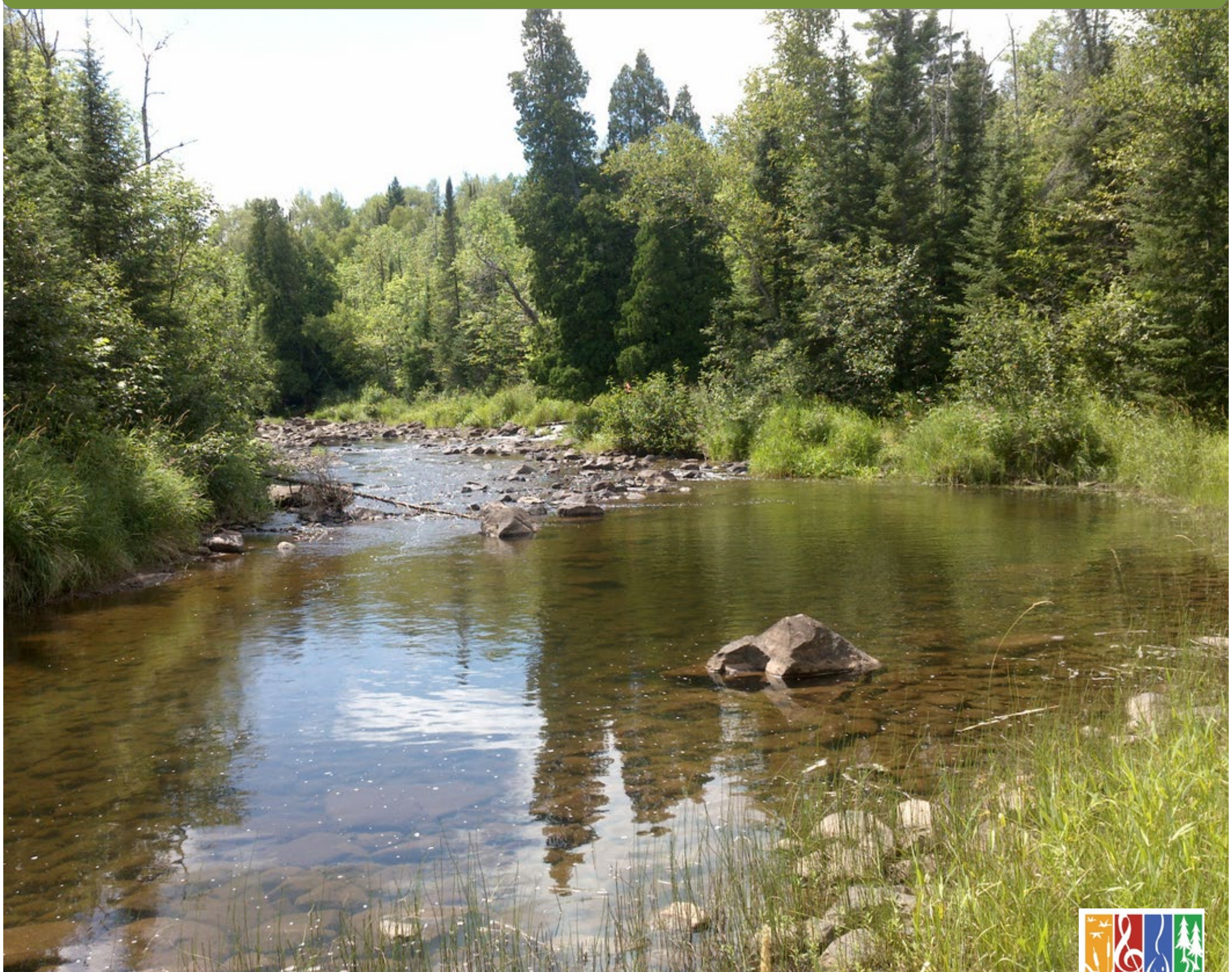
Lake Superior South Watershed Total Maximum Daily Load Report

Protecting and restoring Minnesota's North Shore resources.



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Acronyms and Abbreviations

1W1P	One Watershed, One Plan
AUID	Assessment Unit ID
BANCS	Bank Assessment for Nonpoint source Consequences of Sediment
BEHI	Bank Erosion Hazard Index
BMP	best management practice
CAFO	confined animal feeding operation
DNR	Minnesota Department of Natural Resources
E. coli	*Escherichia coli*
EPA	U.S. Environmental Protection Agency
EQuIS	Environmental Quality Information System
ft	feet
HSPF	Hydrologic Simulation Program-FORTRAN
HUC	hydrologic unit code
IWM	Intensive Watershed Monitoring
LA	load allocation
lb	pound
LiDAR	Light Detection and Ranging
LSS	Lake Superior South
mg/L	milligrams per liter
MGD	million gallons per day
MOS	Margin of Safety
MPCA	Minnesota Pollution Control Agency
MS4	Municipal Separate Storm Sewer Systems
NBS	Near Bank Stress
NPDES	National Pollutant Discharge Elimination System
NVSS	non-volatile suspended solids
SDS	State Disposal System
SSLSWCD	South St. Louis Soil and Water Conservation District
SWCD	soil and water conservation district
TBEL	technology based effluent limit
TMDL	total maximum daily load
TSS	total suspended solids
VSS	volatile suspended solids
WARSSS	Watershed Assessment of River Stability and Sediment Supply
WLA	wasteload allocation
WQBEL	water quality based effluent limit
WRAPS	watershed restoration and protection strategy
WWTP	wastewater treatment plant

Executive Summary

The Clean Water Act, Section 303(d) requires total maximum daily loads (TMDLs) be determined for surface waters that do not meet applicable water quality standards necessary to support their designated uses (e.g., propagation and maintenance of a healthy fish community and associated aquatic life and habitats, swimming). A TMDL determines the maximum amount of a pollutant a receiving water body can assimilate while still achieving water quality standards. This TMDL study addresses the portion of the Lake Superior South (LSS) Watershed (Hydrologic Unit Code [HUC] 04010102) that is located north and east of the Lester River Watershed in northeastern Minnesota. TMDLs have been developed for six impaired streams in the watershed; all six streams are provided with a total suspended solids (TSS) TMDL and one stream is provided with an *Escherichia coli (E. coli)* TMDL.

Forest and wetland land cover are dominant in all of the impaired watersheds with the exception of Skunk Creek. Skunk Creek, the only stream impaired for *E. coli*, passes through Two Harbors and has a large amount of developed lands (39%) in its watershed. Streams in the watershed transition from headwaters with low slope to high slope, bedrock-controlled areas near Lake Superior.

Eroding banks and bluffs, roads and road crossings, and watershed runoff are all significant sources of sediment in the watershed. Geomorphic analysis and other field data have identified priority locations where erosion is likely contributing to impairment. Many of these areas correspond to soils with high clay content and higher stream power. Potential sources of *E. coli* in the Skunk Creek Watershed include watershed runoff, failing septic systems and other sources of untreated wastewater, wildlife, and pets.

The pollutant load capacity of the impaired streams was determined through the use of load duration curves. These curves represent the allowable pollutant load at any given flow condition. Water quality data were compared with the load duration curves to determine load reduction needs. A 10% explicit margin of safety (MOS) was incorporated into all TMDLs to account for uncertainty.

The implementation strategy highlights an adaptive management process to achieving water quality standards and restoring beneficial uses. Implementation strategies include stormwater and wastewater management, addressing sources of untreated wastewater (e.g., failing septic systems, leaky infrastructure), stormwater management, streambank restoration and stabilization, buffers, timber harvesting management, guidance for ditch maintenance and culvert design, culvert and road crossing upgrades, pet and wildlife waste management, and education and outreach.

A core team of local, state, and federal resource management agency staff supported the TMDL process. The TMDL study is supported by previous work including the *Lake Superior - South Monitoring and Assessment Report* (MPCA 2014), the *Lake Superior - South Stressor Identification Report* (MPCA 2017), and the *Lake Superior North and Lake Superior South Basins Watershed Model Development Report* (Tetra Tech 2016).

1. Project Overview

1.1 Purpose

The Clean Water Act and U.S. Environmental Protection Agency (EPA) regulations require that TMDLs be developed for waters that do not support their designated uses (e.g., propagation and maintenance of a healthy fish community and associated aquatic life and habitats, swimming). In simple terms, a TMDL is a study of how to attain and maintain water quality standards in waters that are not currently meeting standards. This TMDL study addresses the portion of the LSS Watershed (U.S. Geological Survey HUC-8 04010102) that is located north and east of the Lester River Subwatershed (Figure 1). The remaining area within the LSS Watershed (HUC8) is addressed in the Duluth Urban Area Streams TMDL. The project area is approximately 548 square miles and is referred to as the “Lake Superior South Watershed” or “LSS” in this report. There are no tribal lands within the project area, however, the entire region is part of the [La Pointe Treaty of 1854](), which reserves hunting and fishing rights for the Ojibwa tribes of the Lake Superior region.

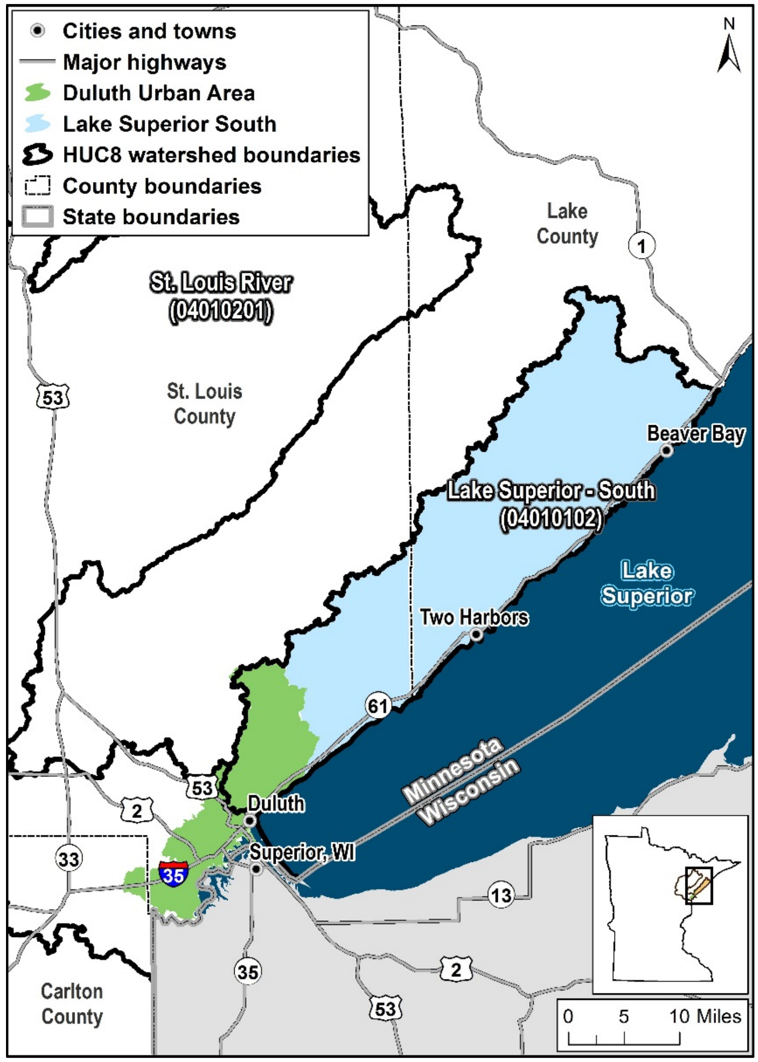

Figure 1. Lake Superior South Watershed project area.

This TMDL report is a component of a larger effort led by the Minnesota Pollution Control Agency (MPCA) to develop Watershed Restoration and Protection Strategies (WRAPS) for the LSS Watershed. Other components of this larger effort include the *Lake Superior South Monitoring and Assessment Report* (MPCA 2014), the *Lake Superior South Stressor Identification Report* (MPCA 2017), the Lake Superior South Hydrologic Simulation Program—FORTRAN (HSPF) watershed hydrology and water quality model (Tetra Tech 2016), the Lake Superior South WRAPS (concurrently developed with this TMDL), and the turbidity TMDL completed for the Knife River in 2010 (SSLSWCD 2010).

1.2 Identification of Waterbodies

This TMDL report addresses impairments in six stream reaches (Table 1 and Figure 2) in the LSS Watershed. A TMDL is not developed to address the biota impairment in Beaver River, West Branch. The impairments affect aquatic life and aquatic recreation designated uses. All of the impairments are on the draft 2016 303(d) list of impaired water bodies. The impairments were identified based on high levels of turbidity or *E. coli*, aquatic macroinvertebrate or fish bioassessments, pH outside of the allowable range, and low dissolved oxygen. A TMDL has already been developed to address a turbidity TMDL for the Knife River (Assessment Unit ID (AUID) 04010102-504) entitled *Total Maximum Daily Load Study of Turbidity on the Knife River Watershed* (SSLSWCD 2010).

The turbidity standard used in previous 303(d) lists was replaced by TSS standards in 2015 (Minn. R. 7050.0222). Existing turbidity impairments will remain as turbidity impairments on the 303(d) list, but the TMDLs developed for them will be based on the TSS standards.

Biotic impairments (i.e., aquatic macroinvertebrate or fish bioassessments) in the Beaver River, West Branch Beaver River, and Talmadge River were further evaluated for the cause of impairment as part of the stressor identification process (MPCA 2017). Table 2 summarizes the candidate causes evaluated. Biotic impairments are primarily due to elevated water temperatures, low dissolved oxygen, poor habitat, elevated turbidity/TSS, and altered hydrology. Biotic impairments will not be fully addressed as part of this TMDL. However, the biotic impairments are inextricably linked and will be favorably influenced by actions taken to address turbidity and *E. coli* impairments.

Table 1. Impaired waters (Draft 2016 303d list)

Reach Name	AUID (04010102-xxx)	Use Class	Location/Reach Description	Affected Designated Use Class	Listing Year	Target Start/Completion	Pollutant or Stressor
Beaver River	501	2A	Headwaters to Lk Superior	Aquatic Life	2014	2013/2017	Fishes bioassessments
					1996		Turbidity
					2002	2009/2017	pH
Beaver River, West Branch [a]	577	2A	Unnamed cr to Unnamed cr	Aquatic Life	2014	2012/2017	Aquatic macroinvertebrate bioassessments
							Fishes bioassessments
Big Sucker Creek (Sucker River)	555	2A	Unnamed cr to Lk Superior	Aquatic Life	2006	2012/2017	Turbidity
French River	698	2A	Unnamed lk (69-1182-00) to Lk Superior	Aquatic Life	2004	2012/2017	Turbidity
Little Knife River (East Branch Little Knife River)	840	2A	Unnamed cr to Knife R	Aquatic Life	2008	2016/2017	Dissolved oxygen
							Turbidity [a]
Skunk Creek	528	2B	Headwaters to Lk Superior	Aquatic Life	2010	2012/2017	Turbidity
				Aquatic Recreation	2014	2015/2017	*E. coli*
Talmadge River (Talmadge Cr)	508	2A	Headwaters to Lk Superior	Aquatic Life	1996	2013/2017	Dissolved oxygen
					2014		Fishes bioassessments
					2004		Turbidity

a. No TMDLs are developed for the Beaver River, West Branch. This reach will remain on the 303(d) list category 5 until a TMDL is completed or the use is met.
b. This segment drains to the Knife River that is listed as impaired for turbidity. A TMDL was completed for the Knife River in 2010 (SSLSWCD 2010).

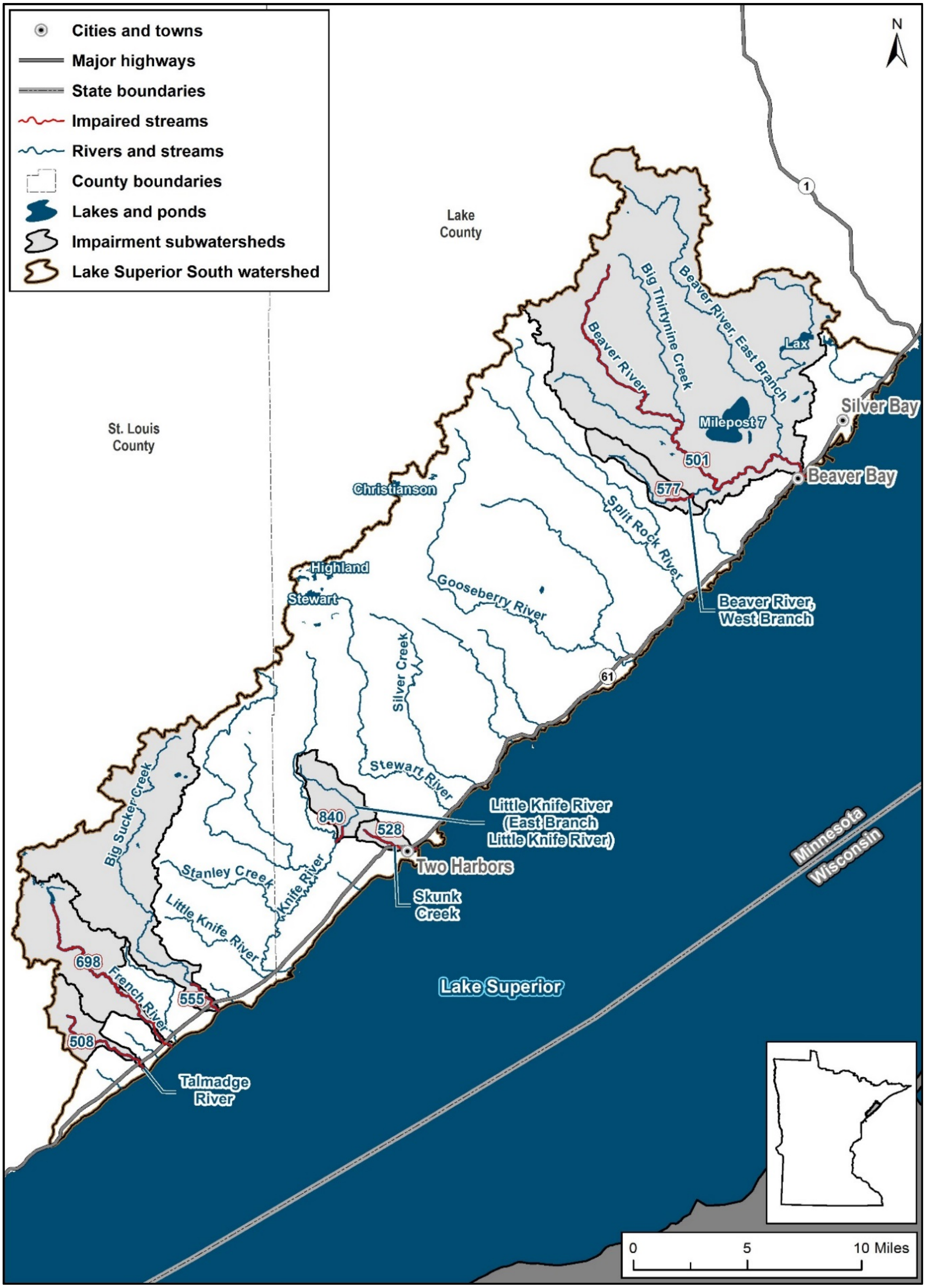

Figure 2. LSS impaired watersheds.

Note: The Knife River is also listed as impaired due to turbidity. A TMDL has been previously completed for this impairment (SSLSWCD 2010).

Table 2. Summary of probable stressors to the biota impaired streams (MPCA 2017)

Candidate Stressor	Beaver River	West Branch Beaver River	Talmadge River
Elevated water temperature	•	X	X
Low dissolved oxygen	X	•	•
Elevated ionic strength	o	--	--
pH	o	--	--
Poor habitat	•	•	•
Loss of connectivity	o	o	o
Elevated turbidity/TSS	•	o	•
Altered hydrology	o	o	•

Key: • = confirmed stressor, o = potential stressor, **X** = eliminated candidate cause, -- = not evaluated

TMDLs are not developed for nonpollutant stressors including poor habitat and altered hydrology. In addition, impairments caused by pH, elevated water temperatures and low dissolved oxygen are being deferred at this time to allow for additional investigation. Table 3 summarizes the TMDLs that are included in this study for each AUID.

Table 3. TMDL pollutants

Reach Name	AUID (04010102-xxx)	Use Class	Location/Reach Description	Affected Designated Use Class	TMDL Pollutant
Beaver River	501	2A	Headwaters to Lk Superior	Aquatic Life	TSS
Beaver River, West Branch	577	2A	Unnamed cr to Unnamed cr	Aquatic Life	None
Big Sucker Creek (Sucker River)	555	2A	Unnamed cr to Lk Superior	Aquatic Life	TSS
French River	698	2A	Unnamed lk (69-1182-00) to Lk Superior	Aquatic Life	TSS
Little Knife River (East Branch Little Knife River)	840	2A	Unnamed cr to Knife R	Aquatic Life	TSS
Skunk Creek	528	2B	Headwaters to Lk Superior	Aquatic Life	TSS
				Aquatic Recreation	*E. coli*
Talmadge River (Talmadge Cr)	508	2A	Headwaters to Lk Superior	Aquatic Life	TSS

1.3 Priority Ranking

The MPCA's schedule for TMDL completion, as indicated on the 303(d) impaired waters list, reflects Minnesota's priority ranking of this TMDL. The MPCA has aligned TMDL priorities with the watershed approach and WRAPS cycle. The schedule for TMDL completion corresponds to the WRAPS report completion on the 10-year cycle. The MPCA developed a state plan Minnesota's TMDL Priority Framework Report to meet the needs of the EPA's national measure (WQ-27) under EPA's Long-Term Vision for Assessment, Restoration and Protection under the Clean Water Act Section 303(d) Program. As part of these efforts, the MPCA identified water quality impaired segments that will be addressed by TMDLs by 2022. The LSS waters addressed by this TMDL are part of that MPCA prioritization plan to meet EPA's national measure.

2. Applicable Water Quality Standards and Numeric Water Quality Targets

Water quality standards are designed to protect designated uses (see below for description) for state waters. The standards consist of the designated uses, criteria to protect the uses, and other provisions such as antidegradation policies that protect the water body.

2.1 Designated Uses

Use classifications are defined in Minn. R. 7050.0140, and water use classifications for individual water bodies are provided in Minn. R. 7050.0470, 7050.0425, and 7050.0430. All of the impaired streams in this report are classified as Class 1B, 2A/B, and 3B waters. This TMDL report addresses the water bodies that do not meet the standards for Class 2 waters, which are protected for aquatic life and recreation designated uses.

Class 2A waters are protected for the propagation and maintenance of a healthy community of cold water sport or commercial fish and associated aquatic life and their habitats. Class 2B waters are protected for the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish, and associated aquatic life and their habitats. Both Class 2A and 2B waters are also protected for aquatic recreation activities including bathing and swimming.

2.2 Water Quality Criteria

Water quality criteria for Class 2 waters are defined in Minn. R. 7050.0222. The pollutants addressed in this TMDL are *E. coli* bacteria and TSS. In Minnesota, *E. coli* is used as an indicator species of potential water pathogens, and exceedances of the *E. coli* criteria indicate that a water body does not meet the aquatic recreation designated use. Two standards are provided for TSS, depending on the stream class. All impaired streams except Skunk Creek are Class 2A streams with a standard of 10 mg/L. Skunk Creek is a Class 2B stream with a standard of 15 mg/L. Table 4 summarizes the criteria and the TMDL endpoints.

Some additional clarification is provided for the Little Knife River. The Little Knife River (East Branch Little Knife River) is within the watershed of the Knife River. In 2010, a TSS TMDL was completed and approved for the Knife River impairment (SSLSWCD 2010) based on the previous turbidity standard in Minnesota. By that process, TSS was calculated as a surrogate for the turbidity standard, and in that TMDL determined to be equivalent to 5 mg/L TSS. A load allocation (LA) for the Little Knife River (East Branch Little Knife River) was not specified in the approved Knife River TMDL. The current TSS water quality standard is set at 10 mg/L, exceeded no more than 10% of the applicable time period defined as April 1 through September 30. In the current TMDL, the allocation for the East Branch Little Knife River is calculated for the TSS standard of 10 mg/L.

The previously approved Knife River TMDL reported that eroding banks and bluffs contributed the majority of sediment as a result of significant flow events (78% to 92%), with the mainstem of the Knife River downstream of the West Branch contributing the most (73% to 84%). Bluff and bank erosion in the reach immediately downstream of the Little Knife River (East Branch Little Knife River) was determined to be negligible. The current TMDL identifies some watershed land uses as likely sources of sediment. Per the earlier approved TMDL reports' findings, it is anticipated that the reductions provided for the Little Knife River (East Branch Little Knife River), as part of this current TMDL, will contribute to meeting the overall aquatic life use requirements in the Knife River.

Table 4. Water quality criteria

Water Body Type	Parameter	Water Quality Criteria	Endpoint(s)
Class 2 (A and B) streams (Skunk Creek)	*E. coli*	Not to exceed 126 organisms per 100 milliliters as a geometric mean of not less than five samples representative of conditions within any calendar month, nor shall more than 10% of all samples taken during any calendar month individually exceed 1,260 organisms per 100 milliliters. The standard applies only between April 1 and October 31.	< 126 organisms / 100 mL water (monthly geometric mean) < 1,260 organisms / 100 mL water (individual sample)
Class 2A streams (All impaired streams except Skunk Creek)	TSS [a]	10 mg/L; TSS standards for Class 2A may be exceeded no more than 10% of the time. This standard applies April 1 through September 30.	< 10 mg/L TSS
Class 2B streams (Skunk Creek)	TSS [a]	15 mg/L; TSS standards for Class 2B may be exceeded no more than 10% of the time. This standard applies April 1 through September 30.	< 15 mg/L TSS

a. A previous turbidity standard was replaced by the TSS standard in 2015. The previous turbidity standard was 10 nephelometric turbidity units for Class 2A waters and 25 nephelometric turbidity units for Class 2B waters for protection of aquatic life.

3. Watershed and Waterbody Characterization

The *Lake Superior South Watershed Monitoring and Assessment Report* (MPCA 2014) provides a description of the watershed, including discussions of the following: ecoregions, soils, land cover, surface hydrology, precipitation trends, hydrogeology, groundwater quality, and wetlands.

3.1 Subwatersheds

Subwatersheds that drain to impaired waters range from 1,319 acres to 78,727 acres (Table 5). All of the impairments drain directly to Lake Superior with the exception of Little Knife River (East Branch Little Knife River), which drains to the Knife River. The subwatershed area includes all drainage area to the impairment, including upstream assessment units.

Impaired water subwatersheds (Figure 2), which are based primarily on HUC12 watershed boundaries, are derived from the HSPF model application of the LSS Watershed (Tetra Tech 2016). Appendix A includes the full model report; Table 5 includes the applicable impaired stream AUIDs and model reaches.

Table 5. Impairment model reaches and subwatershed areas

Impaired Reach Name	Assessment Unit (04010102-###)	DNR Minor Watershed(s)	Subwatershed Area (acres)	Model Reach
Beaver River	501	E Br Beaver R, Cedar Cr, Big Thirty-nine Cr, Beaver R, Kit Cr, W Br Beaver R (partial), unknown (02001, 02003–8, 2024, 02056, 02058, 02060	78,727	150
Big Sucker Creek (Sucker River)	555	Sucker R, unknown (02027–9, 02031)	24,141	119
French River	698	French R (02032)	11,936	116
Talmadge River (Talmadge Creek)	508	Talmadge R (02035)	3,786	113
Little Knife River (East Branch Little Knife River)	840	Little Knife R (02020)	4,185	133
Skunk Creek	528	Skunk Cr, partial (2048)	1,319	135

3.2 Land Cover

Land cover varies throughout the impaired watersheds as provided in Table 6 and Figure 3. Forest and wetland land covers are dominant in all of the impaired watersheds with the exception of Skunk Creek. Skunk Creek passes through Two Harbors and has a large amount of developed lands (39%) in its watershed. Skunk Creek also has the lowest percentage of water and wetlands (2%) in its watershed. Lower open water and wetland areas contribute to flashiness in a stream system because of the lack of storage in the headwater areas. In the case of Skunk Creek, very low available storage (as wetlands and open water) plus significant developed areas have the potential to contribute significantly to the turbidity impairment.

Table 6. Land cover (NLCD 2011)
Percent rounded to nearest whole number.

Water Body Name	Percent of Watershed										Total Area (acres)
	Open Water	Developed	Barren Land	Deciduous Forest	Evergreen Forest	Mixed Forest	Shrub/Scrub	Grassland/Herbaceous/Pasture/Hay	Woody Wetlands	Emergent Herbaceous Wetlands	
Beaver River	3	2	1	31	10	16	7	1	28	1	78,727
Big Sucker Creek (Sucker River)	1	2	0	19	12	25	11	2	27	1	24,141
French River	1	3	0	32	11	20	6	3	21	3	11,936
Talmadge River (Talmadge Creek)	0	5	0	25	19	22	7	4	17	1	3,786
Little Knife River (E Br Little Knife River)	0	7	1	20	13	24	10	7	16	2	4,185
Skunk Creek	0	39	0	7	19	17	7	9	2	0	1,319

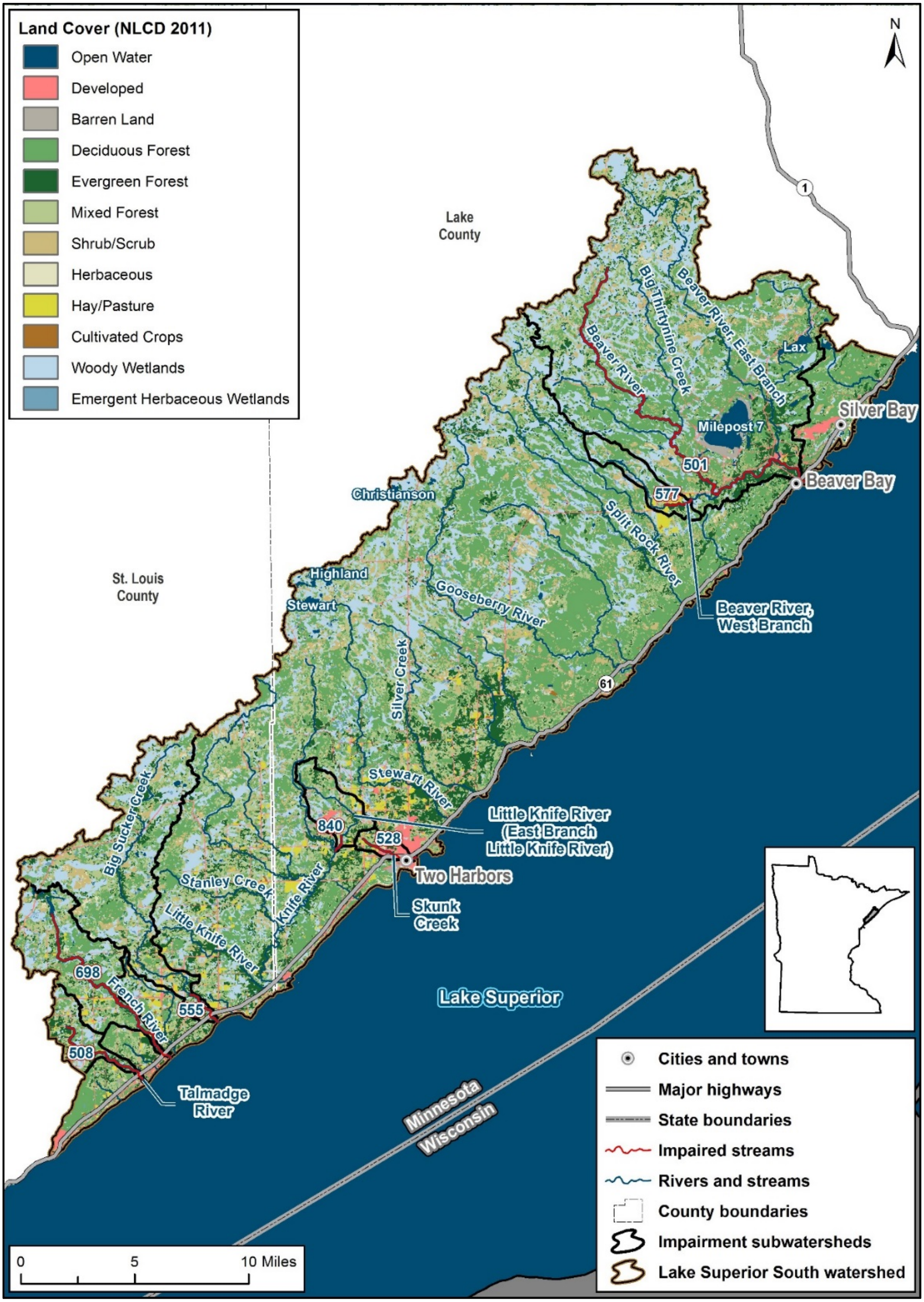

Figure 3. Lake Superior South Watershed land cover (NLCD 2011).

3.3 Current/Historic Water Quality

The *Lake Superior South Monitoring and Assessment Report* (MPCA 2014) contains figures and tables that summarize water quality data on a HUC10 basis, and address habitat, channel condition and stability, and water chemistry. The *Lake Superior South Watershed Stressor Identification Report* (MPCA 2017) includes evaluation of fish, macroinvertebrates, flow alteration, habitat, and water quality data for streams with biotic impairments (i.e., Talmadge River and Beaver River).

Water quality monitoring stations along the impaired reaches are presented in Figure 4 through Figure 6. The assessment of current and historic water quality is based primarily on data from the MPCA's Environmental Quality Information System (EQuIS database, received February 6, 2017 from MPCA). Monitoring data from all sites along an impaired segment were aggregated and presented together. Simulated flow from the MPCA's LSS Watershed HSPF model application was used to supplement the analysis (Tetra Tech 2016). See Appendix A for model documentation including calibration and validation statistics.

TSS and *E. coli* water quality data from 2007 to 2016 were summarized by year to evaluate annual trends in water quality, and by month to evaluate seasonal variation. There were no data during this time frame for the Little Knife River (East Branch Little Knife River); therefore data from 2004 through 2006 were used. The summaries of data by year only consider data during the time period that the standard is in effect (April through September for TSS and April through October for *E. coli*). The frequency of exceedances represents the percentage of samples that do not meet the water quality standard.

Water quality duration curves are provided in Sections 3.3.1 through 3.3.6. Water quality duration curves are used to evaluate the relationship between hydrology and water quality because water quality is often a function of stream flow. For example, sediment concentrations typically increase with rising flows as a result of factors such as channel scour from higher velocities. Other parameters may be more concentrated at low flows and diluted by increased water volumes at higher flows. The water quality duration curve approach provides a visual display of the relationship between stream flow and water quality. Water quality duration curves are provided using water quality monitoring data and simulated daily average stream flow from the LSS Watershed HSPF model application (Tetra Tech 2016; see Appendix A). Flow data from all months (including those outside of the time period that the standard is in effect) are plotted in the water quality duration figures.

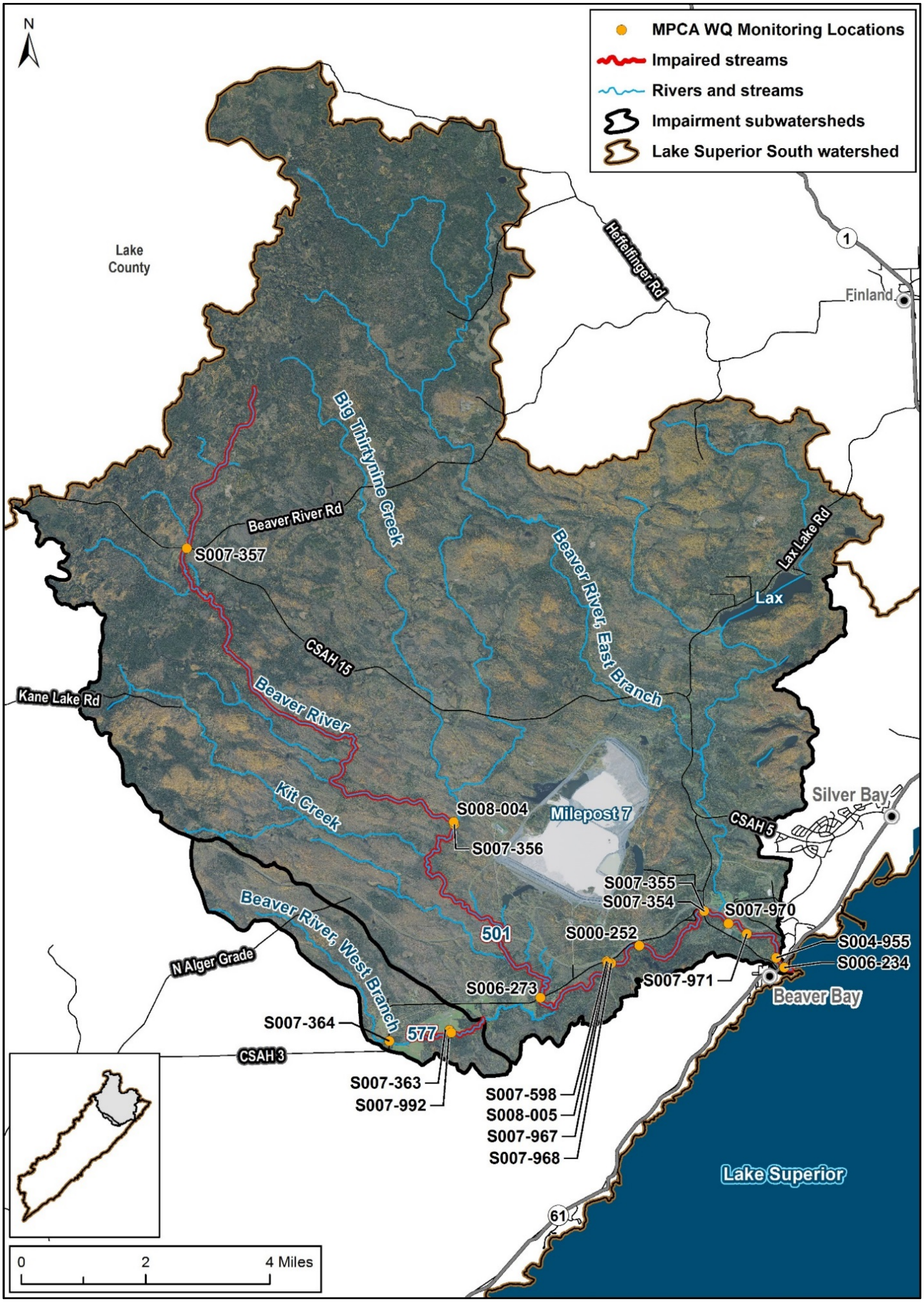

Figure 4. Beaver River water quality monitoring stations.

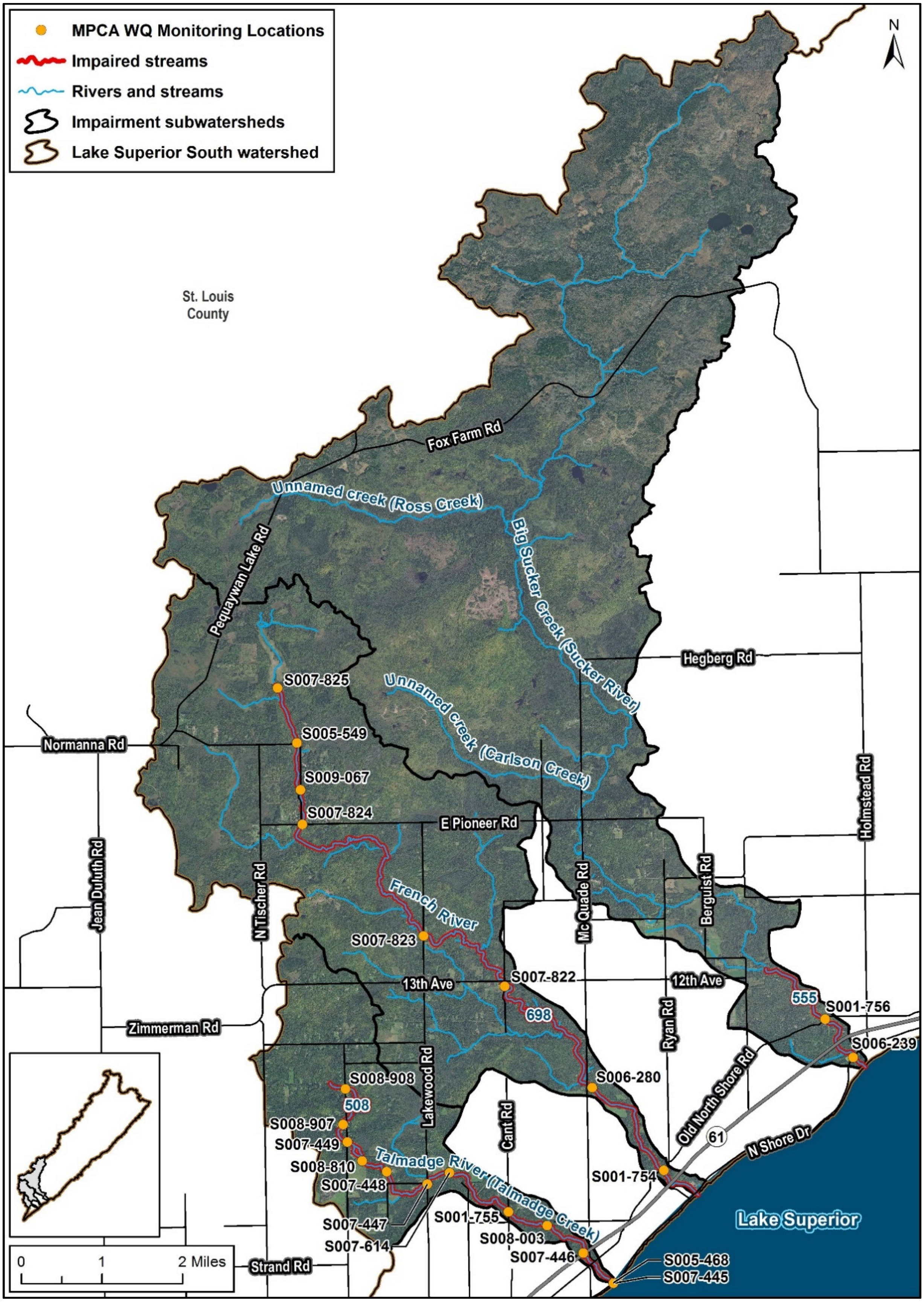

Figure 5. Big Sucker Creek (Big Sucker River), French River, and Talmadge River (Talmadge Creek) water quality monitoring stations.

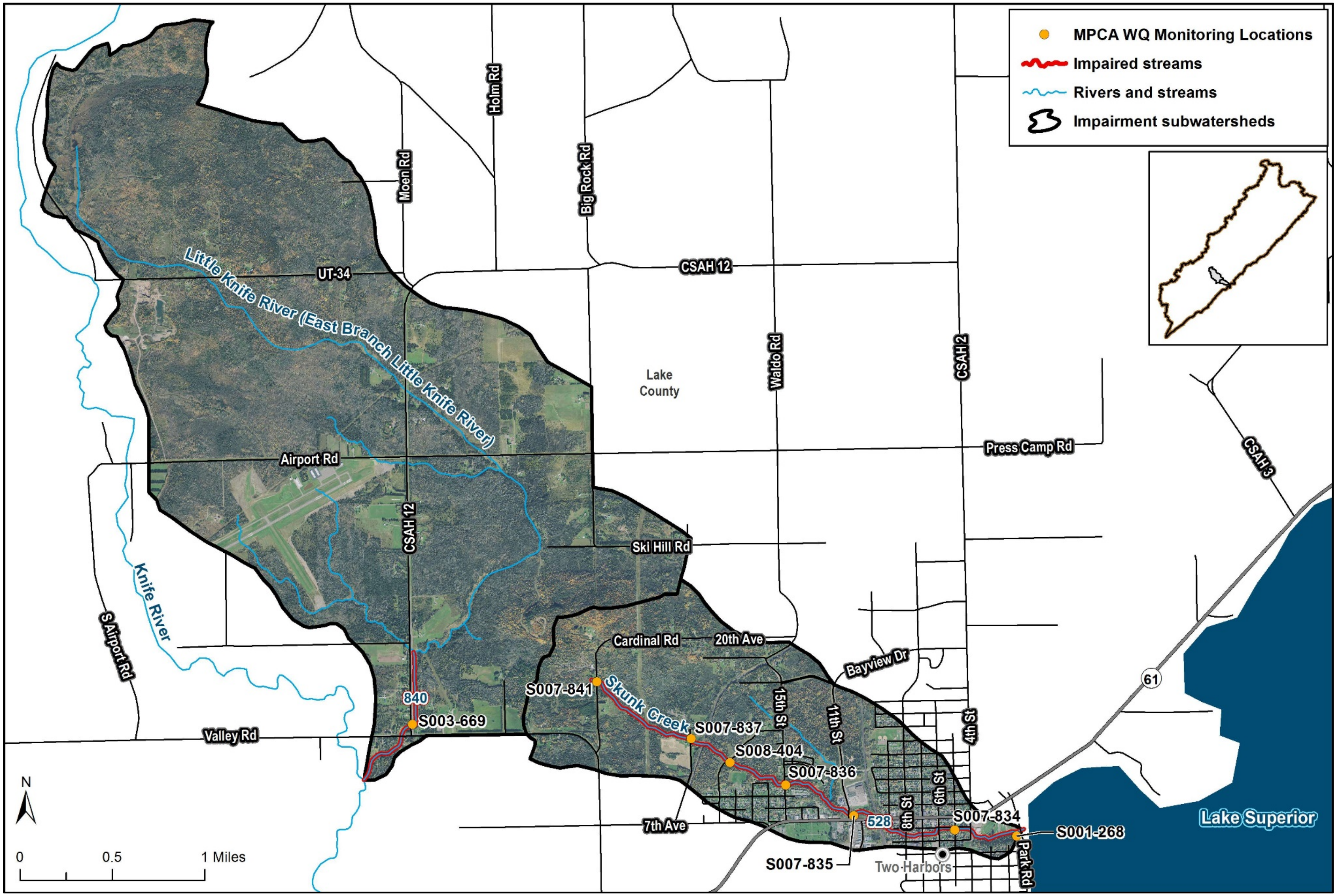

Figure 6. Little Knife River (East Branch Little Knife River) and Skunk Creek water quality monitoring stations.

3.3.1 Beaver River (04010102-501)

Total Suspended Solids

As a component of the stressor identification process, 15 TSS monitoring stations located along the Beaver River (Figure 4) were established. Average annual TSS concentrations in the Beaver River ranged from 2 to 17 mg/L, and greater than 10% of samples exceeded the 10 mg/L TSS standard in all years except for 2010 and 2011 (Table 7). During the months in which the standard applies, monthly means ranged from 7 to 19 mg/L, with exceedances occurring every month (Table 8). Concentrations on average were highest in April. TSS concentrations increased with increasing flows (Figure 7). The standard was exceeded over a range of flows, but the number and magnitude of exceedances were higher under higher flows.

Table 7. Annual summary of TSS data for the Beaver River
(AUID 04010102-501, sites S000-252, S004-955, S006-234, S006-273, S007-354, S007-355, S007-356, S007-357, S007-598, S007-967, S007-968, S007-970, S007-971, S008-004 and S008-005, Apr–Sep). Values in red indicate years in which the numeric criteria of 10 mg/L was exceeded in greater than 10% of the samples.

Year	Sample Count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of Exceedances	Frequency of Exceedances
2008	18	17	0.5	99	8	44%
2009	7	8	4	26	1	14%
2010	7	2	0.5	6	0	0%
2011	10	5	3	9	0	0%
2013	12	11	2	30	5	42%
2014	36	10	2	38	12	33%
2015	47	10	2	47	14	30%
2016	13	13	2	45	6	46%

Table 8. Monthly summary of TSS data for the Beaver River
(AUID 04010102-501, sites S000-252, S004-955, S006-234, S006-273, S007-354, S007-355, S007-356, S007-357, S007-598, S007-967, S007-968, S007-970, S007-971, S008-004 and S008-005; 2007–2011, 2013–2016). Values in red indicate months in which the numeric criteria of 10 mg/L was exceeded in greater than 10% of the samples.

Month	Sample Count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of Exceedances	Frequency of Exceedances
January	1	9	9	9	NA	NA
February	7	3	0.5	7	NA	NA
March	9	7	2	18	NA	NA
April	26	19	1	79	17	65%
May	24	11	0.5	30	8	33%
June	32	10	1	99	8	25%
July	19	7	2	22	2	11%
August	28	7	2	23	5	18%
September	21	9	0.5	22	6	29%
October	15	9	1	96	NA	NA
November	2	1	0.5	2	NA	NA

NA: not applicable because the TSS standard does not apply during these months

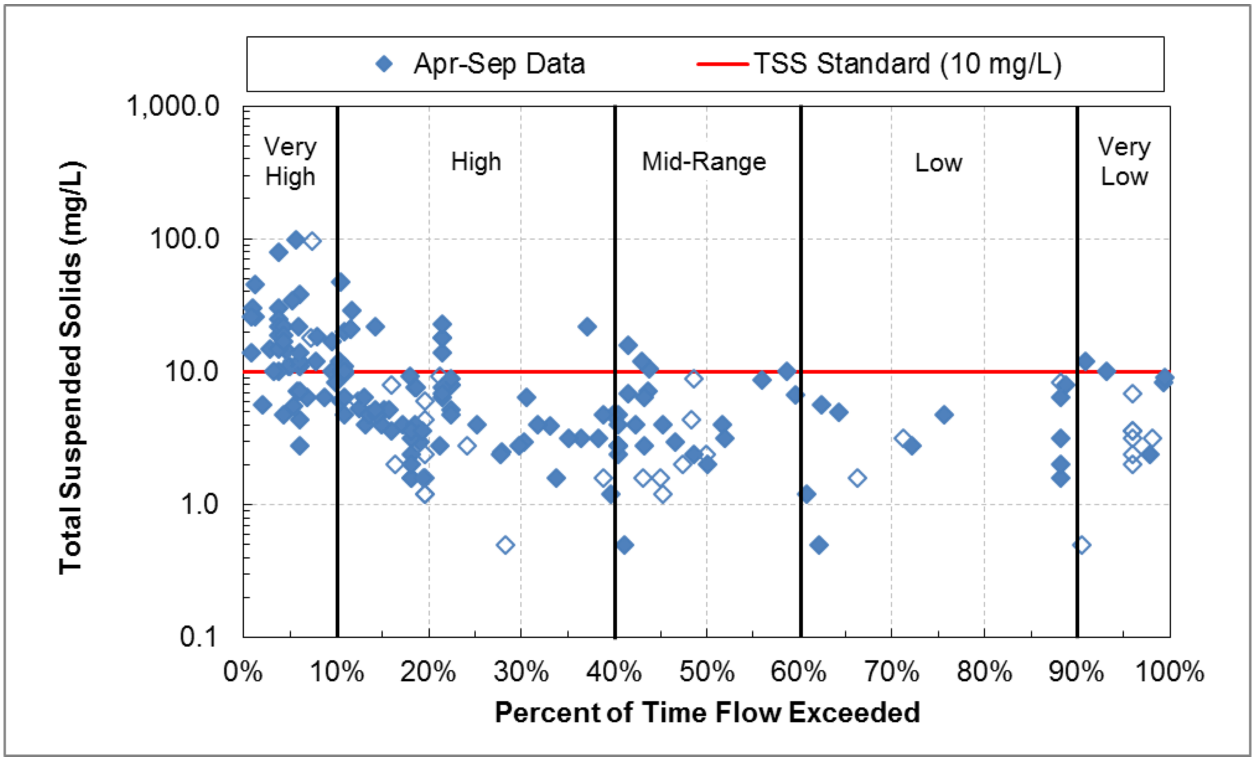

Figure 7. TSS water quality duration plot, Beaver River.
(AUID 04010102-501), 2007–2011, 2013–2016. Hollow points indicate samples during months when the standard does not apply.

3.3.2 Big Sucker Creek (Sucker River; 04010102-555)

Total Suspended Solids

TSS samples were collected from two monitoring stations located along the impaired reach of Big Sucker Creek (Sucker River; Figure 5). Average annual TSS concentrations ranged from 7 to 63 mg/L, and greater than 10% of samples exceeded the 10 mg/L standard in all years except for 2010 and 2015 (Table 9). Annual means have fluctuated, with no apparent trend over time. The highest concentrations on average were in 2013.

During the months in which the standard applies, monthly means ranged from 2 to 34 mg/L, and concentrations on average were highest in March through May (Table 10). TSS concentrations were highest under high flows, with exceedances of the standard occurring primarily in the very high flow zone (Figure 8).

Table 9. Annual summary of TSS data for Big Sucker Creek

(Sucker River; AUID 04010102-555, sites S001-756 and S006-239, Apr–Sep). Values in red indicate years in which the numeric criteria of 10 mg/L was exceeded in greater than 10% of the samples.

Year	Sample Count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of Exceedances	Frequency of Exceedances
2007	12	25	1	110	5	42%
2008	15	27	0.5	110	10	67%
2009	25	10	0.5	49	7	28%
2010	15	7	0.5	48	1	7%
2011	32	10	0.5	79	6	19%
2012	15	24	0.5	150	4	27%
2013	18	63	0.5	350	9	50%
2014	26	16	0.5	110	9	35%
2015	4	7	5	8	0	0%

Table 10. Monthly summary of TSS data for Big Sucker Creek

(Sucker River; AUID 04010102-555, sites S001-756 and S006-239, 2007–2016). Values in red indicate months in which the numeric criteria of 10 mg/L was exceeded in greater than 10% of the samples.

Month	Sample Count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of Exceedances	Frequency of Exceedances
January	5	1	0.5	2	NA	NA
February	4	1	0.5	2	NA	NA
March	14	29	1	130	NA	NA
April	43	31	0.5	110	29	67%
May	31	37	0.5	350	9	29%
June	34	18	0.5	150	9	26%
July	18	2	0.5	6	0	0%
August	20	5	0.5	33	2	10%
September	16	5	0.5	31	2	13%
October	11	21	0.5	70	NA	NA
November	5	1	0.5	3	NA	NA
December	3	2	0.5	3	NA	NA

NA: not applicable because the TSS standard does not apply during these months

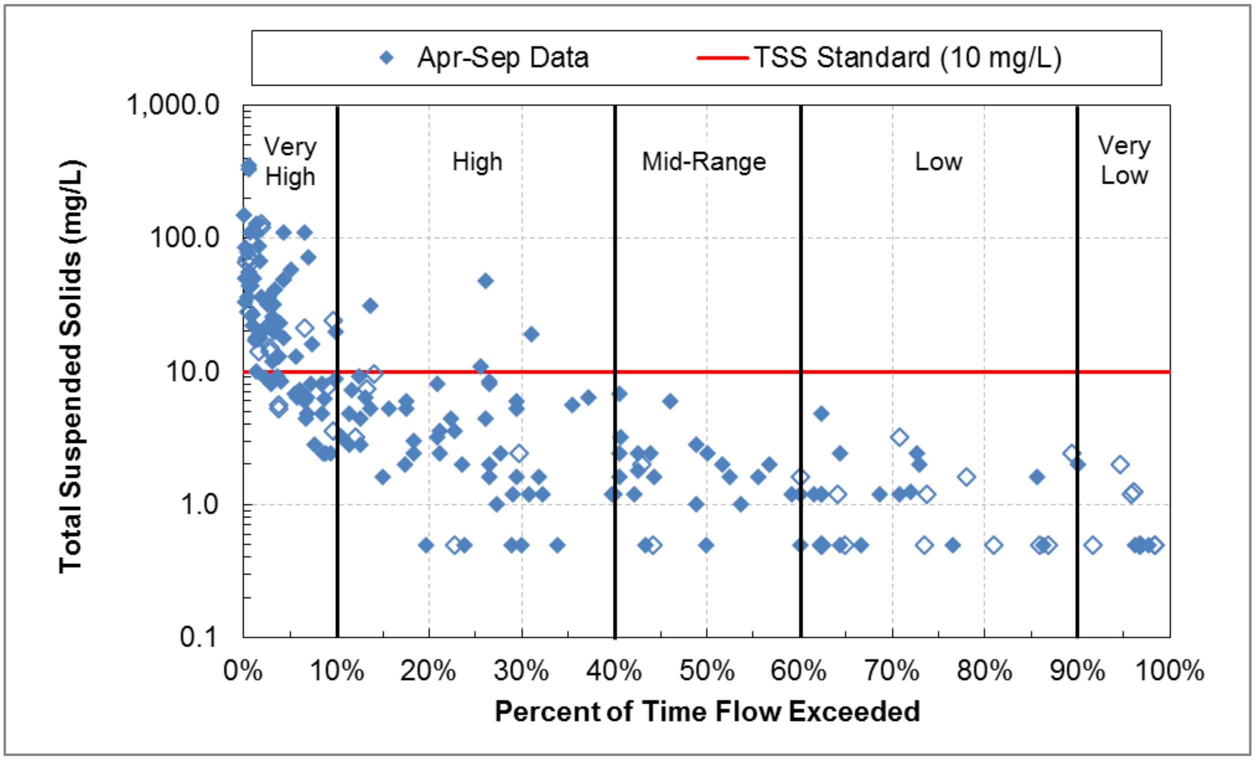

Figure 8. TSS water quality duration plot, Big Sucker Creek.
(Sucker River; AUID 04010102-555), 2007–2016. Hollow points indicate samples during months when the standard does not apply.

3.3.3 French River (04010102-698)

Total Suspended Solids

TSS samples were collected from eight monitoring stations located along the French River (Figure 5). Average annual TSS concentrations range from 3 to 41 mg/L, and greater than 10% of samples exceeded the 10 mg/L standard in all years except 2015 (Table 11). During the months in which the standard applies, monthly means ranged from 0.5 to 40 mg/L, and concentrations on average were highest in March and April (Table 12). TSS concentration increased with increasing flows, with exceedances of the standard occurring primarily in the very high flow zone (Figure 9). TSS was analyzed at multiple stations along the French River when sampling occurred as part of a longitudinal profile (all sites sampled on the same day). TSS concentrations generally increased from upstream to downstream.

Table 11. Annual summary of TSS data for the French River

(AUID 04010102-698, sites S000-255, S001-754, S006-280, S007-822, S007-823, S007-824, S007-825 and S009-067, Apr–Sep). Values in red indicate years in which the numeric criteria of 10 mg/L was exceeded in greater than 10% of the samples.

Year	Sample Count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of Exceedances	Frequency of Exceedances
2007	12	14	0.5	39	5	42%
2008	14	24	0.5	130	7	50%
2014	17	19	0.5	95	6	35%
2015	3	3	2	5	0	0%
2016	15	41	1.6	150	10	67%

Table 12. Monthly summary of TSS data for the French River

(AUID 04010102-698, sites S000-255, S001-754, S006-280, S007-822, S007-823, S007-824, S007-825 and S009-067; 2007–2008, 2014–2016). Values in red indicate months in which the numeric criteria of 10 mg/L was exceeded in greater than 10% of the samples.

Month	Sample Count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of Exceedances	Frequency of Exceedances
March	10	42	6	170	NA	NA
April	24	40	2	150	18	75%
May	2	2	2	3	0	0%
June	17	22	2	130	8	47%
July	1	0.5	0.5	0.5	0	0%
August	8	8	0.5	39	1	13%
September	9	3	0.5	15	1	11%
October	4	24	3	65	NA	NA

NA: not applicable because the TSS standard does not apply during these months

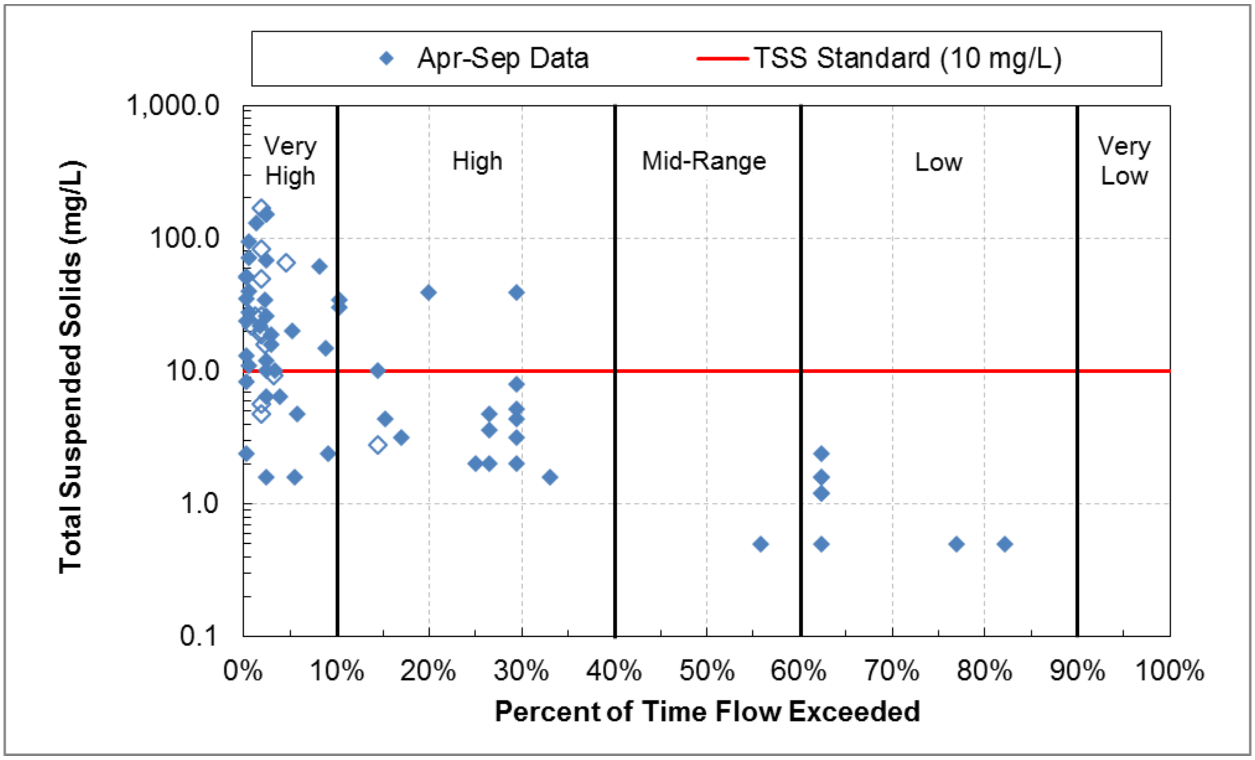

Figure 9. TSS water quality duration plot, French River.
(AUID 04010102-698), 2007–2008, 2014–2016. Hollow points indicate samples during months when the standard does not apply.

3.3.4 Talmadge River (Talmadge Creek; 04010102-508)

Total Suspended Solids

There are eight TSS monitoring stations located along Talmadge River (Talmadge Creek; Figure 5). Average annual TSS concentration ranged from 5 mg/L in 2008 to 87 mg/L in 2013, and greater than 10% of samples exceeded the 10 mg/L standard in 2007 and 2013 (Table 13). During the months in which the standard applies, monthly means ranged from 0.5 to 78 mg/L, and concentrations on average were highest in May (Table 14). TSS concentration increased with increasing flows, with all exceedances under very high and high flow conditions (Figure 10). TSS was analyzed at multiple stations along the Talmadge River during three days in 2013. TSS concentrations generally increased from upstream to downstream.

Table 13. Annual summary of TSS data for the Talmadge River
(Talmadge Creek; AUID 04010102-508, sites S001-755, S007-445, S007-446, S007-447, S007-448, S007-449, S007-614 and S008-003, Apr–Sep). Values in red indicate years in which the numeric criteria of 10 mg/L was exceeded in greater than 10% of the samples.

Year	Sample Count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of Exceedances	Frequency of Exceedances
2007	13	22	0.5	200	2	15%
2008	3	5	3	7	0	0%
2013	19	87	6	520	13	68%
2014	8	7	2	10	0	0%

Table 14. Monthly summary of TSS data for the Talmadge River

(Talmadge Creek; AUID 04010102-508, sites S001-755, S007-445, S007-446, S007-447, S007-448, S007-449, S007-614 and S008-003; 2007–2008, 2013–2014). Values in red indicate months in which the numeric criteria of 10 mg/L was exceeded in greater than 10% of the samples.

Month	Sample Count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of Exceedances	Frequency of Exceedances
March	3	12	5	17	NA	NA
April	18	17	2	76	4	22%
May	16	92	2	520	10	63%
June	6	38	2	200	1	17%
July	1	0.5	0.5	0.5	0	0%
August	1	0.5	0.5	0.5	0	0%
September	1	6	6.4	6	0	0%
October	3	20	3	31	NA	NA

NA: not applicable because the TSS standard does not apply during these months

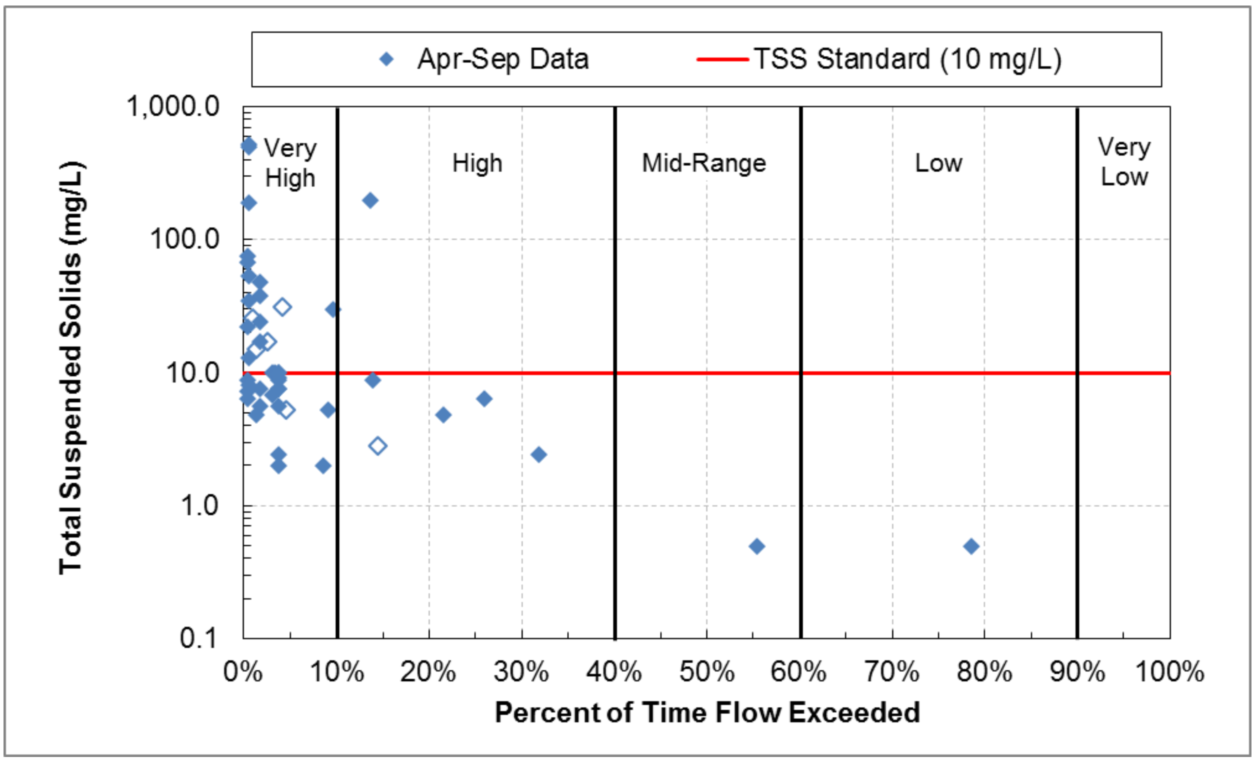

Figure 10. TSS water quality duration plot, Talmadge River.

(Talmadge Creek; AUID 04010102-508), 2007–2008, 2013–2014. Hollow points indicate samples during months when the standard does not apply.

3.3.5 Little Knife River (East Branch Little Knife River; 04010102-840)

Total Suspended Solids

There is one TSS monitoring station located along the impaired reach of Little Knife River (East Branch Little Knife River; Figure 6). TSS samples were only collected in 2004 through 2006, with greater than 10% of the samples exceeding the standard of 10 mg/L across all monitored years (Table 15). During the months in which the standard applies, monthly means ranged from 7 to 21 mg/L, and concentrations on average were highest in June through August (Table 16). There was no clear relationship between TSS concentration and flow (Figure 11).

Table 15. Annual summary of TSS data for the Little Knife River

(East Branch Little Knife River; AUID 04010102-840, site S003-669, Apr–Sep). Values in red indicate years in which the numeric criteria of 10 mg/L was exceeded in greater than 10% of the samples.

Year	Sample Count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of Exceedances	Frequency of Exceedances
2004	19	14	1	63	5	26%
2005	16	12	4	35	5	31%
2006	13	7	2	16	3	23%

Table 16. Monthly summary of TSS data for the Little Knife River

(East Branch Little Knife River; AUID 04010102-840, site S003-669; 2004–2006). Values in red indicate months in which the numeric criteria of 10 mg/L was exceeded in greater than 10% of the samples.

Month	Sample Count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of Exceedances	Frequency of Exceedances
April	8	7	2	11	1	13%
May	11	8	3	20	3	27%
June	8	14	1	35	3	38%
July	8	14	4	61	2	25%
August	6	21	2	63	3	50%
September	7	7	3	12	1	14%
October	7	7	2	31	NA	NA

NA: not applicable because the TSS standard does not apply during this month

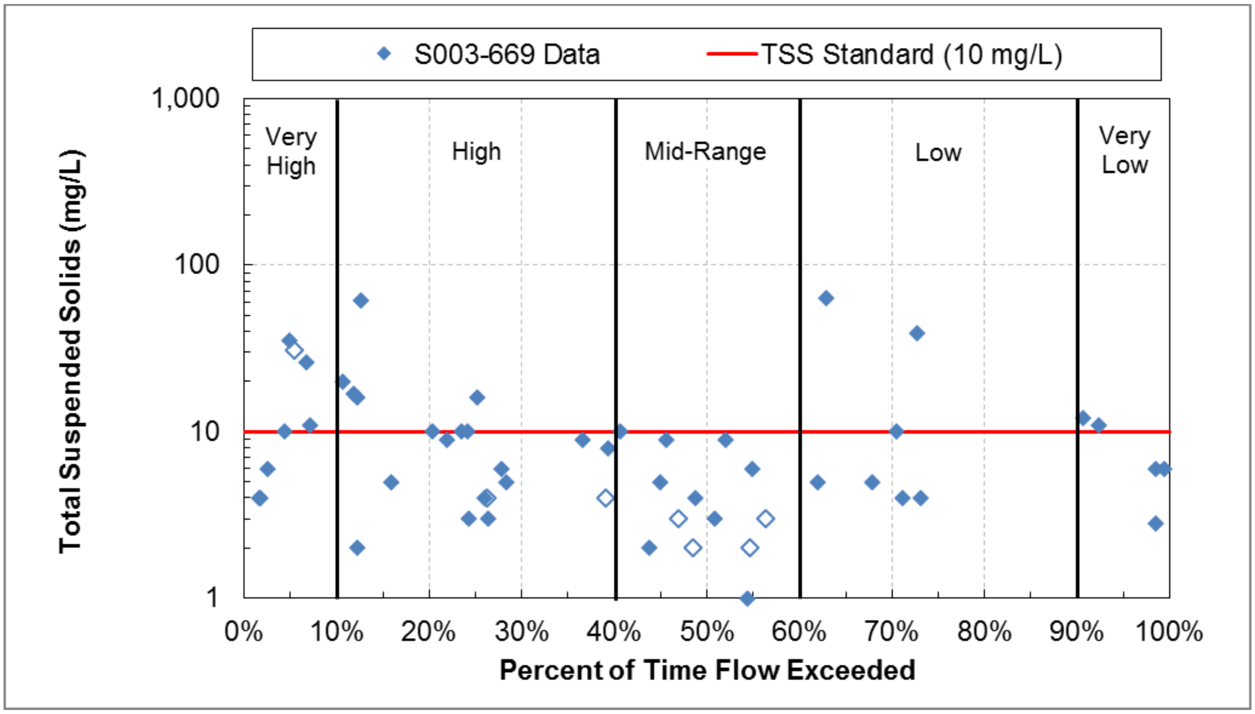

Figure 11. TSS water quality duration plot, Little Knife River.
(East Branch Little Knife River; AUID 04010102-840), 2004-2006. Hollow points indicate samples during months when the standard does not apply.

3.3.6 Skunk Creek (04010102-528)

Total Suspended Solids

There are seven TSS monitoring stations along Skunk Creek (Figure 6). Average annual TSS concentrations ranged from 4 to 28 mg/L, and greater than 10% of samples exceeded the 15 mg/L standard in 2012 and 2014 (Table 17). During the months in which the standard applies, monthly means ranged from 6 to 40 mg/L, and concentrations on average were highest in April and November (Table 18). The majority of exceedances occurred in the very high flow zone, but exceedances occurred under all flow conditions except mid-range flows (Figure 12). TSS was analyzed at multiple stations along Skunk Creek on three days in 2014. There was not a consistent upstream-downstream pattern of TSS concentrations.

Table 17. Annual summary of TSS data for Skunk Creek
(AUID 04010102-528, sites S001-268, S007-834, S007-835, S007-836, S007-837, S007-841 and S008-404, Apr–Sep). Values in red indicate years in which the numeric criteria of 15 mg/L was exceeded in greater than 10% of the samples.

Year	Sample Count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of Exceedances	Frequency of Exceedances
2011	10	4	1	13	0	0%
2012	11	12	0.5	48	3	27%
2014	35	28	0.5	140	20	57%
2015	59	5	0.5	38	4	7%

Table 18. Monthly summary of TSS data for Skunk Creek

(AUID 04010102-528, sites S001-268, S007-834, S007-835, S007-836, S007-837, S007-841 and S008-404; 2011-2012, 2014–2015). Values in red indicate months in which the numeric criteria of 15 mg/L was exceeded in greater than 10% of the samples.

Month	Sample Count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of Exceedances	Frequency of Exceedances
March	6	26	14	42	NA	NA
April	15	40	2	140	9	60%
May	21	6	0.5	27	2	10%
June	19	14	0.5	53	7	37%
July	14	10	0.5	48	3	21%
August	22	8	0.5	45	3	14%
September	24	6	0.5	33	3	13%
October	11	23	1	190	NA	NA
November	6	73	39	140	NA	NA

NA: not applicable because the TSS standard does not apply during these months

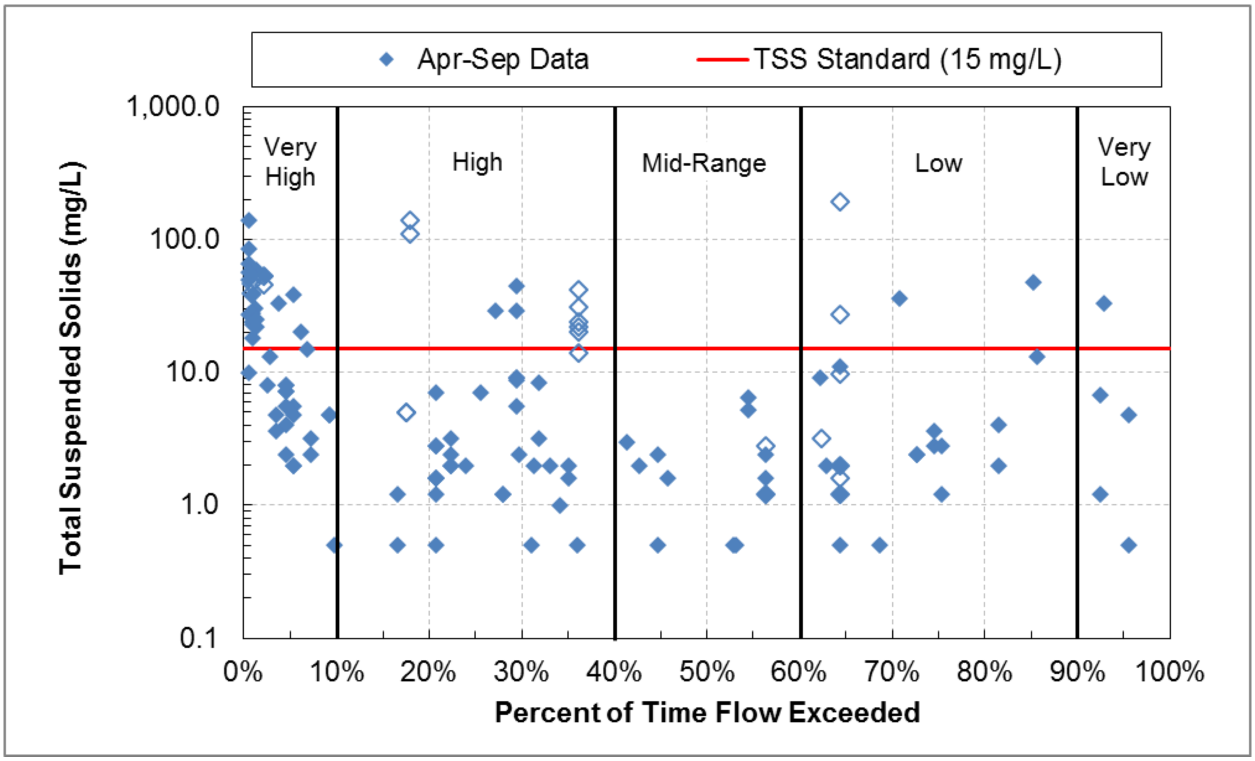

Figure 12. TSS water quality duration plot, Skunk Creek.

(AUID 04010102-528), 2011–2012, 2014–2015. Hollow points indicate samples during months when the standard does not apply.

E. coli

There are seven *E. coli* monitoring stations along Skunk Creek (Figure 6). Annual geometric mean concentrations of *E. coli* ranged from 135 to 566 org/100 mL (Table 19). Exceedances of the individual sample standard occurred during all monitored years. Monthly geometric means ranged from 39 to 608 org/100 mL, and concentrations on average were highest in August (Table 20).There was no clear relationship between *E. coli* concentration and flow, with exceedances under all flow conditions except very low flows (Figure 13).

Table 19. Annual summary of *E. coli* data for Skunk Creek

(AUID 04010102-528, sites S001-268, S007-834, S007-835, S007-836, S007-837, S007-841 and S008-404, May–Oct)

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of Individual Sample Standard Exceedances (>1,260 org/100 mL)	Percent of Individual Sample Standard Exceedances
2011	6	566	91	≥ 2,400 [a]	2	33
2012	9	464	91	2,000	2	22
2014	28	265	3	≥ 2,500 [a]	7	25
2015	37	135	17	≥ 2,400 [a]	2	5

a. The value reported is the method's maximum recordable value.

Table 20. Monthly summary of *E. coli* data for Skunk Creek

(AUID 04010102-528, sites S001-268, S007-834, S007-835, S007-836, S007-837, S007-841 and S008-404; 2011–2012, 2014–2015). Values in red indicate months in which the monthly geometric mean standard of 126 org/100 mL was exceeded or the individual sample standard of 1,260 org/100 mL was exceeded in greater than 10% of the samples.

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of Individual Sample Standard Exceedances (>1,260 org/100 mL)	Percent of Individual Sample Standard Exceedances
May	10	39	17	120	0	0
June	17	343	31	2,000	2	12
July	13	328	66	2,000	2	15
August	18	608	50	≥ 2,500 [a]	7	39
September	14	213	39	≥ 2,400 [a]	2	14
October	8	39	3	580	0	0

a. The value reported is the method's maximum recordable value.

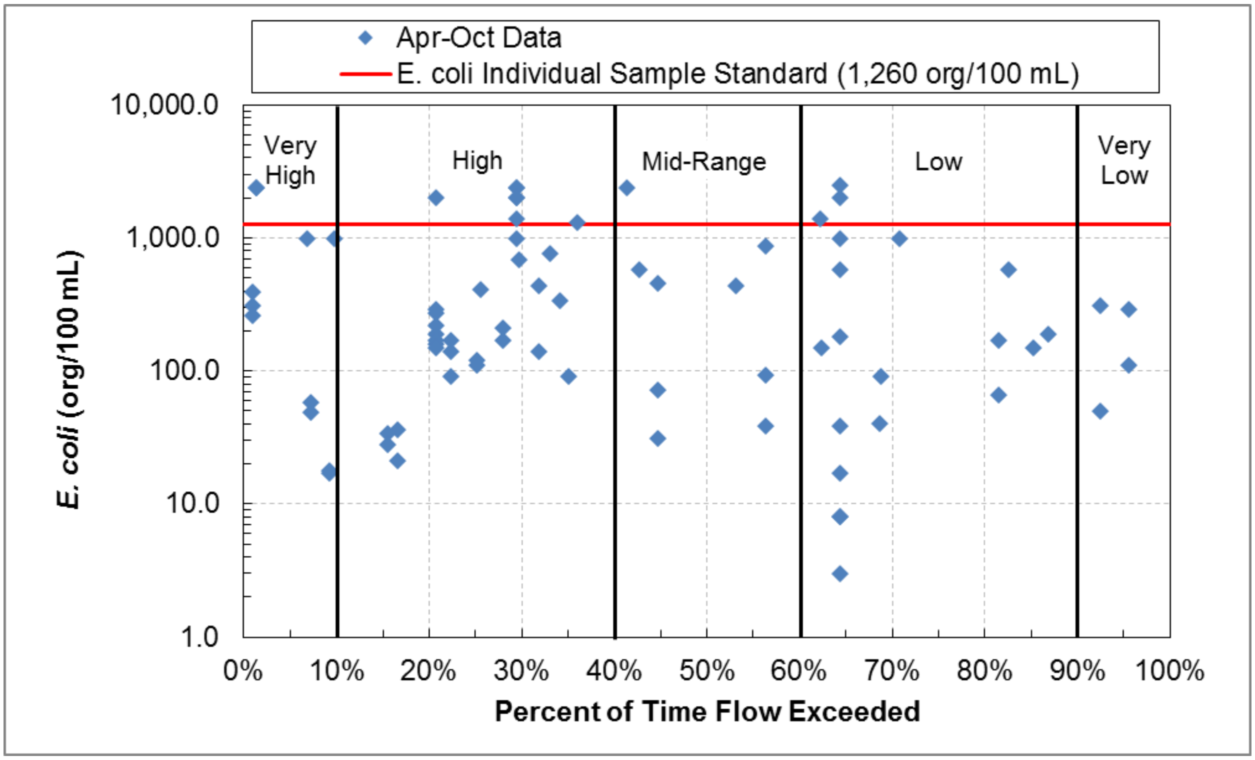

Figure 13. *E. coli* water quality duration plot, Skunk Creek.
(AUID 04010102-528), 2011–2012, 2014–2015.

3.4 Pollutant Source Summary

A pollutant source assessment was developed to identify potential point and nonpoint sources of sediment and *E. coli* in the impaired watersheds. Potential sources were identified through the MPCA permit information and monitoring records, watershed modeling studies, watershed-and stream-specific studies, and field data.

3.4.1 Sediment

Sediment is a primary cause of impairment in all of the impaired stream reaches. The source assessment evaluated permitted sources including wastewater, regulated municipal separate storm sewer systems (MS4s), industrial and construction stormwater, and non-permitted source loads from watershed loading and channel erosion.

Permitted Sources

Permitted sources are those sources that are regulated by a National Pollutant Discharge Elimination System (NPDES) permit and include wastewater (municipal and industrial), stormwater, and confined animal feeding operations (CAFOs). In the LSS, permitted sources include municipal and industrial wastewater and stormwater. There are no regulated CAFOs in the watersheds. There are three NPDES permitted municipal and industrial wastewater facilities in the watershed that potentially contribute to TSS impairments. One additional point source, Two Harbors wastewater treatment plant (WWTP) (MN0022250), discharges to Lake Superior.

Each of the facilities has an existing permit limit that is greater than the water quality standard (10 mg/L). The current monthly average TSS limits are:

- Beaver Bay WWTP (MN0040754): 30 mg/L
- North Shore Mining Co. (MN0055301)–Silver Bay: 20 mg/L
- DNR French River Hatchery (MN0004413): 30 mg/L

Discharge monitoring records (DMR) from the last five years (2012 through 2016) were reviewed for each of the three facilities. The Beaver Bay WWTP's discharge was always below the permit limit and typically below the water quality standard (10 mg/L). Concentrations of 12 and 14 mg/L observed in Beaver Bay WWTP effluent records exceeded the instream water quality target of 10 mg/L in September and October of 2012, respectively. DMRs for North Shore Mining and the French River Hatchery did not show any exceedances of the permit limit or the water quality standard (10 mg/L). Facility flows can constitute most or all of the instream flow under low and very low flow conditions. If facility discharge were to exceed the instream TSS standard under low flows, the facility would be a primary cause of impairment.

The French River Hatchery is being decommissioned and will transition to other uses. However, at the time of this TMDL the facility is still in limited operation, although rearing of rainbow trout to the yearling stage has been discontinued.

Municipal Separate Storm Sewer Systems

Duluth Township (MS400134) is the only entity that contains a regulated MS4 in the watershed. A regulated MS4 is defined as the stormwater conveyance system, which includes storm sewers, roads, and ditches. The Big Sucker Creek (Sucker River) Subwatershed and French River Subwatershed includes a portion of the Duluth Township's regulated MS4 (Figure 14). No other impaired waters have regulated MS4s in their watersheds. Duluth Township as a regulated MS4 includes only roads and ditches.

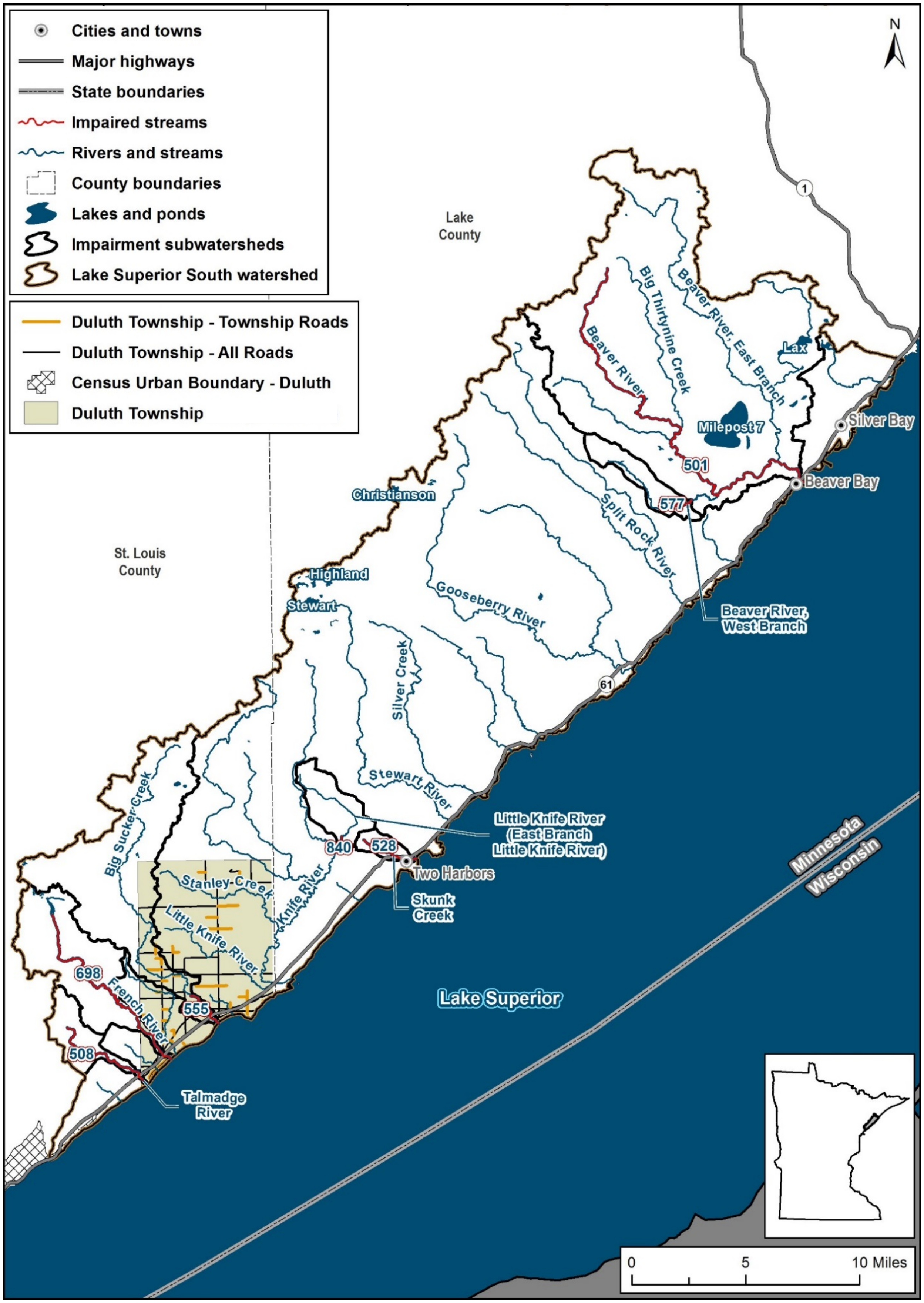

Figure 14. MS4 area.

Industrial Stormwater

Industrial stormwater is regulated through an NPDES permit when stormwater discharges have the potential to come into contact with materials and activities associated with industrial activities. In the LSS, regulated industrial stormwater sources include runoff from gravel and aggregate mining operations, along with runoff associated with airports and other industrial sites. Industrial stormwater loading is not considered a significant source.

Construction Stormwater

Construction stormwater is an additional source of sediment in the LSS Watershed regulated through an NPDES permit. Untreated stormwater that runs off a construction site often carries sediment and other pollutants to surface water bodies. An NPDES permit is needed for construction activity that disturbs one acre or more of soil or for smaller sites if the activity is part of a larger development. A permit may also be needed if the MPCA determines that the activity poses a risk to water resources. Coverage under the construction stormwater general permit requires sediment and erosion control measures that reduce stormwater pollution during and after construction activities. In the LSS Watershed, construction activities can be a potential source of sediment due to the fine-grained soils and difficulty establishing vegetation. The construction stormwater permit does require establishment of vegetation post-construction. The average annual (2010 through 2015) percent areas of St. Louis County and Lake County that are regulated through the construction stormwater permit were calculated as 0.01% and 0.003%, respectively (Minnesota Stormwater Manual contributors 2017).

Non-Permitted Sources

Non-permitted sediment inputs in the LSS Watershed can be dominated by watershed loading or near-channel sources, depending on the impaired segment. Existing watershed loads (annual average 1993-2012) from the LSS Watershed HSPF model application (Tetra Tech 2016; see Appendix A) are provided in Figure 15. Note that while the sediment load from forested land cover is high (i.e., 30%), the per acre loading rate from forested land cover is among the lowest. The high value is due to forest being the dominant land cover in the watershed. Eroding bluffs have been identified as a major source of sediment in many of the North Shore tributaries (Nieber et al. 2008). Loadings from bluffs in the watershed models were specified using a constant rate of replenishment to the bed sediment storage in affected reaches, and are based on high risk erosion areas identified as part of a Light Detection and Ranging (LiDAR)-based bluff assessment conducted by the Natural Resources Research Institute (2015).

The large number of identified bluffs along the Big Sucker Creek, French River, and Talmadge River account for the dominance of near channel sources. Skunk Creek, located in Two Harbors, has the highest proportion of sediment loads from development and roads. For most streams, the highest amount of erosion is found in the transitional area between upstream/headwater areas that have low slopes and the high slope, bedrock-controlled areas near Lake Superior. This area tends to correspond to soils with high clay content and higher stream power as described by Wick (2013). Nieber et al. (2016) recommended overall land management of the clay till, in addition to bluff and near-shore management, as a focus of sediment load reduction. The extent of clay till soils and locations of high slope areas were identified in 2016 by Minnesota DNR (C. Little 2017, personal communication) to focus land management efforts.

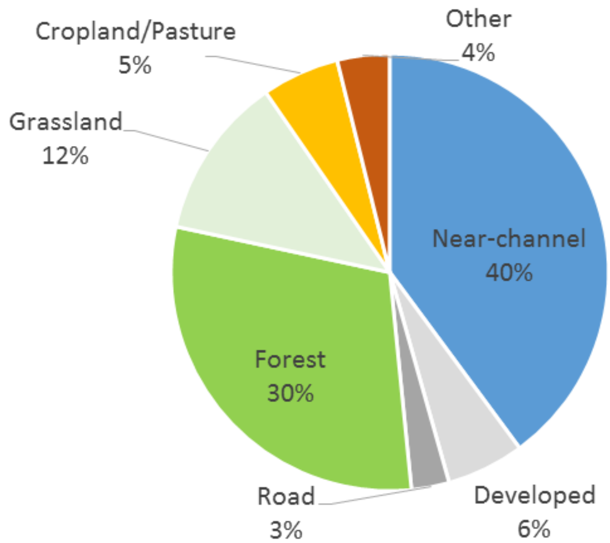

Figure 15. Sources of sediment in the LSS (Tetra Tech 2016).

Lahti et al. (2013) also identified roads and road crossings as the most widespread anthropogenic stressor to North Shore streams. In a more detailed analysis, Lake County conducted a culvert inventory, completed in 2017, that included identifying road crossings that exhibited scour and bank erosion. Figure 16 through Figure 18 include the extent of clay till soils and location of high slope areas, high erosion risk bluffs, and culverts where erosion was identified.

Stream-specific sediment assessments have been conducted for the Beaver River, Big Sucker Creek, French River, and Talmadge River. The assessments are based mainly on the Bank Assessment for Nonpoint Source Consequences of Sediment (BANCS) model developed by Dave Rosgen in 1996 and adopted by the EPA in 2006 as part of the Watershed Assessment of River Stability and Sediment Supply, or WARSSS framework. The BANCS model combines Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) measurements to estimate an erosion rate. Measurements are completed at an individual bank scale and extrapolated to a reach scale. At each assessment bank, characteristics such as plant root depth and density, bank height, and bank angle were used to calculate a BEHI score, and the location of dominant channel flow relative to the bank or depositional properties and other channel characteristics were used to calculate a NBS score. BEHI and NBS relationship curves developed for the BANCS model were then used to predict a bank recession rate. Length and height of the bank are multiplied by the predicted annual recession rate to estimate a mean annual sediment loading rate (for both bedload and suspended sediment) for each bank. The results of this analysis are provided in the following sections.

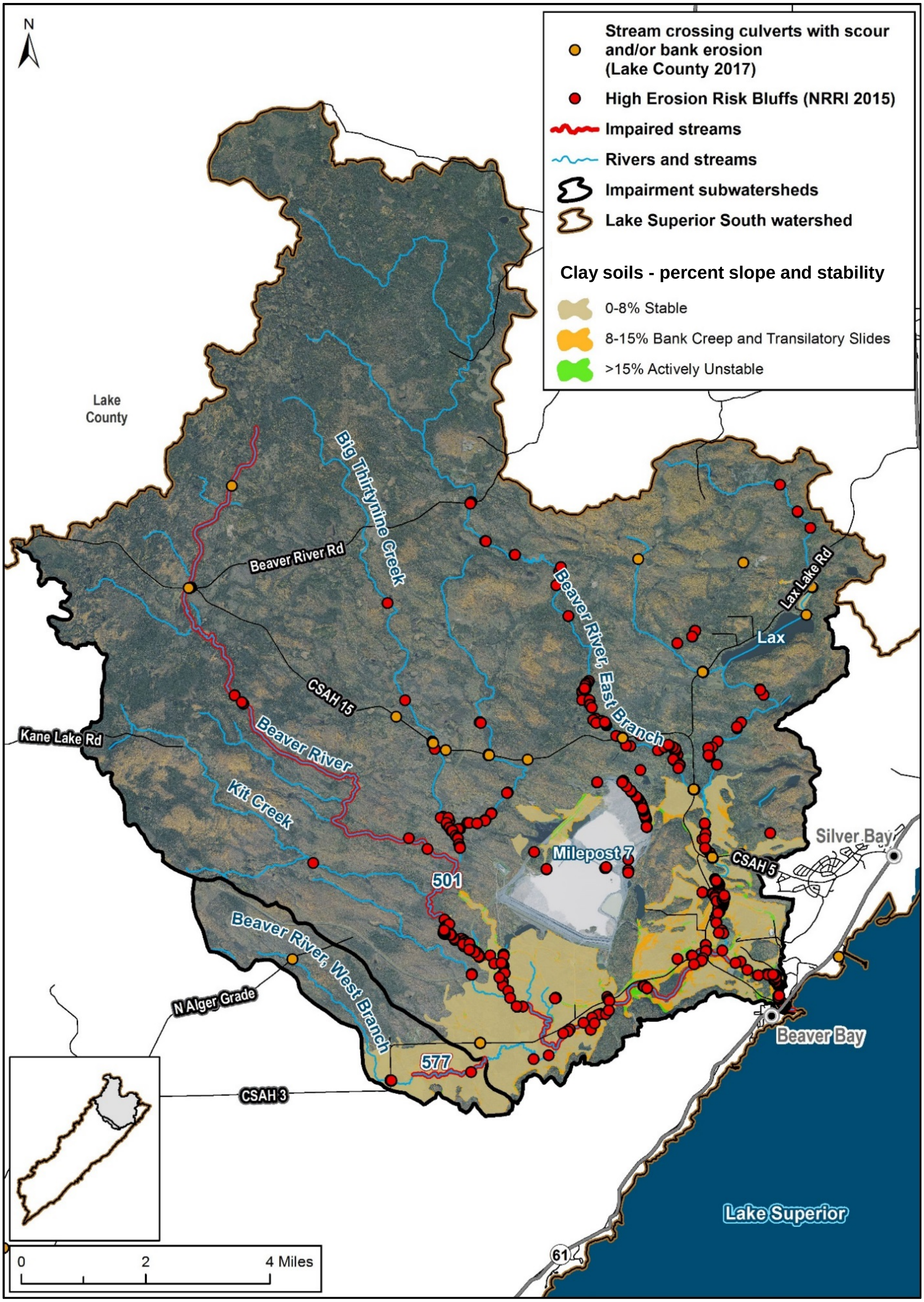

Figure 16. Potential sediment source areas identified within the Beaver River Watershed.

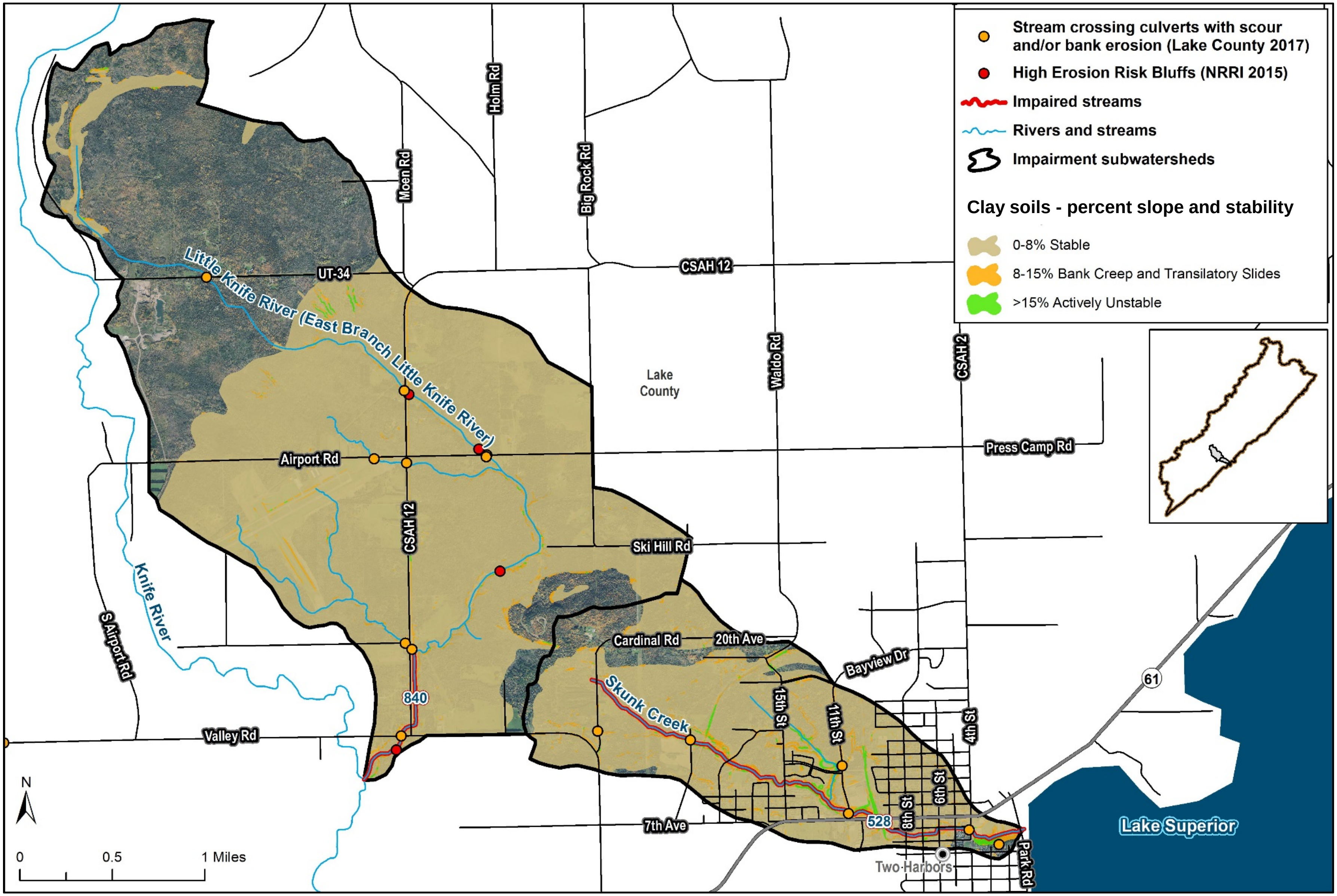

Figure 17. Potential sediment source areas identified within the Little Knife River (East Branch Little Knife River) and Skunk Creek watersheds.

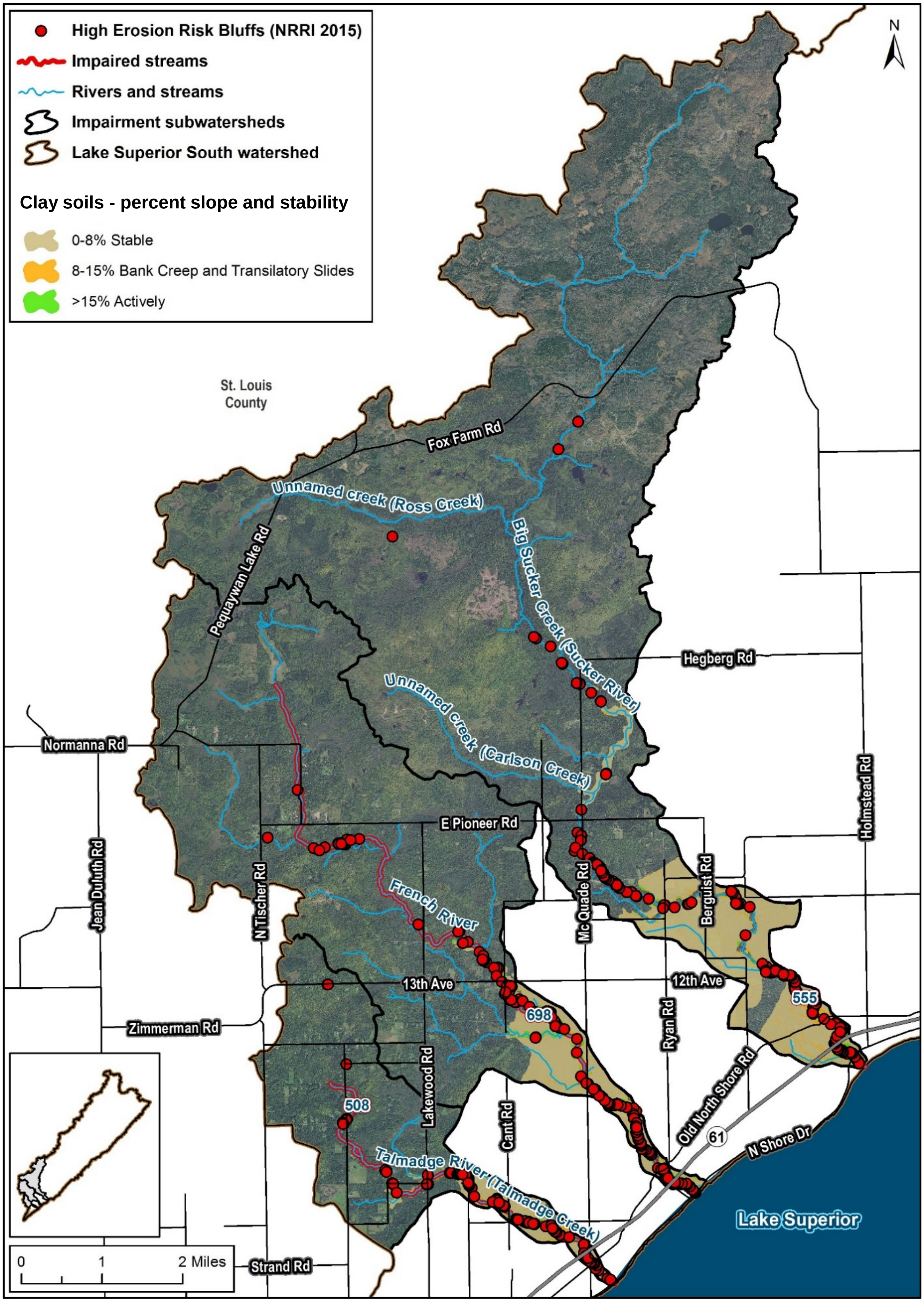

Figure 18. Potential sediment source areas identified within the Talmadge River (Talmadge Creek), French River and Big Sucker Creek (Sucker River) watersheds.

Beaver River (04010102-501)

The Beaver River Subwatershed has been subjected to historic alteration both from logging during the turn of the century and from construction of the Milepost 7 tailings basin during the 1970s. The effects of large scale logging is found throughout the North Shore watersheds, and include increase in snowmelt and rainfall runoff rates, a decrease in vegetation transpiration rates, and subsequent increases in peak flows within the Beaver River and its tributaries (Reidel et al. 2005). The construction of the Mile Post 7 tailings basin included re-routing of tributary streams and changing the drainage areas upstream of the basin, resulting in changes to the channel and increased sediment in the river.

The Stressor ID (MPCA 2017) indicated the following stream reaches were significant sources of sediment in the Beaver River system:

- Beaver River from the Big Thirty-nine Creek confluence to the West Beaver confluence
- Beaver River from Glen Avon Falls to the Superior Hiking Trail crossing
- East Branch Beaver River downstream of Lake County Highway 15
- Cedar Creek downstream of Cedar Creek Road

The BANCS model predicts that 19.5% of the sediment load is coming from about 2.2% of the stream length for the stream reaches analyzed (Figure 19). These banks have predicted erosion rates of about 0.36 tons/feet/year, or 720 lbs of sediment per foot of channel every year. In addition to streambank erosion, sediment also enters the stream as a result of trail and road crossings (MPCA 2017). Clay till soils in West Branch Beaver River could also be contributing to high TSS in the mainstem (Nieber et al. 2016).

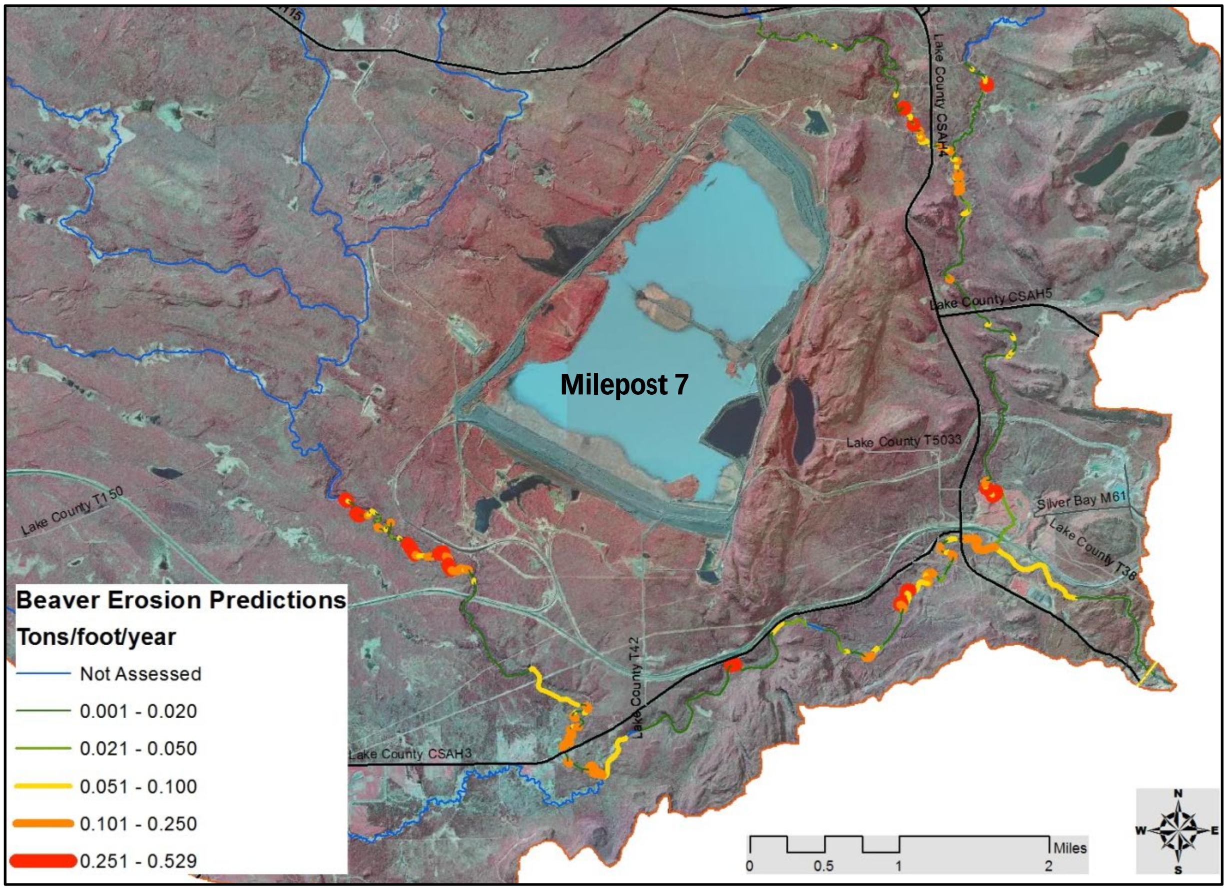

Figure 19. Predicted erosion rates from Beaver River BANCS modeling (MPCA 2017).

Little Knife River (East Branch Little Knife River; 04010102-840)

No new data were collected in the Little Knife River (East Branch Little Knife River) to support TMDL development. Historical information and HSPF modeling for this stream suggests that the Little Knife River has slightly more sediment contributed by watershed loading than near channel sources (Tetra Tech 2016). The fine-grained clay sediment present in much of the watershed is likely contributing to impairment. Brady et al. (2007) identified highly altered riparian habitat in the vicinity of the sampling locations along the Little Knife River, along with grazing in the watershed, as contributing to sediment loads. In addition, open lands within the watershed, including an airport, may be altering flows and sediment loads. Very low flows have been documented in this stream.

Skunk Creek (04010102-528)

No new geomorphic data were collected in Skunk Creek to support TMDL development. Historical information and HSPF modeling for this stream suggests that Skunk Creek is dominated by watershed processes, in particular developed and impervious areas in and around the Two Harbors area (Tetra Tech 2016). A review of longitudinal surveys conducted during three days in 2014 do not reveal hot spots, indicating that a mix of sediment sources are present during different flow conditions in the stream. Likely sources of sediment in Skunk Creek include stormwater runoff, stream crossings (roads, trails, ATVs), and channel scour and bank erosion.

Big Sucker Creek (Sucker River; 04010102-555)

The South St. Louis Soil and Water Conservation Districts (SWCD) conducted a geomorphic assessment and BANCS modeling of the Sucker River in 2017 (Figure 20). Several smaller areas were identified as having higher erosion potential. In addition, Nieber et al. (2016) identified many sites with high erosion potential using LiDAR analysis in the lower stream reaches. These high erosion sites are located in clay till soils. Based on available data at the time of their report (i.e., through 2008), Nieber et al. (2016) estimated an average contribution to sediment loads from bluffs at 39%. Estimates were extrapolated from nearby Amity Creek bluff erosion measurements by Nietzel (2014) using terrestrial laser scanning equipment. Tetra Tech (2016) estimated the near-channel processes contribute closer to 60% of the sediment load to the stream. Watershed loading resulting from activities on the land surface account for the remaining load.

Big Sucker Creek is identified as impaired in only the most downstream reach. Water quality samples with TSS concentrations greater than the 10 mg/L standard have been collected in the past 10 years at existing water quality monitoring stations along upstream reaches. No exceedances were observed upstream of the Hegberg Road crossing. Additional sampling in the upstream reaches may help to refine the sources of sediment causing impairment.

French River (04010102-698)

The MPCA conducted a geomorphic assessment and BANCS modeling of the French River in 2017 (Figure 21). Several high loading banks were inventoried as part of this work upstream of McQuade Road. HSPF modeling of the watershed indicated slightly higher sediment contributions from near-channel sources.

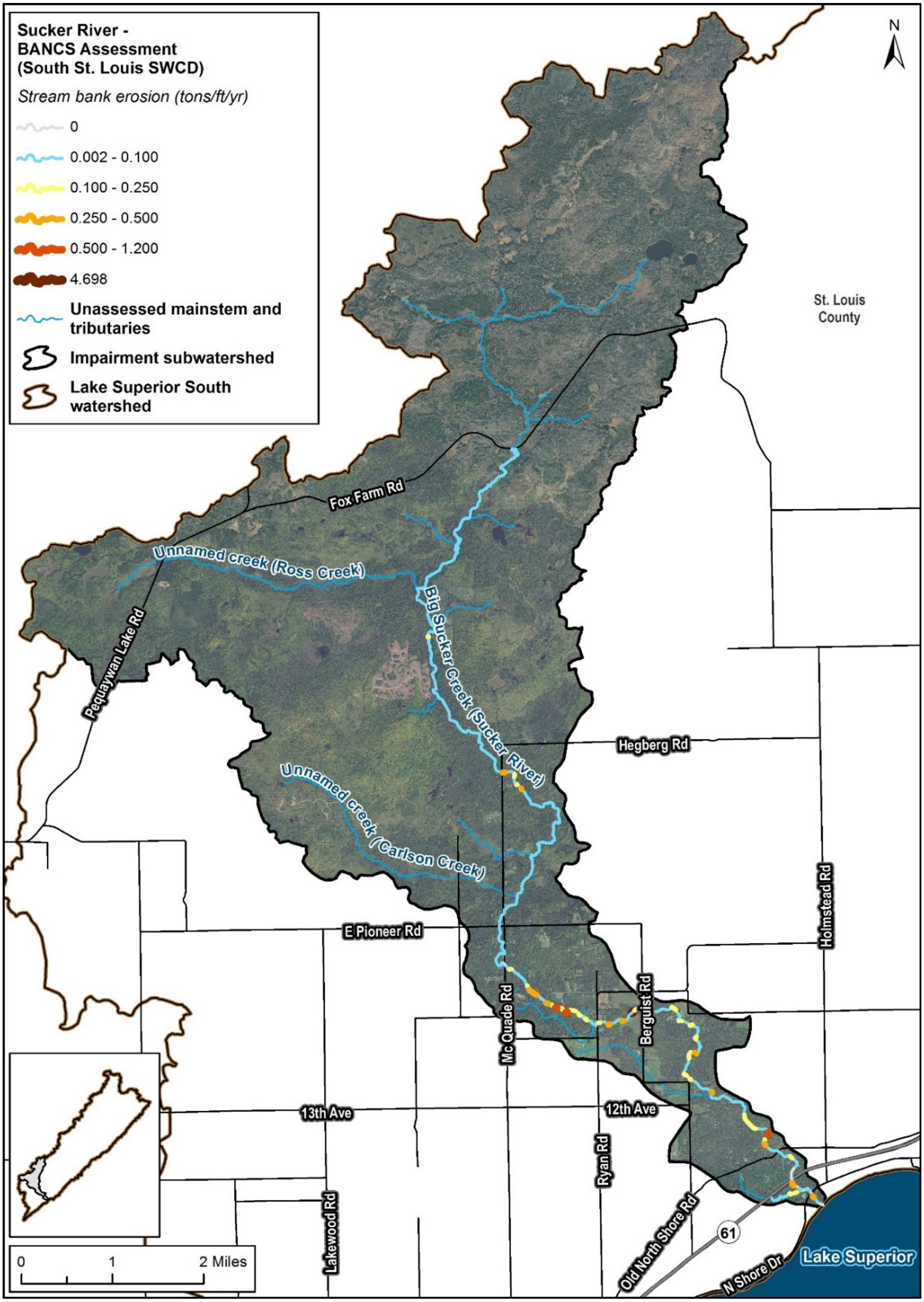

Figure 20. Big Sucker Creek BANCS modeling predicted erosion rates (SSLSWCD undated).

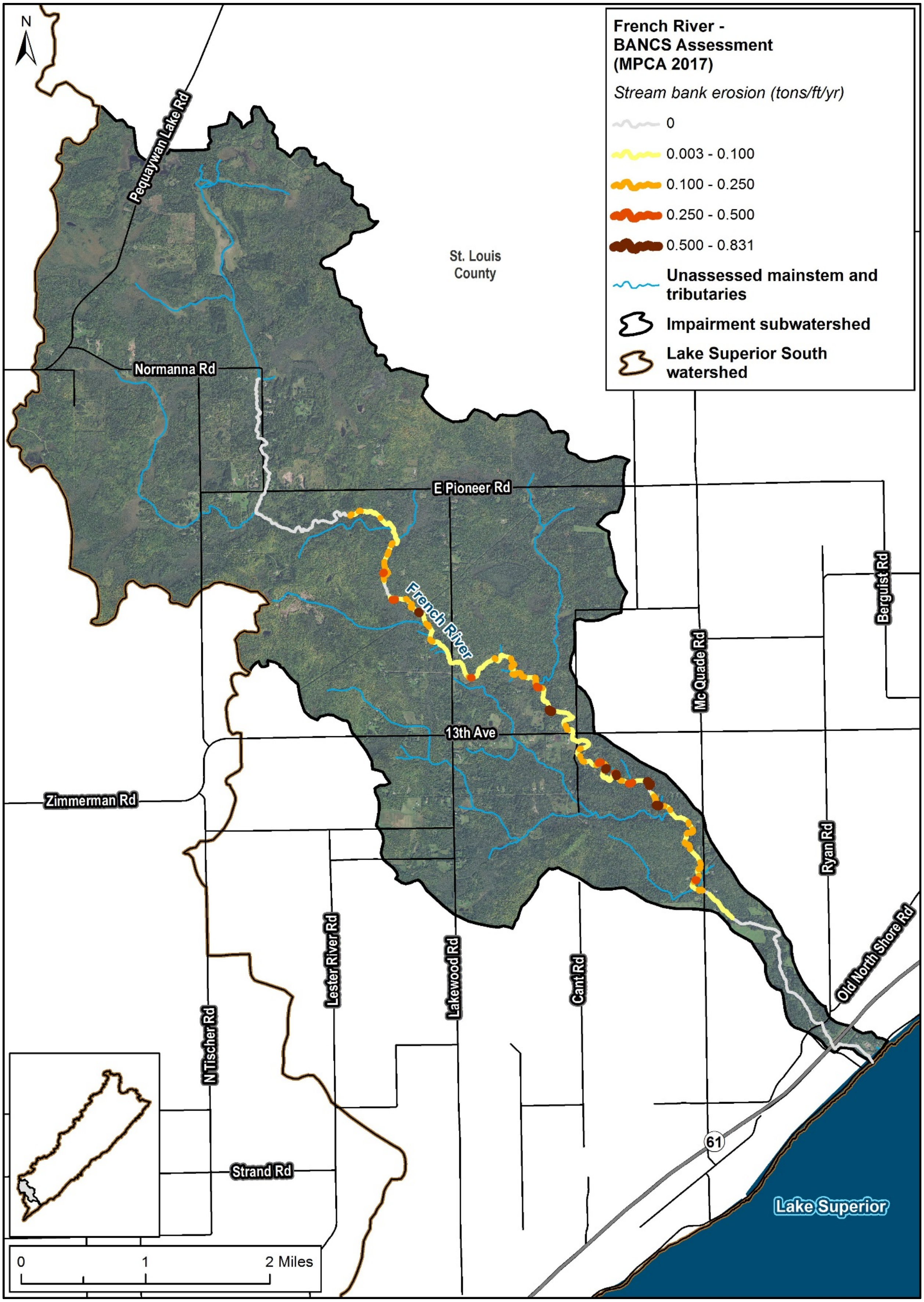

Figure 21. French River BANCS modeling predicted erosion rates (MPCA undated).

Talmadge River (Talmadge Creek; 04010102-508)

Sources of sediment in the Talmadge River include bed and bank scouring and watershed loading. The MPCA (2017) identified areas of channel instability and bank erosion mostly between the McDonnell Road biological monitoring site (11LS038) and the Highway 61 expressway. These reaches mark the transition between the low gradient, unconfined headwater reaches and the bedrock-controlled stretches near Lake Superior. Sediment inputs from the reach between McDonnell Road and the Highway 61 expressway are the primary drivers of the impairment (MPCA 2017). A reach-scale restoration project was completed in 2016 near Highway 61 to reduce bank erosion and improve physical habitat along 700 feet of stream channel. A BANCS modeling assessment predicts that 43% of the sediment load is coming from about 2.5% of the stream length (for reaches that were analyzed), with predicted erosion rates of about 0.35 tons/feet/year, or 700 lbs of sediment per foot of channel every year. The Talmadge River is very flashy, resulting in high peaks and very low flow conditions. Protecting existing wetlands is important in this watershed as they provide storage and help to mitigate peak flows downstream.

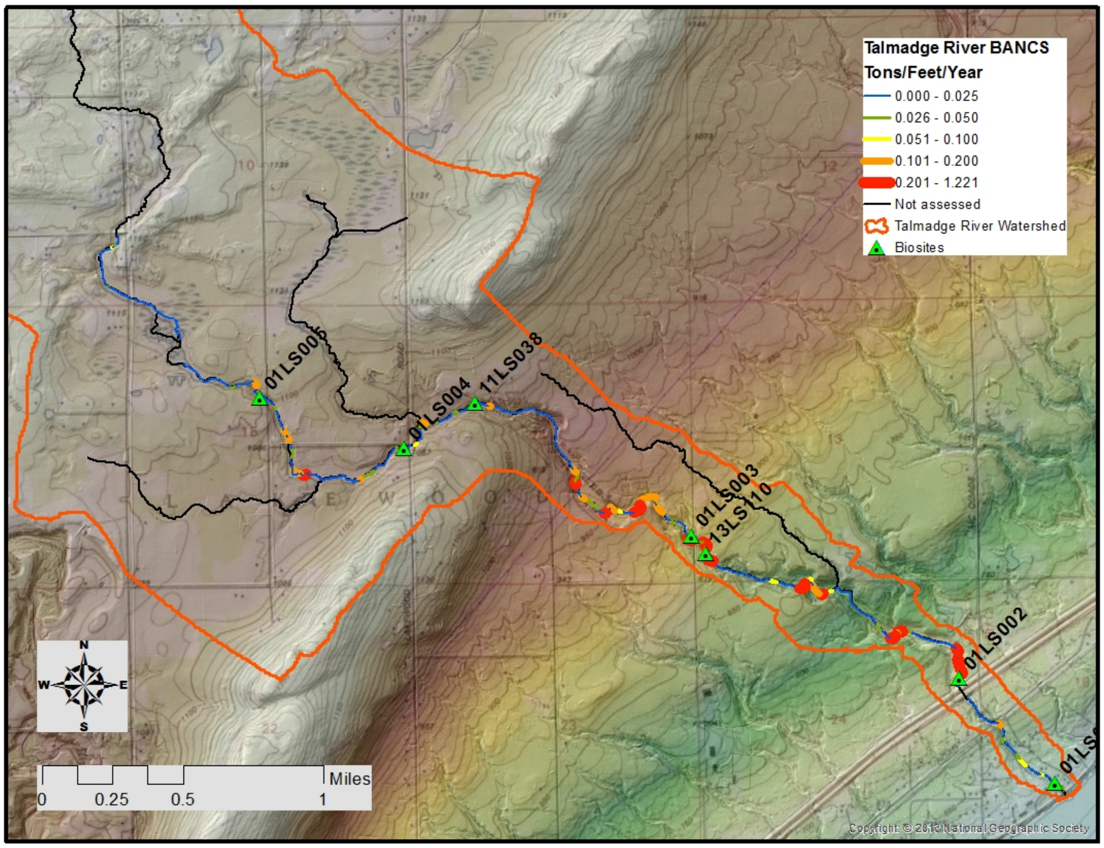

Figure 22. Talmadge River BANCS predicted erosion rates (MPCA 2017).

3.4.2 *E. coli*

Skunk Creek is the only stream in the watershed impaired due to high levels of *E. coli*. In addition to the stream, two Lake Superior beaches are also impaired by *E. coli*. Both impaired beaches are in close proximity to the Skunk Creek confluence with Lake Superior and will be addressed under a separate TMDL process. The Skunk Creek Subwatershed is very small, less than two square miles in size, and includes much of the city of Two Harbors. The watershed has a fairly high residential population density compared to other LSS impaired streams.

The *E. coli* source assessment evaluated permitted and non-permitted source loads from humans, wildlife, and domestic pets. A weight of evidence approach was used to determine the primary sources of *E. coli*, with a focus on the sources that can be effectively reduced with management practices. Die-off or instream growth of *E. coli* was not explicitly addressed. However, *E. coli* strains can become naturalized components of the soil microbial community (Ishii et al. 2006) and have been found in ditch sediment in the Seven Mile Creek Watershed, Minnesota (Sadowsky et al. n.d., Chandrasekaran et al. 2015). The ultimate origin of the naturalized bacteria is unknown.

Permitted

There are no permitted sources of *E. coli* in the Skunk Creek Subwatershed. However, the city of Two Harbors operates a wastewater facility with a permitted discharge to Lake Superior, and in 2013 and 2014, the MPCA reported two events that caused untreated sewage to flow into Skunk Creek. The connection to Skunk Creek had been previously unknown. There are no other known overflows to Skunk Creek. The cause of the overflows was related to an electrical issue. In addition, aging infrastructure could be contributing to *E. coli* loadings in area streams. The city of Two Harbors has identified infiltration and inflow as an issue requiring evaluation and potential infrastructure improvements in the future.

Non-Permitted Sources

Nonpoint sources of *E. coli* may include failing septic and wastewater systems, stormwater runoff, wildlife, and pets. Wildlife such as deer, raccoon, and waterfowl contribute to *E. coli* loading in the watershed; however, these sources are not typically managed. No specific information is available on wildlife populations in the Skunk Creek Subwatershed or their potential to impact *E. coli* loadings.

Septic systems that function properly do not contribute *E. coli* to surface waters. Septic systems that discharge untreated sewage to the land surface are considered an imminent public health threat and can contribute *E. coli* to surface waters. Outside of the developed area near Two Harbors, there are an estimated 60 to 70 homes with septic systems. Of these, it is estimated that 17% are failing (MPCA 2013) and potentially contributing to *E. coli* loading.

Other human sources of *E. coli* in the watershed include straight pipe discharges and earthen pit outhouses. Straight pipe systems are sewage disposal systems that transport raw or partially settled sewage directly to a lake, stream, drainage system, or the ground surface. Straight pipe systems and earthen pit outhouses likely exist in the watershed, but their number and locations are unknown and were not quantified.

Whereas stormwater runoff is not an actual source of *E. coli* to surface waters, it acts as an important delivery mechanism of multiple *E. coli* sources including humans, wildlife, and domestic pets.

Stormwater runoff from impervious areas (such as roads, driveways, and rooftops) can connect the location where *E. coli* is deposited on the landscape to surface waters. For example, there is a greater likelihood that uncollected pet waste in an urban area will reach surface waters through stormwater runoff than it would in a rural area with less impervious surfaces. Wildlife, such as birds and raccoons, can be another source of *E. coli* in urban stormwater runoff (Wu et al. 2011, Jiang et al. 2007).

4. TMDL Development

A TMDL is the total amount of a pollutant that a receiving water body can assimilate while still achieving water quality standards. TMDLs can be expressed in terms of mass per time or by other appropriate measures. TMDLs are composed of the sum of wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL includes a MOS, either implicit or explicit, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving water body. Conceptually, this is defined by the equation:

TMDL = WLA + LA + MOS

A summary of the allowable loads for all impairment-related parameters in the LSS Watershed is presented in this section. The allocations for each of the various sources and parameters are shown in the tables throughout this section.

Allowable pollutant loads in streams are determined through the use of load duration curves. A load duration curve is similar to a water quality duration curve except that loads rather than concentrations are plotted on the vertical axis. Discussions of load duration curves are presented in *An Approach for Using Load Duration Curves in the Development of TMDLs* (EPA 2007). The approach involves calculating the allowable loadings over the range of flow conditions expected to occur in the impaired stream by taking the following steps:

1. A flow duration curve for the stream is developed by generating a flow frequency table and plotting the data points to form a curve. The data reflect a range of natural occurrences from extremely high flows to extremely low flows. The flow data are year-round simulated daily average flows (1993 through 2012) from the LSS HSPF model application. The model report (Tetra Tech 2016; see Appendix A) describes the framework and data were used to develop the model, and includes information on the calibration.
2. The flow curve is translated into a load duration curve by multiplying each flow value by the water quality standard/target for a pollutant (as a concentration), then multiplying by conversion factors to yield results in the proper units. The resulting points are plotted to create a load duration curve.
3. Each water quality sample is converted to a load by multiplying the water quality sample concentration by the average daily flow on the day the sample was collected. Then, the individual loads are plotted as points on the load duration curve graph and can be compared to the water quality standard/target, or load duration curve.
4. Points plotting above the curve represent deviations from the water quality standard/target and the daily allowable load. Those plotting below the curve represent compliance with standards and the daily allowable load.
5. The area beneath the TMDL curve is interpreted as the loading capacity of the stream. The difference between this area and the area representing the current loading conditions is the load that must be reduced to meet water quality standards/targets.

The stream flows displayed on load duration curves may be grouped into various flow regimes. The flow regimes are typically divided into 10 groups, which can be further categorized into the following five hydrologic zones:

- Very high flow zone: stream flows that plot in the 0 to 10-percentile range, related to flood flows
- High flow zone: flows in the 10 to 40-percentile range, related to wet weather conditions
- Mid-range flow zone: flows in the 40 to 60-percentile range, median stream flow conditions
- Low flow zone: flows in the 60 to 90-percentile range, related to dry weather flows
- Very low flow zone: flows in the 90 to 100-percentile range, related to drought conditions

The duration curve approach helps to identify the issues surrounding the impairment and to roughly differentiate among sources. Exceedances at the right side of the graph occur during lower flow conditions, and may be derived from sources such as failing septic systems. Exceedances on the left side of the graph occur during higher flow events, and may be derived from sources such as runoff. The load duration curve approach helps select implementation practices that are most effective for reducing loads on the basis of flow regime.

Table 21 summarizes the general relationship between the five hydrologic zones and potentially contributing source areas (the table is not specific to an individual pollutant). For example, the table indicates that impacts from point sources are usually most pronounced during dry and low flow zones because there is less water in the stream to assimilate their loads. In contrast, impacts from channel bank erosion is most pronounced during high flow zones because these are the periods during which stream velocities are high enough to cause erosion to occur.

Table 21. Relationship between duration curve zones and contributing pollutant sources

Contributing Source Area	Duration Curve Zone				
	Very High	High	Mid-range	Low	Very Low
Livestock access to streams				M	H
Septic systems	M	M-H	H	H	H
Riparian areas		H	H	M	
Stormwater	H	H	M		
Bank erosion	H	M			

Note: Potential relative importance of source area to contribute pollutant loads under given hydrologic condition (H: High; M: Medium; L: Low).

The load duration curve method was used to develop the stream TMDLs. The approach 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, only five points on the entire loading capacity curve are depicted—the midpoints of the designated flow zones (e.g., for the high flow zone [0 to 10-percentile], the TMDL was calculated at the 5th percentile). However, the entire curve represents the TMDL and is what is ultimately approved by the EPA.

4.1 Total Suspended Solids

4.1.1 Approach

Loading Capacity and Load Reduction

The loading capacity was calculated as flow multiplied by the TSS standard (10 or 15 mg/L) and represents the TSS load in the stream when the stream is at the TSS standard. The existing loads were calculated as the 90th percentile of observed TSS loads in each flow zone from the months that the standard applies (April through September); the monitoring data concentrations were multiplied by estimated flow. The percent reductions needed to meet the TMDL were calculated as the TMDL minus the existing load divided by the existing load; this calculation generates the portion of the existing load that must be reduced to achieve the TMDL. If the existing load was lower than the TMDL for a flow regime, the percent reduction needed to meet the TMDL is reported as 0%. The simulated flow data and the TSS monitoring data used to calculate the loading capacity and the percent reductions needed to meet the TMDL are from 1993 through 2012 and 2007 through 2016, respectively. 2016 is the baseline year against which future reductions will be compared.

The Clean Water Act requires that TMDLs take into account critical conditions for stream flow, loading, and water quality parameters as part of the analysis of loading capacity. Through the load duration curve approach it has been determined that load reductions are needed for specific flow conditions; however, the critical conditions (the periods when the greatest reductions are required) vary by location and are inherently addressed by specifying different levels of reduction according to flow.

Load Allocation

The LA represents the portion of the loading capacity that is allocated to unregulated pollutant loads (e.g., watershed runoff, channel erosion). The LA is calculated as the loading capacity minus the sum of the WLAs and MOS. The LA includes nonpoint pollution sources that are not subject to permit requirements and also includes natural background sources of sediment.

Natural background is defined in both Minnesota rule and statute:

Minn. R. 7050.0150, subp. 4:

> "Natural causes" means the multiplicity of factors that determine the physical, chemical or biological conditions that would exist in the absence of measurable impacts from human activity or influence.

The Clean Water Legacy Act (Minn. Stat. § 114D.10, subd. 10) defines *natural background* as:

> … characteristics of the water body resulting from the multiplicity of factors in nature, including climate and ecosystem dynamics that affect the physical, chemical or biological conditions in a water body, but does not include measurable and distinguishable pollution that is attributable to human activity or influence.

Natural background sources are inputs that would be expected under natural, undisturbed conditions. Natural background sources can include inputs from natural geologic processes such as soil loss from upland erosion and stream development; atmospheric deposition; wildlife; and loading from grassland, forests, and other natural land covers. In the LSS, much of the watershed is already assumed to be representing natural background, specifically forested and wetland areas.

Based on the MPCA's water body assessment process and the TMDL source assessment exercises, there is no evidence at this time to suggest that natural background sources are major drivers of the water body impairments or affect their ability to meet state water quality standards. For all impairments addressed in this study, natural background sources are implicitly included in the LA portion of the TMDL, and TMDL reductions should focus on the major anthropogenic sources identified in the source assessment.

Additionally, the TSS standard inherently addresses natural background conditions. Minnesota's regional TSS standards are based on reference or least-impacted streams and take into account differing levels of sediment present in streams and rivers in the many ecoregions across the state, depending on factors such as topography, soils, and climate (MPCA 2011).

Wasteload Allocation

The WLA represents the portion of the loading capacity that is allocated to pollutant loads that are regulated through an NPDES permit. Municipal and industrial wastewater, regulated MS4s, construction stormwater, and industrial stormwater are provided WLAs for TSS TMDLs.

Municipal and Industrial Wastewater

There are three NPDES-permitted facilities discharging to TSS impairments in the LSS Watershed:

- Beaver Bay WWTP (MN0040754) is a stabilization pond facility that discharges municipal wastewater effluent to the Beaver River (04010102-501).
- Northshore Mining–Silver Bay (MN0055301) discharges industrial wastewater to the Beaver River (04010102-501).
- DNR French River Hatchery (MN0004413) discharges industrial wastewater to the French River (04010102-698).

The TSS permit limits of all three facilities are greater than the receiving water bodies' TSS standard of 10 mg/L (Table 22). Individual WLAs were developed for each wastewater facility. WLAs were calculated as the product of each facility's design flow (maximum daily discharge for Beaver Bay WWTP and maximum design flow for the industrial dischargers) and 10 mg/L TSS (Table 22). The following discussion provides additional details for each of the three wastewater WLAs.

<u>Beaver Bay WWTP:</u> The stream TSS standards were developed to protect aquatic life from the effects of inorganic suspended particles, which can clog fish gills and filter feeding organs, leading to impaired biota assemblages (MPCA 2015). However, TSS is composed of both organic (measured as volatile suspended solids [VSS]) and inorganic (measured as non-volatile suspended solids [NVSS]) particles. Most of the TSS in municipal wastewater discharges is organic matter, which does not tend to persist in the environment. Effluent from stabilization pond treatment plants is typically only 30% inorganic particles (MPCA 2015). Therefore, at Beaver Bay WWTP's permitted effluent concentration limit of 30 mg/L (calendar monthly average) or 45 mg/L (calendar weekly average) TSS, the inorganic solids concentration would be approximately 9 mg/L or 13.5 mg/L NVSS, respectively. In MPCA's memo, "Compatibility of existing technology based effluent limits (TBELs) with new TSS water quality standards" (MPCA 2015), it is assumed that the intent of the TSS standards is to represent the concentration of inorganic particles in the stream. Under this assumption, the wastewater

effluent would meet the TSS standard of 10 mg/L at the facility's permitted calendar monthly average effluent concentration limit, but not at the calendar weekly average limit. TSS WLAs for municipal wastewater are typically based on the calendar monthly average limit.

The WLA for Beaver Bay WWTP is expressed in terms of TSS. It is assumed that the facility's 30 mg/L TSS effluent limit is sufficient to ensure that effluent NVSS concentrations will not exceed the 10 mg/L inorganic TSS concentration and that the facility will meet its WLA. Effluent monitoring may be required to confirm this assumption. Future NPDES permits for the facility may contain water quality based effluent limits (WQBELs) to account for the relationship between NVSS and TSS in the discharge. Such limits would be consistent with the assumptions and requirements of the WLAs. The WLA applies from April 1 through September 30, and is based on the TSS standard of 10 mg/L TSS and the facility's maximum daily discharge (Table 22). It is assumed that if the facility's NVSS concentration is less than 10 mg/L, it is meeting the TSS WLA.

<u>Northshore Mining–Silver Bay</u>: The WLA applies from April 1 through September 30, and is based on the TSS standard of 10 mg/L TSS and the facility's maximum design flow (Table 22). The current calendar monthly average permit limit is 20 mg/L TSS. Future NPDES permits for the facility may contain WQBELs; such limits would be consistent with the assumptions and requirements of the WLA.

<u>DNR French River Hatchery:</u> The WLA applies from April 1 through September 30, and is based on the TSS standard of 10 mg/L TSS and the facility's maximum design flow (Table 22). The current calendar monthly average permit limit is 30 mg/L TSS. Future NPDES permits for the facility may contain WQBELs; such limits would be consistent with the assumptions and requirements of the WLA.

The total daily loading capacity in the very low flow zone for the French River TMDL is less than the WLA for DNR French River Hatchery. This is an artifact of using design flows for allocation setting and results in the facility appearing to use more than the available loading capacity. In reality, actual facility flow can never exceed stream flow as it is a component of stream flow. To account for this situation, the WLAs and LA in the very low flow zone are expressed as an equation rather than an absolute number:

Allocation = flow contribution from a given source x 10 mg/L

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

Table 22. NPDES-permitted facilities for TSS TMDLs

NPDES-permitted Facility (NPDES permit #)	Maximum Daily Discharge or Maximum Design Flow (mgd)	TSS WLA (lb/day), April 1 through September 30 [a]	Impairment (AUID)
Beaver Bay WWTP (MN0040754)	0.26	22 [b]	Beaver River (04010102-501)
Northshore Mining – Silver Bay (MN0055301)	5	417	Beaver River (04010102-501)
DNR French River Hatchery (MN0004413)	1.52	127	French River (04010102-698)

a. WLA is based on the water quality standard of 10 mg/L TSS. Future NPDES permits for each facility may contain water quality based effluent limits (WQBELs); such limits would be consistent with the assumptions and requirements of the WLA.
b. WLA for Beaver Bay WWTP is based on the facility's maximum daily discharge (0.26 mgd) and 10 mg/L TSS. It is assumed that the facility's 30 mg/L TSS effluent limit is sufficient to ensure that effluent NVSS concentrations will not exceed the 10 mg/L inorganic TSS concentration, which is the basis for the water quality standard. Effluent monitoring may be required to confirm this assumption. NPDES permits for WWTPs may contain WQBELs that account for the NVSS characteristics of the discharge. Such limits would be consistent with the assumptions and requirements of the TMDL's WLAs.

Municipal Separate Storm Sewer Systems

The Duluth Township MS4 (MS400134) drains a portion of the Big Sucker Creek (Sucker River) and French River impaired subwatersheds. The Duluth Township roads were considered the regulated area under the MS4 permit (see Section 3.4.1). These areas, 0.07% of the Big Sucker Creek (Sucker River) total watershed area and 0.01% of the French River total watershed area, were used to determine the portions of the watershed load allocated to the MS4.

Construction and Industrial Stormwater

The construction stormwater general permit (MNR100001) regulates construction stormwater, and industrial stormwater is regulated through multiple permits: the multi-sector general permit for industrial stormwater (MNR050000), the general permit for non-metallic mining and associated activities (MNG490000), and the No Exposure exclusion permit (MNRNE0000). Categorical WLAs for construction and industrial stormwater are provided within each TSS TMDL. The average annual (2010 through 2015) percent areas of St. Louis County and Lake County that are regulated through the construction stormwater permit were calculated as 0.01% and 0.003%, respectively (Minnesota Stormwater Manual contributors 2017). The St. Louis County percent area of 0.01 was used in the TSS TMDLs to conservatively account for current and future construction activities. The construction stormwater WLA was calculated as the loading capacity (or TMDL) minus the MOS and the wastewater WLAs multiplied by the percent area:

$$\text{construction stormwater WLA} = (\text{TMDL} - \text{MOS} - \text{wastewater WLAs}) \times 0.01\%$$

Several industrial stormwater permitted facilities are located within TSS impairment subwatersheds (Table 23). To account for all existing and any potential future industrial activities in the watershed, a conservative estimate of double the construction stormwater WLA was used for the industrial stormwater WLAs.

Table 23. Industrial stormwater facilities within TSS impairment subwatersheds

Industrial Stormwater Facility (NPDES permit #)	Impairment (AUID)
Lake County Highway Department (MNG490296) – Lax Lake Pit	Beaver River (04010102-501)
B&B Aggregates (MNRNE38YB)	Little Knife River (East Branch Little Knife River; 04010102-840)
Lake County Highway Department (MNG490296) – Nursery Pit	
Richard B Helgeson Airport (MNR0539FF)	
Builtrite Manufacturing Inc (MNR053CHH)	Skunk Creek (04010102-528)
Arrowhead Recycle Center (MNR0539TD)	

Margin of Safety

The LSS HSPF model was calibrated and validated using nine stream flow gaging stations (Tetra Tech 2016). One gaging station has long-term (40 years) flow records, and the remainder have one to 12 years of flow records. Four in-stream water quality stations were used for the sediment calibration and validation. Calibration results indicate that the HSPF model is a valid representation of hydrologic and sediment conditions between 1993 and 2012 in the watershed. The load duration curves were developed using HSPF-simulated daily flow data. An explicit MOS of 10% was included in the TSS TMDLs to account for uncertainty that the pollutant allocations would attain the water quality targets. This MOS accounts for environmental variability in pollutant loading, limitations and variability in water quality monitoring data, calibration and validation processes of modeling efforts, uncertainty in modeling outputs, and conservative assumptions made during the modeling efforts. The MOS also accounts for limitations associated with estimating flow percentiles for TSS data collected from 2013 to 2016 (outside of the model simulation period). Flow percentiles from nearby USGS gauges were used to determine a representative flow in the impaired stream for each sampling date. This method assumes similar weather conditions at the USGS gauge and along the impairment; variations in temperature and rainfall can result in differences between flow conditions at each location.

Seasonal Variation

TSS concentrations and loads vary seasonally. Seasonal variation is partially addressed by the TSS water quality standard's application during the period when the highest TSS concentrations are expected via snowmelt and storm event runoff. The load duration approach accounts for seasonal variation by evaluating allowable loads on a daily basis over the entire range of observed flows and by presenting daily allowable loads that vary by flow.

4.1.2 TMDL Summaries

Beaver River (04010102-501)

The load duration curve and TMDL allocations for the Beaver River are presented in Figure 23 and Table 24, respectively. Load reductions are needed under all flow regimes, with the exception of low flows. The largest reductions are needed under very high and high flow conditions (81% and 62%, respectively).

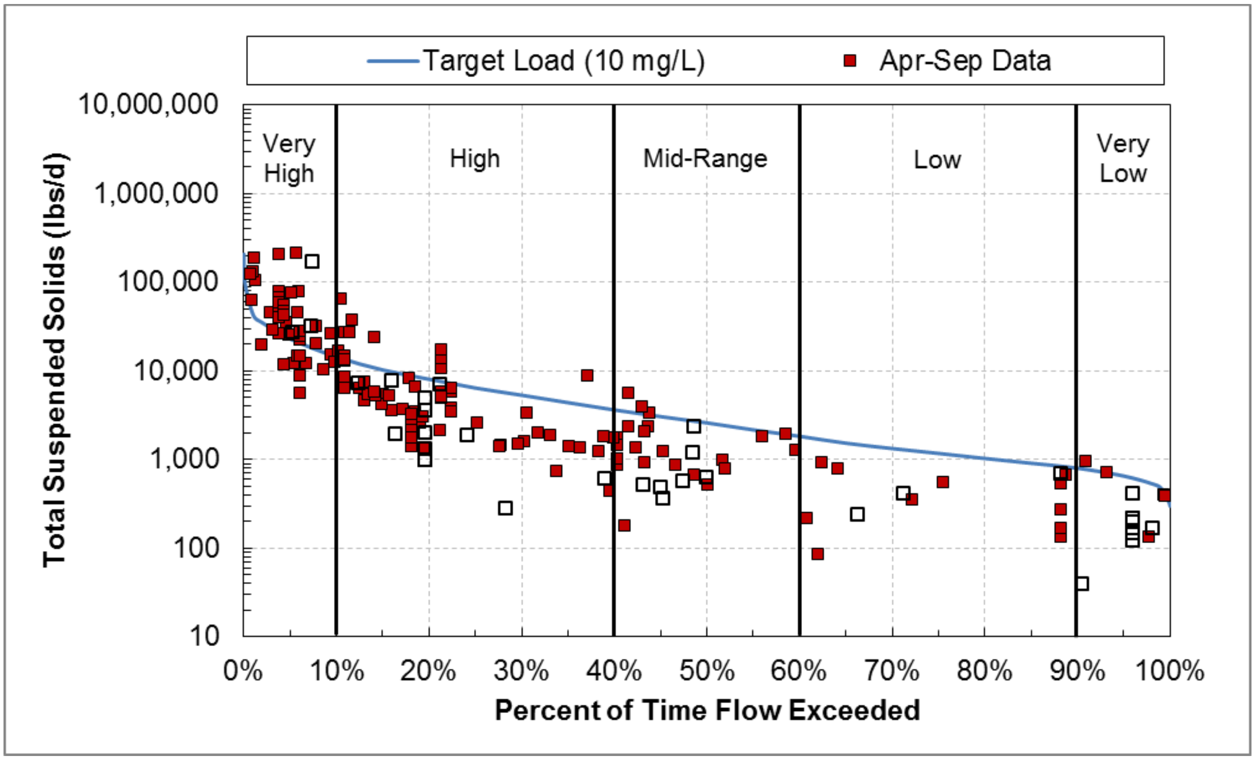

Figure 23. TSS load duration curve, Beaver River (04010102-501).
Hollow points indicate samples during months when the standard does not apply.

Table 24. TSS TMDL Summary, Beaver River (04010102-501)

TMDL Parameter		Very High (267–3,847 cfs)	High (67–267 cfs)	Mid-Range (34–67 cfs)	Low (15–34 cfs)	Very Low (6–15 cfs)
		Flow Regime				
		TSS Load (lbs/day)				
Wasteload Allocation	Beaver Bay WWTP (MN0040754) [a]	22	22	22	22	22
	Northshore Mining – Silver Bay (MN0055301) [b]	417	417	417	417	417
	Industrial Stormwater (MNR050000 and MNG490296) [c]	406	107	38	12	3
	Construction Stormwater (MNR100001) [c]	203	53	19	6	1
Load Allocation		19,678	5,184	1,839	600	144
MOS		2,303	643	259	117	65
Loading Capacity		**23,029**	**6,426**	**2,594**	**1,174**	**652**
Existing Load		120,284	16,926	3,039	785	849
Percent Load Reduction		81%	62%	15%	0%	23%

a. The WLA for Beaver Bay WWTP applies from April 1 through September 30. It is assumed that the facility's 30 mg/L TSS effluent limit is sufficient to ensure that effluent NVSS concentrations will not exceed the 10 mg/L inorganic TSS concentration which is the basis for the water quality standard. Effluent monitoring may be required to confirm this assumption.
b. The current permit limit of Northshore Mining–Silver Bay (MN0055301) is based on 20 mg/L TSS, and the WLA is based on 10 mg/L TSS. A WQBEL will need to be considered upon permit reissuance.
c. It is assumed that loads from permitted construction and industrial stormwater sites that operate in compliance with the permits are meeting the WLA.

Big Sucker Creek (Sucker River; 04010102-555)

The load duration curve and TMDL allocation for Big Sucker Creek (Sucker River) are presented in Figure 24 and Table 25, respectively. Load reductions are needed under very high and high flow conditions. A large load reduction of 96% is needed under very high flow conditions.

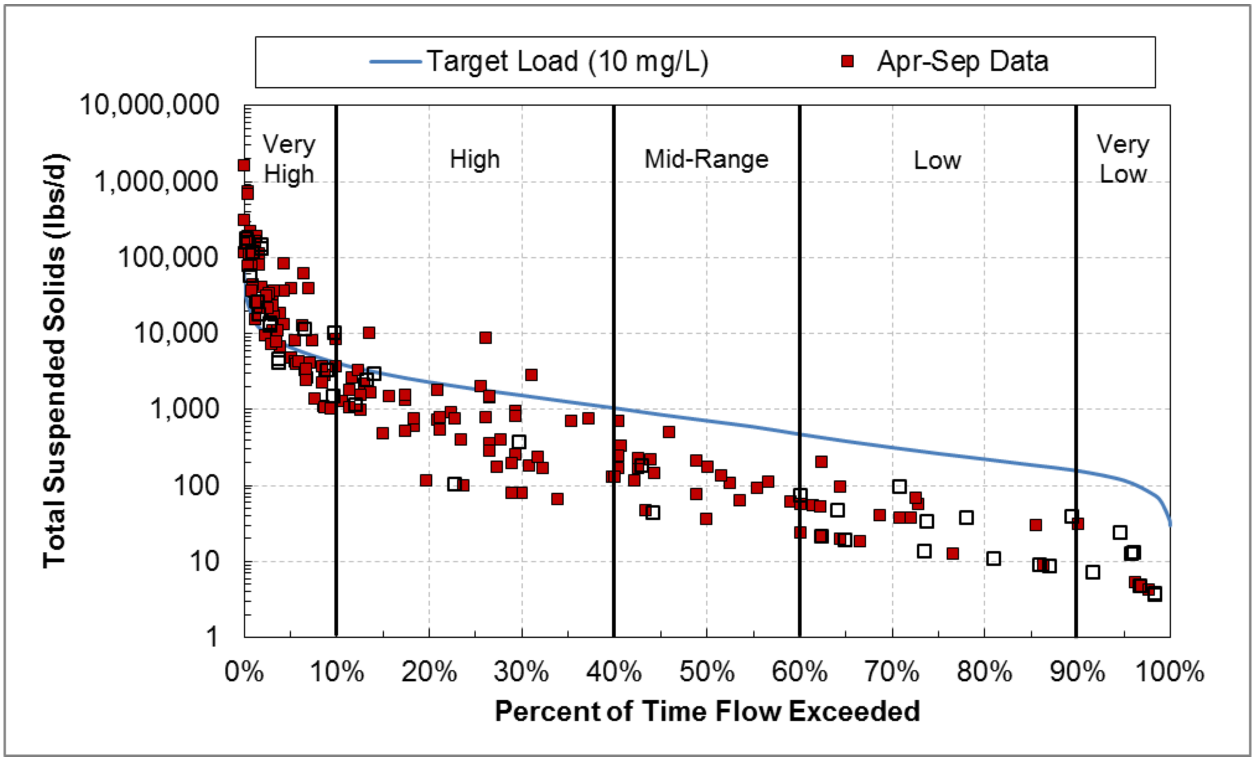

Figure 24. TSS load duration curve, Big Sucker Creek (Sucker River; 04010102-555).
Hollow points indicate samples during months when the standard does not apply.

Table 25. TSS TMDL Summary, Big Sucker Creek (Sucker River; 04010102-555)

TMDL Parameter		Flow Regime				
		Very High (76–1,467 cfs)	High (19–76 cfs)	Mid-Range (9–19 cfs)	Low (3–9 cfs)	Very Low (0.6–3 cfs)
		TSS Load (lbs/day)				
Wasteload Allocation	Duluth Township MS4 (MS400134)	4	1	0.5	0.2	0.1
	Industrial Stormwater (MNR050000) [a]	119	33	13	5	2
	Construction Stormwater (MNR100001) [a]	60	17	6	2	1
Load Allocation		5,781	1,622	623	231	102
MOS		663	186	71	26	12
Loading Capacity [b]		**6,627**	**1,859**	**714**	**264**	**117**
Existing Load		170,024	2,195	328	77	23
Percent Load Reduction		96%	15%	0%	0%	0%

a. It is assumed that loads from permitted construction and industrial stormwater sites that operate in compliance with the permits are meeting the WLA.
b. Loading capacity rounded to nearest whole number.

French River (04010102-698)

The load duration curve and TMDL allocation for the French River are presented in Figure 25 and Table 25, respectively. Significant load reductions are needed under very high and high flow conditions. TSS loads decrease significantly under mid-range and low flow conditions. Samples were not collected under very low flow conditions.

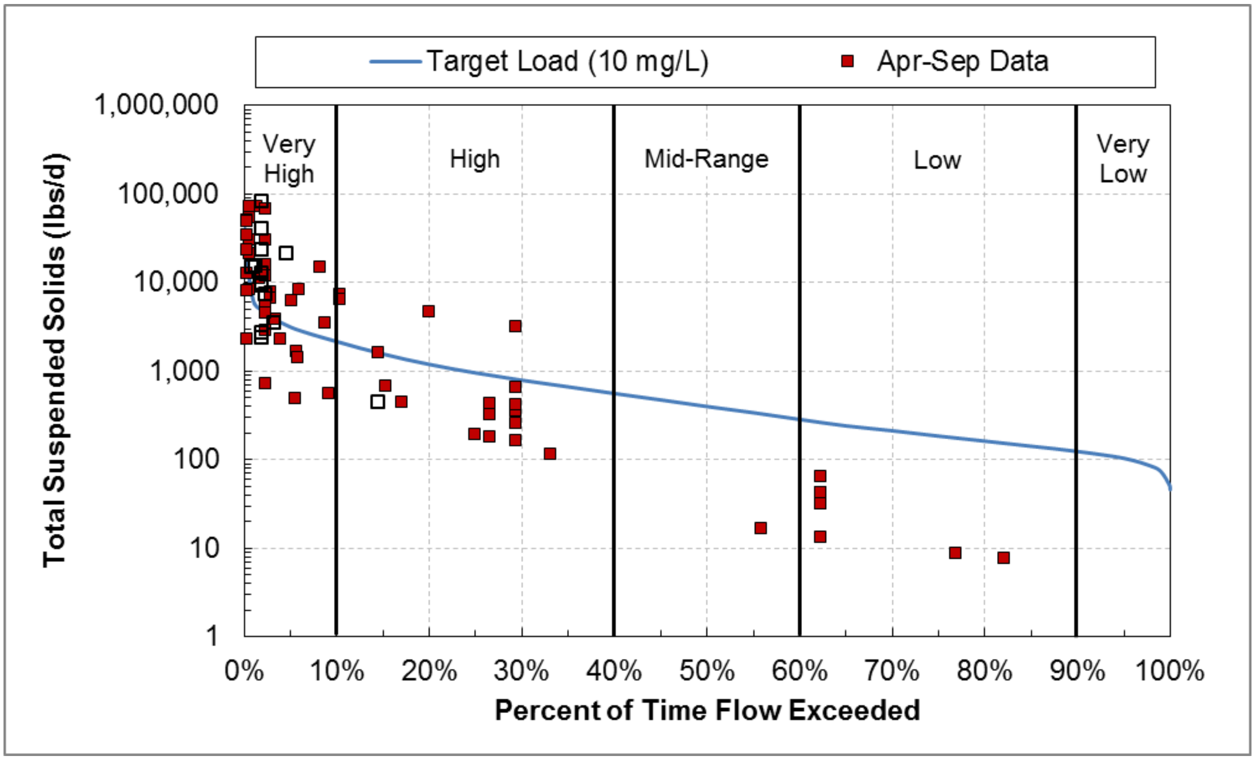

Figure 25. TSS load duration curve, French River (04010102-698).
Hollow points indicate samples during months when the standard does not apply.

Table 26. TSS TMDL Summary, French River (04010102-698)

TMDL Parameter		Flow Regime				
		Very High (40–882 cfs)	High (10–40 cfs)	Mid-Range (5–10 cfs)	Low (2–5 cfs)	Very Low (0.9–2 cfs)
		TSS Load (lbs/day)				
Wasteload Allocation	DNR French River Hatchery (MN0004413) [a]	127	127	127	127	– [b]
	Duluth Township MS4	0.3	0.08	0.03	0.004	– [b]
	Industrial Stormwater (MNR050000) [c]	54	15	5	1	– [b]
	Construction Stormwater (MNR100001) [c]	27	7	2	0.4	– [b]
Load Allocation		2,626	712	226	39	– [b]
MOS		315	96	40	18	10
Loading Capacity [d]		**3,149**	**957**	**400**	**185**	**104**
90th Percentile Existing Concentration (mg/L) [e]		61 mg/L				
Overall Estimated Concentration-Based Percent Reduction (%) [f]		84%				

a. The current permit limit of DNR French River Hatchery (MN0004413) is based on 30 mg/L TSS, and the WLA is based on 10 mg/L TSS. A WQBEL will need to be considered upon permit reissuance.
b. Permitted wastewater design flows exceed stream flow in the indicated flow zone. The allocations are expressed as an equation rather than an absolute number: allocation = flow contribution from a given source x 10 mg/L. See *Municipal and Industrial Wastewater* (Section 4.1.1) for more detail.
c. It is assumed that loads from permitted construction and industrial stormwater sites that operate in compliance with the permits are meeting the WLA.
d. Loading capacity rounded to nearest whole number.
e. The existing concentration was calculated as the 90th percentile of observed TSS concentrations from the months that the standard applies (April through September). The 90th percentile was used because the TSS standard states that the numeric criterion (10 mg/L) may be exceeded for no more than 10 percent of the time.
f. The overall estimated concentration-based percent reduction needed to meet the TMDL was calculated as the 90th percentile existing concentration minus the TSS standard (10 mg/L) divided by the 90th percentile existing concentration. This overall reduction provides a rough approximation of the overall reduction needed for the French River to meet the TMDL. It should not be construed to mean that each of the separate sources listed in the TMDL table need to be reduced by that amount.
-: No data

Talmadge River (Talmadge Creek; 04010102-508)

The load duration curve and TMDL allocation for Talmadge River (Talmadge Creek) are presented in Figure 26 and Table 27, respectively. Significant load reductions are needed under very high and high flow conditions (97% and 95%, respectively). TSS loads decrease significantly under mid-range and low flow conditions. Samples were not collected under very low flow conditions.

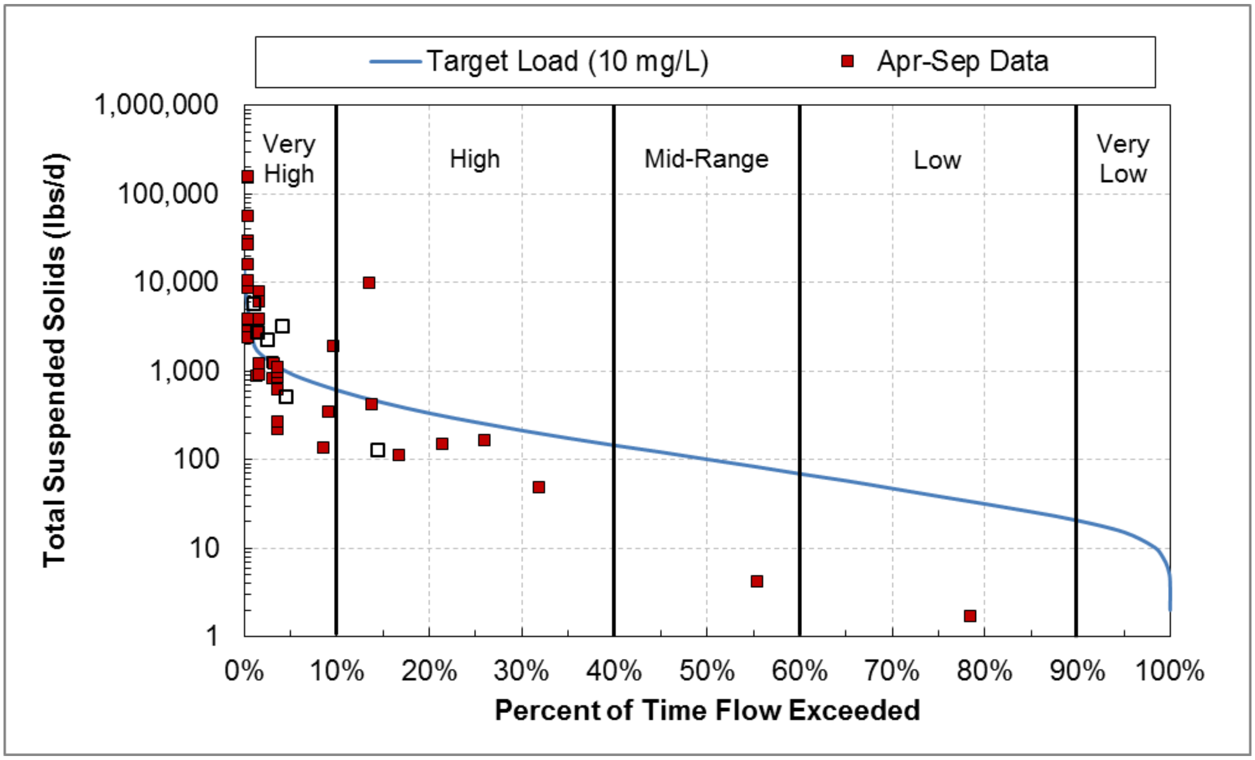

Figure 26. TSS load duration curve, Talmadge River (Talmadge Creek; 04010102-508).
Hollow points indicate samples during months when the standard does not apply.

Table 27. TSS TMDL Summary, Talmadge River (Talmadge Creek; 04010102-508)

TMDL Parameter		Very High (11–261 cfs)	High (3–11 cfs)	Mid-Range (1–3 cfs)	Low (0.4–1 cfs)	Very Low (0.04–0.4 cfs)
		TSS Load (lbs/day)				
Wasteload Allocation	Industrial Stormwater (MNR050000) [a]	16.9	4.8	1.8	0.7	0.3
	Construction Stormwater (MNR100001) [a]	8.5	2.4	0.9	0.3	0.1
Load Allocation		821.9	231.9	88.4	33.7	13.3
MOS		94.1	26.6	10.1	3.9	1.5
Loading Capacity		**941.4**	**265.7**	**101.2**	**38.6**	**15.2**
Existing Load		28,149.7	5,024.5	4.2	1.7	-
Percent Load Reduction		97%	95%	0% [b]	0% [b]	-

-: No data

a. It is assumed that loads from permitted construction and industrial stormwater sites that operate in compliance with the permits are meeting the WLA.

b. Reductions based on one sample point. Additional sampling is needed to verify existing loads.

Little Knife River (East Branch Little Knife River; 04010102-840)

The load duration curve and TMDL allocation for the Little Knife River (East Branch Little Knife River) are presented in Figure 27 and Table 28, respectively. No data collection was completed during the TMDL time period of 2007 through 2016; therefore, existing loads and load reductions cannot be calculated. Data collection from 2004 through 2006 was investigated to determine potential reductions needed. Based on the older data, reductions are needed under all flow conditions, with the exception of mid-range flows. The highest reductions are needed under high flow conditions. New monitoring efforts should be completed within the watershed to determine existing loads and needed reductions.

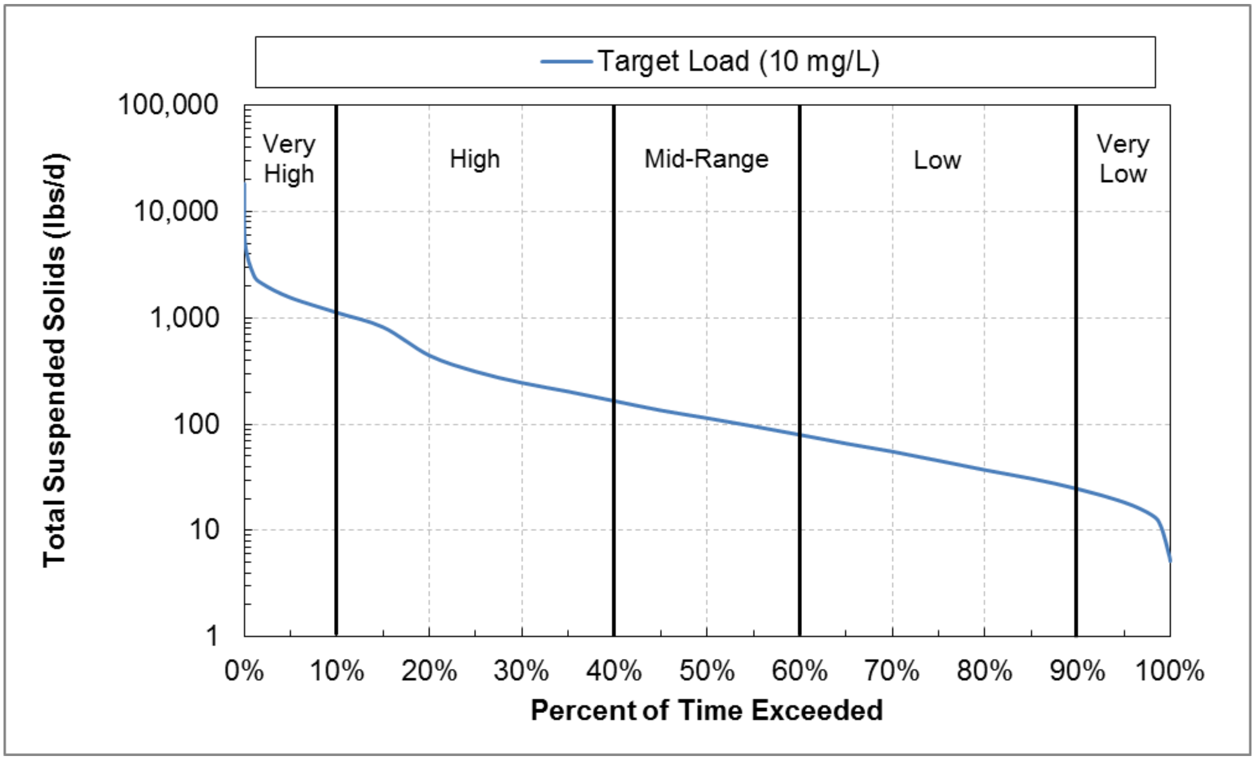

Figure 27. TSS load duration curve, Little Knife River (East Branch Little Knife River; 04010102-840).
No data are available during the TMDL period (2007-2016); older data are provided in Section 3.3.5.

Table 28. TSS TMDL Summary, Little Knife River (East Branch Little Knife River; 04010102-840)

TMDL Parameter		Very High (21–342 cfs)	High (3–21 cfs)	Mid-Range (1–3 cfs)	Low (0.5–1 cfs)	Very Low (0.1–0.5 cfs)
		TSS Load (lbs/day)				
Wasteload Allocation	Industrial Stormwater (MNR050000, MNR0539FF, MNG490296, and MNRNE38YB) [a]	28.0	5.6	2.1	0.8	0.3
	Construction Stormwater (MNR100001) [a]	14.0	2.8	1.0	0.4	0.2
Load Allocation		1,360.0	273.7	99.9	39.7	16.1
MOS		155.8	31.3	11.4	4.6	1.9
Loading Capacity		**1,557.8**	**313.4**	**114.4**	**45.5**	**18.5**
Existing Load		-	-	-	-	-
Percent Load Reduction		-	-	-	-	-

a. It is assumed that loads from permitted construction and industrial stormwater sites that operate in compliance with the permits are meeting the WLA.

-: Data not available during the 2007-2016 TMDL time period

Skunk Creek (04010102-528)

The load duration curve and TMDL allocation for Skunk Creek are presented in Figure 28 and Table 29, respectively. Load reductions are needed under all flow regimes, with the exception of high and mid-range flows. The largest reduction is needed under very high flow conditions.

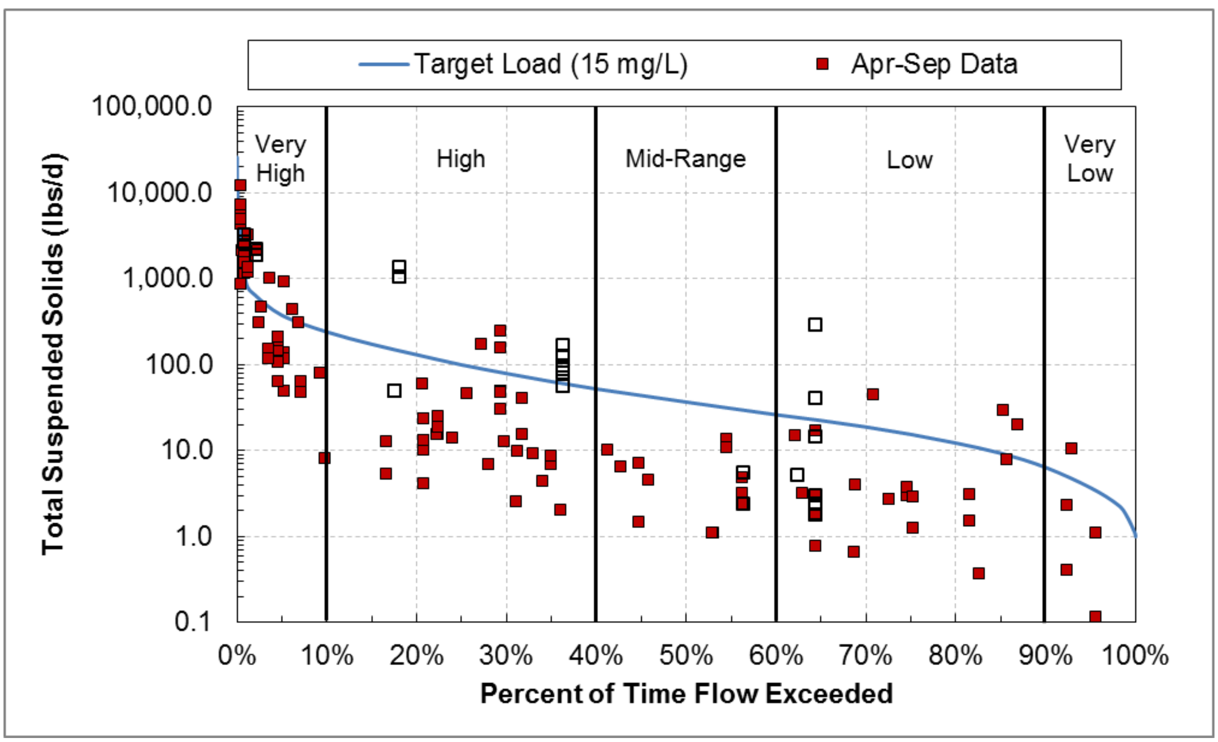

Figure 28. TSS load duration curve, Skunk Creek (04010102-528).

Hollow points indicate samples during months when the standard does not apply; note that Skunk Creek is a Class 2B stream, therefore the water quality standard is based on 15 mg/L.

Table 29. TSS TMDL Summary, Skunk Creek (04010102-528)

TMDL Parameter		Very High (3–321 cfs)	High (0.6–3 cfs)	Mid-Range (0.3–0.6 cfs)	Low (0.08–0.3 cfs)	Very Low (0.01–0.08 cfs)
		Flow Regime				
		TSS Load (lbs/day)				
Wasteload Allocation	Industrial Stormwater (MNR050000, MNR053CHH and MNR0539TD) [a]	6.77	1.79	0.66	0.28	0.07
	Construction Stormwater (MNR100001) [a]	3.39	0.90	0.33	0.14	0.03
Load Allocation		328.44	86.87	32.10	13.48	3.21
MOS		37.62	9.95	3.68	1.54	0.37
Loading Capacity		**376.22**	**99.51**	**36.77**	**15.44**	**3.68**
Existing Load		4,179.49	54.42	10.79	20.14	7.23
Percent Load Reduction		91%	0%	0%	23%	49%

a. It is assumed that loads from permitted construction and industrial stormwater sites that operate in compliance with the permits are meeting the WLA.

4.2 *E. coli*

4.2.1 Approach

Loading Capacity and Percent Reductions

The loading capacity for *E. coli* in Skunk Creek is based on the monthly geometric mean standard (126 org/100 mL). It is assumed that practices that are implemented to meet the geometric mean standard will also address the individual sample standard (1,260 org/100 mL). The loading capacity is calculated as flow multiplied by the *E. coli* standard (126 org/100 mL).

The existing load was calculated as the geometric mean of the observed loads in each flow zone from the months that the standard applies (April through October); the monitored concentrations were multiplied by estimated flow, and then multiplied by a unit conversion factor. The percent reductions needed to meet the TMDL were calculated as the TMDL minus the existing load divided by the existing load; this calculation generates the portion of the existing load that must be reduced to achieve the TMDL. If the existing load is lower than the TMDL for a flow regime, the percent reduction needed to meet the TMDL is reported as 0%. If there are no monitoring data for a flow regime, the existing load and the load reduction are not reported. The simulated flow data and *E. coli* monitoring data used to calculate the loading capacity and the percent reductions needed to meet the TMDL are from 1993 through 2012 and 2011 through 2015, respectively. 2015 is thus the baseline year against which future reductions will be compared.

The Clean Water Act requires that TMDLs take into account critical conditions for stream flow, loading, and water quality parameters as part of the analysis of loading capacity. Through the load duration curve approach it has been determined that load reductions are needed for specific flow conditions; however, the critical conditions (the periods when the greatest reductions are required) vary by location and are inherently addressed by specifying different levels of reduction according to flow.

Load Allocation

The LA represents the portion of the loading capacity that is allocated to pollutant loads that are not regulated through an NPDES permit and is calculated as the loading capacity minus the sum of the WLAs and the MOS. For Skunk Creek, the LA covers watershed runoff and other nonpoint sources such as failing septic systems, leaky wastewater infrastructure, wildlife, and pets. The LA also includes natural background sources of *E. coli* as described in Section 4.1.1. Natural background sources of *E. coli* would include wildlife and naturalized strains of *E. coli*. Quantifying these sources is not possible, and therefore it is also not possible to determine the amount of the LA that should be designated to natural background.

Wasteload Allocation

There are no permitted facilities that discharge *E. coli* in the watershed. Permitted industrial stormwater sources and construction stormwater are not expected to be sources of *E. coli* and are not provided WLAs. Therefore no WLAs are provided for the TMDL.

Margin of Safety

The LSS HSPF model was calibrated and validated using nine stream flow gaging stations (Tetra Tech 2016). One gaging station has long-term (40 years) flow records, and the remainder have 1 to 12 years of flow records. Calibration results indicate that the HSPF model is a valid representation of hydrologic conditions between 1993 and 2012 in the watershed. A load duration curve was developed using HSPF-simulated daily flow data. An explicit MOS of 10% was included in the *E. coli* TMDL to account for uncertainty that the pollutant allocations would attain the water quality targets. The use of an explicit MOS accounts for environmental variability in pollutant loading, limitations and variability in water quality monitoring data, calibration and validation processes of modeling efforts, uncertainty in modeling outputs, and conservative assumptions made during the modeling efforts. The MOS also accounts for limitations associated with estimating flow percentiles for *E. coli* data collected from 2014 to 2015 (outside of the model simulation period). In these cases, flow percentiles from nearby USGS gauges were used to determine a representative flow in the impaired stream for each sampling date. This method assumes similar weather conditions at the USGS gauge and along the impairment; variations in temperature and rainfall can result in differences between flow conditions at each location.

In addition, die-off and instream growth of *E. coli* was not explicitly addressed. The MOS helps to account for variability in *E. coli* concentrations associated with growth and die-off.

Seasonal Variation

Seasonal variations are addressed in this TMDL by assessing conditions only during the season when the water quality standard applies (April 1 through October 31). The load duration approach also accounts for seasonality by evaluating allowable loads on a daily basis over the entire range of observed flows and by presenting daily allowable loads that vary by flow.

4.2.2 TMDL Summary

Skunk Creek (04010102-528)

The load duration curve and TMDL allocations for Skunk Creek are presented in Figure 29 and Table 30, respectively. Based on the observed geometric mean load, reductions are needed under all flow conditions. The largest load reductions are needed under very high to mid-range flow conditions (48% to 66%).

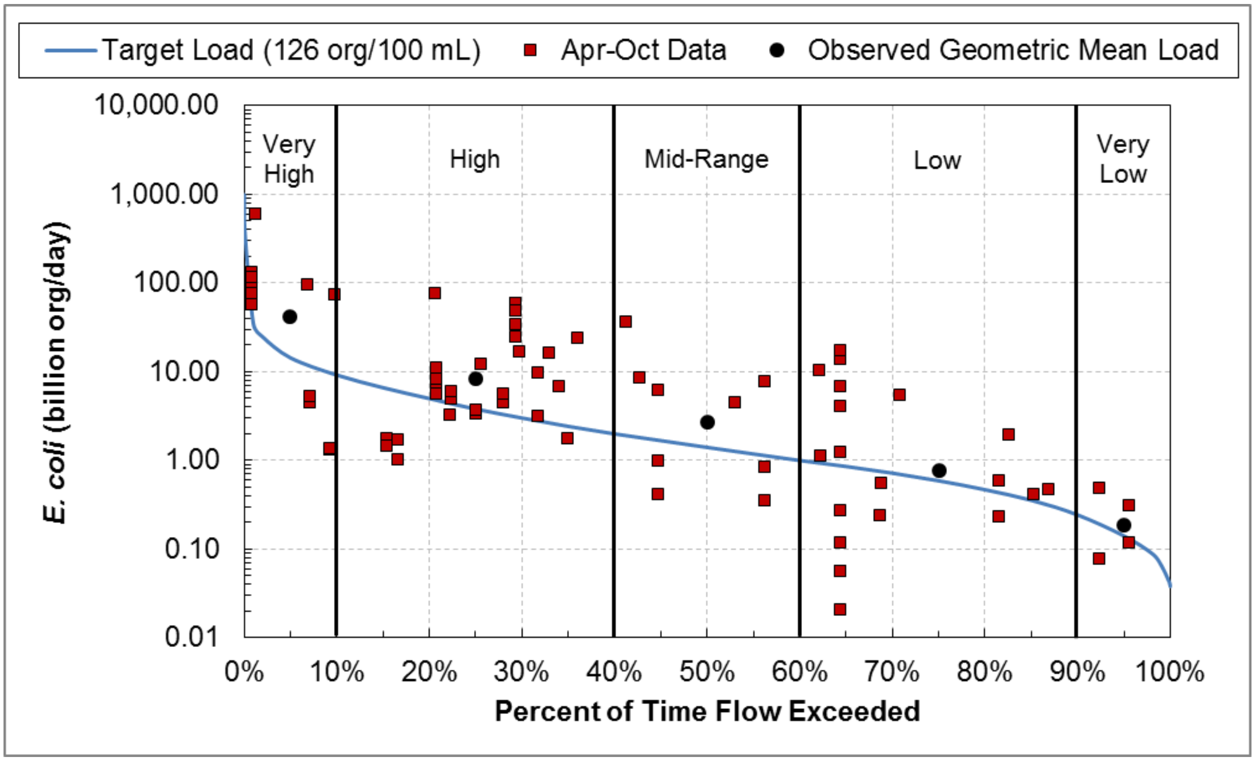

Figure 29. *E. coli* load duration curve, Skunk Creek (04010102-528).

Table 30. *E. coli* TMDL summary, Skunk Creek (04010102-528)

TMDL Parameter	Flow Regime				
	Very High (3–321 cfs)	High (0.6–3 cfs)	Mid-Range (0.3–0.6 cfs)	Low (0.08–0.3 cfs)	Very Low (0.01–0.08 cfs)
	E. coli Load (billion org/day)				
Load Allocation	12.90	3.41	1.26	0.53	0.13
MOS	1.43	0.38	0.14	0.06	0.01
Loading Capacity	**14.33**	**3.79**	**1.40**	**0.59**	**0.14**
Existing Load	42.05	8.31	2.69	0.78	0.19
Percent Load Reduction	66%	54%	48%	24%	26%

5. Future Growth Considerations

5.1 New or Expanding Permitted MS4 WLA Transfer Process

Future transfer of watershed runoff loads in this TMDL may be necessary if any of the following scenarios occur 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, specifically loads will be transferred on a land-area basis between the LA and WLA. 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

The MPCA, in coordination with the U.S. EPA Region 5, has developed a streamlined process for setting or revising WLAs for new or expanding wastewater discharges to water bodies with an EPA approved TMDL (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 U.S. 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 U.S. 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

The EPA requires reasonable assurance that TMDLs will be achieved and water quality standards will be met. Restoration of the LSS Watershed will occur as part of local, regional, state, and federal efforts and will be led by Lake and St. Louis counties, Lake and South St. Louis SWCDs, state agencies, local communities, and residents. In addition, watershed groups such as the Advocates for the Knife River Watershed and entities such as Lake Superior Streams, Trout Unlimited, Lake Superior Steelhead Association, Lake Superior Coldwater Coalition and the University of Minnesota are all active partners in watershed protection and restoration in the LSS Watershed. An updated Lakewide Action and Management Plan was completed in 2016 and also outlines many protection and restoration activities for streams and rivers that are tributary to Lake Superior.

Minnesota's new buffer law requires establishment of up to 50 feet of perennial vegetation along many rivers, streams, and ditches. SWCDs will work with landowners to establish required buffers.

A record of past and on-going activities along with many potential funding sources provide reasonable assurance that progress will be made toward pollutant load reductions and meeting the TMDLs.

Agencies, organizations, and landowners in the LSS Watershed have been implementing water quality projects in an effort to reduce pollutant loading in the watershed, and are expected to continue this effort into the future. For example, the Knife River, a high priority stream, has been the subject of several restoration projects over the past 10 years including:

- Geomorphic assessment of the Main West Branch and Stanley Creek, conducted by the Lake Superior Steelhead Association in partnership with the South St. Louis SWCD in 2015. This work will help prioritize which reaches should be restored first, and what sort of restoration activities would be more appropriate and beneficial for each reach.
- Installation of a toe-wood flood plain bench in 2014 by Lake County SWCD and funded as part of a Great Lakes Commission grant.
- Sediment reduction projects funded by the Great Lakes Commission in 2012 to reduce sediment loads by 750 tons per year through large streambank restoration projects.
- Erosion control project along a riverbank using tree trunks, root wads, brush, clay, fine soil, and sod mats of willow, dogwood, and alder, which was funded by the Clean Water Fund in 2011.
- Tree planting program in 2011 funded by the Clean Water Fund.

Other recently completed plans and projects in impaired watersheds include:

- Nearly 1,300 feet of trout habitat in the Sucker River was restored in 2010 with funding from the Lessard-Sams Outdoor Heritage Council, Minnesota Trout Unlimited, USDA Wildlife Habitat Incentives Program, U.S. Fish & Wildlife Service, DNR, and Namebini.
- East Branch of the Beaver River Restoration and Habitat Enhancement project is planned for public land along the East Branch Beaver River in Silver Bay. The project will stabilize a 1,800 foot long reach of river, restore channel form, create pool and riffle habitat, and stabilize streambanks and reestablish native vegetation to reduce erosion.

- The city of Two Harbors completed a comprehensive management plan that put efforts in place to protect Skunk Creek such as zoning and ordinance changes in vulnerable riparian areas.

Potential funding sources for implementation activities in the LSS Watershed include:

- Clean Water Fund, part of the Clean Water, Land, and Legacy Amendment
- Minnesota's Lake Superior Coastal Program grants
- Local government cost-share and loan programs
- Federal grants and technical assistance programs
- Federal Section 319 program for watershed improvements
- Great Lakes Restoration Initiative
- Great Lakes Commission grants

A WRAPS was developed concurrently with this report that outlines additional implementation opportunities and best management practices (BMPs) that will lead to water quality improvements and achieving the TMDLs. Recently, Lake and Cook County SWCDs developed an updated comprehensive water management plan on a watershed scale that covers the LSS Watershed. This One Watershed, One Plan (1W1P) identifies priority concerns, watershed wide implementation activities and targeted geographic areas for implementation. Implementation of this local water plan will address many watershed issues, including restoration of impaired waters.

7. Monitoring Plan

Monitoring is important for several reasons including:

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

Monitoring is also a critical component of an adaptive management approach and can be used to help determine when a change in management is needed.

The LSS Watershed is scheduled for intensive watershed monitoring (IWM) again in 2021 as part of the MPCA's Watershed Approach. IWM allows the evaluation of the overall health of the state's water resources, assessment of the state's streams for aquatic life, recreation, and consumption use support on a rotating 10-year cycle, and identification of waters in need of protection efforts to prevent impairment.

Monitoring of flow and water quality are needed in streams to refine source assessments and further focus implementation activities. New data can also be used to further improve watershed modeling efforts. This section describes recommended monitoring activities in the watershed. These activities may be, in part, conducted by the MPCA as part of future monitoring efforts or by local partners and other interested stakeholders. Monitoring efforts should use existing programs as much as possible, and are subject to availability of resources.

7.1 Total Suspended Solids

TSS samples are needed throughout the impaired watersheds to further assess potential sources and focus implementation activities.

- Beaver River
    - o Increase sampling at low and very low flow conditions during the target window and near Northshore Mining Mile Post 7 outfall.
- Beaver River, West Branch
    - o Continue monitoring sources to the Beaver River to determine potential impact from West Branch on the Beaver River impairment.
- Big Sucker Creek (Sucker River)
    - o Monitor mainstem headwaters and tributaries to determine source areas. Longitudinal profiles show a slight increase from upstream to downstream, however increased data collection at upstream monitoring stations would improve the relationship.
- French River

- Increase sampling in the headwaters and at downstream stations. Majority of samples have been collected mid-reach at S007-755.
- Increase sampling under mid-range to low flow conditions. Currently no sampling under very low flow conditions.
- Evaluate fish hatchery outflows on TSS in the River, if the hatchery remains open.

- Talmadge River (Talmadge Creek)
  - Continue monitoring effort, with focus on increasing longitudinal samples. Majority of samples collected at downstream station.
  - Increase sampling under mid-range to low flow conditions. Currently no sampling under very low flow conditions.
- Little Knife River (East Branch Little Knife River)
  - No data collection during TMDL time period (2007 through 2016). Priority to start new monitoring effort to define potential reductions needed and inform impairment assessment.
  - Monitor upstream of impaired segment to determine potential source areas as well as monitoring on tributaries and downstream of the airport.
- Skunk Creek
  - Increase sampling in upstream reaches.
  - Monitor storm sewer outlets to determine potential impact.

7.2 *E. coli*

Further assessment of *E. coli* sources in the Skunk Creek Watershed is needed to fully understand the potential sources of *E. coli* and target restoration activities. This assessment should include field evaluation of potential sources such as wildlife. In addition, compliance inspections for all septic systems in the watershed are needed. An assessment of wastewater infrastructure and potential for cross connections between sanitary and storm sewers should be included (e.g., sanitary survey). This assessment, coupled with additional longitudinal sampling, can be used to identify key sources of *E. coli* in the watershed.

7.3 Flow

Stream flow is a critical element to determine compliance with TMDLs and understanding the pollutant loading occurring in the watershed. Additional flow monitoring at all water quality sampling sites is needed. In addition, expanded continuous flow monitoring to more tributaries and during winter time periods is needed to improve hydrologic modeling in the watershed which will in turn improve pollutant loading estimates.

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/State Disposal System (SDS) General Stormwater Permit for Construction Activity (MNR100001). If a construction site owner/operator obtains coverage under the NPDES/SDS General Stormwater Permit and properly selects, installs, and maintains all BMPs required under the permit, including those related to impaired waters discharges and any applicable additional requirements found in Appendix A of the Construction General Permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL. All local construction stormwater requirements must also be met.

8.1.2 Industrial Stormwater

There are currently six industrial stormwater permitted facilities in TSS-impaired watersheds (see Table 23). 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. All local stormwater management requirements must also be met.

8.1.3 MS4

Duluth Township is the only regulated MS4 in the impaired watersheds. Duluth Township regulatory authority is limited to their conveyance network of township roads in the watersheds. County, state and private roads are also located in the watershed, but are not part of an MS4. Implementation strategies that can be used to meet WLAs include stormwater BMPs to reduce TSS loading and disconnecting impervious areas. Management of gravel roads to minimize sediment loss is also an important BMP. MS4 permittees document compliance with WLA(s) over time as part of their MS4 Stormwater Pollution Prevention Program.

Duluth Township conducts regular road inspections, which include culvert inspections and identification of any areas of active erosion. All ditch/culvert maintenance or repair activities undertaken by the

Township include re-seeding/re-vegetation, along with installation of rock armoring, ditch checks and diversions etc. where appropriate to prevent erosion and limit ditch flow/velocity.

Duluth Township has been proactive in addressing potential stormwater problems through their MS4 Water Pollution Prevention Plan, the Township's Comprehensive Plan and coordination with the St. Louis County Comprehensive Water Management Plan. Application of the SWPPP in the watersheds and continuing coordination and participation with the County, city of Duluth and the Regional Stormwater Protection Team is expected to result in the attainment of the WLA.

MS4 permittees with assigned WLAs as part of a TMDL project approved by EPA supplement their SWPPP with information specific to the TMDL. Permittees develop a compliance schedule that lays out interim milestones to achieve during the permit cycle, longer term strategies for implementation beyond the permit term, and target dates to achieve the WLAs. MS4s have flexibility in selecting the types of BMPs implemented to meet permit requirements. An annual report is submitted to MPCA which also provides documented compliance with the program. At periodic intervals the MPCA conducts random audits of programs. In guidance provided to MS4s, MPCA anticipates TMDL reductions will likely take multiple permit cycles to achieve the full load reduction goals of the TMDL. Timelines provided in TMDL reports often note that several years of BMP installation and other watershed management will be necessary to meet water quality standards.

8.1.4 Wastewater

The three permitted wastewater facilities (Beaver Bay WWTP, Northshore Mining–Silver Bay, and DNR French River Hatchery) may require changes to their NPDES permit limits following additional data collection and review by the MPCA permit staff. DMRs from the past five years indicate that TSS concentrations from these facilities are likely meeting the WLAs; however, additional monitoring is needed.

8.2 Non-Permitted Sources

Nonpoint sources of sediment are primarily related to watershed runoff and channel erosion. Nonpoint sources of *E. coli* include failing septic and wastewater systems, stormwater runoff, wildlife, and pets. Additional monitoring is needed in the Skunk Creek Watershed to better assess sources of *E. coli* (see Section 7.2).

A balanced approach will be needed that will include both longer-term/larger-scale and shorter-term/smaller-scale implementation activities. Implementation strategies for non-permitted sources are summarized below.

Strategies to address non-permitted sources of *E. coli* in Skunk Creek

- **Improvements to septic systems**

  Inventory and assess septic systems in unsewered portions of the watershed to eliminate sources of untreated wastewater.

- **Upgrade leaky wastewater infrastructure in urban areas**

Identify and correct leaky wastewater infrastructure to eliminate sources of untreated wastewater. Inflow and infiltration in the Two Harbors area needs additional evaluation to determine needed improvements. Also, ensure the potential for untreated overflow from the Two Harbors wastewater treatment facility is eliminated.

- **Pet waste management programs**

  Enhance existing pet waste management programs to ensure compliance and enforcement as needed. Consider if additional pet waste disposal stations can be added and increase education through city newsletters and other outreach activities. The city of Two Harbors has an existing pet waste ordinance that requires pet owners/guardians to clean up pet waste immediately. The city of Two Harbors also provides pet waste disposal stations and bags throughout the city.

- **Wildlife waste management**

  Continue to educate the public on discouraging feeding of wildlife in the watershed. Consider adding or increasing buffers of vegetation surrounding open water (e.g., ponds, stream) to discourage geese, ducks and other birds from access. Increase the number of trash receptacles in areas frequented by the public and ensure adequate trash removal.

Strategies to address non-permitted sources of sediment in impaired streams

- **Streambank restoration and stabilization**

  Continue to implement streambank restoration activities to address eroding banks and areas of instability in the stream channel. Address channel incision and floodplain cutoffs to ensure stability of channels and reduce runoff.

- **Ditch maintenance guidance**

  Develop and implement new guidance on ditch (public and private) maintenance activities that will minimize un-vegetated channels and associated erosion. Assess the state of existing roadside ditches and identify priority locations for ditch management (e.g., re-vegetation, armoring).

- **Buffer installation**

  Preserve the natural vegetation along stream corridors. Buffers can mitigate pollutant loading associated with human disturbances and help to stabilize streambanks and improve infiltration. Minnesota's buffer law requires establishment of up to 50 feet of perennial vegetation along many rivers, streams, and ditches. SWCDs will work with landowners to establish required buffers. Additional value could be added by working with landowners and residents to also install exclusion fencing or stream crossings to limit access to streams and ensuring enforcement of Minnesota's Shoreland Management Act.

- **Timber harvesting management**

  Work with private land owners to develop forest stewardship plans and implement voluntary site level guidelines provided by the Minnesota Forest Resources Council. Complete open lands assessment every 10 years and work with foresters to maintain a maximum percentage of open land in each watershed (e.g., 60% open lands).

- **Culvert design guidelines and culvert upgrades**

  Work with county and other agencies to upgrade crossings that are barriers for fish passage or contribute to erosion in the stream. Culvert upgrades and replacement should be designed for multiple benefits including fish passage, infrastructure improvement (e.g., roads), erosion control, and grade control. Crossing designs should result in improved fish passage without further degradation of the stream channel. Culverts should be buried to maintain a natural stream bottom and allow bedload transport or, in the case where the culvert is acting as a grade control, rock grade control structures should be used. Recommended design guidelines should be developed.

- **Green infrastructure and stormwater management**

  Provide water quality treatment and storage using green infrastructure and other stormwater BMPs. BMP guidance can be found in MPCA's Stormwater Manual.

In addition to these strategies, education and outreach activities are critical to implementation. Key activities could include providing information to citizens on addressing sources of sediment including stream crossings (e.g., ATV, driveway), forest management activities, and habitat improvements, as well as on addressing sources of *E. coli* such as septic maintenance, proper pet waste disposal, and wildlife.

The Lake Superior South WRAPS Report (concurrently completed with this report) outlines additional implementation opportunities and BMPs that will lead to water quality improvements and achieving the TMDLs.

8.3 Cost

TMDLs are required to include an overall approximation of implementation costs (Minn. Stat. 2007, § 114D.25). The costs to implement the activities outlined in the strategy are approximately $10 to $12 million dollars over the next 25 years. This includes the cost of increasing local capacity to oversee implementation in the watershed as well as planning and capital costs; however it does not include capital costs to address leaky wastewater infrastructure. This range reflects the level of uncertainty in the source assessment.

8.4 Adaptive Management

This list of implementation elements and the more detailed WRAPS report prepared concurrently with this TMDL assessment focuses on adaptive management (Figure 30). Continued monitoring and "course corrections" responding to monitoring results are the most appropriate strategy for attaining the water quality goals established in this TMDL. Management activities will be changed or refined to efficiently meet the TMDL and lay the groundwork for de-listing the impaired water bodies.

Natural resource management involves a temporal sequence of decisions (or implementation actions), in which the best action at each decision point depends on the state of the managed system (Williams et al. 2009). As a structured iterative implementation process, adaptive management offers the flexibility for responsible parties to monitor implementation actions, determine the success of such actions and ultimately, base management decisions upon the measured results of completed implementation actions and the current state of the system. This process enhances the understanding and estimation of predicted outcomes and ensures refinement of necessary activities to better guarantee desirable results. In this way, understanding of the resource can be enhanced over time, and management can be improved (Williams et al. 2009).

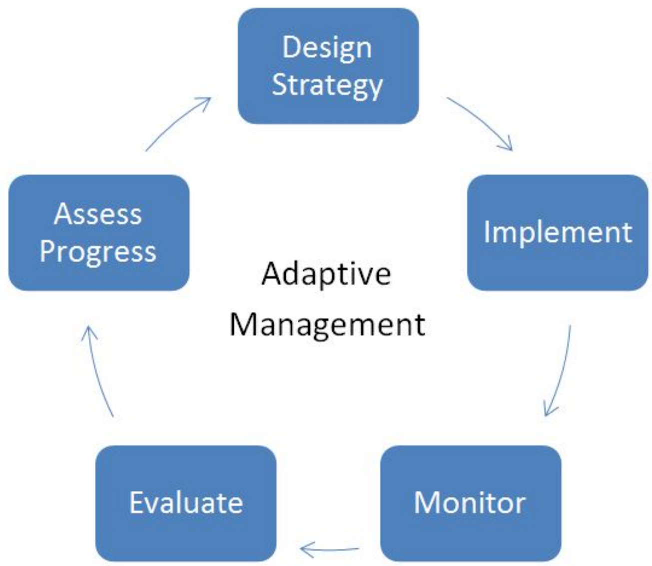

Figure 30. Adaptive management process.

9. Public Participation

A series of stakeholder meetings were held to obtain input on TMDL development. Meetings were held on the following dates:

- **January 24, 2017**

  This meeting kicked off TMDL and WRAPS development and included an overview of the project area, and the TMDL work plan including the watershed modeling work being conducted, water quality assessment, and the approach to source assessments. Attendees shared information on current projects and efforts in the watershed.

- **April 3, 2017**

  This meeting focused on pollutant source assessment, TMDLs, and needed reductions. Attendees shared information on current projects and efforts in the watershed.

- **June 13, 2017**

  This meeting focused on the various TMDL approaches for beaches impaired for *E. coli*, water quality and pollutant source data, and identifying areas for TMDL implementation. For the second half of the meeting, attendees were broken into small groups to provide input on source identification and potential implementation practices for WRAPS development.

- **October 26, 2017**

  This meeting included an overview of the TMDL content, an overview of the MS4 permit program, and information on a stream geomorphic assessment for a nearby creek (Amity Creek). Members of the Core Team, Duluth Urban Watershed Advisory Committee, Regional Stormwater Protection Team, regulated MS4s, and others participated.

Public Notice for Comments

An opportunity for public comment on the draft TMDL report was provided via a public notice in the *State Register* from February 26, 2018, to March 28, 2018. Two response letters were received and updates were made to the report pertinent to the comments. One response letter was received after public notice and updates were made to the report.

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Appendices A, B, C, D, and HSPF Modeling Report