Pioneer-Sarah Creek Subwatershed Watershed Restoration and Protection Strategy Report

(North and South Fork Crow Major Watersheds)

Minnesota Pollution Control Agency

Pioneer-Sarah Creek

CLEAN WATER LAND & LEGACY AMENDMENT

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Project Partners

The following organizations and agencies contributed to the development of the Pioneer-Sarah Creek Watershed Restoration and Protection Strategies document:

Pioneer-Sarah Creek Watershed Management Commission:

- City of Greenfield
- City of Independence
- City of Loretto
- City of Maple Plain
- City of Medina
- City of Minnetrista

Hennepin County Environment and Energy Department

Three Rivers Park District

Metropolitan Council Environmental Services

Minnesota Board of Water and Soil Resources

Minnesota Department of Agriculture

Minnesota Department of Natural Resources

Minnesota Pollution Control Agency

University of Minnesota Extension Services

Wenck Associates, Inc.

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Key Terms

Assessment Unit Identifier (AUID): The unique water body identifier for each river reach comprised of the USGS eight-digit HUC plus a three-character code unique within each HUC.

Aquatic life impairment: The presence and vitality of aquatic life is indicative of the overall water quality of a stream. A stream is considered impaired for impacts to aquatic life if the fish Index of Biotic Integrity (IBI), macroinvertebrate IBI, dissolved oxygen, turbidity, or certain chemical standards are not met.

Aquatic recreation impairment: Streams are considered impaired for impacts to aquatic recreation if fecal bacteria standards are not met. Lakes are considered impaired for impacts to aquatic recreation if total phosphorus, chlorophyll-a, or Secchi disc depth standards are not met.

Hydrologic Unit Code (HUC): A Hydrologic Unit Code (HUC) is assigned by the USGS for each watershed. HUCs are organized in a nested hierarchy by size. For example, the Minnesota River Basin is assigned a HUC-4 of 0702 and the Pomme de Terre River Watershed is assigned a HUC-8 of 07020002.

Impairment: Water bodies are listed as impaired if water quality standards are not met for designated uses including: aquatic life, aquatic recreation, and aquatic consumption.

Index of Biotic integrity (IBI): A method for describing water quality using characteristics of aquatic communities, such as the types of fish and invertebrates found in the waterbody. It is expressed as a numerical value between 0 (lowest quality) to 100 (highest quality).

Protection: This term is used to characterize actions taken in watersheds of waters not known to be impaired to maintain conditions and beneficial uses of the waterbodies.

Restoration: This term is used to characterize actions taken in watersheds of impaired waters to improve conditions, eventually to meet water quality standards and achieve beneficial uses of the waterbodies.

Source (or Pollutant Source): This term is distinguished from 'stressor' to mean only those actions, places or entities that deliver/discharge pollutants (e.g., sediment, phosphorus, nitrogen, pathogens).

Stressor (or Biological Stressor): This is a broad term that includes both pollutant sources and non-pollutant sources or factors (e.g., altered hydrology, dams preventing fish passage) that adversely affect aquatic life.

Total Maximum Daily Load (TMDL): A calculation of the maximum amount of a pollutant that may be introduced into a surface water and still ensure that applicable water quality standards for that water are met. A TMDL is the sum of the wasteload allocation for point sources, a load allocation for nonpoint sources and natural background, an allocation for future growth (i.e., reserve capacity), and a margin of safety as defined in the Code of Federal Regulations.

Summary

The Pioneer-Sarah Creek (PSC) Subwatershed is approximately 70 square miles, and lies mostly in western Hennepin County. The subwatershed is in portions of the North Fork Crow River and South Fork Crow River Watersheds of the Upper Mississippi River Basin. The subwatershed encompasses a diverse landscape that is dominated by undeveloped and agricultural land, with some areas having significant portions of natural resource-based park/preserve areas as well.

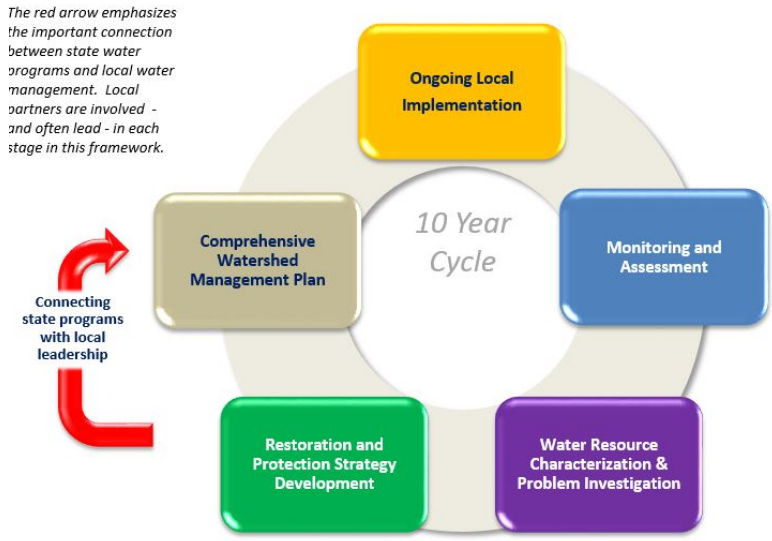
This Watershed Restoration and Protection Strategy (WRAPS) report summarizes past efforts to monitor water quality, identifies impaired water bodies and those in need of protection, and includes strategies for restoring and protecting lakes and streams in the watershed. In general, most lakes in the watershed are impaired by excess nutrients and need to be restored, and the streams are impaired by bacteria. Little Long Lake and Lake Rebecca are currently meeting water quality standards and fully support recreation use. Protection strategies are included in this report to ensure that these lakes continue to be high quality lakes in the watershed.

The primary sources of phosphorus to the lakes include manure, agricultural runoff from cropland areas, internal loading (from sediment release of phosphorus), and urban and rural watershed runoff. The primary sources of *Escherichia coli (E. coli)* to the streams are from livestock, wildlife, and human waste. Bacteria can be transferred to waterbodies from stormwater systems, areas with field-applied manure or manure storage, non-compliant septic systems, or feedlots.

The strategies included in this report to restore and protect lakes and streams in the watershed include:

- Increase buffers as necessary to comply with the buffer law across the watershed
- Reduce internal loading in lakes, which could include an alum treatment, aquatic plant management, and/or rough fish (carp) assessment and management
- Identify and implement livestock and agricultural best management practices (BMPs)
- Improve manure management practices
- Improve urban and suburban stormwater management

What is the WRAPS Report?



The state of Minnesota has adopted a "watershed approach" to address the state's 80 "major" watersheds (denoted by 8-digit hydrologic unit code or HUC). In the Twin Cities Metropolitan Area, subwatersheds are addressed in this framework. This watershed approach incorporates **water quality assessment, watershed analysis, civic engagement, planning**, **implementation**, and **measurement of results** into a 10-year cycle that addresses both restoration and protection.

As part of the watershed approach, waters not meeting state standards are still listed as impaired and Total Maximum Daily Load (TMDL) studies are performed, as they have been in the past, but in addition the watershed approach process facilitates a more cost-effective and comprehensive characterization of multiple water bodies and overall watershed health. A key aspect of this effort is to develop and utilize watershed-scale models and other tools to identify strategies and actions for point and nonpoint source pollution that will cumulatively achieve water quality targets. For nonpoint source pollution, this report informs local planning efforts, but ultimately the local partners decide what work will be included in their local plans. This report also serves as a watershed plan addressing the U.S. Environmental Protection Agency's (EPA's) Nine Minimum Elements to qualify applicants for eligibility for Clean Water Act Section 319 implementation funds.

Purpose

- Support local working groups and jointly develop scientifically-supported restoration and protection strategies to be used for subsequent implementation planning
- Summarize Watershed Approach work done to date including the following reports:
  - *Pioneer-Sarah Creek Subwatershed Total Maximum Daily Load - 2017*
  - *North and South Fork Crow Watershed Monitoring and Assessment - 2011, 2016*
  - *Pioneer-Sarah Creek Third Generation Watershed Management Plan - 2015*

Scope

- Impacts to aquatic recreation and impacts to aquatic life in streams
- Impacts to aquatic recreation in lakes
- Strategies for restoration and protection of water resources

Audience

- Local working groups (local governments, SWCDs, Watershed Management Commission, etc.)
- State agencies (MPCA, DNR, BWSR, etc.)
- Local interest groups (citizen residents, lake associations)

1. Watershed Background & Description

The Pioneer-Sarah Creek (PSC) Subwatershed is in portions of the North Fork Crow River Major Watershed (HUC8: 07010204) and the South Fork Crow River Major Watershed (HUC8: 07010205) of the Upper Mississippi River Basin. However, none of the drainage from the PSC watershed discharges to the North Fork Crow River. It discharges to either the South Fork Crow River or the Crow River (this area is part of the North Crow River Major Watershed). The southern subwatershed drains through Pioneer Creek to Ox Yoke Lake and Rice Lake, and eventually drains to the South Fork Crow River, while the central subwatershed drains through Sarah Creek to the Crow River. The northern subwatershed drains through several small channels to the Crow River. (Figure 1-1).

The watershed is approximately 70 square miles, or about 44,980 acres, and lies mostly in western Hennepin County, with small portions in Wright and Carver counties. The entire subwatershed lies within the North Central Hardwood Forest (NCHF) ecoregion. Based on 2010 data from the Metropolitan Council, about 36% of the land within the watershed is classified as undeveloped, a category that includes undevelopable wetlands and grasslands, in addition to lands that are currently vacant and developable. Nearly 38% of the watershed is classified as agricultural, and less than 10% supports developed land uses.

The Pioneer-Sarah Creek Watershed Management Commission (PSCWMC) is responsible for leading a watershed-wide approach to manage the lakes, streams, and wetlands within the Commission's jurisdictional boundaries. The PSCWMC is a joint powers watershed management organization formed under Minn. Stat. § 103B.201 to 103B.255 and Minn. R. ch. 8410. The PSCWMC is comprised of six cities: Greenfield, Independence, Loretto, Maple Plain, Medina, and Minnetrista.

Additional Pioneer-Sarah Creek Watershed Resources

- *Pioneer-Sarah Creek Watershed Management Commission webpage*
- *Pioneer-Sarah Creek Subwatershed TMDL*
- *North Fork Crow River Watershed webpage* and *South Fork Crow River Watershed webpage*
- *Lake Independence TMDL* and *Implementation Plan*
- *Lake Sarah TMDL and Implementation Plan*
- *USDA Natural Resources Conservation Service (NRCS) Rapid Watershed Assessment for the Crow (Upper Fork) River Watershed*
- *USDA Natural Resources Conservation Service (NRCS) Rapid Watershed Assessment for the South Fork Crow Watershed*
- *Minnesota Department of Natural Resources (DNR) Watershed Assessment Mapbook for the North Fork Crow River Watershed*
- *Minnesota Department of Natural Resources (DNR) Watershed Assessment Mapbook for the South Fork Crow River Watershed*

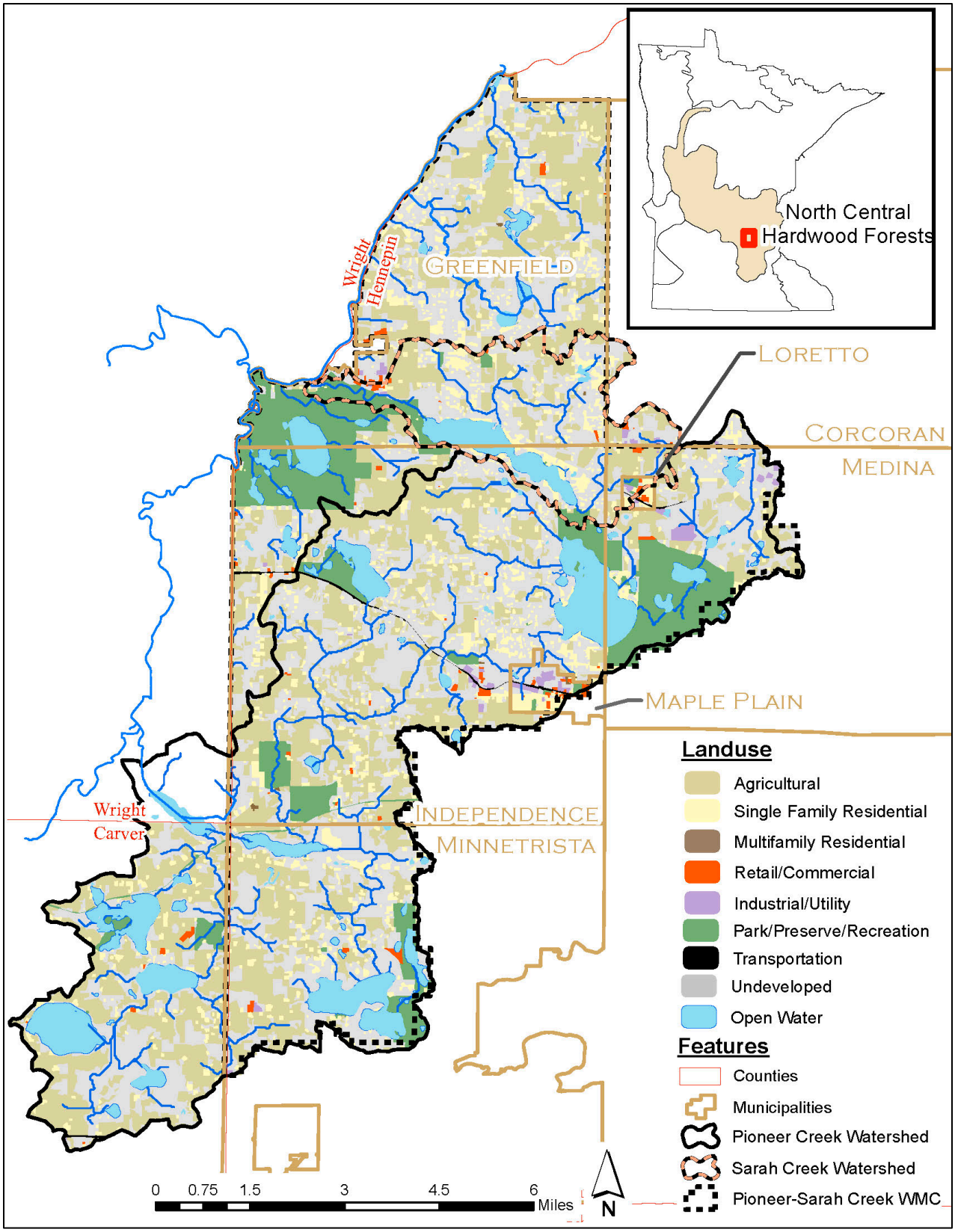


Figure 1-1: 2010 Met Council Land Use for the Pioneer-Sarah Creek Watershed

2. Watershed Conditions

The dominant land use in the PSC Subwatershed is undeveloped and agricultural, with some subwatersheds having significant portions of natural, resource-based park/preserve areas as well. There is one permitted wastewater discharger in the watershed, the Loretto Wastewater Treatment Plant (WWTP, MN0023990), which discharges treated effluent to a wetland tributary to Spurzem Creek, upstream of Spurzem Lake.

There are 18 designated lakes, 23 designated stream reaches, and numerous wetlands in the watershed. Not all of these water resources were assessed as part of this project, primarily due to insufficient data.

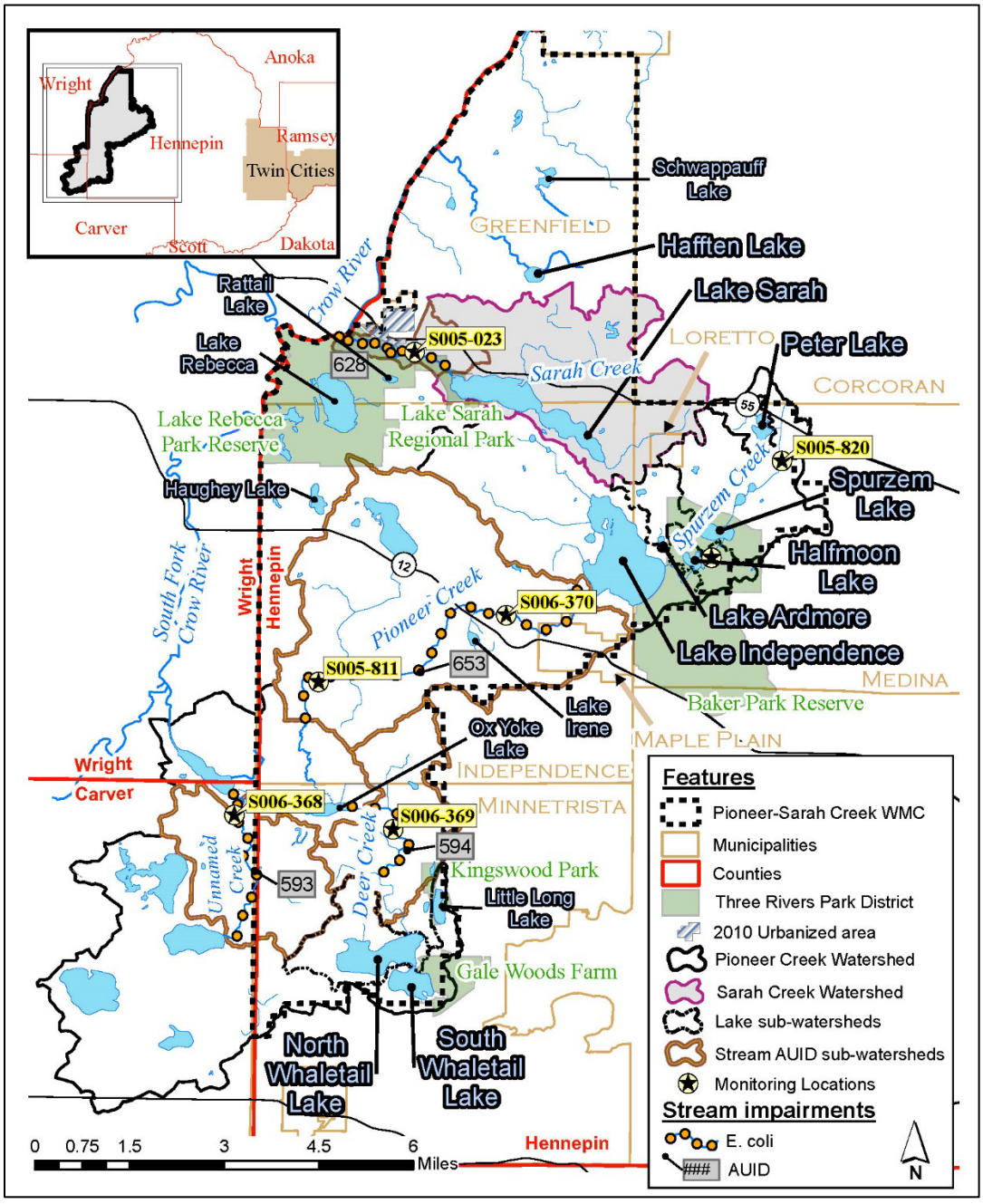


Figure 2-1: Pioneer-Sarah Creek Watershed location and key features

2.1 Condition Status

This section summarizes impairment assessments for the lakes and streams in the PSC Subwatersheds (Table 2.1 and Table 2.2).

Some of the waterbodies in the PSC Watershed are impaired by mercury; however, this report does not cover toxic pollutants. For more information on mercury impairments, see the statewide mercury TMDL.

Streams

Water quality of streams is assessed based on aquatic life and aquatic recreation uses. Aquatic life impairments include assessments of fish index of biotic integrity (Fish IBI), macroinvertebrate index of biotic integrity (Invert IBI), dissolved oxygen (DO), turbidity/total suspended solids (TSS), pH, and chlorides. Aquatic recreation use impairments include assessments of *E. coli*.

There are several stream reaches in the PSC Watershed; however, only seven had sufficient data to assess their impairment status for some parameters. Four stream reaches are impaired by bacteria (*E. coli*), and three of those stream reaches are also impaired by low DO. Table 2.1 summarizes the beneficial use data for the streams that were assessed in the PSC Watershed with their associated assessment unit identifier (AUID) numbers.

Table 2.1: Assessment status of stream reaches in the Pioneer-Sarah Creek Watershed

HUC-10 Subwatershed	AUID (Last 3 digits)	Stream	Reach Description	Aquatic Life					Aq Rec
				Fish Index of Biotic Integrity	Macroinvertebrate Index of Biotic Integrity	Nutrient/eutrophication biological indicators	Dissolved Oxygen	Turbidity/TSS	Bacteria
South Fork Crow River (0701020507)	653	Pioneer Creek	T118 R24W S31, north line to T118 R24W S31, south line	NA	NA	IF	Imp	Sup	Imp
	654	Pioneer Creek	T118 R24W S31, north line to T118 R24W S31, south line	Imp	Imp	IF	NA	NA	NA
	594	Deer Creek	Unnamed Creek to Ox Yoke Lake	NA	NA	IF	Imp	Sup	Imp
	593	Unnamed Creek	Mud Lake (10-0094-00) to Rice Lake (86-0032-00)	NA	NA	IF	Imp	Sup	Imp
	587	Unnamed Creek	Headwaters to Thomas Lake	NA	NA	IF	NA	NA	NA
	710	Unnamed Creek	Headwaters to Lake Rebecca	NA	NA	IF	IF	Sup	NA
	526	Spurzem Creek	Winterhalter Lake to Lake Independence	NA	NA	IF	NA	Sup	NA

HUC-10 Subwatershed	AUID (Last 3 digits)	Stream	Reach Description	Aquatic Life					Aq Rec
				Fish Index of Biotic Integrity	Macroinvertebrate Index of Biotic Integrity	Nutrient/eutrophication biological indicators	Dissolved Oxygen	Turbidity/TSS	Bacteria
Crow River (0701020407)	628	Sarah Creek	Lake Sarah outlet to Crow River	NA	NA	IF	NA	IF	Imp
	627	Unnamed Creek	Headwaters to Lake Sarah	NA	NA	IF	NA	IF	NA
	625	Unnamed Creek	Headwaters to Lake Sarah	NA	NA	IF	NA	IF	NA

Sup = found to meet the water quality standard, Imp = does not meet the water quality standard and therefore, is impaired, IF = the data collected was insufficient to make a finding, NA = not assessed

Lakes

This report addresses nutrient impairments in Peter, Spurzem, Half Moon, and Ardmore lakes in the Sarah Creek Subwatershed and North and South Whaletail lakes in the Pioneer Creek Subwatershed. This report also addresses bacteria impairments in four stream reaches: Sarah Creek, Pioneer Creek, Deer Creek, and an Unnamed Creek in the Pioneer Creek Subwatershed. The condition of these streams and lakes and pollutant sources are detailed in the following sections. Figure 2-1 shows the key lakes and streams in the PSC Watershed, including the lakes and stream reaches that are addressed in this report.

Three lakes in the project area have previously completed TMDL studies and implementation plans: Lake Independence (851 acres in area), Lake Sarah (552 acres), and Hafften Lake (43 acres). The Lake Independence TMDL was approved in 2007 and calls for an overall phosphorus load reduction of 1,081 lbs/yr, which is a 45% decrease in the load affecting the lake at the time the TMDL was prepared. Four of the lakes addressed in this project (Lake Ardmore, Peter, Spurzem, and Half Moon) all discharge water that reaches Lake Independence, and assuring that these lakes meet water quality standards will help achieve the load reduction goal for Lake Independence. The Lake Sarah TMDL was approved in 2011 and requires a phosphorus load reduction of 4,330 lbs/yr, or about 79% of the load affecting the lake at the time the TMDL was prepared. About 26% of the load reduction is targeted to come from watershed sources, and 74% from control of internal sources (curly-leaf pondweed and releases of phosphorus from enriched lake bottom sediments). Finally, the TMDL for Hafften Lake was included as part of the North Fork Crow River TMDL, which was approved in 2015. The approved TMDL calls for a 34% reduction of the phosphorus load affecting the lake. Figure 2-1 shows the location of all three lakes.

Lake impairments are based on an aquatic recreation standard (Class 2) centered on protecting the ability to recreate on and in lakes by preventing nuisance levels of algae and preserving water clarity. Additionally, lakes can be listed as impaired based on aquatic consumption standards.

Nineteen lakes in the PSC Watershed were assessed for support of aquatic recreation. Sixteen lakes are impaired by excess nutrients. All of the lakes are classified as 2B waters for which aquatic life and recreation are the protected beneficial uses. Minnesota standards for all Class 2 waters states "…there shall be no material increase in undesirable slime growths or aquatic plant including algae." To evaluate whether a lake is in an impaired condition, the Minnesota Pollution Control Agency (MPCA) developed "numeric translators" for purposes of determining which lakes should be included in the section 303(d) list as being impaired by nutrients. The translators established are for total phosphorus (TP), chlorophyll-a, and water clarity as measured by Secchi depth.

Table 2.2 summarizes the assessment status of lakes within the PSC Watershed.

Table 2.2: Assessment status of lakes in the Pioneer-Sarah Creek Watershed

HUC-10 Subwatershed	Lake ID	Lake	Aquatic Recreation
Crow River (0701020407)	27-0199	Hafften	Imp
	27-0200	Rattail	IF
	27-0194	Schwappauf	Sup
	27-0191-01	West Sarah[P]	Imp
	27-0191-02	East Sarah[P]	Imp
South Fork Crow River (0701020507)	27-0147-02	Peter	Imp
	27-0149	Spurzem	Imp
	27-0152	Half Moon	Imp
	27-0153	Ardmore	Imp
	27-0176	Independence[P]	Imp
	27-0189	Irene	Imp
	27-0192	Rebecca[P]	Imp*
	27-0187	Haughey	IF
	27-0178	Ox Yoke	IF
	27-0179-01	North Little Long[P]	Sup
	27-0179-02	South Little Long[P]	Sup
	10-0093	Oak Lake	Imp**
	10-0095	Swede Lake	Imp**
	10-0094	Mud Lake	Imp**
	86-0032	Rice Lake	Imp**
	27-0179-02	South Whaletail[P]	Imp
	27-0179-01	North Whaletail[P]	Imp

P =designated a Priority Lake in Metropolitan Council's 2040 Water Resources Policy Plan (2015)
Imp = impaired for impacts to aquatic recreation, Sup = fully supporting aquatic recreation, IF = insufficient data to make an assessment, NA = not assessed, *Impaired for impacts to aquatic recreation, but currently meeting water quality standards,**Water bodies located in Carver County and not within jurisdictional boundaries of PSCWMC

2.2 Water Quality Trends

Stream and lake data have been collected periodically by various entities throughout the PSC Watershed. Flow and water quality monitoring has been conducted at five sites in recent years (2009 to 2013) to support the TMDL analyses for streams. This period of record is considered insufficient to support a reliable trend analysis for any of the key stream water quality parameters that were monitored.

Intensive lake water quality monitoring was also performed in recent years (2009 to 2015) to support the TMDL analyses, with some lakes having nutrient and chlorophyll-*a* data dating back to 1995 (though not as part of a continuous data set). Some of these lakes do have a sufficient data set to provide the basis for reliable trend analysis using these parameters. The MPCA recently completed an analysis of transparency trends in the report, A Review of Secchi Transparency Trends in Minnesota Lakes (MPCA 2016). This report included supporting case studies for counties that had multiple lakes that showed significant trends, including Hennepin County.

South Whaletail, Half Moon, and North Little Long lakes had sufficient data and were included in this analysis. South Whaletail had a subtle but significant increase in transparency since 1990. Half Moon exhibited a significant decrease in transparency based on a record that dates to 1991. In the 1990s, transparency averaged 5 to 10 feet, as compared to 3 to 5 feet in 2008 to 2014. TP data from 2004 to 2014 indicates a distinct increase in TP, with all measures in the hypereutrophic range. Finally, North Little Long Lake exhibited a significant decrease in transparency with measures dating to 1980. The steepest decrease was from 2001 to 2010, with an increase since that time. TP has increased over this period as well, with a shift from borderline oligotrophy to mesotrophy. It is important to acknowledge that even with these changes, transparency remains very high in this lake, which allows for extensive and diverse rooted plant growth across the lake.

2.3 Stressors and Sources

In order to develop appropriate strategies for restoring or protecting waterbodies, the stressors and/or sources impacting or threatening them must be identified and evaluated. Biological stressor identification (SID) is done for streams with either fish or macroinvertebrate biota impairments and encompasses both evaluation of pollutants and non-pollutant-related factors as potential stressors (e.g., altered hydrology, fish passage, habitat). Pollutant source assessments are done where a biological SID process identifies a pollutant as a stressor, as well as for the typical pollutant impairment listings. Section 3 provides further detail on stressors and pollutant sources.

Stressors of Biologically-Impaired Stream Reaches

Pioneer Creek is listed as impaired for aquatic life due to biological indicators. To identify the most probable stressors causing the impairment, a biotic SID study was developed. The stream reach is included in the South Fork Crow SID Report, which provides more detailed information, along with a weight of evidence analysis that links stressors to the aquatic life impairments. Since this WRAPS project was in development before this impairment was identified, the reach will be addressed in 2022 when the South Fork Crow Watershed will be revisited by the MPCA as part of the watershed approach.

Pollutant sources

Pollutant sources vary by subwatershed, and by stream reach and lake, depending on the permitted point source dischargers, surrounding land uses, watershed and internal loading conditions, near-reach land use, and other nonpoint sources throughout the watershed. Potential pollutant sources in the impaired stream and lake watersheds were identified and discussed in the Pioneer-Sarah Creek Watershed TMDL (PSCWMC 2016) and are summarized below in Table 2.4.

Point Sources

There are currently five small Municipal Separate Storm Sewer System (MS4) General Permit holders in the PSC Watershed project area. The city of Loretto WWTP is currently the only active WWTP in the PSC Watershed project area. All permit holders in the PSC Watershed are listed in Table 2.3.

Table 2.3. Point sources in the Pioneer-Sarah Creek Watershed project area

HUC-10 Sub-watershed	Point Source			Pollutant reduction needed beyond current permit conditions/limits ?	Notes
	Name	Permit #	Type		
South Fork Crow River (0701020507) and North Fork Crow River (0701020407)	Loretto WWTP	MN0023990	Municipal wastewater	No	Allocation for Spurzem Lake (TP), PSC TMDL; Lake Independence TMDL (TP). Spurzem Lake TMDL assumes that effluent will not exceed 0.2 mg/l, Lake Independence TMDL assumes discharge will be eliminated to meet WLA
	City of Corcoran	MS400081	Municipal Stormwater	Yes	Allocations for Peter Lake (TP) and Spurzem Lake, (TP), PSC TMDL
	City of Loretto	MS400030		Yes	Allocations for Spurzem Lake (TP) PSC TMDL; Lake Independence TMDL (TP); Lake Sarah TMDL (TP)
	City of Independence	MS400095		Yes	Allocations for Pioneer Cr. Reach -653 (*E. coli*) PSC TMDL; Lake Independence TMDL (TP); Lake Sarah TMDL (TP)
	City of Maple Plain	MS400103		Yes	Allocations for Pioneer Creek Reach -653 (*E. coli*), PSC TMDL
	City of Medina	MS400105		Yes	Allocations for Peter Lake (TP), Spurzem Lake (TP), PSC TMDL; Lake Independence TMDL (TP); Lake Sarah TMDL (TP)

Nonpoint Sources

Non-permitted, nonpoint sources are an important source of nutrients, bacteria, and other pollutants loading to water bodies in much of the PSC Subwatershed. Sources of greatest concern include poorly managed runoff from intensive agricultural operations like cropland, pasture, and non-permitted feedlot operations, failing individual septic systems, and internal loading (especially phosphorus from enriched bottom sediments in lakes).

Table 2.4 Nonpoint Sources in the Pioneer-Sarah Creek Watershed Project Area. Relative magnitudes of contributing sources are indicated.

HUC-10 Subwatershed	Stream/Reach (AUID) or Lake (ID)	Pollutant	Pollutant Sources										
			Agricultural runoff (from cropland, pasture and/or feedlots)	Livestock overgrazing in riparian	Failing septic systems	Wildlife	Runoff from urban stormwater and/or near-shore development	Wetlands	Internal Loading (sediments and/or curly-leaf pondweed)	Atmospheric Deposition	Point Sources (WWTPs)	Upstream lakes	Streambank/channel erosion
0701020507 South Fork Crow River	Pioneer Creek (-653)	Bacteria	˜	›	?	™	™	?	?				
	Deer Creek (-594)	Bacteria	˜	˜	?	™		?	?			?	
	Unnamed Creek (-593)	Bacteria	˜	›	?	™		?	?			?	
	Peter Lake (27-0147-02)	TP	›	™	™		™		˜				
	Spurzem Lake (27-0149)	TP	˜				™	?	˜	™	›	™	
	Half Moon Lake (27-0152)	TP		›				?	›	™		˜	
	Lake Ardmore (27-0153)	TP	˜	›			™	?	˜	™			
	South Whaletail Lake (27-0179-02)	TP	™	™	™				˜	™			
	North Whaletail Lake (27-0179-01)	TP	›	›	™		™		›	™		™	
0701020407 Crow River	Sarah Creek (-628)	Bacteria			?	?			?			?	

Key: ˜ = High, › = Moderate, ™ = Low, ? = present, but contribution to impairment unknown, Blank = not a primary source

2.4 TMDL Summary

States are required to complete TMDLs for impaired waters in order to define the maximum amount of pollutant water can receive while maintaining water quality standards, and to determine the pollutant load reductions necessary to achieve water quality standards. A TMDL is divided into a wasteload allocation (WLA) for point sources, a load allocation (LA) for nonpoint sources and natural background, and a margin of safety (MOS).

There are six impaired lakes and four impaired stream reaches that were included in the Pioneer-Sarah Creek Watershed TMDL study. The TMDL allocations and necessary pollutant load reductions from current conditions for each lake and stream reach are summarized in Table 2.5 and Table 2.6. Section 3 of this report discusses tools to identify and target the high priority pollutant loading areas, and recommended restoration strategies to achieve reductions required for these impaired lakes and stream reaches.

Table 2.5. Allocation Summary for Lake Phosphorus TMDLs in the Pioneer-Sarah Creek Subwatershed Project Area. Data were collected from 2009 to 2015.

Major Sub-watershed (HUC-10)	Lake (ID)	Allowable Load (lbs/yr)	Allocations (lbs/year)								Percent Reduction
			Wasteload Allocation			Load Allocation				MOS	
			Loretto WWTP	Construction & Industrial Stormwater	MS4s	Non-MS4 Runoff	Internal Load	Upstream Lakes	Atmosphere	Margin of Safety	
0701020507 South Fork Crow River	Peter Lake (27-0147-02)	396.9	--	4.0	30.6	131.1	196.1	--	15.2	19.8	20%
	Spurzem Lake (27-0149)	337.2	24.6	3.4	17.2	135.1	94.6	24.3	21.2	16.9	85%
	Half Moon Lake (27-0152)	357.6	--	3.6	--	81.7	55.0	190.8	8.6	17.9	80%
	Lake Ardmore (27-0153)	50.1	--	0.5	1.3	20.5	21.6	--	3.7	2.5	91%
	South Whaletail Lake (27-0179-02)	367.0	--	3.7	--	60.0	243.3	--	41.7	18.4	34%
	North Whaletail Lake (27-0179-01)	620.2	--	6.2	--	201.0	196.6	86.2	99.2	31.0	26%

Table 2.6. Allocation Summary for Stream *E. coli* TMDLs in the Pioneer and Sarah Creek Subwatersheds. Data were collected from 2008 to 2014.

Major Sub-watershed (HUC-10)	Stream / Reach (AUID)	Allowable Load	Flow Zone	*E. coli* allocations (billions org/day)						Unallocated Load	Percent Reduction[1]
				Wasteload Allocation			Load Allocation		MOS		
				WWTPs	Construction & Industrial Stormwater	MS4s	Non-MS4 Watershed Load	Upstream Reach(es) / Boundary conditions	Margin of Safety		
North Fork Crow River (07010204 07)	Sarah Creek (628)	108.78	Very High	--	--	--	13.47	89.87	5.44	0.00	NA
		63.42	High	--	--	--	2.26	15.07	3.17	42.92	0%
		41.35	Mid	--	--	--	2.35	15.68	2.07	21.25	0%
		24.16	Low	--	--	--	2.99	19.96	1.21	0.00	16%
		11.20	Very Low	--	--	--	0.30	2.03	0.56	8.31	0%
South Fork Crow River (07010205 07)	Pioneer Creek (653)	240.91	Very High	--	--	6.24	113.29	109.33	12.05	0.00	62%
		113.82	High	--	--	2.07	37.53	36.22	5.69	32.32	0%
		44.27	Mid	--	--	1.15	20.82	20.09	2.21	0.00	19%
		10.02	Low	--	--	0.26	4.71	4.55	0.50	0.00	51%
		4.67	Very Low	--	--	0.12	2.20	2.12	0.23	0.00	26%
		94.65	Very High	--	--	--	11.17	25.40	4.73	53.36	0%

Major Sub-watershed (HUC-10)	Stream / Reach (AUID)	Allowable Load	Flow Zone	*E. coli* allocations (billions org/day)						Unallocated Load	Percent Reduction[1]
				Wasteload Allocation			Load Allocation		MOS		
				WWTPs	Construction & Industrial Stormwater	MS4s	Non-MS4 Watershed Load	Upstream Reach(es) / Boundary conditions	Margin of Safety		
	Unnamed Creek (593)	55.38	High	--	--	--	7.28	16.55	2.77	28.78	0%
		30.60	Mid	--	--	--	8.88	20.19	1.53	0.00	27%
		16.93	Low	--	--	--	4.91	11.17	0.85	0.00	30%
		6.90	Very Low	--	--	--	2.00	4.55	0.35	0.00	18%
	Deer Creek (594)	48.72	Very High	--	--	--	24.40	21.88	2.44	0.00	53%
		13.76	High	--	--	--	6.89	6.18	0.69	0.00	15%
		3.28	Mid	--	--	--	1.39	1.25	0.16	0.48	0%
		0.63	Low	--	--	--	0.15	0.14	0.03	0.31	0%
		0.07	Very Low	--	--	--	0.03	0.03	0.003	0.00	NA

[1] Total percent reduction (all sources) from existing conditions needed to meet TMDL allocations. When not enough data was available to estimate a load reduction, it was designated as NA.

** For *E. coli*, Allocation = flow contribution from a given source x 126 cfu *E. coli* / 100 ml

During the development of the TMDL study, synoptic surveys and modeling analyses were performed to determine and quantify the sources of low DO in the three DO-impaired reaches. Results suggest that low DO is primarily driven by biochemical oxygen demand (BOD) (algae) loading from upstream impaired lakes (Lake Independence, Whaletail Lake, and Mud Lake) and in-channel sediment oxygen demand (SOD) in reaches that flow through large wetland complexes. Since the drivers of low DO appear to be a combination of natural background conditions (wetlands) and upstream lake loading, DO TMDLs were not developed for the TMDL study. The synoptic survey and modeling efforts are summarized in a series of technical memorandums available on the Pioneer-Sarah Creek WRAPS: TMDL Project webpage.

2.5 Protection Considerations

Watershed wide

Working to protect surface and groundwater resources currently supporting beneficial uses through the implementation of BMPs is vital to the overall health of the PSC Subwatershed and state of Minnesota.

Significant threats to water resources include:

- Declines in surficial groundwater threaten shallow water ecosystems such as wetlands, lakes, and streams. These ecosystems are vitally important to the watershed, the biological communities that rely on their existence, and for recreation.
- Climate change (or climate instability) poses a complex challenge to current water resource management practices. Recent climatological events such as drought, intense localized precipitation, and flooding have all been observed across the watershed. These changes can increase water quality degradation, flooding, and drought duration.

- Aquatic invasive species continue to threaten both the biodiversity and overall ecological health of high value resources within the watershed. The number of infested waterbodies continues to climb across the state of Minnesota.
- Rural and agricultural land uses can have a significant negative impact on flow regimes and water quality if those lands are not well managed. Poorly managed land application of manure from livestock operations, improperly managed cropland drainage and over-application of fertilizers, sediment loss from croplands, and septic systems cause water quality degradation and/or compromise the hydrologic integrity of streams and rivers where proper management practices are not in place.
- Conversion of agricultural and vacant lands to more urbanized use (i.e., single-family residential, multi-family residential, etc.) is anticipated to continue in the PSC Subwatershed for the near future. Land use conversions such as these will increase the amount of impervious area, reduce infiltration, and potentially exacerbate threats previously mentioned, such as declines in surficial groundwater, unless proper stormwater mitigation practices are used. The PSC WMC has adopted and is implementing stormwater mitigation standards aimed at limiting negative impacts on infiltration and reducing phosphorus loads where developed land uses replace high intensity rural land uses like row crop agriculture, pasture, and feedlots.
- Water quality degradation resulting from sediment, phosphorus, and bacteria introduction to surface waters of the PSC Subwatershed is another significant threat. With increasing urbanization, these threats could increase in the future along with other potential contaminants such as chlorides, heavy metals, etc.

Lakes

This report also addresses lakes that currently have good water quality. Little Long Lake and Lake Rebecca are currently meeting water quality standards and fully support recreation use. Protection strategies are included in this report to ensure that these lakes continue to be high quality lakes in the watershed.

Little Long Lake, which has public access and supports public recreational activity, was assessed and found to be meeting applicable standards. Little Long Lake is a small (54 acres), deep lake with a very small watershed. The lake and most of the watershed are located within Kingswood Park, a largely natural area owned and managed by Three Rivers Park District (TRPD). Monitoring data show that water quality has historically been far better than applicable state eutrophication standards, but there is some indication that water quality is gradually deteriorating (see Section 2.2). Lake Rebecca is in the Lake Rebecca Park Reserve, also owned and managed by TRPD. In 2008, the lake was listed as impaired by nutrients, but has since been the subject of an intensive water quality improvement effort managed by TRPD. An alum treatment was completed in 2011 to address massive internal loading. Since the alum treatment, the lake has met applicable water quality standards and will likely be removed from Minnesota's 2018 impaired waters list.

Figure 2.1 in Section 2 of this report shows the location of both lakes, and Table 2.7 shows the key lake and watershed characteristics for each lake, and summarizes protection elements specific to each. Specific protection strategies for these lakes are described in the restoration and protection strategies tables presented in Section 3.3.

Table 2.7. Key Lake/Watershed Characteristics and Protection Elements for "Protect" Lakes

Lake Name	Location	Lake Size (acres)	Max. depth (ft)	Classification	Drainage area (acres)/dominant land use	Water Quality Standards Met			General notes	Key Protection Elements
						TP (year)	Chl-a (year)	Clarity (year)		
Little Long Lake	City of Minnetrista	54	74	Deep lake	168/park reserve, rural/ag.	2009-10, 2012-2015	2009-10, 2012-2015	2009-10, 2012-2015	Consistently meets state water quality standards	· Firmly apply PSCWMC standards for new development if it occurs · Periodically assess internal loading and address if necessary · Continue annual surface water and hypolimnetic monitoring
Lake Rebecca	Cities of Independence, Greenfield	254	30	Deep lake	1,230/park reserve and rural/ag	2011-2016	2011, 2015-16	2011-2016	Lake restoration initiative largely completed in 2011, lake has generally met standards since	· Continue efforts to decrease impact of livestock operations in the watershed · Firmly apply PSCWMC standards for new development if it occurs · Periodically assess effectiveness of internal load controls and supplement if necessary · Continue annual water (surface and hypolimnion) monitoring, aquatic plant surveys, and CLPW control efforts

Priority B Source Protection Area

In 1974, the Federal Safe Drinking Water Act was established to protect the quality of drinking water in the U.S. In 1996, in accordance with amendments to the act, the Minnesota Department of Health (MDH) determined Source Water Assessments and assigned areas of Priority A and B. About 99% of the PSC Subwatershed lies within the Priority B designation (Figure 2-3).

A designation of Priority B is to protect water users from chronic health effects related to low levels of chemical contamination. More information on the Protection of Source Waters can be found at the MDH Source Water Protection website. While the development of a Source Water Protection Plan is voluntary, developing a plan would help protect source water from contamination.

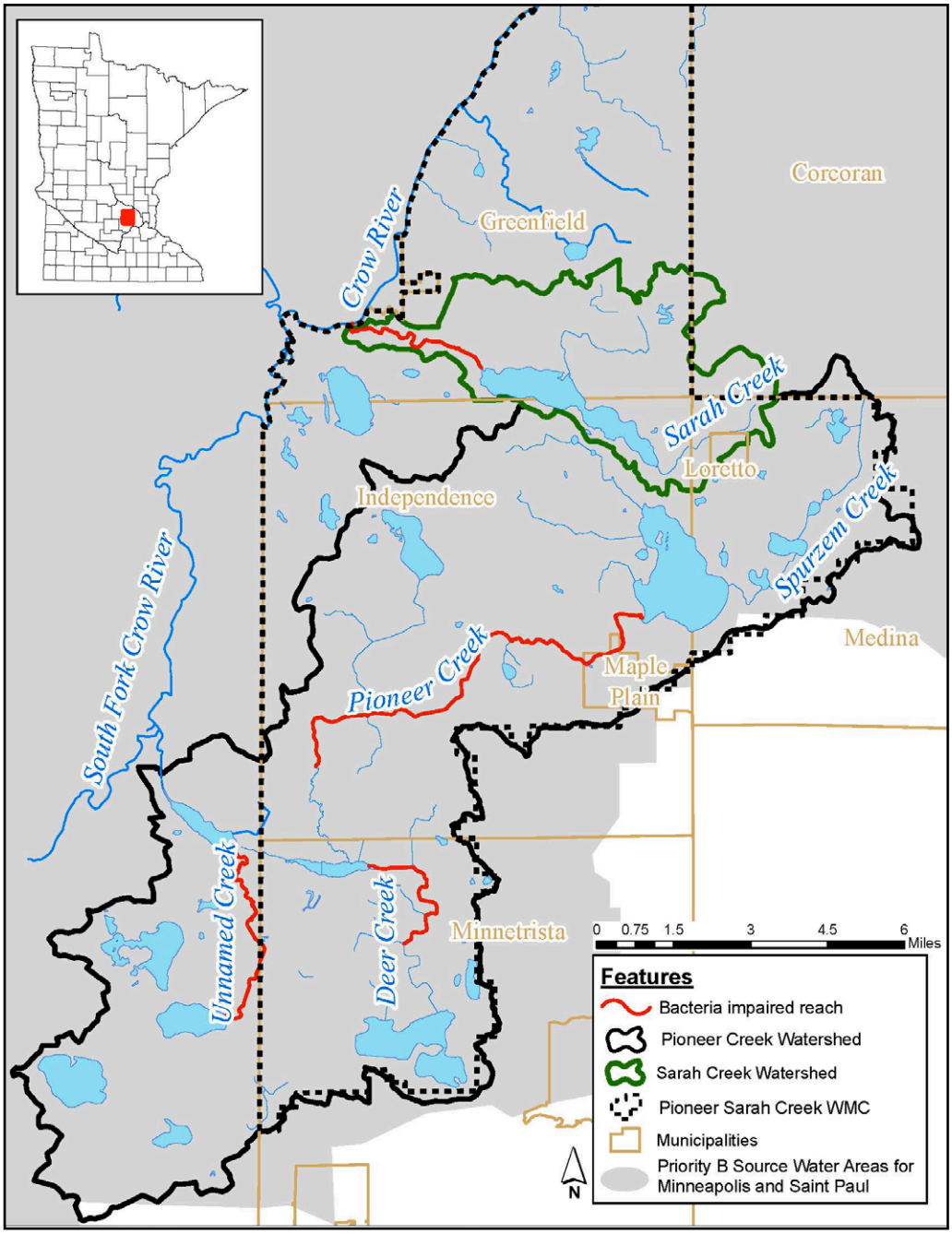


Figure 2-2. Source Water Protection Areas for Minneapolis and St. Paul for the Pioneer-Sarah Creek Watershed

3. Prioritizing and Implementing Restoration and Protection

The Clean Water Legacy Act (CWLA) requires that WRAPS reports summarize priority areas for targeting actions to improve water quality, identify point sources, and identify nonpoint sources of pollution with sufficient specificity to prioritize and geographically locate watershed restoration and protection actions. In addition, the CWLA requires including an implementation table of strategies and actions that are capable of cumulatively achieving needed pollution load reductions for point and nonpoint sources.

This section of the report provides the results of such prioritization and strategy development. Because much of the nonpoint source strategies outlined in this section rely on voluntary implementation by landowners, land users, and residents of the watershed, it is imperative to create social capital (trust, networks and positive relationships) with those needed to voluntarily implement BMPs. Thus, effective ongoing civic engagement part of the overall plan for moving forward.

The implementation strategies, including associated scales of adoption and timelines, provided in this section are the result of watershed modeling efforts and/or data analysis specific to each of the waterbodies in the PSC Subwatershed TMDL and professional judgment based on what is known at this time and, thus, should be considered approximate. Furthermore, many strategies are predicated on needed funding being secured. As such, the proposed actions outlined are subject to adaptive management, an iterative approach of implementation, evaluation and course correction.

There are issues that are not addressed in the strategies tables, such as limited local capacity, funding, and landowner cooperation that can greatly affect the outcomes of this report. If staff and funding resources are limited or nonexistent in the project area, and/or landowner cooperation cannot be secured to implement improvements, it is likely that the strategies and goals laid out in this report will take longer to achieve, or may not be achieved at all. Much of this work relies on reductions from non-permitted actions in the watershed, and to achieve those goals local relationships and trust need to be built where they may not currently exist. Therefore, it is important that as these actions are undertaken, all levels (federal, state, and local governments; non-profits; and landowners) continue to find ways to support local entities and individuals to ensure the waterbodies in the PSC Subwatershed are restored and protected. If this support does not happen, achieving the TMDL reductions and strategies in this report are very unlikely.

3.1 Targeting of Geographic Areas

Targeting has been used at several scales to help identify critical areas in the PSC Watershed project area. To identify priority/critical areas best suited for restoration and protection in the PSC Watershed, a variety of tools were used. Brief summaries of the tools used are provided below along with graphical illustrations of the priority/critical areas. These figures should serve as a starting point to targeting specific areas for restoration and protection efforts. The following discussion begins at the state and basin scale and moves to smaller more focused areas based on the specific tools used for this project.

State, Basin and Regional Scale

The Minnesota Nutrient Reduction Strategy was developed in response to concern about excessive nutrient levels that pose a substantial threat to Minnesota's lakes and rivers, as well as downstream waters including the Great Lakes, Lake Winnipeg, the Mississippi River, and the Gulf of Mexico. In recent decades, nutrient issues downstream of Minnesota have reached critical levels, including the effect of

nutrients in the Gulf of Mexico, which resulted in a dead zone, eutrophication issues in Lake Winnipeg, and algal blooms in the Great Lakes. Several state-level initiatives and actions highlighted the need for a statewide strategy that ties separate but related activities together to further progress in making nutrient reductions. Minnesota conducted both nitrogen (N) and phosphorus (P) assessments to identify nutrient source contributions. The main nutrient sources to the Mississippi River are: P from agricultural cropland runoff, wastewater, and streambank erosion; and N from agricultural tile drainage and water leaving cropland via groundwater. The associated Phase I milestones for the Mississippi River Basin for N and P are 20% and 35% reductions respectively from baseline by 2025. Additional milestones call for 30% (N) and 45% (P) by 2035 and 45% reduction from baseline in N by 2045. The primary tools the State will use to achieve these reductions are the 10-year cycle of watershed assessments and WRAPS studies to: identify high-loading areas and critical management areas; enhanced P and N reduction strategies for wastewater effluent; facilitating implementation of agricultural BMPs targeted at increasing fertilizer use efficiency, reducing field erosion, and treating tile drainage water; and continued implementation of the stormwater discharge permitting system for Minnesota MS4s.

The Nitrogen in Minnesota Surface Waters study was developed in response to a concern for human health when elevated N levels reach drinking water supplies. The 10 mg/l nitrate-N drinking water standard established for surface and groundwater drinking water sources and for cold-water streams is exceeded in numerous wells and streams in the state. The purpose of this study was to provide an assessment of the science concerning N in Minnesota waters so that the results could be used for current and future planning efforts, thereby resulting in meaningful goals, priorities, and solutions.

More specifically, the purpose of this project was to characterize N loading to Minnesota's surface waters, and assess conditions, trends, sources, pathways, and potential BMPs to achieve N reductions in our waters. The N study contains a spreadsheet tool called the NBMP tool (NBMP is described in more detail in the Nitrogen in Minnesota Surface Waters Report Chapter F1 (Wall 2013)).

The Twin Cities Metropolitan Area Chloride Management Plan (CMP) was developed to address the increasing concentrations of chloride found in Minnesota's waters in urban areas as well as across the state. The CMP provides the framework to assist local communities in reducing chloride concentrations in both the states ground and surface waters through protection and restoration efforts. The CMP contains a variety of BMPs that reduce salt use while still maintaining safe conditions for the public. The chloride reduction strategy outlined in the plan uses a performance-based approach that does not have specific numerical requirements but focuses on implementing BMPs and tracking trends in chloride concentrations. The primary recommended strategies for reducing chloride concentrations in the CMP include: 1) a shift to using more liquid deicing chemical products rather the granular ones, 2) improved physical snow and ice removal, 3) use of practices that prevent the formation of a bond between snow/ice and the pavement, 4) strategies that eliminate salt waste, 5) training for winter maintenance professionals, and 6) education for the public and elected officials.

Pioneer-Sarah Creek Watershed

Various reports, datasets and geographical information systems (GIS) tools were developed through the PSC Subwatershed assessment process and the TMDL studies that can be used to identify degraded waterbodies and potential areas to implement restoration and protection strategies. A summary of these resources is included in Table 3.1. These resources were developed by various groups and agencies including the Board of Soil and Water Resources (BWSR), the University of Minnesota Duluth,

Minnesota Department of Natural Resources (DNR), TRPD, and several other agencies. It is important to point out that these tools were developed using a wide range of input datasets with different restoration and protection initiatives in mind, ranging from stream shading to sediment and nutrient loading.

Generalized Watershed Function-E Tool (GWLF-E)

A suite of modeling tools was used to support the TMDL development. The Generalized Watershed Loading Function-E Tool (GWLF-E) model was chosen as one of the modeling tools to simulate watershed hydrology and water quality to in the Pioneer Creek Subwatershed. The GWLF-E modeling effort relied on use of light detection and ranging (LIDAR) information to provide subwatershed delineation input information for the model, as well as algorithms for the Revised Universal Soil Loss Equation (RUSLE) to estimate landscape soil erosion load. The intended use of the GWLF-E model was primarily to quantify landscape contributions of water, sediment and nutrients in the Pioneer Creek Subwatershed where needed. Landscape loads from the GWLF-E model were then used as an input to other modeling tools (e.g., BATHTUB) to support the simulation of receiving water responses in the Pioneer Creek Subwatershed. The GWLF-E modeling was also used to help identify subwatersheds that had a higher potential for exporting nutrients and sediment to the downstream resources (Figure 3.1). The Commission intends to focus its initial implementation efforts in those areas.

Board of Water and Soil Resources (BWSR) Environmental Benefits Index (EBI)

The Environmental Benefits Index (EBI) Dataset was developed by BWSR and the University of Minnesota. This dataset was developed through the use of raster-based spatial data to identify lands that have high potential for precipitation runoff and soil erosion impacts to surface waters, due to relatively large catchment areas, steep slopes, highly erodible soils, and close proximity to surface waters. The high biological habitat scores for these lands also suggest that they are, in some cases, high value areas for conservation, and in other cases, areas with good recovery potential and thus strong candidates for restoration projects.

Figure 3-2 shows the top 5% of the priority sites within the PSC Subwatershed based on the EBI data.

Watershed Health Assessment Framework (WHAF)

Recently, DNR has completed development of the Watershed Health Assessment Framework (WHAF), which provides a comprehensive overview of the ecological health of Minnesota's watersheds. The WHAF is based on a "whole-system" approach that explores how all parts of the system work together to provide a healthy watershed. The WHAF divides the watersheds ecological processes into five components: biology, connectivity, geomorphology, and hydrology and water quality. A suite of watershed health index scores has been calculated that represent many of the ecological relationships within and between the five components. These scores have been built into a statewide GIS database that is compared across Minnesota to provide a baseline health condition report for each of the 80 major watersheds in the state. The DNR has applied the condition report to larger (HUC-8) watersheds, and more recently has applied the framework at smaller (HUC-12) subwatershed levels. The WHAF may be a helpful resource in monitoring and assessing the health of the watershed as restoration and protection practices are implemented.

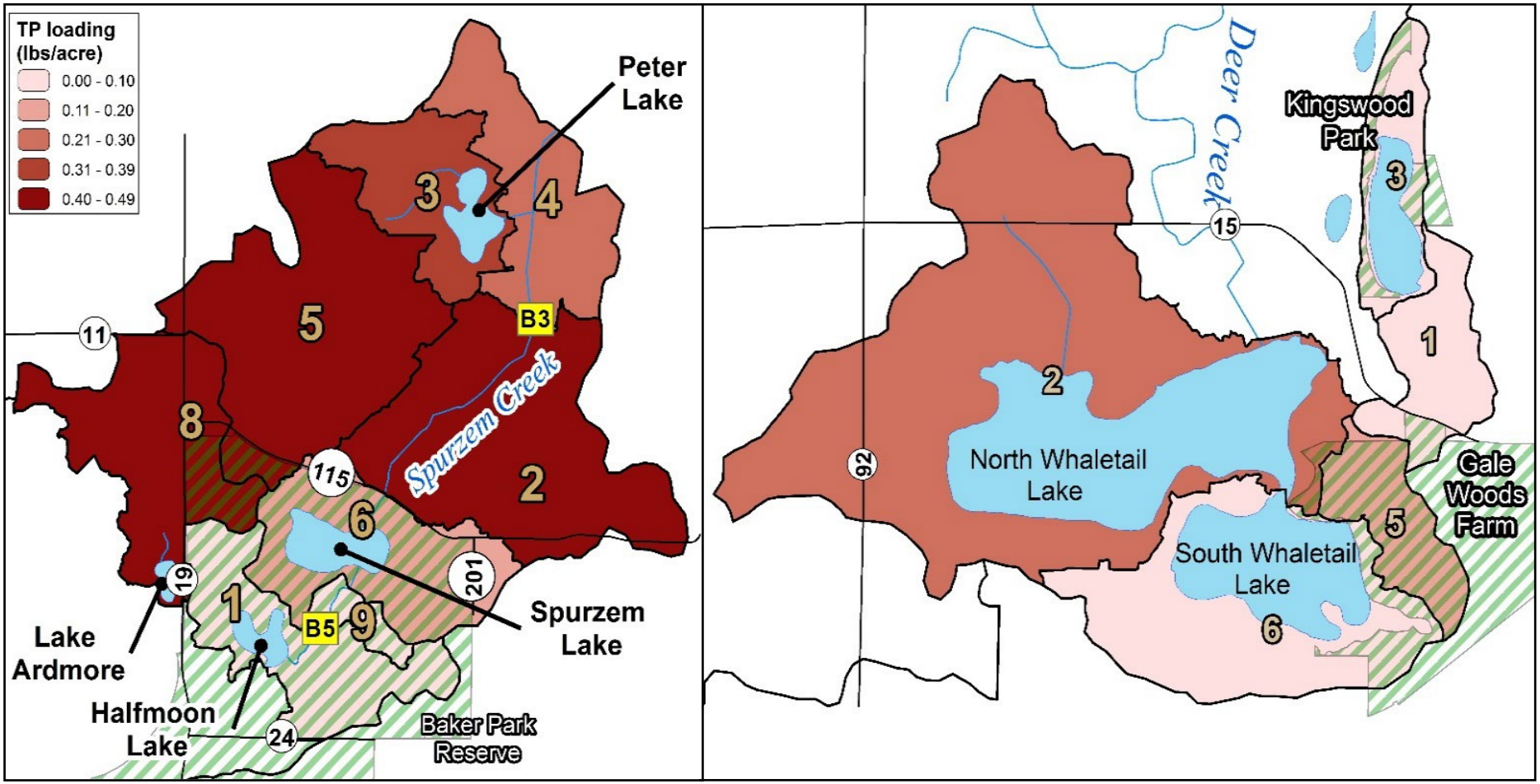


Figure 3-1: Potential TP Loading Rate by Subwatershed (Delineated Using LiDAR) as Modeled for the TMDL Using GWLF-E

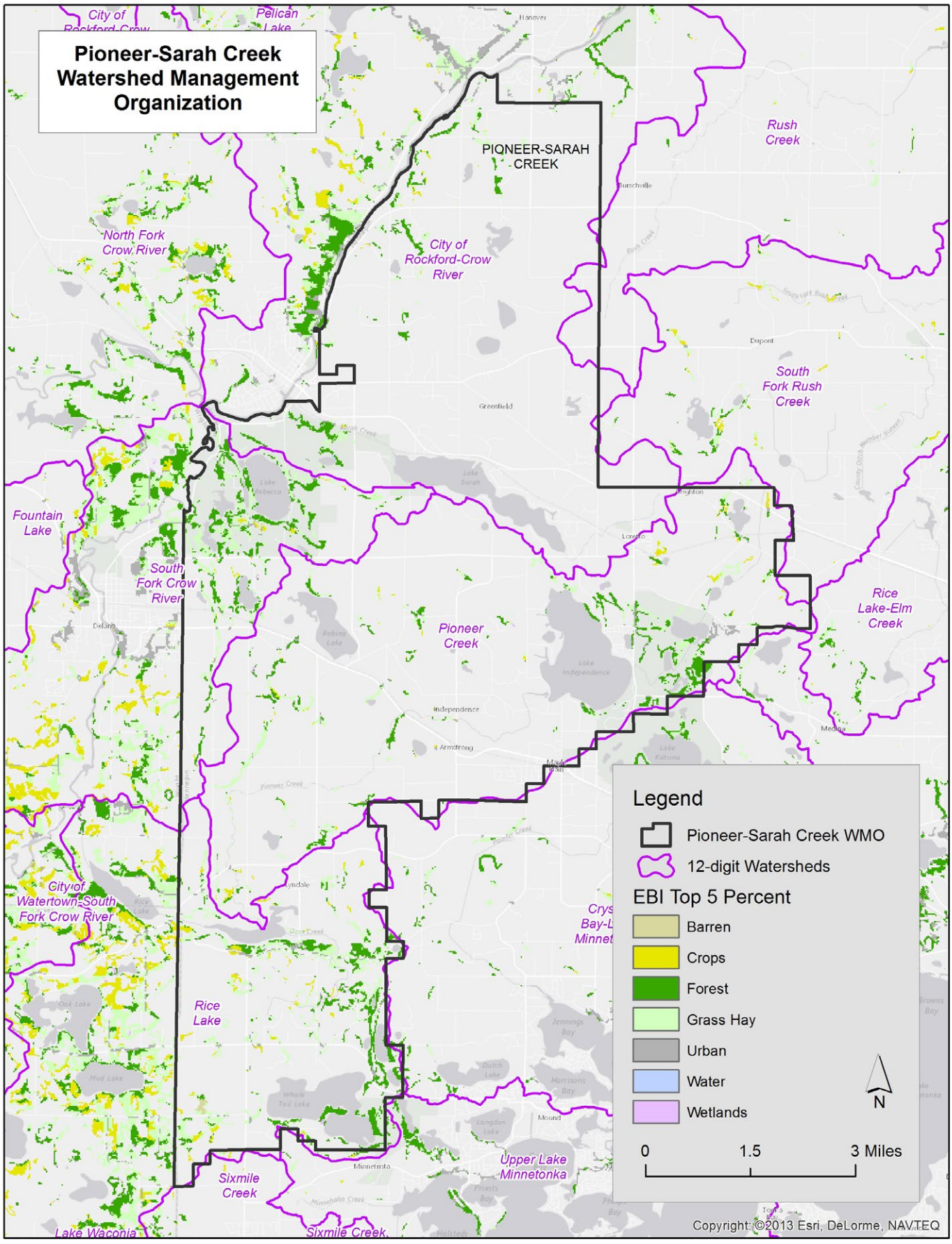


Figure 3-2: The Top 5% EBI Areas by Land Use for the Pioneer-Sarah Creek Watershed Management Organization

Table 3.1. Prioritization tools

Tool	Description	How can the tool be used?	Notes	Link to Information and data
Pioneer Creek GWLF-E (Generalized Watershed Loading Function)	Computer model of watershed processes to show where pollutants originate and which mitigation strategies are most effective.	The Pioneer Creek GWLF-E model is able to display the phosphorus, sediment and other pollutant export throughout the watershed. The Pioneer Creek GWLF-E model was calibrated to observed (monitored) data and can be used to identify pollutant-loading hot spots and help determine scenarios for pollution reduction on a subwatershed scale.	The Pioneer Creek GWLF-E model was developed for the PSC project area watershed TMDL study.	Contact the TRPD for GWLF-E model files and output
Ecological Ranking Tool (Environmental Benefit Index - EBI)	Three GIS layers containing: soil erosion risk, water quality risk, and habitat quality. Locations on each layer are assigned a score from 0-100. The sum of all three layer scores (max of 300) is the EBI score. This higher the score, the higher the value in applying restoration or protection.	Any one of the three layers can be used separately or the sum of the layers (EBI) can be used to identify areas that are in line with local priorities. Raster calculator allows a user to make their own sum of the layers to better reflect local values.	GIS layers are available on the BWSR website.	BWSR
Zonation	A framework and software for large-scale spatial conservation prioritization; it is a decision support tool for conservation planning. This values-based model can be used to identify areas important for protection and restoration.	Zonation produces a hierarchical prioritization of the landscape based on the occurrence levels of features in sites (grid cells). It iteratively removes the least valuable remaining cell, accounting for connectivity and generalized complementarity in the process. The output of Zonation can be imported into GIS software for further analysis. Zonation can be run on very large data sets (with up to ~50 million grid cells).	The software allows balancing of alternative land uses, landscape condition and retention, and feature-specific connectivity responses. (Paul Radomski, DNR, has expertise with this tool.)	CBIG
Restorable Wetland Prioritization Tool	A GIS-based tool developed by the University of Minnesota Duluth and other agencies and uses readily available GIS data consisting of 5 primary layers.	The tool helps prioritize areas for maximizing water quality improvements, in the form of N or P removal, and/or habitat and for restoring or protection high functioning sustainable wetlands.	Tool and GIS layers are available on the Restorable Wetland Prioritization Tool website.	*UMD, MPCA*

Tool	Description	How can the tool be used?	Notes	Link to Information and data
Revised Universal Soil Loss Equation (RUSLE) and Soil Erosion Risk Tool	RUSLE predicts the long-term average annual rate of erosion on a field slope based on rainfall pattern, soil type, topography, land use and management practices. A soil erosion risk (similar to RUSLE) tool is available through the Ecological Ranking Tool (EBI) website and uses a subset of RUSLE to determine relative soil erosion risk values on a 0-100 point scale.	The RUSLE model provides an assessment of existing soil loss from upland sources and the potential to assess sediment loading through the application of BMPs. The Soil Erosion Risk Tool provides users with a general sense of the highest potential areas of soil loss in a given watershed/subwatershed.	RUSLE results present maximum amount of soil loss that could be expected under existing conditions and do not represent sediment transport and loading to receiving waters.	RUSLE Soil Erosion Risk Tool
Light Detection and Ranging (LiDAR)	Elevation data in a digital elevation model (DEM) GIS layer. Created from remote sensing technology that uses laser light to detect and measure surface features on the earth.	General mapping and analysis of elevation/terrain. These data have been used for erosion analysis, water storage and flow analysis, siting and design of BMPs, wetland mapping, and flood control mapping. A specific application of the data set is to delineate small catchments.	The layers are available on the Minnesota Geospatial Information website for most counties.	MGIO
National Hydrography Dataset (NHD) & Watershed Boundary Dataset (WBD)	The NHD is a vector GIS layer that contains features such as lakes, ponds, streams, rivers, canals, dams and stream gages, including flow paths. The WBD is a companion vector GIS layer that contains watershed delineations.	General mapping and analysis of surface-water systems. These data has been used for fisheries management, hydrologic modeling, environmental protection, and resource management. A specific application of the data set is to identify buffers around riparian areas.	The layers are available on the USGS website.	*USGS*
Hydrological Simulation Program – FORTRAN (HSPF) Model	Simulation of watershed hydrology and water quality for both conventional and toxic organic pollutants from pervious and impervious land. Typically used in large watersheds (greater than 100 square miles).	Incorporates watershed-scale and nonpoint source models into a basin-scale analysis framework. Addresses runoff and constituent loading from pervious land surfaces, runoff and constituent loading from impervious land surfaces, and flow of water and transport/ transformation of chemical constituents in stream reaches.	Local or other partners can work with MPCA HSPF modelers to evaluate at the watershed scale: 1) the efficacy of different kinds or adoption rates of BMPs, and 2) effects of proposed or hypothetical land use changes. An HSPF model has already been created that includes the Pioneer-Sarah Creek watershed.	*USGS*

Tool	Description	How can the tool be used?	Notes	Link to Information and data
Watershed Nitrogen Reduction Planning Tool (NBMP)	The NBMP is an Excel spreadsheet tool that can be used to develop a framework to compare and optimize selection of BMPs for reducing nitrogen loads from the highest contributing sources and pathways.	This tool is intended to compare the effectiveness and cost potential on nine different BMPs that could be implemented to reduce nitrogen loading from cropland. The tool can be used by local resource managers to better understand the feasibility and cost of these BMPs.	Excel spreadsheet and information are available on the University of Minnesota Extension website	Extension
MDA Agricultural BMP Handbook of Minnesota	A literature review of empirical research on the effectiveness of conservation practices and agricultural BMPs	Intended as a reference to help management professionals and producers prioritize practices that would have the greatest impact in reduction loading pollutants of concern		MDA

3.2 Civic Engagement

Accomplishments

Knowledge, Attitudes, and Practices (KAP) Survey

As an initial step in the stakeholder/public involvement process, a Knowledge, Attitudes, and Practices (KAP) Survey was conducted of watershed residents (Eckman 2013). While the relatively small sample size of returned surveys cannot be considered representative of all property owners in the watershed, study findings provide some information on audience knowledge, constraints, information needs, attitudes, and current practices. Among the key findings are the following:

- There is a very high awareness of the connection between people's actions and water quality in local lakes.
- An overwhelming majority of all respondents felt that individuals degrading a public water body have the responsibility for clean-up.
- There is very strong support and unmet demand for education and outreach programs on water quality issues.
- In terms of fostering BMP adoption, financial incentives and cost-share appear to be important to some respondents. Also important is a sense of leaving a legacy for future generations, which should factor into PSCWMC messaging.
- There is considerable scope to expand the role of PSCWMC as a source of information for both groups.

The survey results also offer suggestions for civic engagement, education, and outreach. These recommendations include stronger roles for the PSCWMC in:

- developing educational programming centered on the information needs and priorities expressed by the survey respondents;
- leading a civic engagement effort that provides opportunities for individuals and families to become involved in clean water activities,
- offering an incentive program for watershed residents including financial incentives and cost-shares to support the adoption of BMPs; and
- partnering with lake associations (e.g. Lake Sarah Improvement Association) in communications with shoreline property owners, which is a preferred and trusted source of information

Public Participation

A stakeholder participation process was undertaken to obtain input from, review results with, and take comments from the public and interested/affected agencies and local jurisdictions regarding the development and conclusions of the project. The following cities/agencies/interested parties were invited to project meetings and/or received communications regarding the project:

City of Corcoran
Hennepin County Environmental Services

City of Greenfield	Board of Water and Soil Resources
City of Independence	Metropolitan Council Environmental Services
City of Loretto	Minnesota Department of Natural Resources
City of Maple Plain	Minnesota Department of Transportation
City of Medina	Minnesota Pollution Control Agency
City of Minnetrista	Minnesota Department of Agriculture
Lake Sarah Improvement Association	Lake Independence Citizen's Association

Technical Stakeholder Process

Part of the public participation process involved meeting with a Technical Stakeholders Group (TSG) comprised primarily of technical experts of the communities affected by the TMDL project as well as agency technical experts. This TSG first met in March 2014 to receive information on why the project was being undertaken and how the outcome might affect their organizations. It met a second time in March 2016 to review the preliminary results of the project, including the proposed allocations and the implications of those allocations for their organization.

Community Conversations

Another key component of the stakeholder review process was a series of "community conversations." Three community conversations were held between November 2014 and November 2016 (specific meeting dates were November 20, 2014; November 16, 2015; and November 3, 2016), with total attendance exceeding 100 people. Each session brought together a broad cross-section of people with a direct interest in water quality management, including persons representing production agriculture, horse farm operations, outdoor recreation, lake associations, elected local government leaders, and state and local agency staff. The meetings included opportunities to share information and perspectives in small group discussions; provide information on the condition of the water resources of interest through presentations by technical staff; publicize stories of local water quality improvement successes; provide input and feedback on water quality restoration priorities; and discuss what each group was willing to contribute to advancing pollution reduction efforts. Agendas and presentations from each meeting are available from the PSCWMC, and summaries of each meeting were prepared and distributed to PSCWMC members as well as posted on the PSCWMC's website to reach all other participants.

Current and Future Plans

As part of its Third Generation Watershed Management Plan, adopted in 2015 for the period 2015 through 2020, the PSCWMC has laid out an expanded education and outreach effort. The over-arching goal for this effort is "to educate and engage everyone in the watershed by increasing awareness of water resources, and to create and support advocates willing to protect and preserve the resources in the watershed." Specific priorities include:

- Convene citizen advisory committees as necessary to advise the Commission and to assist in program development and implementation.

- Participate with collaborative groups to pool resources to undertake activities in a cost-effective manner, promote interagency cooperation and collaboration, and promote consistency of messages.
- Use the Commission's, member cities', and educational partners' websites and newsletters, social media, co-ops, local newspapers, and cable TV to share useful information with stakeholders on ways to improve water quality.
- Prominently display the Commission's logo on information and outreach items, project and interpretive signs, and other locations to increase visibility.
- Provide opportunities for the public to learn about and participate in water quality activities.
- Provide education opportunities for elected and appointed officials and other decision makers.
- Enhance education opportunities for youth.
- Provide opportunities for bridge building between stakeholders with sometimes-competing ideas and interests, such as lakeshore owners and agricultural operators.

Specific critical areas for the period 2015 through 2017 for education and outreach include:

1. Sponsor watershed and water resources training opportunities such as NEMO (Nonpoint Education for Municipal Officials) for the Commissioners, all city councils, and planning commissions in the member cities.
2. Convene citizen's advisory committees as needed to make recommendations on education and outreach actions and assist the Commission with implementation.
3. Disseminate education materials to all stakeholders about actions they can take to protect water quality. Targeted messages are:
    a. Redirect your runoff on to pervious areas.
    b. Clean up after your pets.
    c. Keep organic matter (leaves, grass clippings, seeds, etc.) out of streets, ditches, lakefronts, and storm sewers.
    d. Reduce chemical and salt use.
4. Participate with collaborative groups such as the West Metro Water Alliance (WMWA).
5. Develop and host an education and outreach multi-generational event for families to promote watershed and water quality education.
6. Maintain and update the Commission's web site to provide information/education to the public.

The Commission intends to budget between $8,000 and $12,000/yr over the next five years to support these and other education and civic engagement initiatives. The Commission will also look for opportunities to work with regional park and special recreation feature authorities to identify and implement education and outreach activities.

Public Notice for Comments

An opportunity for public comment on the draft WRAPS report was provided via a public notice in the State Register from May 1, 2017 to May 31, 2017. Two comment letters were received.

3.3 Restoration & Protection Strategies

Specific strategies have been developed to restore the impaired waters within the PSC Subwatershed and to protect waters within the subwatershed that are not impaired. The subwatershed-based implementation strategy tables that follow (Table 3.2 to Table 3.6) outline the strategies and actions that are capable of cumulatively achieving the needed pollution load reductions for point and nonpoint sources. The tables were developed by reviewing the specific conditions affecting each of the waters and collecting input from the TMDL report and watershed stakeholders.

It is important to note that loading reduced from some implementation actions listed in the strategies tables below are creditable to the LAs and some to the WLAs. Examples of non-WLA-creditable projects include strategies aimed at reducing in-lake loading (e.g., alum treatment, aquatic plant management). For clarification on a particular project's applicability to a WLA, a project proposer should contact the MPCA Stormwater Program.

Subwatershed Assessments

The watershed modeling and monitoring completed for the TMDL identified subwatersheds where nutrient loading potentially occurs at higher rates than average. The PSCWMC will undertake more detailed and systematic subwatershed assessments and modeling to focus load reduction efforts in those high-loading areas where actions such as retrofitting existing ponds with iron-enhanced filter benches, mitigating stream erosion, enhancing stream buffers, improving individual site manure management, or adding new bioinfiltration basins are likely to be most cost-effective. Examples of subwatershed assessments that provide actionable information to guide implementation efforts in the PSC Subwatershed include the Dance Hall Creek Subwatershed Assessment (for Lake Sarah) and the Ardmore Area Subwatershed Stormwater Retrofit Assessment (for Lake Ardmore).

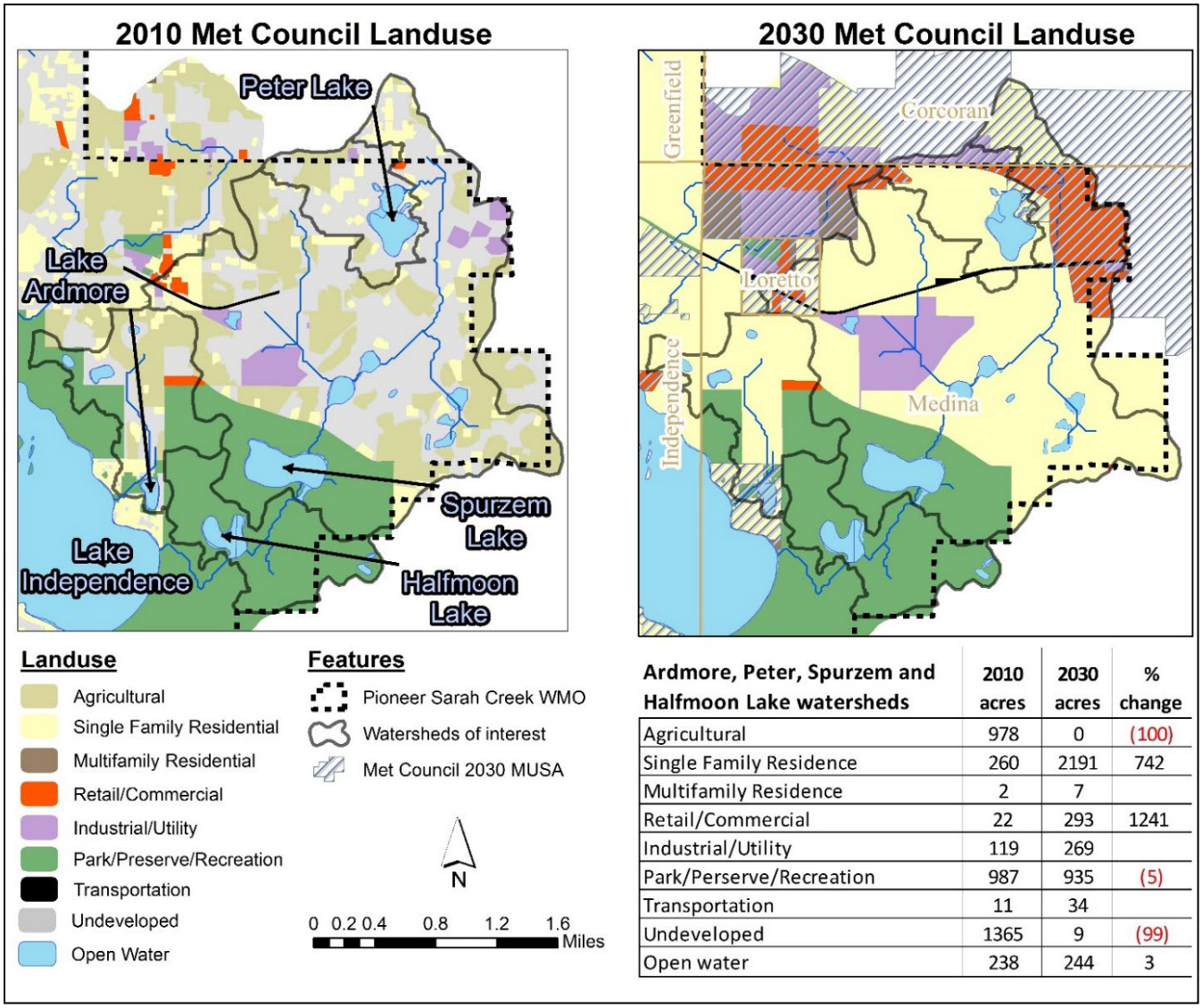
Future subwatershed assessments will identify nonpoint source problem areas and potential upland BMP projects throughout the various subwatersheds. The in-channel walking surveys/assessments will identify areas of streambank erosion and evaluate riparian vegetation and habitat conditions. Below is a list of the types of urban, rural, and in-channel BMP projects these assessments and surveys will help apply appropriately:

- Bioretention/infiltration basins and tree-trenches
- Pervious pavement
- Hydrodynamic separators and St. Anthony Falls Laboratory (SAFL) Baffles
- Residential raingardens
- Iron-enhanced sand filters
- Other stormwater pond retrofits and maintenance

- Wetland restoration
- Conservation and reduced tillage BMPs in sensitive cropland areas
- Water and sediment control basins
- Grassed waterways
- Agricultural nutrient management
- Contour farming
- Stream and edge of field buffers
- Managed livestock access control areas near streams
- Manure storage/manure management plan development and implementation
- Alternative watering sources for livestock in pasture or winter feeding areas
- Pastureland runoff controls/buffers and pasture management education (neighbor-to-neighbor walking tours)
- Lakeshore restorations
- Riparian forest buffer
- Bank stabilization/restoration
- Re-meandering (in-channel)
- Low-flow channel construction (e.g. two-stage ditches)
- Substrate installation (in-channel)
- Fine sediment removal (in-channel)

Watershed Rules and Standards

Much of the PSC Subwatershed is in land use transition (see Figure 3-3 as an example of anticipated land use changes in the subwatersheds of Peter, Spurzem, Half Moon, and Ardmore Lakes). It is expected that much of the area now in agricultural uses will be converted over the next 10 to 30 years to large-lot development with some suburban and commercial/industrial development occurring as well. The PSCWMC has enacted more stringent rules and standards for managing runoff rates and volumes and requiring nutrient and sediment load reductions. Developers and redevelopers are now required to infiltrate or abstract 1.1" of runoff from new impervious surface. Where infiltration is not feasible, the new rules require that runoff be filtered before discharge from the site. The rules also establish a performance standard for stormwater quality to achieve a loading reduction as good as or better than that which would be achieved by abstracting 1.1" of runoff depth from new impervious surfaces, or no-net increase in TP or TSS, whichever is lower.



Ardmore, Peter, Spurzem and Halfmoon Lake watersheds	2010 acres	2030 acres	% change
Agricultural	978	0	(100)
Single Family Residence	260	2191	742
Multifamily Residence	2	7	
Retail/Commercial	22	293	1241
Industrial/Utility	119	269	
Park/Perserve/Recreation	987	935	(5)
Transportation	11	34	
Undeveloped	1365	9	(99)
Open water	238	244	3

Figure 3-3. 2010 and Anticipated 2030 Land Use for Peter, Spurzem, Half Moon and Ardmore Lake Watersheds

Funding Opportunities

Funding sources are available to help cover some of the cost to implement practices that will reduce pollutants from entering our surface waters and groundwater. There are several programs listed below that contain web links to the programs and contacts for each entity. The contacts for each grant program can assist in the determination of eligibility for each program as well as funding requirements and amounts available.

On November 4, 2008, Minnesota voters approved the Clean Water, Land & Legacy Amendment to the constitution to:

- *protect drinking water sources;*
- *protect, enhance, and restore wetlands, prairies, forests, and fish, game, and wildlife habitat;*

- *preserve arts and cultural heritage;*
- *support parks and trails;*
- *and protect, enhance, and restore lakes, rivers, streams, and groundwater.*

The Clean Water, Land, and Legacy Fund has several grant and loan programs that could potentially be used for implementation of the BMPs and education and outreach activities.

Various programs and sponsoring agencies related to clean water funding and others are:

- Agriculture BMP Loan Program (Minnesota Department of Agriculture)
- Clean Water Fund Grants (BWSR)
- Clean Water Partnership Loans (MPCA)
- Environment and Natural Resources Trust Fund (Legislative-Citizen Commission on Minnesota Resources)
- Environmental Assistance Grants Program (MPCA)
- Phosphorus Reduction Grant Program (Minnesota Public Facilities Authority)
- Clean Water Act Section 319 Grant Program (MPCA)
- Small Community Wastewater Treatment Construction Loans & Grants (Minnesota Public Facilities Authority)
- Source Water Protection Grant Program (MDH)
- Surface Water Assessment Grants (MPCA)
- Wastewater and storm water financial assistance (MPCA)
- Conservation Partners Legacy Grant Program (DNR)
- Environmental Quality Incentives Program (NRCS)
- Conservation Reserve Program (USDA)
- Minnesota Agricultural Water Quality Certification Program
- Hennepin County Natural Resources Grants
- Metropolitan Council Environmental Services Grants
- Pioneer-Sarah Creek Watershed Management Commission Cost Share Funding

There are several grant and loan programs through the federal government that could be used for education and outreach as well as purchasing equipment and implementation of the BMPs. A list of federal grant programs can be found at: https://www.epa.gov/grants.

Table 3.2: Watershed Wide Strategies and Actions Proposed for the Pioneer-Sarah Creek Watershed

Major Subwatersheds	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr milestone and final water quality targets. Scenarios and adoption levels may change with additional local planning, research showing new BMPs, changing financial support and policies, and experience implementing the plan.					Governmental Units with Primary Responsibility[1]															Estimated Year to Achieve Water Quality Target
								Estimated Adoption Rate				PSC WMC	Hennepin County	3-Rivers Park District	MPCA	BWSR	MDNR	MDA	UMN Extension	City of Loretto	City of Corcoran	City of Medina	City of Independence	City of Greenfield	City of Maple Plain		
	Waterbody (ID)	Location		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction		Strategy Type	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units																
Pioneer-Sarah Creek watershed	All	Pioneer-Sarah Creek watershed	All Conventional Pollutants	--	Various	Subwatershed assessments are likely to identify other projects that were not included at the level of detail the technical analysis was conducted to support this WRAPS/TMDL. Those projects should be considered as recognized/adopted under this plan and prioritized for implementation based on their cost, effectiveness in reducing pollutant load, local/landowner support, and other factors.																			Ongoing
						Improve fertilizer and manure application management, eliminate livestock traffic through waterways	Promote/educate hobby and production livestock owners on appropriate livestock and manure management practices (rotational grazing, manure storage, land application based on soil conditions and soil and manure nutrient testing, precautions to take if spreading in sensitive areas, etc.) and eliminating livestock traffic through water ways,as per University of Minnesota guidelines, MDA guidelines, and Minnesota rules. In particular, see MDA's MN Ag Water Quality Certification Program[2]	As needed	Hold workshops as needed, work with willing landowners as opportunities arise	As needed	N/A	P	P	A	A			A	S		S	S	S	S	S	
							Implement non-production animal operation siting and management ordinance as per 2015 approved watershed plan	PSCWMC has developed guidance for cities	Cities adopt ordinance	Ongoing	N/A	S	S					A			P	P	P	P	P	
						Address failing septic systems	Identify and upgrade 100% of SSTS systems in shoreland areas	None	Upgrade 50% of failing SSTS	100	% of failing SSTS systems in compliance		P							S	S	S	S	S	S	
						Improve riparian vegetation	Evaluate compliance with state stream buffer requirements on all DNR streams and public ditches	In progress	Complete	Complete	N/A	S	P					S			S	S	S	S	S	S	
							Achieve minimum of 50 ft buffer as necessary to comply with law, enforce buffers on 100% of affected streams and ditches	Unknown	Complete - Buffers in place on public waters by July 2017, on public ditches by Dec. 2018	100	% of required buffers installed	S	P	S				A	A		S	S	S	S	S	S	
						Improve urban/suburban stormwater management	Implement updated Commission standards for runoff volume and rate control for new development projects throughout watershed	New standards approved in 2015 as part of PSCWMCs 3rd gen. plan	Ongoing		N/A	P	S							P	P	P	P	P	P	
			Social Infrastructure (to address all pollutants/stressors)	--	--	Improve education and outreach	K-12 watershed education	Ongoing			N/A	P	A	A						A	A	A	A	A	A	
							General public outreach and education					P	A	A						A	A	A	A	A	A	
						Improve coordination/collaboration	Involve citizen networks in water resource-related projects					P	A	A						A	A	A	A	A	A	
							Coordinate planning/improvement projects with stakeholders					P	A	A						A	A	A	A	A	A	
						Implement/review policies and rules	Ongoing review of policies and procedures to meet WLA goals					P	A	A						P	P	P	P	P	P	
			Chloride	--	--	Road Salt Management	Promote and adopt strategies in the TCMA Chloride Management Plan: https://www.pca.state.mn.us/sites/default/files/wq-iw11-06ff.pdf	Ongoing			N/A	A	P	P	A				A	P	P	P	P	P	P	Ongoing

[1] P - Primary/Lead role, S - Secondary role, A - Assist as needed

[2] The Minnesota Agricultural Water Quality Certification Program (MAWQCP; http://www.mda.state.mn.us/awqcp) is a voluntary opportunity for farmers and agricultural landowners to take the lead in implementing conservation practices that protect our water; producers seeking certification can obtain specially designated technical and financial assistance to implement practices that promote water quality.

Table 3.3: Strategies and Actions Proposed for the Sarah Creek and Direct North Fork Crow River Subwatersheds

Major Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr milestone and final water quality targets. Scenarios and adoption levels may change with additional local planning, research showing new BMPs, changing financial support and policies, and experience implementing the plan.					Governmental Units with Primary Responsibility[1]							Estimated Year to Achieve Water Quality Target
							Strategy Type	Estimated Adoption Rate				PSC WMC	Hennepin County	City of Greenfield	3-Rivers Park District	MPCA	MDNR	BWSR	
	Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction			Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units								
North Fork Crow River Direct	Lake Sarah (27-0191)	Hennepin Co., Corcoran MS4, Independence MS4, Medina MS4, Loretto MS4	TP	Detailed allocations and strategies have been developed for the Lake Sarah Nutrient TMDL (2011) and Implementation Plan (2011). These documents are approved by the EPA and available through the MPCA website: https://www.pca.state.mn.us/water/tmdl/lake-sarah-excess-nutrients-tmdl-project															
	Hafften Lake (27-0199)	Hennepin Co., City of Greenfield	TP	Detailed allocations and strategies were developed for Hafften Lake through the North Fork Crow River TMDL (2014) and WRAPS (2014). These documents are, or will be available through the MPCA website: https://www.pca.state.mn.us/water/watersheds/north-fork-crow-river															
	Sarah Creek (07010204-628)	Hennepin Co., City of Greenfield	*E. coli*	21 - 303 cfu/100ml (monthly geomeans)	0% - 16% reduction depending on flow condition	Improve riparian vegetation	Achieve minimum of 50 ft buffer as necessary to comply with law, enforce buffers on 100% of affected streams and ditches	Unknown	Complete 2,000 ft not currently in wetland or regional park	2,000	Linear feet of stream with minimum 50 ft buffer	S	P	S		A	A		2018

Restoration
Protection
Strategies to address downstream impairments

P - Primary/Lead role, S - Secondary role, A - Assist as needed

Table 3.4: Strategies and Actions Proposed for the Lake Rebecca and Direct South Fork Crow River Subwatersheds

Major Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr milestone and final water quality targets. Scenarios and adoption levels may change with additional local planning, research showing new BMPs, changing financial support and policies, and experience implementing the plan.					Governmental Units with Primary Responsibility[1]										Estimated Year to Achieve Water Quality Target
								Estimated Adoption Rate														
	Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction		Strategy Type	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	PSC WMC	Hennepin County	S-Rivers Park District	MPCA	BWSR	MDNR	MDA	UMN Extension	City of Independence	
Lake Rebecca and South Fork Crow River Direct	Lake Rebecca (27-0192)	Hennepin Co.	TP	Summer average TP typically 25 - 40 ug/L since 2011	Protect to maintain NCHF deep lake state WQ standards: <40 ug/l TP	Continue to reduce watershed pollutant loadings	Work with Shriners Horse Farm and City of Independence to continue improvements in horse farm operations to minimize off-site export of phosphorus, bacteria, and other pollutants to tributary that discharges to Lake Rebecca	Improvements made in manure management in 2009, livestock grazing densities continue to be above recommended levels	Ongoing		N/A	P	P	P	A			A	A	P	Currently meets standards
						Monitoring	Continue annual surface water quality monitoring and periodic assessment of rooted aquatic plant community through surveys every 1-2 years	Annual WQ monitoring and plant surveys being conducted by TRPD	Ongoing		N/A	P		P							
						Internal load assessment and control	Periodically assess internal loading from sediment release and CLPW to determine effectiveness/longevity of alum treatment conducted in 2010/2011 and CLPW control efforts.	Last sediment assessment completed in 2013	Ongoing		N/A			P							
							Supplement internal loading control measures as necessary (both sediment release and CLPW vectors).	N/A	As needed based on monitoring		N/A	P		P			A				

Restoration
Protection
Strategies to address downstream impairments

1 P - Primary/Lead role, S - Secondary role, A - Assist as needed

Table 3.5: Strategies and Actions Proposed for the Pioneer Creek Subwatershed

Major Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr milestone and final water quality targets. Scenarios and adoption levels may change with additional local planning, research showing new BMPs, changing financial support and policies, and experience implementing the plan.					Governmental Units with Primary Responsibility																Estimated Year to Achieve Water Quality Target
								Estimated Adoption Rate				PSC WMC	Hennepin County	S-Rivers Park District	MPCA	BWSR	MDNR	MDA	NRCS	Metropolitan Council	UMN Extension	City of Loretto	City of Corcoran	City of Medina	City of Independence	City of Maple Plain	
	Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction		Strategy Type	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units																	
Pioneer Creek Above Oxbow Lake	Lake Independence (27-0176)	Hennepin Co., Independence MS4, Loretto MS4, Medina MS4	TP	Detailed allocations and strategies have been developed for the Lake Independence Phosphorus TMDL (2007) and Implementation Plan (2007). These documents are approved by the EPA and available through the MPCA website: https://www.pca.state.mn.us/water/tmdl/lake-independence-excess-nutrients-tmdl-project. Strategies																						
	Peter Lake - North Bay (27-0147-02)	Hennepin Co., Corcoran MS4, Medina MS4	TP	473 lbs/yr	397 lbs/yr 20% reduction	Reduce internal loading (in-lake load reduction goal is 96 lbs/yr)	Conduct assessment to determine appropriate dose and cost of alum treatment	N/A	Complete	Complete	N/A	S		A	A									P			2036
							Execute chemical precipitant treatment to reduce phosphorus release from sediments (alum treatment)	N/A	Complete	Complete	N/A	S		A	A									P			
							Conduct follow-up monitoring to track effectiveness and longevity of treatment	N/A	Complete following treatment	Complete following treatment	N/A	P		A									P			
	Spurzem Lake (27-0149)	Hennepin Co., Loretto MS4, Corcoran MS4, Medina MS4	TP	2,189 lbs/yr	337 lbs/yr 85% reduction	Improve upland/field surface runoff controls and management	Perform rural subwatershed assessment, identify and implement 5 to 10 rural/agricultural BMPs	None	Complete	5 to 10	# of agricultural BMPs completed	P	P		A			A	A				P	P	P		2023
						Determine influence of wetlands on nutrient loading	Monitor upstream wetland(s) to try to establish degree of enrichment and degree to which it acts as phosphorus source to downstream priority waters.	None	Complete	Complete	N/A	P			P												
							Take appropriate measures to reduce wetland loading as appropriate	None	Complete	Complete	N/A																
						Remove discharge from Loretto WWTP	Work toward hook-up of Loretto sanitary system to regional MCES interceptor to eliminate need for local treatment pond system; de-commission existing WWTP	WWTP maintaining high quality effluent discharge at this time	Complete	Complete	N/A				A					P		P					
						Reduce in-lake loading (internal load reduction goal is 715 lbs/yr)	Develop lake vegetation management plan to manage curlyleaf pondweed on a whole lake basis	Point/intercept surveys completed to support lake vegetation management plan (LVMP)	Complete	Complete	N/A	S			P		A								S			
							Conduct assessment to determine appropriate dose and cost of chemical precipitant treatment	N/A	Complete	Complete	N/A	S			P	A									S			
							Execute chemical precipitant treatment to reduce phosphorus release from sediments	N/A	Complete	Complete	N/A	S			P	A									P			
							Conduct follow-up monitoring to track effectiveness and longevity of treatment	N/A	Complete following treatment	Complete following treatment	N/A	S			P												
						Improve quality of upstream lake(s) (load reduction goal for Peter Lake outflow is 2.6 lbs/yr)	Improve water quality in Peter Lake to meet state water quality standards for phosphorus (see strategies for Peter Lake)	None	See Peter Lake strategies	Complete	N/A	S			A									P			
	Half Moon Lake (27-0152)	Hennepin Co.	TP	1,713 lbs/yr	358 lbs/yr 80% reduction	Improve upland/field surface runoff controls and management	Perform rural subwatershed assessment, identify and implement 3 to 5 rural/agricultural BMPs	None	Identify and implement 3 to 5 rural/agricultural BMPS	5 to10	# of agricultural BMPs completed	P	S	S				A	A					A			2030
						Determine influence of wetlands on nutrient loading	Monitor upstream wetland(s) to try to establish degree of enrichment and degree to which it acts as phosphorus source to downstream priority waters.	None	N/A	Complete	N/A	P	S														
							Determine management options and take corrective action as necessary	Point/intercept surveys completed to support LVMP	N/A	Complete	N/A	P	S			P	A							A			
						Reduce in-lake loading (internal load reduction goal is 319 lbs/yr)	Develop lake vegetation management plan to manage curlyleaf pondweed on a whole lake basis	Point/intercept surveys completed to support LVMP	Complete	Complete	N/A	S			P		P										
							Assess roughfish population to determine potential impact on native vegetation, water quality. Pursue removals/establish barriers as necessary	Preliminary assessment completed Dec 2016	Complete assessment, manage rough fish population if necessary	Manage rough fish population if necessary	N/A	S					S										
							Conduct assessment to determine appropriate dose and cost of chemical precipitant treatment	None	Complete	Complete	N/A	S	P			A											
							Execute chemical precipitant treatment to reduce phosphorus release from sediments	None	Complete	Complete	N/A	S	P			A											
							Conduct follow-up monitoring to track effectiveness and longevity of treatment	None	Complete following treatment	Complete following treatment	N/A	P	P														

Major Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr milestone and final water quality targets. Scenarios and adoption levels may change with additional local planning, research showing new BMPs, changing financial support and policies, and experience implementing the plan.					Governmental Units with Primary Responsibility																Estimated Year to Achieve Water Quality Target
							Strategy Type	Estimated Adoption Rate				PSC WMC	Hennepin County	S-Rivers Park District	MPCA	BWSR	MDNR	MDA	NRCS	Metropolitan Council	UMN Extension	City of Loretto	City of Corcoran	City of Medina	City of Independence	City of Maple Plain	
	Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction			Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units																	
						Improve quality of upstream lake(s) (load reduction goal for Spurzem Lake outflow is 580 lbs/yr)	Improve water quality in Spurzem Lake to meet state water quality standards for phosphorus	None	See Spurzem Lake strategies	Complete	N/A	P	P														
	Lake Ardmore (27-0153)	Hennepin Co., Loretto MS4, Medina MS4	TP	538 lbs/yr	50 lbs/yr 91% reduction	Improve upland urban and agricultural surface runoff controls and management	Perform suburban and rural subwatershed assessment, identify and implement 5-10 urban/agricultural BMPs	Subwatershed assessment completed by Medina in 2016	Identify and implement 5-10 urban/agricultural BMPs	10 to 20	# of urban and ag BMPs completed	P	P		A			A	A				P			2025
						Determine influence of wetlands on nutrient loading	Monitor upstream wetland(s) to try to establish degree of enrichment and degree to which wetland(s) acts as phosphorus source to downstream priority waters.	None	Complete	Complete	N/A	P		A										P			
							Determine management options and take corrective action as necessary	None	Complete	Complete	N/A	P	A	A		A	A							P			
						Reduce in-lake loading (internal load reduction goal is 243 lbs/yr)	Develop lake vegetation management plan	Point/intercept surveys completed to support LVMP	Complete	Complete	N/A	P		A										P			
							Assess roughfish population to determine potential impact on native vegetation, water quality. Pursue removals/establish barriers as necessary	Preliminary assessment completed December 2016	Complete assessment, manage rough fish population if necessary	Manage rough fish population if necessary	N/A	P		A										P			
							Conduct assessment to determine appropriate dose and cost of chemical precipitant treatment	None	Complete	Complete	N/A	P		A										P			
							Execute chemical precipitant treatment to reduce phosphorus release from sediments	None	Complete	Complete	N/A	P		A										P			
							Conduct follow-up monitoring to track effectiveness and longevity of treatment	None	Complete following treatment	Complete following treatment	N/A	P		P										A			
	Pioneer Creek (07010205-653)	Hennepin Co., Independence MS4, Maple Plain MS4	*E. coli*	127 - 258 cfu/100ml (monthly geomeans)	0% - 62% reduction depending on flow condition	Reduce livestock bacteria in surface runoff	Establish livestock managed access control areas near streams, alternative watering sources and/or pastureland and feedlot runoff controls/buffers farms in shoreland areas	Unknown	Implement BMPs/buffers on 50% of farms in shoreland areas	100	% of BMPs/buffers on farms in shoreland areas	S	P		A			A	A		A	A	A	A		A	2030
							Perform rural subwatershed assessment study to identify and implement livestock/agricultural BMPs in areas draining to Pioneer Creek	None	Perform study, implement 5-10 BMPs	10 to 20	# of BMPs implemented	P			A			A	A		A	A	A	A		A	
						Improve urban stormwater management.	Educate and enforcement of proper pet waste management in urban areas	Ongoing			N/A	P										S	S	S		S	
						Improve riparian vegetation	Achieve minimum of 50 foot buffer as necessary to comply with law, enforce buffers on 100% of affected streams and ditches	Unknown	Complete 5,000 feet not currently in wetland or regional park	5,000	Linear feet of stream with minimum 50 ft. buffer	S	P			P	A							S	S	S	
	Pioneer Creek (07010205-653)	Hennepin Co., Independence MS4, Maple Plain MS4	DO	DO currently not meeting 5.0 mg/L standard as a daily minimum during summer months	Allocations were not developed as part of this TMDL since sources were primarily natural background	Improve quality of upstream lakes	Achieve phosphorus load reduction goals for Lake Independence to reduce algae and oxygen demand loads to Pioneer Creek	Ongoing	See Lake Independence strategies	Complete	N/A	P		S			A					P		P	P		2030
						In-channel restorations	Channel restorations, where possible, through development of low-flow channel to decrease width and increase velocity, meandering, riffles, and aeration throughout Unnamed and Deer Creek	Unknown	Complete 2,500 feet not currently in wetland	2,500	Linear ft of stream channel restoration	P					A								P		
						Wetland restorations	Improve hydrology and water quality flow-through wetland system to decrease sediment oxygen demand and improve overall water quality	Unknown	Perform monitoring, 1-2 BMPs	3-5	Wetland outlet BMPs	P					A								P	P	

Restoration
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Strategies to address downstream impairments

1 P - Primary/Lead role, S - Secondary role, A - Assist as needed

Table 3.6: Strategies and Actions Proposed for the Rice Lake Subwatershed

Major Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr milestone and final water quality targets. Scenarios and adoption levels may change with additional local planning, research showing new BMPs, changing financial support and policies, and experience implementing the plan.					Governmental Units with Primary Responsibility																Estimated Year to Achieve Water Quality Target
								Estimated Adoption Rate				PSC WMC	Hennepin County	Carver County	Carver SWCD	Three Rivers Park	MPCA	BWSR	MDNR	MDA	NRCS	UMN Extension	Independence	Maple Plain	Minnetrista	Watertown Twnsp		
	Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction		Strategy Type	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units																	
Pioneer Creek Below Oxbow Lake	Oak Lake (10-0093) Swede Lake (10-0095)	Carver Co.	TP	Detailed allocations and strategies have been developed for Oak and Swede Lake through the South Fork Crow River Lakes Excess Nutrients TMDL Report (2010) and Implementation Plan (2011). These documents are approved by the USEPA and available through the MPCA web site: https://www.pca.state.mn.us/water/tmdl/south-fork-crow-river-lakes-excess-nutrients-tmdl-project																							
	Mud Lake (10-0094) Rice Lake (86-0032)	Carver & Wright Co.	TP	Detailed allocations and strategies are being developed for Mud and Rice Lake through the South Fork Crow River Watershed TMDL (2016) and WRAPS (2016). These documents are, or will be available through the MPCA web: https://www.pca.state.mn.us/water/watersheds/south-fork-crow-rivesite																							
	South Whaletail Lake (27-0184-02)	Hennepin Co.	TP	529 lbs/yr	367 lbs/yr 34% reduction	Reduce internal loading (in-lake load reduction goal is 243 lbs/yr)	Conduct assessment to determine appropriate dose and cost of chemical precipitant treatment	N/A	Complete	Complete	N/A	S				P	A								P		2020
							Execute chemical precipitant treatment to reduce phosphorus release from sediments	N/A	Complete	Complete	N/A	S				P	A								P		
							Conduct follow-up monitoring to track effectiveness and longevity of treatment	N/A	Complete	Completed	N/A	P				P								A		
	North Whaletail Lake (27-0184-01)	Hennepin Co.	TP	801 lbs/yr	620 lbs/yr 26% reduction	Improve upland rural/agricultural surface runoff controls and management	Perform rural/agricultural subwatershed assessment, identify and implement 5-10 rural/agricultural BMPs	N/A	Subwatershed Assessment Complete	5 to 10	# of agricultural BMPs completed	S	P				A			A	A				P		2025
						Reduce in-lake loading (internal load reduction goal is 94 lbs/yr)	Develop lake vegetation management plan and manage curlyleaf pondweed on a whole lake basis per DNR Invasive Aquatic Plant Management permit	Point/intercept surveys completed to support LVMP	Complete	Complete	N/A	S				A			A						P		
							Assess roughfish population to determine potential impact on native vegetation, water quality. Pursue removals/establish barriers as necessary	N/A	Assessment Complete	Manage roughfish population if necessary	N/A	S				A			A						P		
							Conduct assessment to determine appropriate dose and cost of chemical precipitant treatment	N/A	Complete	Complete	N/A	S				A	A								P		
							Execute chemical precipitant treatment to reduce phosphorus release from sediments	N/A	Complete	Complete	N/A	S				A	A								P		
							Conduct follow-up monitoring to track effectiveness and longevity of treatment	N/A	Complete	Complete	N/A	P				P								A		
						Improve quality of upstream lake (load reduction goal for South Whaletail Lake outflow is 21 lbs/yr)	Improve water quality in South Whaletail Lake to meet state water quality standards for phosphorus	N/A	Complete	Complete	N/A	P				P	S								P		
	Unnamed Creek (07010205-593)	Carver & Hennepin Co.	*E. coli*	12 - 307 cfu/100ml (monthly geomeans)	0% - 30% reduction depending on flow condition	Reduce livestock bacteria in surface runoff (Unnamed & Deer Creek)	Establish livestock managed access control areas near streams, alternative watering sources and/or pastureland runoff controls/buffers farms in shoreland areas	Unknown	BMPs/buffers on 50% of farms in shoreland areas	100	% BMPs/buffers on farms in shoreland areas	S	P			P		A			A	A	S				2037
							Perform rural subwatershed assessment studies to identify and implement livestock/agricultural BMPs	None	Complete subwatershed study, implement 5-10 BMPs	10 to 20	# of livstock/agricultural BMPs completed	S				P		A			A	A						
						Improve riparian vegetation	Achieve minimum of 50 ft buffer as necessary to comply with law, enforce buffers on 100% of affected streams and ditches	Unknown	Complete 3,000 ft not currently in wetland or regional park	3,000	Linear feet of stream with minimum 50 ft buffer	S	P			P			P	A					S	S	
	Deer Creek (07010205-594)	Carver & Hennepin Co.	*E. coli*	52 - 596 cfu/100ml (monthly geomeans)	0% - 53% reduction depending on flow condition	Improve riparian vegetation	Achieve minimum of 50 ft buffer as necessary to comply with law, enforce buffers on 100% of affected streams and ditches	unknown	Complete 1,500 ft not currently in wetland or regional park	1,500	Linear feet of stream with minimum 50 ft buffer	S	P			P			P	A					S	S	
	Deer Creek (07010205-594) & Unnamed Creek (07010205-593)	Carver & Hennepin Co.	*DO*	DO currently not meeting 5.0 mg/L standard as a daily minimum during summer months	Allocations were not developed as part of this TMDL since sources were primarily natural background	Improve quality of upstream lakes	Achieve phosphorus load reduction goals for North Whaletail Lake to reduce algae and oxygen demand loads to Deer Creek	Unknown	See North Whaletail Lake strategies	Complete	N/A	P				P									P		
							Achieve phosphorus load reduction goals for Mud Lake to reduce algae and oxygen demand loads to Unnamed Creek. A lake nutrient TMDL is currently being developed for Mud Lake as part of the South Fork Crow River TMDL/WRAPS process..	Unknown	See Mud Lake strategies	Complete	N/A	P				P									P		
						In-channel restoration	Channel restorations, where possible, through development of low-flow channel to decrease width and increase velocity, meandering, riffles, and aeration throughout Unnamed and Deer Creek	Unknown	Complete 2,000 feet not currently in wetland	2,000	Linear ft of stream channel restoration	P				A									P		
						Wetland Restorations	Improve hydrology and water quality in Deer and Unnamed Creek flow-through wetland systems to decrease sediment oxygen demand and improve overall water quality	Unknown	Perform monitoring, 1-2 BMPs	3-5	Wetland outlet BMPs	P				A									P		
	North & South Little Long (27-0179-01 & 02)	Hennepin Co.	TP	Summer average TP typically 15 - 20 ug/L	Protect to maintain NCHF deep lake state WQ standards: <40 ug/l TP	Minimize watershed pollutant loadings	Avoid enlarging watershed draining to the lake if development occurs in Minnetrista	N/A	Ongoing		N/A	P	A			A									P		Currently meets standards
							Firm application of Commission's new development standards adopted in 2015 for stormwater management					P	A			A									P		
						Monitoring	Continue annual surface water quality monitoring and periodic assessment of rooted aquatic plant community through surveys every 2-4 years					P				P											
						Internal load assessment and control	Periodically assess internal loading and address through suitable control measures if necessary					P				P											

Restoration
Protection
Strategies to address downstream impairments

[1] P - Primary/Lead role, S - Secondary role, A - Assist as needed

Table 3.7: Key for Strategies Column

Parameter (incl. non-pollutant stressors)	Strategy Key	
	Description	**Example BMPs/actions**
TSS	Improve upland/field surface runoff controls: Soil and water conservation practices that reduce soil erosion and field runoff, or otherwise minimize sediment from leaving farmland	Cover crops
		Water and sediment basins, terraces
		Rotations including perennials
		Conservation cover easements
		Grassed waterways
		Strategies to reduce flow- some of flow reduction strategies should be targeted to ravine subwatersheds
		Residue management - conservation tillage
		Forage and biomass planting
		Open tile inlet controls - riser pipes, French drains
		Contour farming
		Field edge buffers, borders, windbreaks and/or filter strips
		Stripcropping
	Improve urban stormwater management [to reduce sediment and flow]	See MPCA Stormwater Manual: https://stormwater.pca.state.mn.us/index.php?title=Main_Page
Nitrogen (TN) or Nitrate	Increase fertilizer and manure efficiency: Adding fertilizer and manure additions at rates and ways that maximize crop uptake while minimizing leaching losses to waters	Nitrogen rates at Maximum Return to Nitrogen (University of Minnesota rec's)
		Timing of application closer to crop use (spring or split applications)
		Nitrification inhibitors
		Manure application based on nutrient testing, calibrated equipment, recommended rates, etc.
	Increase vegetative cover/root duration: Planting crops and vegetation that maximize vegetative cover and capturing of soil nitrate by roots during the spring, summer and fall.	Conservation cover (easements/buffers of native grass & trees, pollinator habitat)
		Perennials grown on marginal lands and riparian lands
		Cover crops
		Rotations that include perennials
		Crop conversion to low nutrient-demanding crops (e.g., hay).
Phosphorus (TP)	Improve upland/field surface runoff controls: Soil and water conservation practices that reduce soil erosion and field runoff, or otherwise minimize sediment from leaving farmland	Strategies to reduce sediment from fields (see above - upland field surface runoff)
		Constructed wetlands
		Pasture management
	Increase vegetative cover/root duration: Planting crops and vegetation that maximize vegetative cover and minimize erosion and soil losses to waters, especially during the spring and fall.	Conservation cover (easements/buffers of native grass & trees, pollinator habitat)
		Perennials grown on marginal lands and riparian lands
		Cover crops
		Rotations that include perennials
	Preventing feedlot runoff: Using manure storage, water diversions, reduced lot sizes and vegetative filter strips to reduce open lot phosphorus losses	Open lot runoff management to meet 7020 rules
		Manage livestock and manure storage in ways that prevent polluted runoff from reaching surface waters (See https://www.mda.state.mn.us/animals/livestock.aspx for livestock resources)

Parameter (incl. non-pollutant stressors)	Strategy Key	
	Description	**Example BMPs/actions**
	Improve fertilizer and manure application management: Applying phosphorus fertilizer and manure onto soils where it is most needed using techniques that limit exposure of phosphorus to rainfall and runoff.	Soil P testing and applying nutrients on fields needing phosphorus
		Incorporating/injecting nutrients below the soil
		Manure application meeting all 7020 rule setback requirements
	Address failing septic systems: Fixing septic systems so that on-site sewage is not released to surface waters. Includes straight pipes.	Sewering around lakes
		Eliminating straight pipes, surface seepages
	Reduce in-water loading: Minimizing the internal release of phosphorus within lakes	Rough fish management
		Curly-leaf pondweed management
		Alum treatment
		Lake drawdown
		Hypolimnetic withdrawal
	Reduce Industrial/Municipal wastewater TP	Municipal and industrial treatment of wastewater P
	Treat tile drainage waters: Treating tile drainage waters to reduce phosphorus entering water by running water through a medium which captures phosphorus	Phosphorus-removing treatment systems, including bioreactors
	Improve urban stormwater management	See MPCA Stormwater Manual: https://stormwater.pca.state.mn.us/index.php?title=Main_Page
E. coli	Reducing livestock bacteria in surface runoff: Preventing manure from entering streams by keeping it in storage or below the soil surface and by limiting access of animals to waters.	Strategies to reduce field TSS (applied to manured fields, see above)
		Improved field manure (nutrient) management
		Adhere/increase application setbacks
		Improve feedlot runoff control
		Animal mortality facility
		Manure spreading setbacks and incorporation near wells and sinkholes
		Rotational grazing and livestock exclusion (pasture management)
	Reduce urban bacteria: Limiting exposure of pet or waterfowl waste to rainfall	Pet waste management
		Filter strips and buffers
		See MPCA Stormwater Manual: https://stormwater.pca.state.mn.us/index.php?title=Main_Page
	Address failing septic systems: Fixing septic systems so that on-site sewage is not released to surface waters. Includes straight pipes.	Replace failing septic (SSTS) systems
		Maintain septic (SSTS) systems
Dissolved Oxygen	Reduce phosphorus	See strategies above for reducing phosphorus
Chloride	Road salt management	Promote and adopt strategies in the Twin Cities Metro Area Chloride Management Plan: https://www.pca.state.mn.us/water/road-salt-and-water-quality

Parameter (incl. non-pollutant stressors)	Strategy Key	
	Description	Example BMPs/actions
All [protection-related]	Implement volume control / limited-impact development: This is aimed at development of undeveloped land to provide no net increase in volume and pollutants	See MPCA Stormwater Manual: https://stormwater.pca.state.mn.us/index.php?title=Main_Page

4. Monitoring Plan

Progress on the implementation of the PSC Subwatershed TMDL and WRAPS will be measured through regular periodic monitoring of water quality and tracking of the BMPs completed. This will be accomplished through the combined efforts of the organizations receiving allocations as well as the cooperating agencies (notably the PSCWMC and MPCA).

The Intensive Watershed Monitoring program conducted by the MPCA is expected to provide a large-scale, longer-term picture of the degree to which conditions are changing in the PSC Subwatershed. The MPCA conducted monitoring in 2007 to 2008 in the North Fork Crow Watershed and 2012 to 2013 in the South Fork Crow Watershed. Monitoring is expected to be undertaken again in 2017 to 2018 and 2022 to 2023 respectively, as part of the 10-year monitoring cycle.

The PSCWMC adopted a detailed routine monitoring plan as part of its Third Generation Watershed Management Plan that includes both routine and as-needed monitoring to monitor trends in water quality and to assess progress toward achieving TMDLs.

Lake Monitoring

The Commission's monitoring plan establishes Sentinel Lakes (Lake Independence, Lake Sarah, North and South Whaletail, and Little Long Lake) for annual monitoring due to their visibility and priority as public resources. TRPD intends to monitor Lake Rebecca every year as well because of its recreational importance in the Park system, and to track the long-term effectiveness of the lake restoration activities it has implemented. Other lakes will be monitored on a rotating basis, either under contract with TRPD (Half Moon, Spurzem, and Rattail), or through Metropolitan Council's Citizen-Assisted Monitoring Program (CAMP) (Ardmore, Hafften, and Peter). Lakes are generally monitored for chlorophyll-*a*, TP, and Secchi disk transparency. Aquatic plant surveys should also be conducted on each lake at approximately three to five year intervals.

In-lake monitoring will continue as implementation activities are undertaken across the respective watersheds. These monitoring activities will continue until water quality goals are met. The DNR will continue to conduct fish surveys on lakes with developed public access (currently Whaletail Lake, Lake Rebecca, Little Long Lake, and Spurzem Lake) as allowed by their regular schedule. Historically, fish surveys have been conducted about every 5 to 10 years.

Stream Monitoring

Stream monitoring in the PSC Subwatershed, which includes Sarah Creek, Pioneer Creek, Deer Creek, and Unnamed Creek, has been coordinated by the PSCWMC, which partners with TRPD. Other efforts have included those funded by the MPCA through a Surface Water Assessment Grant (SWAG) and the TMDL itself to carry out flow and/or water quality monitoring at various sites.

The PSCWMC will continue to collaborate with TRPD to obtain routine flow and water quality data. The PSCWMC's Third Generation Watershed Management Plan monitoring plan also calls for additional stream sites to be monitored annually for flow and water quality, rotating among several sites across all four major stream systems so that each site is monitored every two to three years.

The PSCWMC will also periodically perform longitudinal *E. coli* and DO surveys on each *E. coli* and DO-impaired stream to better understand sources of bacteria and low DO in these streams, and to assess progress toward meeting the state water quality standards. For example, additional *E. coli* monitoring should be performed at the outlet of Lake Sarah to better understand the potential of the lake as a source of *E. coli*. A longitudinal assessment should also be conducted to better pinpoint watershed sources so that the most appropriate reduction actions can be identified and implemented.

Similarly, both Unnamed and Deer Creeks should be considered for longitudinal monitoring to better pinpoint *E. coli* potential hot spots, including assessing the potential for waterfowl sources along the Unnamed Creek stream corridor through Timber Creek Golf Course.

In addition, the Commission may from time to time undertake special stream monitoring on other tributaries where necessary, for example to calibrate models or refine subwatershed assessments or to gauge the effectiveness of BMP practices in the watershed.

Tracking of Best Management Practices

The PSCWMC will work with its member communities to track the number, type, location, load reduction benefits, and costs of BMPs (with an emphasis on structural BMPs) that are implemented in the watershed, to address the TMDL and restoration and protection strategies presented in this report. The PSCWMC expects to summarize this information annually and have it available for agencies and interested members of the public.

It is the intent of the implementing organizations in this watershed to make steady progress in terms of pollutant reduction. Accordingly, as a very general guideline, progress benchmarks are established for this watershed that assume that improvements will occur resulting in a water quality pollutant concentration decline each year equivalent to approximately 1% of the starting (i.e., long-term) pollutant concentration. For example, for a lake with a long-term growing season TP concentration of 90 µg/L, by year 10 it would be 90 – (10 * 0.9) = 81 µg/L.

Again, this is a general guideline. Factors that may slow progress include, limits in funding or landowner acceptance, challenging fixes (e.g., unstable bluffs and ravines, invasive species), and unfavorable climatic factors. Conversely, there may be faster progress for some impaired waters, especially where high-impact fixes could occur.

5. References and Further Information

Eckman, K. 2013. Pioneer-Sarah Creek Watershed Knowledge, Attitudes, and Practices (KAP) Study Report (Report no. wq-iw1-56d). Minnesota Pollution Control Agency

Pioneer-Sarah Creek Watershed Management Commission (Report no. wq-iw8-55b). 2016. Pioneer-Sarah Creek Watershed TMDL (September 7, 2016)

Wall, D. 2013. Nitrogen in Minnesota Surface Waters: F1 Reducing Cropland Nitrogen Losses to Surface Waters (Report no. wq-s6-26f1). Minnesota Pollution Control Agency

Pioneer-Sarah Creek Watershed Reports

All Pioneer-Sarah Creek Reports referenced in this watershed report are available at the Pioneer-Sarah Creek Watershed webpage: https://www.pca.state.mn.us/water/tmdl/pioneer-sarah-creek-watershed-restoration-and-protection-strategy-tmdl-project