonation Synthesis, WRAPS protection considerations, complete HSPF 2nd wave scenarios, new and historical TMDLs in the CRW	County, City and SWCD staff, state agency staff, elected officials, urban residents, lakeshore residents, farmers, commodity group representatives, Extension staff, CRWP Board members, The Nature Conservancy, The Trust for Public Land
February 17, 2016	Watershed Finale meeting covering feedback and comments on the draft WRAPS report, draft watershed TMDLs including phosphorus WLAs, next step 1W1P overview, and a practitioner's perspective on growing cover crops in a corn-soybean rotation	County, City and SWCD staff, state agency staff, elected officials, urban residents, lakeshore residents, farmers, commodity group representatives, and CRWP Board members and staff

*Note that these are only meetings in 2015-2016 over the course of building the WRAPS Report. Other meetings focused on watershed approach components (e.g. Professional Judgment Group meeting to examine preliminary assessment results) were held prior to March 2015.

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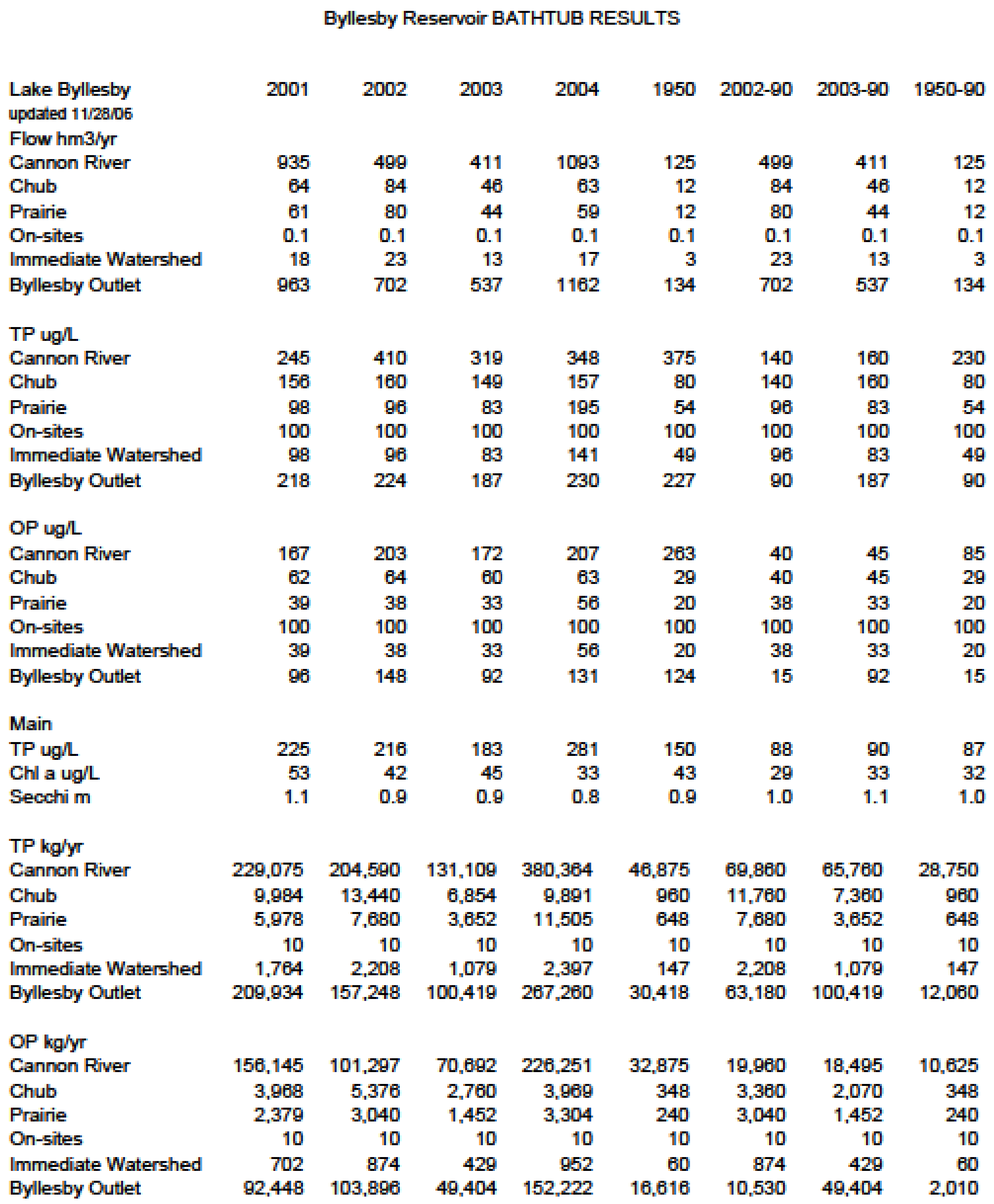
Appendix A

Aquatic Life impairment listings not addressed in this TMDL report.

Lobe	Reach Name	Reach Description	AUID or HUC	Designated Use	Bases for Aquatic Life Listing			New Data Confirm Use not Impaired	Insufficient Information to Conclusively Identify Stressors	Non-pollutant Stresor(s)?	Insufficient Information to Link Stressor to a Pollutant	No Water Quality Standard for Identifed Stressor(s)	Downstream of AUIDs that Provide Sufficient Load Reduction Goals	Notes
					MIBI Exceed Criteria?	FIBI Exceed Criteria?	Based on Turbidity Only?							
Lower Cannon	Cannon River	Byllesby Dam to Little Cannon R	07040002-539	Aquatic Life	YES				●					
Lower Cannon	Little Cannon River (Goodhue County)	T111 R17W S18, west line to Cannon R	07040002-526	Aquatic Life	YES					Habitat		Nitrate		TSS TMDL for this AUID but none for other stressors.
Lower Cannon	Unnamed creek (Trout Brook)	Unnamed cr to Cannon R (trout stream portion)	07040002-567	Aquatic Life			YES	●						Nitrate TMDL for this AUID per drinking water standard but turbidity listing subject to list correction.
Lower Cannon	Little Cannon River (Goodhue County)	T110 R18W S10, west line to T111 R18W S13, east line	07040002-589	Aquatic Life	YES	YES				Habitat & Connectivity				TSS TMDL and nitrate TMDL for this AUID per drinking water standard.
Lower Cannon	Unnamed creek (Trout Brook)	Unnamed cr to Unnamed cr	07040002-580	Aquatic Life	YES					Habitat		Nitrate		
Middle Cannon	Cannon River	Wolf Cr to Heath Cr	07040002-507	Aquatic Life	YES				●					
Middle Cannon	Prairie Creek	Headwaters to Cannon Lk Byllesby	07040002-504	Aquatic Life	YES					Habitat		Nitrate		TSS TMDL for this AUID but none for other stressors.
Middle Cannon	Cannon River	Heath Cr to Northfield Dam	07040002-508	Aquatic Life			YES		●					Need more information to conclusively determine use support status.
Middle Cannon	Cannon River	Northfield Dam to Lk Byllesby inlet	07040002-509	Aquatic Life	YES	YES				Connectivity		Nitrate		TSS TMDL for this AUID but potential phosphorus stressor not confirmed via preliminary RES assessment; further, the Byllesby Reservoir TMDL has provided a goal for this AUID of 0.150 mg/l FWM.
Middle Cannon	Unnamed creek	Headwaters to Prairie Cr	07040002-512	Aquatic Life	YES					Habitat		Nitrate		TSS TMDL for this AUID but none for other stressors.
Middle Cannon	Chub Creek	Headwaters to Cannon R	07040002-528	Aquatic Life	YES	YES					Dissolved Oxygen			TSS TMDL for this AUID but dissolved oxygen stressor not conclusively linked to phosphorus load.
Middle Cannon	Unnamed ditch	T111 R22W S1, north line to Unnamed cr	07040002-555	Aquatic Life	YES	YES				Habitat				Chloride TMDL for this AUID but none for other stressors.
Middle Cannon	Unnamed creek (Spring Brook)	Unnamed cr to Cannon R	07040002-557	Aquatic Life	YES					Habitat				Nitrate TMDL for this AUID per drinking water standard.
Middle Cannon	Spring Creek	T112 R15W S18, west line to T113 R15W S34, north line	07040002-569	Aquatic Life			YES	●						
Middle Cannon	Spring Creek	T113 R15W S27, south line to Spring Creek Lk	07040002-571	Aquatic Life			YES	●						
Middle Cannon	Cannon River	T110 R20W S19, NE 1/4 line to Wolf Cr	07040002-582	Aquatic Life	YES				●					
Middle Cannon	Unnamed creek	Unnamed cr to Unnamed cr	07040002-587	Aquatic Life	YES					Habitat		Nitrate		
Middle Cannon	Spring Creek	Unnamed cr to Unnamed cr	07040002-591	Aquatic Life	YES					Habitat		Nitrate		
Middle Cannon	Unnamed creek	Unnamed cr to Prairie Cr	07040002-723	Aquatic Life	YES					Habitat		Nitrate		
Straight	Straight River	Maple Cr to Crane Cr	07040002-503	Aquatic Life	YES							Nitrate		TSS TMDL for this AUID but none for other stressors.
Straight	Straight River	Rush Cr to Cannon R	07040002-515	Aquatic Life	YES							Nitrate		TSS TMDL for this AUID but none for other stressors.
Straight	Straight River	Crane Cr to Rush Cr	07040002-536	Aquatic Life	YES					Habitat		Nitrate		TSS TMDL for this AUID but none for other stressors.
Straight	Medford Creek	Headwaters to Straight R	07040002-547	Aquatic Life	YES	YES				Habitat		Nitrate		
Straight	Unnamed creek	Unnamed cr to Unnamed cr	07040002-731	Aquatic Life	YES							Nitrate		
Upper Cannon	Cannon River	Headwaters to Cannon Lk	07040002-542	Aquatic Life	YES								●	Not appropriate scale for TMDL; intersects many lakes that provide phosphorus load reduction goals.
Upper Cannon	Waterville Creek	Hands Marsh to Upper Sakatah Lk	07040002-560	Aquatic Life	YES	YES				Habitat		Nitrate		
Upper Cannon	MacKenzie Creek	T108 R21W S7, west line to Cannon Lk	07040002-576	Aquatic Life	YES					Habitat		Nitrate		
Upper Cannon	Devils Creek	Unnamed cr to Cannon R	07040002-577	Aquatic Life	YES						Dissolved Oxygen			Dissolved oxygen stressor not conclusively linked to phosphorus load.
Upper Cannon	Unnamed creek	Unnamed cr to Cannon R	07040002-638	Aquatic Life	YES								●	Roberds Lake outlet; lake provides load reduction goal.
Upper Cannon	Unnamed creek	Unnamed cr to Cannon R	07040002-705	Aquatic Life		YES				Habitat & Flow Alteration				
Upper Cannon	Whitewater Creek	Unnamed cr to Waterville Cr	07040002-706	Aquatic Life	YES					Habitat		Nitrate		

Appendix B



Byllesby Reservoir BATHTUB RESULTS

Lake Byllesby	2001	2002	2003	2004	1950	2002-90	2003-90	1950-90
updated 11/28/06								
Flow hm3/yr								
Cannon River	935	499	411	1093	125	499	411	125
Chub	64	84	46	63	12	84	46	12
Prairie	61	80	44	59	12	80	44	12
On-sites	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Immediate Watershed	18	23	13	17	3	23	13	3
Byllesby Outlet	963	702	537	1162	134	702	537	134
TP ug/L								
Cannon River	245	410	319	348	375	140	160	230
Chub	156	160	149	157	80	140	160	80
Prairie	98	96	83	195	54	96	83	54
On-sites	100	100	100	100	100	100	100	100
Immediate Watershed	98	96	83	141	49	96	83	49
Byllesby Outlet	218	224	187	230	227	90	187	90
OP ug/L								
Cannon River	167	203	172	207	263	40	45	85
Chub	62	64	60	63	29	40	45	29
Prairie	39	38	33	56	20	38	33	20
On-sites	100	100	100	100	100	100	100	100
Immediate Watershed	39	38	33	56	20	38	33	20
Byllesby Outlet	96	148	92	131	124	15	92	15
Main								
TP ug/L	225	216	183	281	150	88	90	87
Chl a ug/L	53	42	45	33	43	29	33	32
Secchi m	1.1	0.9	0.9	0.8	0.9	1.0	1.1	1.0
TP kg/yr								
Cannon River	229,075	204,590	131,109	380,364	46,875	69,860	65,760	28,750
Chub	9,984	13,440	6,854	9,891	960	11,760	7,360	960
Prairie	5,978	7,680	3,652	11,505	648	7,680	3,652	648
On-sites	10	10	10	10	10	10	10	10
Immediate Watershed	1,764	2,208	1,079	2,397	147	2,208	1,079	147
Byllesby Outlet	209,934	157,248	100,419	267,260	30,418	63,180	100,419	12,060
OP kg/yr								
Cannon River	156,145	101,297	70,692	226,251	32,875	19,960	18,495	10,625
Chub	3,968	5,376	2,760	3,969	348	3,360	2,070	348
Prairie	2,379	3,040	1,452	3,304	240	3,040	1,452	240
On-sites	10	10	10	10	10	10	10	10
Immediate Watershed	702	874	429	952	60	874	429	60
Byllesby Outlet	92,448	103,896	49,404	152,222	16,616	10,530	49,404	2,010

Appendix C

Byllesby Reservoir Site Specific Nutrient Criteria Development

Public Notice Draft

April 2009

Submitted to:

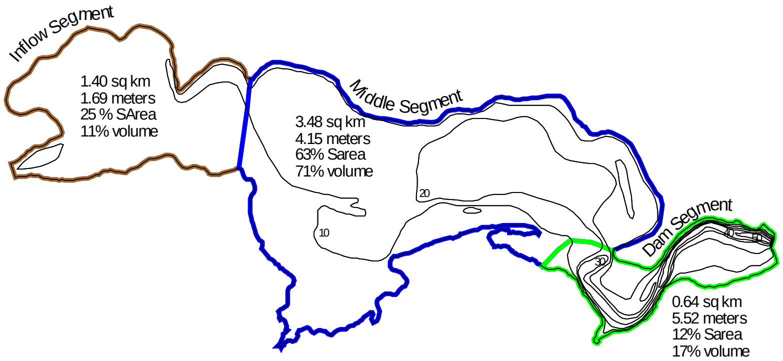
United States Environmental Protection Agency

Submitted by:

Minnesota Pollution Control Agency

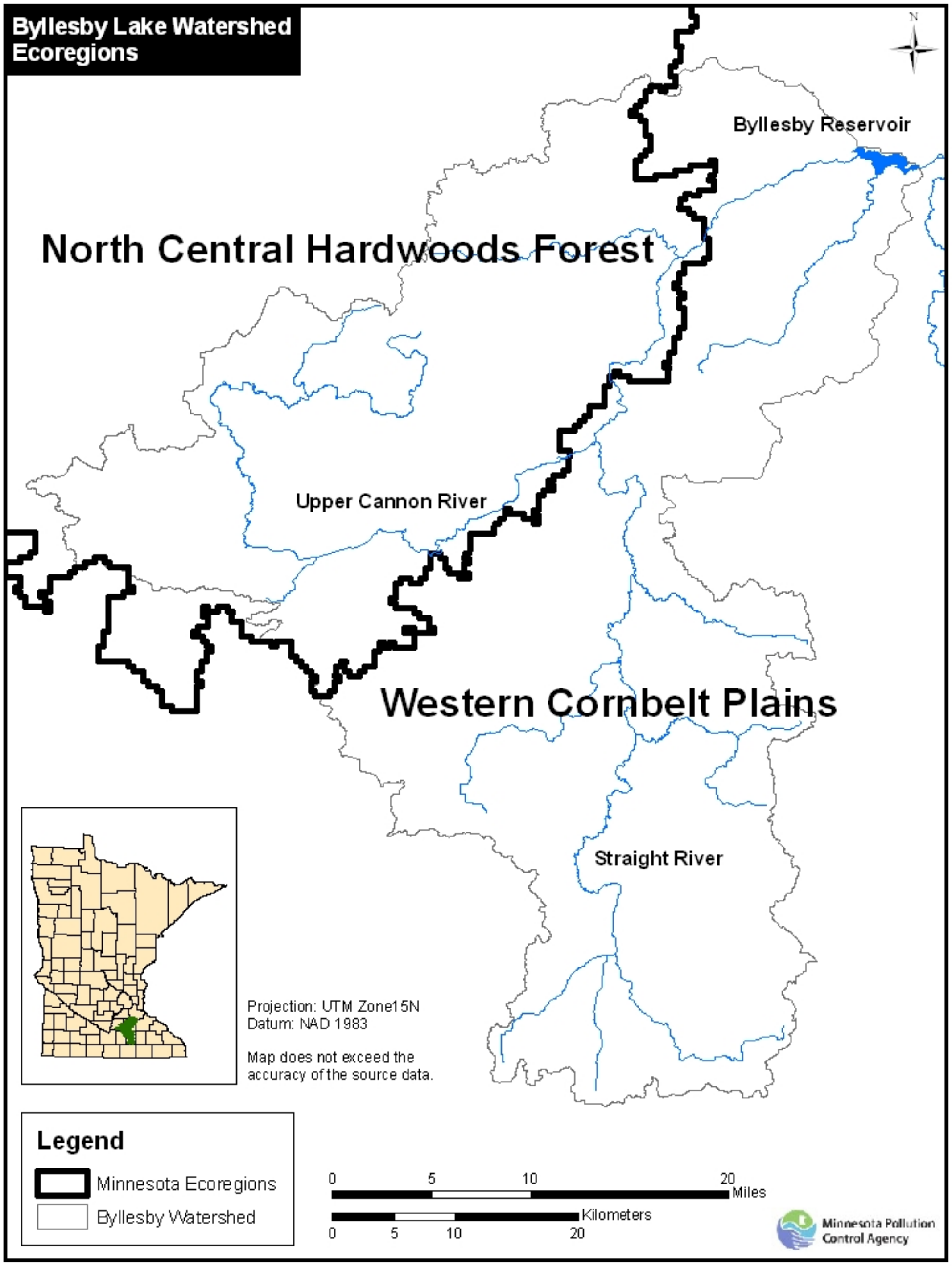
Lake Byllesby is a run-of-the- river reservoir on the Cannon River that was first established in 1911. With a surface area of about 1,365 acres it has a high watershed to surface area ratio (506:1). As such, water loading is very high and water residence time is rather short, typically ranging from about 10 days at 25th percentile flows to 40 days at 75th percentile flows. The reservoir has two somewhat distinct segments: a shallow inflow/middle (often referred to as transitional) segment where the Cannon River enters the reservoir and a small but deeper near-dam segment (Figure 1).

Figure 1. The Byllesby Reservoir.



The Cannon River drains an area of 1,116 square miles and represents a transition from the NCHF ecoregion to the northwest and WCBP ecoregion to the south (Figure 2). A mosaic of landuses are present in the watershed ranging from a mixture of forested and open lands, including numerous lakes and wetlands, in the northwest to the predominately agricultural lands to the south. Though this portion of the watershed contains many lakes, most are quite eutrophic and several such as Cannon, Tetonka, and Roberds are on the Impaired Waters list as well. The Straight River is the largest single tributary in the watershed and drains 440 square miles in the highly agricultural southern portion of the watershed. The reservoir itself is located in the WCBP ecoregion. It has multiple boat accesses, two county parks, and is used for swimming, boating and fishing. A majority of the recreation in the reservoir takes place in the eastern portion of the transitional and near-dam segments (Figure 1). The reservoir's fishery is dominated by carp and black bullhead, typical of a highly eutrophic waterbody.

Figure 2. Byllesby Reservoir Watershed's ecoregions.



The reservoir itself, as well as the Straight River drainage (which accounts for most of the land area that drains directly to Byllesby) are within the Western Cornbelt Plains.

The Byllesby Reservoir was included on the 2002 303(d) list for nutrient impairment. Mean TP and Chl-*a* of 236 ppb and 52 ppb respectively, are far in excess of both the NCHF and WCBP thresholds. Secchi at 0.8 m was below the NCHF threshold. Eight summers of data (ranging between 1991 through 2004) are available for assessing lake condition. TP typically ranges from 200-250 ppb as a whole lake mean. Chl-*a* averages 47 ppb (Figure 3) and about 60% of the Chl-*a* measurements are above 30 ppb, a level often associated with severe nuisance blooms. Over this same period summer-mean Secchi ranged from 0.6 – 0.9 m with 65% of the measures less than 1.0 m. As is common in reservoirs there was a transition in water quality from the inflow to the near-dam segment; with the inflow segment being distinctly different from the transitional and near-dam segments. The inflow segment is characterized by very low Secchi (because of high TSS), high TP and moderate Chl-*a* while the near-dam segment exhibited higher transparency, lower TP but elevated Chl-*a* (Figure 4). Chl-*a* is strongly related to river flow (lake residence time) whereby summer-mean and maximum Chl-*a* increase as flow decreases.

Figure 3. Byllesby Reservoir Watershed in Context of CRW

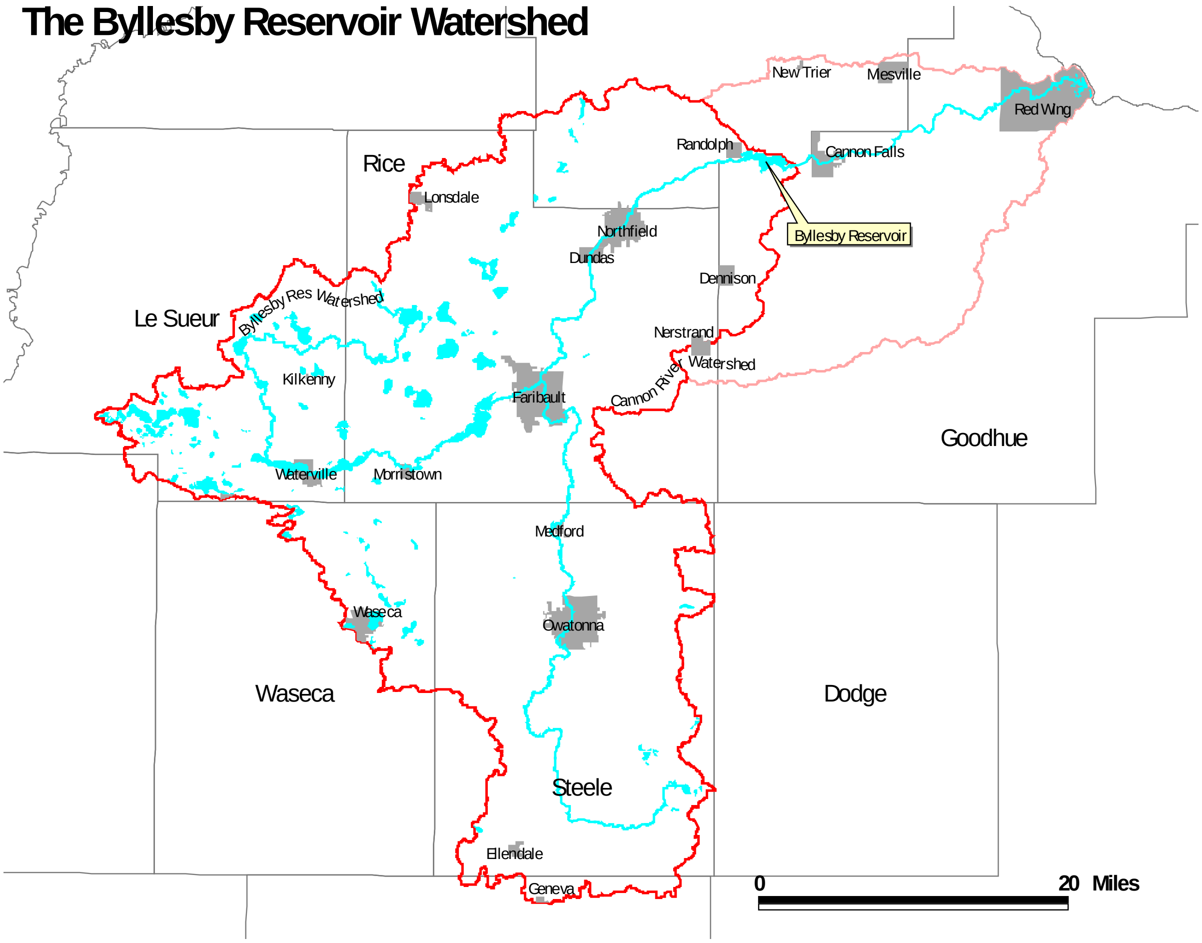


Figure 4. Summer-mean Chl-*a*

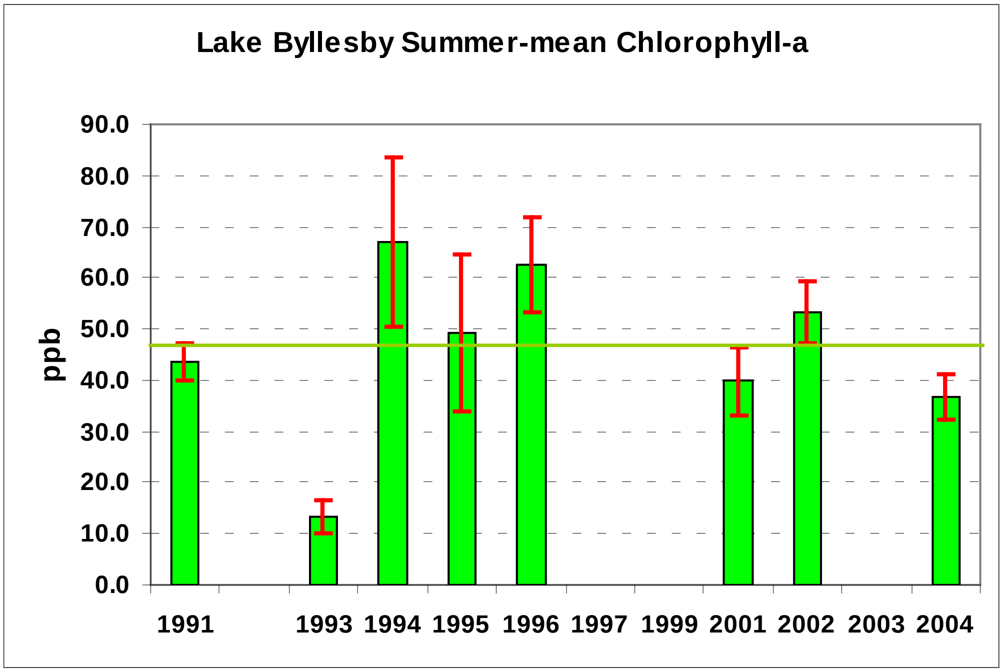
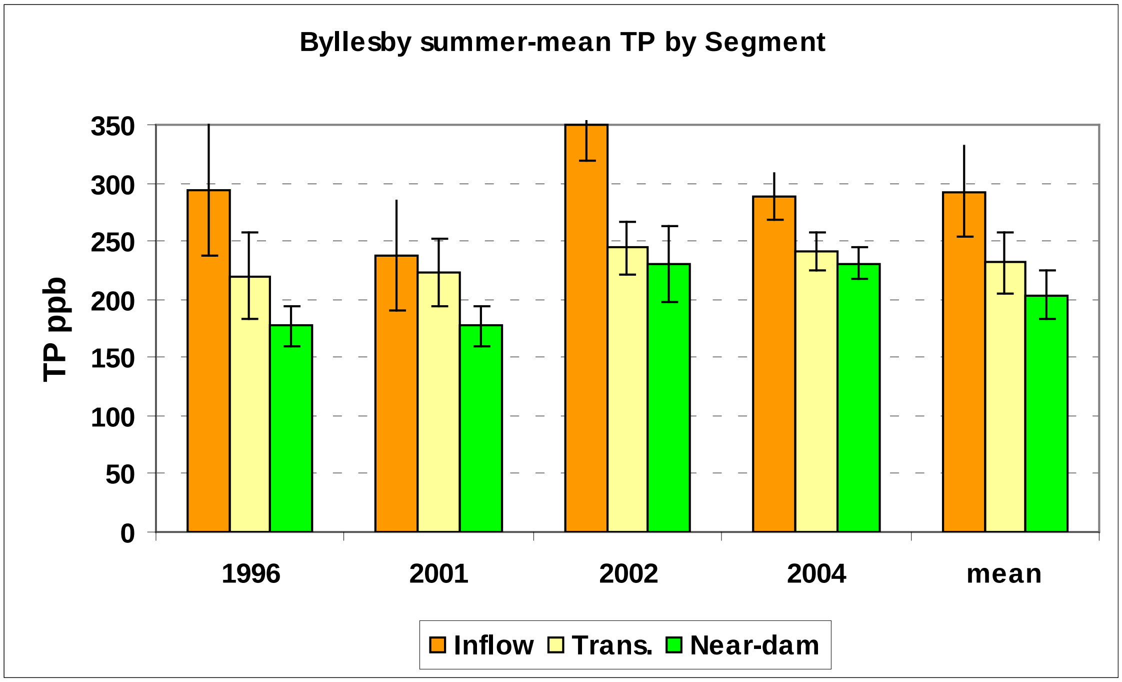
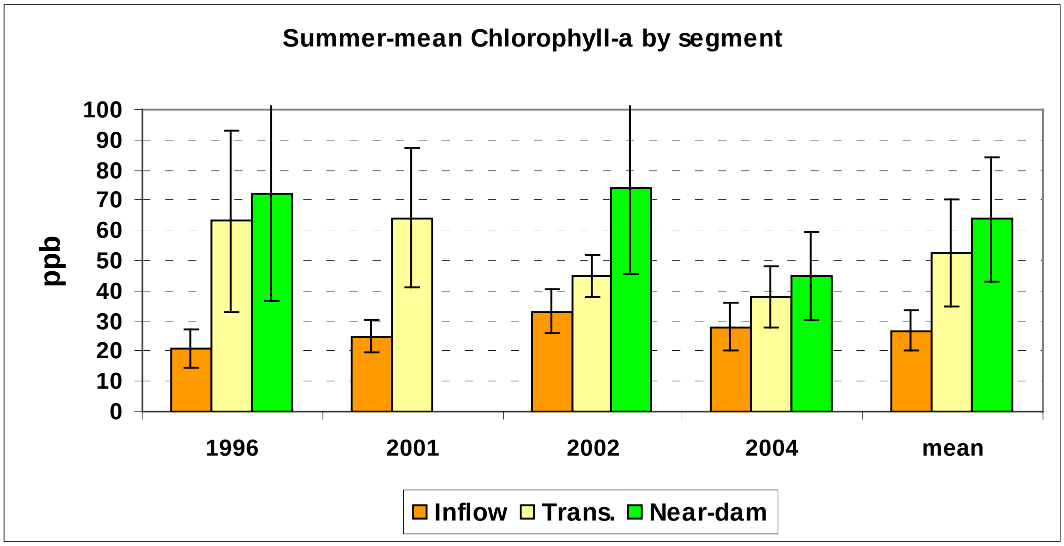


Figure 5. Summer-mean TP and Chl-*a* by Segment





Site Specific Criteria Selection

Byllesby clearly meets the criteria outlined in the reservoir definition in the recently promulgated water quality standards for class 2 waters (see Subp. 4, item S, here: (https://www.revisor.leg.state.mn.us/rules/?id=7050.0150):

> *"Reservoir" means a body of water in a natural or artificial basin or watercourse where the outlet or flow is artificially controlled by a structure such as a dam. Reservoirs are distinguished from river systems by having a hydraulic residence time of at least 14 days. For purposes of this item, residence time is determined using a flow equal to the 122Q10 for the months of June through September, a 122Q10 for the summer months.*

Because it is a reservoir and drains more than one ecoregion the lake eutrophication standards allow for establishment of site-specific criteria for the Byllesby Reservoir (https://www.revisor.leg.state.mn.us/rules/?id=7050.0222).

The best available bathymetry data suggest that 48% of the Byllesby Reservoir is less than 10 feet deep, and a simple approximation (interpolation of 15 foot contour area using 10 foot and 20 foot contour areas) of the littoral area is 66%. That value is very close to the criterion put forth in the shallow lake definition (see Subp. 4, item S, here: https://www.revisor.leg.state.mn.us/rules/?id=7050.0150): maximum depth of 15 feet or 80% or more littoral. The other criterion in the shallow lake definition is that it is uncommon for shallow lakes to thermally stratify in the summer. In terms of surface area, the majority of the Byllesby Reservoir meets that criterion as well, with the exception of the single deep hole in the near-dam portion of the reservoir. Absent this portion, the remainder of the transitional and near-dam bays remains well-mixed throughout the summer, with at most temporary stratification during very warm and calm periods.

Given this relative shallowness, its very large watershed, short water residence time, and predominance of agriculture throughout the watershed (consistent with typical land use pattern for WCBP) the focus for site-specific criteria for Byllesby should be on reducing the frequency and severity of nuisance algal blooms. This would be consistent with other shallow WCBP lakes. Since there appears to be minimal difference in the trophic indicators between the transitional and near-dam segments (Figure 4), intra-segment residence time is quite short, and these two segments are the primary focus of recreational activities in the reservoir it would be reasonable to combine them for purposes of establishing site-specific criteria and evaluating compliance with the TMDL. Following is a summary of pertinent criteria setting considerations and draft site-specific criteria:

- TP < 90 ppb as a summer-mean as measured in the combined transitional and near-dam segments. This value is equivalent to the criteria for shallow WCBP lakes. To achieve this in-lake concentration, Cannon River inflow on the order of 150 ppb may be required. Relative to minimally impacted streams in the NCHF ecoregion this corresponds to about the 75th percentile and for WCBP streams this is below the 25th percentile.
- Viable Chl-*a* < 30 ppb as a summer-mean as measured in these two segments. This should keep maximum Chl-*a* below 60 ppb and reduce frequency of 30 ppb (severe nuisance blooms) from about 55% to 60% of the summer to about 30 percent of the summer. This value is also equivalent to the Chl-*a* criterion for shallow WCBP lakes.

- Secchi as a summer-mean of 0.8 m or greater as measured in these two segments. This value is close to the long-term mean for the reservoir and is intermediate between the draft criteria values for shallow and deep WCBP lakes (0.7 and 0.9 respectively). It also corresponds with the proposed TP and Chl-*a* criteria based on the MPCA regression equations.
- These values should apply over a range of flows from ~156 cfs (summer 122 day 1 in 10 year recurrence, 90th percentile flow) up to ~1,000 cfs (~20th percentile), which corresponds to a residence time of about 8 to 10 days. This is the range of flows inside which lake criteria are appropriate. Outside of this range are infrequent low flow occurrences (less than 10% of years) and river-like high flow conditions during which nuisance algae blooms are not an issue.
- To assess compliance with the TMDL water quality must be monitored at consistent sites within each of the three segments. Data from the transitional and near dam segments will be area-weighted and the subsequent values will be used in modeling and to assess compliance with the TMDL.

Attachments

(1) Agenda and notes from 4/24/06 Byllesby Reservoir Phosphorus TMDL meeting of Technical and Advisory Committee.

(2) Agenda and notes from 1/16/07 Byllesby Reservoir Phosphorus TMDL meeting of Technical and Advisory Committee.

(3) Agenda and notes from 5/24/07 Byllesby Reservoir Phosphorus TMDL Nonpoint Stakeholders and Public Meeting..

Byllesby Reservoir Phosphorus TMDL

Technical and Advisory Committee Meeting

Monday April 24, 2006; 9 a.m. – noon

St. Olaf College, Northfield

Buntrock Commons Room 142

<u>Agenda</u>

1. Welcome and Introductions – Beth Kallestad

2. <u>PROJECT BACKGROUND</u>
    a. Brief review of project scope, sequence, and timeline – Beth Kallestad, Lee Ganske
    b. Q & A related to timeline.

3. <u>FOLLOW UP FROM PREVIOUS MEETINGS</u>
    a. Literature review – Fate and transport of riverine phosphorus – Justin Watkins
    b. Discussion of limited monitoring in 2006
    c. FLUX and BATHTUB brief review and updates - Justin Watkins, Mark Tomasek

3. <u>SETTING THE PHOSPHORUS CONCENTRATION GOAL FOR THE BYLLESBY RESERVOIR</u>
    a. Statewide nutrient criteria development - Steve Heiskary, MPCA
        - Background on Lake Byllesby. Byllesby/Lake Pepin similarities.
        - Current water quality trends for TP, chlorophyll –a, Secchi, and TSS.
        - Variability over time & flow regime.
        - User perception relative to Secchi and chl – a
    b. Q & A
    c. Discussion of proposed phosphorus criteria for Byllesby Reservoir
    d. Direction for the writers of the TMDL document.

4. Next steps, including group members' perceptions of communication needs.

5. Date for next meeting- Please cross out dates/times that you would NOT be able to come below, tear off, and return to box near exit.

Name:____

For the next Byllesby TMDL Technical or Technical and Advisory Committee meeting, I would NOT be able to come on the dates/times I have Xed out below:

Tuesday, May 23 a.m. p.m. Tues., June 20 a.m. p.m.

Wednesday, May 24 a.m. p.m. Wed., June 21 a.m. p.m.

Tuesday, June 13 a.m. p.m.

Wednesday, June 14 a.m. p.m.

Terms and acronyms

TMDL – Total Maximum Daily Load. The maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. TMDL also refers to the process of allocating pollutant loadings among point and nonpoint sources.

TP – The amount of total phosphorus in a water sample. Units: ppb (parts per billion; µg/L; micrograms per Liter). Also, mg/L(milligrams/ Liter; parts per million). 1000 µg/L = 1mg/L 90µg/L = .09mg/L

Chlorophyll – a – A measurement of the quantity of algae present in a water sample.

Units: ppb (parts per billion)

Secchi – A measurement of the transparency of the water at a specified location in the lake. Units: meters. Lakes dominated by large, colonial algae, such as Aphanizomenon sp. (look like clumps of grass clippings), may have high transparencies relative to the phosphorus concentration. This is because these colonies of algae may form "rafts" or scums at the surface of the water which are easily displaced by wind or lowering of the Secchi disk, and hence Secchi readings may be deeper than if the algae were dispersed evenly throughout the water column. This is very common in hypereutrophic lakes and hence Secchi may not be the best indicator of trophic status in highly nutrient-rich lakes.

Ecoregion abbreviations:

NLF – Northern Lakes and Forests

CHF –same as NCHF – North Central Hardwood Forests

WCBP- Western Cornbelt Plains

NGP – Northern Glaciated Plains

Lake Morphometry- The size and shape of a lake; generally includes lake area, mean and maximum depth, watershed acres, and ratio of watershed area to lake area.

Residence Time – For a small volume of water, the time elapsed between entrance to the reservoir to exit from the reservoir. Residence time illustrates lake-like or river-like qualities of a reservoir.

Geometric Mean - The geometric mean of 'n' samples is the nth root of their product. For example, the geometric mean of 5 values is the 5th root of the product of the 5 values.

Byllesby Reservoir Phosphorus TMDL

Nonpoint Source stakeholders and public meeting

Thursday, May 24, 2007; 9-11:30 A.M. (Coffee, juice, and pastries at 8:30.)

South Central College, Faribault, MN.

Agenda

1. 10 Minutes: **Welcome and Introductions** – Hilary Ziols, Beth Kallestad

   1 hour: **How the Byllesby TMDL is shaping up – MPCA and CRWP staff**

   i) Site-specific in-lake goals – **Steve Heiskary**

   ii) Modeling the phosphorus capacity of the lake – **Dennis Wasley/Justin Watkins**

   iii) Sources of phosphorus – Summary of Barr report to legislature – **Hilary Ziols**

        iv) Point and Nonpoint Source reductions – **Lee Ganske, Dennis Wasley**

Break: 15 minutes

1 hour: **Discussion** – Facilitated by **Jim Klang.**

b) Pros and cons of point and nonpoint source reductions
  - List of BMPs will be available, and attendees will add to this list
  - Prioritize PS and NPS BMPs
  - Identify pros and cons for top 3 PS and NPS BMPs

c) Input for best practices to achieve reductions

d) Ideas for monitoring
  - Past and current monitoring sites– **Justin Watkins, Beth Kallestad**
  - Where and what should be included in the future?

d) **Questions for Technical Committee**

e) **Conclusion**

Byllesby Reservoir Phosphorus TMDL

Technical and Advisory Committee Meeting

Tuesday, January 16, 2007; 9 – 11:30 a.m.

Buckham Library, 2nd Floor, Faribault, MN

<u>Agenda</u>

1. Welcome and Introductions – CRWP staff
2. <u>PROCESS AND PROGRESS TO DATE</u>
   a. Notes overview – Hilary Ziols
   b. Modeling overview: Flux and Bathtub Results – Justin Watkins, Mark Tomasek
   c. Water quality standards (In-lake Goals) – Hilary Ziols, Lee Ganske
   d. WLA recommendation – Mark Knoff, Lee Ganske
3. <u>DISCUSSION</u> – recorders to write input on flip charts
   a. Pros and cons of recommended WLA and LA - All
   b. Possible positive and negative consequences of WLA and LA
   c. Questions
4. <u>NEXT STEPS</u>
   a. Draft TMDL document with peer review
   b. Continue outreach – SWCDs, Waseca, Goodhue, and LeSueur County
   c. Public meeting with Non-Point Source stakeholders

STATE OF MINNESOTA
MINNESOTA POLLUTION CONTROL AGENCY

IN THE MATTER OF THE PROPOSAL TO DEVELOP
A SITE SPECIFIC STANDARD
FOR THE BYLLESBY RESERVOIR
DAKOTA & GOODHUE COUNTIES, MINNESOTA

FINDINGS OF FACT
CONCLUSIONS OF LAW
AND ORDER

FINDINGS OF FACT

Based on the MPCA staff review, comments and information received during the comment period, and other information in the record of the MPCA, the MPCA hereby makes the following Findings of Fact, Conclusions of Law, and Order:

Jurisdiction

1. The MPCA is authorized to enforce and administer all laws relating to the pollution of any waters of the State. Minn. Stat. § 115.03, subd. 1 (a).

2. The MPCA has authority to establish and alter such reasonable standards for the waters of the State. Minn. Stat. § 115.03, subd. 1(c).

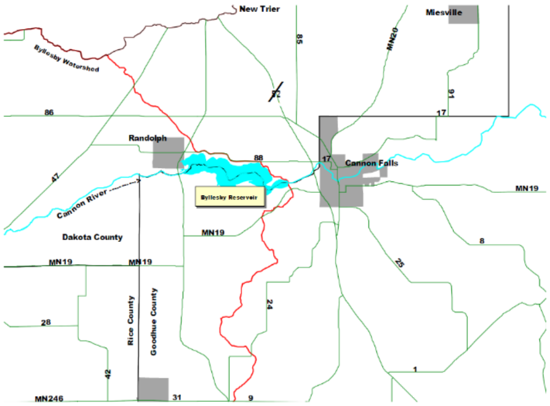
3. MPCA has specific authority to develop site specific standard:

> 7050.0220 SPECIFIC WATER QUALITY STANDARDS BY ASSOCIATED USE CLASSES.
>
> Subp. 7. Site-specific modifications of standards.
>
> A. The standards in this part and in parts 7050.0221 to 7050.0227 are subject to review and modification as applied to a specific surface water body, reach, or segment. If site-specific information is available that shows that a site-specific modification is more appropriate than the statewide or ecoregion standard for a particular water body, reach, or segment, the site-specific information shall be applied.
>
> B. The information supporting a site-specific modification can be provided by the commissioner or by any person outside the agency. The commissioner shall evaluate all relevant data in support of a modified standard and determine whether a change in the standard for a specific water body or reach is justified.
>
> C. Any effluent limit determined to be necessary based on a modified standard shall only be required after the discharger has been given notice of the specific proposed effluent limits and an opportunity to request a hearing as provided in part 7000.1800.

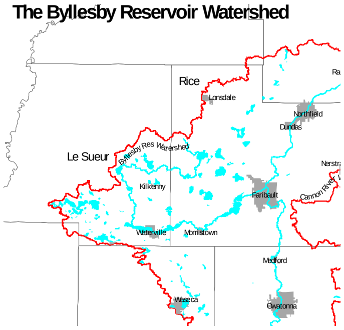
Description of Byllesby Reservoir

1. The Byllesby Reservoir (19-0006) is a run-of-the-river reservoir on the Cannon River that was created by a dam built in 1911. The reservoir lies in southeastern Minnesota, near the communities of Randolph and Cannon Falls. The Cannon River channel – even through the reservoir – is a county line: Goodhue County is to the south, and Dakota County to the north.

Figure 1. The Byllesby Reservoir.



The Byllesby Reservoir Watershed



2. With a surface area of about 1,365 acres the reservoir has a high watershed to surface area ratio (506:1). As such, water loading is very high and water residence time is rather short, typically ranging from about 10 days at 25th percentile flows to 40 days at 75th percentile flows. The reservoir has two somewhat distinct segments: a shallow inflow/middle (often referred to as transitional) segment where the Cannon River enters the reservoir and a small but deeper near-dam segment. It has multiple boat accesses, two county parks, and is used for swimming, boating and fishing. A majority of the recreation in the reservoir takes place in the middle and near-dam segments. The reservoir's fishery is dominated by carp and black bullhead, typical of a highly eutrophic waterbody.

Criteria for Determining Whether to Develop a Site Specific Water Quality Standard

3. In 2008 the State of Minnesota promulgated water quality standards for class 2 waters (see https://www.revisor.leg.state.mn.us/rules/?id=7050.0222). The standards provide, among other things, the following:

    a. Definition of a reservoir, which is clearly met by Byllesby (see 7050.0150 Subpart 4(S)):

    > *"Reservoir" means a body of water in a natural or artificial basin or watercourse where the outlet or flow is artificially controlled by a structure such as a dam. Reservoirs are distinguished from river systems by having a hydraulic residence time of at least 14 days. For purposes of this item, residence time is determined using a flow equal to the 122Q10 for the months of June through September, a 122Q10 for the summer months.*

    b. In-lake eutrophication criteria (numeric values for TP, Chl-*a*, Secchi depth) according to ecoregion; in some ecoregions the standards assign different numeric values for shallow and deep lakes.

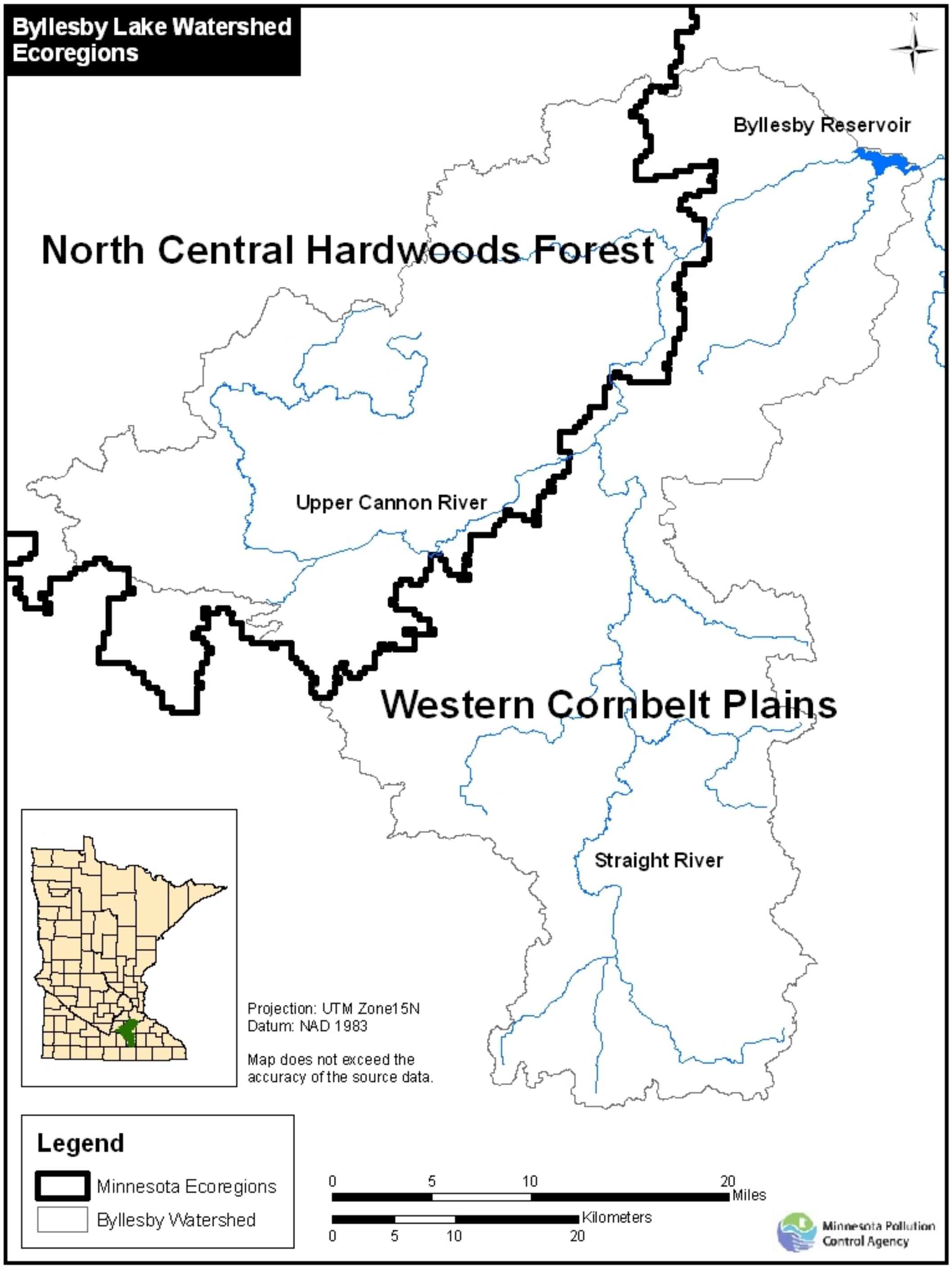
    c. A provision that states that eutrophication standards for reservoirs may be formulated on a site-specific basis to account for characteristics unique to reservoirs that can affect trophic status, such as water temperature, variations in hydraulic residence time, watershed size, and the fact that reservoirs may receive drainage from more than one ecoregion (see 7050.0222, subpart 4a(E)).

4. The Byllesby Reservoir watershed drains large land areas in two ecoregions: the WCBP and the NCHF:

   The Cannon River upstream of Byllesby drains an area of 1,116 square miles and represents a transition from the NCHF ecoregion to the northwest and WCBP ecoregion to the south. A mosaic of landuses are present in the watershed ranging from a mixture of forested and open lands, including numerous lakes and wetlands, in the northwest to the predominately agricultural lands to the south.

5. It follows from findings #3 and #4 above that the Byllesby Reservoir requires a site specific standard consideration. The numeric eutrophication criteria were developed for natural lakes in the various ecoregions of Minnesota. The Byllesby Reservoir is not a natural lake, nor does it belong to one particular ecoregion (see finding #6). Thus it presents precisely the case addressed by 7050.0222, subpart 4a(E) cited above: it is a unique waterbody, to which the standard eutrophication criteria do not apply; a site specific standard consideration is appropriate.

6. Byllesby Reservoir Ecoregions.



Applicable Standards

7. The following two rules govern MPCA's adoption of site-specific standards:

Minn. R. 7050.0220 subp 7, items A, B and C:

Subp. 7. Site-specific modifications of standards:

A. The standards in this part and in parts 7050.0221 to 7050.0227 are subject to review and modification as applied to a specific surface water body, reach, or segment. If site-specific information is available that shows that a site-specific modification is more appropriate than the statewide or ecoregion standard for a particular water body, reach, or segment, the site-specific information shall be applied.
B. The information supporting a site-specific modification can be provided by the commissioner or by any person outside the agency. The commissioner shall evaluate all relevant data in support of a modified standard and determine whether a change in the standard for a specific water body or reach is justified.
C. Any effluent limit determined to be necessary based on a modified standard shall only be required after the discharger has been given notice of the specific proposed effluent limits and an opportunity to request a hearing as provided in part 7000.1800.

Minn. R. 7050.0222 Subp 4a, items A. and E:.

Subp. 4a. Narrative eutrophication standards for Class 2B lakes, shallow lakes, and reservoirs.

A. Eutrophication standards applicable to lakes, shallow lakes, and reservoirs that lie on the border between two ecoregions or that are in the Red River Valley, Northern Minnesota Wetlands, or Driftless Area Ecoregions must be applied on a case-by-case basis. The commissioner shall use the standards applicable to adjacent ecoregions as a guide.

E. When applied to reservoirs, the eutrophication standards in this subpart and subpart 4 may be modified on a site-specific basis to account for characteristics of reservoirs that can affect trophic status, such as water temperature, variations in hydraulic residence time, watershed size, and the fact that reservoirs may receive drainage from more than one ecoregion. Information supporting a site-specific standard can be provided by the commissioner or by any person outside the agency. The commissioner shall evaluate all data in support of a modified standard and determine whether a change in the standard for a specific reservoir is justified. Any TP effluent limit determined to be necessary based on a modified standard shall only be required after the discharger has been given notice of the specific proposed effluent limits and an opportunity to request a hearing as provided in part 7000.1800.

The MPCA Findings With Respect to These Criteria

8. The Byllesby Reservoir is unique and distinctly apart from the natural lakes of Minnesota. It has the most expansive lake or reservoir drainage in the Lower Mississippi River Basin in Minnesota (with the exception of Lake Pepin) and 80-90% of its water budget comes by way of the Cannon River. Given its relative shallowness, very large watershed, and short residence time, it would be inappropriate to apply to the Byllesby Reservoir a eutrophication standard designed for deep, natural lakes. Rather, the focus should be on reducing the frequency and severity of nuisance algae blooms. This is consistent with shallow Western Corn Belt Plains (WCBP) lakes, and thus the proposed numeric criteria for the Byllesby Reservoir are similar to the WCBP shallow lakes values. Since there appears to be minimal difference in the trophic indicators between the transitional and near-dam segments, intra-segment residence time is quite short, and these two segments are the primary focus of recreational activities in the reservoir it would be reasonable to combine them for purposes of establishing site-specific criteria and evaluating compliance. Following is a summary of pertinent criteria setting considerations and draft site-specific criteria:

   - TP < 90 ppb as a summer-mean as measured in the combined transitional and near-dam segments. This value is equivalent to the criteria for shallow WCBP lakes. To achieve this in-lake concentration, Cannon River inflow on the order of 150 ppb may be required. Relative to minimally impacted streams in the NCHF ecoregion this corresponds to about the 75th percentile and for WCBP streams this is below the 25th percentile.
   - Viable Chl-*a* < 30 ppb as a summer-mean as measured in these two segments. This should keep maximum Chl-*a* below 60 ppb and reduce frequency of 30 ppb (severe nuisance blooms) from about 55-60 percent of the summer to about 30 percent of the summer. This value is also equivalent to the Chl-*a* criterion for shallow WCBP lakes.
   - Secchi as a summer-mean of 0.8 m or greater as measured in these two segments. This value is close to the long-term mean for the reservoir and is intermediate between the draft criteria values for shallow and deep WCBP lakes (0.7 and 0.9 respectively). It also corresponds with the proposed TP and Chl-*a* criteria based on MPCA regression equations.
   - These values should apply over a range of flows from ~156 cfs (summer 122 day one-in-ten year recurrence, 90th percentile flow) up to ~1,000 cfs (~20th percentile), which corresponds to a residence time of about 8-10 days. This is the range of flows inside which lake criteria are appropriate. Outside of this range are infrequent low flow occurrences (<10 percent of years) and river-like high flow conditions during which nuisance algae blooms are not an issue.
   - To assess compliance with these criteria, water quality must be monitored at consistent sites within each of the three segments. Data from the transitional and near dam segments will be area-weighted and the subsequent values will be used in modeling and to assess compliance.

9. The eutrophication standards are designed to protect designated uses, including aquatic recreation. They are based on a detailed analysis of several databases (see the following list of *Data used in criteria development*), including a thorough analysis of user perceptions relative to Secchi transparency and the frequency and severity of nuisance algae blooms. The shallow lake standards place an emphasis on the ecological health of lakes but are also designed to be supportive of aquatic recreational use (e.g. swimming, wading, boating etc.), where these uses are attainable (*Statement of Need and Reasonableness, In the Matter of Proposed Revisions of Minnesota Rules Chapter 7050, Relating to the Classification and Standards for Waters of the State* [heretofore referred to as *SONAR*]), Book II, page 74. The *SONAR* and the promulgated eutrophication standards, which were reviewed by an administrative law judge and approved by the US EPA, state that these standards will not prevent algae blooms; however, they will serve to minimize the intensity and duration of the very severe nuisance blooms, which often make waters unusable (*SONAR*, Book II, page 66). The proposed criteria for the Byllesby Reservoir set a goal that, if attained would support and protect all dimensions of aquatic recreation in and on the waterbody: boating, wading, skiing, swimming, etc. It must be noted that attainment of designated use support, pursuant to the promulgated lake water quality standards, does not require elimination of all algae blooms.

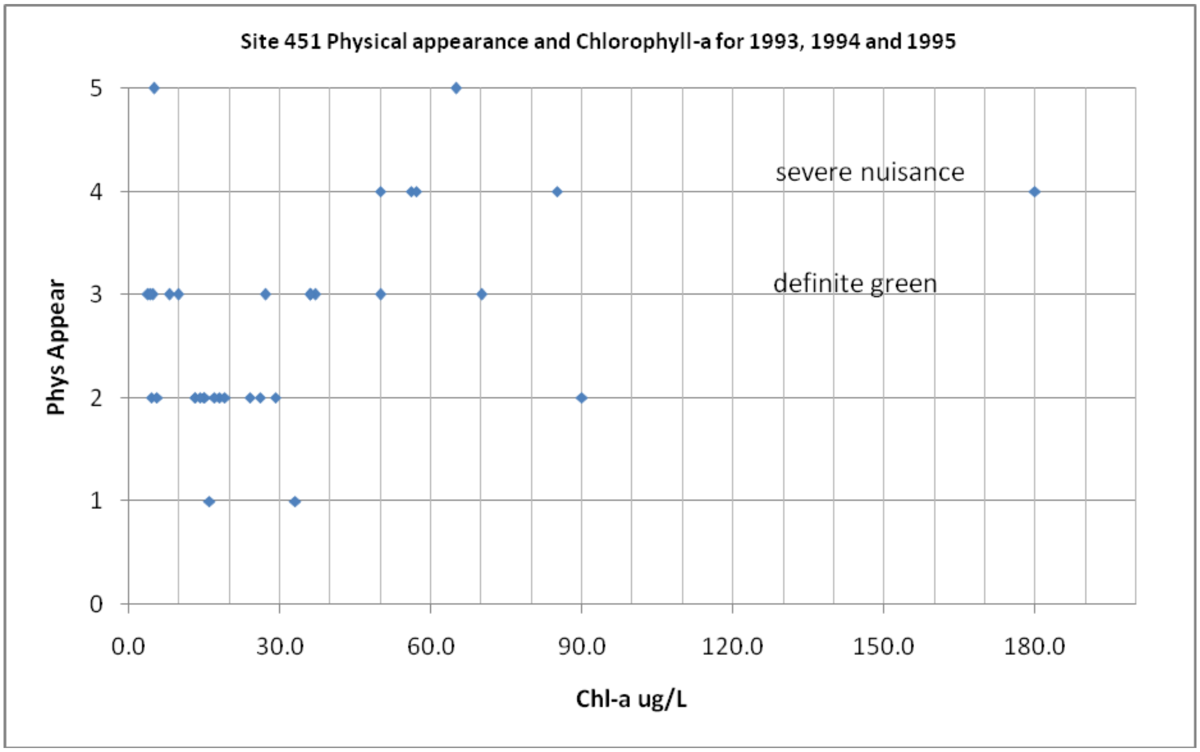
Data used in criteria development:

MINNESOTA LAKE WATER QUALITY ASSESSMENT REPORT: DEVELOPING NUTRIENT CRITERIA, Third Edition
(This publication contains or references the important databases (e.g. reference lakes) that were used in nutrient criteria development)
http://www.pca.state.mn.us/publications/reports/lwq-a-nutrientcriteria.pdf

Interrelationships Among Water Quality, Lake Morphometry, Rooted Plants and Related Factors for Selected Shallow Lakes of West-Central Minnesota
http://www.pca.state.mn.us/publications/reports/lakes-shallow-westcentral.pdf

Water Quality Reconstruction from Fossil Diatoms: Applications for Trend Assessment, Model Verification, and Development of Nutrient Criteria for Lakes in Minnesota, USA
http://www.pca.state.mn.us/publications/reports/lakes-wqdiatoms.pdf

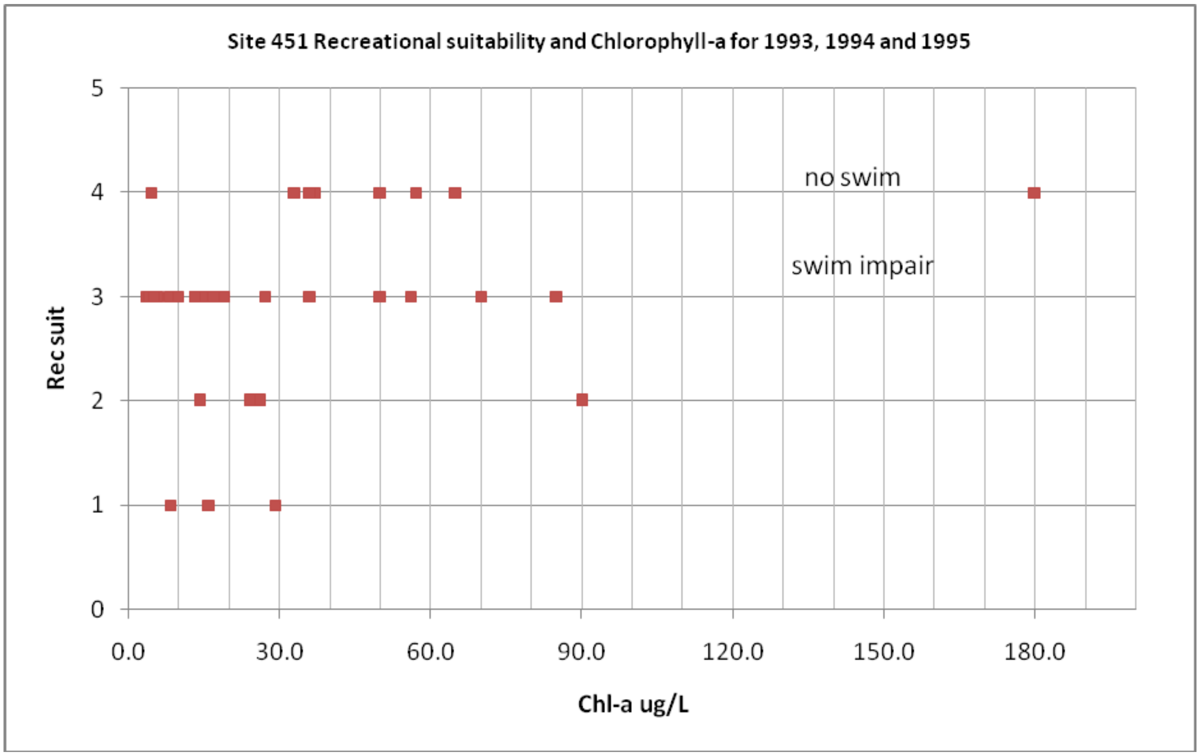
10. The Chl-*a* thresholds that typically correspond to nuisance and severe nuisance algae bloom conditions were set according to a large dataset derived primarily from information collected on natural glacial lakes in Minnesota. Reservoirs – given their man-made nature – may exhibit varying relationships among TP, Chl-*a* and Secchi transparency and the frequency and magnitude of algal blooms may vary as well. Further, Chl-*a* thresholds with respect to what constitutes “nuisance and severe nuisance” algae blooms may vary as well. In the case of the Byllesby Reservoir, lake data collected by volunteers in a Metropolitan Council Environmental Services monitoring program (in 1993-1995) indicate that 30 ug/l Chl-*a* is a “tipping point” beyond which user perceptions of “definite green” and “severe nuisance” condition are more common. The majority of user perception appearance notes recorded at Chl-*a* values <= 30 ug/l describe the condition as “low algae.”



Physical Appearance Key:

1. Crystal clear water.
2. Not quite crystal clear, a little algae present/visible.
3. Definite algal green, yellow, or brown color apparent.
4. High algal levels with limited clarity and/or mild odor apparent.
5. Severely high algae levels with one or more of the following: massive floating scums on lake of washed up on shore, strong foul odor, or fish kill.

11. Likewise, the user perception of recreational suitability changes: values <= 30 ug/l show notes ranging from "very good" to "fair."



Recreational Suitability Key:

1. Beautiful, could not be any nicer.
2. Very minor aesthetic problems; excellent for swimming, boating, enjoyment.
3. Swimming and aesthetic enjoyment slightly impaired because of algae levels.
4. Desire to swim and level of enjoyment of the lake substantially reduced because of algae levels (would not swim, but boating is okay).
5. 5. Swimming and aesthetic enjoyment of the lake nearly impossible because of algae levels.

12. Historical Citizen Lake Monitoring Program (CLMP) data show that when water clarity is >=0.8 meters (the proposed numeric value), user perception of appearance is "low algae" (numeric value 2) or "medium algae" (numeric value 3) 87% of the time and user perception of recreational suitability is "good" (numeric value 2) to "fair" (numeric value 3) 87% of the time (sites 203 (mid-lake) and 202 (near-dam); n=135 from 1999-2008).

13. In summary: according to BATHTUB modeling, the proposed summer mean TP criterion (90 ppb) corresponds to the proposed summer mean Chl-*a* criterion (30 ppb), as described in finding #8 above. These summer mean values are expected to keep maximum Chl-*a* below 60 ppb and reduce frequency of 30 ppb (severe nuisance blooms) from about 55-60 percent of the summer to about 30 percent of the summer. The user perception data (findings #10 and #11) support the 30 ug/l Chl-*a* criterion, as they indicate that it is a "tipping point" beyond which user perceptions of "definite green" and "severe nuisance" condition are more common. The majority of user perception appearance notes recorded at Chl-*a* values <= 30 ug/l describe the condition as "low algae." Likewise the proposed Secchi depth criterion of 0.8 meters (which regression analysis and BATHTUB modeling suggest corresponds to the TP and Chl-*a* criteria, as described in finding #8 above) is generally associated with fair or positive user perceptions. It follows that the proposed criteria for the Byllesby Reservoir set a goal that, if attained would support the designated use of aquatic recreation in and on the waterbody: boating, wading, skiing, swimming, etc. (as described in finding #9, it must be noted that attainment of designated use support, pursuant to the promulgated lake water quality standards, does not require elimination of all algae blooms).

Procedural History

14. The MPCA made the proposed site specific standard for the Byllesby Reservoir available for public review and comment for a period of thirty days. The MPCA notified the public of the public comment period via (1) The State Register (TUESDAY 26 May 2009, Volume 33, Number 47 (Page1929)), and (2) the June 2009 MPCA Waterfront Publication (electronically mailed to approximately 200 subscribers and posted on the MPCA web site). The public comment period was May 26, 2009 to June 26, 2009.

15. During the 30-day public notice period, the MCPA received six comment letters: (in order received):
    - Dakota County (Travis Thiel)
    - Joyce & Al Moorhouse
    - Jeff Moorhouse
    - Minnesota Center for Environmental Advocacy (Kris Sigford)
    - Minnesota Department of Transportation (Frank Pafko)
    - Flaherty & Hood, representing Owatonna, Northfield, Faribault (Steve Nyhus)

16. Prior to the public comment period noted above, there were numerous meetings held to discuss the proposed site specific standard for the Byllesby Reservoir. At a number of the meetings, the numeric goals for the reservoir were discussed at length by the project stakeholder group. The following meetings included agendas that specifically listed in-lake water quality goals or site specific standards as prominent presentation and discussion items:

    - April 24, 2006: St. Olaf College, Northfield

    - January 16, 2007: Buckham Library, Faribault

    - May 24, 2007: South Central College Faribault [this meeting was titled *Nonpoint Source stakeholders and public meeting*]

17. The MPCA prepared responses to comments received during the 30-day public notice period. Comment letters and MPCA responses are attached.

CONCLUSIONS OF LAW

18. The MPCA has jurisdiction to adopt a site specific standard for the Byllesby Reservoir.
19. Due, adequate, and timely public notice of the proposed site specific water quality standard was given in accordance with Minn. R. 7001.0100 and that MPCA staff Responses to Comments was sufficient.
20. The criteria for establishing a site specific standard for the Byllesby Reservoir as set forth in Minn. R7050.0220 Subp. 7. are satisfied.
21. As the above findings establish, a site specific standard for the Byllesby Reservoir is appropriate and protective of designated uses.
22. Any findings that might properly be termed conclusions and any conclusions that might properly be termed findings are hereby adopted as such.

ORDER

The Minnesota Pollution Control Agency approves the adoption of a site specific standard for the Byllesby Reservoir. This site specific standard shall be forwarded to U.S. EPA for its review and approval before being implemented by the MPCA.

IT IS SO ORDERED

____
Commissioner Paul Eger
Chair, Citizens' Board
Minnesota Pollution Control Agency

____
Date

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

AUG 26 2011

REPLY TO THE ATTENTION OF:
WQ-16J

Michael J. Sandusky, Division Director
Environmental Analysis and Outcomes Division
Minnesota Pollution Control Agency
520 Lafayette Road North
St. Paul, Minnesota 55155-4194

Dear Mr. Sandusky:

The U.S. Environmental Protection Agency has completed its review of water quality standards submitted by the Minnesota Pollution Control Agency (MPCA). On May 12, 2010, EPA received a submittal by MPCA for site specific water quality criteria for total phosphorus, chlorophyll-a, and secchi depth for Lake Byllesby. On April 30, 2010, Minnesota's Office of the Attorney General sent EPA a statement certifying that MPCA has the authority to adopt site specific water quality standards and on April 19, 2011 MPCA sent to EPA additional clarifying information from the Minnesota Attorney General, thereby completing the submittal package. The site-specific water quality standards submitted by MPCA for Lake Byllesby is reviewed by EPA under section 303(c) of the Clean Water Act (CWA) and EPA's regulations at 40 CFR Parts 131 and 132 (if applicable).

Consistent with section 303(c) of the CWA and federal regulations at 40 CFR 131.21, EPA is required to review and approve, or disapprove, new or revised state water quality standards. EPA has reviewed the site-specific water quality standards identified above and the information submitted by MPCA in support of these standards and hereby approves the standards identified above pursuant to section 303(c) of the CWA and federal regulations at 40 CFR 131.21.

The Lake Byllesby site-specific criteria are based on the same rationale used in the 2008 Minnesota lakes eutrophication criterion (2008) for total phosphorus, chlorophyll-a, and secchi depth for lakes and reservoirs across Minnesota, including the region in which Lake Byllesby resides. EPA supports the approach used in the 2008 eutrophication criteria and accordingly approved the criteria. The Lake Byllesby site-specific criteria were selected from the scientifically defensible estimates used in the 2008 lakes eutrophication criteria and thus are consistent with the 2008 criteria.

Consistent with Section 7 of the Endangered Species Act and federal regulations at 50 CFR Part 402, EPA is required to consult with the U.S. Fish and Wildlife Service on any action that may affect federally-listed threatened and endangered species. EPA has determined that there are no federally-listed threatened and endangered species in the action area that may be affected by EPA's approval of the site-specific water quality standards for Lake Byllesby.

If your staff has any questions regarding this approval, please have them contact Brian Thompson of my staff at (312) 353-6066 or thompson.brian@epa.gov.

Sincerely,

Tinka G. Hyde

Tinka G. Hyde
Director, Water Division

cc: Steven Heiskary, MPCA

Appendix D

Lake Byllesby
File: **X:\Agency_Files\Water\Standards\P Effluent Limit Review\~TMDL\Byllesby\TMDL assessment\BYL02-2.TP 90 1950.btb**
Description:

Model runs updated for 2006 TMDL assessment. MDT. Inflow data is from Justins final flux calculations. Set model variables secchi/chl a slope to 0.01 due to bloom forming species. Model not calibrated.

Global Variables	Mean	CV
Averaging Period (yrs)	0.42	0.0
Precipitation (m)	0.75	0.2
Evaporation (m)	0.54	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	30	0.50
Total N	1000	0.50
Ortho P	15	0.50
Inorganic N	500	0.50

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

Segment Morphometry

													Internal Loads (mg/m2-day)					
		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		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	Inflow	2	1	1.38	1.3	3	1.3	0.12	0	0	2.73	0.19	0	0	0	0	0	0
2	Main	0	2	4.12	4	6	3.9	0.12	0	0	0.52	0.48	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	350	0.09	0	0	33	0.22	0.31	0.16	0	0	0	0	0	0	0	0
2	0	0	242	0.1	0	0	49	0.17	0.8	0.17	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
2	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	Cannon River	1	1	2479	125	0.1	0	0	230	0.084	0	0	85	0.068	0	0
2	Chub	1	1	217	12	0.1	0	0	80	0.138	0	0	29	0.138	0	0
3	Prairie	2	1	206	12	0.1	0	0	54	0.203	0	0	20	0.203	0	0
4	On-sites	2	3	0	0.1	0.1	0	0	100	0.1	0	0	100	0.1	0	0
5	Immediate Watershed	2	1	60	3	0.1	0	0	49	0.203	0	0	20	0.203	0	0
6	Byllesby Outlet	2	4	2967	134	0.1	0	0	90	0.034	0	0	15	0.059	0	0

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Tributary Non-Point Source Drainage Areas (km^2)

		Land Use Category--->							
Trib	**Trib Name**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	Cannon River	193	105	33	1892	110	0	0	0
2	Chub	17	9	22	163	9	0	0	0
3	Prairie	17	9	23	164	9	0	0	0
4	On-sites	0	0	0	0	0	0	0	0
5	Immediate Watershed	0	0	0	0	0	0	0	0
6	Byllesby Outlet	0	0	0	0	0	0	0	0

Non-Point Source Export Coefficients

		Runoff (m/yr)		Conserv. Subs.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Categ	**Land Use Name**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**
1	forest	0.2	0	0	0	50	0	0	0	0	0	0	0
2	wetland	0.2	0	0	0	50	0	0	0	0	0	0	0
3	pasture	0.2	0	0	0	150	0	0	0	0	0	0	0
4	cultivated	0.2	0	0	0	200	0	0	0	0	0	0	0
5	urban	0.2	0	0	0	300	0	0	0	0	0	0	0
6		0	0	0	0	0	0	0	0	0	0	0	0
7		0	0	0	0	0	0	0	0	0	0	0	0
8		0	0	0	0	0	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	0.200	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

Appendix E

A Study of Sediment Phosphorus Release from Lake Byllesby (Cornwell and Owens 2004)

A Study of Sediment Phosphorus Release from Lake Byllesby, July 2004

Final Report October 2004

Prepared For:

Cities of Faribault and Owatonna, Minnesota

Prepared By:

Jeffrey Cornwell and Michael Owens
Chesapeake Biogeochemical Associates
P.O. Box 167
Sharptown, MD 21861

EXECUTIVE SUMMARY

The internal cycling of phosphorus in aquatic systems can be a major source of phosphorus for phytoplankton growth. In relatively shallow systems, release of phosphorus from sediments can have a deleterious effect on water quality. The measurement of phosphorus release or uptake from sediment is increasingly being used in overall assessments of the condition of lakes and reservoirs.

In July 2004, the measurement of sediment release of soluble reactive phosphorus was measured at 4 stations in the Lake Byllesby Reservoir. Two of the stations had low bottom water oxygen concentrations and two of the shallow water sites had high concentrations of oxygen; oxygen uptake and denitrification were measured only at the shallow sites. At each station, triplicate cores were incubated, as was a water-only control core. The apparatus used maintained near-ambient temperatures and provided stirring within the chamber.

The phosphorus flux measurements ranged from 6-19 mg P m^{-2} d^{-1} and indicated a net flux of phosphorus from the lake sediments to the water column. The flux experiments showed a continual uptake of soluble reactive phosphorus by the water column, with such uptake driving the observed phosphorus efflux rates at several stations. Oxygen uptake at the two shallower stations was high (1.2-1.4 mg O_2 m^{-2} d^{-1}), with high rates of sediment denitrification (132-158 mg N m^{-2} d^{-1}). The sediment data was consistent with the observed depletion of water column oxygen and the enrichment of bottom water with soluble reactive phosphorus and di-nitrogen gas.

On a mass balance basis, the recycling of sediment phosphorus to the water column varies from year to year, but averages about 7% of total phosphorus inputs to the lake. Sediment releases of soluble reactive phosphorus, the most available form of phosphorus, were equivalent to about 16% of soluble reactive phosphorus inputs. Sediment phosphorus releases are likely to have the greatest impact during low flow periods during the summer.

INTRODUCTION

This measurement program was designed to provide best estimates of the sediment-water exchange of phosphate (hereafter "phosphorus" or "P") in the Lake Byllesby Reservoir ("Byllesby Reservoir"). This information was requested by the Cities of Faribault and Owatonna, Minnesota in conjunction with their evaluation of phosphorus cycling in the Byllesby Reservoir. Our approach for studies of phosphorus exchange between sediment and water employs core incubations of sediments to assess the direction and magnitude of this process.

Aquatic sediments are important to nutrient cycles because they can 1) be important sinks for the permanent burial of nitrogen and phosphorus, 2) transform particulate forms of nutrients to dissolved forms of nutrients and provide an important flux to overlying water, and 3) serve as a sink for nitrogen via the conversion of fixed nitrogen to dinitrogen gas, a process known as denitrification. In reservoirs, the relative importance of these processes depends on the trophic status of the water body, the presence/absence of anoxic hypolimnetic waters, the rate of organic and inorganic matter sedimentation, water temperature, and water residence time. There are relatively few studies of directly-measured sediment-water exchange in North American reservoirs (i.e. Erikson and Auer 1998); in contrast, there are numerous such studies in estuaries (i.e. Cowan and Boynton 1996 and references therein). The motivation for many such flux studies often is tied into the need to incorporate the sediment exchange and burial of nutrients into water quality models.

The environmental controls of phosphorus cycling in non-calcareous freshwater sediments have been a topic of scientific inquiry for a considerable period of time (Einsele 1936; Mortimer 1941). In sediments such as the Byllesby Reservoir, the inorganic phosphorus is generally bound by adsorption to or co-precipitation with iron oxides. The freshwater release of inorganic phosphorus from iron oxides generally requires either 1) reducing conditions or 2) high pH (e.g. Jensen and Andersen. 1992), though we have observed high flux rates in Lake Champlain that were associated with bivalves (Cornwell and Owens 1999).

WORK PLAN OVERVIEW

This analysis of the Byllesby Reservoir contains two main study elements:

1. Sediment-water exchange of soluble reactive phosphorus. Measurements were made at 4 stations within the lake in July 2004. Triplicate cores were used for incubation. In order to understand the rates of phosphorus release in shallow water aerobic sediments, we also measured the rate of oxygen uptake; in the deeper sediments, there was no dissolved oxygen. A no-extra-cost byproduct of the oxygen measurements was the measurement of denitrification at the two aerobic stations.

2. Water column profile of soluble reactive P. The accumulation of phosphorus in bottom water is an additional indicator of sediment phosphorus release. We also profiled oxygen, temperature and di-nitrogen.

SEDIMENT STATIONS

Four stations were used in this study. Station I coincides with the monitoring Station 105. This was a deep anoxic station with soft bottom sediments. Station II was the most westerly deep station we could find and was devoid of oxygen in the bottom water. Station III was near the center of the middle segment of the lake and had bottom water oxygen. Station IV was a shallow water station near the inflow segment of the lake and was aerobic. We present a satellite view with general station locations in Appendix I.

Table 1. Station locations and bottom water characteristics.

Station ID	GPS Coordinates	Depth m	Dissolved O_2 mg L^{-1}	Temperature ^{o}C
Station I	44° 30.738'N 92° 56.509'W	12.74	0.14	18.21
Station II	44° 30.622'N 92° 57.357'W	9.14	0.90	20.48
Station III	44° 30.976'N 92° 58.080' W	5.67	7.46	19.78
Station IV	44° 31.196'N 92° 59.620'W	1.43	12.3	20.65

METHODS

WATER COLUMN

At each station on July 7, 2004, we profiled the water column at ~1 m intervals with a YSI XL600 sonde equipped with sensors for depth, pH, dissolved oxygen, and conductivity. Data was manually recorded. Water sampling was carried out using a 12 volt diaphragm pump. At each sediment station, we sampled bottom water 0.5 m above the sediment water interface; this water was used for replacement water during the incubations. On July 8, we sampled the water column at Station I for the same YSI parameters, but collected samples for both dissolved gases and soluble reactive phosphate. Samples were pumped and SRP samples were filtered with a 0.45 µm syringe filter. SRP samples were put on ice until frozen within 3 hours of collection. Dissolved gas samples were collected in 7 mL ground glass stoppered tubes, preserved with Hg, and submerged in water until analysis.

SEDIMENT COLLECTION

Sediments at Stations I and II were collected using a Soutar-designed box corer for soft muds (http://www.oceaninstruments.com/products/box_corers/pbc_100.html); the triggering mechanism has been modified to increase efficiency. This device collected a 6" x 6" box of sediment from which we collected three cores; in all cases we had minimal resuspension and an intact sediment-water interface. At Stations III and IV, we collected cores using a pole corer; this is a device of our design that uses a valve to close the top of the core to provide suction during core retrieval.

SEDIMENT-WATER EXCHANGE MEASUREMENTS

Our sediment-water exchange techniques are similar to our previous studies (i.e. Cornwell and Owens 1999; 2002). Intact 2.5" inner diameter cores were collected and returned to the incubation site, the Faribault sewage treatment plant. Station water was collected in 5 gallon carboys, with water from the shallow Stations III and IV filtered with a ~ 1 µm filter in line with our collection pump. A heating/refrigerating circulator was used to maintain temperature in our water-jacketed incubator. From each station, triplicate cores were incubated. Anoxic cores from Stations I and II were kept sealed to avoid atmospheric oxygen. The cores from Stations III and IV were preincubated overnight using air lift pumps in each core to prevent anoxia and to recirculate the overlying water with a large reservoir of bath water. Cores were sealed airtight with an acrylic top equipped with a magnetic stirrer. Incubations were conducted in the dark with continuous stirring for approximately 5-6 hours. A control core without sediment was used to correct for any water column effects. The water used to replace the sampled water in the anoxic cores was bubbled with N_2 for 30 minutes prior to sample collection. Gas samples (O_2, Ar and N_2) were collected and preserved (using HgCl) in a 7 ml gas tight test tubes (similar to a small BOD bottle). Solute samples were filtered using a 25 mm diameter, 0.45 mm cellulose acetate syringe filter (Nalgene #191-2045). Typically, 20 mL was filtered into vials for analyses of SRP, with sample water replaced by station water fed into the cores via plastic tubing. Samples were frozen for preservation. At the end of the experiment, the water column heights were recorded to calculate the volume of overlying water.

CHEMICAL ANALYSES

Soluble reactive phosphorus (SRP), also called dissolved ortho-phosphate or dissolved inorganic phosphate, was measured colorimetrically following Parsons et al. (1984). This analysis is the most commonly used technique and is based on the formation of a phosphomolybdate compex. The sulfuric acid in the reagents may partially hydrolyze some organic P, but SRP represents the form remineralized in sediments. The measurement of dissolved oxygen, argon and di-nitrogen was carried out using a membrane inlet mass spectrometer (Kana et al. 1994, 1998). This technique provides extremely high precision for this analysis. By using the ratio of dissolved N_2 or O_2 to the biologically inert Ar concentration, we can detect low levels of biological activity.

Typically, gas ratios are determined with precision better than 0.02%. This level of precision is required for the measurement of denitrification (Cornwell et al. 1999).

RESULTS

WATER COLUMN

The water column was vertically stratified on July 7 at Stations I, II and III; the very shallow Station IV was vertically homogenous (Tables 2-5; Figure 1). Surface water temperatures ranged from 20.6°C to 22.4°C, with the lowest temperature at Station IV, suggesting recent cool air temperatures or a strong influence of cooler inflowing water. For Stations I, II and III, large decreases in dissolved oxygen were evident below 4 m. At Station I, there was no dissolved oxygen below 9 m. These data are consistent with the vertical "Hydrolab" profiles from 2001 and 2002 that we were provided in spreadsheet format; our conductivity data is similar to the Hydrolab data. The pH data (not plotted) showed higher pH's in the upper water column, consistent with increased pH from photosynthesis and lowered pH from organic matter decomposition below the euphotic zone.

Table 2. Water column YSI data from Station I on July 7, 2004.

Depth	Temperature ^{o}C	Dissolved Oxygen mg L^{-1}	pH	Conductivity mS cm^{-1}
0	22.25	9.57	8.48	0.563
1	22.10	9.25	8.49	0.564
2	22.08	9.18	8.47	0.565
3	22.02	9.10	8.46	0.566
4	21.97	8.80	8.41	0.566
5	21.94	8.71	8.40	0.567
6	21.91	8.52	8.37	0.568
7	21.22	5.27	8.10	0.576
8	19.56	1.23	7.75	0.583
9	18.92	0.26	7.69	0.583
10	18.65	0.18	7.68	0.583
11	18.45	0.15	7.69	0.586
12	18.33	0.15	7.68	0.591
12.73	18.21	0.14	7.78	0.667

The Station I data from July 8 was remarkably different from that on July 7 (Figure 2), with a much more diffuse thermocline and much thinner bottom anoxic layer. We don't know if the change is the result of changing water inputs or discharge, or perhaps a small seiche, but this is clearly a very dynamic system.

There was a generally good agreement in dissolved oxygen trends in our YSI dissolved oxygen data and that obtained using the DGA mass spectrometric analysis (Appendix II; Figure 3); differences between the two techniques may be related to sampling strong gradients with two different devices. The DGA data tended to be a little lower than that from the YSI. The appearance of excess N_2 in bottom water (relative to saturation) indicates high rates of denitrification in this system (Appendix II); this process reduces nitrate to N_2 gas and removes it from biological cycling. Moreover, high levels of nitrate and denitrification can have both positive and negative influences on the release of sediment phosphorus to overlying water (i.e. Andersen 1982; Jensen and Andersen 1992).

Table 3. Station II water column data from YSI on June 7, 2004.

Depth	Temperature °C	Dissolved Oxygen mg L^{-1}	Dissolved Oxygen µmol L^{-1}	pH	Conductivity mS cm^{-1}
0	22.44	10.79	337	7.85	0.567
1	22.34	10.60	331	8.05	0.567
2	22.20	10.46	312	8.08	0.567
3	22.12	10.30	296	8.11	0.566
4	22.10	10.26	322	8.12	0.567
5	21.84	9.46	321	8.09	0.569
6	21.35	6.65	296	7.87	0.577
7	21.23	5.67	208	7.79	0.582
8	21.11	4.28	177	7.76	0.585
8.7	20.48	0.90	134	7.69	0.583

Table 4. Station III water column data from YSI on June 7, 2004.

Depth	Temperature °C	Dissolved Oxygen mg L^{-1}	Dissolved Oxygen µmol L^{-1}	pH	Conductivity mS cm^{-1}
0	22.24	11.69	365	8.39	0.562
1	22.21	11.72	366	8.43	0.562
2	22.11	11.61	363	8.44	0.563
3	21.93	11.40	356	8.43	0.563
4	20.33	9.38	293	8.25	0.563
5	19.86	8.57	268	8.09	0.555
5.3	19.78	7.46	233	8.04	0.548

Table 5. Station IV water column Data from YSI on June 7, 2004.

Depth	Temperature °C	Dissolved Oxygen mg L^{-1}	Dissolved Oxygen µmol L^{-1}	pH	Conductivity mS cm^{-1}
0	20.65	10.86	339	7.88	0.497
1	20.66	10.72	335	7.93	0.497
1.3	20.65	10.68	334	7.97	0.497

With increasing depth, there was a large increase in SRP concentrations at Station I (Table 6). Surface waters had high SRP concentrations of 3.3 µmol L^{-1} (0.10 mg L^{-1}) and increased to even higher concentrations in the anoxic bottom layer 6.8 µmol L^{-1} (0.21 mg L^{-1}). The interpretation of this profile involves the uptake of phosphorus by algae in the upper water column and the release of phosphorus into deeper water from both sediment and water column decomposition of organic matter. Input concentrations of SRP just above the lake averaged ~ 0.19 mg L^{-1}, with output concentrations averaging ~ 0.22 mg L^{-1} (Cannon River Watershed Partnership (CRWP) 2003). The CRWP data suggest that the conversion of either dissolved organic phosphorus or particulate phosphorus to SRP occurs within the lake basin.

If we interpret the water column phosphorus increase below 3 m to be mainly a phenomena associated with sediment release (likely an overestimate of sediment importance) and that it has taken ~ 60 days to build this amount up (i.e. the warm period of the lake), we can make an estimate of SRP remineralization. The accumulation of SRP is 13.3 mmol m^{-2} (0.4 g P m^{-2}). The average rates of SRP accumulation would be 9 µmol m^{-2} h^{-1} (7 mg m^{-2} d^{-1}). These will be compared with the sediment flux data.

Table 6. Water column data from Station I on July 8, 2004.

Depth	Temperature oC	Dissolved Oxygen mg L^{-1}	Dissolved Oxygen µmol L^{-1}	pH	Conductivity mS cm-1	SRP µmol L-1
0.5	22.52	11.27	302	8.53	0.561	3.32
2.0	21.32	8.39	243	8.34	0.566	3.37
4.0	21.25	8.44	230	8.35	0.566	3.91
6.0	20.94	8.00	214	8.30	0.562	4.31
7.0	20.27	7.16	186	8.12	0.564	4.65
8.0	19.85	5.71	156	8.00	0.548	5.10
9.0	19.7	5.29	137	7.96	0.548	5.20
10.0	19.59	4.04	91	7.92	0.561	4.90
11.0	19.15	1.01	20	7.76	0.578	5.55
11.9	18.43	0.21	8	7.37	0.591	6.78

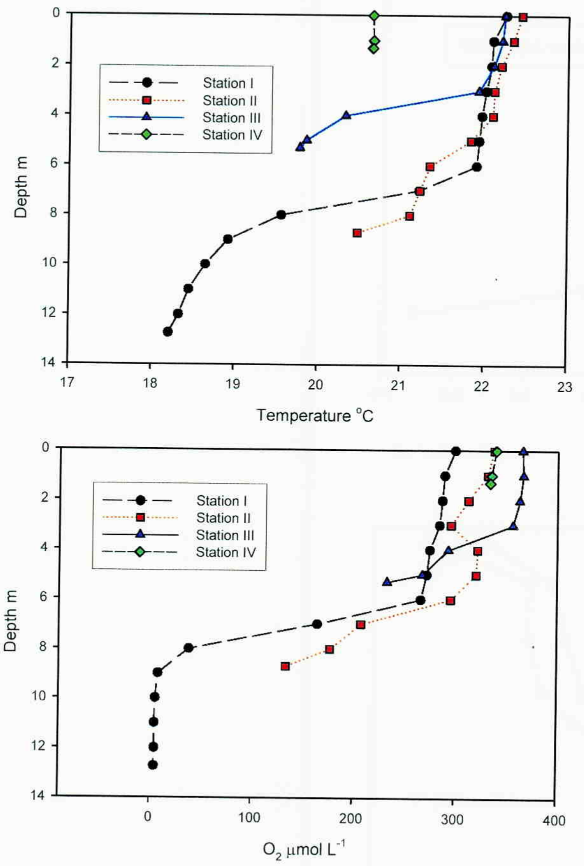

Figure 1. Vertical profiles from YSI sonde from July 7, 2004. The upper panel depicts temperature and the lower panel is dissolved oxygen.

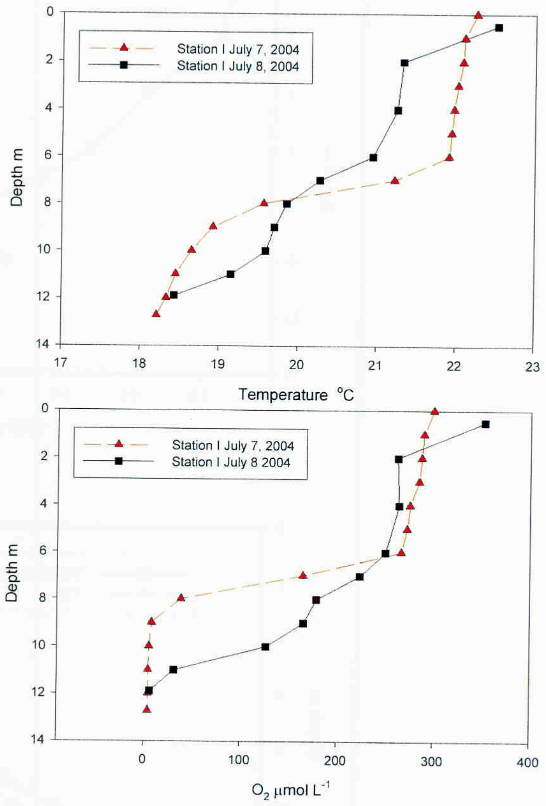

Figure 2. Vertical profiles of temperature (upper panel) and dissolved oxygen (lower panel) at Station I on July 7 and July 8, 2004.

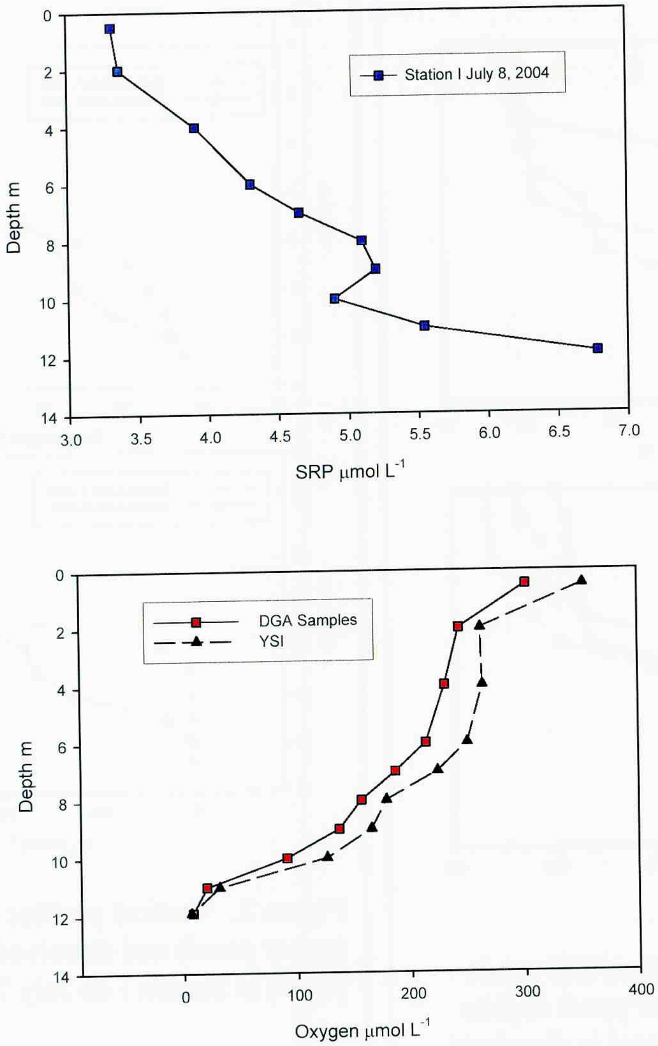

Figure 3. Vertical profiles of SRP (upper panel) and dissolved oxygen measured with the YSI (field) and DGA techniques (lower panel).

SEDIMENT-WATER EXCHANGE

For this analysis, the time courses of sediment-water exchange covered more than 30 hours, with shorter incubations for gases and longer incubations to increase the signal to noise in the phosphorus flux measurements. At Stations III and IV, the time course of O_2 and N_2-N incubation was less than 3.5 hours (Figure 4); this time course maintained the O_2 concentration at > 75% saturation and minimized the potential effects of low oxygen on nitrogen and phosphorus fluxes. Replication was very good. The flux of SRP was continued beyond this short time frame for 24 hours (Figure 5); we inserted an air headspace above the core to maintain oxygen within the core. In the anaerobic cores, we incubated for longer time periods (> 30 hours). This long incubation was used to overcome potentially high bottom water SRP concentrations (that were indeed found) and to allow a sufficient signal to noise ratio.

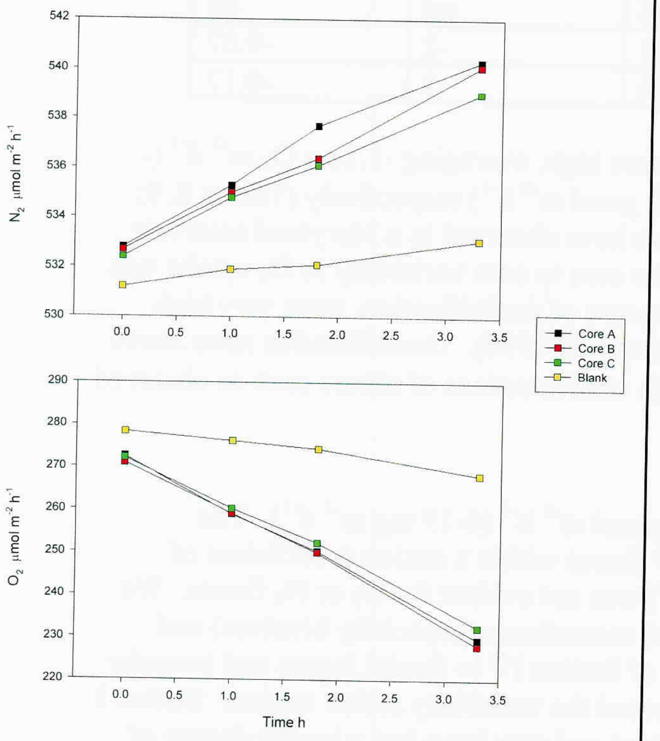

Figure 4. Time courses of dinitrogen and dissolved oxygen concentrations for Station III.

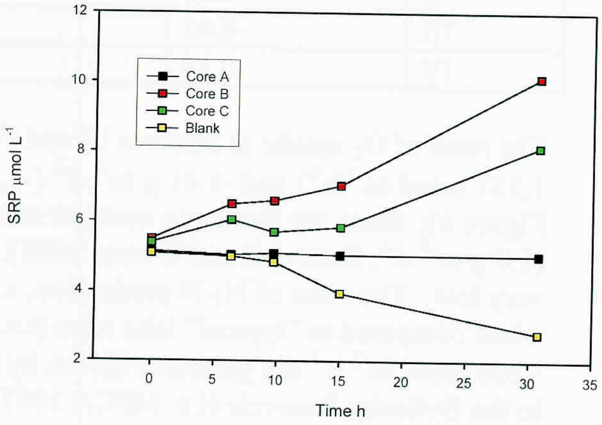

Figure 5. Time courses of SRP concentration for Station I.

The "blank" incubations of bottom water, carried out to correct for water column metabolic activity, indicated modest O_2 uptake and modest N_2-N production in the water. Core flux measurements were corrected for these changes. In the case of SRP fluxes, we observed SRP uptake in all incubations. At Station I, SRP concentrations increased in 2 of 3 sediment cores ; In core A, the occurrence of no net SRP change, when combined with water column uptake, resulted in a net SRP efflux. We generally have not observed such a large "blank" uptake rate as we did in the Byllesby Reservoir; while we filtered out the algae at Stations III and IV, our filtration would not have removed water column bacteria. The uptake of SRP by the water was similar in all stations, so redox-related issues are not a likely problem. Uptake rates ranged from 0.05 – 0.15 µmol L^{-1} d^{-1}, a substantial correction. The efflux of N_2-N was observed in our incubation gear and was not likely an indication of water column denitrification. Oxygen uptake by the water was a modest correction to the sediment oxygen demand rates.

Table 7. Blank flux rates. Positive values indicate production, negative values indicate uptake within the core.

Station	SRP Flux µmol L^{-1} h^{-1}	N_2-N Flux µmol L^{-1} h^{-1}	O_2 Flux µmol L^{-1} h^{-1}	O_2 Flux mg L^{-1} h^{-1}
I	-0.08	nd	nd	nd
II	-0.09	nd	nd	nd
III	-0.05	1.12	-2	-0.07
IV	-0.15	0.46	-5	-0.17

The rates of O_2 uptake at Stations III and IV were high, averaging -1.18 g O_2 m^{-2} d^{-1} (-1,531 µmol m^{-2} h^{-1}) and -1.41 g m^{-2} d^{-1} (-1,842 µmol m^{-2} h^{-1}) respectively (Tables 8, 9; Figure 6); these are similar to summer rates we have observed in a Maryland reservoir (1.0 g m^{-2} d^{-1}; Cornwell and Owens 2002). The core to core variability in O_2 uptake was very low. The rates of N_2-N production, a measure of denitrification, were very high when compared to "typical" lake rates (i.e. Seitzinger 1990). Denitrification rates above ~200 µmol m^{-2} h^{-1} are generally driven by high concentrations of nitrate such as observed in the Byllesby Resevoir (i.e. MPCA 1997).

The SRP flux rates (Figure 7) averaged 8-26 µmol m^{-2} h^{-1} (6-19 mg m^{-2} d^{-1}). The relatively high core to core variability of SRP fluxes within a station (coefficient of variation ranged from 15% at II to 45% at IV) was not evident for O_2 or N_2 fluxes. We have observed such variability in stations with macrofauna (especially bivalves) and irregular bottom topography. The proximity of Station IV to fluvial inputs and irregular distribution of organic matter may have increased the variability at that station; Station I was located at the edge of a sharp depth gradient and may have had a higher degree of variability.

Table 8. Sediment-water exchange rates. All rates are µmol m^{-2} h^{-1}. nd indicates measurement not determined. Positive values indicate fluxes out of sediment; negative values indicate fluxes into sediment.

Station	Core	SRP Flux	O_2 Flux	N_2-N Flux
I	A	15.6	nd	nd
	B	36.8	nd	nd
	C	25.5	nd	nd
	Average	26.0	nd	nd
	Standard Deviation	8.7	nd	nd
II	A	6.4	nd	nd
	B	8.6	nd	nd
	C	7.9	nd	nd
	Average	7.6	nd	nd
	Standard Deviation	.92	nd	nd
III	A	13.0	-1600	519
	B	15.3	-1590	485
	C	7.8	-1403	510
	Average	12.0	-1531	471
	Standard Deviation	3.1	111	18
IV	A	27.5	-1770	351
	B	13.1	-1875	435
	C	13.9	-1881	423
	Average	18.2	-1842	403
	Standard Deviation	6.6	74	45

Table 9. Mean values from Table 8 shown as mass units.

Station	SRP Flux mg m^{-2} d^{-1}	O_2 Flux g m^{-2} d^{-1}	N_2-N Flux mg m^{-2} d^{-1}
I	19.3	ND	ND
II	5.6	ND	ND
III	8.9	-1.18	158
IV	13.6	-1.41	135

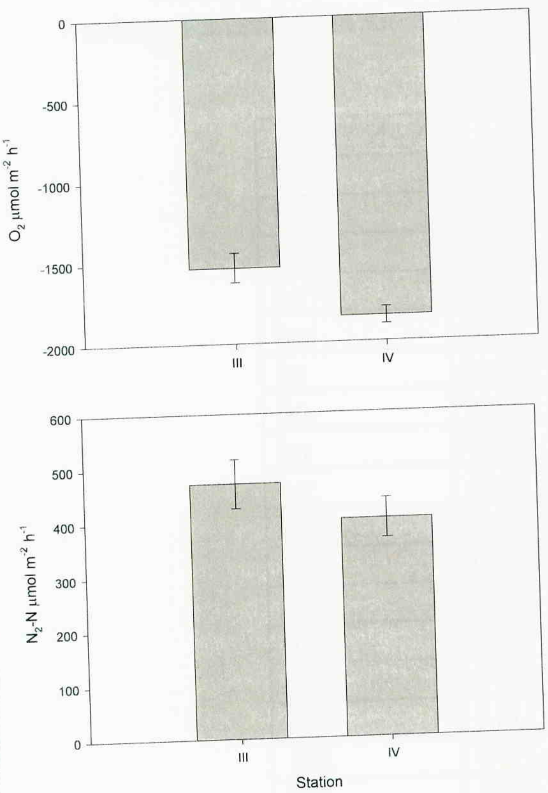

Figure 6. Mean (± standard deviation) for the fluxes of dissolved oxygen and dinitrogen for stations III and IV.

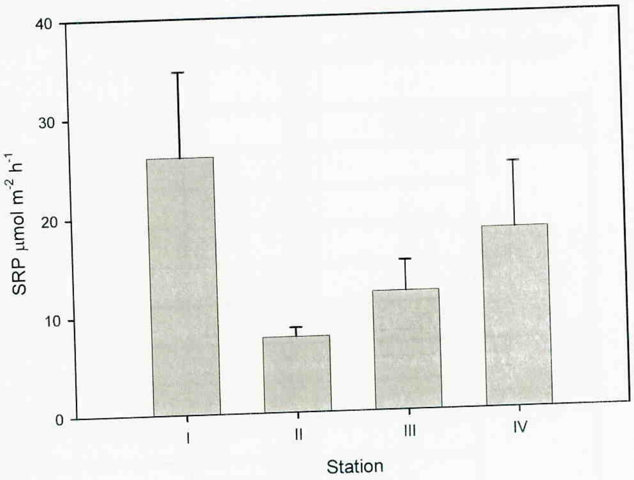

Figure 7. Mean (± standard deviation) for the fluxes of SRP at all Stations. The error bars are from triplicate cores at each Station.

DISCUSSION

The rates of phosphorus efflux from sediments in the Byllesby Reservoir were fairly high for a freshwater ecosystem. Rates of anoxic efflux from a Maryland Reservoir (Cornwell and Owens 2002) were somewhat lower (~ 7-11 µmol m^{-2} h^{-1}) than the Byllesby Reservoir by a factor of 2 or so. The rough estimate of phosphorus recycling based on a single water column profile of SRP provided a flux estimate of ~ 9 µmol m^{-2} h^{-1} at the deep Station I, a rate somewhat less than the observed sediment flux. That calculation assumes a relatively long water residence time of 2-3 weeks; such water turnover would result in an underestimate. However, we are pleased that the simple water column calculation is of the same order as the sediment observation.

Estimating the total sediment SRP efflux on an annual basis for the lake requires knowledge of the area of the lake and an idea of how long the rates are valid for. We have one time point for each of the four stations, and we assume that water temperatures are high enough for about half of the year to support these efflux rates. If we segment the lake into the 3 segments that Justin Watkins (Cannon River Watershed Partnership) provided us, take the average of the anoxic Stations for the "dam" segment and use the single cores for each of the other two segments, we can estimate the efflux of SRP on a whole systems basis (Table 10). Our best estimate is 58 kg d^{-1}, or about 10,000 kg over 180 days.

Table 10. Estimating Total Flux. The segment areas were provided by Justin Watkins (CRWP) and form the basis of an ongoing modeling effort. The mean phosphorus flux for the middle and inflow segments was from single Stations (III and IV respectively); the dam section data was the mean of Stations I and II.

Segment	Area m^2	Mean P Flux mg m^{-2} d^{-1}	P Flux kg/segment d^{-1}	P Flux kg/segment/180d
Dam	640,000	0.01245	7.968	1434
Middle	3,480,000	0.0089	30.972	5575
Inflow	1,400,000	0.0136	19.040	3427
Sum			57.98	10,436

This number is especially useful when compared to the terms in other budget estimates. Using estimates of total phosphorus (TP) into the Byllesby Reservoir, we can estimate how important sediment SRP effluxes are (Table 11). On average, sediment recycling is approximately 7% of the total TP input. If we examine our SRP efflux relative to SRP input (in 2002 only), we may get a better idea of how these fluxes affect the biogeochemistry of the lake. Measurements of TP include both dissolved organic and particulate P; the reactivity of the incoming particulate phosphorus has not been determined, but it is likely to be much less available than SRP. In 2002, sediment could account for ~ 1/3 of the SRP input.

Table 11. Putting the flux data on a mass balance perspective. The TP and SRP inflow and outflow data are from MPCA (1997) and CRWP (2003).

Parameter	Year 1996	Year 2001	Year 2002	Average
	Units are kg per year*			
TP in	118,607	208,000	138,000	173,000
TP out	66,135	157,000	118,000	137,500
SRP in		nd	61,000	
SRP out		nd	74,000	
TP retention	52,471	51,000	20,000	35,500
SRP retention		nd	-13,000	
SRP sediment flux	10,000	10,000	10,000	10,000
Percent of TP input recycled in sediments	8	5	7	7
Percent of SRP input recycled in sediments			16	
Percent sediment recycling efficiency	16	16	33	22

*the "year" was actually the time period of March to November.

We can also estimate how much of the sedimented phosphorus is recycled. If we look at the sum of SRP efflux and "permanent" TP retention, we get an idea of how much phosphorus reaches the bottom of the lake. On average, about 22% of the phosphorus reaching the sediments is recycled; we have observed proportionally higher effluxes in oligotrophic lakes (i.e. Lake Champlain; Cornwell and Owens 1999). In Green Bay, Michigan, Klump et al. observed < 20% recycling of phosphorus from sediments. In an arctic lake, Cornwell (1987) found that high phosphorus binding to Fe oxides limited phosphorus fluxes from sediment.

The importance of sediment recycling may be greater on a seasonal basis than on an annual basis. The greatest concerns for water quality occur in the summer, when oxygen depletion and algal concentrations are greatest. A sediment efflux of 15 μmol m^{-2} h^{-1} would support the production of ~0.5 g C m^{-2} d^{-1}; combined with water column SRP recycling, internal sources of SRP may be important. However, the lack of SRP depletion within the water column, even in surface waters, indicates that SRP remains abundant even in summer months. While sediment SRP effluxes are important to the budget, their importance may be most important during low flow periods within the Byllesby Reservoir.

SUMMARY

1. In July 2004 we measured the sediment-water exchange of soluble reactive phosphorus in triplicate cores from 4 stations in the Byllesby Reservoir. Sediment fluxes of oxygen and di-nitrogen (denitrification) were determined at two shallow water stations. Vertical profiles of oxygen, di-nitrogen, conductivity, soluble reactive phosphorus and pH were carried out.
2. We observed moderate rates of oxygen uptake, high rates of denitrification and relatively high rates of phosphorus efflux (range: 6-19 mg m^{-2} d^{-1}). The impact of anoxia was not especially large.
3. The rate of internal phosphorus cycling from sediment is an important term in the overall Byllesby Reservoir budget; on average, our data suggest that it is about 7% of the TP input values or about 16% of the soluble reactive phosphorus input. The importance of sediment recycling will be maximal under low flow summer conditions.

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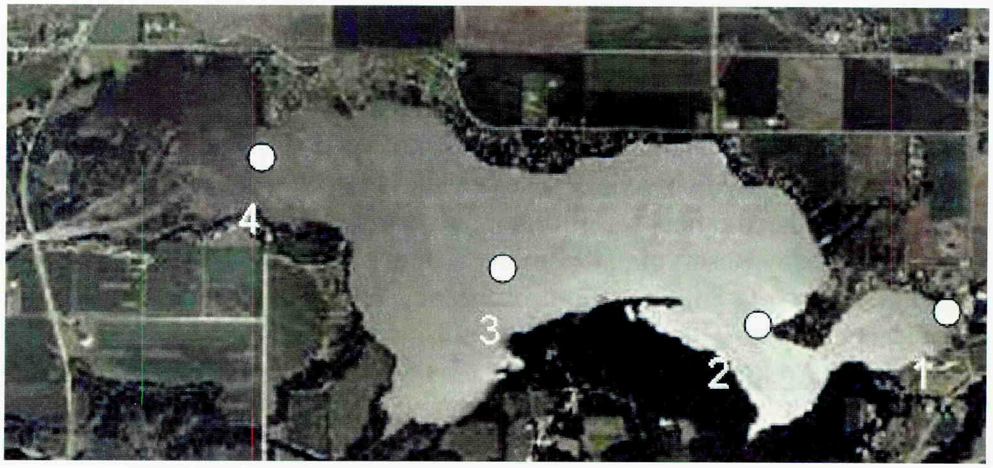
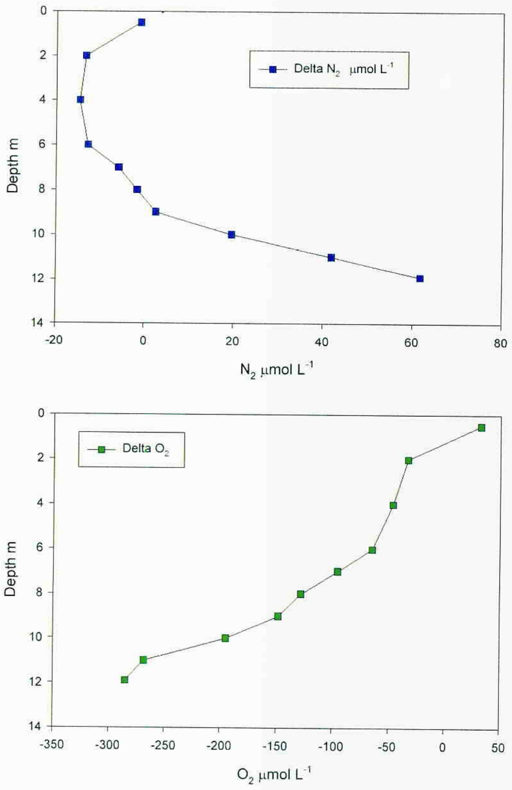
Appendix I. Map of the Byllesby Reservoir with sample stations. Map obtained from CRWP web site.



APPENDIX II. WATER COLUMN N_2 DATA

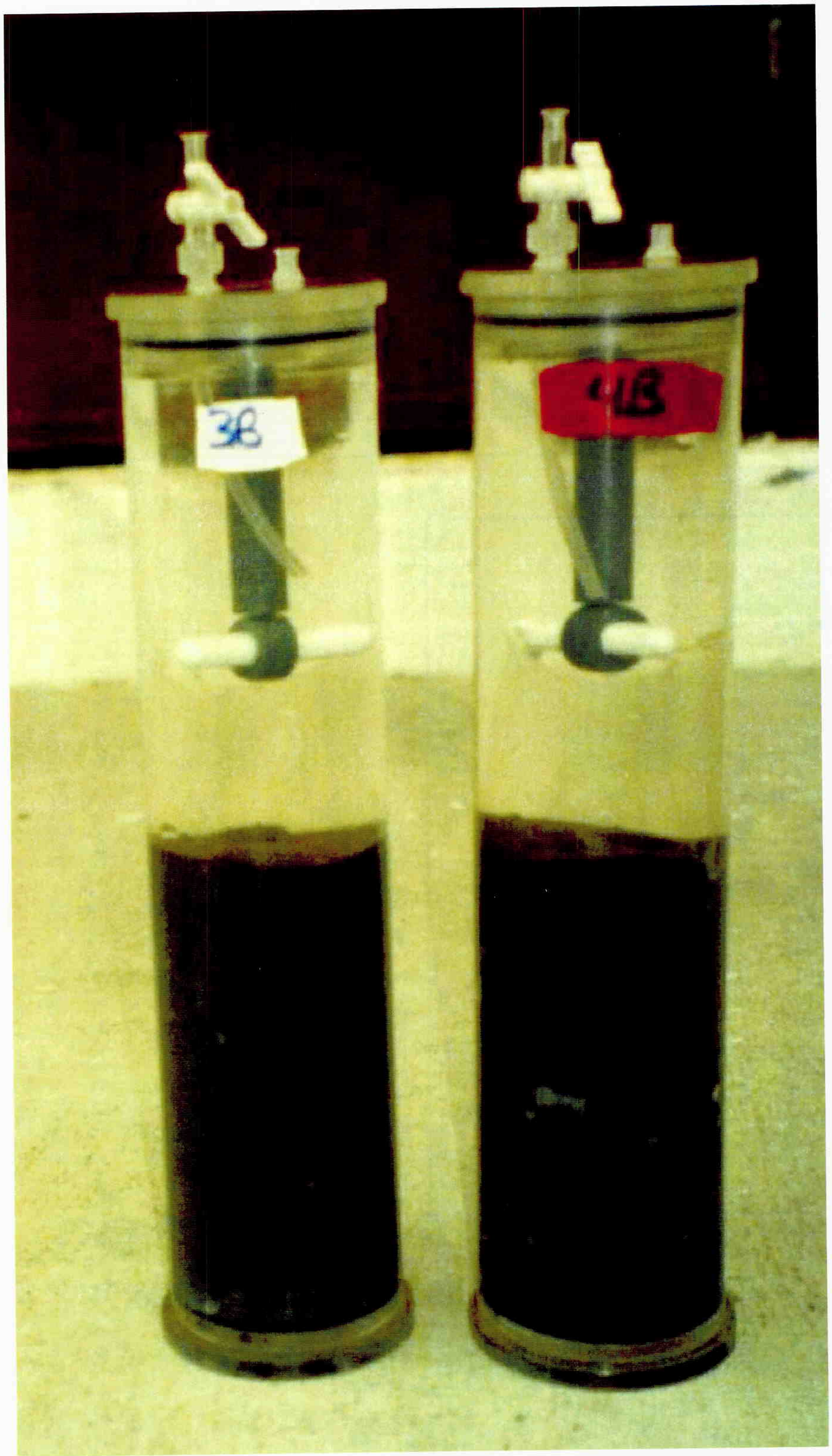
Discrete pump samples collected July 8, 2004 at station I.

Depth	DGA N_2 µmol L^{-1}	Delta N_2 µmol L^{-1}	DGA O_2 µmol L^{-1}	Delta O_2 µmol L^{-1}
0.5	506.9	-1.0	302.0	32.0
2.0	505.4	-13.3	243.3	-33.0
4.0	504.7	-14.7	230.3	-46.4
6.0	509.5	-12.8	213.7	-64.7
7.0	522.7	-5.8	186.5	-95.7
8.0	530.9	-1.7	156.3	-128.2
9.0	536.6	2.6	137.1	-148.3
10.0	554.7	19.6	90.8	-195.2
11.0	581.4	41.9	20.3	-268.2
11.9	608.5	61.8	8.0	-284.9

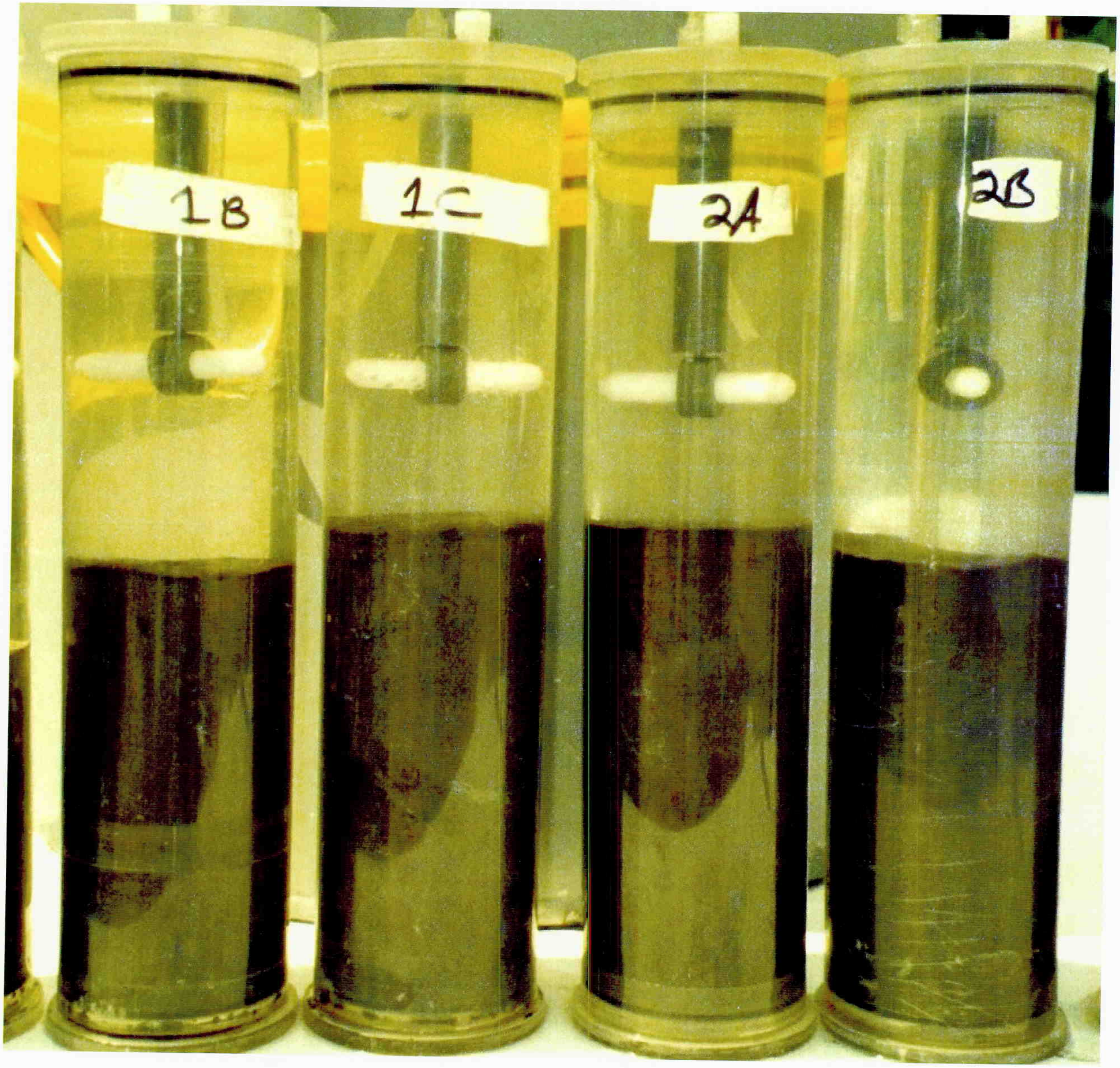


Vertical profiles of the deviation between saturated N_2 (top panel) and O_2 (bottom panel) and the predicted solubility of each gas.

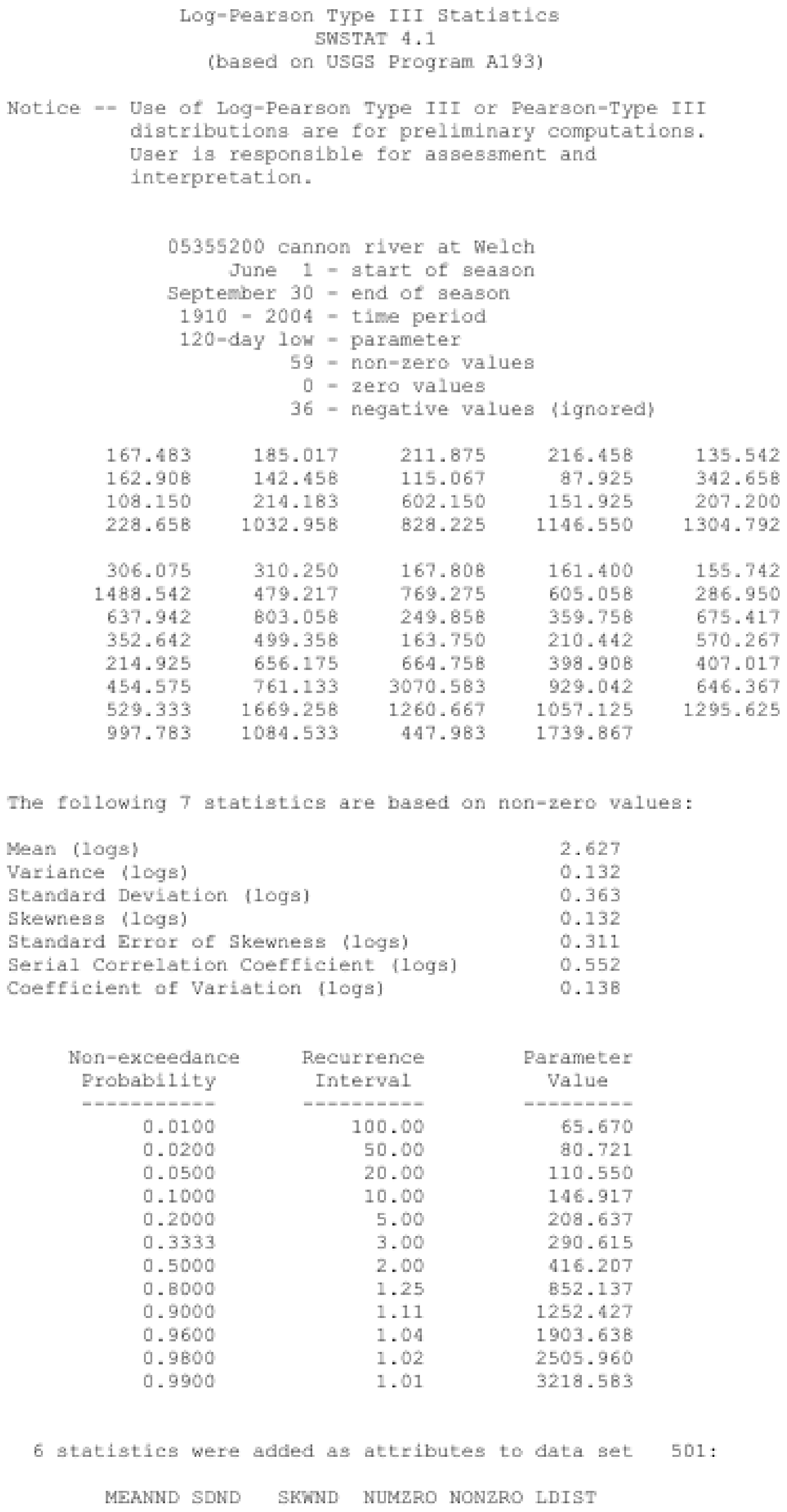
Appendix IIIa. Photos of flux core apparatus with the left core showing sediment from Station III and the right core showing sediment from Station IV.



Appendix IIIb. Photos of flux core apparatus with the left two cores showing sediment from Station I and the right two cores showing sediment from Station II.



Appendix F



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               Log-Pearson Type III Statistics
                          SWSTAT 4.1
                 (based on USGS Program A193)

Notice -- Use of Log-Pearson Type III or Pearson-Type III
          distributions are for preliminary computations.
          User is responsible for assessment and
          interpretation.


              05355200 cannon river at Welch
                   June  1 - start of season
              September 30 - end of season
               1910 - 2004 - time period
               120-day low - parameter
                        59 - non-zero values
                         0 - zero values
                        36 - negative values (ignored)

        167.483     185.017     211.875     216.458     135.542
        162.908     142.458     115.067      87.925     342.658
        108.150     214.183     602.150     151.925     207.200
        228.658    1032.958     828.225    1146.550    1304.792

        306.075     310.250     167.808     161.400     155.742
       1488.542     479.217     769.275     605.058     286.950
        637.942     803.058     249.858     359.758     675.417
        352.642     499.358     163.750     210.442     570.267
        214.925     656.175     664.758     398.908     407.017
        454.575     761.133    3070.583     929.042     646.367
        529.333    1669.258    1260.667    1057.125    1295.625
        997.783    1084.533     447.983    1739.867


The following 7 statistics are based on non-zero values:

Mean (logs)                                      2.627
Variance (logs)                                  0.132
Standard Deviation (logs)                        0.363
Skewness (logs)                                  0.132
Standard Error of Skewness (logs)                0.311
Serial Correlation Coefficient (logs)            0.552
Coefficient of Variation (logs)                  0.138


     Non-exceedance     Recurrence        Parameter
      Probability        Interval           Value
      -----------       ----------        ---------
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           0.0200           50.00            80.721
           0.0500           20.00           110.550
           0.1000           10.00           146.917
           0.2000            5.00           208.637
           0.3333            3.00           290.615
           0.5000            2.00           416.207
           0.8000            1.25           852.137
           0.9000            1.11          1252.427
           0.9600            1.04          1903.638
           0.9800            1.02          2505.960
           0.9900            1.01          3218.583


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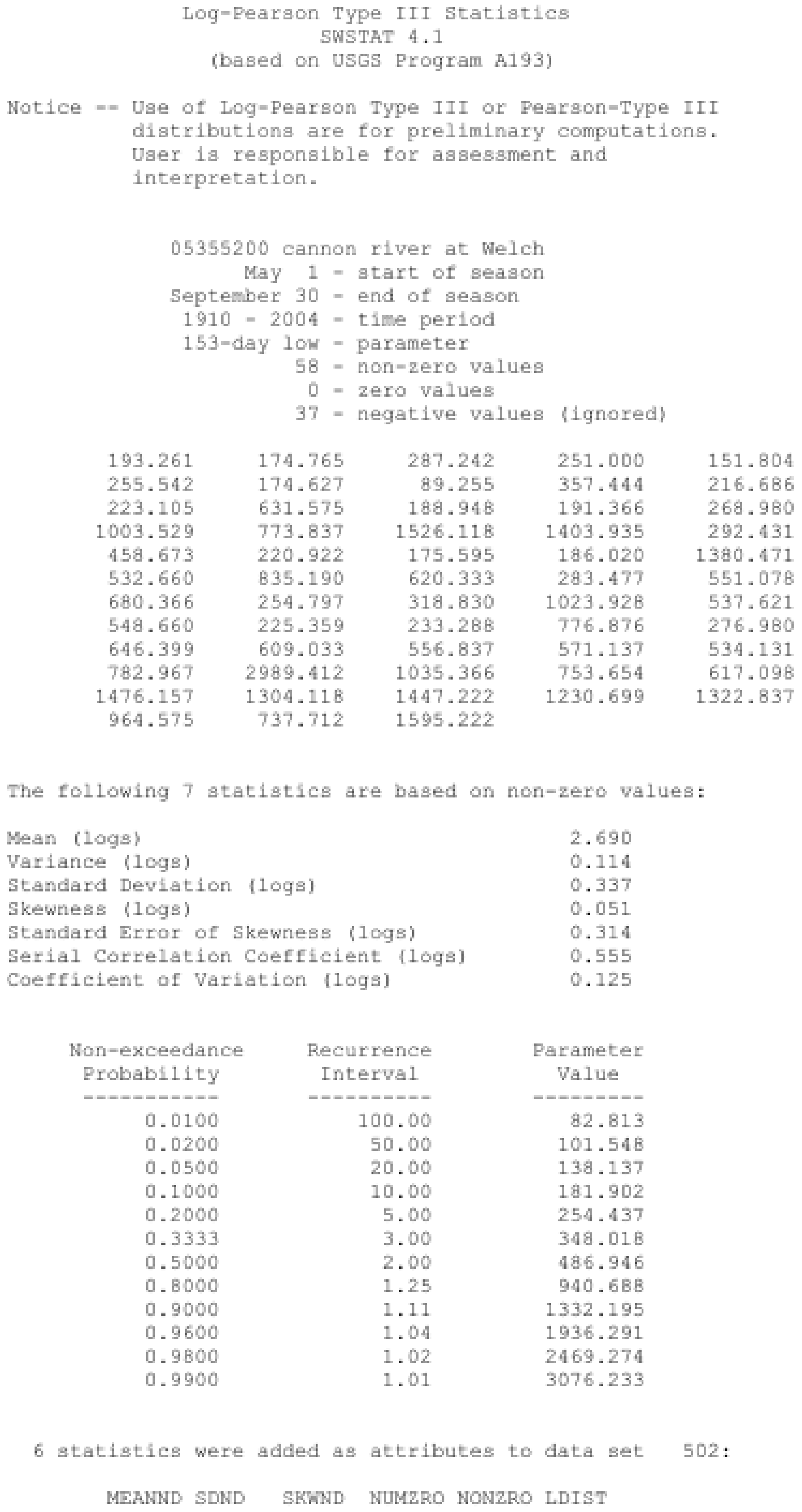

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Notice -- Use of Log-Pearson Type III or Pearson-Type III
          distributions are for preliminary computations.
          User is responsible for assessment and
          interpretation.


             05355200 cannon river at Welch
                   May  1 - start of season
             September 30 - end of season
              1910 - 2004 - time period
              153-day low - parameter
                       58 - non-zero values
                        0 - zero values
                       37 - negative values (ignored)

        193.261     174.765     287.242     251.000     151.804
        255.542     174.627      89.255     357.444     216.686
        223.105     631.575     188.948     191.366     268.980
       1003.529     773.837    1526.118    1403.935     292.431
        458.673     220.922     175.595     186.020    1380.471
        532.660     835.190     620.333     283.477     551.078
        680.366     254.797     318.830    1023.928     537.621
        548.660     225.359     233.288     776.876     276.980
        646.399     609.033     556.837     571.137     534.131
        782.967    2989.412    1035.366     753.654     617.098
       1476.157    1304.118    1447.222    1230.699    1322.837
        964.575     737.712    1595.222


The following 7 statistics are based on non-zero values:

Mean (logs)                                  2.690
Variance (logs)                              0.114
Standard Deviation (logs)                    0.337
Skewness (logs)                              0.051
Standard Error of Skewness (logs)            0.314
Serial Correlation Coefficient (logs)        0.555
Coefficient of Variation (logs)              0.125


     Non-exceedance     Recurrence        Parameter
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           0.2000             5.00          254.437
           0.3333             3.00          348.018
           0.5000             2.00          486.946
           0.8000             1.25          940.688
           0.9000             1.11         1332.195
           0.9600             1.04         1936.291
           0.9800             1.02         2469.274
           0.9900             1.01         3076.233


  6 statistics were added as attributes to data set   502:

        MEANND SDND   SKWND  NUMZRO NONZRO LDIST
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Appendix G

Assumed seasonal and annual TP WLAs for all permitted point sources that would result in goal attainment for the Byllesby Reservoir (Cannon River inflow TP concentration of ≤0.15 mg-P/L at the 80th percentile flow during June through September) as simulated by the CRWHSPF model.

Name	Permit Number		Discharge Type	Basis for WLA*	Units	AWW Design or Maximum Flow (mgd)	Daily Pond Effluent Volume @ 6"/day (mgd)	Oct - May WLA (Kg/day)	June - Sept WLA (Kg/day)	WLA (Kg/y)
Hope Creamery	MN0001317	Industrial	Non Contact Cooling Water	0.09	mg/L	0.016		0.005	0.005	2
Center Point Energy - Waterville	MN0063967	Industrial	Process wastewater	0.09	mg/L	0.02		0.007	0.007	2
MNDOT Heath Creek Rest Area***	MN0069639	Domestic	Stabilization Pond WWTP	1.00	mg/L	0.006	0.0456	0.17	0.17	8
Faribault Dairy Co Inc - Faribault	MNG255092	Industrial	Non Contact Cooling Water	0.09	mg/L	0.1		0.034	0.034	12
Genova Minnesota Inc	MN0046957	Industrial	Contact & Non Contact Cooling Water	0.09	mg/L	0.19		0.06	0.06	24
Mathiowetz Construction	MNG490137	Industrial	Pit Dewatering - periodic/seasonal	0.09	mg/L	0.2327		0.08	0.08	29
Kilkenny WWTP***	MNG580084	Domestic	Stabilization Pond WWTP	1.00	mg/L	0.0228	0.32	1.21	1.21	31
MNDOT Straight River Rest Area***	MN0049514	Domestic	Stabilization Pond WWTP	2.00	mg/L	0.012	0.095	0.72	0.72	33
Meriden Township WWTP***	MN0068713	Domestic	Stabilization Pond WWTP	2.00	mg/L	0.0161	0.21	1.59	1.59	44
Dennison WWTP***	MN0022195	Domestic	Stabilization Pond WWTP	2.00	mg/L	0.025042	0.26	1.97	1.97	69
Hope - Somerset Township WWTP	MN0068802	Domestic	Constructed Wetland WWTP	5.00	mg/L	0.0102		0.19	0.19	70
Sanders North - SD012 (Millersburg S&G)	MNG490273	Industrial	Pit Dewatering - periodic/seasonal	0.09	mg/L	0.9		0.31	0.31	75
Sanders North - SD002 (Medford North S&G)	MNG490273	Industrial	Pit Dewatering - periodic/seasonal	0.09	mg/L	1.2		0.41	0.41	89
Elysian WWTP***	MN0041114	Domestic	Stabilization Pond WWTP	135	kg/y	0.13	1.37	5.19	5.19	135
Morristown WWTP	MN0025895	Domestic	Mechanical WWTP	145	kg/y	0.21		0.79	0.79	145
Viracon	MNG255078	Industrial	Non Contact Cooling Water	0.50	mg/L	0.275		0.52	0.52	190
Geneva WWTP***	MN0021008	Domestic	Stabilization Pond WWTP	2.00	mg/L	0.069	0.63	4.77	4.77	191
Medford WWTP	MN0024112	Domestic	Mechanical WWTP	0.72	kg/day	0.14		0.72	0.72	263
OMG Midwest Inc/Southern MN Construction (Owatonna Quarry, Steele County)	MNG490131	Industrial	Pit Dewatering - periodic/seasonal	0.09	mg/L	2.16		0.74	0.74	269
Ellendale WWTP***	MNG580014	Domestic	Stabilization Pond WWTP	2.00	mg/L	0.1003	1.27	9.61	9.61	277
Lonsdale WWTP	MN0031241	Domestic	Mechanical WWTP	285	kg/y	0.687		2.60	2.60	285
Waterville WWTP	MN0025208	Domestic	Mechanical WWTP	387	kg/y	0.4		1.51	1.51	387
Wondra Pit	MNG490130	Industrial	Pit Dewatering - periodic/seasonal	0.09	mg/L	3.168		1.08	1.08	394
Mathy Construction - Aggregate Milestone Materials: Spinler Quarry****	MNG490081	Industrial	Pit Dewatering - periodic/seasonal	0.09	mg/L	9.216		3.14	3.14	562
OMG Midwest Inc/Southern MN Construction (Dundas Wash Plant S&G, Rice)	MNG490131	Industrial	Pit Dewatering - periodic/seasonal	0.09	mg/L	4.68		1.59	1.59	582
OMG Midwest Inc/Southern MN Construction (Thomas S&G, Rice)	MNG490131	Industrial	Pit Dewatering - periodic/seasonal	0.09	mg/L	4.68		1.59	1.59	582
Faribault Foods - Faribault Division	MN0050491	Industrial	Contact Cooling Water	1.00	mg/L	0.5		1.89	1.89	691
Lakeside Foods Inc - Owatonna Plant	MN0001571	Industrial	Contact Cooling Water	1.00	mg/L	0.561		2.12	2.12	775
Owatonna WWTP**	MN0051284	Domestic	Mechanical WWTP	1.00	mg/L	5		18.93	11.36	5,984
Northfield WWTP**	MN0024368	Domestic	Mechanical WWTP	1.00	mg/L	5.2		19.68	11.81	6,223
Faribault WWTP**	MN0030121	Domestic	Mechanical WWTP	1.00	mg/L	7		26.50	15.90	8,378
							SUM =	**110**	**84**	**26,802**

*Concentrations at Byllesby TP goal of 0.090 should be verified at time of permit reissuance.

**Basis for Owatonna, Northfield and Faribault WLAs is TP = 0.60 mg/l * design flow (June – September) + TP = 1.00 mg/L * design flow (October – May).

***Stabilization ponds are authorized to discharge March 1 - June 15 and September 15 - December 31; outside of those windows their daily wasteload allocations are 0 kg/day.

****Spinler Quarry annual mass based on annual water appropriation limit (1.65 billion gallons/yr) and 0.090 mg/l; daily mass based on daily max design flow 9.216 MGD and 0.090 mg/l.

Appendix H

List of all permitted facilities that make up each impaired AUIDs WLA.

Table 117. Permitted facilities discharging to Union Lake 66-0032-00

Facility Name	Permit No.	Phosphorus Load (kg/yr)
Lonsdale WWTP	MN0031241	285
Sanders North - SD012 (Millersburg S&G)	MNG490273	75.93
TOTAL		**359.93**

Table 118. Permitted facilities discharging to Upper Sakatah Lake 40-0002-00

Facility Name	Permit No.	Phosphorus Load (kg/yr)
CenterPoint Energy - WWTS	MN0041114	2.49
Waterville WWTP	MN0025208	387
TOTAL		**389.49**

Table 119. Permitted facilities discharging to Sabre Lake 40-0014-00

Facility Name	Permit No.	Design Flow (MGD)	Phosphorus Limit (mg/L)	Phosphorus Load (kg/yr)
Kilkenny WWTP	MNG580084	0.0228	1	31
TOTAL			-	**31**

Table 120. Permitted facilities discharging to Tetonka Lake 40-0031-00

Facility Name	Permit No.	Design Flow (MGD)	Phosphorus Limit (mg/L)	Phosphorus Load (kg/yr)
Elysian WWTP	MN0041114	0.13	1	134.79
Kilkenny WWTP	MNG580084	0.0228	1	31
TOTAL			-	**165.79**

Table 121. Permitted facilities discharging to Gorman Lake 40-0032-00

Facility Name	Permit No.	Design Flow (MGD)	Phosphorus Limit (mg/L)	Phosphorus Load (kg/yr)
Kilkenny WWTP	MNG580084	0.0228	1	31
TOTAL			-	**31**

Table 122. Permitted facilities discharging to Tustin Lake 40-0061-00

Facility Name	Permit No.	Design Flow (MGD)	Phosphorus Limit (mg/L)	Phosphorus Load (kg/yr)
Elysian WWTP	MN0041114	0.13	1	134.79
TOTAL			-	**134.79**

Table 123. Permitted facilities discharging to Cannon Lake 66-0008-00

Facility Name	Permit No.	Design Flow (MGD)	Phosphorus Limit (mg/L)	Phosphorus Load (kg/yr)
CenterPoint Energy - WWTS	MN0063967	0.02	0.09	2.49
Elysian WWTP	MN0041114	0.13	1	134.79
Kilkenny WWTP	MNG580084	0.0228	1	31
Morristown WWTP	MN0025895	0.21	1	145
Waterville WWTP	MN0025208			387
TOTAL			-	**700.28**

Table 124. Permitted facilities discharging to Wells Lake 66-0010-00

Facility Name	Permit No.	Design Flow (MGD)	Phosphorus Limit (mg/L)	Phosphorus Load (kg/yr)
CenterPoint Energy - WWTS	MN0063967	0.02	0.09	2.49
Elysian WWTP	MN0041114	0.13	1	134.79
Kilkenny WWTP	MNG580084	0.0228	1	31
Morristown WWTP	MN0025895	0.21	1	145
Waterville WWTP	MN0025208			387
TOTAL			-	**700.28**

Table 125. Permitted facilities discharging to Lower Sakatah Lake 66-0044-00

Facility Name	Permit No.	Design Flow (MGD)	Phosphorus Limit (mg/L)	Phosphorus Load (kg/yr)
CenterPoint Energy - WWTS	MN0063967	0.02	0.09	2.49
Elysian WWTP	MN0041114	0.13	1	134.79
Kilkenny WWTP	MNG580084	0.0228	1	31
Waterville WWTP	MN0025208			387
TOTAL			-	**555.28**

Table 126. Permitted facilities discharging to Little Cannon River 07040002-526

Facility Name	Permit No.	Design Flow (MGD)	TSS Limit (mg/L)	TSS Load (tons/day)	*E. coli* Limit (#/100 mL)	*E. coli* Load (Billion#/day)
Nerstrand WWTP	MN0065668	0.042	30	0.005	126	0.200
TOTAL			**-**	**0.005**	-	**0.200**

Table 127. Permitted facilities discharging to Little Cannon River 07040002-589

Facility Name	Permit No.	Design Flow (MGD)	TSS Limit (mg/L)	TSS Load (tons/day)	Nitrate Limit (mg/L)	Nitrate Load (kg/day)	*E. coli* Limit (#/100 mL)	*E. coli* Load (Billion#/day)
Nerstrand WWTP	MN0065668	0.042	30	0.005	10.000	4	126	0.200
TOTAL				**0.005**	**-**	**4**	-	**0.200**

Table 128. Permitted facilities discharging to Cannon River 07040002-501

Facility Name	Permit No.	Design Flow (MGD)	*E. coli* Limit (#/100 mL)	*E. coli* Load (Billion#/day)
Cannon Falls WWTP	MN0022993	0.92	126	4.388
CenterPoint Energy - WWTS	MN0063967	0.02	NA	NA
Dennison WWTP	MN0022195	0.26	126	1.240
Ellendale WWTP	MNG580014	1.27	126	6.057
Elysian WWTP	MN0041114	1.36	126	6.487
Faribault Dairy Co Inc - Faribault	MNG255092	0.1	NA	NA
Faribault Foods - Faribault Division	MN0050491	0.5	NA	NA
Faribault WWTP	MN0030121	7	126	33.387
Geneva WWTP	MN0021008	0.65	126	3.100
Genova-Minnesota Inc	MN0046957	0.19	NA	NA
Hope - Somerset Township WWTP	MN0068802	0.0102	126	0.049
Hope Creamery	MN0001317	0.016	NA	NA
Kilkenny WWTP	MNG580084	0.317	126	1.512
Lakeside Foods Inc - Owatonna Plant	MN0001571	0.561	NA	NA
Lonsdale WWTP	MN0031241	0.687	126	3.277
Mathy Construction – Aggregate Milestone Materials: Spinler Quarry	MNG490081	9.216	NA	NA
Medford WWTP	MN0024112	0.14	126	0.668
Meriden Township WWTP	MN0068713	0.205	126	0.978
MNDOT - Heath Creek Rest Area	MN0069639	0.045	126	0.215
MNDOT Straight River Rest Area	MN0049514	0.091	126	0.434
Morristown WWTP	MN0025895	0.21	126	1.002
Nerstrand WWTP	MN0065668	0.042	126	0.200
Northfield WWTP	MN0024368	5.2	126	24.802
OMG Midwest Inc/Southern MN Construction (Dundas Wash Plant S&G, Rice)	MNG490131	4.68	NA	NA
OMG Midwest Inc/Southern MN Construction (Owatonna Quarry, Steele County)	MNG490131	2.16	NA	NA
OMG Midwest Inc/Southern MN Construction (Thomas S&G, Rice)	MNG490131	4.68	NA	NA
Owatonna WWTP	MN0051284	5	126	23.848
Viracon	MNG255078	0.275	NA	NA
Waterville WWTP	MN0025208	0.595	126	2.838
Wondra Pit	MNG490130	3.168	NA	NA
TOTAL			-	**114.481**

Table 129. Permitted facilities discharging to Cannon River 07040002-507

Facility Name	Permit No.	Design Flow (MGD)	*E. coli* Limit (#/100 mL)	*E. coli* Load (Billion#/day)
CenterPoint Energy - WWTS	MN0063967	0.02	NA	NA
Ellendale WWTP	MNG580014	1.27	126	6.057
Elysian WWTP	MN0041114	1.36	126	6.487
Faribault Dairy Co Inc - Faribault	MNG255092	0.1	NA	NA
Faribault Foods - Faribault Division	MN0050491	0.5	NA	NA
Faribault WWTP	MN0030121	7	126	33.387

Facility Name	Permit No.	Design Flow (MGD)	*E. coli* Limit (#/100 mL)	*E. coli* Load (Billion#/day)
Geneva WWTP	MN0021008	0.65	126	3.100
Genova-Minnesota Inc	MN0046957	0.19	NA	NA
Hope - Somerset Township WWTP	MN0068802	0.0102	126	0.049
Hope Creamery	MN0001317	0.016	NA	NA
Kilkenny WWTP	MNG580084	0.317	126	1.512
Lakeside Foods Inc - Owatonna Plant	MN0001571	0.561	NA	NA
Mathy Construction – Aggregate Milestone Materials: Spinler Quarry	MNG490081	9.216	NA	NA
Medford WWTP	MN0024112	0.14	126	0.668
Meriden Township WWTP	MN0068713	0.205	126	0.978
MNDOT Straight River Rest Area	MN0049514	0.091	126	0.434
Morristown WWTP	MN0025895	0.21	126	1.002
OMG Midwest Inc/Southern MN Construction (Dundas Wash Plant S&G, Rice)	MNG490131	4.68	NA	NA
OMG Midwest Inc/Southern MN Construction (Thomas S&G, Rice)	MNG490132	2.16	NA	NA
OMG Midwest Inc/Southern MN Construction (Owatonna Quarry, Steele County)	MNG490133	4.68	NA	NA
Owatonna WWTP	MN0051284	5	126	23.848
Viracon	MNG255078	0.275	NA	NA
Waterville WWTP	MN0025208	0.595	126	2.838
Wondra Pit	MNG490130	3.168	NA	NA
TOTAL			-	**80.359**

Table 130. Permitted facilities discharging to Cannon River 07040002-508

Facility Name	Permit No.	Design Flow (MGD)	*E. coli* Limit (#/100 mL)	*E. coli* Load (Billion#/day)
CenterPoint Energy - WWTS	MN0063967	0.02	NA	NA
Ellendale WWTP	MNG580014	1.27	126	6.057
Elysian WWTP	MN0041114	1.36	126	6.487
Faribault Dairy Co Inc - Faribault	MNG255092	0.1	NA	NA
Faribault Foods - Faribault Division	MN0050491	0.5	NA	NA
Faribault WWTP	MN0030121	7	126	33.387
Geneva WWTP	MN0021008	0.65	126	3.100
Genova-Minnesota Inc	MN0046957	0.19	NA	NA
Hope - Somerset Township WWTP	MN0068802	0.0102	126	0.049
Hope Creamery	MN0001317	0.016	NA	NA
Kilkenny WWTP	MNG580084	0.317	126	1.512
Lakeside Foods Inc - Owatonna Plant	MN0001571	0.561	NA	NA
Lonsdale WWTP	MN0031241	0.687	126	3.277
Mathy Construction – Aggregate Milestone Materials: Spinler Quarry	MNG490081	9.216	NA	NA
Medford WWTP	MN0024112	0.14	126	0.668
Meriden Township WWTP	MN0068713	0.205	126	0.978
MNDOT - Heath Creek Rest Area	MN0069639	0.045	126	0.215
MNDOT Straight River Rest Area	MN0049514	0.091	126	0.434

Facility Name	Permit No.	Design Flow (MGD)	*E. coli* Limit (#/100 mL)	*E. coli* Load (Billion#/day)
Morristown WWTP	MN0025895	0.21	126	1.002
OMG Midwest Inc/Southern MN Construction (Dundas Wash Plant S&G, Rice)	MNG490131	4.68	NA	NA
OMG Midwest Inc/Southern MN Construction (Owatonna Quarry, Steele County)	MNG490131	2.16	NA	NA
OMG Midwest Inc/Southern MN Construction (Thomas S&G, Rice)	MNG490131	4.68	NA	NA
Owatonna WWTP	MN0051284	5	126	23.848
Viracon	MNG255078	0.275	NA	NA
Waterville WWTP	MN0025208	0.595	126	2.838
Wondra Pit	MNG490130	3.168	NA	NA
TOTAL			-	**83.851**

Table 131. Permitted facilities discharging to Cannon River 07040002-509

Facility Name	Permit No.	Design Flow (MGD)	TSS Limit (mg/L)	TSS Load (tons/day)
CenterPoint Energy - WWTS	MN0063967	0.02	30	0.003
Ellendale WWTP	MNG580014	1.27	45	0.238
Elysian WWTP	MN0041114	1.36	45	0.255
Faribault Dairy Co Inc - Faribault	MNG255092	0.1	30	0.013
Faribault Foods - Faribault Division	MN0050491	0.5	30	0.063
Faribault WWTP	MN0030121	7	30	0.876
Geneva WWTP	MN0021008	0.65	45	0.122
Genova-Minnesota Inc	MN0046957	0.19	19	0.015
Hope - Somerset Township WWTP	MN0068802	0.0102	30	0.001
Hope Creamery	MN0001317	0.016	no conc. limit	0.0042
Kilkenny WWTP	MNG580084	0.317	45	0.060
Lakeside Foods Inc - Owatonna Plant	MN0001571	0.561	30	0.070
Lonsdale WWTP	MN0031241	0.687	30	0.086
Mathiowetz Construction	MNG490137	0.504	45	0.095
Mathy Construction – Aggregate Milestone Materials: Spinler Quarry	MNG490081	9.216	30	1.154
Medford WWTP	MN0024112	0.14	30	0.018
Meriden Township WWTP	MN0068713	0.205	45	0.038
MNDOT - Heath Creek Rest Area	MN0069639	0.045	45	0.008
MNDOT Straight River Rest Area	MN0049514	0.091	45	0.017
Morristown WWTP	MN0025895	0.21	30	0.026
Northfield WWTP	MN0024368	5.2	30	0.651
OMG Midwest Inc/Southern MN Construction (Dundas Wash Plant S&G, Rice)	MNG490131	4.68	30	0.586

Facility Name	Permit No.	Design Flow (MGD)	TSS Limit (mg/L)	TSS Load (tons/day)
OMG Midwest Inc/Southern MN Construction (Owatonna Quarry, Steele County)	MNG490131	2.16	30	0.270
OMG Midwest Inc/Southern MN Construction (Thomas S&G, Rice)	MNG490131	4.68	30	0.586
Owatonna WWTP	MN0051284	5	30	0.626
Sanders North - SD002 (Medford North S&G)	MNG490273	1.2	30	0.150
Sanders North - SD012 (Millersburg S&G)	MNG490273	0.9	30	0.113
Viracon	MNG255078	0.275	30	0.034
Waterville WWTP	MN0025208	0.595	30	0.074
Wondra Pit	MNG490130	3.168	30	0.397
TOTAL				**6.65**

TSS had no limit - assumed to be 30 mg/L per discussion with MPCA

Assumed TSS load as 1.94 kg/day from WQBEL and discussion with MPCA

Table 132. Permitted facilities discharging to Heath Creek 07040002-521

Facility Name	Permit No.	Design Flow (MGD)	*E. coli* Limit (#/100 mL)	*E. coli* Load (Billion#/day)
Lonsdale WWTP	MN0031241	0.687	126	3.277
MNDOT - Heath Creek Rest Area	MN0069639	0.045	126	0.215
TOTAL			-	**3.491**

Table 133. Permitted facilities discharging to Unnamed Ditch 07040002-555

Facility Name	Permit No.	Design Flow (MGD)	Chloride Limit (mg/L)	Chloride Load (tons/day)
Lonsdale WWTP	MN0031241	0.687	230	0.66
TOTAL			**-**	**0.66**

Table 134. Permitted facilities discharging to Cannon River 07040002-581

Facility Name	Permit No.	Design Flow (MGD)	*E. coli* Limit (#/100 mL)	*E. coli* Load (Billion#/day)
CenterPoint Energy - WWTS	MN0063967	0.02	NA	NA
Ellendale WWTP	MNG580014	1.27	126	6.057
Elysian WWTP	MN0041114	1.36	126	6.487
Faribault Dairy Co Inc - Faribault	MNG255092	0.1	NA	NA
Faribault Foods - Faribault Division	MN0050491	0.5	NA	NA
Faribault WWTP	MN0030121	7	126	33.387
Geneva WWTP	MN0021008	0.65	126	3.100
Genova-Minnesota Inc	MN0046957	0.19	NA	NA
Hope - Somerset Township WWTP	MN0068802	0.0102	126	0.049
Hope Creamery	MN0001317	0.016	NA	NA
Kilkenny WWTP	MNG580084	0.317	126	1.512

Facility Name	Permit No.	Design Flow (MGD)	*E. coli* Limit (#/100 mL)	*E. coli* Load (Billion#/day)
Lakeside Foods Inc - Owatonna Plant	MN0001571	0.561	NA	NA
Mathy Construction – Aggregate Milestone Materials: Spinler Quarry	MNG490081	9.216	NA	NA
Medford WWTP	MN0024112	0.14	126	0.668
Meriden Township WWTP	MN0068713	0.205	126	0.978
MNDOT Straight River Rest Area	MN0049514	0.091	126	0.434
Morristown WWTP	MN0025895	0.21	126	1.002
OMG Midwest Inc/Southern MN Construction (Owatonna Quarry, Steele County)	MNG490131	2.16	NA	NA
Owatonna WWTP	MN0051284	5	126	23.848
Viracon	MNG255078	0.275	NA	NA
Waterville WWTP	MN0025208	0.595	126	2.838
Wondra Pit	MNG490130	3.168	NA	NA
TOTAL			-	**80.359**

Table 135. Permitted facilities discharging to Cannon River 07040002-582

Facility Name	Permit No.	Design Flow (MGD)	*E. coli* Limit (#/100 mL)	*E. coli* Load (Billion#/day)
CenterPoint Energy - WWTS	MN0063967	0.02	NA	NA
Ellendale WWTP	MNG580014	1.27	126	6.057
Elysian WWTP	MN0041114	1.36	126	6.487
Faribault Dairy Co Inc - Faribault	MNG255092	0.1	NA	NA
Faribault Foods - Faribault Division	MN0050491	0.5	NA	NA
Faribault WWTP	MN0030121	7	126	33.387
Geneva WWTP	MN0021008	0.65	126	3.100
Genova-Minnesota Inc	MN0046957	0.19	NA	NA
Hope - Somerset Township WWTP	MN0068802	0.0102	126	0.049
Hope Creamery	MN0001317	0.016	NA	NA
Kilkenny WWTP	MNG580084	0.317	126	1.512
Lakeside Foods Inc - Owatonna Plant	MN0001571	0.561	NA	NA
Mathy Construction – Aggregate Milestone Materials: Spinler Quarry	MNG490081	9.216	NA	NA
Medford WWTP	MN0024112	0.14	126	0.668
Meriden Township WWTP	MN0068713	0.205	126	0.978
MNDOT Straight River Rest Area	MN0049514	0.091	126	0.434
Morristown WWTP	MN0025895	0.21	126	1.002
OMG Midwest Inc/Southern MN Construction (Dundas Wash Plant S&G, Rice)	MNG490131	4.68	NA	NA
OMG Midwest Inc/Southern MN Construction (Owatonna Quarry, Steele County)	MNG490131	2.16	NA	NA
OMG Midwest Inc/Southern MN Construction (Thomas S&G, Rice)	MNG490131	4.68	NA	NA
Owatonna WWTP	MN0051284	5	126	23.848
Viracon	MNG255078	0.275	NA	NA
Waterville WWTP	MN0025208	0.595	126	2.838
Wondra Pit	MNG490130	3.168	NA	NA
TOTAL			-	**80.359**

Table 136. Permitted facilities discharging to Prairie Creek 07040002-504

Facility Name	Permit No.	Design Flow (MGD)	TSS Limit (mg/L)	TSS Load (tons/day)
Dennison WWTP	MN0022195	0.26	45	0.049
TOTAL			-	**0.049**

Table 137. Permitted facilities discharging to Unnamed Creek 07040002-512

Facility Name	Permit No.	Design Flow (MGD)	TSS Limit (mg/L)	TSS Load (tons/day)
Dennison WWTP	MN0022195	0.26	45	0.049
TOTAL			-	**0.049**

Table 138. Permitted facilities discharging to Straight River 07040002-503

Facility Name	Permit No.	Design Flow (MGD)	TSS Limit (mg/L)	TSS Load (tons/day)
Ellendale WWTP	MNG580014	1.27	45	0.238
Geneva WWTP	MN0021008	0.65	45	0.122
Hope - Somerset Township WWTP	MN0068802	0.0102	30	0.001
Hope Creamery	MN0001317	0.016	no conc. limit	0.0042
Lakeside Foods Inc - Owatonna Plant	MN0001571	0.561	30	0.070
Mathiowetz Construction	MNG490137	0.504	45	0.095
Mathy Construction – Aggregate Milestone Materials: Spinler Quarry	MNG490081	9.216	30	1.154
MNDOT Straight River Rest Area	MN0049514	0.091	45	0.017
OMG Midwest Inc/Southern MN Construction (Owatonna Quarry, Steele County)	MNG490131	2.16	30	0.270
Owatonna WWTP	MN0051284	5	30	0.626
Sanders North - SD002 (Medford North S&G)	MNG490273	1.2	30	0.150
Viracon	MNG255078	0.275	30	0.034
Wondra Pit	MNG490130	3.168	30	0.397
TOTAL				**3.179**
TSS had no limit - assumed to be 30 mg/L per discussion with MPCA				
Assumed TSS load as 1.94 kg/day from WQBEL and discussion with MPCA				

Table 139. Permitted facilities discharging to Straight River 07040002-515

Facility Name	Permit No.	Design Flow (MGD)	TSS Limit (mg/L)	TSS Load (tons/day)
Ellendale WWTP	MNG580014	1.27	45	0.238
Faribault Dairy Co Inc - Faribault	MNG255092	0.1	30	0.013
Faribault WWTP	MN0030121	7	30	0.876
Geneva WWTP	MN0021008	0.65	45	0.122
Hope - Somerset Township WWTP	MN0068802	0.0102	30	0.001
Hope Creamery	MN0001317	0.016	no conc. limit	0.0042
Lakeside Foods Inc - Owatonna Plant	MN0001571	0.561	30	0.070
Mathiowetz Construction	MNG490137	0.504	45	0.095
Mathy Construction – Aggregate Milestone Materials: Spinler Quarry	MNG490081	9.216	30	1.154
Medford WWTP	MN0024112	0.14	30	0.018
Meriden Township WWTP	MN0068713	0.205	45	0.038
MNDOT Straight River Rest Area	MN0049514	0.091	45	0.017
OMG Midwest Inc/Southern MN Construction (Owatonna Quarry, Steele County)	MNG490131	2.16	30	0.270
Owatonna WWTP	MN0051284	5	30	0.626
Sanders North - SD002 (Medford North S&G)	MNG490273	1.2	30	0.150
Viracon	MNG255078	0.275	30	0.034
Wondra Pit	MNG490130	3.168	30	0.397
TOTAL				**4.124**
TSS had no limit - assumed to be 30 mg/L per discussion with MPCA				
Assumed TSS load as 1.94 kg/day from WQBEL and discussion with MPCA				

Table 140. Permitted facilities discharging to Straight River 07040002-536

Facility Name	Permit No.	Design Flow (MGD)	TSS Limit (mg/L)	TSS Load (tons/day)
Ellendale WWTP	MNG580014	1.27	45	0.238
Geneva WWTP	MN0021008	0.65	45	0.122
Hope - Somerset Township WWTP	MN0068802	0.0102	30	0.001
Hope Creamery	MN0001317	0.016	no conc. limit	0.0042
Lakeside Foods Inc - Owatonna Plant	MN0001571	0.561	30	0.070
Mathiowetz Construction	MNG490137	0.504	45	0.095
Mathy Construction – Aggregate Milestone Materials: Spinler Quarry	MNG490081	9.216	30	1.154
Medford WWTP	MN0024112	0.14	30	0.018
Meriden Township WWTP	MN0068713	0.205	45	0.038
MNDOT Straight River Rest Area	MN0049514	0.091	45	0.017
OMG Midwest Inc/Southern MN Construction (Owatonna Quarry, Steele County)	MNG490131	2.16	30	0.270
Owatonna WWTP	MN0051284	5	30	0.626
Sanders North - SD002 (Medford North S&G)	MNG490273	1.2	30	0.150
Viracon	MNG255078	0.275	30	0.034
Wondra Pit	MNG490130	3.168	30	0.397
TOTAL				**3.235**
TSS had no limit - assumed to be 30 mg/L per discussion with MPCA				
Assumed TSS load as 1.94 kg/day from WQBEL and discussion with MPCA				

Table 141. Permitted facilities discharging to Cannon River 07040002-540

Facility Name	Permit No.	Design Flow (MGD)	*E. coli* Limit (#/100 mL)	*E. coli* Load (Billion#/day)
CenterPoint Energy - WWTS	MN0063967	0.02	NA	NA
Elysian WWTP	MN0041114	1.36	126	6.487
Faribault Foods - Faribault Division	MN0050491	0.5	NA	NA
Genova-Minnesota Inc	MN0046957	0.19	NA	NA
Kilkenny WWTP	MNG580084	0.317	126	1.512
Morristown WWTP	MN0025895	0.21	126	1.002
Waterville WWTP	MN0025208	0.595	126	2.838
TOTAL			-	**11.838**

Table 142. Permitted facilities discharging to Cannon River 07040002-542

Facility Name	Permit No.	Design Flow (MGD)	*E. coli* Limit (#/100 mL)	*E. coli* Load (Billion#/day)
CenterPoint Energy - WWTS	MN0063967	0.02	NA	NA
Elysian WWTP	MN0041114	1.36	126	6.487
Kilkenny WWTP	MNG580084	0.317	126	1.512
Morristown WWTP	MN0025895	0.21	126	1.002
Waterville WWTP	MN0025208	0.595	126	2.838
TOTAL			-	**11.838**